

Global transition to BEVs - Why Elon Musk is begging miners to mine more nickel #20



First published April 2023

1st reason Musk worry about nickel in BEVs?

1. Nickel is most expensive raw material

- Nickel currently cost 25.42 USD per kg and we need 62 kg of it to make a typical BEV with a nickel rich battery
- In other words, a typical BEV contain 1,571 USD worth of nickel just for the battery pack or 1/4 of total raw material costs
- Furthermore, nickel price is volatile sometimes it cost 2X as much
- Today most nickel is used for making alloys e.g. stainless steel is from 0% to 9% pure nickel and an average of 3.8%
- Vehicles with combustion engines contain 15 to 22 kg of stainless steel and most of that is for the exhaust system that BEVs do not have
- The highest energy density batteries that can be mass produced require a high nickel content so unless we mine more nickel the price will go up**

Price of raw materials needed to make battery electric vehicles

Material type	One average BEV in kg per vehicle	Price in USD per kg	Price USD of needed material in BEV	Date of price info
Graphite battery cells 19% 83kWh	58.73	1.50	88.10	25-Mar-23
Nickel battery cells 20% 83kWh	61.82	25.42	1,571.57	20-Apr-23
Lithium carbonate or equivalent	44.23	28.01	1,239.23	17-Apr-23
Lithium battery cells 2.7% 83kWh	8.35	148.48	1,239.23	17-Apr-23
Copper (battery, motor, wires)	91.00	9.02	820.82	25-Mar-23
Manganese (batteries, steel alloy)	10.00	4.73	47.30	25-Mar-23
Magnesium (VW Beetle)	20.00	3.90	78.00	15-Apr-23
Zinc (rust protection battery etc)	17.50	2.85	49.82	15-Apr-23
Cobalt in battery cells 2%, 83kWh	6.18	34.18	211.31	18-Apr-23
Rare earth (fx Nd, Pr, Dy, Tb)	0.90	103.33	92.99	25-Mar-23
Aluminum (vehicle GM Volt))	169.00	2.35	396.81	25-Mar-23
Crude steel (98% Fe/iron)	900.00	0.59	535.04	25-Mar-23
Plastics textile & other	250.00	4.00	1,000.00	25-Mar-23
Total vehicle weight	1,629.37	Total cost	6,131.00	

Sources: Follow link below video to download spreadsheet containing clickable sources

Consumption of nickel first use in 2021

First Use	Percentage
Stainless Steel	69%
Batteries	11%
Non-Ferrous Alloys	7%
Plating	6%
Alloy Steels	3%
Foundry	2%
Other	2%
Total	100%

Source/attribution: <https://nickelinstitute.org/en/about-nickel-and-its-applications/#04-first-use-nickel>



Source/attribution: <https://tradingeconomics.com/commodity/nickel>



2nd reason Musk worry about nickel in BEVs?

2. **Supply chain risk issues** are certain to arise in a world that aspire to make 100 million BEVs per year by 2032

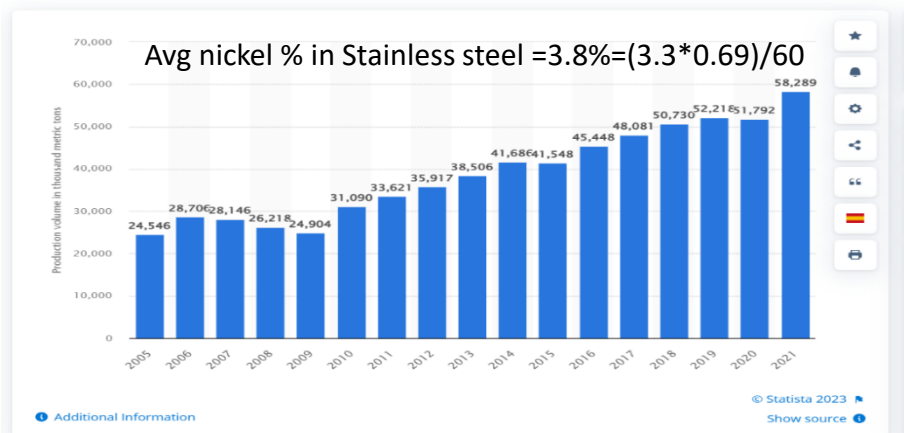
- 6.2 million tons of nickel per year is needed to make nickel rich lithium-ion batteries for 100 million BEVs
- 6.2 million tons compare to 187% of current global nickel consumption of 3.3 million tons of nickel per year
- Also, by 2032 we likely need to double use of nickel for making stainless steel
- Nickel for making 120 million tons of SS by 2032 will require 4.6 million tons of nickel (=3.8%*120M)
- **Nickel demand by 2032 could therefore be up to 11.2 million tons (=4.6+6.2+0.4)**

Raw materials needed to make 100 million BEVs per year if no innovation

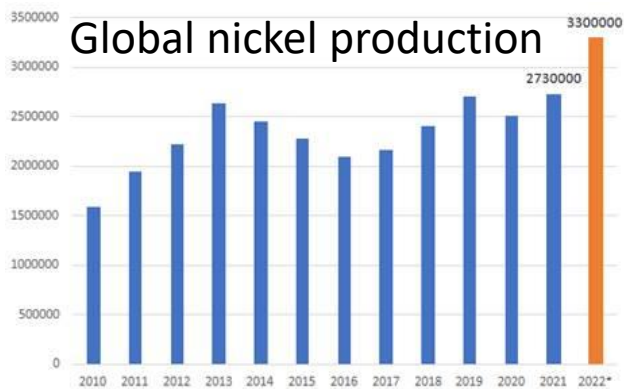
Material type	One average BEV in kg per vehicle	100M BEVs in tons	Global production in tons	Data year	In % of current global production
Graphite battery cells 19% 83kWh	58.73	5,873,280	3,034,000	2021	193.58%
Nickel battery cells 20% 83kWh	61.82	6,182,400	3,300,000	2022	187.35%
Lithium carbonate or equivalent	44.23	4,423,490	540,000	2021	819.16%
Lithium battery cells 2.7% 83kWh	8.35	834,624	130,000	2022	642.02%
Copper (battery, motor, wires)	91.00	9,100,000	21,200,000	2021	42.92%
Manganese (batteries, steel alloy)	10.00	1,000,000	19,000,000	2019	5.26%
Magnesium (VW Beetle)	20.00	2,000,000	1,022,000	2022	195.69%
Zinc (rust protection battery etc)	17.50	1,750,000	13,080,000	2021	13.38%
Cobalt in battery cells 2%, 83kWh	6.18	618,240	190,000	2022	325.39%
Rare earth (fx Nd, Pr, Dy, Tb)	0.90	90,000	300,000	2019	30.00%
Aluminum (vehicle GM Volt))	169.00	16,900,000	68,000,000	2022	24.85%
Crude steel (98% Fe/Iron)	900.00	90,000,000	1,951,000,000	2021	4.61%
Plastics textile & other	250.00	25,000,000	-	-	-
Total vehicle weight	1,629.37				

Sources: Follow link below video to download spreadsheet containing clickable sources

Global stainless steel melt shop production from 2005 to 2021 (in 1,000 metric tons)



Source/attribution: <https://www.statista.com/statistics/223028/world-stainless-steel-production/>



Source/attribution: <https://www.kitco.com/news/2023-02-06/Global-nickel-production-up-21-in-2022-as-indonesian-output-jumps-54.html>

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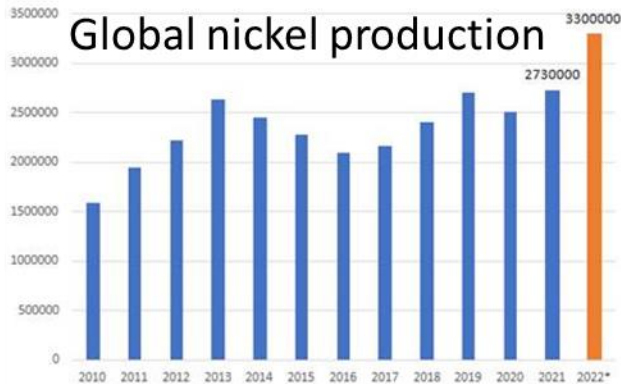
Nickel is not critical as alternatives do exist

- But 11.2M tons of nickel not needed by 2032
- Last 12 years nickel production doubled so **another doubling to 6.6 million by 2032 seems realistic without much change in Ni price**
- If 4.6M +0.4M =5M tons of nickel is used for SS and other it leaves **1.6M tons of nickel for battery production or enough to make 26M nickel rich BEVs (=1.6M/62kg)** in 2032
- E.g., Tesla use nickel rich batteries for their long-range offerings because these batteries have the highest energy density of 244 to 269Wh/kg (cell 4680 and 2170 respectively)
- For everything else Tesla use nickel free cells like LiFePO4 at 160 Wh/kg to 200Wh/kg
- Future Na-ion at 160 Wh/kg is also a possibility

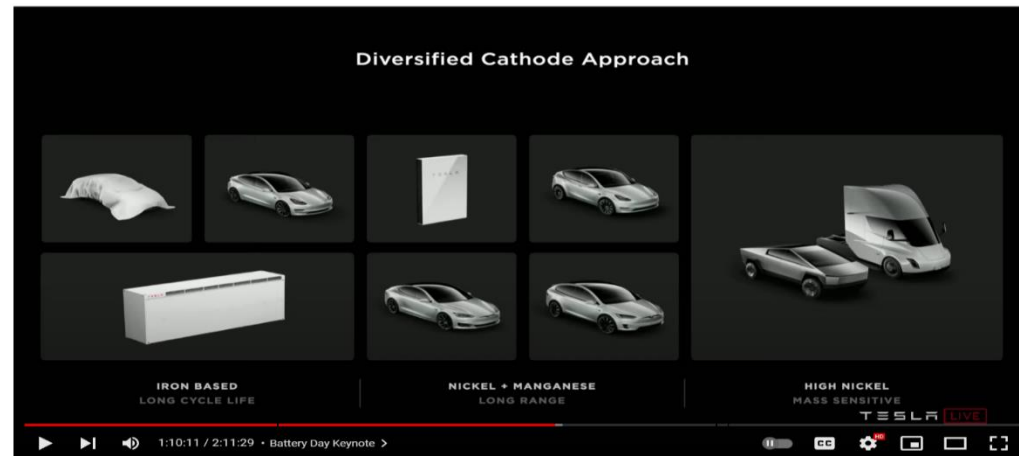
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Plastics textile & other	250.00	25,000,000	-	-	-
Total vehicle weight	1,629.37				

Sources: Follow link below video to download spreadsheet containing clickable sources



Source/attribution: <https://www.kitco.com/news/2023-02-06/Global-nickel-production-up-21-in-2022-as-Indonesian-output-jumps-54.html>



Tesla Battery Day

Streamed Sep 22, 2020: <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s>

Source and attribution: My own tables. For sources for data points follow link below video and download excel spreadsheet

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Still low supply chain risks for nickel

- ✓ **Low supply chain risk with regard to nickel production and nickel reserves**
- ✓ Friendly countries like Australia, Indonesia and Brazil have a combined 55% of the nickel reserves
- ✓ Production is concentrated by 48% in Indonesia but is otherwise spread over many countries
- ✓ China and Russia are the two risky suppliers and they only control 10% combined of both global nickel production and reserves
- ✓ **The current global nickel reserves** are 102 million tons and if every kg was used to make nickel rich BEVs it is enough to make 1,645 million BEVs (= (102M*1000)kg/62kg)
- ✓ Considering that at least 3/4 of the nickel reserves are likely to be used for other things than making batteries the 1,645 million BEVs is not a very high number IMO and this is good reason for Musk to worry about nickel
- ✓ **However, nickel reserves more than doubled the past 22 years** so we should expect continued growth
- ✓ Nickel reserves will grow with 1) new discoveries, 2) new extraction technology 3) increased price for nickel
- ✓ And nickel reserves will fall with 1) lower nickel prices, 2) extraction, 3) lower nickel ore quality

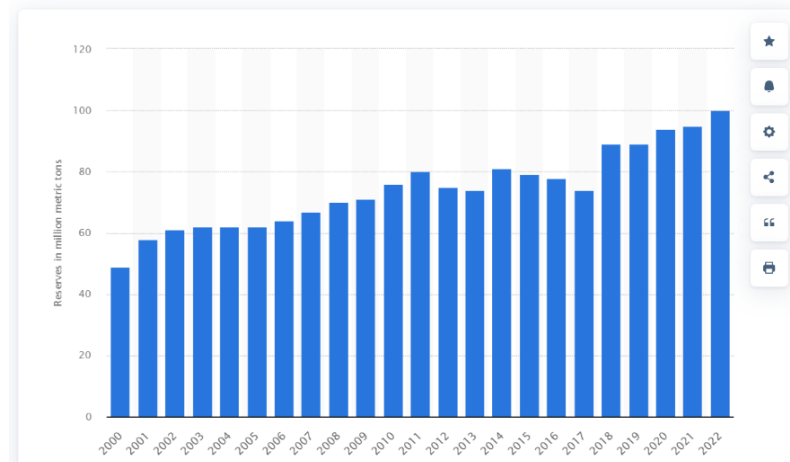
Nickel production and reserves in tons in 2022/2021

Country	Production	% of total	Reserves	% of total
Australia	160,000	4.85%	21,000,000	20.57%
Indonesia	1,600,000	48.48%	21,000,000	20.57%
Brazil	100,000	3.03%	16,000,000	15.68%
Russia	220,000	6.67%	7,500,000	7.35%
New Caledonia	190,000	5.76%	7,100,000	6.96%
Philippines	330,000	10.00%	4,800,000	4.70%
Canada	130,000	3.94%	2,200,000	2.16%
China	120,000	3.64%	2,100,000	2.06%
United States	18,000	0.55%	370,000	0.36%
Other countries	432,000	13.09%	20,000,000	19.59%
World total	3,300,000	100.00%	102,070,000	100.00%

Sources: Follow link below video to download spreadsheet containing clickable sources

Reserves of nickel worldwide from 2000 to 2022

(in million metric tons)



Source/attribution: <https://www.statista.com/statistics/1003284/nickel-reserves-worldwide/>



How hard is it to scale nickel production

- ✓ **Question:** How hard is to double nickel production to 6.6 million tons annually by 2032?
- ✓ Recall 6.6M tons should be enough to meet expected demand from both stainless steel and batteries in 2032
- ✓ It is very doable as we will need to mine the equivalent of 550 million tons of nickel ore at 1.2%
- ✓ 550 million tons only represent 14.1% (=550/3902) of the iron ore mined in 2021
- ✓ Also note that **BEV batteries and stainless steel can be recycled** so eventually much less mining is needed for nickel

Scale of global raw materials industry by size in tons and USD sales

Material type	Production and mining in tons	Data year	In % of iron ore	Price USD/kg	Date of price info	Global sales million USD	Materials tons for 100M BEVs
Graphite battery cells 19% 83kWh	3,034,000	2021	0.08%	1.50	25-Mar-23	4,551	5,873,280
of which is mined graphite	1,034,000	2021	-	-	-	1,551	-
of which is synthesized graphite	2,000,000	2021	-	-	-	3,000	-
Nickel in battery cells 20% 83kWh	3,300,000	2022	-	25.42	20-Apr-23	83,886	6,182,400
Nickel ore at 1.2%	275,000,000	2022	7.05%	-	-	-	515,200,000
Lithium carbonate or equivalent	540,000	2021		28.01	17-Apr-23	15,128	4,423,490
Lithium battery cells 2.7% 83kWh	130,000	2022		148.48	17-Apr-23	19,302	834,624
Lithium ore at 0.7%	18,571,429	2022	0.48%	-	-	-	119,232,000
Copper (battery, motor, wires)	21,200,000	2021	-	9.02	25-Mar-23	191,224	9,100,000
Copper ore at 0.6%	3,533,333,333	2021	90.55%	-	-	-	1,516,666,667
Manganese (batteries, steel 1%)	19,000,000	2019		4.73	25-Mar-23	89,865	1,000,000
Manganese ore at 30%	63,333,333	2019	1.62%	-	-	-	3,333,333
Magnesium Mg	1,022,000	2022		3.90	15-Apr-23	3,986	2,000,000
Magnesium ore at 3.86%	26,450,000	2022	0.68%				51,761,252
Zinc (rust protection battery etc)	13,080,000	2021		2.85	15-Apr-23	37,239	1,750,000
Zinc ore at 5%	261,600,000	2021	6.70%				35,000,000
Cobalt in battery cells 2%, 83kWh	190,000	2022	-	34.18	18-Apr-23	6,494	618,240
Cobalt ore at 0.2%	95,000,000	2022	2.43%				309,120,000
Rare earth (fx Nd, Pr, Dy, Tb)	300,000	2019	-	103.33	25-Mar-23	30,998	90,000
Aluminum (vehicle GM Volt)	68,000,000	2022	-	2.35	25-Mar-23	159,664	16,900,000
Aluminium ore Bauxite at 18%	380,000,000	2022	9.74%	-	-	-	94,441,176
Crude steel (98% Fe/Iron)	1,951,000,000	2021		0.59	25-Mar-23	1,159,858	90,000,000
Iron ore needed at 50%	3,902,000,000	2021	100.00%	0.12	4-Apr-23	481,897	180,000,000
Coal (price is Newcastle Europe)	7,700,000,000	2021	197.33%	0.20	6-Apr-23	1,524,600	0
Oil (price is WTI US crude)	4,200,000,000	2021	107.64%	0.56	6-Apr-23	2,343,180	0
Gas (price is UK natural gas)	3,872,074,514	2021	99.23%	0.49	6-Apr-23	1,914,013	0

Sources: Follow link below video to download spreadsheet containing clickable sources

Streamed Sep 22, 2020 (1:18:11): <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s>

Recycling Elements From Cells Is Far More Desirable Than From Raw Ores

SOURCE	NICKEL	LITHIUM	COBALT	Copper
RECYCLED CELLS	20%	2.7%	2%	8%
TYPICAL ORES	1.2%	0.7%	0.2%	0.6%

Sources/attribution for previous slides

- Tesla 2023 Investor Day, Powertrain technologies 52:40: <https://www.youtube.com/watch?v=Hl1zEzVUV7w&t=2982s>
- Growth in Reserves of nickel worldwide from 2000 to 2022: <https://www.statista.com/statistics/1003284/nickel-reserves-worldwide/>
- Growth in global nickel production from 2010 to 2022: <https://www.kitco.com/news/2023-02-06/Global-nickel-production-up-21-in-2022-as-Indonesian-output-jumps-54.html>
- Top nickel producing countries from 2021 to 2022: <https://www.kitco.com/news/2023-02-06/Global-nickel-production-up-21-in-2022-as-Indonesian-output-jumps-54.html>
- 45 kg in a Tesla vehicle: <https://www.mining.com/all-the-mines-tesla-needs-to-build-20-million-cars-a-year/>
- 50 kg of nickel in a Tesla vehicle: <https://www.abc.net.au/news/2022-08-16/nickel-metal-batteries-energy-race-to-produce-to-match-demand/101334424>
- Up to 40 kg of nickel in a Tesla with nickel rich battery chemistry 8-1-1: <https://www.reuters.com/business/autos-transportation/costs-nickel-cobalt-used-electric-vehicle-batteries-2022-02-03/>
- Number of 2170 cells in Tesla Model Y long range is 4416 cells 75kWh: <https://themotordigest.com/how-much-do-tesla-batteries-weigh/>
- Weight of a single Tesla 2170 cell is 70 grams: <https://cleantechnica.com/2019/01/28/tesla-model-3-battery-pack-cell-teardown-highlights-performance-improvements/>
- Best source of nickel content in Tesla high nickel 2170 cell is 20% by weight: (1:18:11): <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s> (so we can now calculate the nickel content in Model Y long range in kg as $((70g \cdot 4416) / 1000) \cdot 20\% = 62kg$)
- Consumption of nickel first use in 2021: <https://nickelinstitute.org/en/about-nickel-and-its-applications/#04-first-use-nickel>
- Stainless steel contain 0 to 10% nickel: <https://www.coalitionbrewing.com/how-much-nickel-is-in-stainless-steel/>
- 15 to 22 kg of stainless steel in a vehicle with combustion engine and most of that is for the exhaust system: <https://www.worldstainless.org/Files/issf/non-image-files/PDF/Stainlesssteelautomotiveandtransportdevelopments.pdf#:~:text=The%20average%20passenger%20car%20uses%20about%2015%20to,and%20transport%20uses%20are%20set%20to%20gain%20ground.>
- At Tesla Battery Day - Tesla use zero cobalt for their high nickel lithium ion batteries (timestamp 1:09:40): <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s>
- At Tesla Battery Day – Elon Musk pleads with miners to make more nickel (timestamp 1:10:10): <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s>
- At Tesla earnings call July 2020 Musk said “Please mine more nickel...Tesla will give you a giant contract for a long period of time if you mine nickel efficiently and in an environmentally sensitive way,”: <https://www.reuters.com/article/us-tesla-nickel-idUSKCN2400RV>
- At Tesla Battery Day – Elon Musk and Drew Baglino talk about lithium from clay and why lithium is not their biggest concern: pleads (timestamp 1:17:00): <https://www.youtube.com/watch?v=l6T9xleZTds&t=4628s>
- High nickel Tesla 2170 and 4680 battery cells have respectively 269 and 244 Wh/kg: <https://www.notebookcheck.net/Tesla-4680-vs-2170-battery-cell-test-reveals-lower-energy-density-in-the-Texas-made-Model-Y.669162.0.html>
- LiFePO4 by CATL at minimum 160 Wh/kg: <https://cleantechnica.com/2020/02/18/how-catl-lithium-iron-phosphate-batteries-could-be-leading-to-100-kwh-tesla-model-3/>
- Na-ion (sodium-ion) at minimum 160 Wh/kg by CATL: <https://cnevpost.com/2023/04/16/chery-to-be-1st-to-adopt-catl-sodium-ion-batteries/>

