



**Private Markets**

# **Transition Center of Expertise: Batteries**

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# Powering an electric future

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## Center of Expertise - Batteries



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## Key takeaways

- ✓ Electrification, the replacement of combustion with electricity, is an essential element of the transition to a low-carbon economy – and batteries are a vital part of the shift.
- ✓ As an opportunity set, batteries are driven by rapid technological advances, falling costs, regulatory tailwinds and accelerating adoption.
- ✓ Batteries are a key enabler for two major trends: the rise of electric vehicles and the growth of renewable electricity generation.
- ✓ Most large automotive manufacturers in the world are launching new EVs, while also electrifying more aspects of their cars.
- ✓ The increase in solar and wind energy has created intermittency in the power grid, making batteries an essential solution to stabilizing the energy supply.
- ✓ To address potential supply-chain constraints in the battery space, companies are turning to efficient, larger-scale recycling of essential minerals.
- ✓ The opportunities to invest in batteries exist across both private and public markets.

# Introduction

One of the key factors in the transition to a low-carbon economy is electrification – the replacement of combustion with electricity across industries. And as the pace of electrification accelerates, the importance of batteries is becoming clear.

Across passenger EVs and other forms of mobility, stationary storage and consumer electronics, demand is booming. For lithium-ion batteries, estimates suggest demand could grow roughly 6-fold by 2030, with more than 90% of market demand concentrated in electric mobility<sup>1</sup>. Similarly, the entire battery value chain – from mining to refining to manufacturing, and through recycling and second-life applications – could see revenues quintuple.

The low-carbon transition is ultimately a story of technology adoption. When the relative cost of new technologies falls below incumbent ones, we expect a tipping point. Batteries are quickly approaching – and even arriving at – these tipping points, and as a result the industry appears to be poised for massive growth.

The unit cost of a lithium-ion battery cell, for example, has declined dramatically since 2010, driven by manufacturing improvements, innovations and, until recently, falling commodity costs. Even amid possible supply bottlenecks for lithium, cobalt, manganese and nickel, overall costs are likely to continue to fall.

1. “Battery 2030: Resilient, sustainable, and circular,” McKinsey, January 2023

## About BlackRock’s Transition Centers of Expertise

The transition to a low-carbon economy is among a handful of major structural shifts that we see rewiring economies, sectors and businesses. The transition will likely cause ripple effects around the globe and change where revenues and profits are generated.

The transition’s pace of change, however, is highly uncertain, which creates complexity and risk – as well as opportunity – for companies and investors alike.

At BlackRock, we define transition investing as: Investing with a focus on preparing for, being aligned to, benefitting from and/or contributing to the transition to a low-carbon economy. We recognize that clients across the world are investing in the transition to a low-carbon economy to generate returns, manage risk, or execute on commitments.

BlackRock’s new Transition Centers of Expertise (CoEs), of which our Battery CoE is one, bring together the knowledge of our more than 600 sustainable and transition specialists across the firm, as well as external experts and industry associations. These virtual communities, organized by sector technology, encompass expert views throughout the capital stack and across industry value chains, contribute to the assumptions used in the BlackRock Investment Institute Transition Scenario (BIITS), and help source new opportunities for our clients.

We hope the insights developed by the CoEs will lead to a better understanding of the uncertainty around the transition by bringing together a range of perspectives and experience.

We currently manage over \$110bn in transition-related assets globally. This paper is produced in close cooperation with our Battery CoE.

Source: BlackRock, as of Q3 2023. \$ denotes USD.



# Batteries are, and will be, essential in two particular transition segments: powering electric vehicles and supporting renewable electricity on the power grid.

## EVs

Batteries are critical to the electrification of transport, which will rapidly accelerate in the coming decades.

The BlackRock Investment Institute Transition Scenario (BIITS) expects nearly all new light-duty vehicles to be electric by 2050, up from less than 4% in 2020. We see roughly one third of global transport demand being electrified by 2050, with near-universal electrification of passenger road transport. The advances in EVs will also have benefits for the power grid as new technologies allow the grid to access vehicle batteries for resilience.

## The power grid

In the BIITS view, global power demand will grow roughly two-and-a-half times by 2050, with more than eighty percent of the rise in power generation coming from low-carbon sources, primarily wind and solar. By 2050 we expect the global power grid to be 90% decarbonized compared with 2020 levels.

As renewable power sources take an increasingly large share, batteries will become essential to support the grid. They'll be required to supply energy when the sun isn't shining and the wind isn't blowing.

But the role of batteries in the grid of the future isn't limited to stepping up delivery when renewable power generation is low. Stationary batteries can help operators manage grids, while off-the-grid, distributed batteries can provide on-site resilience to homes, hospitals and office buildings where grid service is unreliable or nonexistent.

With the tailwind of supportive policy and regulation for grid-scale batteries, stationary battery deployment is set to grow by two-thirds by 2050 across a diverse set of power systems.

## Headwinds

There are still significant concerns that could hinder the outlook for the industry: Sourcing the minerals required to make batteries, accessing the full range of battery chemistries and potential supply-chain bottlenecks as the industry scales up.

Minerals such as lithium, nickel and cobalt can be hard to access given current geopolitical tensions, and their prices in commodities markets often fluctuate. And we saw during the pandemic that supply chains can be vulnerable to disruption, especially in cutting-edge technology sectors. Even without these challenges, battery manufacturing is capital intensive and technically complex – it may not be a smooth, straightforward expansion for business in the sector.

## Innovations

While the market today is dominated by lithium-ion batteries, there may soon be alternative technologies that could solve some of the mineral-sourcing issues that now face the industry. For instance, sodium-ion batteries do not contain any lithium, nickel, or cobalt – potentially leading to lower costs, along with fewer supply chain risks and environmental concerns. Other innovations, such as solid-state batteries and flow batteries, are worth watching, along with evolving technologies that could improve the recycling of costly, supply-constrained, and often toxic battery metals.

In the following pages, our investors delve deeper into the opportunities, challenges and changes facing the battery sector.

**[Click here to explore the BlackRock Investment Institute Transition Scenario](#)**

## Investor Q&A

BlackRock's Centers of Expertise bring together our leading experts for specific industries that will play a key role in the low-carbon transition. Our Batteries CoE includes Kojo Ako-Asare, who invests in early-stage private companies, Charles Lilford, an active manager in public markets, Akhil Mehta, who specializes in energy infrastructure and Tomas Peshkatari, who looks closely at manufacturing.

### Where do you see the opportunity set around batteries?

*Charles Lilford:* It's very broad, but right now, it starts with the electrification of vehicles. When you consider the volume, a typical electric vehicle has over 3,000 times more battery content than a smart phone. And global volumes of EV batteries represent more than two-thirds of all the lithium-ion battery capacity currently going into the marketplace.

The installed fleet of electric passenger vehicles is close to 30 million today<sup>2</sup>. However, we remain at the early stages of electrification, with the penetration rate of electric vehicles to the global automotive fleet at barely 2% today<sup>2</sup>.

And you have to add to that the electrified two- and three-wheelers, effectively motorbikes – a fleet of about 280 million vehicles. It's an exciting new area, particularly for places such as Southeast Asia, India and parts of Latin America, where motorbikes resonate from an economic perspective and have a much larger penetration rate. And among these electrified motorbikes, battery swapping is unlocking new use cases.

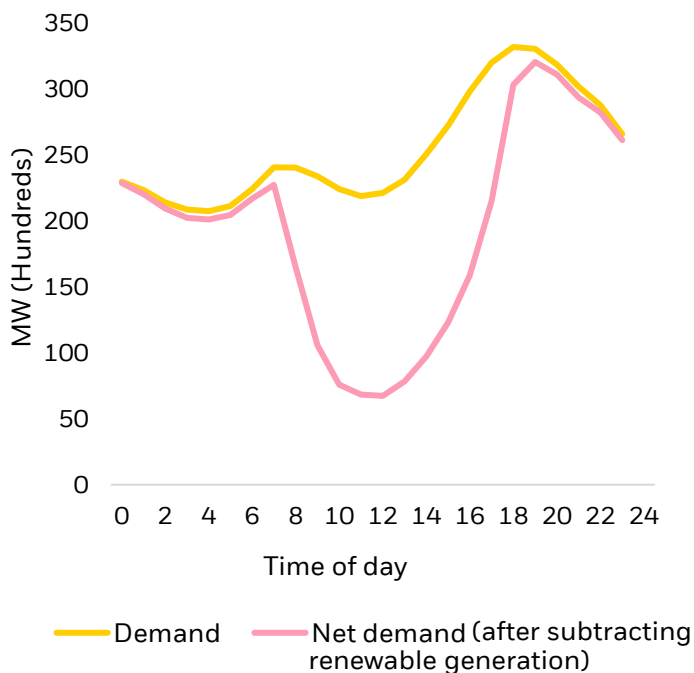
*Akhil Mehta:* I agree that EVs are huge now, and continue to grow. Looking ahead, I'd say the biggest opportunity in the power sector is the global trend towards decentralizing the power grid. Batteries are a huge part of that, simply because people are building battery storage instead of traditional electric substations to supplement traditional electric power plants.

There's more demand for storage. That's a result of more renewable energy sources coming online, as well as the growing number of climate-related events.

Some grids, such as California, now are nearly 50% powered by renewable, intermittent energy sources, which creates unpredictability. That unpredictability will increase globally as other regions, especially Asia, decarbonize over the next 30 years.

Batteries can be essential to stabilizing the grid both in front of the meter, in the form of utility-scale batteries, but also localized batteries in homes and other buildings that can store and distribute electricity as needed.

### The 'Duck curve' and the need for storage batteries



Demand for electricity fluctuates throughout the day, often in patterns that don't match energy generation. On cloudy or windless days, the mismatch between solar and wind production and the need for energy can be especially pronounced, as the chart above illustrates. And battery storage can be essential to managing this shortfall.

Source: [California Independent System Operator](#), as of 31<sup>st</sup> October 2023.

2. Source: BloombergNEF, BNEF Long Term Electric Vehicle Outlook data up to 2022. The total number of EV units sold is 26.2m units up to and including 2022.

Large-scale battery energy storage systems, or BESS, have the potential to be a driver of significant growth. When you think about it, cell phones require one battery cell, an EV requires thousands, while a BESS requires millions of cells. In addition, BESS will be essential to providing energy to remote, off-the-grid sites.

*Kojo Ako-Asare:* Our landscape review points to most of the near-term lithium-ion battery growth being driven by the emerging prominence of passenger hybrids and EVs.

As Akhil mentioned, the other large opportunity for lithium-ion batteries is in supporting the grid with energy storage systems. Within the home battery storage market, we've seen several emerging companies that are using batteries in new ways, such as high-quality induction stoves, low-cost grid backup, and even the creation of new household income streams through the consolidation of home batteries into virtual power plants. As battery production capacity increases, we expect the prices to rapidly fall. And those lower prices, coupled with increases in energy density, should lead to an even wider range of uses for lithium-ion batteries, including trucking, aviation and shipping.

*Lilford:* I'd add that there's the broader opportunity set within the supply chain. If you think about an internal combustion engine car today, typically the 12-volt starter is lead acid. We expect to also see this battery evolving towards higher-capacity lithium-ion cells over time.

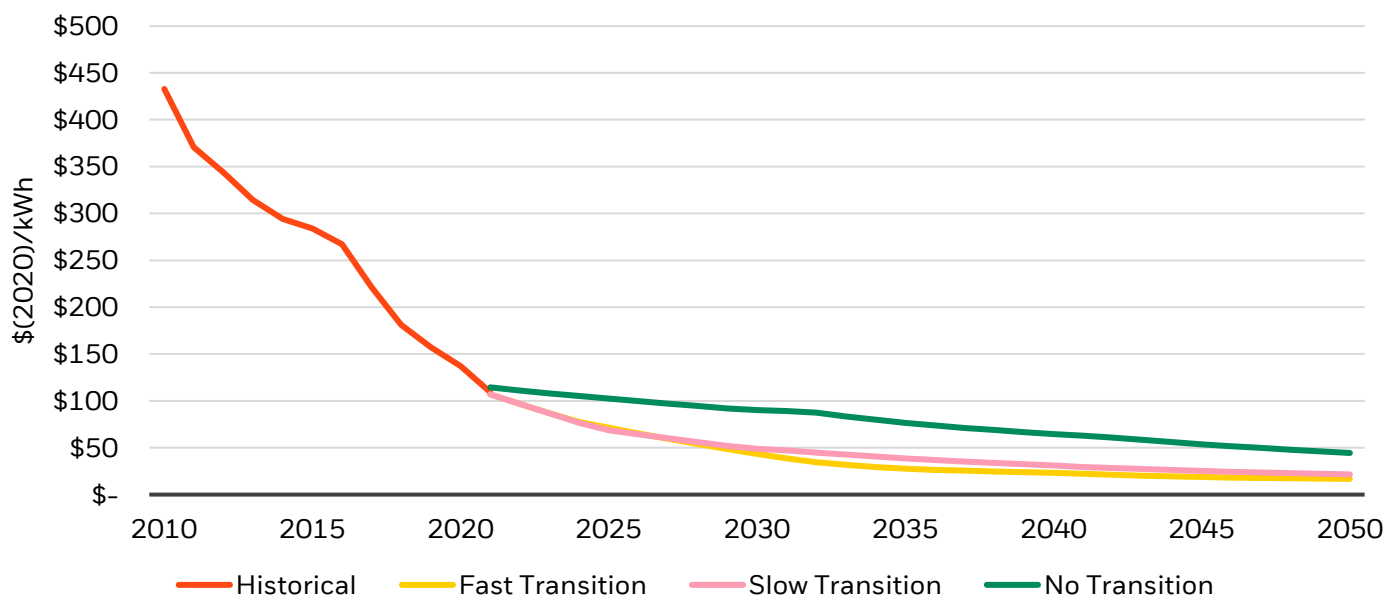
And more electrified vehicles will expand the battery markets further. Every new EV sold instead of an internal-combustion vehicle represents 40-100 kWh of additional battery capacity. At current pricing levels this can represent approximately \$4,000 to \$12,000 of additional battery-related revenue per vehicle<sup>3</sup>.

*Tomas Peshkatari:* I agree with Charlie – and the opportunity is so large precisely because batteries are such a critical piece of the value chain to decarbonize both transport and electricity generation.

Government policy, technology advances and the industrialization of battery production are leading to significant investment opportunities on a global basis. Hundreds of billions of dollars are being invested in innovation, in building supply chains – from the mining

## Getting cheaper

The cost of battery power is falling. The only question is *how fast*?



Source: The plot shows battery cost forecast distributions under No, Slow, and Fast Transition scenarios, representing blended historical consumer cells and electric vehicle (EV) battery pack prices, though these are now almost identical. The forecast is based on consumer cells. Source: Way et al., Joule 6, 2057–2082 September 21, 2022 Published by Elsevier Inc. <https://doi.org/10.1016/j.joule.2022.08.009>. Last accessed on 31<sup>st</sup> October 2023.

3. Source: BloombergNEF, BNEF Long Term Electric Vehicle Outlook data up to 2022. Assuming \$120-150/kWh in battery cell and pack costs.

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metals used in batteries, to manufacturing, to recycling – and in businesses that benefit from batteries’ growing storage capabilities.

At the same time, new business models are emerging for batteries. We expect increased demand for on-site storage at commercial and industrial sites, especially in remote areas. This lends itself to a storage-as-a-service leasing model that would enable businesses to expand their production capabilities, without the need for costly and time-consuming grid upgrades. This model has the potential to ease the burden on corporate balance sheets and further expand the attractiveness of large-scale battery storage systems.

## What’s the relationship between cost and growth in this space?

*Ako-Asare:* If you look at the big picture, this is a transformation of the way we consume energy. I am quite focused on the new battery technologies that are approaching the point where they begin to enter mass commercialization. That’s coming closer as mass production reduces costs, which lower the barriers to access, which will lead to more applications. In a way, the future of lithium-ion batteries is a case of induced demand in action. This is an exciting time.

*Lilford:* We expect those costs to continue to go down. Because if you look out over the next three years or even five years, the true benefits will start to appear in terms of the increasing magnitude of battery-manufacturing facilities. We’re seeing the ability to manufacture batteries at greater scale using automation, evolving supply chains, and greater economies of scale.

Until last year, costs were coming down towards the industry target of US\$100 a kilowatt hour in battery-cell costs – the simplified benchmark cost. That threshold meant they were priced comparably with internal combustion engines. Then lithium prices went up and supply chains became more difficult to manage. In 2022, we saw lithium-ion battery cell costs closer to US\$120 a kilowatt hour.

But now material and supply constraints are easing. Our channels suggest that battery cells are moving closer to US\$100 per kilowatt hour in terms of cost per cell. So we are starting to see once again this very, very aggressive price-down environment.

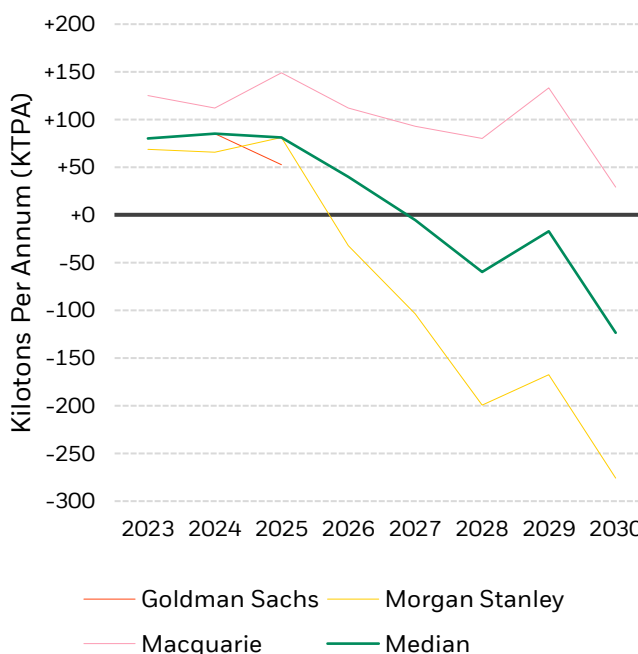
One result is that EVs are penetrating more of the mass market. The next big evolution we see is manufacturers coming out with EVs at lower price points. In many regions, the economic choice is becoming quite attractive.

For many regions, the next step in EVs is that mass-market adoption.

*Mehta:* And of course, scale affects the price of the minerals involved. I think one of the biggest concerns for expanding the use cases of batteries is just having the raw materials – the lithium, the nickel, the cobalt – and all the enabling technologies to facilitate the transition. In fact, lithium supply may need to increase nearly 10 times in the next 20 years to meet the demand.

*Peshkatari:* That’s right – and in fact I’d say the biggest concern right now is uncertainty around the entire supply chain from sourcing to processing the key metals used in manufacturing battery cells.

## Nickel supply-demand balance



Source: Benchmark Minerals, Cowen and Company, as of 31<sup>st</sup> October 2023. There is no guarantee that any forecasts made will come to pass.

That leads to unpredictability on how much it costs to build a battery storage system, which can account for 40%-60% of the cost of a new car. And when you're talking about costs, it's also important that government support becomes predictable and user-friendly to ensure a level playing field globally.

Right now, Asian manufacturers led by China dominate battery manufacturing, aided by significant government support over the past decade. China currently controls between 75% and 90% of the battery supply chain capacity across metals and battery cells.

*Mehta:* And going back to those metals, I think there's also the question of what you do with them when the battery's life is over.

## Would that be an opportunity for recycling?

*Ako-Asare:* Yes, I believe so. Lithium-ion battery recycling has really picked up. For some of the reasons already discussed, it simply does not make sense to take an end-of-life battery and discard it into a dump. Never to be used again.

Today, recyclers can recover over 90% of the key metals within a lithium-ion battery. These metals, once recovered, are the same as their virgin metals and are reused in the production of new batteries. This is a cool opportunity especially when you think of the potential

shortages expected from extracting some critical materials.

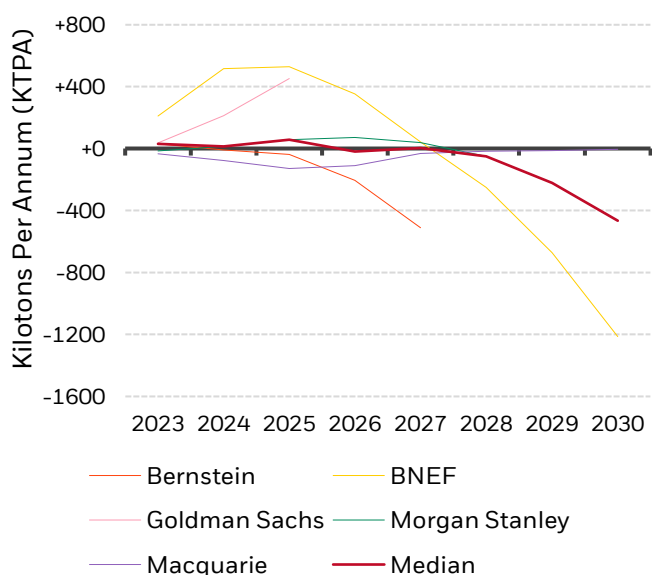
Everything we need is right here. Recycling reduces the need to dig into the earth to extract critical metals (like nickel and cobalt). At scale, you could quickly find yourself in a place where one could potentially produce recycled batteries at a lower cost than batteries with virgin materials.

The recycled battery does not need to carry extraction costs. This potential cost saving, among others, is driving the enthusiasm around recycling. And to expand on Tomas's point, recycling also has the potential to mitigate some of the geopolitical risks around the minerals when it comes to energy security.

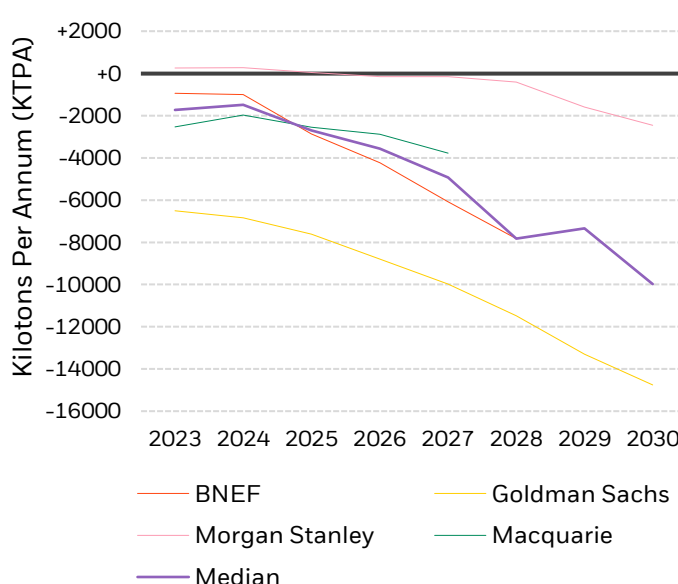
*Lilford:* And that's a factor. If you look at the current battery supply, the majority of that battery supply, whether it's cells or even the components that are going into manufacturing those cells is dominated outside of the U.S. and the EU. So as Tomas was suggesting, this creates a frailty in the global supply chain, very similar to what we've seen historically in solar.

Western governments have recognized how strategic the automotive industry is, and how important the transportation industry is to local employment. Close to 1 million people in Germany are directly or indirectly exposed to the automotive sector for their livelihoods. This is a socially and politically sensitive topic.

### Lithium supply-demand balance



### Copper supply-demand balance



Source: BlackRock Alternatives Commodities Research compilation as of 31<sup>st</sup> October 2023. There is no guarantee that any forecasts made will come to pass.

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The EU has a very strong ambition to create battery cell capacity domestically - targeting 550 gigawatt hours in capacity, which would represent close to 90% of it's internal battery demand. In the U.S. it's not an explicit capacity target, but the Inflation Reduction Act allocates an investment tax credit. And we're seeing a lot of new capacity potentially coming online there being led by a combination of automotive OEMs and battery cell manufacturers.

*Peshkatari:* I think these policies will lead to significant investment opportunities, and in fact they are already attracting significant private capital.

## What role does technological innovation play?

*Mehta:* Those regulatory tailwinds are happening at the same time as some truly game-changing advances in battery technology.

For example, some manufacturers are saying that recent technological advances have made the lithium-iron-phosphate, or LFP, battery more competitive than before. LFP batteries show added longevity compared to nickel-manganese-cobalt batteries, so if they are able to close the gap on energy density and lower failure rates it would increase their end market applications. In systems with thousands or millions of cells, such as those used in grid-

scale energy storage, an incrementally lower failure rate can be significant, saving costs on maintenance and making financing easier.

Overall, the advances are remarkable. We had 100 years before we were able to store very much energy at all in a battery. Why is that? First, the technology wasn't needed. Second, the technology is hard to develop. It can take years in a lab before you realize your ideas.

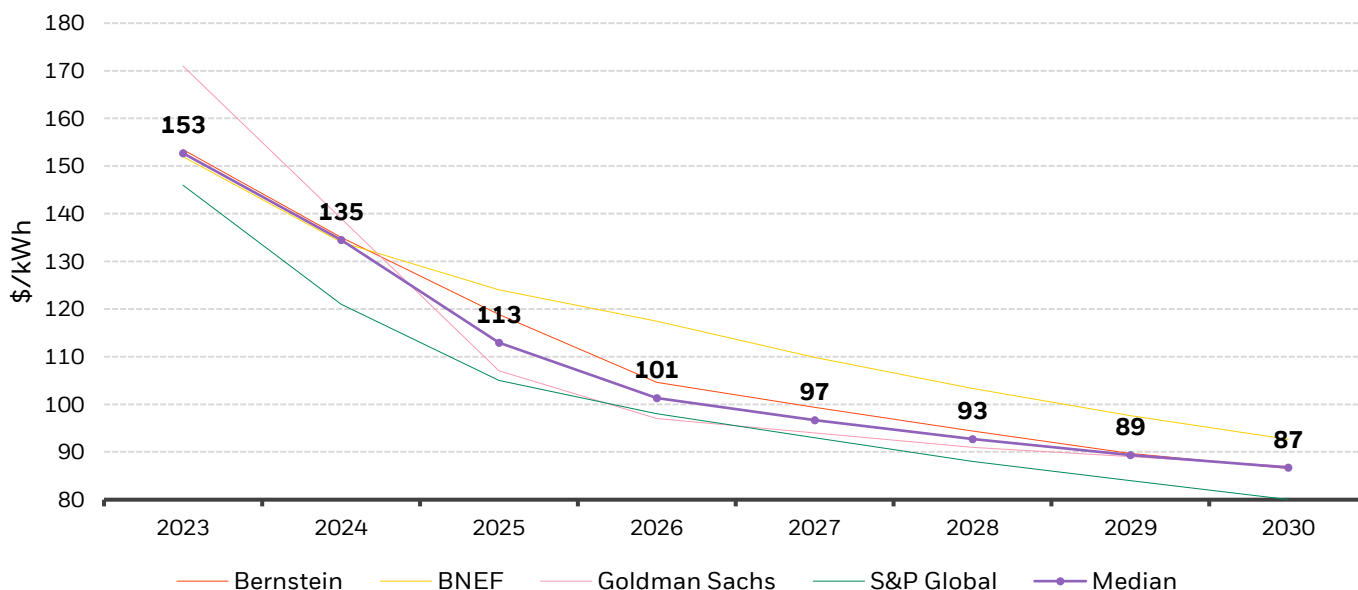
But computing power has grown exponentially. You can run models and test hypotheses about materials in a fraction of the time.

And beyond the manufacturing side, that same ability to run simulations helps grid operators and power-generation owners determine if the battery is going to be effective and economically sound in a given location.

*Ako-Asare:* Absolutely, Akhil. Moore's Law has given us amazing advances in electronics, while the mass production of the semiconductor has led to the rapid decline in the cost high-performance computing, with widespread cloud access. These changes have provided scientists and researchers the tools to explore problems that would have been prohibitive 20 years ago.

*Lilford:* We see that wave of new technology on the public side as well. And I think it's often underappreciated how some of these larger, more-established companies drive innovation.

## EV battery cost projections



Source: BlackRock Alternatives Commodities Research compilation as of 31<sup>st</sup> October 2023. There is no guarantee that any forecasts made will come to pass.

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They might not necessarily be as nimble or fast-moving as some of the smaller, private companies. But when they get their mass and their focus behind some of this technology, they can bring it to commercial markets in a much more significant way.

## **As investors, how do you act on these trends and developments?**

*Lilford:* Batteries are an industry where the public and private opportunity set actually marries up quite nicely. And it's a place where investments can also result in significant economic growth and employment creation.

We see the transportation opportunity as being really about moving people and goods more efficiently. And we are headed in the direction of greater electrification, principally in transportation. Every large automotive manufacturer in the world today has an electrification strategy in play, so the mainstream is on board. It is now about mass-market adoption.

On the battery-manufacturing side, you are dealing with a very discretionary customer base. If you're an automotive manufacturer, there's no way you're going to risk equipping your vehicles with battery cells that have higher risk of accidents or thermal runaway because they're not manufactured at the correct standards. That lends itself to a tier-one type of procurement system where you have four or five very strong players in the marketplace providing a large share of the batteries. After all, this is a highly brand-conscious industry, where reliability and safety are at the forefront of consumers' minds.

*Peshkatari:* Some of the biggest opportunities we have seen are in distributed battery energy storage systems and contracted battery cell manufacturing. Both opportunity sets have been accelerated by the government policies mentioned earlier.

*Mehta:* There are especially compelling opportunities among companies that have a first-mover advantage in the sector, especially one that's as quickly moving as batteries.

As an asset class, infrastructure is further down the value chain, so investors tend to stay as technology-agnostic as possible to remove any technology risk. The focus is more on platforms over single assets due to their diversity around assets, geographies and revenue streams.

Another factor for infrastructure investors to consider is management track record. These are large scale construction projects. Having an idea is fantastic. But without a team that can execute the idea, an idea is worthless. And sometimes the people who developed the business aren't the right team to see it into maturity. They're very different skill sets, and ultimately it's up to management to execute.

*Ako-Asare:* Among private companies, there are attractive opportunities to invest in markets that are large and growing. But investors in this space should also look closely at management teams to see if they offer unique perspectives on where the market is going, such that it drives their competitive advantage.

Especially in the late-venture, early-growth space, there are many companies actively working to commercialize new technologies.

Batteries are part of a growing market, so it's important to spend time studying broader trends in the market to rapidly respond to emerging opportunities.

*Peshkatari:* I'm sure everyone will agree with me, though, that not all opportunities will make great investments. This especially true in infrastructure.

But there are still investment opportunities among proven technologies and established business models that benefit from contracted cash flows with strong counterparties.

One thing investors should look for is counterparties that benefit from sustainable competitive advantages, which isn't easy in a relatively young industry that is likely to continue to see disruptive technologies introduced on a regular basis.

# Conclusion

The demand for batteries is set to grow significantly through this decade. And beyond that, we view it as an exciting 30-year investment opportunity.

It will play out with major global effects across mining, transportation, electricity storage and transmission and waste management.

Batteries are ultimately a truly global opportunity, though progress will be uneven over time, across regions and technologies.

The size of the investment opportunity for batteries is immense. The growth of EVs presents the largest single opportunity for battery manufacturers today. And looking ahead, the electrification of transport and other aspects of our life will increase energy needs around the planet.

As more energy comes from wind, solar and other intermittent sources, grid stability will become ever more important. In the near term, the lithium-ion value chain stands to benefit while other chemical, mechanical and thermal energy storage solutions may become more prevalent in the medium and long term. Between EVs, grid stabilization and other applications, the lithium-ion value chain, from mining through recycling, could grow by over 30% annually through 2030, to reach a value of more than \$400 billion<sup>1</sup>.

That said, investing in the battery value chain is nuanced. And a broad portfolio approach can allow investors to exploit opportunities in the adjacent parts of the transition that benefit from broader electrification trends.

There is complexity layered into the growth story for batteries – from raw-material extraction and manufacturing ramp-up, to ongoing technological evolution, and the significant investment needed for supporting infrastructure, starting with the electricity grid and ending with EV chargers.

There are also other factors at play, such as government policies, an increasing drive for onshoring, a widespread desire for supply-chain diversity and differing consumer behaviors by region.

In the near term, the APAC region, and China specifically, will hold the lead in battery manufacturing, though Europe and North America are taking policy and investment steps to catch up. New innovations will create fresh opportunities within the battery sector, across the technologies that enable batteries and the spaces where those batteries are deployed.

Fundamentally, we anticipate that innovation and the increasing industrialization of the value chain will drive battery prices lower, creating more demand and new uses. We believe that investors who are developing portfolios that seek to benefit from the transition to a low-carbon economy will increasingly see exciting investment opportunities in this space.

1. McKinsey, 2022

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