CAN WE WESTERNIZE THE BATTERY SUPPLY CHAIN?

A Conversation With Wood Mackenzie

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Within the WisdomTree range of thematic investing strategies, we frequently have the opportunity to work with various subject-matter experts. In a conversation from March 30, 2023, Christopher Gannatti, WisdomTree Global Head of Research, and Adam Woods, Senior Research Analyst, Global Coal Markets, for Wood Mackenzie, discuss the energy storage space as well as some of the intersections between these dynamics and the specific WisdomTree investment strategy.

The relationship between WisdomTree and Wood Mackenzie centers around the WisdomTree Battery Value Chain and Innovation Index, which underlies the WisdomTree Battery Value Chain and Innovation Fund (WBAT). Two times per year, in May and in November, Wood Mackenzie's knowledge and expertise across the battery value chain and energy storage space help drive the selection and weighting of constituents within the WisdomTree Battery Value Chain and Innovation Index. This results in a group of companies that represent truly global exposure to the types of activities that we believe will necessarily grow if we, as a global society, are truly serious about pursuing such things as electric vehicles, solar power, wind power, hydrogen fuel cells and many other important innovations that would contribute to a net zero emissions environment in 2050.

Chris Gannatti: Energy storage is an exciting topic; it relates partly to the China-U.S. discussion, which you feel like you can't escape at the time of this conversation. It relates partly to the Inflation Reduction Act (IRA), which was one of the biggest such pieces of legislation in some time. We plan to touch on this during our discussion.

First, I wanted to give Adam a chance to introduce both himself and his background as well as the firm, Wood Mackenzie, because I'm sure there are people out there that might see the words "Wood Mackenzie" but may not be familiar with the firm and what their expertise brings.

Adam Woods: For those not familiar, at Wood MacKenzie, we are leaders in the power and renewable and commodity research and consultancy space. Within the past year and a half, I've had the pleasure of acting as a liaison between WisdomTree and the core teams that support the WisdomTree strategy. That's going to involve dozens of teams carving up the whole value chain, anything from the raw materials to the demand at the end use. It's been really exciting getting to know those analysts a little bit better, bringing myself up to speed on the mega trend that is storage and electric vehicles (EVs).

But my background is actually in thermal coal markets in North America and Europe. For those not familiar with that, that is coal for power generation. I've been really close to how coal has interacted with other fossil fuels and, of course, renewables and how that builds into the storage story. It's been really interesting in the past years, especially where coal is a little bit, not to use the term "super cycle," but we're in the back half of a super cycle, mainly based off of geopolitics and the tensions that have put certain fuels, natural gas, into scarcity and how the relations between power markets, coal, gas, renewables and storage have all interacted with each other. I've had a front-row seat to that, and that's been really exciting for me, along with working with WisdomTree and all the great analysts we have in our power and renewables research.

Chris Gannatti: Can you talk about what countries the key raw materials are being extracted from and possibly some of the geopolitical dynamics and implications? I think that's an excellent starting point. For reference, below in figure 1 are the building blocks of the Battery Value Chain.

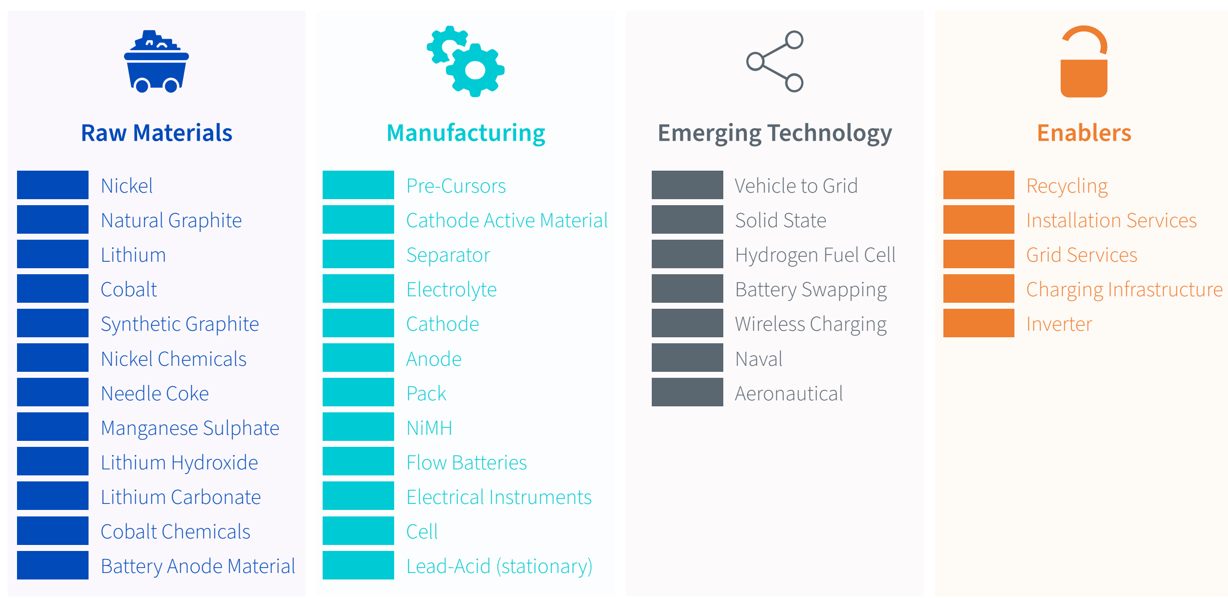
Adam Woods: Right now, when you think of battery raw materials, you're thinking specifically of lithium-ion batteries. And those go into the cell phones; they go into the EVs; they go into what we're considering storage. And that would be for power generation, energy storage, but EVs is the largest part of that by far; 80% of our demand outlook for lithium-ion batteries is for EVs.

So, you think about the big ones, visible in figure 1, but nickel, lithium, cobalt, graphite, those are the big ones. And the regional areas that those all come from are going to be Australia, Indonesia, Argentina and Chile, as well as China. The importance of that, and obviously environmental, social, governance (ESG) plays a big role with it, but what's really being talked about right now in the U.S. is the IRA.

We're already on it. But the tax credits available for domestically made cells and packs are dependent on where those materials are sourced. It's going to need to be either sourced from the U.S. or from a free trade partner. And so, of the list I threw out there, we have Australia, Chile and Argentina—those are the "friendlies." The Democratic Republic of the Congo, on the other hand, is not a free trade player and also has its own ESG concerns with labor, water use and the sustainability of that mining practice there. And then there is obviously China, and China wouldn't be able to reap any of the benefits in the IRA. However, we should note that it doesn't have so much of the raw materials aside from graphite. Most of the graphite production and refining happens in China. But all those raw materials do flow into China for the refining and the component manufacturing. So even if we have sustainably sourced lithium from Australia, it's still going into China first before it goes anywhere else, at least in the current supply chain.

Chris Gannatti: And just so people understand some of what is shown in figure 1, the value chain is what you see on the page. Part of what we were talking now there relates to the orange, which is the raw materials.

Figure 1: Building Blocks of the Battery Value Chain



Sources: WisdomTree, Wood Mackenzie.

The reason that there are so many of these boxes is they represent—we call them sub-sectors with Wood Mackenzie—and they represent the areas in which we believe there are valuable activities occurring. What we want to do with Wood Mackenzie, and thankfully Wood Mackenzie has the expertise to find companies that are operating within each of these boxes, so essentially what you do is you find companies to fill in as many of these boxes as possible. And you assemble them all together. You call it a fund that represents the entire value chain as we see it.

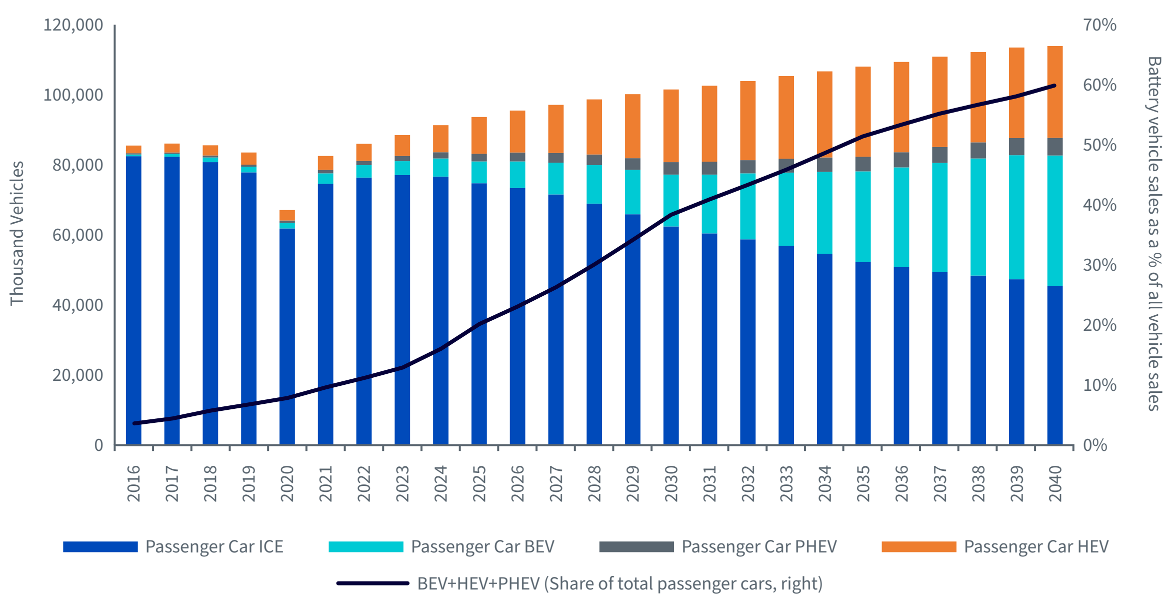
There are certain strategies out there that might focus a bit more on the raw materials, or they might focus more on the mobility, and you see the end vehicle manufacturers. These are the categories that are well represented. One question, Adam, it makes sense to think about and explain is how Wood Mackenzie would approach this as well as some of the areas of the value chain that could be impacted. What is an estimate of how large we're expecting the battery market, in general, to be in five years, 10 years, 15 years from now. I know certain parts of it are probably going to grow a lot in five years, maybe different parts are growing in 10 or 15 years.

Adam Woods: In short, it's going to be massive. That's the five-word answer. But the longer answer is it's better to think about it and segment it out into what we think of as energy storage and batteries. Energy storage for power generation, the growth there is massive. Over 10 years, it's something like a 30% compound annual growth rate (CAGR), just massive growth year-on-year.

But as I mentioned earlier, that storage system only accounts for 10% to 20% of battery demand, and in the future, it's all going to be with EVs. And that EV growth is expected to grow not as quickly but steadily all the way out into 2050. We're talking 5% per year all the way out. We don't see any real lags in that growth potential on the EV side. And that's mainly specific to lithium-ion batteries that we're talking about. So, in short, tons and tons of growth potential mainly driven by EVs.

Chris Gannatti: In looking at it, I would reference figure 2, which shows the benefit of working with Wood Mackenzie, which is that they provide us on a semiannual basis with these illustrations. If you're looking at the black line, you go from left to right, and by 2040, there's an estimate that six out of every 10 new vehicles globally will be EVs. We understand that China is different from Norway—in Norway today, eight out of every 10 new vehicles is electric already, so every market is different, but globally six in 10 cars by 2040 will be EVs.

Figure 2: Global Passenger Car Sale Forecasts



Source: WisdomTree, Wood Mackenzie, forecasts from 2021. ICE = Internal Combustion Engine Vehicle, BEV = Battery Electric Vehicle, PHEV = Plug-in Hybrid Electric Vehicle, HEV = Hybrid Electric Vehicle, PC = Passenger Cars. Forecasts are not an indicator of future performance and any investments are subject to risks and uncertainties.

Adam, one of the things that it makes us think is, can you even get enough lithium or cobalt or nickel because you have all these different chemistries out there? You're basically saying over the course of a given year, there's a certain number of cars that are purchased. And if you're really at that point where six in 10 are electric, not even thinking yet about the grid and whether the grid in every country can support that, how are we even going to get enough of these metals to get the job done here? There are articles I see in the journal Science and the journal Nature—from time to time basically wondering same.

Adam Woods: That's a huge one. And that's one we're looking at really closely. We have individual teams looking at each material on its own. And the consensus is that the supply is there; the reserves are there. Even the planned and pledged investment does meet the demand for this lithium-ion growth within the EV battery sector in the short-term. It's possible, but there are caveats, of course.

And one of them is going to be, we're going to need more investment to convert those reserves into supplies. They're planned; they're there in the earth. It's just going to be a matter of will the investment side meet up with those reserves and be able to bring them to market. However, past 2040 we forecast deficits in lithium, nickel and graphite when compared to demand levels.

Another side that we touched on already is sustainable sourcing. Obviously, EVs are going to be on the greener side of things, but this massive influx of mining has its detriments as well. And where it's mined can have detrimental effects. When you talk about the IRA, you have to be very careful about where exactly you are sourcing these materials. If you're going to want to take advantage in its entirety of the IRA and the credits it provides, the IRA is pledging about $7,500 per car right now per EV passenger. If you want to take advantage of that, you're going to have to invest in the trade partners; you're going to have to invest locally in the U.S. and Canada. Right now, most of that supply is going to be in Indonesia, China, the Democratic Republic of the Congo and Australia.

Chris Gannatti: Now, a topic related to the IRA and related to the sourcing; by the way the rules and regs are written, it matters where the majority of the raw material is coming from. And just as if we were talking about semiconductors, we would know there's a preference away from China. It's quite clear that here as well, we would expect a similar preference, and we do see that preference expressed. You start to see whether it's Redwood or certain other companies that are popping up on the recycling side.

At the same time, you think, EVs, it's still relatively new; the average car on the streets globally is more than 10 years old. It might have a couple of different owners over the course of its life then be sent to the scrapyard. Some of the estimates I see are that recycling is really going to hit its stride perhaps in the mid-2030s, based on the usable life expectancies of some of these cars.

The question here, Adam, is: Can you speak to the battery recycling landscape? Referencing back to figure 1, this is one of the topics in the strategy, Enablers: Recycling. There are recycling companies in the strategy today.

Adam Woods: Yes, I think with the recycling, you hit the nail on the head with the mid-2030s, maybe early 2030s. There's a lot of excitement around it right now, though. The obvious potential, especially for cobalt recycling, is massive.

But what we're seeing right now is that the price of cobalt/cost of cobalt versus the cost of recycling has a bit of a disparity. We've seen cobalt surge in price before, but we're going to need to see a more sustained high price of cobalt in order to encourage the build-out of the recycling plants. There's simply not enough recycling capacity right now to really be commercially viable.

We're going to need more batteries, and we're going to need a higher price for cobalt in order for it to be worth bringing recycling plants into play. There are a couple of other things in play, like policies in Europe that would encourage more of this and more build-out of recycling plants. But where it stands right now, it's just not competitive. It's a future endeavor that has to take off in the late 2020s to, like you said, mid-2030s.

Chris Gannatti: It's a good point. Since Adam mentioned cobalt, there was something I was thinking to bring up. One of the things that we hear a lot of in this space is all sorts of different chemistries, so one of the things I personally feel is I wish that I was paying more attention in chemistry class back in the day. Because sometimes I'm talking to Wood Mackenzie, and they're talking about these different molecules, these different atoms coming together in these interesting ways. And I feel bad because I just can't match that level of understanding.

One of the concepts that I want to illustrate: If you think of a unit of weight, and you think of a particular fuel—one kilogram of crude oil as an example—it's not that much. It's estimated that a normal car is going to get about, 20 kilometers with one kilogram of crude oil. If you think of uranium, think e=mc2, with the c as the speed of light, 186,000 miles per second. A kilogram of nuclear fuel could take the equivalent of a car 1.77 million kilometers.

It's this idea that you've have the same mass of two different types of fuel, and one of them has just so much more bang for the buck. Now, nuclear has other risks and issues, and these are not completely equivalent. But this idea of energy density, the amount of energy per unit of weight, is such an important idea because some say are we going to have electric helicopters. Are we going to have electric planes? The idea of power per unit of weight of jet fuel versus whether lithium-ion batteries can ultimately match it.

Adam, could talk about the different chemistries that are competing with each other? Recognizing that the goal is to match internal combustion, but there are so many different variables and levers in play on the journey from where we are today to hopefully getting to the point where we're matching internal combustion engines.

Adam Woods: Of course. And Chris, I'm no chemist either, but luckily, like you said, we do have plenty of PhDs within our renewables group whom I have gotten to talk to about these chemistries. I'll start with the technologies we have today. And, like I mentioned, we're limited to the lithium-ion batteries, a term we're all familiar with. But there are different chemistries and componentry that can make different types of lithium-ion batteries. And for the sake of the discussion, we'll keep it on EVs, as for now, that's where most of the demand is coming from.

Within EVs, you have your NCMs, nickel, cobalt, manganese, and then you have your LFPs, your lithium, iron, phosphorus, and those are the two most popular ones. LFPs were where things started, they then transferred into the NCM, the nickel cobalt. That's why you hear so much about it today. It's because that is, in comparison, more energy dense. It has a higher output per kilogram than an LFP would, which isn't as reliant on the cobalt and the nickel. So, what you're seeing more and more of in the EV space is the NCM.

But now, with the potential of sourcing this cobalt and this nickel and all the incentives to move away from non-sustainable nickel and cobalt, there has been more and more research going back into LFP. How do we make it more dense? Okay. We've learned how to make this great NCM battery with nickel and cobalt, but how do we revert back and go more toward this iron and phosphorous, still lithium-ion but iron and phosphorous componentry batteries? There's a lot of investment going into both options right now.

Then, from there, you think about the next step. And that is, you hear the term "solid-state" thrown around a lot. Instead of having lithium salt dissolved in solvent on each side of the cell, the electrolyte is the solid; but you still have your metal-dependent cathode and your anodes. Being a solid, it would be more compact. That solid electrolyte is going to take up less space, be super dense still, and take less space and be more suitable for EVs. There is even potential for solid states to be lighter than liquid-electrolyte cells since the electrolyte can be made much thinner.

On the complete other end of the spectrum, you may have heard of flow batteries. And this is pivoting away from EVs a little bit, just as a comparison to talk about different sizes. Flow batteries tend to be giant. Instead of having the liquid in the same pack, the same cell, and moving those electrons, creating electricity, it's giant. And that's going to serve as more of a backup generator or support building because you have the room and the luxury of having this space. And the anode and cathode are completely separate from each other. And you have the ability to scale it up.

Although its true nature isn't as dense, and it can't do that mega-high output that makes your Tesla go 200 miles per hour, it's able to expend energy longer. We're talking 10 hours of life to power a whole building just because you can make it so much larger. Those are where we're at right now. There are more things in the future that are coming to market or have not come to market yet, but that's where we're at right now, and it's a really interesting space.

Chris Gannatti: Looking at Emerging Technology from figure 1, Adam mentioned solid-state and there are publicly listed companies to represent that. Another topic that may catch people's eye, because it's been quite volatile if you go back two to three years, is hydrogen fuel cells. In 2020 and early 2021, the returns were unbelievable. If you look at the return since, 2021 to now, I don't need to spoil the story there, it's basically spoiled itself in terms of what's transpired.

So the hydrogen story, Adam, it feels big. If you're in Europe, you talk about green hydrogen; if you're in the U.S., you talk about blue hydrogen. The difference is how you're getting the hydrogen. Once you get the hydrogen, you then have to consider, is it a vehicle application where you're using the hydrogen similar to how you pull up to a gas station? Or are there other use cases for fuel cells? Adam, I think it's a big topic, and we're going to see more and more of it.

Adam Woods: Agreed. And it's so exciting too, which explains some of the volatility that we've seen around it. It's just that it seemed very tangible because of the advancements we saw so quickly within the past couple of years. But then you have to look further. And there's just a lot of ifs involved with commercially bringing hydrogen fuel cells to market. I think that all the ifs and the cost reductions and the investment required may have dampened that excitement a little bit. But we still are doing a lot of research. It's still one of the most researched topics, most inquired-upon topics from our clientele. We're still very excited about it.

There's a lot of potential for, like you mentioned, the blue hydrogen. For those not completely familiar, green hydrogen would be hydrogen electrolyzed and produced with renewable energy. Whereas gray hydrogen would be with gas. And then blue is produced with natural gas but carbon sequestration. In some reports and some research, we lump green and blue together as low-carbon hydrogen. And depending on the demand center, there is a lot of potential for the blue hydrogen, especially in the U.S. and Canada.

Chris Gannatti: It's the classic story where essentially you've got your fuel source, it might be electricity, it might be hydrogen, it might be something else. And some of these fuel sources, when you're using them, do not create any carbon dioxide emissions. So driving the electric vehicle, it's not emitting anything. But if there's a coal power plant around, then powering the electric vehicle, in theory, has to account for the fact that coal is burned to generate it. Hydrogen is the same, in the sense that you are generating emissions from getting the hydrogen. And that's how all these different colors come into play ultimately.

Looking at the Enablers space again in figure 1 and the statistic that in 2040 six out of 10 new vehicles are, in fact, electric, as it indicates in figure 2, what does Wood Mackenzie think needs to happen such that the grid and the charging infrastructure can actually support that? Because you don't necessarily see headlines that say there's enough charging infrastructure, the grid is great, the grid is ready. You tend to see the opposite in most reports. I'm wondering, how much work needs to be done? And what types of different metals may need to be gotten to get the grid ready?

Adam Woods: I think that question could be Wood Mackenzie's core activity. That's what we're trying to answer: what needs to be done? We know where we're headed, but what needs to be done? There's a lot of different angles to answer this from. Step one is renewable generation. We have to encourage a larger capacity of renewable generation. We're thinking, say now we're at 40%, 45%, we're expecting to get up to 60% in 10 years, whatever it is, 80% in another 10, 90% by 2050, 90% renewables is the goal. And there's a lot of issues around getting there.

But just to home in on one is transmission. Sure, we have these great incentives for building out renewables. We have tax credits and componentry incentives, we have mandates from the government, which is great. And so we build all these cost-effective offshore wind, solar farms. But the issue, like you said, is getting it to these grid services, getting it to the EV, getting it to the storage facility. And it so quickly becomes, well, step one is building out this renewable capacity, renewable generation. Well, step two is, we're instantly dependent on storage now. It's a bit of a chicken and the egg catch-22 situation that you need both to demand each other simultaneously.

The idea of this growth in renewable generation does create this demand for EVs because, with renewable generation, it needs to either be used right away or it needs to be stored. And with EV growth, we see more opportunity for that solar generation to not be wasted. When we see more developments in grid scale storage, we see more opportunity for peaking with batteries instead of peaking with coal and gas. It all trickles back to the source of the electricity, Chris, to start. That's a simple answer, but there's a lot of different ways we can look at that.

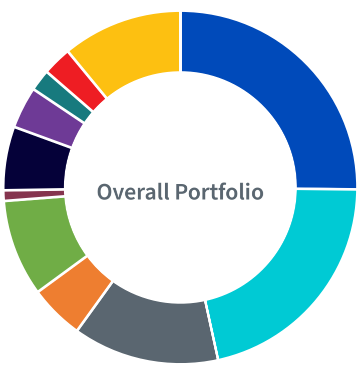
Chris Gannatti: Every country is going about it in their own way. Some countries are trying to use wind, some offshore wind, some solar, some a mix, all of the above. You see the small-scale or more compact nuclear reactors. Natural gas has not disappeared, even if the Russian-sourced natural gas is harder to come by these days. But, by and large, it's clear the world seems to want to address all of the above.

Now, because we promised a discussion on China, I reference figure 3 as we are talking about an exposure that is meant to capture the value chain. There are articles that indicate if you buy an electric vehicle, the actual components of metals may have traveled 50,000 miles before the vehicle itself even travels 1 mile. As Adam was alluding to, there are certain components coming from Argentina or Chile and Australia, and they need to get to China. Then they need to get back to California, and then they need to get to all these different locations.

So, you wonder, and you see this in the chip space, namely, can they actually Westernize the supply chain? A tall order, meaning that the general battery in the U.S. doesn't need to go to China at all. Adam, does Wood Mackenzie have a view on whether or not that's even possible? It's a big change relative to where we are today.

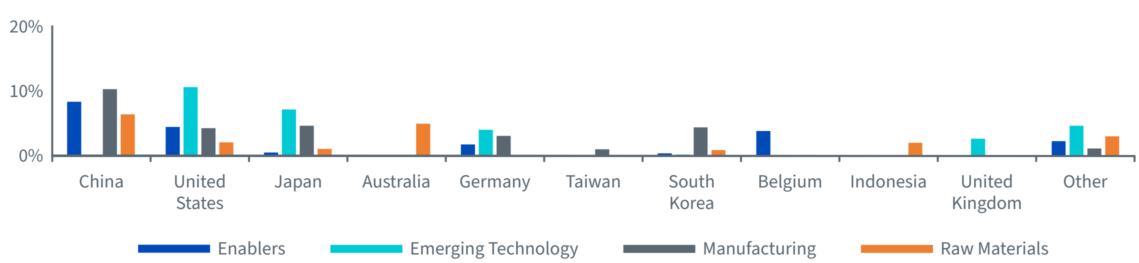
Figure 3: Country Exposure of the WisdomTree Battery Value Chain & Innovation Index

Country Caps (50% for U.S. and 25% for All Other Countries) Ensures No Country Will Be Overexposed in the Index



Country Breakdown	Overall	Enablers	Emerging Technology	Manufacturing	Raw Materials
Total	100.0%	21.5%	29.4%	28.8%	20.4%
China	25.2%	8.4%	0.0%	10.3%	6.4%
United States	21.4%	4.4%	10.6%	4.3%	2.0%
Japan	13.4%	0.5%	7.2%	4.6%	1.1%
Australia	5.0%	0.0%	0.0%	0.0%	5.0%
Germany	8.9%	1.8%	4.0%	3.1%	0.0%
Taiwan	1.0%	0.0%	0.0%	1.0%	0.0%
South Korea	5.8%	0.3%	0.2%	4.4%	0.9%
Belgium	3.8%	3.8%	0.0%	0.0%	0.0%
Indonesia	2.0%	0.0%	0.0%	0.0%	2.0%
United Kingdom	2.7%	0.0%	2.7%	0.0%	0.0%
Other	11.0%	2.2%	4.7%	1.1%	3.0%

Country Exposure Across Index Categories (% Weight)



Source: WisdomTree, Wood Mackenzie, forecasts from 2021. ICE = Internal Combustion Engine Vehicle, BEV = Battery Electric Vehicle, PHEV = Plug-in Hybrid Electric Vehicle, HEV = Hybrid Electric Vehicle, PC = Passenger Cars. Forecasts are not an indicator of future performance and any investments are subject to risks and uncertainties.

Adam Woods: It is. Yes, we definitely have a view. Every team is looking at this, especially since the IRA was signed in. And the answer is today, it can't be. I don't know if there's a metric that really shows it here. But we're talking 70% to 90% of the componentry is Chinese based. It is massive. Even if the materials aren't sourced there, which they normally aren't, they're globally sourced, it still goes through China.

And so, can it be done without? Our view is yes, but it's not easy. It's going to require so much investment. The first number that we throw out there is 10 years from today; if all facets of the value chain were to start investing either domestically or with trade partners, we're looking at 10 years until we see those projects come to fruition and be commercially available. It's a long road, but it's definitely possible.

Our view is that on the renewables side, to pivot just a little bit, it's even more commercially viable. We expect that the componentry cost component, if fully taken advantage of the IRA credits, is cost competitive with imported componentry for renewable generation. Just simply because we already have component manufacturers set up. There's certain areas of this battery value chain that aren't even in their infancy yet. They're just being talked about, they're being planned, we don't even have any active ones domestically. It's going to require a massive amount of investment and something like the IRA to make it competitive because right now the cost competition is just... It's hard to beat the Chinese import right now.

Chris Gannatti: Adam, because see a lot of announcements, whether it's in Georgia, Tennessee, North Carolina, Ohio, you see these joint ventures, whether it'll be GM and LG coming together, making batteries, Panasonic making batteries possibly for some of the Tesla gigafactories. Is the correct way to think of it, you're getting the raw materials from somewhere, could be many different places around the world, and those raw materials need to be processed? Referencing figure 1, you don't just end up with nickel chemicals, for instance, or lithium hydroxide. You need to go from whatever's coming out of the ground to these chemicals, that's happening in China. And then it's being sent to factories that we're seeing headlines in the Wall Street Journal and Financial Times that are being built in the U.S. Is that the right way to think of it?

Adam Woods: Correct, yes, that's exactly it.

Chris Gannatti: It seems like there are two forces working against each other. One, government wants green energy requiring this value chain. However, Biden's restrictions on mining and not issuing mining permits limits, if not stops, U.S. production. How is the Wood Mackenzie team trying to square the circle on that?

Adam Woods: Yes, that's an interesting one. One I know pretty well, too, with my background in U.S. coal research, especially since I started out on the supply side. The leasing of federal lands, or just the issuing of permits at a state or federal level, is a huge issue for all mining sectors. And it's interesting; I think that there's two ways to think about it. One, we allow it. Or two, we make some changes to our new policies going forward to bring incentives from other trade agreement countries. If we can still source it from abroad, but also still incentivize that and provide production credits, tax credits, then that's a way around that. But yes, that's definitely a big issue as far as domestic minerals and materials go.

Chris Gannatti: Yes, we want to be energy independent and independent on many topics, but that costs money and potentially has an environmental impact. And we're always searching for that right balance. Another interesting question, we talked about solid-state. TDK is already involved in the solid-state space and some of those batteries are the really tiny ones. Because you think of all the various devices, we spend a lot of time talking about cars where the battery could weigh hundreds of pounds. But on the other end of the spectrum, a really tiny battery that has good energy density where you don't have to charge your Apple watch or your headphones for weeks on end, is also immensely valuable. The question here is: Toyota has stated their aim to solve the solid-state battery challenge. Where are they in the process, and would it be an enormous change, or only incremental, to their current business?

Adam Woods: I will caveat the answer with, I am not familiar with Toyota's innovations on the solid-state side. But let's just say, for a scenario, if someone were to bring a solid-state battery, commercially viable, cost viable, to market within the next two or three years instead of the next five to 15 years, that would be a big disruptor. That certainly could change the landscape quite a bit for that issue of all the list of reasons people don't buy an electric vehicle. Or that energy density conversation that we started off with, that would change that narrative if it had a longer life cycle, more power, shorter charge times, that could definitely reinvigorate some of the things. And it definitely would spur a huge trigger of investment. Because everyone right now is still very, very focused on the lithium-ion battery. And our view is that lithium-ion will remain king in this space for the next 10, 20, 30 years. But that's an interesting one. I'll have to circle back with the teams and look into that one more specifically.

Chris Gannatti: Yes, it's a fascinating topic. I was surprised listening to a Jeremy Grantham podcast, many people view him as a value investor and someone who talks about markets globally. In his charitable foundation, there big exposure to QuantumScape. I admit that I don't know how much more energy dense a solid-state battery would be. It's interesting to think that the 330 mile of range of a typical high-end EV today could, with a solid-state, could be 500 miles. Or the time it takes to charge could be cut that in half, or cut that in a fifth? Admittedly, I'm not sure. But people got really, really, really excited about QuantumScape, again, back at that period in early 2021. The valuation's been more reasonable recently than it was. But admittedly, solid-state remains quite an important topic.

Adam Woods: It is. But at the end of the day, still definitely an emerging technology. Something that a lot of that popularity is coming around research and design; that's where the excitement is coming from. Not necessarily coming to market commercially viable. But tons of companies are pushing for it, obviously.

Chris Gannatti: Another question relates to the supply of lithium. What about the new lithium extraction facilities in the Salton Sea? Do you think they will have a price impact, meaning potentially a lower price for lithium?

Adam Woods: Yes, that's interesting. I think that the short answer is yes, it could lower cost and price. Another pro, obviously, is that it's produced domestically. Some self-sufficiency in lithium would be huge. Not only for economics but for cost savings as far as you don't have to import it, you can refine it domestically as well. That's huge. It cuts down costs across the value chain, not just on the mining side for the raw lithium or the refined lithium hydroxide. I think yes.

I think that the caveat there is that it's a proposed project, so there's still some geologic mapping and testing to be done around that. But I think that if it was permitted and the lithium itself was of high quality and brought to market in the right way, which is a couple of ifs, but if it all came together, yes, it definitely could lower the price and the cost for domestic U.S. lithium certainly.

Chris Gannatti: There's a company that sometimes is in the top 10 amongst the exposures of the strategy; it's a big Tesla supplier. Referred to as CATL which stands for Contemporary Amperex Technology; it's based in China. It's one of the more successful Chinese ventures within the battery space. A recent article was discussing how they're doing some research on using sodium instead of lithium. Similar to different cathodes where you have nickel, manganese, cobalt, but then you might have lithium-ion and phosphorus. There are different trade-offs from using different ones.

We know sodium, salt, is widely available, at least you would imagine. I'm curious on the potential for that where we spent a lot of time talking about the cathode and the metals, but what if you change the makeup of the electrolyte itself before you get to that solid-state phase, and you use something that might be even cheaper like sodium, what type of change might that entail?

Adam Woods: I'm not extremely familiar with the potential for that change. But I think that if you can lower the cost and do something as available as salt, that would be massive. But the question that comes to my mind when I hear about something like that is, well, what are the trade-offs? Why hasn't it already been done? What is the salt electrolyte going to lack that a lithium salt electrolyte compound would offer? And although I'm not super familiar with that one, it does remind me of the anode side graphite in that, similarly, there's a trend to use more and more silicone in that anode with the graphite. Which in the graphite is needed for both the LFPs and the NCMs. And so, if we were able to lower the amount of dependence on that graphite, I mean, the graphite is the one that is sourced from China, refined in China and then put into components in China. China pretty much owns the graphite space.

If we're able to bring more silicone into that, where there's also the idea of using the synthetic graphite. You hear needle coke thrown around a bit—that's produced from petroleum products or coal tar. I mean, that's a space that no one else besides China has stepped into yet. There's a lot of potential to change up the compounds of these batteries. There' are people who are optimizing what we have and then the people that are looking to disrupt it. And it's huge on both sides, the potential and amount of research and amount of investment that's going into this.

Chris Gannatti: We thank Adam Woods and Wood Mackenzie for working with us on the specific Battery Value Chain and Innovation strategy as well as participating in this conversation. Anyone looking to do further research on this or any of WisdomTree's Megatrend strategies should visit our website.

Glossary

Commodity: A raw material or primary agricultural product that can be bought and sold. Compound Annual Growth Rate (CAGR): The mean annual growth rate of an investment over a specified period of time longer than one year. Inflation Reduction Act (IRA): A 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.

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