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Opportunities and challenges of the raw material industry for the purpose of battery cell manufacturing- Investing into localized battery value chains in North America

Simon Buderath[1], Chandler Crockett, Cooper Jay

[1]*Simon Buderath (corresponding author) P3 USA, Inc., 1 North Main Street 4th floor, Greenville, SC 29601, simon.buderath@p3-group.com*

Executive Summary

Currently, raw materials for battery production are primarily sourced from a select few countries around the world resulting in geopolitical dependencies and the risk of supply chain disruptions. Hence, localized material extraction and upstream manufacturing are crucial and will be propelled even more by tax credits from the Inflation Reduction Act. Inherent opportunities and challenges around raw material mining, battery manufacturing capacities, and alliances will be the subject of this abstract.

Introduction

As it stands, the battery and minerals supply chains need to expand ten-fold in order to meet government EV ambitions [1]. Year over year, the demand for electric vehicles (EVs) has steadily increased. It is predicted that by 2030, up to 75% of all new vehicle registrations will be electric vehicles [2]. Considering that EV's made up less than 3% of all vehicles in 2021 [5], this large demand increase will need to be matched by an equally large supply increase. While the supply of raw material deposits around the world is more than capable of meeting such an increase in demand, the supply chain is not. China dominates the entire downstream EV battery supply chain which increases the likelihood of market instability [1].

1 Demand Forecasts and Supply Chain Issues

Current forecasts indicate that lithium-ion batteries will continue to be the best solution for the EV market through 2030 and, as a result, the raw materials used will be in high demand; namely graphite, cobalt, lithium, nickel, and manganese. Even if the anticipated demand more than doubles by 2030, the supply of said resources currently available in natural deposits are more than capable of keeping up with our growing demand [2]. Unfortunately, most bottlenecks arise elsewhere. Most minerals are not evenly distributed across the planet and therefore, few countries and even fewer companies currently supply these resources. Without change, the supply required to meet U.S. government ambitions will not be hindered by lack of supply, but rather exporting issues and lack of domestic funding. Since very few companies oversee the extraction of the major resources used to make lithium-ion batteries, the rest of the world is left to export leading price volatility to become a prevalent issue [2].

2 East Asian Oligopoly

In 2021, China accounted for half of all EV growth. More vehicles were sold in China in 2021 alone than the rest of the world in 2020. Our battery and minerals supply chains revolve around China. China produces ¾ of all lithium-ion batteries, houses 70% of production capacity for cathodes and 85% for anodes. Over ½ of lithium, cobalt, and graphite processing and refining capacity is in China. Large consumers like Europe and the US cumulatively make up less than 30% of EV production. The control China has on the downstream supply chain of EVs is likely to cause the most problems with global uptake [1].

2.1 Material Breakdown

By 2030, there are expected to be only few innovations that will allow for significant reductions in material-by-weight of lithium-ion batteries and thus exporting becomes the biggest concern to reach our ambitious goals [2].

Graphite

Graphite is the resource most commonly used as anode. Natural graphite resources are estimated to be 230 million tons. In addition, there are 800 million tons of recoverable graphite. Here too, production is concentrated in China with a share of 66 % (China produces 50% of the world’s synthetic graphite and 70% of flake graphite [2]). Other production sites are in Brazil (15%) and Norway (9%). At the application of batteries, graphite has a sustainability index of 0.3 [6].

Cobalt

Cobalt, commonly used as cathode, is the resource most likely to cause supply issues in the future. Demand for cobalt is expected to increase 4 times the current amount by 2030. Currently the Democratic Republic of Congo (DRC) is the biggest cobalt supplier with 70% of the world’s production. This requires most cobalt to be exported for manufacturing, resulting in higher prices for consumers, and it also comes with many human rights concerns. For years, the DRC has been known to severely violate human rights in mining operations on top of struggles with ethnic conflict and major corruption. Violence, child labor, and fatal accidents are common in small mines where much of the world's cobalt is sourced and by exporting it, we become complicit in the DRC's human rights violations [2] [4].

Lithium

Lithium supply needs to triple by 2026 just to meet forecasted demand and its extraction is almost entirely limited to Australia, Chile, and Argentina. Furthermore, only 4 businesses control 60% of global lithium production. Many Asian battery manufacturers have already secured long-term lithium contracts through 2030 which significantly reduces the supply available to the rest of the world [2].

Nickel

Nickel is the key metal to reduce the cobalt content in batteries while also increasing the energy density of the cells. Currently only 5% of nickel is used in the production of lithium-ion batteries, with the share expected to grow to 15% by 2030. The issue with nickel for batteries is the required grade, as most of the nickel currently produced is utilized for steel production. High grade nickel is predominantly sourced from Russia, due to its favorable deposits, while the necessary additional supply is expected to originate from Indonesia. However, Indonesian nickel mining and refining represents a major risk for the pristine local ecosystems and is heavily controlled by Chinese companies [2].

Manganese

Most of the global manganese is utilized in steel production. Only .2% of manganese is allocated to the lithium-ion battery market but by 2030, that number is expected to rise to 1%. However, manganese is the least likely to experience supply shortages in the future. Battery-grade manganese could be a potential bottleneck because the grade needed for steel production is much lower and $MnSO_4$ is usually a byproduct of other products or produced in limited quantities. Since refinery capacity is being expanded more rapidly, the likelihood of a bottleneck occurring can be mitigated.

3 Chances of a Localized Supply Chain

Due to the historical monopolization of the production of synthetic raw materials on the Asian and Australian continent, raw materials and finished products must be exported at a high price. Many countries have recognized the problem and passed legislation to encourage domestic production of batteries for electric cars and the procurement of the necessary raw materials. The corresponding opportunities (and challenges) for localizing the supply chain are great for the battery industry in the United States and around the world.

With the Inflation Reduction Act and the President's Bipartisan Infrastructure Law, for example, the U.S. has laid the first important milestones for the turnaround to localization of the supply chain. The Department of Energy has recently announced its first set of projects funded by the President's Bipartisan Infrastructure

Law which will serve as a monumental step towards the United States' ability to ease supply chain bottlenecks. $2.8 billion will be distributed across 20 companies to expand commercial-scale facilities in 12 states to extract lithium, graphite, and other battery materials. Also, the subsidy aims to expand manufacturing capabilities of battery components and the usage of recycled components- another critical step in meeting growing demand. Furthermore, the federal investment will be matched by its recipients to now total over $9 billion to boost production of American clean energy. The United States aims to align federal investments and activities, domestic and international, to accelerate development of the full end-to-end battery supply chain. In particular, the funding intends to develop enough battery-grade lithium to supply approximately 2 million EVs annually, enough graphite to supply roughly 1.2 million EVs annually, and enough nickel to produce 400,000 EVs annually. Besides a multitude of upgrades for battery component production, the law will also support more than 8,000 jobs from various construction and industrial unions, including 5,000 permanent jobs [3].

4 Closing Remarks

By May of 2022, lithium prices were 7 times higher than they were in early 2021. Demand for EV batteries are expected to increase from a current 340 GWh to over 3500 GWh by 2030. Lithium demand alone is expected to increase 6 times by then, requiring approximately 50 new, average-sized mines alone. With a small portion of the world controlling most of the battery supply chain, prices are only expected to rise. Without drastic innovations in material efficiency, the only way to accelerate global adoption is to ensure secure, resilient, and suitable EV supply chains without geopolitical dependencies [2].

4.1 Supporting Figures

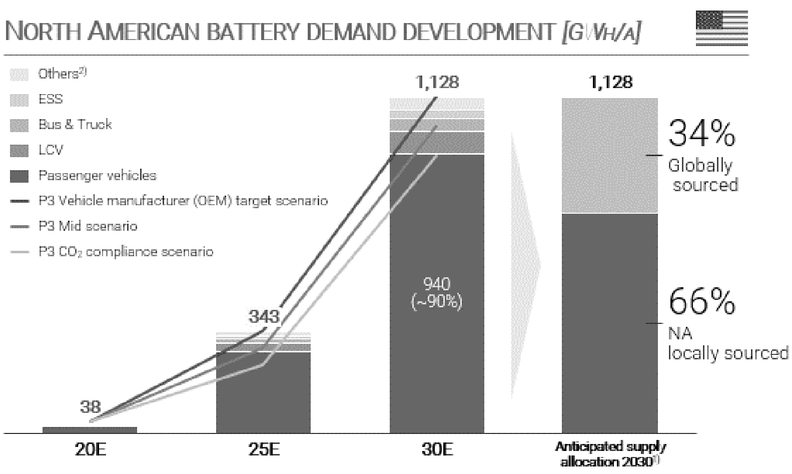

Figure1: North American Battery Demand Development [7]

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[7] P3 Group Market Research

Simon Buderath - Presenter

Having received his diploma in engineering and business administration in 2008, Mr. Buderath was a consultant for P3 automotive GmbH in Germany, with a focus on R&D Strategy and Organization. In 2013, he became the Head of P3 Trucks Product Engineering and Planning and held that position through 2021. Currently, he is responsible for Principal Strategy & Technology and is leading this sector for P3 USA inc., focusing on electric mobility. His team of engineers and consultants are working on the latest powertrain and charging technologies from early concept definition to market roll-out. His customers include OEMs, Tier 1 and 2, as well as financial investors.