

Energy Storage Systems Outlook

10-year forecast

Q3 2024





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In this inaugural publication of the Fastmarkets Energy Storage Outlook, we find the following key trends from our report are the timeliest for our clients.



Renewable Energy Forecast

Renewable energy is expected to continue its growth trajectory, driven by supportive policies and technological advancements. This will significantly impact the demand for energy storage systems, particularly in regions with high renewable energy penetration.



ESS Demand Outlook

The demand for Energy Storage Systems (ESS) is projected to rise steadily over the next decade, fueled by the increasing need for grid stability and the integration of intermittent renewable energy sources.



ESS Chemistry Outlook

Advancements in battery chemistry, particularly in lithium-ion and solid-state technologies, are expected to drive innovation and improve the performance and cost-efficiency of ESS.



Upstream Insights

Despite downward trends in raw material prices due to oversupply in the market, we expect prices to tick upwards throughout the decade due to expected deficits.



ESS Cell Insights

ESS cell manufacturing is set to see significant growth over the decade, with a focus on scaling production and reducing costs. This will be crucial for meeting the increasing demand for ESS across various applications.



Supply Chain Insights

From our partner Infyos; Supply chain risks are now a top priority for downstream customers, regulators and investors of BESS manufacturers and integrators. EU and US Battery Regulations are key to this understanding.



Market Fundamentals

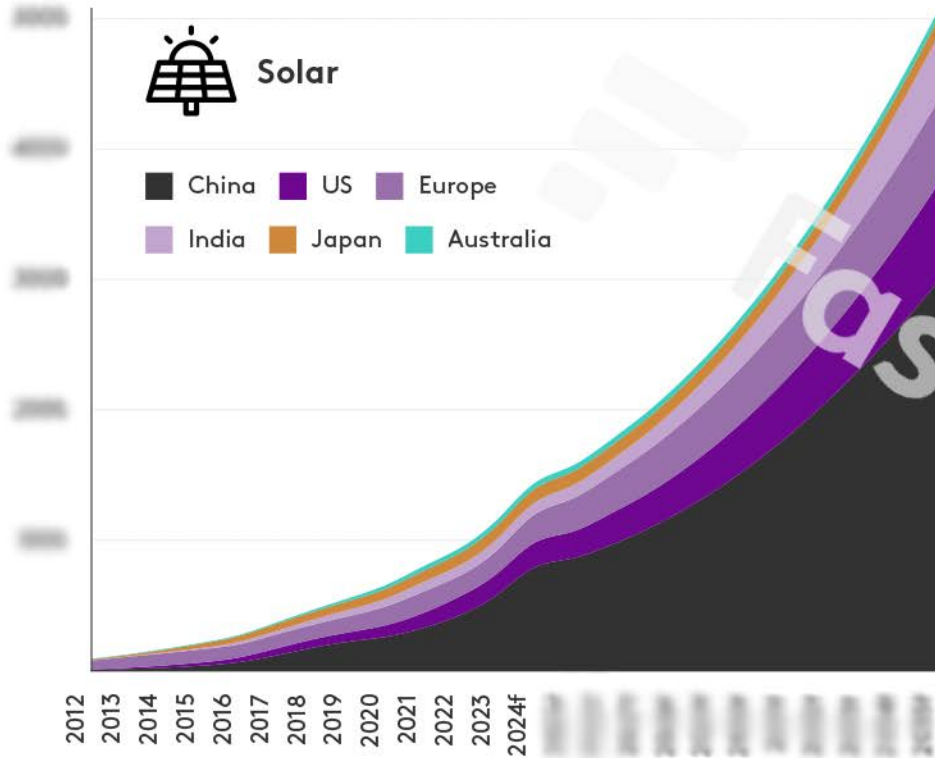
Policy remains the key driving force for ESS and vital to ensuring that more regulated revenue opportunities open up to ESS projects to make increasing profits across a breadth of markets.

Renewable Energy Forecast

Solar and Wind Generation Outlook

Currently, a significant portion of the investment in battery energy storage systems (BESS) is directed towards services that enhance the flexibility of energy providers, such as firm frequency response. Over time, the expansion of BESS is expected to be driven more by the development of solar parks and wind farms, which will require batteries to manage their short-term storage demands. As a result, we will see ESS build-out align with renewable energy development, primarily driven by the following key regions and markets.

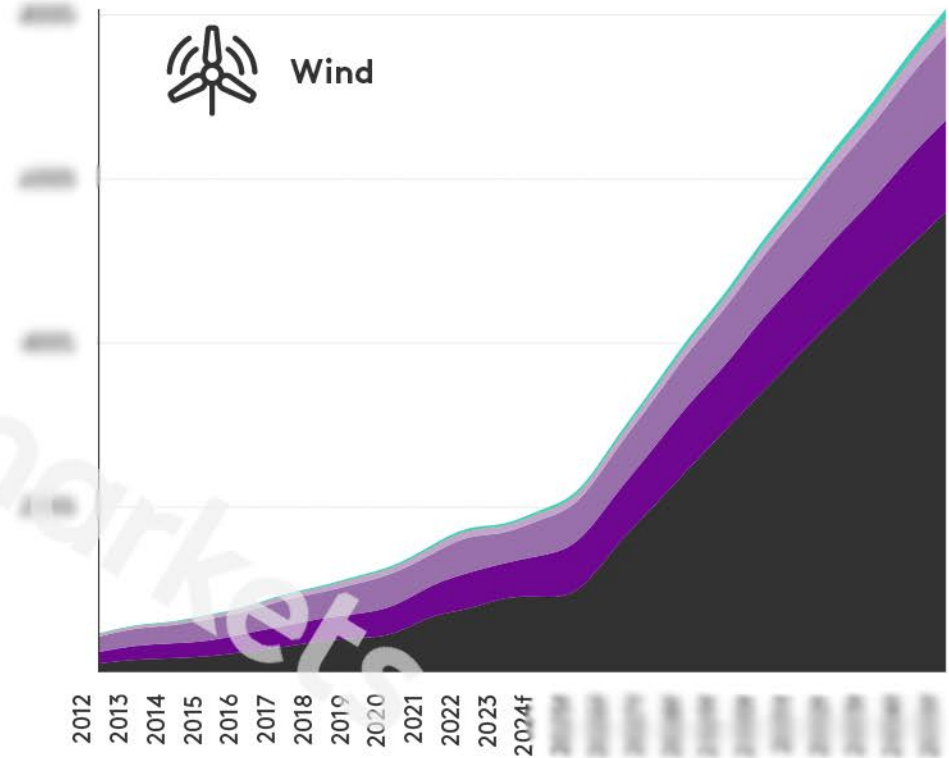
Solar generation forecast



Key takeaways

- China will be the largest market for solar energy production with over 200TWh by 2034
- India will be the fastest growing solar market with a compound annual growth rate (CAGR) of 20%, reaching 100TWh by 2034, followed by the US with over 70TWh of solar production

Wind generation forecast



Key takeaways

- China will again be the largest source of wind generation by 2034, with a CAGR of 20% from 100TWh to 1,000TWh
- The US will also see strong growth of wind power due to Inflation Reduction Act (IRA) funding, growing to 1,000TWh by 2034
- In Europe in offshore wind we have seen stronger wind investments in Germany, the UK and Denmark. Onshore wind development has been led by the Netherlands and France

Renewable Energy Forecast

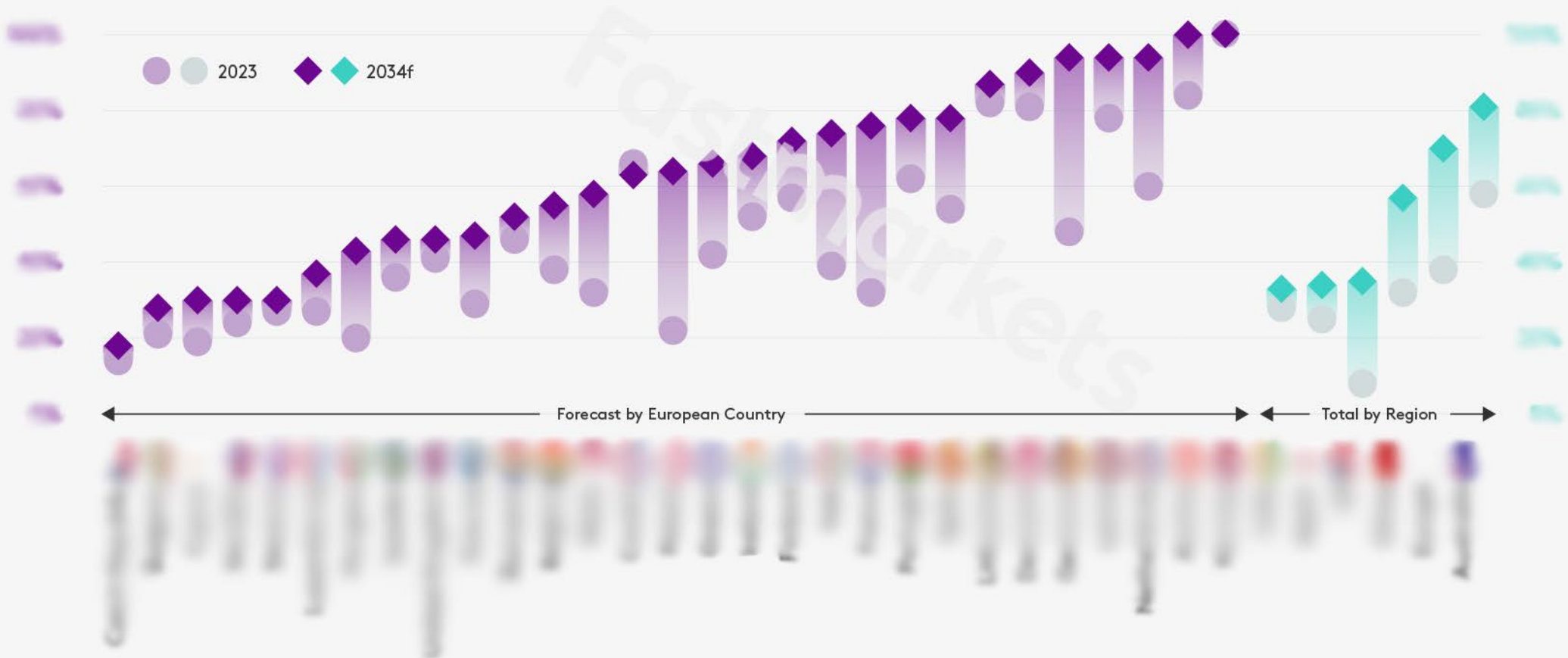
Renewable Energy Share Outlook

Certain key markets in Europe are enabling the region to replace thermal energy resources with renewables, while others have sufficiently developed their renewable energy sources to already be nearly 100% green (Norway).

Most notable markets for rapid growth of renewable energy market share over the decade will be France, Germany, Netherlands, Poland and Portugal, as shown in the graph. This is due to the dual role out of impactful policies to ensure domestic supply of energy, in addition to large-scale investments by private and public sector groups.

While investments into renewable energy are surging rapidly, certain markets still require extensive build-out to reduce their reliance on fossil-fuel, thermal sources.

Percent of energy from renewable sources

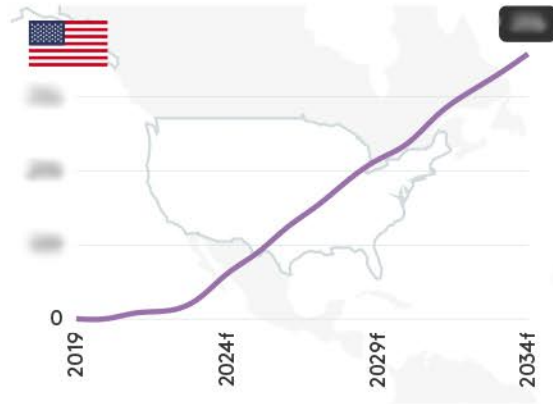


SOURCE: FASTMARKETS

ESS Demand

Energy Storage Demand Outlook – US, China, Europe

China annual ESS Installations (GWh)



US annual ESS Installations (GWh)



Europe annual ESS Installations (GWh)



US

The largest source of annual installations in 2034 is the US with 30% of the total global share. We expect the US to become the leading market for storage over the decade as a result of two key factors; extensive renewable energy build-out and bullish policies and regulation. Most notably, the Inflation Reduction Act has significantly improved project bankability, making it incredibly attractive for investors to support project development.

Looking ahead, we expect upwards of 85% of ESS build-out in the US to be grid-scale. This is due to a lack of policy aimed at supporting BESS generation. We do however see opportunities from the Commercial and Industrial (CI) segment expanding strongly in the near term, with year on year growth of 39% in 2023 and 45% in 2024.

China

We believe that the biggest driver of annual ESS installations in the near term will continue to be bullish policy and targeted subsidies. In China, we have seen this play out with the introduction of the national and additional state-driven co-location policies, requiring renewable energy projects to build batteries on site.

While we saw a surge of 76% y-o-y in China's ESS installations in 2023, we expect this to slow to 31% in 2024 as project owners struggle to address bankability given the tight regulatory environment in the country. While we expect continued growth, we expect the market to struggle to make profits due to the volatility of ESS over the past year.

Europe

We expect Germany to be the largest market for annual ESS installations, with 48,000GWh by 2034. This is followed by Italy with 44,000GWh and the UK with 41,000GWh. 45% of the batteries in Germany are from the residential segment, the market also leads the region in ESS fleet. While the market has been slow to increase its grid-scale ESS fleet, we expect growing regulatory support and the potential opening of new capacity markets will develop revenue streams. In contrast, we expect the UK market to grow more steadily given the situation of revenue streams, and grid connection difficulties.

Outside of these leading markets, we see the Rest of Europe reaching 2500GWh of annual installations by 2034. This market continues to be underpinned by the strong build-out of renewable energy sources such as Czech Republic, investment in additional energy build-out of solar and wind farms, which is expected to see batteries being introduced to support generation.

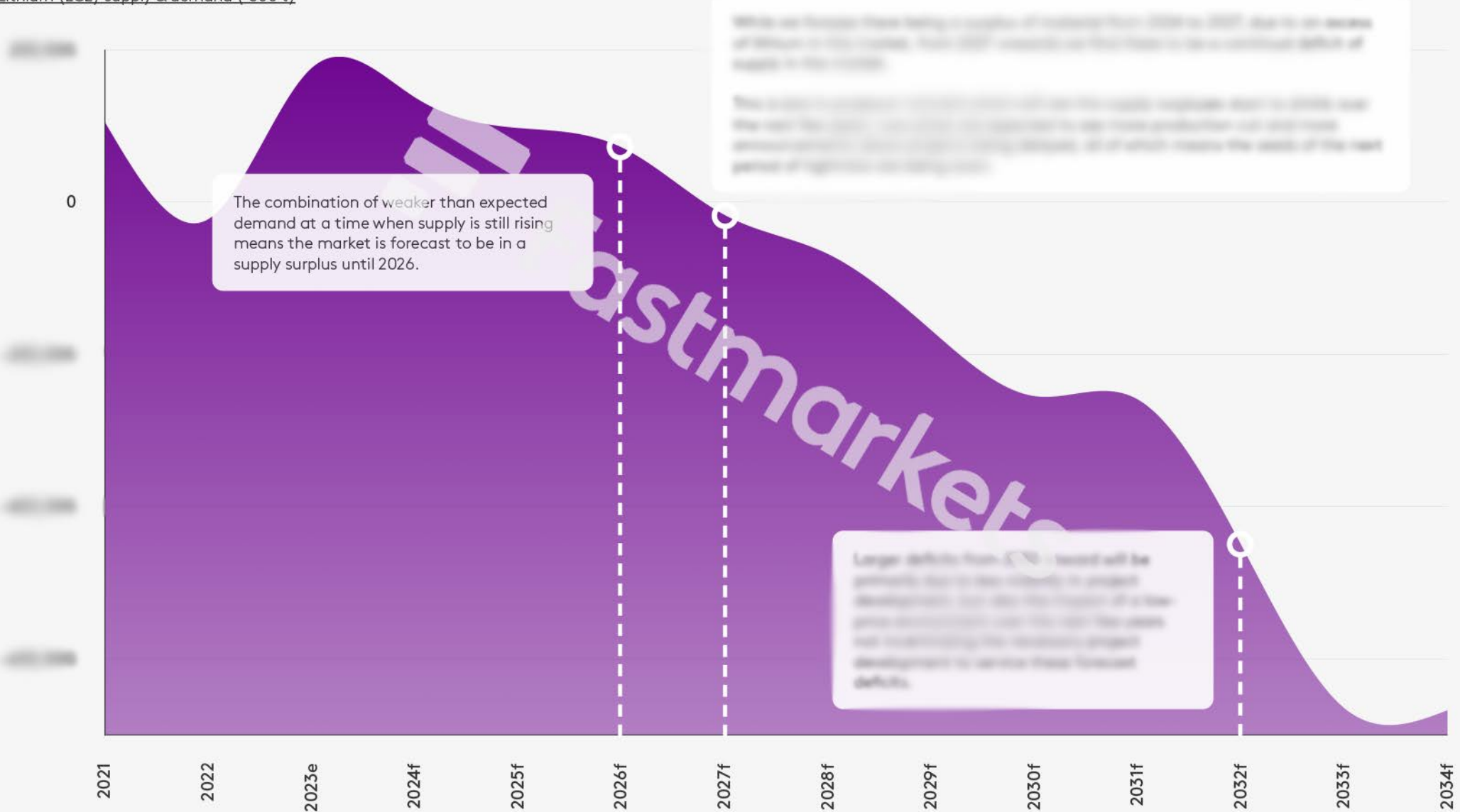
SOURCE: FASTMARKETS, ROLAND BERGER. NOTE: ESS IN THIS CONTEXT REFERS TO STORAGE USING BATTERIES AND NOT HYDROPOWER.

Raw Material Price Outlook

Downward Trend in Lithium Prices Poses Upside for BESS Costs

Weaker demand has pushed market into surplus in near term, but long-term deficits remain

Lithium (LCE) supply & demand ('000 t)



SOURCE: FASTMARKETS LITHIUM LONG TERM FORECAST

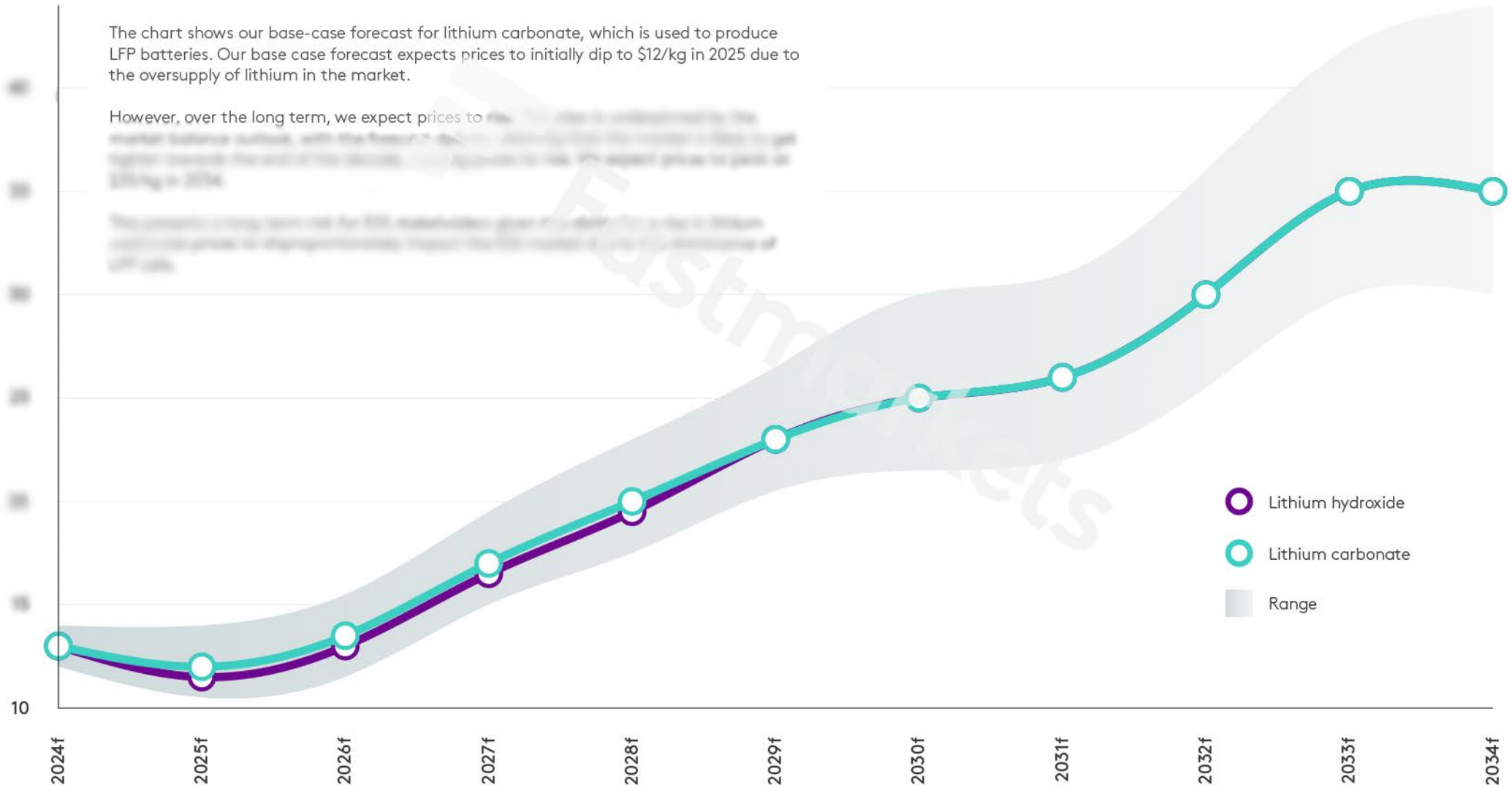


Raw Material Price Outlook

Rising Prices Present a Long-term, Unseen Risk to ESS Stakeholders

LCE prices rise, underpinned by the market balance outlook

Lithium carbonate - base, high and low scenario (\$ per kg)

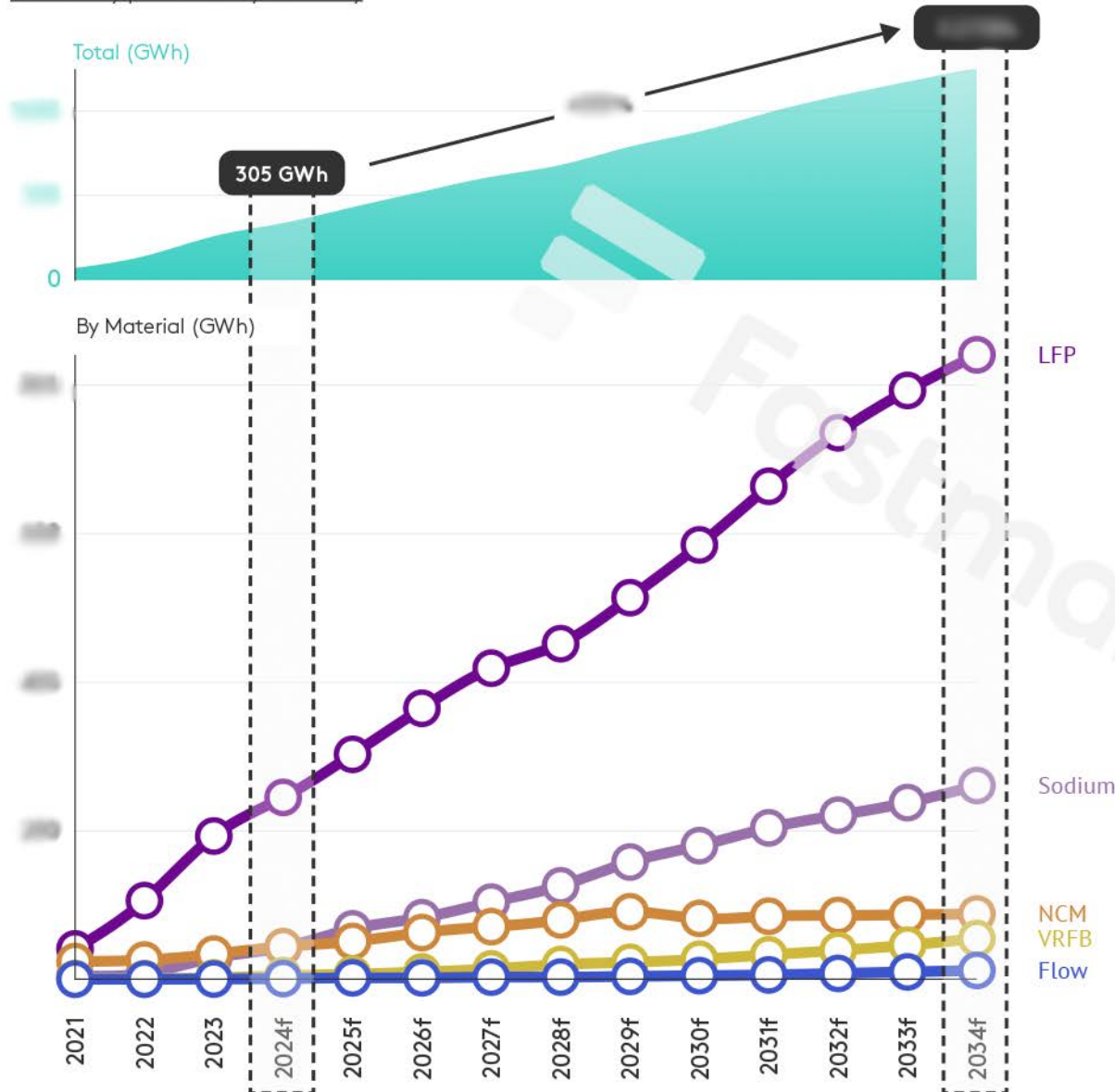


SOURCE: FASTMARKETS LITHIUM LONG TERM FORECAST

Chemistry Outlook

ESS Battery Chemistry Outlook

ESS battery production by chemistry



- The volume of 2024f of ESS cells will be produced in 2024. The 2025f volume will be produced in 2025 and 2026f of ESS cells produced in 2026 and 2027.
- Within our gigafactory database, 75% of the plants are located in China, 7% in Europe, 3% in the US and 12% in ROW. China will remain the locus of production throughout the decade, but by 2034, regionalisation will have developed ESS cell production in other regions, the US in particular where we have seen extensive investments due to the Inflation Reduction Act tax credits.

Within our ESS gigafactory database, in 2024, 75% of the plants are located in China, 7% in Europe, 3% in the US and 12% in ROW. China will remain the locus of production throughout the decade, but by 2034, regionalisation will have developed ESS cell production in other regions, the US in particular where we have seen extensive investments due to the Inflation Reduction Act tax credits.

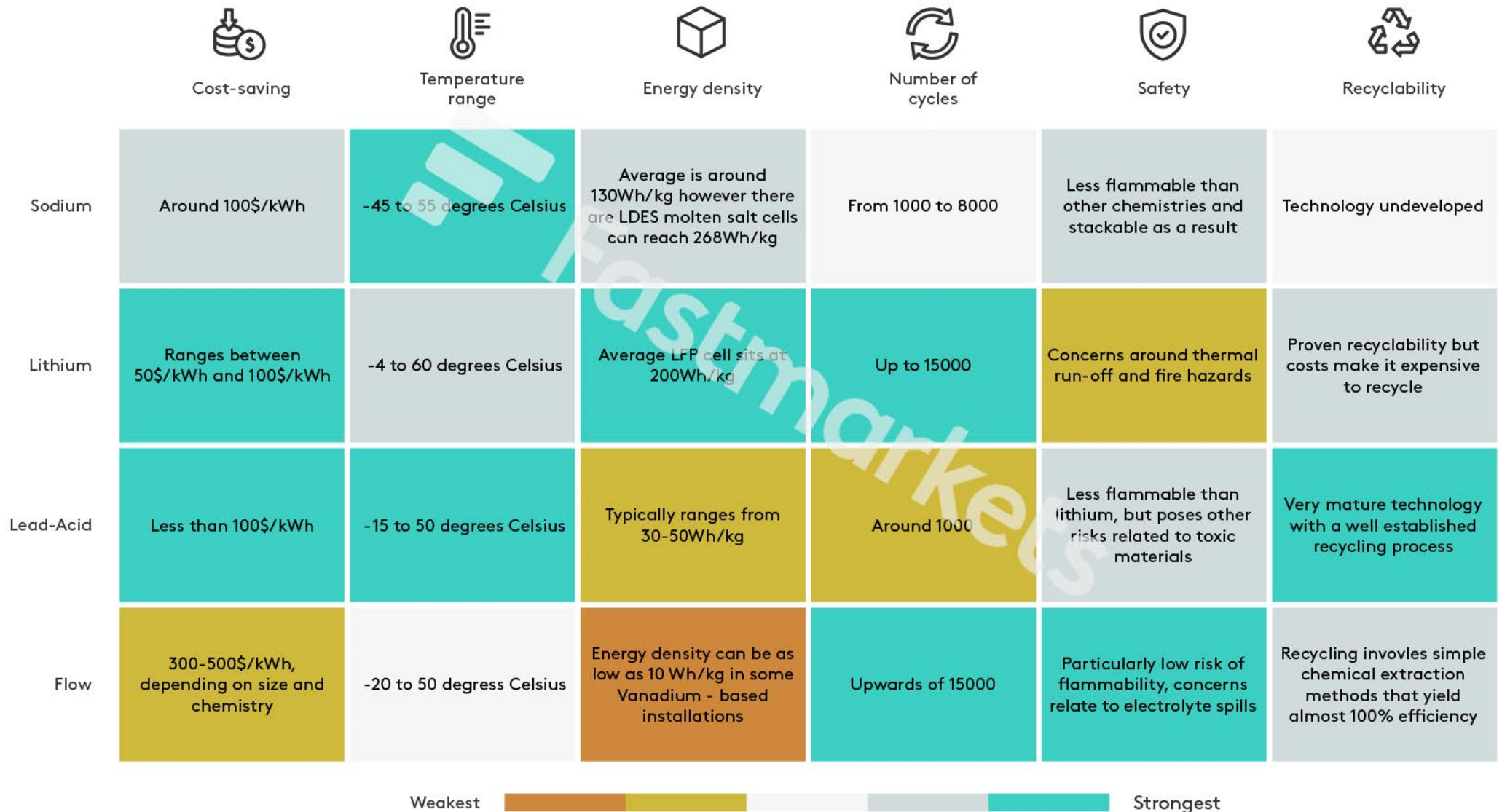
Going forward, we expect to see LFP continue to dominate ESS cell production, rising to 80% of ESS cell production by 2034. NCM production will reduce to a share of 1% of the total by 2034, down from 12% in 2024 as the affordability

of LFP cells remains most attractive to developers. LFP cells remains most attractive to developers. LFP cells remains most attractive to developers.

SOURCE: FASTMARKETS

Strengths and Weaknesses of Sodium Compared to Other Chemistries

Comparison of the strengths and weaknesses of chemistries for ESS battery chemistries



SOURCE: FASTMARKETS

Cell Cost Trends Summary July 2024



Key Highlights

- Cell costs continued to fall in July on sluggish buying during the seasonal summer lull.
- Cathode Active Material (CAM) costs fell once again in July, down 1.3-11.0% across the range of chemistries.
- Weak seasonal demand and bearish raw material prices were the major cause of the declines seen last month. Lithium hydroxide prices saw the largest monthly falls for raw materials, down by 11.3-12.4% in the Asian and seaborne market.
- Anode production in China fell in July following the end of restocking cycle by battery producers in Q2, leading to declining demand for anode material precursors.

The Fastmarkets Battery Cost Index (BCI) is a monthly publication that tracks and forecasts the should-cost of various lithium-ion cells. It aims to provide transparency for stakeholders across the battery value chain to make informed investment decisions.

The BCI breaks down cell costs into core components, quantifying the impact of material price volatility, such as lithium carbonate, on downstream cell costs. It also considers key manufacturing parameters, especially the cell plant's location. For more information go to the [BCI](#) information page.

In this report, our analysis showcases the monthly cost trends and cost breakdown for three cells used for ESS by CATL, BYD and EVE.

Cell Cost

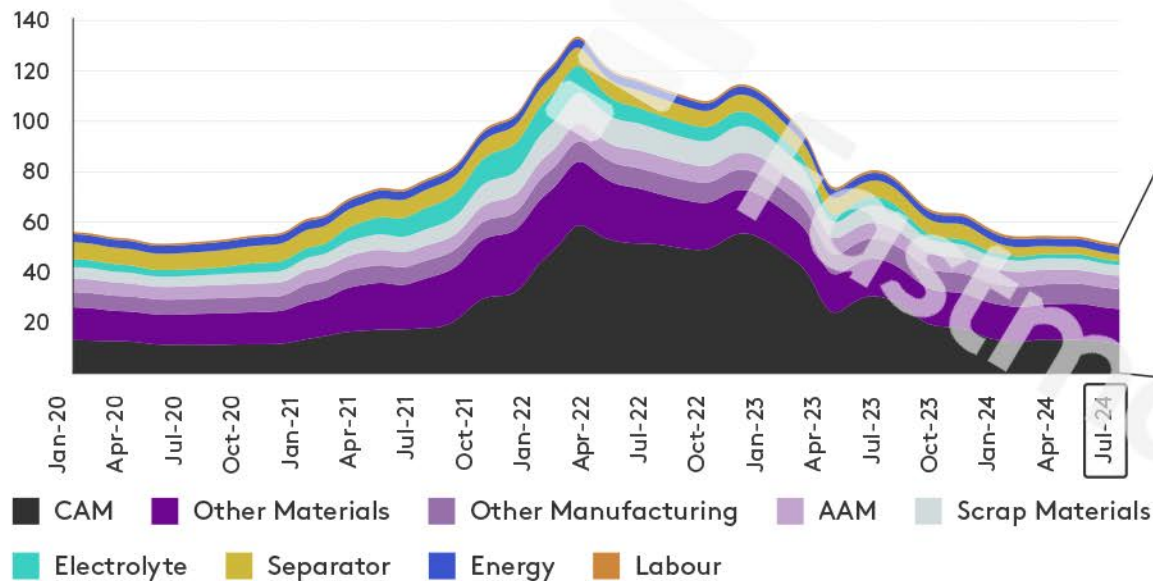
Estimated Cell Cost Structure of Energy Storage Cells

EVE LFP108Ah ESS Cell Analysis

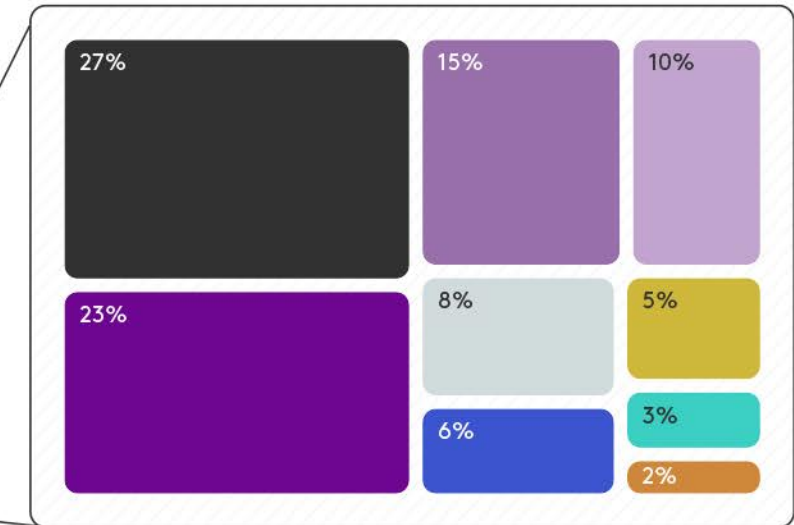
Monthly Cost Trends

Latest data from July 2024 shows that cell cost sits at \$51.3/kWh, down from highs of \$133.4/kWh in March 2022. The most notable drop in costs came from the CAM cost falling by 7% due to falling lithium carbonate prices.

EVE LFP108Ah historical cost data (\$/kWh)



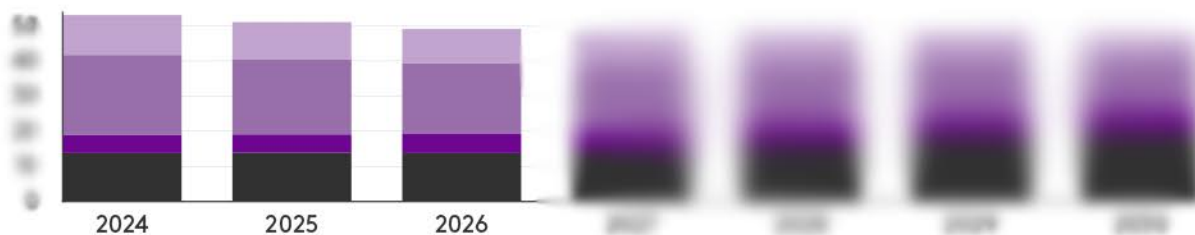
EVE LFP108Ah cost breakdown



Cost Breakdown

Compared to the other cells, this EVE cell has a lower CAM cost at \$11.7/kWh, explained by the lower energy density of the cell. By contrast, the cost for Other Materials is higher for this cell at \$13.8/kWh, while CATL's is at \$10.4/kWh, making the overall cell cost higher despite the savings in the CAM cost.

EVE LFP108Ah historical cost forecast (\$/kWh)



Forecast

We expect this cell to fall to a cost of \$37.6/kWh in 2028. This is a notable decline in price over time compared to the other cells due to the lower CAM costs, meaning that falling raw material prices will not have as notable an impact.

Cell Cost

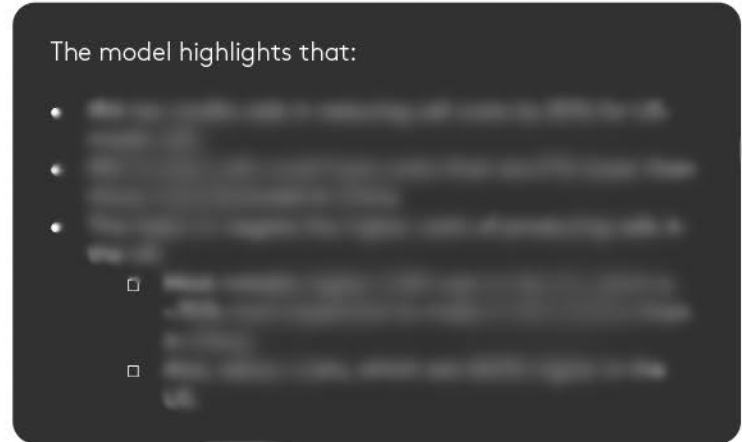
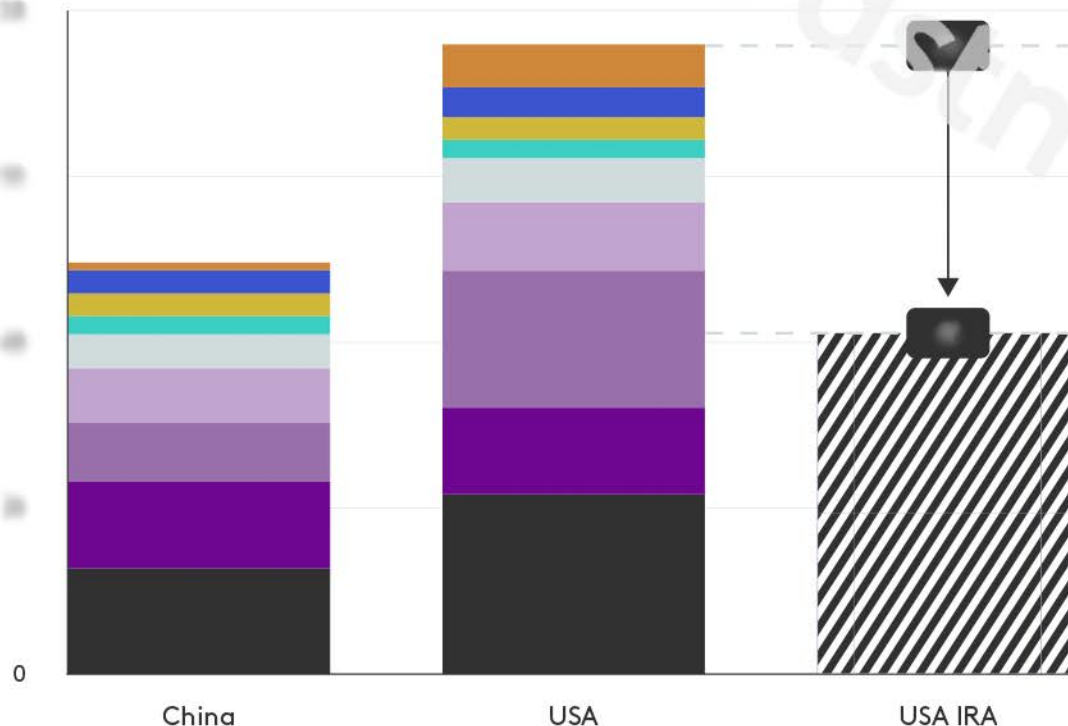
Inflation Reduction Act Impacts

Assessing tax incentives on ESS cell costs

We also want to highlight the cell cost efficiencies that could be reached in the US due to subsidies from the Inflation Reduction Act, namely via the 45X tax credit that offers \$35/kWh to manufacturers producing cells in the US.

US IRA ESS cell cost analysis – using CATL 160 Ah LFP

Cell cost comparison by market, including Inflation Reduction Act subsidies



Our model examines the cost comparison of producing CATL LFP cells in different countries in 2024. This is a like-for-like analysis, assuming each cell gigafactory is equally mature in the two countries, with 10 GWh/year production at 100% utilization and a 5% cell rejection rate.

In the model, the cells are produced locally in each country. Other cell components (e.g. separator, electrolyte) have the same cost, however, US cells have had shipping costs added on to reflect the cost of purchasing these products from China. For the US, we have also added a 25% tariff to the graphite material price due to the Section 301 Tariff's in place that apply import tariffs on Chinese graphite anodes.

Cell Technical Design

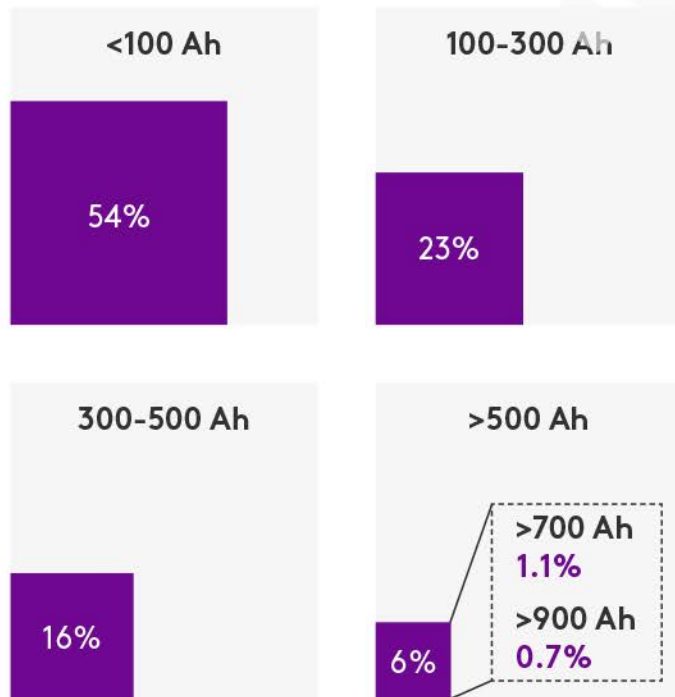
Cell Technical Analysis

Status-Quo

We collected information of around 320 cells (286 of them are from Chinese companies) from the market.

Of all the cells in database, 54% has capacity lower than 100Ah, 23% is 100~300Ah, 16% is 300~500Ah. The remaining 6% are larger than 500Ah. Specifically, 2 cells are larger than 900Ah (from *LiBMS* and *HTHIUM*).

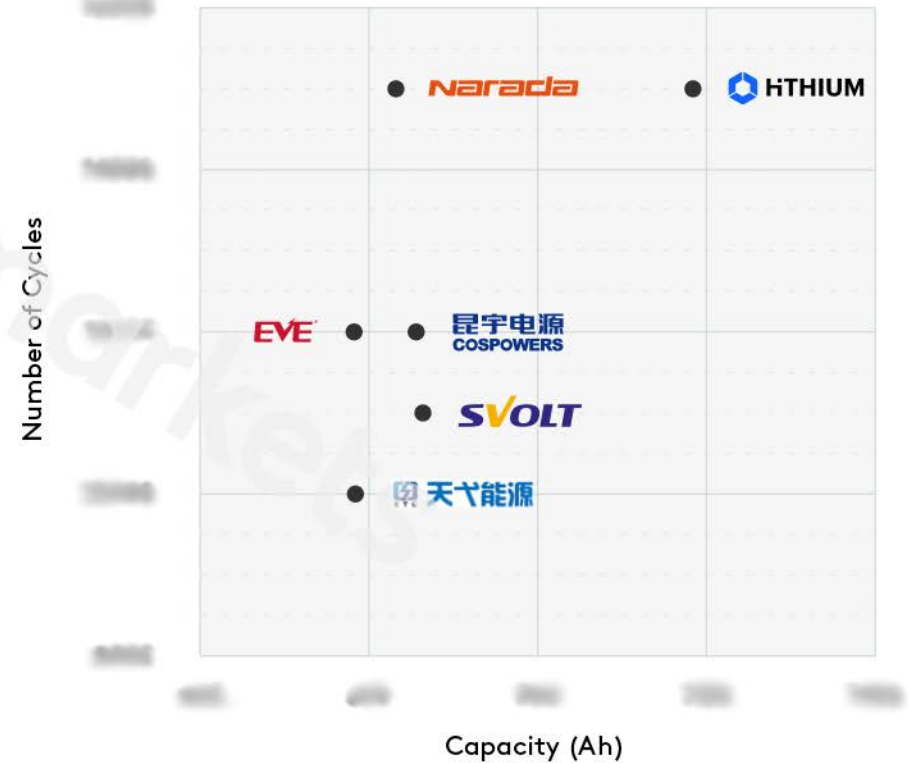
ESS cell count, by capacity (Ah)



Trend

New type energy storage stations are showing a trend of larger operation scale (average duration: 2.2 hours in 2023 vs 2.1 hours in 2022). Given LFP being a trend, cell producers are reacting with larger-format cells.

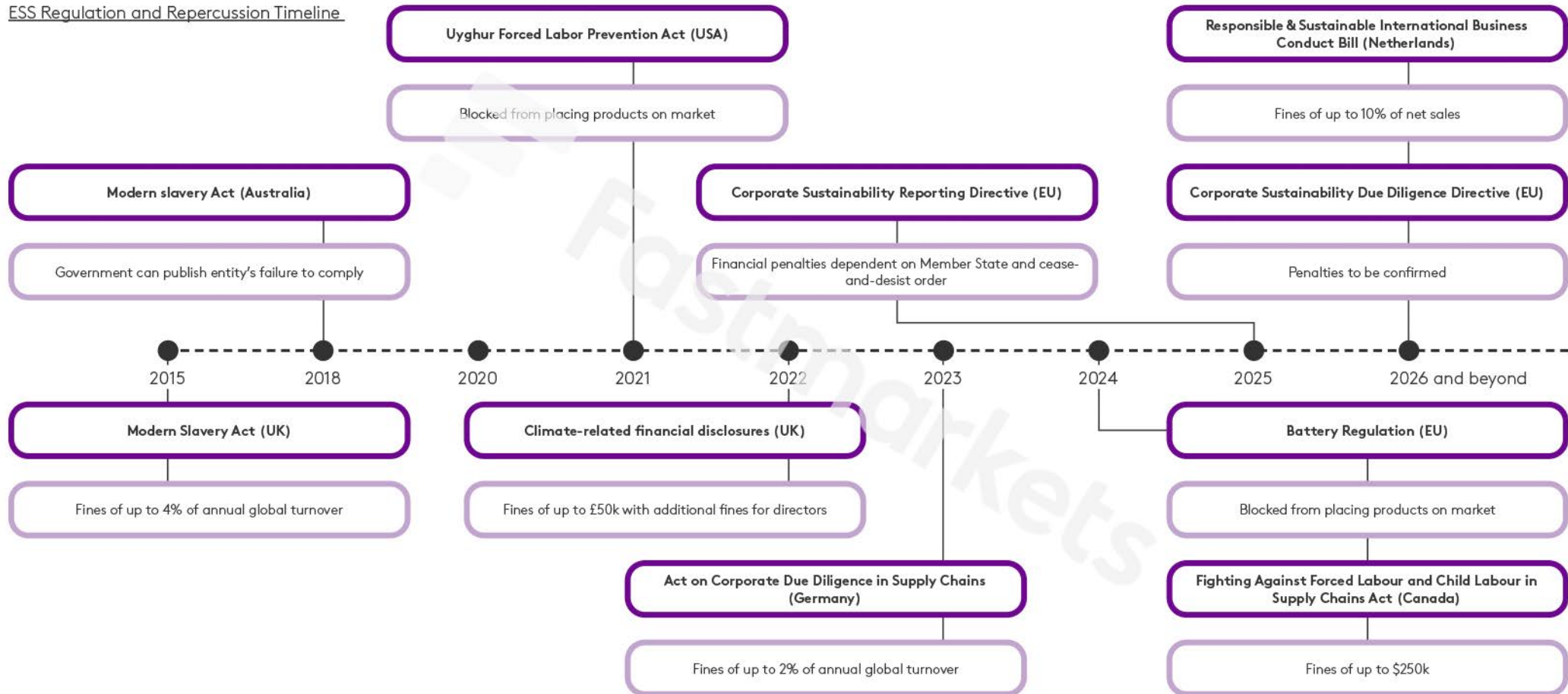
Below we list 6 large-format (ranging from 120Ah to 1100Ah) cells released/announced in 2023 and 2024. We see that all these cells have cycles >10,000.



Supply Chain Risks

Supply chain risks are now a top priority for downstream customers, regulators and investors of BESS manufacturers and While serious concerns remain over whether the growth in the production of critical raw materials will keep up with projected ESS demand, broader regulatory and investor pressures have led to increased scrutiny over the environmental, social and governance (ESG) credentials of battery supply chains.

ESS Regulation and Repercussion Timeline



Over the past five years there has been a significant uptake in ESG regulations that target the entire supply chain and now hold downstream companies accountable for ESG impacts further upstream. Companies that fall afoul of these regulations are now subject to financial penalties and risk having their products blocked from certain markets (see Figure 1). We now provide two case studies from Europe and the US to showcase how this is playing out.



This content was produced by Infyos based on analysis of their risk database and secondary sources. Infyos is a supply chain risk management tool that helps renewable energy players identify ESG and regulatory risk and work with their suppliers to solve these risks step-by-step

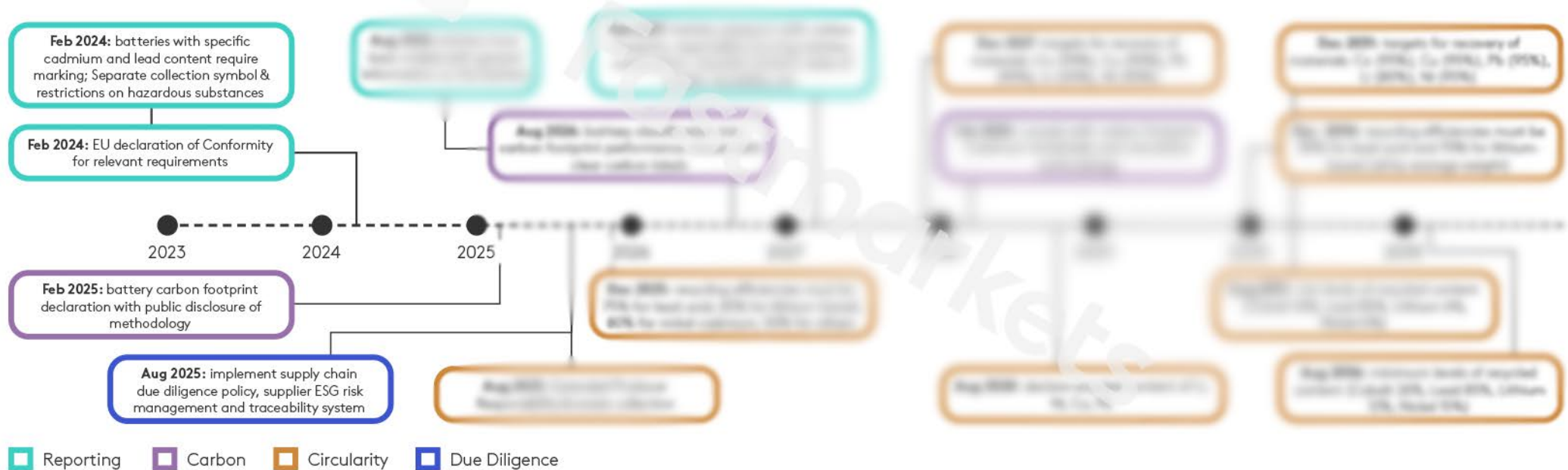
EU Battery Regulation

Meanwhile, in the EU there is also a growing list of regulations that now require companies to integrate ESG criteria into their due diligence and supply chain practices. The most notable for the battery industry is the EU Battery Regulation, which, among other sustainability requirements (see Figure 2), places due diligence obligations on companies placing batteries onto the EU market starting August 2025. Companies, excluding SMEs, are required to not only have a due diligence policy specifically for battery supply chains, but also put in place a risk management system to identify, assess and mitigate a pre-defined list of environmental and social risks. Moreover, the regulation introduces stringent traceability requirements, which includes having a detailed chain of custody from mine to manufacturer.

Other due diligence regulations in the EU

These due diligence requirements sit alongside other pieces of EU regulations, such as the recently passed Corporate Sustainability Due Diligence Directive (CS3D), and national regimes currently in place, including Germany's Supply Chain Act (LkSG).

EU Battery Regulation Timeline



Investments risk being blocked, and financing opportunities limited if ESG isn't firmly integrated into supply chain management

The growing trend in sustainable investments, of which the energy transition is a core pillar, has also contributed to increased scrutiny of the upstream ESG risks in battery supply chains. By the end of June 2023, funds in Europe that either promote environmental or social characteristics or have sustainable investments as a primary objective accounted for \$6.4 trillion in assets under management. This number is potentially set to grow as well, according to research by PwC. Over the next two years, 79 percent of institutional investors plan to allocate more financing to ESG product.

SOURCE: INFYOS

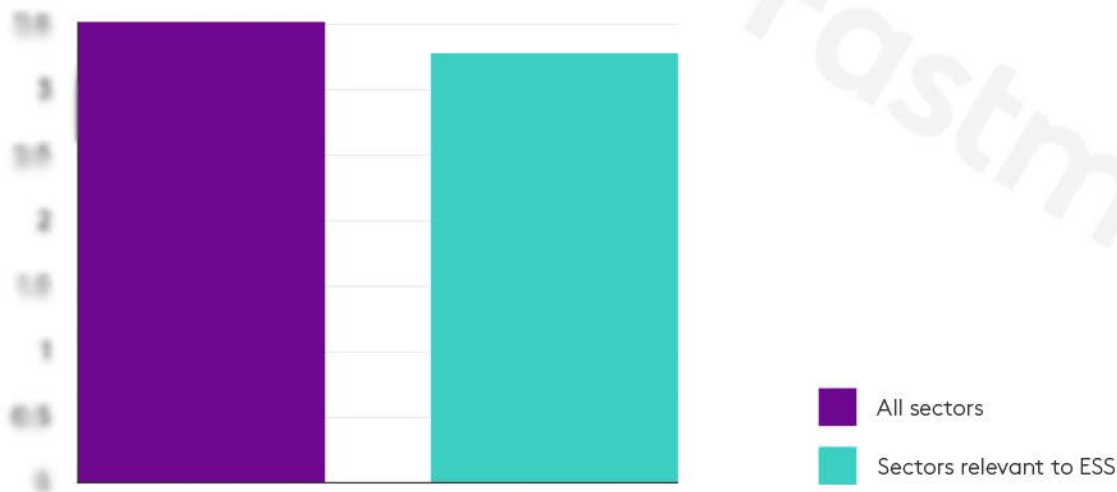
US Battery Regulation

Uyghur Forced Labour Prevention Act (UFLPA)

In 2023, the U.S. Custom and Border Protection (CBP) designated lithium-ion batteries as a potential risk area under the Uyghur Forced Labour Prevention Act (UFLPA). The UFLPA presumes that all goods that are produced, in whole or in part, in Xinjiang or are connected to certain entities are made with forced labour and therefore barred from US markets. Sectors and entities that are designated as high-risk face tighter scrutiny and are more exposed to enforcement actions under the act.

Companies that are subject to enforcement actions have 30 days to prove their products are not connected to Xinjiang or, if they are, not produced, in whole or in part, with forced labour. If a company is not able to provide clear and convincing evidence, then the product may be destroyed or re-exported. To avoid this, companies are required to evidence a substantive due diligence process, supply chain management system and establish a chain of custody system to identify who the supplier are, who is conducting the work with

Value of shipments stopped for review or enforcement under UFLPA, 2023 - 2024



The value of shipments stopped under the UFLPA equals 3.12 billion USD, most of which is concentrated in sectors relevant for ESS, such as base metals, electronics and manufacturing materials. Data compiled from U.S. Customs and Border Protection.

Shipments stopped for review or enforcement under UFLPA, 2023 - 2024



Sectors relevant to ESS - including automotive and aerospace (batteries), Base Metals, Electronics, and Industrial and Manufacturing Materials - account for approximately 40% of the total number of shipments stopped under the UFLPA. Data compiled from U.S. Customs and Border Protection.

Suppliers are signing codes of conducts saying there are no human rights violations or environmental impacts in their supply chain; however, exposure to these risks tells a different story. We find the following three risks to be the most prevalent to the ESS industry at this moment.

Labour risks

Regulations, such as the UFLPA in the US and the incoming EU Forced Labour Regulation, have focused industry attention on forced labour. Overall, the ESS industry's exposure has intensified, approximately 85% of battery grade lithium is produced in China, with large scale investments in lithium mining and refining underway in Xinjiang. Additionally, reports have suggested that at least 85% of lithium reserves of lithium are located in the Xinjiang region. Reports from the United Nations have previously noted concerns about involuntary labour programmes in the Xinjiang Autonomous Region of China, saying that the programmes carry the risk of forced labour.

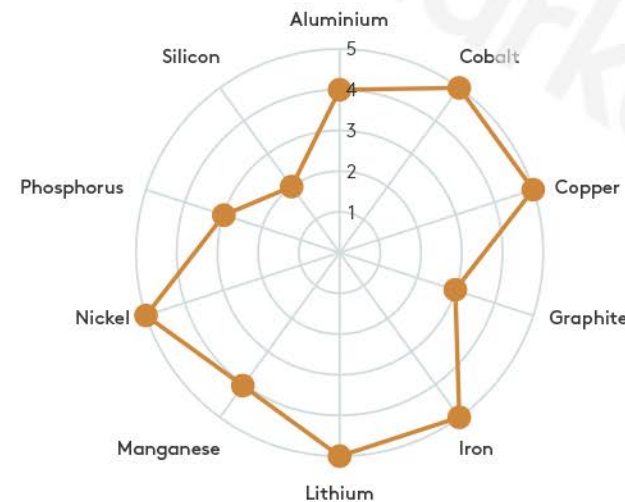
Child labour is another risk. While this is predominately tied to cobalt, which is not used in the more dominant LFP chemistries, countries noted as having a high risk of child labour accounted for approximately 24% of

Research by Infyos suggests that cell manufacturers making up over 75% of the market in 2023 have at least one link to a company exposed to forced labour.

Biodiversity loss & deforestation

77% of mineral water within a 50 kilometre radius of Key Biodiversity Areas, and the extraction of many key raw materials are concentrated in areas with high levels of biodiversity, including South America, Asia, Australia, the Democratic Republic of Congo, Central America, and Western Europe. Cobalt, Nickel, among others, is global commodities, such as the Tallahassee on Nature's critical minerals database (2023), became more prevalent among the broader community. Requirements around avoiding or mitigating impacts on nature will soon be included across the supply chain. A large number of materials critical for ESS production have negative impacts on biodiversity and conservation programmes.

Strength of various material's association with negative biodiversity and conservation impacts. Five represents highest exposure.



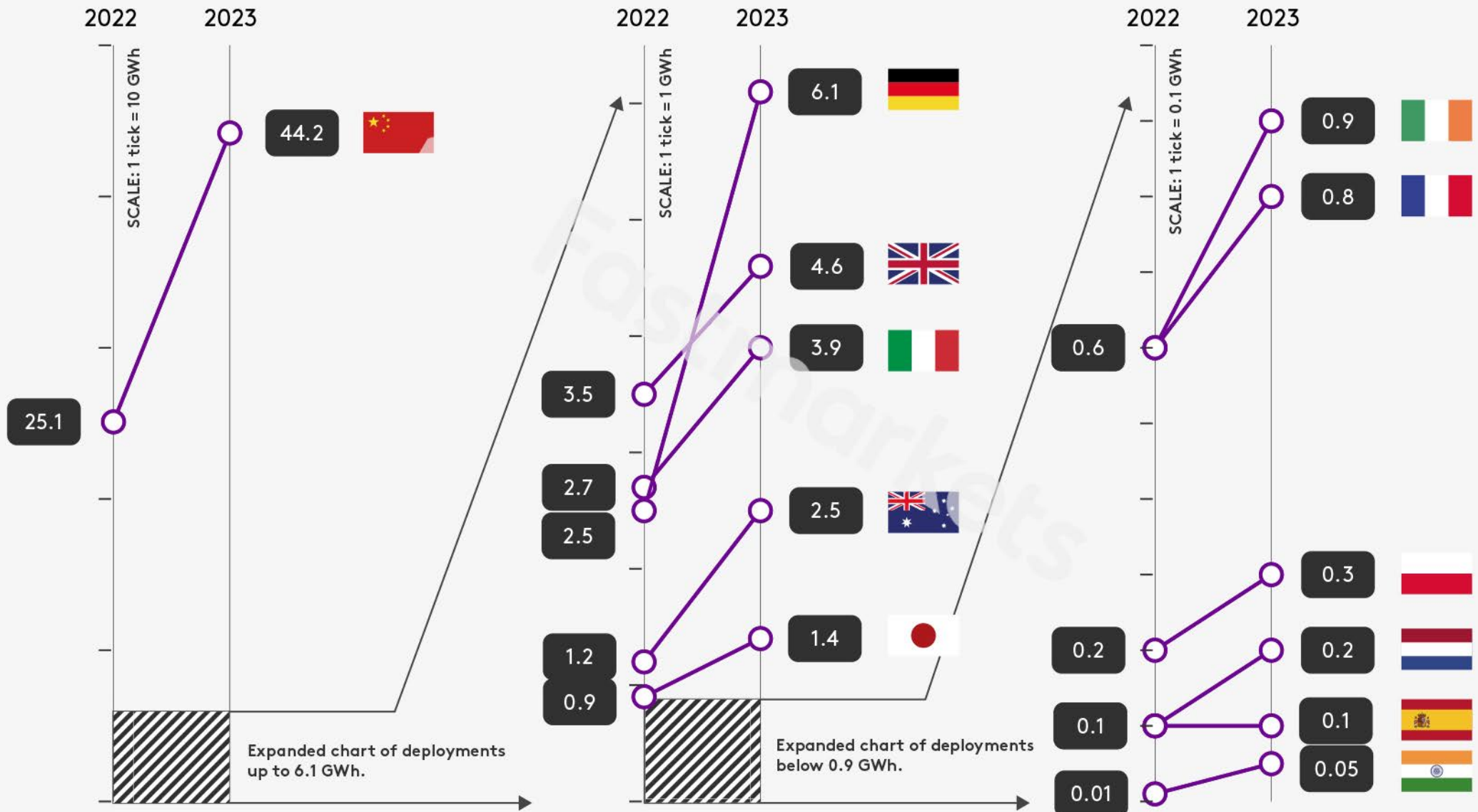
Indigenous Peoples' Rights & local communities

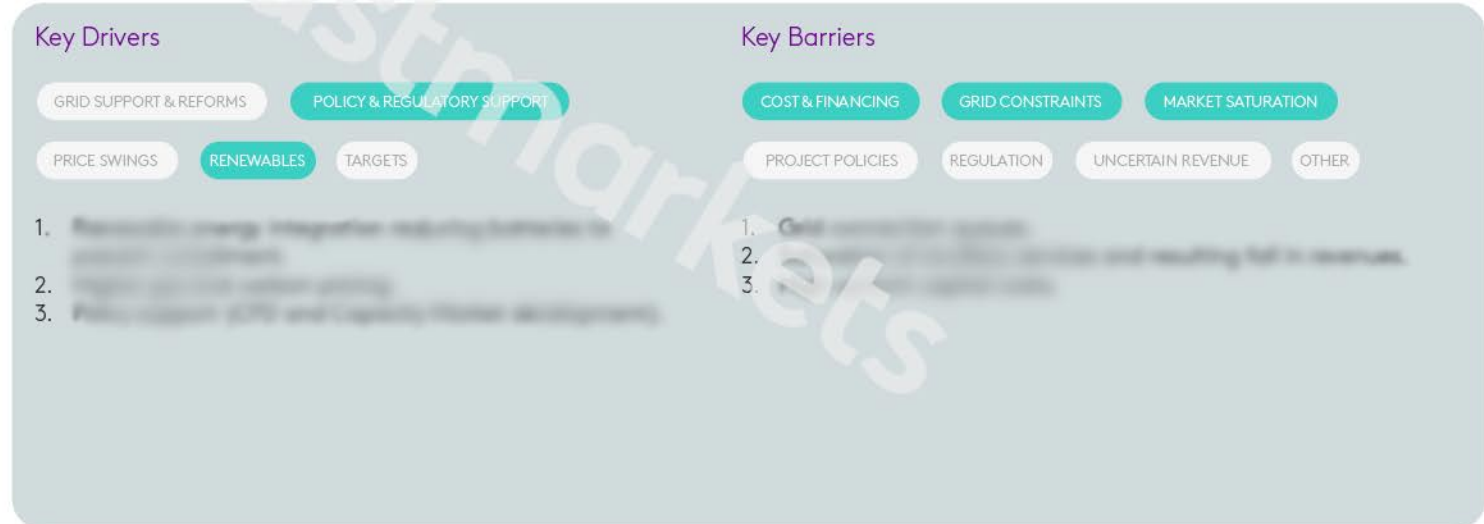
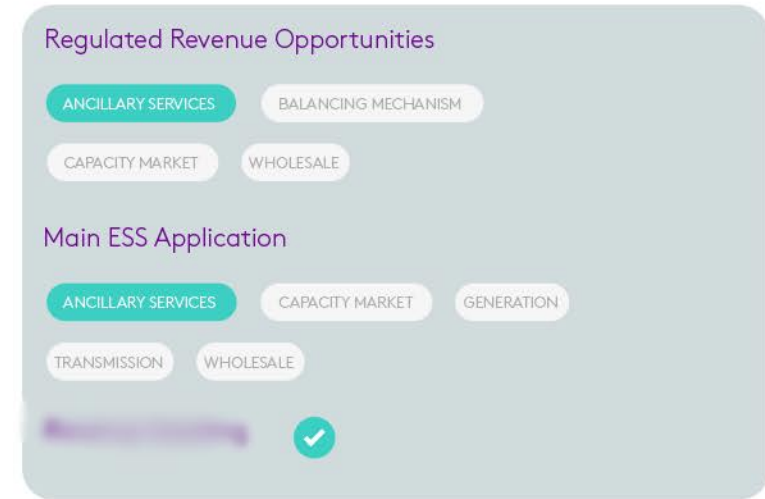
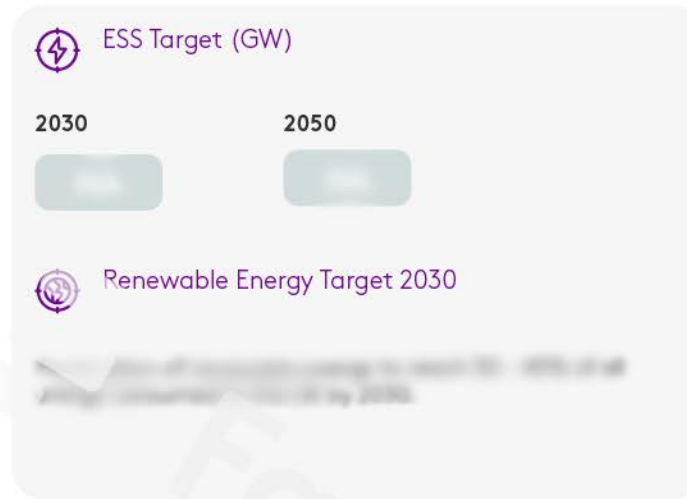
Indigenous communities have raised concerns over the impact the extraction of critical minerals may have on their rights and livelihoods, and it is estimated that 54% of energy transition metals being located on or near Indigenous Peoples' lands. This includes 80% of lithium projects and over 50% of copper and nickel projects. The Business & Human Rights Resource Centre's Transition Minerals Tracker found that 54% of allegations in 2023 impacted local communities and their environment.

As with many risks in the ESS supply chains, impacts associated with local and Indigenous communities have a high correlation with other impacts, such as water scarcity, food insecurity and conflict.

Global ESS Deployments (GWh)

A comparative overview of the change in global markets between 2022 and 2023

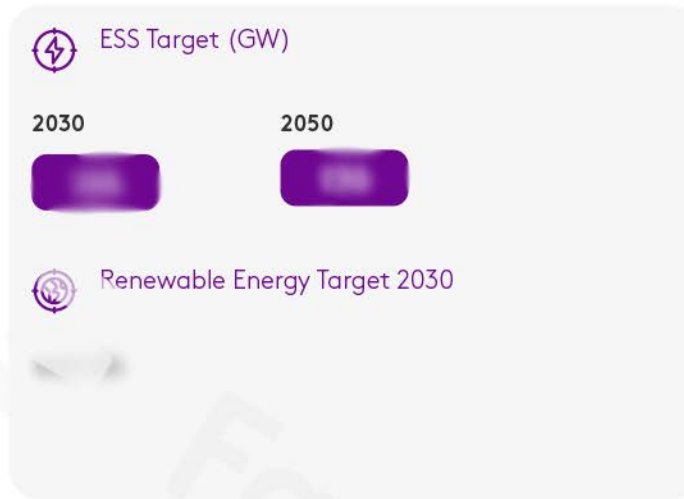




<p>Leading Developers</p> <p>Gresham House, Statera, Harmony, SMS, Zenobe.</p>	<p>Grid Operators</p> <p>National Grid.</p>	<p>Auction Operators</p> <p>Capacity Market Auctions - Department for Business, Energy and Industrial Strategy. National Grid ESO manages the technical aspects of auctions.</p>	<p>Tender Dates</p> <ul style="list-style-type: none"> 2024 - 2025 2025 - 2026
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China



Regulated Revenue Opportunities

- ANCILLARY SERVICES
- BALANCING MECHANISM
- CAPACITY MARKET
- WHOLESALE

Main ESS Application

- ANCILLARY SERVICES
- CAPACITY MARKET
- GENERATION
- TRANSMISSION
- WHOLESALE

✓

Average Duration (hours)

Category	Value
2023 installed batteries	2.1
At most recent auction	NA

2023 Average Price (¥/MWh)

Price Type	Value
Spot Price	[Value]
Day-Ahead Price	[Value]

Key Drivers

- GRID SUPPORT & REFORMS
- POLICY & REGULATORY SUPPORT
- PRICE SWINGS
- RENEWABLES
- TARGETS

Key Barriers

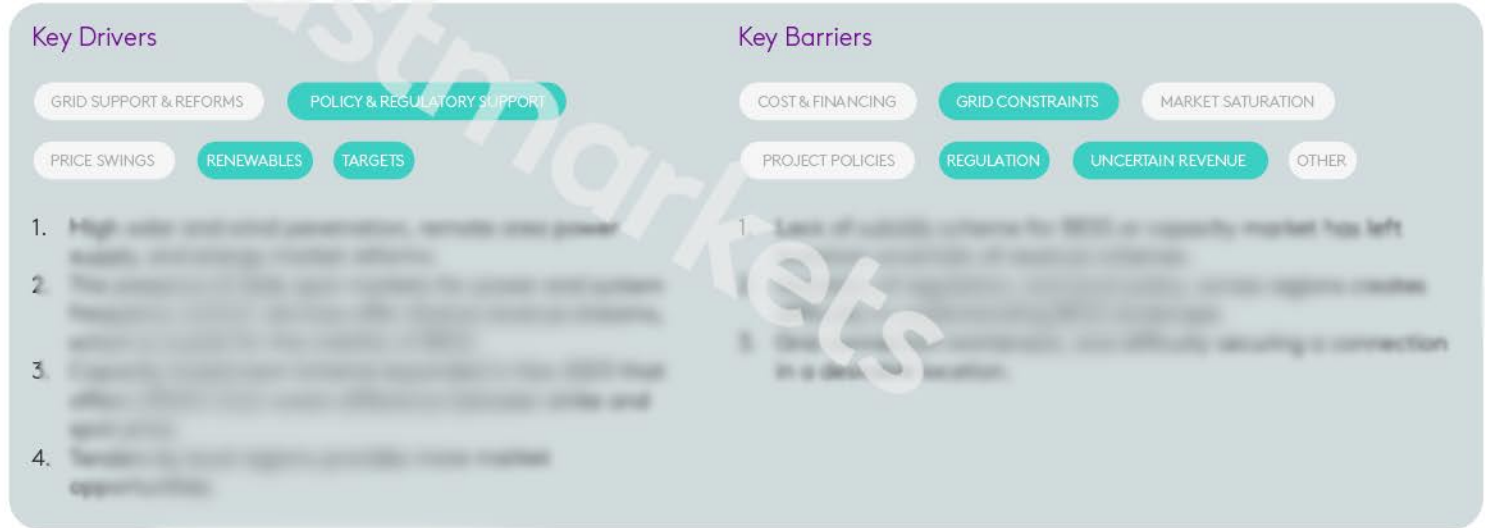
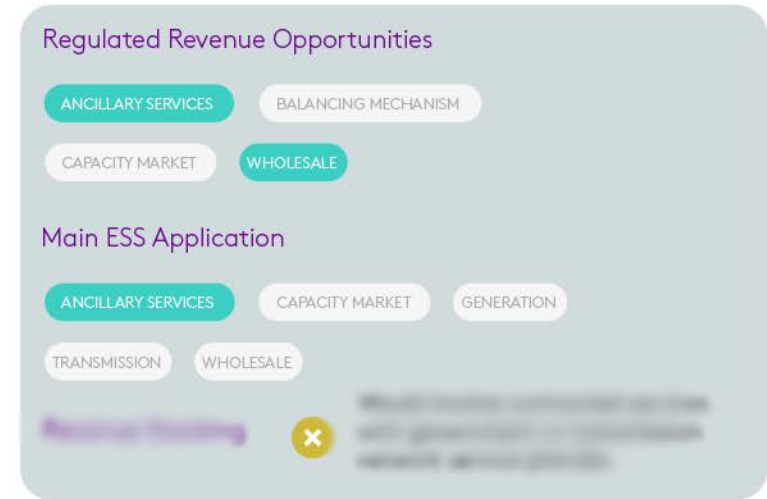
- COST & FINANCING
- GRID CONSTRAINTS
- MARKET SATURATION
- PROJECT POLICIES
- REGULATION
- UNCERTAIN REVENUE
- OTHER

1. Stringent regulatory policies requiring 100% of new renewable energy projects to be subscribed to existing, in addition to other mandates pushing grid operators to integrate storage solutions.
2. Large investments with low return barriers to current investments, low return barriers.
3. Technology innovation and cost reduction has made ESS increasingly affordable and viable for grid-scale use cases.

Leading Developers	Grid Operators	Auction Operators	Tender Dates
	3 Major: State Grid Corporation of China (SGCC) ; China Southern Power Grid ; West Inner Mongolia Power Grid.	Each province has its own respective auction operator depending on the grid design.	



Australia



Leading Developers	Grid Operators	Auction Operators	Tender Dates
	Australian Energy Market Operator (AEMO) - multiple DNSP's.	Australian Government - Capacity Investment Scheme - the expanded CIS should hold auctions at six monthly intervals until 2027.	<ul style="list-style-type: none"> 10 September 2024 10 November 2024



Authors:

Phoebe O'Hara – Energy Storage Lead
phoebe.ohara@fastmarkets.com

Yanlei Chen – Energy Storage & Cell Analysis
yanlei.chen@fastmarkets.com

Iveta Zagorova – Market Fundamentals & Policy
iveta.zagorova@fastmarkets.com

Donika Atanosova – Renewable Energy Outlook
donika.atanosova@fastmarkets.com

Christina Ilieva – Chemistry Outlook
christina.ilieva@fastmarkets.com

Muthu Krishna – Battery Cost Modelling
muthu.krishna@fastmarkets.com

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