A CONVERSATION WITH WOOD MACKENZIE ON THE STATE OF THE BATTERY VALUE CHAIN

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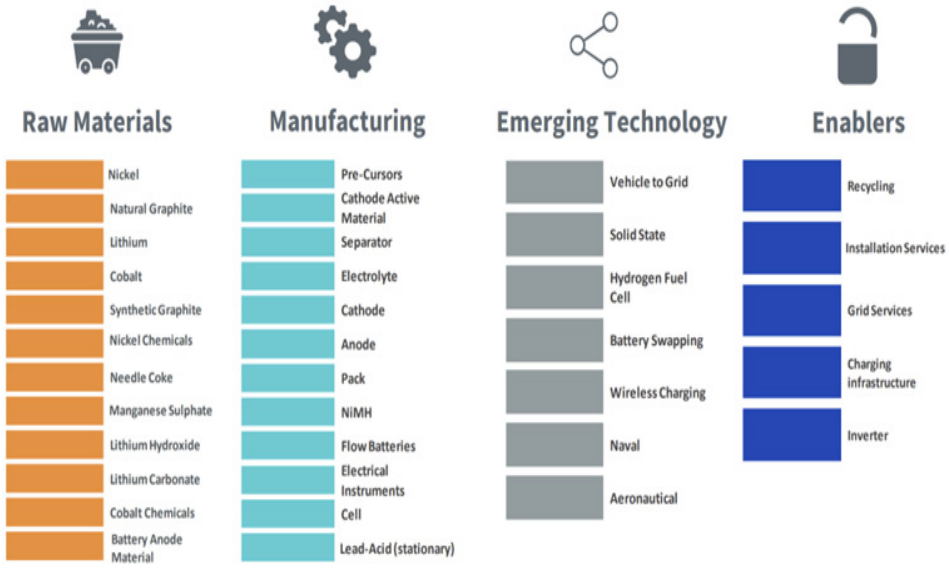
On March 30, 2023, we had the opportunity to speak with Adam Woods, Senior Research Analyst, Global Coal Markets for Wood Mackenzie. By way of background, Wood Mackenzie is a leader in the power and renewable and commodity research and consultancy space. The ecosystem that represents the battery value chain contains a lot more than the big vehicle manufacturers that we hear about all the time. Figure 1 is a good representation:

- There are the four higher-level focal areas, Raw Materials, Manufacturing, Emerging Technology and Enablers.
- Within each of the four higher-level areas are various "sub-sectors." The sub-sectors represent specific value-added activities within the broader groupings. It is helpful to have these more specific categorizations when it comes down to defining the relative purity of different companies that are thought to represent the themes.
- We made the decision with Wood Mackenzie not to include a direct focus on automotive manufacturers. A company like Tesla may still qualify due to its activities that touch some of the other areas but not due solely to the fact that it makes electric vehicles.

Figure 1: WisdomTree and Wood Mackenzie's Representation of the Battery Value Chain



Sources: WisdomTree, Wood Mackenzie.

Geopolitical Dynamics of the Battery Value Chain

As of March 2023, the raw materials that underlie the battery value chain are those that go into lithium-ion batteries, even if we hear about certain other chemistries or new ones are being researched at present. Some of the ingredients include, of course, lithium, but then also nickel, cobalt and graphite—these are the big ones. Where geopolitics comes in regards where these different metals come from and how they are processed.

Some of the core concerns come from environmental, social and governance (ESG) factors. An example is the Democratic Republic of the Congo, where a lot of the world's cobalt supply is sourced. There are concerns around labor, water usage and the overall sustainability of certain mining processes there. One of the responses to these difficulties is that researchers are exploring ways to use less cobalt, replacing it with other metals.

Other concerns come from the recently passed Inflation Reduction Act (IRA) in the U.S. A core part of the legislation that includes tax credits available for domestically made cells and packs is dependent on where those materials are sourced and the political climate in the U.S. at present is positioned very much against China, so China would not be able to reap any benefits from the IRA. However, we'd note that China is not a major area for all sorts of different raw materials besides graphite. China's strength in the battery value chain is in the processing of raw materials, in that even if certain metals come from Australia, Argentina, Chile or Indonesia, they tend to have to go to China for processing before then being able to be used as ingredients in cells and packs.

Can the World Make Batteries AND Avoid China?

We had to get Wood Mackenzie's perspective on this very important question since so much of what we see in the news these days regards a greater and greater adversarial relationship between the U.S. and China. A way to frame the answer could very well hinge on asking one further word—when? When do you intend to avoid China in the battery value chain?

If the answer is "now," then it is not possible. A very large majority of battery production processes related to getting the different raw materials ready to be used in batteries only happens, at least at scale, in China. China positioned itself as a key player in these processes, where other regions might have tended to let concerns about environmental impact or other details deter them.

If the answer is that it is important enough to have less of a dependence on activities occurring in China's neck of the woods, like we are seeing in semiconductors, then it's possible that sustained investments can be made. In something approximating 10 years, it would be possible to have a new battery value chain that takes the activities formerly dominated by Chinese players somewhere else.

What About All These Different Battery Chemistries?

Lithium-ion batteries are certainly not all the same, for numerous reasons—including our aforementioned case of using less cobalt—and the implications of different chemistries taking off into widespread use could be significant when considering the overall value chain.

The two main chemistries in use with lithium-ion batteries at present are lithium-iron-phosphate (LFP) and nickel-cobalt-manganese (NCM). Each chemistry has different trade-offs, and it would be incorrect to think we have found a so-called "perfect" chemistry. While we prefer to use less cobalt because of sourcing concerns, for example, the reason that all batteries are not simply LFP is that NCM batteries have greater "energy density." One can think of this as the energy in a given fuel source per unit of weight. The energy density of gasoline sets a very high bar, and neither NCM nor LFP technologies today are able to match it. Part of the reason we keep experimenting and attempting different chemistries is that we are seeking to match the bar set by traditional fossil fuels.

This focus on energy density is one of the reasons why solid-state batteries are particularly exciting, although we note that it is currently an emerging technology—not available at scale in electric vehicles at present. When we spoke with Wood Mackenzie, they agreed that a commercially available solid-state battery would be a game-changer, but it's something more likely to be years away than immediately around the corner.

Bottom Line: Investing in the Battery Value Chain

Every six months, in May and in November, WisdomTree and Wood Mackenzie rebalance the WisdomTree Battery Value Chain & Innovation Index[1], which seeks to track, after fees and expenses, by the WisdomTree Battery Value Chain & Innovation Fund (WBAT). The concept behind the strategy, which we hinted at in the description of figure 1, is to recognize that the underpinnings of the battery value chain are very broad and represent many different activities. This megatrend is likely to have multiple phases, in that it's clear we are seeing a strong uptake in electric vehicles, but that doesn't mean that 10 years from now, we might not see more battery recycling or hydrogen fuel cells. Certain elements are growing today, and others, like solid state, are more nascent but could be quite large tomorrow.

We, along with Wood Mackenzie, are excited to see how the story unfolds.

[1] The WisdomTree Battery Value Chain and Innovation Index is designed to track the performance of companies primarily involved in Battery and Energy Storage Solutions ("BESS") that meet Index eligibility requirements.

For the top 10 holdings of WBAT please visit the Fund's fund detail page at https://www.wisdomtree.com/investments/etfs/megatrends/wbat

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DEFINITIONS

Commodity : A raw material or primary agricultural product that can be bought and sold.

ESG : An acronym for environmental, social and governance, ESG standards quantify the degree to which a company is socially responsible. .

Inflation Reduction Act : The Inflation Reduction Act of 2022 is a landmark United States federal law which aims to curb inflation by reducing the deficit, lowering prescription drug prices, and investing into domestic energy production while promoting clean energy.

Semiconductor : A semiconductor is a material product usually comprised of silicon, which conducts electricity more than an insulator, such as glass, but less than a pure conductor, such as copper or aluminum. Their conductivity and other properties can be altered with the introduction of impurities, called doping, to meet the specific needs of the electronic component in which it resides.