

Lithium - Breaking China's battery monopoly and making 100 million BEVs per year by 2032 #19



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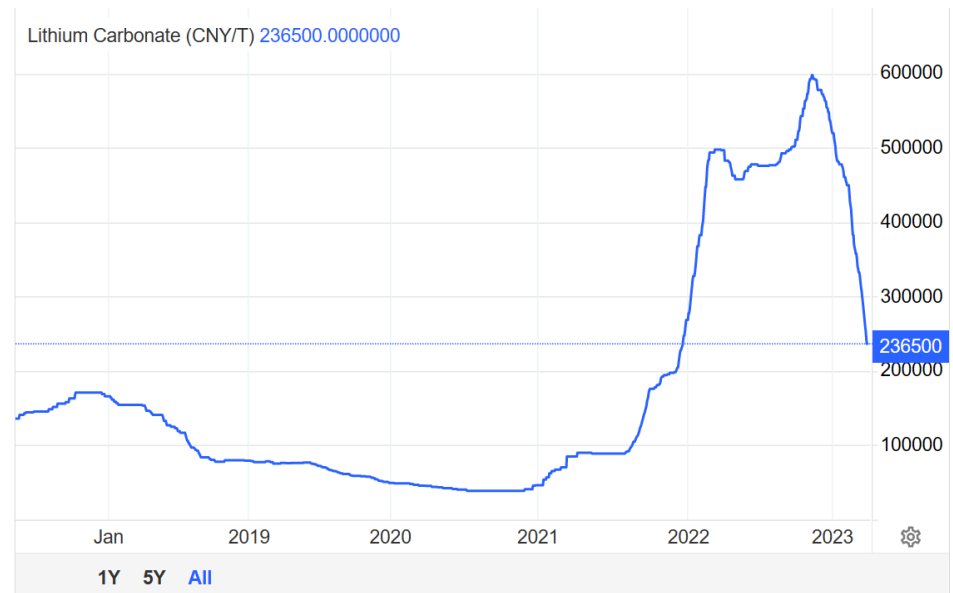
Why worry about lithium use in BEVs?

1. Lithium carbonate is very expensive

- 63 kg of lithium carbonate cost 2169 USD at 1. April, 2023 (>1/3 of all raw material cost of 6195 USD)
- 1 kg of lithium carbonate contain 189 grams of lithium metal
- That means lithium metal would cost 182 USD/kg $(=(1000/189)*34.43\text{USD})$ or more than the price of Neodymium
- On Nov. 17, 2022 lithium carbonate traded for 600,000 CNY per ton or 87.35 USD per kg or 5503 USD for a typical BEV!
- This is outrageous because production price for lithium carbonate is only about 30,000 CNY or 275 USD per BEV!**
- So nearly all profits >95% are made in refining of lithium carbonate Li_2CO_3 and lithium hydroxide LiOH
- Only modest profits are made in mining or extraction of lithium raw materials (salt brine and spodumene rock)

Price of raw materials needed to make battery electric vehicles

Material type	One average BEV in kg per vehicle	100M BEVs in tons	Price in USD per kg	Price USD of needed material in BEV	Date of price info
Graphite (99.95% pure anode)	100.00	10,000,000	1.50	150.00	25-Mar-23
Nickel (tesla battery 78kWh)	45.00	4,500,000	23.30	1,048.50	25-Mar-23
Lithium carbonate or equivalent In terms of lithium metal 100%	63.00	6,300,000	34.43	2,169.16	1-Apr-23
	11.89	1,188,684	182.48	2,169.16	1-Apr-23
Copper (battery, motor, wires)	91.00	9,100,000	9.02	820.82	25-Mar-23
Manganese (batteries)	1.04	104,055	4.73	4.92	25-Mar-23
Cobalt (batteries)	3.42	341,575	34.18	116.75	25-Mar-23
Rare earth (fx Nd, Pr, Dy, Tb)	0.90	90,000	103.37	93.03	25-Mar-23
Aluminum (vehicle GM Volt)	169.00	16,900,000	2.35	396.81	25-Mar-23
Crude steel (98% Fe/Iron)	1,000.00	100,000,000	0.59	594.72	25-Mar-23
Other textile and plastic	200.00	20,000,000	4.00	800.00	25-Mar-23
Total vehicle weight	1,673.36		Total cost	6,194.71	



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

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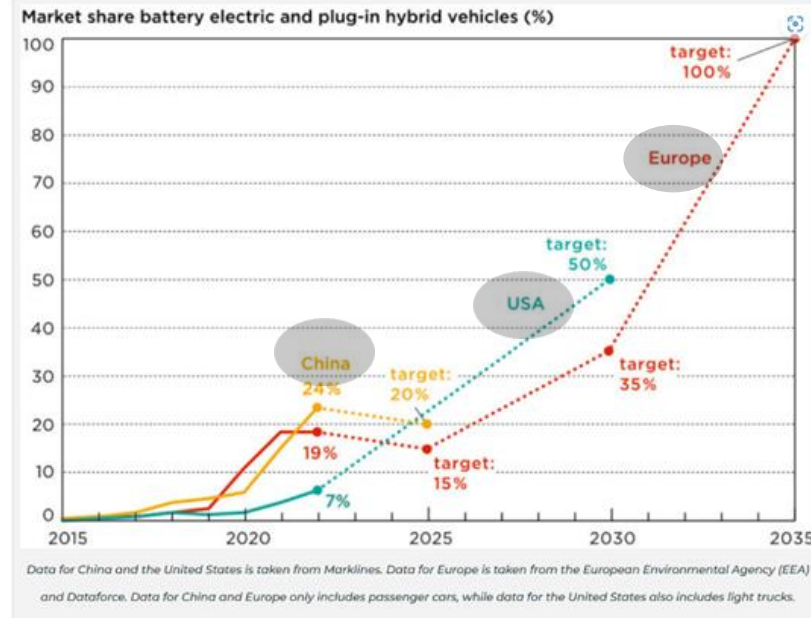
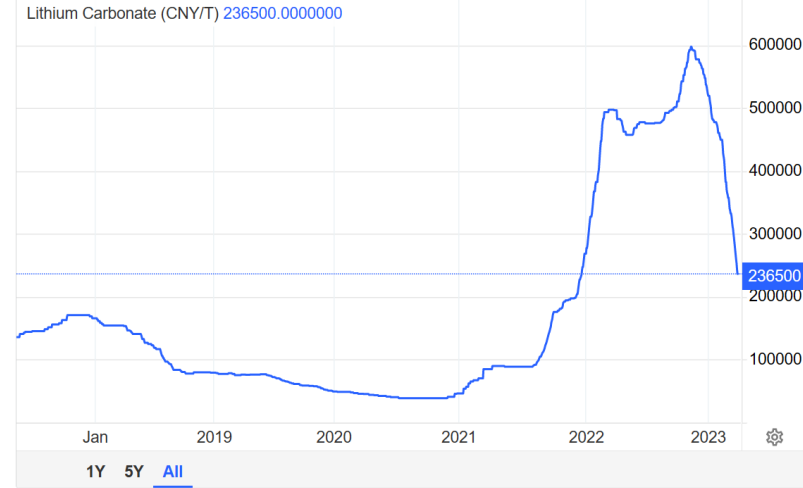
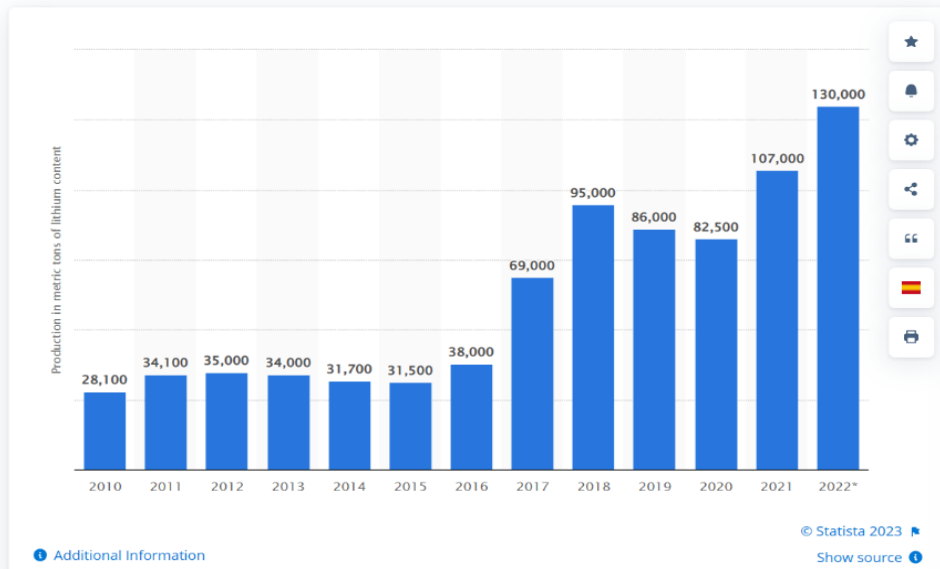


Why is price of lithium so volatile?

- Why did lithium carbonate price go up 10x in 2021/22 and subsequently drop 2.5X since Nov. 2022?
- One explanation is that incentives for BEVs were cut in EU and China in 2022/23 so now less demand growth than anticipated by refiners of lithium
- Another explanation is that Chinese refiners was told by CCP to rise prices to compensate China for rising prices in 2022 on the commodities China imports

Mine production of lithium worldwide from 2010 to 2022

(in metric tons of lithium content)



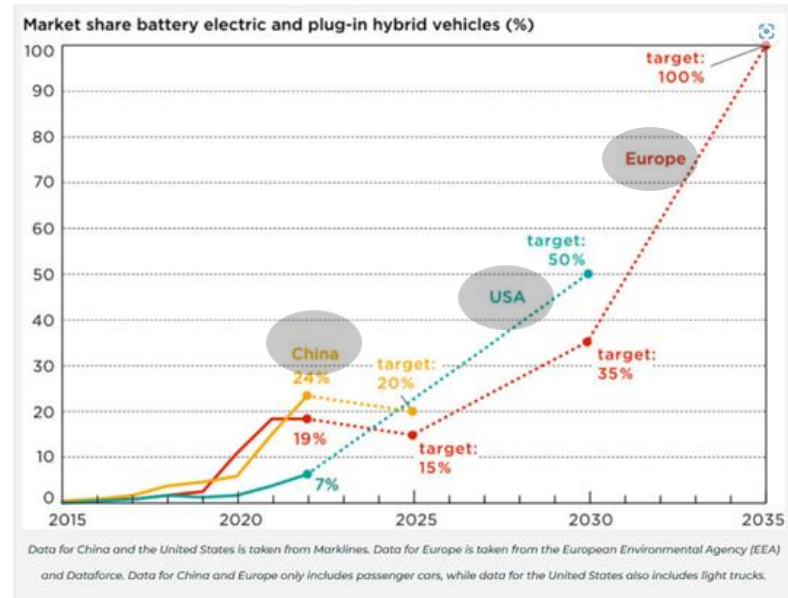
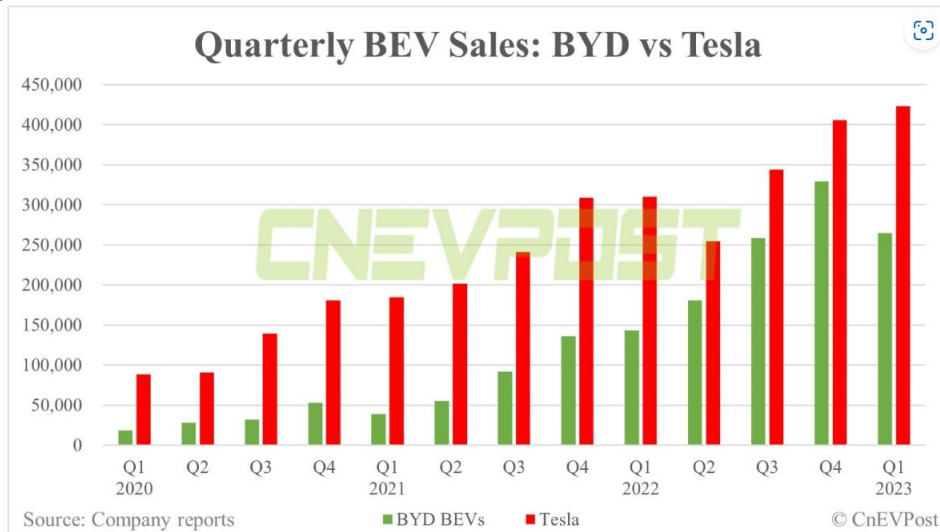
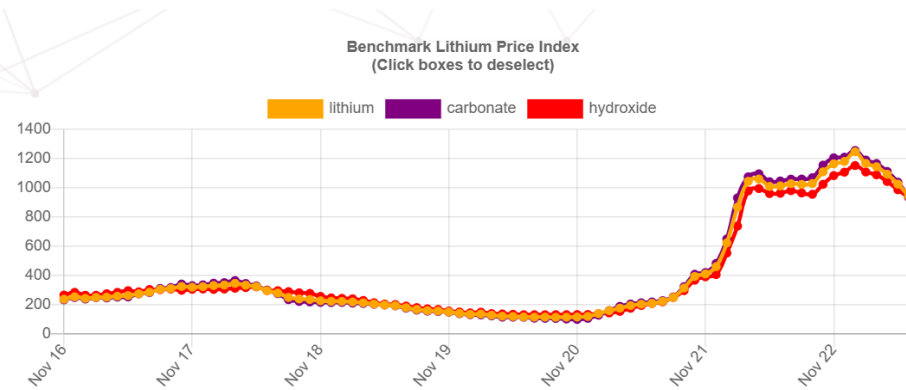
Source and attribution: <https://tradingeconomics.com/commodity/lithium>

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Why is price of lithium so volatile?

- Continued: Why did lithium price go up 10x in 2021/22 and subsequently drop 2.5X since Nov. 2022?
- BEV sales from Tesla and BYD suggest continued strong growth in 2023, Q1 vs. 2022, Q1 and also in Q4, 2022
- So lithium prices has been falling since Q4, 22 despite continued strong growth in BEV production and sales
- IMO demand spike and subsequent shortfall for lithium carbonate because of EV incentives is therefore not likely explanation for price increase and subsequent decrease
- More likely politically driven by CCP
- Note price pattern is same for lithium metal and hydroxide



Source and attribution: <https://www.benchmarkminerals.com/lithium-prices/>

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Why worry about lithium use in BEVs?

- Supply chain risk** issues are certain to arise in a world that need to make 100 million BEVs per year by 2032 or what is 914% of current global production

 - Specifically we need to expand lithium production by 26% annually until 2032
 - 10X expansion of current production is needed to satisfy demand from both BEV battery production and other products that use lithium
 - We also need to make batteries for grid storage but that will likely be done predominantly using Na-ion batteries
 - Future video will discuss Na-ion vs Li-ion

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 (99.95% pure anode)	100.00	10,000,000	3,034,000	2021	329.60%
Nickel (tesla battery 78kWh)	45.00	4,500,000	3,300,000	2022	136.36%
Lithium carbonate or equivalent	63.00	6,300,000	540,000	2021	1166.67%
In terms of lithium metal 100%	11.89	1,188,684	130,000	2022	914.37%
Copper (battery, motor, wires)	91.00	9,100,000	21,200,000	2021	42.92%
Manganese (batteries)	1.04	104,055	19,000,000	2019	0.55%
Cobalt (batteries)	3.42	341,575	190,000	2022	179.78%
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)	1,000.00	100,000,000	1,951,000,000	2021	5.13%
Other textile and plastic	200.00	20,000,000	-	-	-
Total vehicle weight	1,673.36				

Needed growth of lithium production in metal equivalents

Year	Production tons	Annual growth %	Multiplier
2016	38,000		
2022	130,000	22.75%	1.00
2023	163,800	26.00%	1.26
2024	206,388	26.00%	1.59
2025	260,049	26.00%	2.00
2026	327,662	26.00%	2.52
2027	412,854	26.00%	3.18
2028	520,196	26.00%	4.00
2029	655,446	26.00%	5.04
2030	825,862	26.00%	6.35
2031	1,040,587	26.00%	8.00
2032	1,311,139	26.00%	10.09

End-use	Lithium Consumption 2010 (%)	Lithium Consumption 2021 (%)
Batteries	23%	74%
Ceramics and glass	31%	14%
Lubricating greases	10%	3%
Air treatment	5%	1%
Continuous casting	4%	2%
Other	27%	6%
Total	100%	100%

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Low supply chain risks for Li-raw materials

- ✓ Low supply chain risk with regard to production of **>raw materials<** for lithium production
- ✓ Friendly countries like Australia makes 49% (lithium rich rocks) and Chile 22% (lithium rich brine) of worlds raw materials for lithium
- ✓ China is the only risky supplier and they only make 17% of global raw materials output
- ✓ **Lithium reserves** in existing lithium mines are 21 million tons and is enough to make 1.76 billion BEVs (=100M*(21M/1.19M))
- ✓ Moreover, known **resources of lithium** are 91 million tons and are enough to make 7.68 billion BEVs (=100M*(91.4M/1.19M))
- ✓ **These resources will grow many times over** in the future because of exploration and new extraction technology
- ✓ For example, Tesla is currently developing a technology that will make it possible to **extract lithium from lithium rich clay** that can be found many places all over the world
- ✓ **Lithium from clay is not done commercially today** so when Tesla succeeds it will greatly expand the available lithium resources available

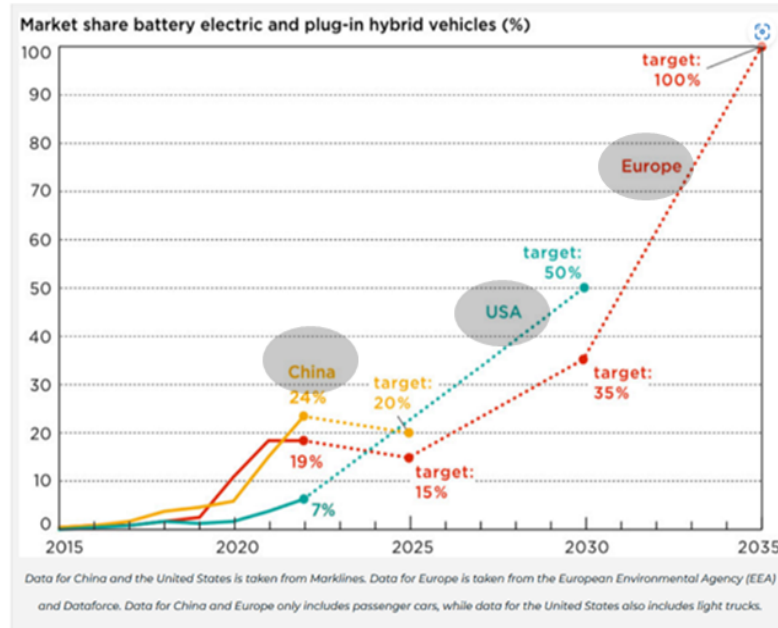
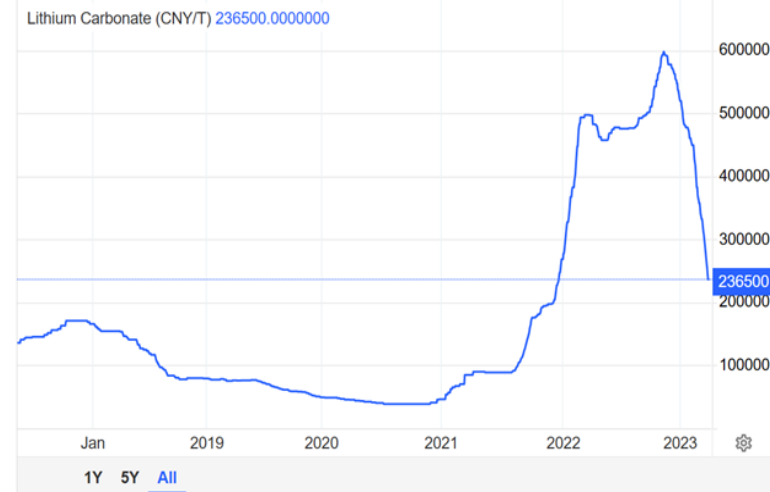
Lithium production (2020), reserves and resources in tons						
Country	Production	% of total	Reserves	% of total	Resources	% of total
Argentina	6,200	7.56%	1,900,000	9.05%	19,300,000	21.11%
Australia	40,000	48.78%	4,700,000	22.38%	6,400,000	7.00%
Austria	-	-	-	-	50,000	0.05%
Bolivia	-	-	-	-	21,000,000	22.97%
Brazil	1,900	2.32%	95,000	0.45%	470,000	0.51%
Canada	0	0.00%	530,000	2.52%	2,900,000	3.17%
Chile	18,000	21.95%	9,200,000	43.81%	9,600,000	10.50%
China	14,000	17.07%	1,500,000	7.14%	5,100,000	5.58%
Czech Republic	-	-	-	-	1,300,000	1.42%
DR Congo	-	-	-	-	3,000,000	3.28%
Finland	-	-	-	-	50,000	0.05%
Germany	-	-	-	-	2,700,000	2.95%
Ghana	-	-	-	-	90,000	0.10%
India	-	-	5,900,000	28.10%	5,900,000	6.45%
Kazakhstan	-	-	-	-	50,000	0.05%
Mali	-	-	-	-	700,000	0.77%
Mexico	-	-	-	-	1,700,000	1.86%
Namibia	-	-	-	-	50,000	0.05%
Peru	-	-	-	-	880,000	0.96%
Portugal	900	1.10%	60,000	0.29%	270,000	0.30%
Serbia	-	-	-	-	1,200,000	1.31%
Spain	-	-	-	-	300,000	0.33%
United States	870	1.06%	750,000	3.57%	7,900,000	8.64%
Zimbabwe	1,200	1.46%	220,000	1.05%	500,000	0.55%
World total	82,000	100.00%	21,000,000	100.00%	91,410,000	100.00%

Own table source: <https://en.wikipedia.org/wiki/Lithium#Production>



High supply chain risks for Li-ion batteries

- ✓ **Supply chain risk for lithium ion battery production is extremely high as China make 79% of all such batteries in 2021**
- ✓ Moreover, China also do the associated processing/refinery of battery materials like lithium carbonate & lithium hydroxide
- ✓ The world in 2023 are critically dependent on China's willingness to supply its batteries BEVs, smartphones, mobile computers, etc.
- ✓ To repeat, China also makes nearly all the profit in the supply chain as their cost of making lithium carbonate is 30,000 CNY/ton and they currently sell it for 230,000 CNY/ton
- ✓ **Obviously for both security and economic reasons** the free world needs to make its own Li-ion batteries and battery materials
- ✓ **What to do to end China's Li-ion battery monopoly:**
 1. Pass legislation that require battery materials and cell production to be localized, (NA, EU, Japan, SK etc.)
 2. Phase legislation in over 5 years with 2028 as the year where all battery materials and cell production has to be 100% localized
 3. Allow Chinese companies like BYD and CATL to set up fully owned factories in the free world and require China to allow western companies to set up fully owned factories in China
 4. China and the West are much better off in terms of growth & peace with continued tech transfer and investments
 5. If we are mutually invested that is an incentive to keep the peace



Supply chain risks: Raw materials

- ✓ **Question 1:** Is it hard to 10X production of raw materials for lithium production by 2032?
- ✓ No, because we will need to mine the equivalent of 59.4 million tons of spodumene ore at 2% to make 100 million BEVs per year
- ✓ 59.4 million tons may sound like a lot but it only represent 1.52% (=59.4*100/3902) of the iron ore mined in 2021
- ✓ So we need mining capacity (trucks and excavators) equal to 1.5% of the current mining capacity for iron ore to mine enough lithium ore/brine for 100 million BEVs per year
- ✓ Also note that **BEV batteries can be recycled** so eventually much less mining is needed

Scale of global raw materials industry by size and USD

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 (99.95% pure anode)	3,034,000	2021	0.08%	1.50	25-Mar-23	4,551	10,000,000
of which is mined graphite	1,034,000	2021	-	-	-	1,551	-
of which is synthesized graphite	2,000,000	2021	-	-	-	3,000	-
Nickel (tesla battery 78kWh)	3,300,000	2022	-	23.30	25-Mar-23	76,890	4,500,000
Nickel ore at 2%	165,000,000	2022	4.23%	-	-	-	225,000,000
Lithium carbonate or equivalent	540,000	2021	-	34.43	1-Apr-23	18,593	6,300,000
In terms of lithium metal 100%	130,000	2022	-	182.48	1-Apr-23	23,723	1,188,684
Li in terms of spodumene ore 2%	6,500,000	2022	0.17%	-	-	-	59,434,200
Copper (battery, motor, wires)	21,200,000	2021	-	9.02	25-Mar-23	191,224	9,100,000
Copper ore at 0.6%	4,240,000,000	2021	108.66%	-	-	-	1,820,000,000
Manganese (batteries)	19,000,000	2019	-	4.73	25-Mar-23	89,899	104,055
Manganese ore at 30%	63,333,333	2019	1.62%	-	-	-	346,850
Cobalt (batteries)	190,000	2022	-	34.18	25-Mar-23	6,494	0
Rare earth (fx Nd, Pr, Dy, Tb)	300,000	2019	-	103.37	25-Mar-23	31,010	0
Aluminum (vehicle GM Volt)	68,000,000	2022	-	2.35	25-Mar-23	159,664	16,900,000
Aluminium ore Bauxite at 17%	380,000,000	2022	9.74%	-	-	-	99,411,765
Crude steel (98% Fe/Iron)	1,951,000,000	2021	-	0.59	25-Mar-23	1,160,296	100,000,000
Iron ore needed at 50%	3,902,000,000	2021	100.00%	0.12	4-Apr-23	481,897	200,000,000
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

- ✓ **Full transition to a sustainable economy** based on solar and wind power will end 16,000 million tons of mining/extraction in coal, gas and oil
- ✓ These 16,000 million tons of coal, oil and gas can not be recycled
- ✓ Unlike the materials needed for BEVs, solar, wind power, heat pumps that all can be recycled and therefore require less and less mining



Supply chain risks: Processed materials

- ✓ **Question 2:** Can the world 10X production of lithium carbonate and lithium hydroxide for making enough batteries by 2032 to make 100 million BEVs annually
- ✓ YES, because we are still talking about very small quantities of chemical processing
- ✓ Even after 10X production increase the amounts of processing are tiny compared to mining and extraction industries like iron, copper, coal oil and gas
- ✓ I even think China could do it alone if the free world is stupid enough to let them do it
- ✓ Obviously the free world need to do this production ourselves
- ✓ If not China's CCP can use their monopoly powers to impose their will upon us and shut down our economy if we refuse

Scale of global raw materials industry by size and USD

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 (99.95% pure anode)	3,034,000	2021	0.08%	1.50	25-Mar-23	4,551	10,000,000
of which is mined graphite	1,034,000	2021	-	-	-	1,551	-
of which is synthesized graphite	2,000,000	2021	-	-	-	3,000	-
Nickel (tesla battery 78kWh)	3,300,000	2022	-	23.30	25-Mar-23	76,890	4,500,000
Nickel ore at 2%	165,000,000	2022	4.23%	-	-	-	225,000,000
Lithium carbonate or equivalent	540,000	2021	-	34.43	1-Apr-23	18,593	6,300,000
In terms of lithium metal 100%	130,000	2022	-	182.48	1-Apr-23	23,723	1,188,684
Li in terms of spodumene ore 2%	6,500,000	2022	0.17%	-	-	-	59,434,200
Copper (battery, motor, wires)	21,200,000	2021	-	9.02	25-Mar-23	191,224	9,100,000
Copper ore at 0.6%	4,240,000,000	2021	108.66%	-	-	-	1,820,000,000
Manganese (batteries)	19,000,000	2019	-	4.73	25-Mar-23	89,899	104,055
Manganese ore at 30%	63,333,333	2019	1.62%	-	-	-	346,850
Cobalt (batteries)	190,000	2022	-	34.18	25-Mar-23	6,494	0
Rare earth (fx Nd, Pr, Dy, Tb)	300,000	2019	-	103.37	25-Mar-23	31,010	0
Aluminum (vehicle GM Volt))	68,000,000	2022	-	2.35	25-Mar-23	159,664	16,900,000
Aluminum ore Bauxite at 17%	380,000,000	2022	9.74%	-	-	-	99,411,765
Crude steel (98% Fe/Iron)	1,951,000,000	2021	-	0.59	25-Mar-23	1,160,296	100,000,000
Iron ore needed at 50%	3,902,000,000	2021	100.00%	0.12	4-Apr-23	481,897	200,000,000
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

- ✓ We also make more money making battery materials and cells ourselves
- ✓ China's pricing of lithium carbonate at 600,000 CNY in Nov. 2022 or 20X its manufacturing cost of 30,000 CNY is a great example of that
- ✓ Again, Tesla is leading by making one of the first large scale lithium hydroxide fabs in Texas and as well as cathode and cell manufacturing



Sources/attribution for previous slides

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- **63 kg of lithium carbonate equivalent in a BEV:** <https://www.quora.com/How-much-lithium-in-kg-is-used-in-an-electric-car>
- **Price of lithium carbonate slide 2:** <https://tradingeconomics.com/commodity/lithium>
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- **The actual cost of lithium carbonate per ton is around RMB 30,000:** <https://cnevpost.com/2023/04/03/lithium-carbonate-likely-to-fall-below-rmb-100000-says-chairman-of-farasis/>
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- **The conversion ratio of lithium carbonate to lithium metal is about 5.3 to 1. This means that 1 kg of lithium carbonate contains about 188.68 g of lithium metal:** <https://www.thoughtco.com/lithium-production-2340123>
- **Slide 3 graph with market share for BEVs and plug-ins:** <https://theicct.org/publication/european-vehicle-market-statistics-2022-23/>
- **Lithium reserves:** <https://en.wikipedia.org/wiki/Lithium#Production>
- **Slide 7 Tesla developing lithium extraction tech for clay time 1:17:00:** <https://www.youtube.com/watch?v=l6T9xleZTds&t=5614s>
- **Abundance Of Elements:** https://en.wikipedia.org/wiki/Lithium#/media/File:Elemental_abundances.svg
- **China produced some 79 percent of all lithium-ion batteries that entered the global market in 2021:** <https://www.statista.com/statistics/1249871/share-of-the-global-lithium-ion-battery-manufacturing-capacity-by-country/?ssp=1&darkschemeovr=1&setlang=en-XL&safesearch=moderate>
- **Attribution for image of lithium salt piles in landscape:** Alicia Nijdam/Flickr/CC-BY-2.0
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- **“how much lithium in percent of Li₂O” prompt Bing ai and you get 30% and the exact calculation and 30% of 6% is 2% lithium in spodumene ore**
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