Baker McKenzie.

Battery Storage - a global enabler of the Energy Transition

2022

Energy Transition
Transform, powerfully

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Foreword

2021 was yet another record year for renewable energy, despite continued disruption from the COVID-19 pandemic and the rising costs for raw materials around the world. Yet in the future we may well look back and see 2021 just as importantly as the beginning of the energy storage decade.

Declines in cost for wind, solar PV and energy storage technologies have profoundly impacted the rate of deployment of renewable energy in global power systems. Solar PV and onshore wind have become the cheapest sources of new generation for around two-thirds of the world's population. As the share of variable renewable sources increases compared to conventional fossil fuel generation, energy storage is becoming increasingly important to grid resilience and flexibility and the massive deployment of wind and solar generation which is planned for the next 10 years practically necessitates the mass adoption of energy storage as a balancing asset.

BloombergNEF analysts predicted in November that globally there will be USD 262 billion worth in investment in making 345GW of new energy storage by 2030. And this forecast may yet prove to be conservative, with new technologies and storage applications coming into the picture.

Primarily driven by intense research and development into Electrical Vehicles, lithium-ion batteries takes up the majority of new energy storage capacity, both installed and under construction, with older battery technologies being replaced or retained only for smaller projects. Yet as battery costs continue to reduce, battery energy storage has already become cost effective new-build technology for "peaking" services, particularly in natural gas-importing areas or regions where new-build gas generation is no longer being pursued (such as California).

The development of the global energy storage sector has many similarities with earlier years of the renewable energy sector. With costs declining, private investors are entering the market and bringing new business models to commercialise the technologies. Governments of countries with a high share of renewable energy, or looking to facilitate development of the same, have seen the need to support energy storage from policy and regulation perspectives, even if the efforts in some countries are still nascent. Using the renewable energy sector as a guide, over the next few years the energy storage market will accelerate with the continued scaling up of manufacturing processes, technology innovation and the maturing of business models.

Yet there are differences as well. Energy storage competes with demand-side response, since they both provide flexibility services to the grid. Despite the current ascendancy of lithium-ion technology, the battle over core technologies is also still being waged, with emerging technologies (such as flow batteries and renewable-hydrogen) poised to potentially disrupt the business case for new projects.

Within this exciting context, I am very pleased to present this report which considers key opportunities and challenges for the energy storage sector both from a global perspective and from the perspective of several key jurisdictions, yet again highlighting the depth and breadth of our expertise in the renewable energy sector.

The transition to a carbon-neutral economy is a seismic shift on a global scale, leaving no sector untouched. The urgent strategic, operational and reputational challenges are considerable, but so are the opportunities for growth.

Our multi-disciplinary global team helps energy producers, investors and users forge their energy transition journey in an increasingly complex regulatory environment enabling them to ***transform, powerfully***.

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Why energy storage?

The growth and expansion of renewable generation globally has been one of the energy sector's greatest successes over the last decade. However, with this success comes the challenge of maintaining efficient and effective power grids by properly integrating variable renewable energy sources, such as solar and wind. As the penetration of renewable energy increases, maintaining grid reliability becomes ever more challenging and costly.

Meeting rising flexibility needs while decarbonizing electricity generation is a central challenge for the entire sector and all sources of flexibility need to be utilized. While the use of energy storage in national networks is not new, energy storage, and in particular battery storage, has emerged in recent years as a key piece in this puzzle.

This report discusses the energy storage sector, with a focus on grid-scale battery storage projects and the status of energy storage in a number of key countries.

02 Energy storage applications

Energy storage projects generally have a more complicated part to play in energy grids than renewable energy generation. Storage systems can fulfil different roles and storage technologies need to be understood in the context of the applications and services they provide. These range, for example, from short-term balancing of supply and demand, to restoring grid operation following a blackout, to providing operating reserves or deferring investment in new transmission and distribution lines.

Several applications that energy storage can fulfil can also be performed by alternative measures and/or infrastructure, such as demand response, power plant retrofits, smart-grid measures that enhance power networks and other technologies that improve grid flexibility. The advantages and disadvantages of these other measures compared to energy storage need to be considered in the context of the particular energy market. For example, in coming years, natural gas fuelled power stations with carbon capture and storage can act as "peakers", generating power quickly to ensure capacity is sufficient to meet system demand while still limiting emissions. For gas-importing regions (i.e. much of Asia) or those without much gas generation, energy storage may provide that application more cost effectively. This is exactly the scenario that California faces in coming years, with its grid estimated to need 12GW of storage for balancing after solar PV power generation replaces 9GW of retired gas generation[1].

There have been various attempts to categorize energy storage applications for stationary storage systems.

STATIONARY STORAGE APPLICATION DESCRIPTIONS[2]

Sector	Application	Description
Grid-related – utility	Peaking capacity	Provision of capacity to meet system maximum demand
	Energy shifting	Uptake is driven by increasing system flexibility needs. Storage is charged during low prices and surplus supply and discharged to meet demand. Batteries can be charged from surplus renewable energy or from assets that, along with battery, become dispatchable
	Ancillary services	Provision or absorption of short bursts of power to maintain supply and demand and thus the frequency of the grid; frequency regulation and reserves (this is sometimes split between balancing services and other ancillary and grid management services)
	Transmission-level	Use of an energy storage system as an alternative to traditional network reinforcement, such as to meet an incremental increase in transmission capacity instead of an expensive transmission line upgrade
	Distribution-level	Use of an energy storage system as an alternative to traditional network reinforcement such as to meet an incremental increase in distribution capacity instead of an expensive distribution line upgrade
Grid-related -residential	Residential energy storage	Energy storage that is used to increase the rate of self-consumption of a PV system from a residential customer
Grid-related – C&I	C&I energy storage	Energy storage that is used to increase the rate of self-consumption of a PV system from a commercial or industrial customer
Grid-related – utility/ residential and C&I	EV charging infrastructure	Energy storage that is used as an energy source for EV charging infrastructure, including in combination with an on-site PV system
Long-duration energy storage		Energy storage that can fulfil most of the above applications over longer periods of time

1 US Department of Energy: Energy Storage Grand Challenge Market Report 2000

2 US Department of Energy: Energy Storage Grand Challenge Market Report 2000

02

This table excludes industrial uses such as use of batteries for uninterruptible power and data centers, telecom backup power and use of battery systems on forklifts. The deployment of storage for such industrial uses currently exceeds grid related applications, but that is quickly reversing.

Of these potential applications, some are more likely to be and become in demand more than others. BNEF has forecast that 55% of energy storage projects built by 2030 will predominantly be performing energy shifting (i.e. by storing solar or wind power to discharge later).[3]

Other applications, such as distribution-level and transmission-level, are less likely to be available for a particular project as the demand for these kind of services relies substantially on a permissive regulatory scheme and incentives. For a network owner to wish to utilize these types of services it needs both the ability and reason to do so as opposed to relying on traditional infrastructure investment.

This report focuses on grid-scale front-of-the-meter (FTM) storage projects. However, the behind-the-meter (BTM) market is also one with important potential for the energy storage sector, particularly as corporates seek to reduce their own emissions to achieve their sustainability goals. BTM installations includes customer-sited stationary storage systems for commercial, residential and industrial self-use of stored energy. BNEF expects these BTM installations to make up about one quarter of global storage capacity by 2030.[4] There is direct cross-over with storage in the transportation sector here, especially with EV batteries becoming increasingly viable as a source of energy storage for home uses as well as powering EVs themselves.

Energy storage is also being considered more and more for incorporation into distributed generation networks or "mini-grids" (or "micro-grids"). While mini-grids have tended to be associated with developing nations with smaller networks and limited renewable generation, energy storage is increasingly being trialed in developed countries such as the UK and Japan for discrete or remote areas (in the case of Japan, small islands) with renewable generation powering a mini-grid with storage at its heart.[5]

"HYBRID" RENEWABLES PLUS STORAGE PROJECTS

So-called "hybrid" co-located, renewable generation plus storage projects are becoming increasingly common, particularly in the US due to its particular market features and incentives (**see US section**). This is due in part to steadily falling costs.

In addition to generation, hybrid projects facilitate energy shifting applications with rising renewable capacity and changing energy consumption patterns creating opportunities for price arbitrage, allowing developers to shift dispatch to times of higher prices. In addition to improving grid flexibility, this can unlock greater value for hybrid project developers as higher volumes of zero marginal cost renewables are connected to the grid, allowing developers some mitigation of periods of zero of negative prices, depending on the market.

Hybrid projects also become more attractive economically as developers gain access to the power balancing market and are able to provide grid services. In some markets, hybrid projects can currently provide peaking applications even more cheaply than natural gas generation.

While integrating the energy storage system with the rest of the plant adds an additional technical challenge during commissioning, this can also add cost savings and other technical benefits, such as increasing utilization of the transformer (which can reduce system cost) and a higher capacity factor.

"BNEF has forecast that 55% of energy storage projects built by 2030 will predominantly be performing energy shifting (i.e. by storing solar or wind power to discharge later)."

"Hybrid projects also become more attractive economically as developers gain access to the power balancing market and are able to provide grid services."

3 https://about.bnef.com/blog/global-energy-storage-market-set-to-hit-one-terawatt-hour-by-2030/
4 https://about.bnef.com/blog/global-energy-storage-market-set-to-hit-one-terawatt-hour-by-2030/
5 https://www.energy-storage.news/japanese-island-will-reduce-power-sector-emissions-to-virtually-zero-with-renewable-microgrid/

03 Energy storage technologies

CURRENT TECHNOLOGIES

The main parameters for evaluating current and alternative energy storage technologies are: (i) technical and economic feasibility; (ii) locational constraints and (iii) system size.

Stationary energy storage has been in use for decades, with the first pumped storage projects implemented in the early 1900s. More recently, other technologies have advanced rapidly along with the use of portable consumer electronics, electrification of the transport sector (in large part due to the increased popularity of EVs and the growth and increasing penetration of renewable generation).

Legacy energy storage is dominated by pumped-hydro storage (PHS), one of the most conventional storage solutions and the oldest, but its potential is limited by suitable hydropower and the availability of sites, as well as political issues and other challenges. The hydropower market in Europe, for example, is nearly built out. While several countries, including the US and China, are still exploring avenues for PHS growth, the capability of most countries to substantially increase PHS capacity relative to current and future needs is limited and the share of global PHS capacity to total global energy storage is in steady decline.

In contrast, the great majority of new energy storage projects use battery storage, a market being driven by rapidly evolving battery technology, a steady decline in the cost of batteries and the reduction in the cost of renewable generation itself. As at 2021, almost all new battery storage used lithium-ion battery technology, with lithium-ion systems comprising over 90% of stationary battery capacity[6]. Of the balance, the majority is made up of sodium-sulfur (NaS) batteries, a technology that is generally considered to be inferior to lithium-ion and with more safety concerns, and lead-acid batteries.

The latter deserves some note. While, lead-acid technology is older than lithium-ion, it is in use as part of storage for data centers and is still being used in the transport sector. However, in stationary storage projects it is generally being gradually replaced with lithium-ion (which is cheaper and has a longer life cycle) or is only being used in smaller storage installations.

Lithium-ion deployment is of course primarily driven by intense research and development in EVs, making this technology the easiest and fastest to deploy. Lithium-ion and its derivatives are winning out based on price competitiveness, an established supply chain (dominated by Asia and China in particular) and as at 2021, a significant track record.

Interestingly though, while it is the increasing deployment of lithium-ion in the automotive sector that has facilitated the cost competiveness of similar batteries in the relatively smaller stationary energy storage market, these batteries are not optimized for storage applications in all respects. For instance, the lithium-ion batteries developed in use for EVs have high power density and output, making them lighter and very well suited to energy storage for the transport sector. These characteristics are of course helpful for stationary applications, such as those used to provide “peaking” services where electricity needs to be capable of being discharged from the batteries almost instantaneously, but high energy density is less important for stationary applications where space and weight aren’t as restricted.

Stationary applications, depending on their application, may also have different priorities in terms of durability (of both the batteries and related infrastructure such as inverters), discharge rates, life cycle, temperature stability and safety, among others.

Accordingly, while the continued evolution of lithium-ion technologies in the automotive space works to advance energy storage in terms of innovations and cost reductions, the different priorities of energy storage applications are leading to increasing divergence in the technologies used for the two markets. This is not necessarily a negative factor for the storage market. As the ideal battery technology for EVs sees increasing use amongst automotive battery supply chains, technology that is less suitable for EVs may be deployed in storage for reduced cost. However, it is important for storage developers to keep this growing divergence in mind, particularly in the medium-to-long-terms.

A good example of the divergence in lithium-ion technologies is the growing use of lithium-iron phosphate (LFP) chemistry in grid-scale storage, particularly in China, over nickel-manganese-cobalt (NMC) chemistries predominantly used in EV supply chains [7]. LFP chemistries see less use overall (counting EVs), but in 2021 became the most common choice for grid-scale stationary applications for the first time. LFP chemistries offers several advantages for stationary storage, having higher durability (in turn reducing maintenance costs) and reducing some safety concerns. In turn, LFP chemistries have lower energy density than NMC, a disadvantage for use in EVs.

LFP chemistry deployment in storage is expected to increase over the next decade, again due to increasing use by Chinese storage developers, with costs expected to continue to fall.

Another very important consideration for lithium-ion batteries is that their performance is better for short-duration storage, that is where the storage duration is less than eight hours before discharge. This does not present substantial issues for most storage projects in the short or medium-terms as the average grid-scale storage project currently aims for around four hour storage. However, in the long-term, and particularly after 2030, rising penetration of renewable energy will require not just increasing amounts of energy storage but long-duration storage (i.e. eight hours or more), depending on the country and the characteristics of its energy market.

The rush to develop cost-competitive, long-duration storage to use in place of lithium-ion batteries has already well and truly commenced, particularly in locations such as California where the expected future need for long-duration storage is great.

6 REN21: Renewables 2021 Global Status Report
7 Lithium-ion are often categorised by the chemistry of their cathodes: IEA: The Role Of Critical Minerals in Clean Energy Transitions 2021

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ALTERNATIVE TECHNOLOGIES

Lithium-ion batteries in their various chemistries are expected by most commentators to dominate the storage market over the next decade to 2030.[8] While research continues on alternative lithium-ion chemistries and using silicon-based anodes, some commentators do not see truly significant improvements over more or less conventional lithium-ion technology in terms of cost reductions and improvements in energy density until the advent of lithium-metal anode all solid-state batteries (ASSBs). However, these are generally considered to be some years away from being commercially available and, from that point, the technology would require a considerable build-up of manufacturing capacity before it could be deployed at scale.

It's also worthwhile, given the incredible rate of evolution in battery technologies to date, to consider the most likely potential alternatives to lithium-ion.

Flow-batteries (also referred to as redox flow batteries or RFBs) are aqueous-based batteries that use tanks of liquid electrolyte. The electrolyte is run through electrodes to charge and then run in reverse to discharge, hence "flow". Large flow-battery storage projects operate or are being developed in China and Japan and are in the planning stage elsewhere.

The technology is relatively new and has advantages. It is easily scalable, and has a long life cycle and effectively unlimited capacity. However, flow-batteries have lower energy density than lithium-ion and are not currently cost competitive (although that could change given that large-scale flow-battery projects have only been in operation for a few years). Commentators have suggested that the emergence of iron-based chemistries to solve some of the cost issues of flow-batteries could improve their economic feasibility sufficiently to compete with lithium-ion for just under half of the stationary storage market by 2030.[9]

Vanadium, a transition metal, is currently the preferred electrolyte for flow-batteries due to its stability, although the metal faces supply issues which, may in turn, affect cost. The largest vanadium-based storage project, a 200MW installation in Dalian, China is due to be commissioned in late 2021. However, several countries have announced recent investments in vanadium production in order to facilitate flow-battery storage projects, including Australia and the US.[10] Vanadium flow-batteries are also being trialed in South Korea and Australia to support EV charging systems.

Aside from batteries, there are also many other potential energy storage technologies such as the previously mentioned PHS, compressed-air energy storage (CAES), hydrogen, flywheel and thermal energy storage, all being further refined and developed. Again, these technologies all have various advantages and disadvantages. Several can dispatch for longer compared to batteries, supplying more energy during prolonged periods of low renewable energy.

CAES, which stores energy as compressed air and is generally deployed in large underground caverns, may be the technology closest to cost competiveness, with batteries with projects in operation in the US and China providing peaking and energy shifting applications.

Hydrogen technology is often considered to have the highest long-term potential, with enormous flexibility of use in both the energy storage and transportation sectors and much lower dependence on critical metals. Many countries have targeted hydrogen as a key part of their carbon-reduction goals, and recent changes in several of these have provided a much more favourable policy context for further research and development. However, while producing renewable hydrogen via renewable energy-driven water electrolysis is gaining traction globally, it still represents a small fraction of total global hydrogen production and is some way from being cost competitive. Research and development into hydrogen storage for use as energy storage is also at relatively early stages. Gaseous hydrogen storage is achievable with current technology but is dependent on locating appropriate sites, such as large salt caverns or depleted gas fields. Accordingly, while large-scale hydrogen storage projects do exist in the US, UK and elsewhere, and there is further capacity planned in US and Europe (particularly Germany), there is currently limited potential for commercial deployment.

LONG-DURATION TECHNOLOGIES

A further key issue is the suitability of the various technologies for the long-duration storage (more than eight hours of storage) that national grids will require in coming years. As renewable content on the grid increases, the duration of storage needed to provide reliability also increases. For very high (i.e. more than 80%) renewable penetration, storage durations as long as over 120 hours (sometimes called "seasonal storage") will be needed.[11]

While lithium-ion batteries are, at present, generally the most economical solution for short-duration storage, that technology is not optimized for lifecycle or durability and lithium-ion systems do not scale as effectively for long-duration storage. Longer or more frequent dispatch of lithium-ion battery systems accelerates degradation, eventually requiring replacement or upgrade of the battery components, and tends to shorten maintenance cycles for shared components such as inverters (another key maintenance cost).

Several technologies are currently available or in development to address the need for long-duration storage. These include PHS, flow-batteries, chemical (including hydrogen) and thermal storage, gravity-based approaches and electrochemical couples.

Flow-batteries can provide long-duration storage but as above have cost issues, including, at least historically, the high and volatile cost of vanadium. Other chemistries using earth-abundant materials may end up being more cost-competitive. For example, iron based flow-batteries have been tested at the small-scale and are now being scaled up.

At present, hydrogen for energy storage typically requires appropriate cavern storage to be economical, which obviously limits locations. Hydrogen systems with the right site conditions can even provide seasonal storage and projects with geological storage and natural gas (combined with carbon capture and storage) are viewed by many commentators as a key technology for the future.

Electrochemical couples include a number of unconventional battery systems. These include "aqueous air" batteries, the product of a US start-up that has promised 150 hours of storage at a competitive cost although few details about the technology have been made public.[12] The technology has already received a utility contract from Minnesota-based utility Great River Energy to provide a 1MW/150MWh grid-connected system that would allow storage and discharge even through extreme weather events such as a polar vortex or heat wave. If this pilot is successful (the project is due to be commissioned in 2023/2024), and the technology could be scaled, it could open up all new business models around low utilization but low capital cost.

Hydrostar, a Canadian company that claims a proprietary "advanced" CAES, has applied for licenses in California for a 500MW/4GWh project in Kern County and a 400MW/3.2GWh project in San Luis Obispo County.[13]

Other companies have also made bold announcements about building cheap MW-scale long-duration storage but these remain to be demonstrated.

8 https://about.bnef.com/blog/global-energy-storage-market-set-to-hit-one-terawatt-hour-by-2030/
9 US Department of Energy: Energy Storage Grand Challenge Market Report 2020
10 https://www.energy-storage.news/australias-aspiring-upstream-vanadium-flow-battery-players-take-steps-forward/
11 US Department of Energy: Energy Storage Grand Challenge Market Report 2020
12 https://www.pv-magazine.com/2020/05/08/form-energy-claims-its-aqueous-air-battery-provides-150-hour-duration-storage/
13 https://www.energy-storage.news/hydrostor-applies-for-license-for-4gwh-california-compressed-air-storage-project/

04 The global energy storage market

PERFORMANCE AND FORECASTS

2021 was a strong year for global energy storage with reports from November showing 12.4GW of new capacity, an over 150% increase from 2020 which saw supply chain disruptions and travel restrictions arising from COVID-19. Utility-scale FTM installations accounted for around two-thirds added capacity.

While significant, this investment is just the early stages of the ramp up in capacity that is critical to meet flexibility needs in a decarbonized electricity system. Wood Mackenzie estimates that 346.2GW/964GWh of new energy storage capacity[14] will be added globally between 2021 and 2030, with well over half of that capacity in the US and China (see Figure 1). That is more than 20 times the 17GW in operation at the end of 2020. Supportive government policy, ambitious climate commitments and the growing need for grid flexibility are the common drivers.

Importantly, the 2030 estimate itself falls well short of the 585GW needed to align with the IEA's Net Zero Emissions by 2050 Scenario, 585GW of energy storage is estimated to be required to address the variability of renewables, especially as their share of generation increases in that Scenario.[15]

LITHIUM-ION BATTERY MANUFACTURING

With lithium-ion batteries as the dominant storage technology for new projects, countries with a strong localized battery supply chain have a competitive advantage in terms of developing new storage projects.

Lithium-ion battery costs have fallen sharply in recent years, with prices dipping below USD 100 per kWh for the first time in 2020 with a market average of USD 137 per kWh[16] (see Figure 2). The average price for lithium-ion batteries in the US is expected to drop below USD 100 per kWh by 2023 as larger factories reduce manufacturing costs. By way of comparison, battery costs in 2013, just 10 years earlier, were pegged at USD 680 per kwH.

Global manufacturing capacity of lithium-ion batteries has expanded from 14GWh in 2010 to 457GWh in 2020.[17] Asia Pacific accounted for 81% of global capacity in 2020 (with an immense 73% of global capacity manufactured in China). Chinese manufacturers are also leading on the generally more favourable LFP chemistries for energy storage, providing further advantages.

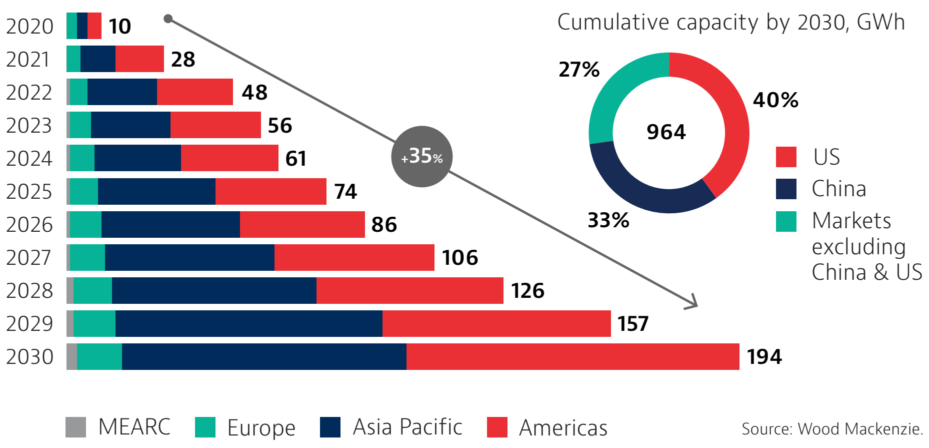
The largest manufacturers of lithium-ion batteries outside China are in South Korea, Japan and the US.

Global lithium-ion battery manufacturing capacity is expected to double in the next two years and exceed 2,000GWh in 2028[18] with Chinese capacity remaining dominant, if less than the share it currently enjoys.

Part of this expansion will be in the US as manufacturers strive to supply growing local demand for both EVs and storage. The US does face a number of well-publicized supply chain challenges, including obtaining sufficient battery metals to leverage increased capacity.

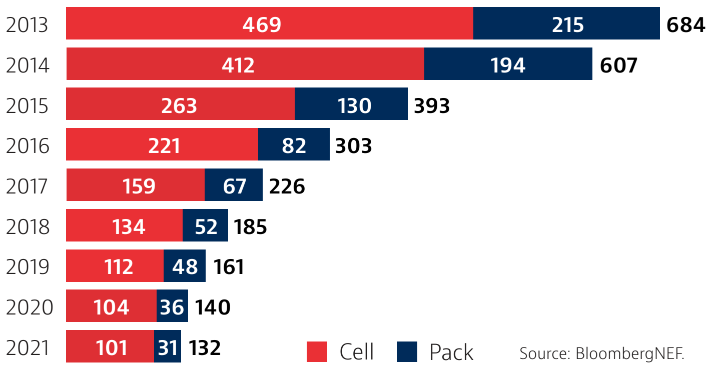
The EU is also seeking to strengthen its own fairly weak local supply chain (at least relative to Asia and the US) with new legislation and government-backed financing assistance (see European Union section) after several years of growing internal concern that the region has fallen behind in this area. Several gigafactories, which are plants capable of producing over one million EVs, are in various stages of development.

FIGURE 1 - GLOBAL ENERGY STORAGE ANNUAL CAPACITY GWH



Source: Wood Mackenzie.

FIGURE 2 - AVERAGE LITHIUM-ION BATTERY COST USD (2021)



Source: BloombergNEF.

14 Stationary storage excluding PHS: Wood Mckenzie: Global Energy Storage Outlook H2 2021
15 IEA: Energy Storage Tracker Report November 2021
16 REN21: Renewables 2021 Global Status Report
17 Wood Mckenzie: Global Energy Storage Outlook H2 2021
18 https://www.statista.com/statistics/1247625/global-production-capacity-of-lithium-ion-battery-factories/

05 Impact on demand for critical metals

The future evolution of battery and other storage technologies will have a significant impact on mining and metals, if less significant than the impact of technology changes in the larger EV market.

The longer lithium-ion batteries remain as the technology of choice for energy storage, the greater the segment of the overall lithium-ion battery market (including for EVs) that storage will take up. However, even changes in the immediate-term are having an impact. For example, the growing trend toward using LFP chemistries over NMC chemistries for grid-scale projects (as well as the trend toward such larger projects) impacts demand for nickel and cobalt as LFP chemistries require less of these. If, on the other hand, demand for batteries for use in homes increases over expectations, as some commentators predict, demand for all battery metals will increase, as these use NMC chemistries.

Demand for battery metals is likely to shift depending on **whether**, and if so, **when**, other technologies end up supplementing or replacing lithium-ion batteries, the current leading technology. As above, **whether** is more likely for long-duration storage applications, as it seems likely that the storage market will eventually diversify away from lithium-ion toward more suitable technologies, especially as research and development on alternative long-term storage options accelerates.

> "...the growing trend toward utilizing LFP chemistries over NMC chemistries for grid-scale projects (as well as the trend toward such larger projects) impacts on demand for nickel and cobalt."

If flow-batteries (see above) achieve cost-competitiveness and begin to displace lithium-ion batteries for use in storage, demand for vanadium is likely to increase at the expense of battery metals used in lithium-ion (i.e. cobalt, nickel and manganese).

Overall, **how** storage technology evolves in the future, along with the intensity of efforts (by governments and corporations) to accelerate the energy transition, will result in a wide range of mineral demand. Demand for cobalt was referred to above in a single context. Commentators have suggested that cobalt, and graphite used in the battery anode, may see a potential range of six times all the way up to 30 times higher demand in 2040 compared to 2021, depending on the actual direction of battery chemistry evolution in that period.[19]

Of course uncertainty around the future can hamper mining companies' investment decisions, in turn causing demand and supply imbalances in the future, affecting storage markets. The other side of the demand and supply equation (i.e. consumption) is also changing as a result of the pressures to secure supply in two relatively new ways.

Firstly, the consumers of these battery metals, consumer product and energy production equipment manufacturers, are no longer content to secure supply through traditional, middle person models. In addition to economic risks of arm's length supply arrangements, in a lot of countries, while these minerals may be considered critical, they are not entirely domestic and many are imported from places which carry political risks. For example, as discussed above, many lithium-ion batteries use cobalt in their cathode. Despite being so widely used, over 90% of cobalt is produced as a by-product of extracting other resources, making its production dependent on factors besides the demand for batteries. As well, over 65% of global production of cobalt is concentrated in the Democratic Republic of the Congo, a country in which the United Nations still maintains a peacekeeping presence.[20] China also has invested into a very significant proportion of global cobalt mining, granting them a strong competitive advantage in the battery supply chain. One solution is for companies to secure offtake agreements or acquire direct interests in producing mines. These arrangements improve confidence regarding a secure supply. For example, Tesla has agreed with Piedmont Lithium that the company will supply about one-third of its planned production of spodumene concentrate (160ktpa) over an initial five-year term.[21]

> "If flow-batteries achieve cost competitiveness and begin to displace lithium-ion batteries for use in storage, demand for vanadium is likely to increase at the expense of battery metals used in lithium-ion (i.e. cobalt, nickel, manganese)."

Secondly, to address increasing pressure to be aware of and influence ESG considerations in production, battery mineral consumers are working together with mining companies to not only more effectively reduce emissions along the value chain, but also to lessen their environmental impact and protect workers' human rights. This is much easier to do when companies have a direct line of sight to production and can use blockchain technology to confirm responsible sourcing. For example, IBM, Ford and Volkswagen Group have launched the Responsible Sourcing Blockchain Network,[22] which is scaling the ethical sourcing of minerals.

Some commentators predict that research and development into hydrogen technology will produce cost-competitive electrolysers sometime between 2030 and 2050. The EU in particular appears to pin much of its hopes of building up adequate long-term storage on developing economical hydrogen applications (**see European Union section**).

19 IEA: The Role Of Critical Minerals in Clean Energy Transitions 2021
20 McKinsey & Company: Lithium and cobalt: A tale of two commodities: https://www.mckinsey.com/industries/metals-and-mining/our-insights/lithium-and-cobalt-a-tale-of-two-commodities
21 "Tesla taps into Piedmont lithium supply," Australian Mining, 29 September 2020 https://www.australianmining.com.au/news/tesla-signs-lithium-sales-agreement-with-piedmont/
22 "Volvo Cars Joins Responsible Sourcing Blockchain Network, Launched by IBM, Ford, and Volkswagen Group; Advancing Ethical Sourcing of Minerals Continues to Scale With This Network," IBM News Room, 6 November 2019, https://newsroom.ibm.com/2019-11-06-Volvo-Cars-Joins-Responsible-Sourcing-Blockchain-Network-Launched-by-IBM-Ford-and-Volkswagen-Group-Advancing-Ethical-Sourcing-of-Minerals-Continues-to-Scale-With-This-Network

06 Barriers and challenges

REGULATION AND ITS IMPACT ON BUSINESS CASE

While rapidly increasing in size and geographic spread, energy storage remains a global market in its developing stages and regulatory impacts rest hand-in-hand with the business case. This can be complex for energy storage given all of its applications and it is generally not going to be viable for legacy market and regulatory conditions which may permit renewable generation but do not yet allow energy storage to participate in the wholesale electricity market.

While almost all countries with growing renewable penetration in their energy mix have acknowledged the need to accommodate energy storage, each is progressing regulatory reform in varying degrees and at different speeds. As a further complication, the role of energy storage in local energy markets remains a contentious issue in many countries, especially in terms of who should be permitted to own storage assets.

In looking at changes to energy policy and regulatory reform to accommodate energy storage (focusing on FTM installations), we can roughly divide changes into **three** categories:(i) basic reforms sufficient to enable private energy storage developers to reasonably enter the local energy market as a level playing field; (ii) incentives encouraging the development and growth of the energy storage market by potentially strengthening the business case, and (iii) direct subsidization and support (whether through research grants, targeted mandates, tax benefits, etc.).

A country enacting category (i) measures is essentially allowing storage developers to compete in the market but leaving developers to establish the business case off the back of market mechanisms and exposure to market risks. Most investors are generally only going to respond to the need for storage, particularly large-scale storage, if they are able to build a strong business case. category (ii) and (iii) measures may, to a varying extent depending on the local market, be expected to improve the position of developers as well as increase the security of investors.

To date, most governments who have initiated substantial reforms have focused on category (i) and limited actions in categories (ii) and (iii), with China and the US generally providing the most attractive framework for storage developers (noting that with the US much of the category (iii) assistance has come at the state level). Unsurprisingly, this has helped these countries develop the largest energy storage markets, and both are poised for further rapid growth. The EU has largely created a framework to enable member states to enact category (i) measures, which some have progressed and others are considering, with some exceptions (**see European Union section**). It has also adopted various targeted measures to boost regional battery manufacturing capacity, which boosts energy storage indirectly.

Category (i) reforms include the following:

- Reform of wholesale electricity market design to allow energy storage projects (and potentially other installations providing demand-side response) to participate and earn revenue without discrimination and regardless of technology. This includes removing barriers to entry and participation.

  This is a simple statement of a complex goal. Of course, there are varying levels of participation in the market. Some countries have allowed access to the market but not yet capacity mechanisms, while others (i.e. the UK) have allowed energy storage to participate directly in capacity markets. In some countries participation in the capacity market is legally possible but effective participation and impact on profitability is limited. Developers will generally wish to be able to earn revenue under clear remuneration mechanisms from providing grid flexibility and other ancillary services as a minimum. It is also important that reforms are clear as uncertainty increases risk and therefore the expectations of investors.
- Ensuring what is an energy storage project is defined and treated separately to generation assets.

  This is important (i) to clarify the services that power generators can provide versus the services that storage owners can provide, avoiding competition; and (ii) in terms of restrictions on energy storage ownership. In many markets, storage is considered a generation asset, and system operators are prohibited from owning generation assets. This can block off transmission and distribution deferral, an important application for storage, although, in some countries, network operators are procuring the services of storage rather than physically owning them.
- Eliminating regulations that require energy storage owners to pay grid fees or tariffs twice.

  Legacy regulations in many countries require energy storage owners to pay fees to both draw power from the grid as well as inject power into it. Double-charging fees is against the concept of a level playing field. A similar barrier to energy storage can apply in relation to taxation in many countries if a storage owner drawing energy for storage is considered to be an energy consumer for taxation purposes.

Category (ii) reforms include the following:

- Measures that facilitate long-term contracts between energy storage owners and parties responsible for balancing or system operators to increase revenue certainty.

  When relying on market mechanisms without direct support or revenue certainty it can be difficult for developers to establish a base case. A common feature even of countries that have made category (i) reforms and allowed energy storage to compete in the market is that contracts are relatively short-term, which is generally one to five years depending on the application and country.

  In addition, the procurement of ancillary services, particularly services not related to balancing, is often not market-based.
- Measures that incentivize storage owners to invest in and develop energy storage systems.

  Even with network owners permitted to own energy storage systems, they need sufficient reasons to do so. Legacy market structures generally do not reward network owners for investing in such assets and/or reducing capex.
- Ensure the market and regulations place adequate value on grid flexibility and contributions to system adequacy and decarbonisation in order to provide signals for investment.

  Again, this is a complex issue. There is a non-discrimination aspect, which is ensuring that the flexibility contribution by energy storage is remunerated in an equal way as other systems. Then, there is the aspect of ensuring that remuneration is equal to the value created for

06

both centralized and decarbonization applications and both mature and developing technologies all in different sectors. This requires a holistic approach, and while governments have recognized the need to do this, they are generally still working out how best to do so.

Facilitating the development of long-duration storage is also a bit of a special case. More long-duration storage is going to be needed in the future for countries targeting a high penetration of renewable generation, but is generally not needed now. Generally, current market structures do not remunerate network owners for investing in such assets. Accordingly, the countries seeking to assist research and development into long-duration storage, again mainly China and certain states in the USA, have done so via special measures such as research grants, tenders for pilot projects and direct utility procurement.

Of course, changes in energy policy and regulation can boost energy storage without targeting it directly. This includes changes to improve electricity infrastructure, such as those aimed at expanding or modernizing transmission and distribution systems, as well as those based around facilitating successful integration of renewable energy into the grid. As above, measures to boost local battery manufacturing capacity or reduce the costs of other storage technologies can also improve business case.

Finally, there is general recognition from countries seeking to accommodate energy storage that it is significant enough that they need to have a comprehensive national regulatory framework for energy storage within their wider energy market framework and strategy. Some countries have progressed this in part. Others are still in planning or consultation stages.

SPECIAL FEATURES FOR BUSINESS CASE

Producing a business case for energy storage in a particular local market shares many features of applying to other capital-driven investments in the wider energy sector. Overall, the business case will depend on all of the underlying technical, economic, regulatory and strategic aspects that apply to the particular local market. As an investment, energy storage does generally need reasonably secure long-term revenue streams to ensure its viability. As with renewable generation, costs and the technical performance of different technologies are improving.

However, there are some important differences. Capital costs play a central role in the case or storage, while operational costs are lower relative to a generation project. Replacing batteries is the exception, and unexpected degradation of the batteries may spike the costs of operation and maintenance. Excess wear on related systems can also lead to additional costs. Operation and maintenance is also going to depend in part on the applications that the energy storage is used for, and this needs to be factored in. Battery storage projects are also much easier to expand on to than generation projects.

On the revenue side, remuneration depends on the applications that the storage system can perform, but just as importantly how remuneration is calculated and whether the market allows developers to monetise the value of storing energy. How quickly or how often system assets respond may add value to the grid but may not be compensable.

In most markets it appears that securing long-term contracts is difficult, even where storage is able to compete in the local capacity market. This presents a significant challenge for developers. One option for getting around this is where the storage owner can “stack” revenue, i.e. where the owner can combine different revenue streams say by bidding into different markets and/or providing ancillary services or supplementing fixed income by doing the same. Other options may present themselves due to the characteristics of the particular market. For example, in some US states a segment of storage projects appear to focus mainly on providing peaking capacity. This is a low utilization approach but can still be profitable by storage owners keeping costs lower than the alternatives. This may not be achievable in other markets.

In addition, most local energy markets can be considered still developing when it comes to energy storage and as more private investors enter the market, new business models can be expected to form and further commercialize the technology.

LEGAL RISKS

Developing energy storage projects presents a series of legal risks several of which are similar in nature to renewable generation projects, bearing in mind that renewable generation is generally going to be a much more developed market. Regulatory uncertainty was mentioned above in the context of business case, but applies also to other areas, i.e. permitting, project design, testing and guarantees/warranties, etc.

Changes in law are something to consider in particular. What applications energy storage can perform, what applications it may perform in the future and remuneration are just some of the things that may be rapidly changing in the local market along with electricity market design itself. This presents an area in which developers will wish to take particular care, both to mitigate risks from changes and in order for the developer to be able to take advantage of opportunities.

Warranties/guarantees are another key issue which may present challenges, particularly for those new to the sector.

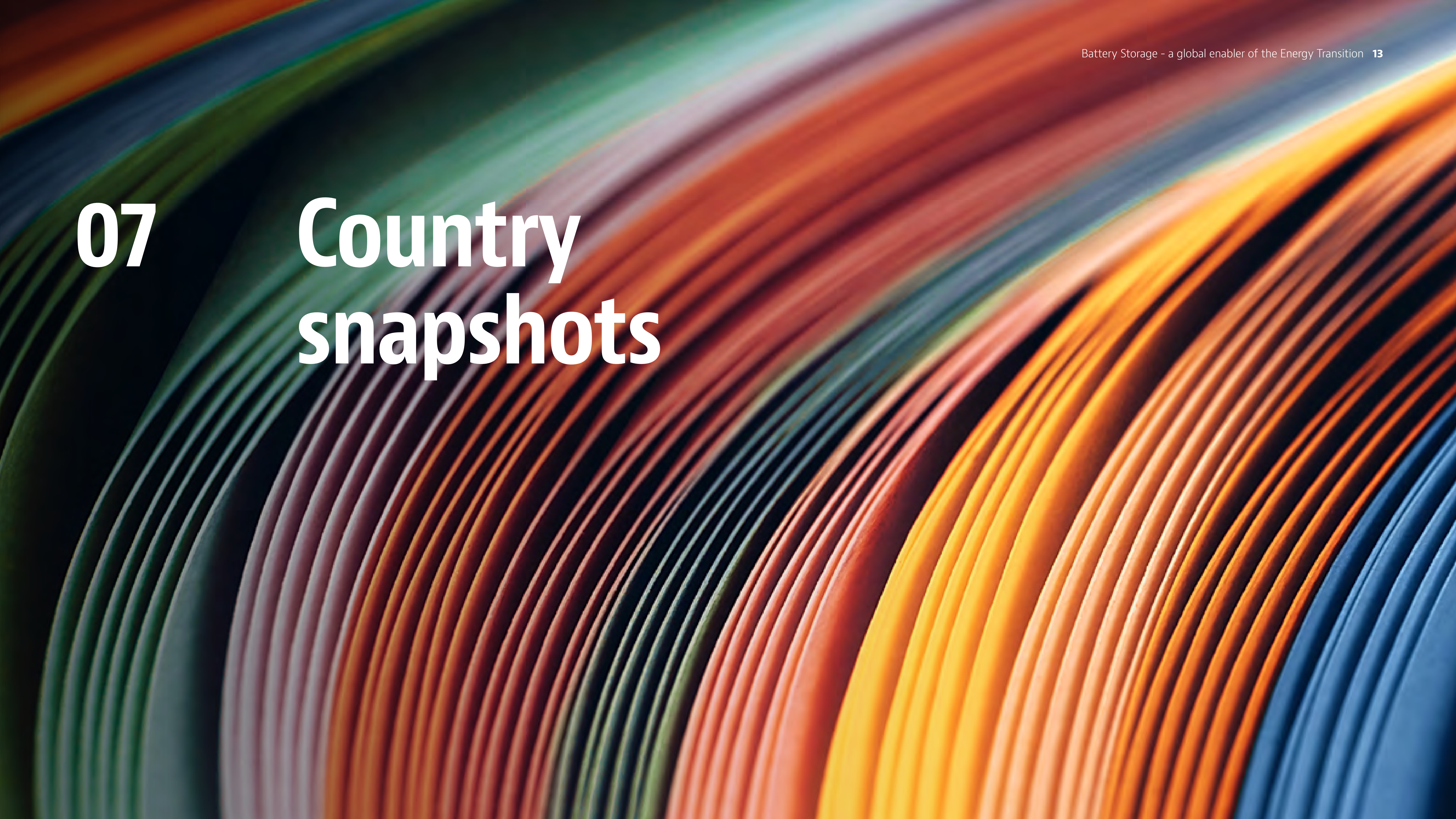
For pure energy storage projects, the most focus will be on battery performance, particularly on those characteristics which are key for the applications to be performed which may include output, start-up time, discharge rates, life-cycle and others. As above, replacing batteries early could also result in substantial additional costs.

While basic lithium-ion technology is well-established there are a number of variations, including between different products, manufacturers and chemistries. Most battery storage projects are also fairly early on in their total design life. This presents the issue of whether the particular batteries to be used for a project are proven or unproven technology with the ramifications that flow from that. Developers will wish to ensure that warranties or guarantees mitigate as much risk as possible, including by seeking direct rights from battery manufacturers. However, there is also the important insurance aspect and the potential need for a developer to seek particular insurance solutions.

For hybrid storage projects, developers need to consider integration of the energy storage system into the renewable generation system as well as the generation and storage systems themselves. This is a key and potentially complex task based on the technology and how this work is structured in the construction contracts is also worthy of consideration, particularly if direct involvement of the battery manufacturer is required. Several fires and other accidents have been blamed on inexperienced installers and capability is an important issue, particularly in new markets. Performance of the storage system is also something that needs to be factored into the plant commissioning and tests.

Another factor common to the earlier days of renewable generation projects is the relatively smaller size of players in the storage market and resulting insolvency risks. Contractors and developers are more likely to have limited assets, with battery suppliers themselves potentially being the most creditworthy participants in the project. It is generally yet to be seen whether this will substantially affect lending.

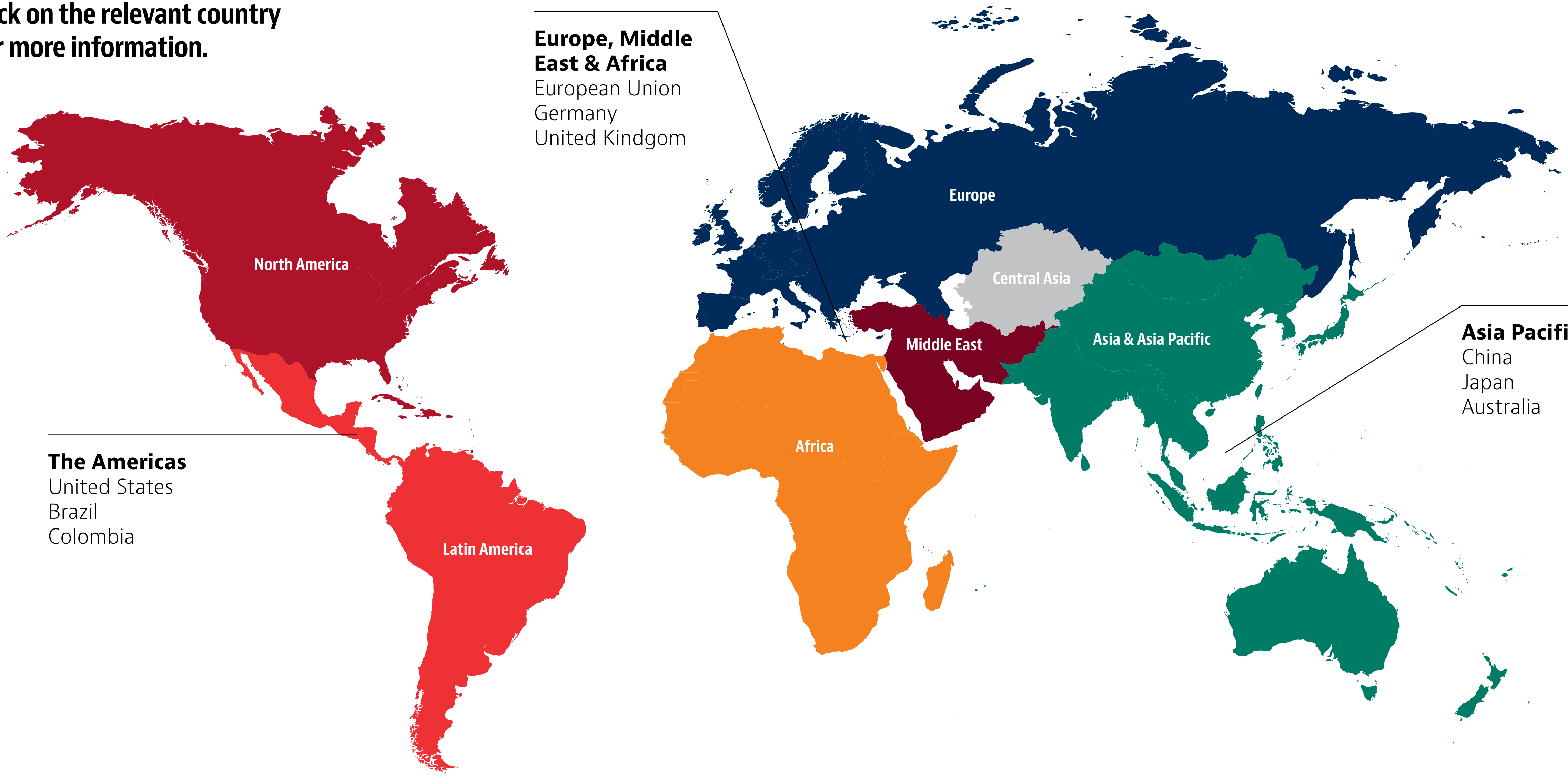
07 Country snapshots



07 Country snapshots

Click on the relevant country for more information.

Europe, Middle East & Africa
European Union
Germany
United Kindgom



Asia Pacific
China
Japan
Australia

The Americas
United States
Brazil
Colombia

08 United States

08 United States

Along with China, the US is set to dominate the global energy storage market over the next decade, with the two countries forecast to represent over half of battery storage projects by 2030.

Renewable energy projects, mostly solar PV and wind, now generate record numbers of energy with renewable energy sources now the second most prevalent energy source in the US.[23] With renewable penetration continuing to increase (by the end of 2020 the pipeline of utility-scale solar PV alone was nearly 70GW[24]), falling costs (of both renewable generation and batteries) have driven interest in utility-scale energy storage that can dispatch power to meet peak demand.

But while federal agencies have set the scene with the removal of regulatory barriers (see below), it has been the clean power ambitions of state governments and utilities that have really propelled energy storage and integration to the forefront. It is estimated that installations in the US will make up over 95% of the North American storage market by 2030, driven by state incentives, large-scale investment from utilities and developers taking advantage of wholesale market opportunities and emerging geographies.[25]

In addition to grid related storage projects, the number of "hybrid" solar plus storage projects is soaring, with over one-quarter of all commissioned solar projects in the country in 2021 (to August) including energy storage[26]. While the take-up of "hybrid" projects is increasing globally, project economics and preferential tax treatment (see below) makes this type of project particularly attractive for US developers who can improve their ability to dispatch at times of higher prices.

REGULATORY OUTLINE

In recent years, the US Federal Energy Regulatory Commission (FERC) has implemented regulatory frameworks that provide clarity on how energy storage (including utility-scale projects) will be governed as related technology evolves. FERC defines energy storage resources (ESR) as "a resource capable of receiving electric energy from the grids and storing it for later injection of electric energy back to the grid."[27]

In 2018, FERC enacted landmark Order No. 841 (the "Order"), which requires Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) to revise their energy tariff regulations to establish a wholesale market participation model that specifically facilitates the participation of ESRs in the RTO/ISO market. The Order requires transmission grid operators to provide ESRs with access to their wholesale markets, including ESRs connected to distribution systems or behind the meter. The Order provides that RTO/ISO participation models must (i) encourage ESRs to be dispatched and have the ability to establish the wholesale market clearing price as a buyer and seller, (ii) account for physical and operational characteristics of ESRs through bidding parameters; and (iii) establish a minimum size for market participation. The Order was affirmed by the US Court of Appeals for the District of Columbia Circuit on 10 July 2020[28]. In March 2021, FERC approved the changes made by all ISOs and RTOs; however, several RTOs have yet to fully implement the approved changes.[29]

Although the Order does not address compensation mechanisms for ESRs as transmission and grid-load assets, FERC has enacted the following orders to ensure appropriate and separate asset classification for ESRs:

- Order 775 - Frequency Regulation: This order adjusted compensation rules to better account for "quick-resource" sources, such as storage batteries.
- Order 784 - Opportunities for Ancillary Services: This order provided additional ESR revenue opportunities by allowing ESRs to sell imbalance and operating reserve services at market-based rates, instead of this service being dominated only by transmission operators.
- Order 792 - SGIP Amendments: This order amended the pro forma SGIP and pro forma Small Generation Interconnection Agreement to include "storage for later injection of electricity" allowing for "fast-track" designation for interconnection requests for small generation and storage facilities that satisfy certain parameters.
- Order 890 - Opportunities for Non-Generation Resources: This order opened the energy and ancillary services markets to non-generation resources, such as ESRs.

In September 2020, FERC issued Order No. 2222 directing regional transmission organizations and independent system operators to open their electricity markets to participation to allow distributed energy resources (DERs), including energy storage, to participate in the markets, including by providing grid services in an aggregated manner. The rule allows several sources of distributed electricity to aggregate in order to satisfy minimum size and performance requirements that each may not be able to meet individually.

As demand for energy storage grows, FERC is expected to continue updating regulations to account for the multi-use complexity of ESRs to promote increased use of ESRs as an essential element of the US grid.

Regulation at the state level is also significant in terms of allowing energy storage to meet in the relevant market. For example, the California Public Utilities Commission has set new interconnection policies for distributed resources including energy storage, which can permit these resources to incorporate flexibility into the grid.

23 U.S. Energy Information Administration, Monthly Energy Review October 2021
24 REN21: Renewables 2021 GSR
25 Wood Mackenzie: Global Energy Storage Outlook H2 2021 September 2021
26 Solar Energy Industries Association, Solar Industry Research Data, https://www.seia.org/solar-industry-research-data
27 FERC Order No. 841; 18 CFR Part 35
28 Nat'l Ass'n of Regulatory Util. Comm'Rs v. FERC, 964 F.3d 1177
29 U.S. Energy Information Administration: U.S. Battery Storage Market Trends August 2021

08 United States

GOVERNMENT / INVESTMENT SUPPORT

After passing Order No. 841, US legislative bodies and stakeholders have worked to establish policies that provide financial support and tax incentives for energy storage. In December 2020, Congress passed the USD 2.3 trillion omnibus spending bills as well as the Better Energy Storage Technology Act authorizing USD 1.08 billion towards energy storage research, development and demonstration from fiscal years 2021 to 2025.[30] The Act also included several initiatives that prioritize energy storage technology.

- Research, Development, and Deployment Program: The research, development, and deployment project includes the development of a 10-year energy storage strategic plan and prioritizes key objectives such as (i) implementing energy storage systems, components, and materials designed to further the development of technology; (ii) distributed energy storage technologies and applications, including building-grid integration; (iii) long-term cost, performance, and demonstration targets for different types of energy storage systems and for use in a variety of regions, including rural areas; (iv) transportation energy storage technologies and applications, including vehicle-grid integration; (v) cost-effective systems and methods for ESRs; (vi) advanced control methods for ESRs; and (vii) advanced manufacturing technologies that have the potential to improve US competitiveness in energy storage manufacturing or reduce US dependence on critical materials.
- Pilot Grant Program: The competitive pilot grant program enables eligible grant awardees to carry out demonstration projects for pilot energy storage systems. In an effort to increase regional diversity among award grants, especially in rural states and states with high energy costs, greater consideration is given to storage deployment proposals that achieve one of the pilot program's objectives.
- Long-Duration Demonstration Initiative and Joint Program: The Energy Act established a joint program between the Department of Energy and the Department of Defense to demonstrate long-duration energy storage technologies at different scales and to help new, innovative long-duration energy storage technologies become commercially viable.
- Critical Material Recycling and Reuse Research, Development and Demonstration Program: The Energy Act amended the United States Energy Storage Competitiveness Act of 2007 by establishing a recycle and reuse system for energy storage systems that contained critical minerals.
- Energy Storage Technology and Microgrid Assistance Program: The Energy Act provides grants and technical assistance to rural elective cooperatives. In addition, information regarding opportunities, potential and existing energy storage technology, and microgrid projects is shared with eligible entities.

In January 2021, the White House issued an executive order pledging to achieve a carbon-free electricity sector by 2035.

The Bipartisan Infrastructure Deal (Infrastructure Investment and Jobs Act) signed by President Biden on 6 November 2021 includes USD 6 billion to support the battery supply chain (USD 3 billion for battery material processing grants and USD 3 billion for battery manufacturing and recycling grants). The infrastructure bill also provides approximately USD 355 million for pilot projects that explore the potential of energy storage and an additional USD 150 million toward an initiative that focuses on long-duration storage.

While the energy storage industry continues to experience great momentum, one major challenge is the lack of investment tax credit (ITC) incentives to propel the deployment of energy storage in the US. ITCs are reductions claimed against one's tax liability based on the amount of investment in eligible renewable energy sources. Commercial and utility investors may claim the tax credit upon the installation, development, and/or financing of a renewable energy project. Given the unique feature of the US tax system that allows one to separately allocate cash and tax benefits/liability, major financial institutions have been very active in the renewables tax equity market driving renewables investments and benefiting from various tax credits, including ITCs.

To claim the full benefit of an ITC, energy storage projects must be part of renewable energy projects that reap the benefits of existing ITCs, such as hybrid solar projects with storage. The project must be charged by renewable energy 75% to 100% of the time, rather than from the grid, over the course of a year. Several energy storage advocates continue to introduce bills containing ITC incentives for stand-alone energy storage systems; however, no such legislation has been passed as yet.

Despite extensive lobbying efforts from ESR advocates, no legislation designates ITCs toward stand-alone energy storage systems. Critics of recent legislation believe that the failure to provide ITCs to stand-alone energy storage systems limits the overall impact of US infrastructure investments and delays the ability to achieve environmental targets and goals.

In addition to advocating for ITCs, the renewables industry is actively promoting the idea of "direct-pay" elections in lieu of a tax credit. A direct-pay election proposal would permit renewables project sponsors/developers to treat the tax credit as a payment on their tax return and receive a government refund for the amount by which such credit exceeds the developer's tax liability. Without a direct-pay provision, the ITCs are not refundable. This limits the value of the ITCs to the tax liability of a developer and often results in the actual ITC being significantly less than the potential maximum value of the ITC. As noted above, developers have been able to lessen the effects of this limitation by obtaining investment from tax-equity investors who have a greater tax capacity, which increases the amount of the ITC that can be monetized for their projects. However, the inclusion of a tax equity investor generally adds complexity and cost to the development of a renewable energy system, and there is typically a limited number of large investors who have sufficient tax appetite and are willing to make these type of investments.[31]

Additionally, even without a renewable energy system installed, ESRs may be eligible for the seven-year Modified Accelerated Cost Recovery System (MACRS) depreciation schedule:

> *"an equivalent reduction in capital cost of about 20%. If the battery system is charged by the renewable energy system more than 75% of the time on an annual basis, the battery should qualify for the 5-year MACRS schedule, equal to about a 21% reduction in capital costs."*[32]

Again, mandates and targets from state governments are also advancing the industry. California alone has published plans to install 2.4GW of energy-storage through to 2023, about 90% of which are to be based on lithium-ion technologies. State officials estimate that they will need another 20,000 to 30,000 MW of energy storage by 2045.

30 Energy Act of 2020
31 https://www.lexology.com/library/detail.aspx?g=4e1d2c00-2c1d-49df-8913-150099189b0c
32 https://www.nrel.gov/docs/fy18osti/70384.pdf

08 United States

Utility commissions in some states such as Nevada have established goals for energy storage procurement, and some utilities have brought new solar-plus-storage plants into operation, while others have released solicitations for new capacity.

State governments are also incentivising the development of alternative technologies for long-duration (over eight hours) storage projects. In 2020, California issued the first major US procurement for long-duration storage, with bidders responding with a range of technologies, including pumped-storage, gravity-based, compressed air and flow batteries, as well as lithium-ion batteries.[33] California also recently invested USD 16.8 million in energy-storage technologies specifically excluding lithium-ion.[34]

MARKET FEATURES

The capacity and prevalence of large-scale energy storage systems have increased greatly in the past decade. Between 2010 and 2019, capacity from large-scale battery storage increased by a net of 972 MW, and 1,022 MW of battery storage power capacity was operational by the end of 2019. On a smaller scale (less than 1 MW of generating capacity), in 2019 utilities reported 402 MW of existing small-scale storage power capacity in the US. About 41% of this capacity was installed in the commercial sector, 41% was installed in the residential sector and 14% was installed in the industrial sector. The remaining 4% was directly connected to the distribution grid, such as a utility at its own distribution substation"[35].

Together with China, the US led the world in installation of battery storage in 2020 with over 1GW of additions. Additions from utility-scale projects more than quadrupled in 2020, led by two of the world's largest battery storage projects, the 400MW/1,600MWh Vistra Moss Landing[36] and 250MW LS Power Gateway projects (both in California).

In 2021, the annual deployment of energy storage in the US is projected to reach 14.6 GWh, 10.8 GWh more than installations made in 2020. By 2026, annual US energy storage deployments are expected to grow 9.3 times compared to 2020, becoming a USD 8.9 billion annual market.[37] The front-of-the meter segment will continue to account for the bulk of the market 89% for 2021, driven by massive investment from utilities and developers taking advantage of wholesale market opportunities and incentives.

California has been the country's most prolific deployer of battery storage in recent years, driven by mandates and direct procurement from utilities. The state's most recent Integrated Resources Plan (IRP), which models the state's long-term energy needs and is moderated by the regulator, California Public Utilties' Commission ("CPUC") includes an estimate that California needs 9.8GW of energy storage by 2030, with 973MW of that being long-duration.[38] Then, between 2030 and 2045, a further 44.4GW of long-duration energy storage should be added to the grid, according to the IRP.

As the US energy storage industry expansion continues, so will the regulatory and legislative frameworks.

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34 https://www.forbes.com/sites/jeffmcmahon/2020/10/06/california-shifts-attention-from-lithium-ion-to-zinc-energy-storage/
35 U.S. Energy Information Administration: U.S. Battery Storage Market Trends (August 2021)
36 300MW of expansion was added in 2021
37 Including residential, non-residential and front-of-meter - US Energy Storage Monitor: Q3 2021 Executive Summary, Energy Storage Association, Wood Mackenzie Power & Renewables (September 2021)
38 https://www.energy-storage.news/california-will-need-up-to-55gw-of-long-duration-energy-storage-by-2045-study-finds/

09 China

09 China

China has a strong legacy of pumped-hydro energy storage and has over recent years paired that with battery storage, leveraging its predominant battery manufacturing capacity. In 2020, the cumulative installed capacity of China's energy storage was 35.6GW (including pumped-hydro), accounting for 18.6% of the global market, with an increase of 4.9% over the same period in 2019.[39]

By the end of 2020, China had nearly 3.3GW of battery storage, up a massive 91.2% from 2019.[40] Installations included the 200MW SPIC Huanghe New Energy Base project in Qinghai province. China's total installed capacity already ranks highest in the world, and its ambitious renewable and battery capacity targets, as well as stricter renewable integration rules are expected to drive strong growth over the next decade. Together with the US, the two countries are expected to have over half of global battery storage installations by 2030.

REGULATORY OUTLINE

In July 2021, China announced plans to install over 30GW of energy storage by 2025, as part of efforts to boost renewable power consumption while ensuring stable operation of the grid system. This would be a nearly ten-fold increase on its installed capacity as of 2020.

This complements the country's aim for renewable power to account for more than 20% of its total electricity generation capacity by 2025.

In light of development objectives and approaches for energy storage set out in China's 14th five-year plan, China's National Energy Administration, the country's major energy policymaking authority, has launched a series of supporting policies regarding storage investment, pricing, grid access and safety operation since the beginning of 2021. These supporting policies are seen as the main drivers behind China's rapid growth in storage deployment.

GOVERNMENT / INVESTMENT SUPPORT

The Chinese government encourages (and in a third of China's provinces at the beginning of 2021 mandates[41]) developers to pair their renewable capacity with a storage capacity equivalent to 5-20% of the renewable capacity. By adding storage facilities to renewable plants, developers benefit from prioritized grid connection, guaranteed offtake by grid companies, more streamlined project filing and approval, compensation for providing ancillary services and, in some regions, subsidies. Storage facilities and renewable plants are encouraged to form a consortium to participate in grid dispatch as a "special plant" by entering into grid connection and power purchase agreements with grid companies but compensation for storage facilities under this structure needs to be clarified and improved by the government.

The government supports the construction of grid-connected front-of-the-meter storage projects and allows storage facilities to participate in the ancillary services market as independent entities. To that end, the government has issued policies to improve the compensation scheme for power ancillary services and encourages the implementation of a performance-based fee structure. Despite this, there are areas in such schemes that need to be further improved and refined, compared with more mature compensation schemes developed and used in merchant markets abroad.

The government has proposed establishing a capacity payment scheme for independent storage developers and exploring what rules ought to be in place regarding storage's participation in the capacity market. Although the government has clearly set out its goal of establishing a capacity compensation scheme for a while, it has yet to provide detailed legal guidance on how such scheme would be formulated and implemented.

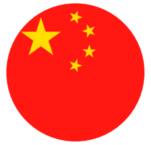
The government supports power sales companies with the right to operate distribution networks and qualified residential users to install storage facilities, so as to improve the consumption ratio of locally distributed energy, as well as to participate in demand-side response.

In terms of planning and permits, the government optimized the approval procedure for storage projects: except for certain specified projects, government approval is no longer required. Instead, a filing system will be implemented and storage developers are only required to make a filing of their proposed projects with competent authorities in accordance with relevant local regulations. However given the central planned nature of the Chinese energy sector, any proposed storage projects would need to fall within the energy development plan formulated by competent authorities and meet their planning requirements.

Finally, renewable energy, including battery storage, is open to foreign investment. Activities relating to storage, including research and development activities and development of large projects, are specified in the Catalogue of Encouraged Industries for Foreign Investment and do not require a minimum domestic participation.

39 REN21: Renewables 2021 GSR
40 REN21: Renewables 2021 GSR
41 REN21: Renewables 2021 GSR

09 China



MARKET FEATURES

Capacity additions in China for energy storage projects more than doubled in 2020, with over 1GW of new capacity. This strong growth was driven by projects for renewable energy integration and the commissioning of projects delayed from 2019 due to COVID-19 and other factors.

Among all storage technologies, lithium-ion batteries are currently the most popular due to the technology's maturity, simple structure, and deployment convenience. China of course already enjoys a huge competitive advantage in lithium-ion battery manufacturing.

Revenue uncertainty is a key challenge for storage projects, as power prices in China rely on policy and regulations rather than market fundamentals. While the government continues to promote the peak-to-valley electricity price mechanism, it has also established a super peak electricity price mechanism and improved the seasonal pricing mechanism that is already in place. The improved electricity pricing mechanism creates more room for the development of demand side battery storage, and helps to secure reasonable compensation for storage facilities through participating in electricity trading activities. However, difficulty in stacking revenue streams remains an issue for storage projects.

China's renewable capacity additions (and market for centralized utility systems) are being boosted through the completion of enormous "hybrid" projects combining solar PV, wind and storage by some of the biggest stated owned companies. This includes the 2.2 GW/203MW (at the time of commissioning in late 2020, China's largest hybrid project) solar plus storage facility in the desert of Qinghai province, completed in late 2020.

The relaxation of foreign investment requirements (see above) for storage may present huge market opportunities for foreign investors looking to enter the Chinese renewable market.

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10 European Union

10 European Union

The EU is implementing its ambitious plan to achieve net zero carbon emissions across the bloc by 2050.[42] It has recognised energy storage as a key enabler to achieve this goal. However, while overall investment in the energy transition (including renewables and electrified transport) surged in Europe over 2020, eclipsing both China and the US,[43] investment in battery storage has lagged behind the two countries due in part to a less-developed existing storage market more focused on grid balancing, less targeted storage policies and incentives, and a weaker battery supply chain.

Against this background, the EU has intensified its efforts to support the expansion of battery storage infrastructure with the help of regulatory measures and massive funding programs (see below). Regional growth is also expected to accelerate as a result of rising renewables penetration, the retirement of more fossil-fuel power plants and an expanding localized battery supply chain. It is estimated that the European storage market will exceed 100GWh by 2030, which is 910% of growth since the end of 2019.

REGULATORY OUTLINE

The regulatory framework for battery storage in the EU dates back to 2006 and the EU has come to the conclusion that, from today's perspective, there are too many limitations against a fundamentally changed context characterized by the strategic importance of batteries for the European internal market for electricity.

In March 2019, the EC launched the Clean Energy for all Europeans initiative (**"Clean Energy Package"**).[44] The Clean Energy Package set forth uniform Regulations and Directives for the electricity market. The Regulations are binding legislative acts applicable to every EU member state. The Directives establish common principles for national regulatory frameworks and set a uniform definition for "energy storage", meaning, in the electricity system, deferring an amount of the electricity that was generated to the moment of use, either as final energy or converted into another energy carrier."[45]

Importantly, the Clean Energy Package defines storage as an "entity separate from generation, transmission or load", preventing developers of storage systems from having to pay fees twice when charging and discharging power.[46] This removed a substantial disincentive affecting energy storage development, although it does not extend to potential double taxation, that being an issue for individual member states.

The following Regulations and Directives were released on 5 June 2019 as part of the Clean Energy Package:

- Regulation 2019/943: "The Internal Market for Electricity"[47]
  - This Regulation sets forth standards for the wholesale market and network operations and encourages market-based incentives for investment into energy storage.[48]
  - It provides that network tariffs should not discriminate against energy storage systems and that market rules shall enable the efficient dispatch of generation assets, energy storage and demand response.[49]
  - It mandates that network charges must not discriminate between production connected at the distribution level and production connected at the transmission level. Network charges shall not discriminate either positively or negatively against energy storage or aggregation and shall not create disincentives for self-generation.[50]

42 https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2050-long-term-strategy_en
43 BNEF: Energy Transition Investment Trends 2021
44 https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en
45 European Union Directive 2019/944, Article 1; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN
46 https://www.iea.org/reports/energy-storage
47 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN
48 *Id.* at Clause 22
49 *Id.* at Clause 39
50 *Id.* at Section 2, Article 18(1)

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- Directive 2019/944: "Common Rules for the Internal Market for Electricity"[51]
  - The purpose of this Directive is to establish common rules for the generation, transmission, distribution, energy storage and supply of electricity.[52] It provides that the transmission system operator shall establish procedures for non-discriminatory connection of new generation installations and energy storage systems.[53]
  - Importantly, the Directive provides that transmission system operators should not own, develop, manage or operate energy storage facilities. In the new electricity market design, energy storage services should be market-based and competitive. Consequently, cross-subsidization between energy storage and the regulated functions of distribution or transmission should be avoided. Such restrictions on the ownership of energy storage facilities are to prevent distortion of competition, eliminate the risk of discrimination, ensure fair access to energy storage services to all market participants, and foster the effective and efficient use of energy storage facilities, beyond the operation of the distribution or transmission system.[54]

More so than the US, the EU's regulatory landscape is beginning to shift towards differential standards for generators, energy-load facilities and energy storage. There is an increasing number of regulations that prohibit discriminatory market practices against energy storage, encourage energy storage market participation and define energy storage as a separate asset-category. The increasing prevalence of energy storage installations within EU member states suggests that it is invariable that member states will implement energy storage specific regulations distinct from the traditional energy market players. While most EU members states with significant renewable capacity do allow (or are at least in the process of reform to allow) all energy storage technologies to participate in the wholesale market and perform ancillary services, barriers do remain in the short term.

In December 2020, the EC released its proposal for a Sustainable Batteries Regulation[55] (**"Proposal"**) in order to modernize the EU legislative framework. The Proposal is part of the EC's New Circular Economy Action Plan,[56] which is in turn one of the main building blocks of the European Green Deal, an action plan under which the EU is striving to be the first climate-neutral continent.[57]

The Proposal, which focuses more on the localized battery supply chain, is meant to address three groups of highly interlinked challenges related to batteries:

- lack of framework conditions providing incentives to invest in production capacity for sustainable batteries
- sub-optimal functioning of recycling markets and insufficiently closed material cycles i.e. recovery and recycling of materials, which limit the EU's potential to mitigate the supply risk for raw materials
- social and environmental risks that are currently not covered by EU environmental law, including (i) a lack of transparency on sourcing raw materials; (ii) hazardous substances; and (iii) the untapped potential to offset the environmental impacts of battery life cycles.[58]

The Proposal would establish mandatory requirements for all batteries (i.e. portable batteries, automotive batteries, electric vehicle batteries and industrial batteries) placed on the EU market throughout their entire life cycle, relating to sustainability and safety as well as to labelling and information. It would establish requirements to facilitate the conversion of industrial and electric-vehicle batteries into stationary energy storage batteries and define obligations of economic operators linked to product requirements and schemes for supply-chain due diligence for raw materials in industrial and EV batteries. In addition, a battery passport would be established, allowing economic operators to gather and reuse in a more efficient way the information and data on individual batteries placed on the market and to make better-informed choices in their planning activities.

The EC claims that these measures shall strengthen the competitiveness of the EU internal battery market, increase the resilience of the EU battery supply chain and reduce the environmental and social impact in all stages of batteries' life cycle.[59] However, the new measures would also place an increased regulatory burden on manufacturers, producers, importers and distributors of batteries, who will need to take necessary steps to ensure compliance.

Initially, according to Art. 79 of the Proposal, the new regulation was supposed to apply from 1 January 2022 (whereas certain measures were to apply at a later point in time). However, the legislative process has been delayed with the next milestone envisaged for January 2022.[60]

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51 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN
52 *Id.* at Article 1
53 *Id.* at Article 42
54 *Id.* at Clause 62
55 EU Commission: Proposal for a Regulation concerning batteries and waste batteries, COM/2020/798 final, 10 December 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0798
56 EU Commission: Circular Economy Action Plan, 11 March 2020, https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf
57 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
58 EU Commission: Proposal for a Regulation concerning batteries and waste batteries, COM/2020/798 final, 10 December 2020, Explanatory Memorandum Section 1
59 EU Commission: Research & Innovation for Sustainable Batteries, December 2020, p. 1, https://op.europa.eu/en/publication-detail/-/publication/682933cb-39d5-11eb-b27b-01aa75ed71a1/language-en
60 https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-eu-battery-directive-(refit)/10-2021

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GOVERNMENT / INVESTMENT SUPPORT

Support for research on electricity storage has been on the EC's plan for a more sustainable future for years[61] aand has widened over time, although some have suggested that the lack of targeted mandates for storage has slowed growth. Notably, the EU has taken steps to strengthen its regional battery manufacturing capacity which lags behind China and the US.

Projects and initiatives already in effect include the following:

- The European Battery Alliance (EBA) was launched by the EC in 2017 in order to address the fast growing need for efficient batteries for power, transport and industrial applications. The industrial development program of the EBA, the EBA250, is a project-driven community that brings together more than 700 industrial and innovation actors, from mining to recycling, with the common objective to build a strong and competitive European battery industry.[62]
- In January 2021, Horizon Europe kicked-off with a budget of EUR 95.5 billion as a follow-up to the EU's flagship program "Horizon 2020". Under Pillar II, Cluster 5, Climate, Energy and Mobility,[63] in the span of six years, several research projects on energy storage will be supported to ensure a competitive international position for Europe in a fast-paced worldwide energy market.[64] Examples of these projects include the following:[65]
  - The European Battery Call Pilot Line Network, which aims to build a more competitive lithium-ion battery cell-manufacturing ecosystem and increase the production of lithium-ion cells towards industrial scale; and
  - Support for research and development of redox flow batteries, which it is hoped will significantly reduce the costs of that technology by 2030
- The European Partnership for Batteries in Horizon Europe will, in close cooperation with the European Battery Alliance, help prepare and equip Europe to manufacture and commercialise the next generation battery technologies by 2030. Started in 2021, the partnership aims to enable the rollout of zero-emission transport and renewable energy storage solutions, contributing to key goals of the European Green Deal.[66]
- The Just Transition Fund dedicates EUR 40 billion to support the development of energy storage facilities in fossil-fuel dependent regions. In addition, the "Recovery and Resilience Facility", with a volume of EUR 250 billion for COVID-19 recovery, dedicates 37% of its funding to sustainable climate spending. The development of energy storage is expected to profit from this.[67]
- BATT4EU is a co-programmed partnership established under Horizon Europe that gathers the EU Commission and Batteries European Partnership Association, which regroups all the battery stakeholders from the European research community in order to establish by 2030 in Europe the best innovation ecosystem in the world to boost a competitive, sustainable and circular European battery value chain and to drive the transformation towards a carbon-neutral society[68].

The Storage Research Infrastructure Eco-System Project (StoRIES) under the European Energy Research Alliance (consisting of more than 250 members from universities, associations, research organizations and industry) received EUR7 million in funding from the EU for a period of four years from 2021. According to their website, the main technological objectives of StoRIES are linked to energy storage development by providing access to 64 world-class research infrastructures and services.[69]

61 For an overview on pat projects: https://ease-storage.eu/eu-projects/past-projects/
62 https://www.eba250.com/
63 https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-5-climate-energy-and-mobility_en.
64 https://ease-storage.eu/news/how-eu-funding-is-driving-energy-storage-innovation/
65 EU Commission: Research & Innovation for Sustainable Batteries, December 2020, https://op.europa.eu/en/publication-detail/-/publication/682933cb-39d5-11eb-b27b-01aa75ed71a1/language-en, p.2.
66 EU Commission: Research & Innovation for Sustainable Batteries, December 2020, https://op.europa.eu/en/publication-detail/-/publication/682933cb-39d5-11eb-b27b-01aa75ed71a1/language-en, p.2.
67 https://ease-storage.eu/news/how-eu-funding-is-driving-energy-storage-innovation/
68 https://bepassociation.eu/about/batt4eu-partnership/
69 https://www.eera-energystorage.eu/news-and-resources/2758-stories-project-storage-research-infrastructure-eco-system-granted-eu-funding-28.html

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MARKET FEATURES

Until recent years, energy storage in Europe was generally limited to mechanical technologies, such as pumped hydro and liquid air energy storage, with Germany and Spain having the largest legacy capacity.[70] However, the European hydropower market has reached near-maturity and possibilities for new, large installations are limited. Accordingly, new sources of large-scale pumped hydro are limited, with the only large pumped-hydro project coming online in the EU in 2020 being Greece's 680 MW Amfilochia complex.

As battery costs have plummeted, new battery storage projects have become viable with lithium-ion technology representing the bulk of new capacity, following the global trend.

Within the EU-27, the localization of new battery capacity is uneven, with Germany having the largest capacity by some measure as at mid-2020: (103MW with 406MW in the pipeline). Several of its largest projects (Cottbus 50MW (BigBattery Lausitz) and Cremzow 22MW) are used for frequency regulation and grid protection. Germany also has surging residential behind-the-meter capacity with installations nearly doubling in 2020.

Ireland and Spain also have substantial capacity either in operation or in the pipeline.[71]

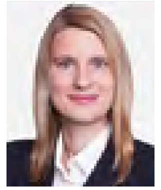
At the other end, several countries particularly in Eastern Europe, have little or no capacity in operation or in the pipeline, due to either regulatory reasons or the fact that renewable energy has not sufficiently penetrated the market (or legacy mechanical storage is sufficient at least in the short-to-medium term). France and Italy, two countries that do have significant shares of renewable capacity, also have negligible capacity but are using interconnectors to acquire flexibility.

According to a Study on Energy Storage published by the EC in March 2020 (**"Study"**), the key barriers to the expansion of utility-scale energy storage projects are the following:

- Various member states' policy barriers (while, as above, the EU has passed measures to facilitate new storage projects and made recommendations for the removal of energy market impediments these are in various states of follow-through within the EU-27)
- Lack of a viable business case for some new projects mainly due to uncertainty as to revenue streams, especially with utilities taking a less pro-active stance compared to the US

In the short-to-medium term, the ability of various EU member states to trade electricity with each other (including from conventional power generation) does provide an important advantage to those states in terms of meeting required levels of flexibility. The Study found that, by 2030, the EU-27 will still need 97GW of at least short-term storage (thus batteries and pumped hydro) for the provision of daily flexibility. Storage needs become more uncertain to 2050 (when the EU aims to have reached its target of 80% renewable penetration[72]) depending in part on the development of hydrogen technology and the extent to which the deployment of electrolysers or alternate technologies becomes cost effective. But even with hydrogen-based technologies providing short and long-term flexibility from as early as 2030, battery storage is still expected to play a significant role to at least 2050.

Notably, the EU has taken early steps in the development of renewable hydrogen with a number of projects in the pipeline of 1GW electrolyser capacity or more. The largest is being developed by a consortium of European companies that plans to use 95GW of solar capacity to power 67GW of electrolysers across multiple European countries by 2030.[73]



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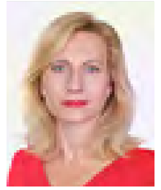

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70 EU Commission: Study on energy storage
71 EU Commission: Study on energy storage
72 EU Commission: A Clean Planet for all -A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018)773
73 REN21: Renewables 2021 GSR

11 Germany

11 Germany

Germany's long-term goal is to become largely greenhouse gas neutral by 2045. The expansion of renewable energy (RE) is an essential part of the country's energy transition (*Energiewende*) efforts required to reach this goal. 80% of the electricity in Germany is planned to come from RE by 2030. However, the integration of RE into the national grid requires a high degree of flexibility. Battery storage technologies are considered to be key to balance the feed-in from RE, which is, to a large extent, wind power and solar power.

Number-wise, this means this following:

- The German battery storage market is separated into home storage (up to 30kWh), mid-sized industrial storage (30-1000kWh) and large-scale storage units (over 1MWh). The three categories can further be divided into BTM storage (which is typically residential storage) and FTM storage (which is typically large-scale storage units).
- All storage facilities - no matter which size - have to be registered in the so called market base data register (*Marktstammdatenregister* or MaStR) administered by the Federal Network Agency (*Bundesnetzagentur*). The residential storage segment is clearly ahead in terms of registrations. By the end of 2020, more than 170,000 residential storage units were registered with a cumulative capacity of 1,400MWh.
  - The mid-sized industrial storage segment was increasingly reflected in the registrations in the MaStR in 2020. A total of around 1,450 mid-sized industrial storage facilities with a cumulative capacity of around 117MWhr and an output of around 61MW were registered.
  - In total, 56 large-scale storage systems with a cumulative capacity of 448MWhr and an output of 414MW have been recorded in the MaStR, with nine large-scale storage systems with a capacity of around 77MWhr and an output of 90MW being registered in 2020.[74]
- According to a study by the EU Commission, in 2020 within EU-28 (EU member states plus Estonia. Norway, Switzerland and UK), Germany ranked in 3rd place with 103MW of operational capacity plus 406MW projected electrochemical storage capacities.[75] Amongst others, Germany hosts the BigBattery Lausitz project (53MWh), currently the biggest battery storage project in Europe.

REGULATORY OUTLINE

Although the German battery storage market has developed rapidly over recent years, the lack of an investment-friendly legal framework attracted substantial criticism. This led in turn to significant improvements of the regulatory framework for battery storage, amongst others in the Energy Industry Act (*Energiewirtschaftsgesetz, EnWG*).[76]

Legal uncertainty arose largely from a missing definition for "storage systems". It was widely discussed if storage systems have to be seen as "end consumers" (with respect to the energy stored) or "producers" (with respect to the energy fed into the grid) or as both (i.e. dual function) or even as something of their own. This had an effect on the applicable regulation, e.g. on the obligation to pay network charges for end consumers. The issue is now addressed in the coalition agreement (*Koalitionsvertrag*) of the newly formed German government. The new government plans to legally define storage as an independent pillar of the energy system.[77] However, there is no timeline yet and the coalition agreement does not provide any additional outlook on support schemes for the development of the domestic battery storage market.

74 https://www.pv-magazine.de/2021/01/15/marktstammdatenregister-beinhaltet-batteriespeicher-mit-einer-kapazitaet-von-insgesamt-knapp-2-000-megawattstunden/
75 EU Commission: Study on energy storage – Contribution to the security of the electricity supply in Europe, Figure 7 and 8.
76 Stromspeichersysteme: Rechtliche Rahmenbedingungen und Entwicklungen, DFBEW, p. 10.
77 SPD, Bündnis 90/Die Grünen und FDP: Koalitionsvertrag Mehr Fortschritt wagen, S. 59, https://www.spd.de/fileadmin/Dokumente/Koalitionsvertrag/Koalitionsvertrag_2021-2025.pdf.

For the time being, the following regulatory regime applies, amongst others, in favour of battery storage facilities:

- **Reduction of network fees:** Sec. 118 Para. 6 sentence 1 EnWG contains a special regulation that allows for the elimination of network fees for electricity storage facilities (including storage losses).
- **Exemption from certain surcharges:** Generally, consumers have to pay various surcharges on top of the electricity price. However: (i) the surcharge under the Renewable Energy Act *(Erneuerbare Energien Gesetz, EEG)* that promotes the expansion of renewable energies; (ii) the surcharge under the Combined Heat and Power Act *(Kraft-Wärme-Kopplungsgesetz, KWK-G)* that promotes the generation of electricity from combined heat and power plants, and (iii) the offshore liability surcharge *(Offshore Haftungsumlage)* that was introduced to finance compensation payments to operators of offshore wind farms in case of delayed grid connection are not due for the use of grid electricity *(Netzstrom)* during storage if the electricity that is generated at a later stage completely fed into the grid (see Sec. 61l EEG, Sec. 27b KWKG and Sec- 17f Para. 5 EnWG). This includes the electricity losses that occur in the storage facility.
- **Additional payments:** According to Sec. 18 para. 1 Electricity Network Fee Ordinance *(Stromnetzentgeldverordnung, StromNEV)*, operators of decentralized generation plants that were commissioned before 1 January 2023 receive additional payments for so called "avoided grid fees" from the distribution system operator. It is the legal opinion of the German Regulatory Authority *(Bundesnetzagentur, BNetzA)* that this provision is applicable to battery storage operators.[78] However, in fact, Sec. 18 para. 1 StromNEV does not directly address the entitlement of battery storage operators to avoided grid fees and legal action is ongoing to get clarity. Therefore, usually the distribution system operator reserves the right to claim repayment of the avoided grid fees.
- **Electricity tax special regulation:** According to Sec. 5 Para. 4 Electricity Tax Act *(Stromsteuergesetz, StromStG)*, special regulations apply to stationary battery storage systems if they have the purpose of feeding electricity into a supply grid after storage.

In addition, grid operators are generally not entitled to build and operate battery storage facilities in the light of the unbundling regime (i.e. a strict separation between the monopoly grid market and the competitive upstream- and downstream markets) according to Sec. 7 para 1 sentence 2 EnWG. This increases the need for external investors and requires an investment friendly regulatory regime in Germany.

GOVERNMENT/INVESTMENT SUPPORT

Germany has implemented several funding programmes to encourage the development of battery storage on the way to a more sustainable future.

- The Federal Ministry for Economic Affairs (*Bundeswirtschaftsministerium*) is funding and supporting various energy storage technologies, such as electromechanical storage (batteries), SuperCaps (electrical storage), mechanical storage (pumped storage) and high temperature heat storage (so-called carnot batteries).[79] A total of 117 electrochemical energy storage projects were funded by the federal government in 2020 with a funding amount of 16.23 million euros.[80] Another 30 new projects were additionally approved in 2020.[81]
- The funding for private home storages is dependent on various funding programmes by the 16 German States.
- In June 2020, The Federal Ministry for Economic Affairs and Energy started a competition for a so-called World Storage, a vision for decentralized battery storage solutions, primarily targeted for the use in rural areas not only in Germany, but also in Africa and India.[82]
- ReserveBatt was a project funded from 2017 to 2021 to develop and test a battery storage for a momentary reserve. The concept contains a so-called stack-inverter, which couples a lithium-ion battery with the power grid. The inverter controls the energy flow between the two systems.[83]
- The Funding for Renewable Energies of the German export credit agency KfW (Programme 270) supports solar panels and battery storage for homes, enterprises and public facilities. The funding can be as high as EUR 50 million.[84]

An in-depth overview on past and current battery storage funding projects can be found in the project data base of the German battery forum (a platform sponsored by the Federal Ministry for Education and Research), under **www.batterieforum-deutschland.de/projektdatenbank**.

78 Bundesnetzagentur: Bericht Regelungen zu Stromspeichern im deutschen Strommarkt, p. 19, https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/ErneuerbareEnergien/Speicherpapier.pdf?__blob=publicationFile&v=2

79 Bundesministerium für Wirtschaft und Energie, Bundesbericht Energieforschung 2021, S. 44.

80 Bundesministerium für Wirtschaft und Energie, Bundesbericht Energieforschung 2021, S. 89.

81 Bundesministerium für Wirtschaft und Energie, Bundesbericht Energieforschung 2021, S. 89.

82 Bundesministerium für Wirtschaft und Energie, Bundesbericht Energieforschung 2021, S. 44.

83 Bundesministerium für Wirtschaft und Energie, Bundesbericht Energieforschung 2021, S. 46.

84 https://www.kfw.de/inlandsfoerderung/Privatpersonen/Bestandsimmobilie/F%C3%B6rderprodukte/Eneuerbare-Energien-Standard-(270)/.

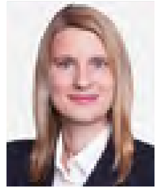
MARKET FEATURES

As above, the increase of storage capacity is seen as an essential part of the German energy transition. Investment in battery storage facilities in Germany is worthwhile for a number of reasons:

- Grid operators need storage facilities for grid balancing. However, they are generally not allowed to build and operate storage facilities on their own due to unbundling requirements.
- New projects are not limited or subject to capacity auctions, therefore entering the market is quite easy. This covers all parts from residential storage solutions to large-scale storage projects.
- The number of battery storage projects in Germany is steadily increasing. This provides for a mature market with a large number of potential contract partners for the construction and operation as well as government authorities that are familiar with permitting procedures. The set-up allows to realize projects and to either keep them for their lifespan or to sell them to investors before or after commissioning.
- Storage operators profit from various existing support mechanisms and it is expected that the under the new government the regulatory framework will become even more investment friendly.

However, this set-up is challenged by certain difficulties in achieving economic operation. There is almost no intraday market to sell storage capacity for peak prices. Instead, stored electricity is usually offered: (i) as primary control power (*Primärregelleistung, PRL*) or secondary control power (*Sekundärregelleistung, SRL*) for short-term grid balancing; or (ii) to secure black start capability (*Schwarzstartfähigkeit*) of conventional power plants. Prices on the PRL and SLR market result from a tender system and are highly fluctuating (if no or few control power is needed, prices remain low but in case more control power is needed, prices go very high to due to the limited availability) , PRL and SRL require extensive certification procedures and the number of conventional power plants for black starts is decreasing. In addition, payments for avoided grid fees, which are another important source of income, are being phasing out by 1 January 2023. Therefore, the business case for new projects has to be considered carefully.

Entering into pooling agreements can increase the rewards from battery storage investments. Operators of battery storage facilities have therefore started to enter into such pooling agreements for the joint marketing of their capacities. This allows a better utilization of the storage facilities and potentially increases efficiency, which can help to optimize the return on investment.



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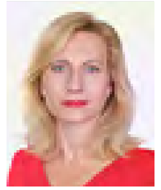

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Historically, there has not been great capacity for energy storage in the UK, with the grid using around 3GW of pumped hydro storage.[85] However, in recent years its renewable generation has surged along with its flagship offshore wind program (with over 10GW capacity in 2020 up from 1GW in 2010[86]). This in turn is rapidly increasing the need for grid flexibility with renewables today providing anywhere from around 10% to 60% of the UK's energy demand on any given day.[87]

The UK Energy White Paper: Powering our Net Zero Future (**"White Paper"**) was published on 14 December 2020, setting out a road map for the future of the UK's energy sector and how the government plans to meet its legally binding target of net-zero emissions by 2050. This targets a massive expansion of renewable and other low-carbon power generation with 100% of electricity supplied from low-carbon sources (compared to around 50% as at the end of 2020). The White Paper builds on the UK Prime Minister's 2020 "Ten Point Plan" which calls for a quadrupling of offshore wind generation to 40GW (and the installation of 1GW of floating wind capacity along with other low cost renewable technologies) and 5GW of low carbon hydrogen capacity both by 2030.

Even more so than the EU, the UK government has set its long term sights on hydrogen technology to achieve many of its low-carbon aims, seeking to leverage synergies between hydrogen and its growing offshore wind capacity. It expects to use hydrogen to provide long-duration storage and address grid flexibility past 2050 but it is uncertain to what extent hydrogen technology such as electrolysers will become cost competitive prior to then, leaving battery storage as one of the likely means to address grid needs for some years. With increasing penetration of the grid by wind and solar PV, the UK is also likely to require cost-effective long duration storage technologies from 2030 and perhaps sooner. An important factor here is how the UK fares in its plans to achieve 18GW of interconnection capacity by 2030 via its neighbours now that it has left the EU. If there is less interconnection capacity to call on, the UK will likely need to lean more heavily on energy storage projects in coming years.

Reductions in battery costs have led to the UK building up the largest battery capacity in Europe despite certain regulatory barriers (see below) and limited government support without the state government mandates seen in the US.

REGULATORY OUTLINE

UK regulators have been alert to the need to remove regulatory barriers so as to facilitate energy storage.

In 2017, the government published the first Smart Systems and Flexibility Plan ("Plan"), assessing barriers to energy storage and other impediments to efficiency in UK electricity market design.

The Plan was built on by the National Energy and Climate Plan (2019) which set out the most pressing challenges and indicative issues such as double-charging of network fees for energy storage projects.

Since the Plan, regulators and the UK National Grid have progressed a series of reforms with the Plan expected to be fully implemented by 2022. These included, for example, simplifying the planning process for large-scale storage projects, publishing a modified generation license for storage, which exempts certain facilities from payment of certain costs, generally ending double-charging of fees and clarifying that network operators cannot own or operate energy storage projects.

The White Paper promised an update to the Plan and this was published by the government in August 2021. One of the four core policy areas to the update is removing barriers to flexibility on the grid in relation to energy storage and interconnection. In that regard, the updated Plan sets out several key actions relevant to energy storage:

- The UK government passing a law to define energy storage as a distinct subset of generation. This would allow for differential treatment between energy storage and other types of electricity generation and demand.
- The energy market regulator, Ofgem, will consider how network charges should be applied where storage creates benefits for the system as well as options for removing final consumption levies on electricity imported by domestic storage (this is part of the double-charging issue).
- The government will launch the GBP 68 million Longer Duration Energy Storage Demonstration (LODES) competition to accelerate the commercialisation of long- duration energy storage, with the intention of building at least six demonstrator projects by March 2025.
- The government will take further action to de-risk investment for large-scale and long-duration storage projects.
- The government will work with industry to remove regulatory barriers to "hybrid" renewables plus storage projects and produce guidance to clarify location requirements under the Contracts for Difference (CfD) scheme in order to facilitate the addition of storage to CfD projects.

By 2030, the government aims to have "unlocked 'full chain' flexibility, meaning that all flexible supply and demand energy resources can contribute to their full potential, responding efficiently to available energy and network resources. Dynamic, close-to-real-time markets will play an important role in ensuring that the most efficient assets are dispatched".[88] The Plan also notes that the government is exploring more fundamental market intervention to support deployment of energy storage and address existing financing challenges. Of course, stakeholders might expect that any substantial shifts from the government's competitive market approach to electricity market design may only come into play if the deployment of energy storage by the private sector substantially falls short of anticipated requirements.

85 Transitioning to a net zero energy system: Smart Systems and Flexibility Plan August 2021
86 UK Energy White Paper: Powering our Net Zero Future: December 2020
87 https://www.nationalgrideso.com/news/easter-monday-sees-record-low-carbon-intensity-gb-electricity
88 Transitioning to a net zero energy system: Smart Systems and Flexibility Plan 2021

12 United Kingdom

These measures should all assist the deployment of energy storage in the UK, although the timing for implementation at least for some remains to be clarified (some actions have carried over from the original Plan).

The government is also proposing to legislate to introduce a competitive tendering process for the building, owning and operating of onshore electricity network assets.

After a trial by several Distribution Network Operators ("DNOs"), the Piclo Flex independent platform is being used as a market place for DNOs to request bids and award tenders to energy storage projects, demand side response, electrical vehicles and generators. This provides a means for DNOs to rapidly seek bids for flexibility services to resolve anticipated network issues.[89]

GOVERNMENT / INVESTMENT SUPPORT

The UK government's approach has been to avoid subsidizing the energy storage market (beyond permitting it to operate in the capacity market) given the dramatic reduction in battery costs over recent years. There have been exceptions for research and demonstration projects such as the world's largest "cryogenic" energy storage project to be built in Manchester, part of the government's GBP 505 million Energy Innovation Programme for advancing low-carbon technologies.

In 2019, the government launched the "Storage at Scale" competition to fund the demonstration of innovative large-scale energy storage.

The GBP 1 billion Net Zero Innovation Portfolio announced by the Prime Minster in 2020 allocates GBP 100 million to research new energy storage technologies and innovative flexibility challenges. The government also pledged in the White Paper to provide further support to innovative storage technologies (particularly those focusing on long-duration storage but excluding "conventional" lithium-ion batteries and pumped hydro), building on the Energy Innovation Programme.

These measures are all consistent with the government's current approach of allocating the majority of research funds to newer, unproven energy storage technologies, particularly those related to long-duration energy storage.

While the government has indicated an intention to, in the future, fold energy storage within its CfD scheme, many developers are currently looking to secure a Capacity Market Agreement for revenue. There have been calls from industry for markets to reward the additional value of storage, such as through renewable curtailment avoidance and providing support to network stability.

MARKET FEATURES

As at mid-2021, there was around 4.3GW of electricity storage operational in the UK (3GW of pumped storage and 1.3GW battery storage built since 2017).[90] However, battery capacity in operation is dwarfed by the battery storage pipeline, which is over 19GW across 800 projects, with the second quarter of 2021 alone seeing an increase of 3GW. Average project size is also becoming larger, with projects above 30MW becoming the norm and a pre-application submitted for a site in Scotland with capacity of 500MW (which would be over twice the size of mega battery projects commissioned in 2020). To place this in context, in the 2017 National Grid annual report (which is about the time the first wave of battery storage projects became operational in the UK), National Grid expected capacity in the range of 6-9 GW by 2030.

Some of these projects may not leave the planning stages of course (about 10.5GW of capacity has planning approval) but the next few years should still see a massive increase in battery deployment. By contrast, pumped hydro has a pipeline of around 2GW and that is unlikely to increase due to limited sites and capacity.

"Hybrid" renewables plus storage projects are also taking off, with many developers submitting applications for new-build wind and solar projects co-located with battery storage. A number of developers have announced plans to use battery storage to improve the profitability of renewable projects. For example, Macquarie's Green Investment Group and renewable energy developer Enso Energy have entered into a joint venture to develop 1GW of solar plus storage. In addition, the French electricity provider EDF partnered with the UK renewable energy developer Octo Energy to build 200MW of solar-plus-storage capacity in England and Wales.

As at mid-2021, around 900MW of new build battery storage projects had secured Capacity Market Agreements, providing a revenue stream.[91] Many developers will be looking to future expansion of the government's CfD scheme to include stand-alone projects, which can only assist to improve their business case for financing. Even without that assistance, several recently completed, or in development, projects are notable for their size and/or scope. In November 2020, InterGen announced that it had been granted consent for a 320MW capacity project with potential to expand to 1.3GWh.[92] In June 2021, Pivot Power, Wärtsilä and Habitat Energy' brought on line the UK's first grid-scale battery storage system directly connected to the transmission network, using a hybrid battery combining lithium-ion and vanadium redox flow systems[93].

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89 https://picloflex.com/
90 https://www.solarpowerportal.co.uk/news/a_record_amount_of_battery_storage_applications_submitted_in_q221
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93 https://www.solarpowerportal.co.uk/news/pivot_activates_50mw_transmission_connected_battery_in_oxford

13 Japan

13 Japan

Grid-scale energy storage is an area that is expected to experience strong growth in coming years as renewable penetration of the Japanese grid increases. At COP26 Prime Minister Fumio Kishida affirmed the government's ambitions to achieve net zero emissions by 2050. In July 2021, the Ministry of Economy, Trade and Industry (METI) announced a draft revision to its strategic energy plan which increased its renewable energy target from 22%-24% to 36%-38% of electricity production by 2030.[94]

As part of recent power market reforms, the transmission and distribution arms of the vertically-integrated electricity power utilities were legally unbundled in April 2020. The newly formed "Transmission and Distribution Operators" (Souhaiden Jigyousha) are now required to procure balancing capability from third parties, including energy storage developers.

Plans for Japan's first stand-alone grid-scale battery storage project (excluding those built in conjunction with substations) were released in August 2021. In November the government announced a JPY13 billion direct subsidy scheme for new energy storage projects.

REGULATORY OUTLINE

The Electricity Business Act (EBA) is the main source of legislation regulating businesses involved in the generation, transmission and distribution and sale of electric power.

A key issue is that under the current EBA there are no provisions specifically enabling grid-scale energy storage. Based on recent discussions within the Japanese government, it appears that the EBA will soon be amended to explicitly categorize energy storage as a "Power Generation Business" (Hatsuden Jigyo). If so, grid-scale energy storage developers will likely be required to file a "Power Generation Business Notification" (Hatsuden Jigyo Todokede) with the government, prior to the commencement of business.

Energy storage developers will be eligible to participate in various power markets in Japan, including the (i) "Spot Market" (Oroshi Denryoku Shijo), (ii) "Capacity Market" (Youryou Shijo), and (iii) "Balancing Market" (Jukyu Chousei Shijo). In addition to these markets, energy storage developers may also participate in the "Balancing Service Public Tenders" (Chouseiryoku Koubo), which are currently run by the Transmission and Distribution Operators. However, these tenders will eventually close out and be entirely replaced by the Balancing Market.

The Capacity Market was established in 2020 under amendments to the EBA. The aim of this new market is to enhance and stabilize the electricity market and encourage new investment into various power generating sources. Generally, any power source that is capable of supplying electricity in the target supply yearis eligible to participate in Capacity Market auctions and to receive compensation in an amount determined through public auctions.

The key issue for this Capacity Market is that bidders can only bid for a "one-year term" contract. As developers are generally unable to count on long-term capacity payments, projects that rely on compensation from the Capacity Market (such as pre-construction grid-scale energy storage projects) may not be bankable for large amounts of Capex finance. Please see below for further discussion on this point.

The Balancing Market was established in 2021. The aim of this new market is to allow the new Transmission and Distribution Operators to procure balancing capabilities to manage supply-demand fluctuations that had previously been managed by the vertically-integrated electricity power utilities.

GOVERNMENT / INVESTMENT SUPPORT

Government subsidies were offered to four pilot programs involving grid-scale energy storage that were constructed during 2013 and 2018 in conjunction with substations. However, these subsidies do not appear to be available any longer for new energy storage projects.

The Japanese government seems to be aware that, without sufficient government subsidies, grid-scale energy storage projects will need reliable, long term revenue for new projects to be developed. In November 2021, the Japanese Cabinet approved and released the government's draft supplementary budget for fiscal year 2021. A budget of JPY13 billion was allocated to assist the development of grid-scale energy storage projects in Japan. The Japanese government will subsidize a portion of the costs to develop new grid-scale energy storage projects - up to one half or one third of such costs, depending on the nature of the project. Once the details become clearer, developers who are interested in these subsidies may need to move quickly in order to apply for such subsidies.

It does not appear at this time that developers will be able to secure fixed-fee revenue from Transmission and Distribution Operators (in a way that is seen in some other jurisdictions). Therefore, unless developers are able to qualify for subsidies, they will likely need to rely on revenue derived from participating in the abovementioned three power markets namely the Spot Market, the Capacity Market and the Balancing Market.

Revenue from the Capacity Market will likely be the most stable (as revenue from the other two markets will fluctuate). As mentioned above though, the key issue for energy storage developers in the Capacity Market is that the current Capacity Market rules only allow for "one year term" contracts. Such short-term contracts may not provide sufficient

94 https://ihsmarkit.com/research-analysis/japan-raises-renewables-target-for-2030-to-3638-of-power-mix.html

13 Japan

comfort for lenders, especially in case the construction of the project will be funded through project finance. Based on recent discussions within the Japanese government, it does appear that the Capacity Market rules may be amended to allow "multiple year term" contracts for newly built power projects. A final decision is yet to be made, and further developments in this area should therefore be closely monitored.

Aside from the above revenue from participating in various power markets, another possible source of revenue for developers may be entering into bilateral arrangements with Transmission and Distribution Operators and offering balancing services. However, the current rules are not very clear on whether developers may be able to directly contract with Transmission and Distribution Operators without going through the Balancing Market. Based on recent discussions within regulatory bodies, it appears that such bilateral arrangements may not be possible except in extreme cases.

Another possibility is entering into bilateral arrangements with the newly proposed "Distribution Operators" (Haiden Jigyousha), which are expected to be introduced in April 2022 pursuant to the amended EBA. Distribution Operators are expected to operate the local distribution system, separately from the Transmission and Distribution Operators. The rules for such Distribution Operators are still being drafted, and it is not clear whether the Distribution Operators would be subject to the same rules as Transmission and Distribution Operators. Developments in this area should therefore be closely monitored.

MARKET FEATURES

Japan is in the early stages of developing energy storage but it has already installed several pilot projects. Most notably, in 2016, Mitsubishi commissioned the world's largest sodium-sulfur battery in Fukuoka Prefecture.

The primary challenge for developers is that stand-alone grid-scale energy storage in Japan is still in its infancy and the laws and regulations related to energy storage are still not very clear, although reforms are being progressed.

The competitive advantage though, is that this sector is expected to grow rapidly in the next few years, with the volume of transactions in the new power markets expected to rise. Achieving METI's 2030 targets for renewable energy will require an immense increase in investment in renewable projects, particularly offshore wind given limitations on space for grid-scale solar PV. As battery costs reduce, battery storage also becomes more cost effective for "peaking" services particularly in gas-importing countries like Japan. Without interconnectors to help address grid flexibility needs, it seems likely that Japan will need substantial short-duration storage in the medium term and long-duration storage in the long term. Given this, there may be certain business advantages in entering this sector early.

The key governmental agency is the Ministry of Economy, Trade and Industry ("METI"). METI is mainly in charge of drafting the various rules that are applicable to utility scale ESS projects. Other key institutions include: (i) the "Organization for Cross-regional Coordination of Transmission Operators, Japan" ("OCCTO"), which oversees the Transmission and Distribution Operators and the Balancing Market; and (ii) Japan Electric Power Exchange ("JEPX"), which operates the Spot Market and the Capacity Market.

As mentioned above, plans for Japan's first independent grid-scale energy storage project were announced from Global Engineering Co. Ltd. in August 2021. The developer plans to install grid connected battery storage with a capacity of 1.5 MW/6.1 MWh, batteries to be supplied by Tesla.

Though Japan has lower manufacturing capabilities in the battery market than some other countries in the region, it does of course have the industrial base to potentially ramp this up as needed. The Japanese manufacturers that supplied batteries for the abovementioned four pilot programs were Sumitomo Electric Industries, Toshiba and NGK Insulators.

Both Japanese and foreign contractors and suppliers are also active in the behind-the-meter storage sector, which has seen strong performance in recent years. Total capacity for both residential and commercial installations reached nearly 300MW by the end of 2020.[95]

With more variable renewable energy sources connecting to the grid, there is no doubt that grid-scale energy storage will play an important role in stabilizing the Japanese grid. However, the level of demand from the new transmission and distribution operators, and the volume of transactions that will take place in the new power markets, are still unclear.

While the market for stand-alone utility-scale energy storage projects is still emerging, Japan is seeing "hybrid" renewable plus storage projects, both wind and solar PV, in development. At present, both grid-scale and hybrid projects together amount to about 1.2GWh of battery storage, with the largest hybrid project being 130MWh. The number and capacity of such hybrid projects may well will rise when the current Feed-in Tariff scheme transitions to the Feed-in Premium scheme in 2022.

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95 IEA: Energy Storage Tracking Report – November 2021

14 Australia

14 Australia

Recent years have seen substantial growth in renewable generation in Australia. Renewable energy sources supply about 27% of Australia's electricity generation, and at times up to 52%[96]. Such rapid penetration of renewables is already posing significant challenges to grid stability with utility-scale energy storage become increasingly important.

Australia is also well known for the size of its battery storage projects. The Tesla supplied Hornsdale Power Reserve, a 100MW/129MWh battery storage project completed in 2017 (later expanded by 50MW in 2020), was once claimed as the world's first "big battery", however this has now been surpassed by the recently commissioned 300MW/450MWh Victorian "Big Battery" .

While utility-scale FTM deployments are expected to dominate the storage market over the next few years, Australia has also developed into a key market for BTM installations, with customer-sited batteries, both residential and commercial & industrial types, set to continue with strong growth as well.

The recently released draft Integrated System Plan (ISP)[97] highlights the significant investment required in, and opportunities for, energy storage in Australia. Some key opportunities identified include the following:

- The need to treble the firming capacity that can respond to a dispatch signal, including utility-scale batteries, hydro storage, gas generation, and smart behind-the-meter batteries or virtual power plants (VPPs).
- By 2032, over half of the homes attached to the NEM will have rooftop solar, rising to 65% by 2050 with most systems complemented by energy storage. The associated 69GW of capacity and 90TWh of electricity will represent one fifth of the NEM's total underlying demand.
- By 2050, a NEM without coal will require 45GW/620GWh of storage (in all forms, including batteries, hydropower, VPPs, viable alternative energy storage, vehicle-to-grid, etc.).

REGULATORY OUTLINE

The National Electricity Market (NEM) is a wholesale spot market that sells electricity generated from over 300 generators across five regions in Australia: Queensland, New South Wales (including Australian Capital Territory), Victoria, South Australia and Tasmania. The spot price is determined by changes in electricity supply and demand, with the lowest cost generation scheduled by the Australian Energy Market Operator (AEMO) to meet demand every five minutes. The NEM services almost 10 million residential, commercial and industrial energy users through its transmission and distribution grid. The National Electricity Rules (NER) govern the operation of the NEM.

The main body for energy policy in Australia is the National Federation Reform Council (NFRC) (formerly the Council of Australian Governments), the peak intergovernmental forum in Australia that develops and monitors the implementation of policy reforms. The NFRC oversees three market bodies in Australia's energy market, including: (i) AEMO, which is responsible for the day-today management of the wholesale and retail energy market operations; (ii) the Australian Energy Market Commission (AEMC), which is the rule maker for the Australian electricity and gas markets; and (iii) the Australian Energy Regulator ("AER"), which is the regulator of the wholesale electricity and gas markets.

Energy storage is able to participate in the NEM, but there has been general acknowledgement by government, regulators and stakeholders that further policy reform on storage is needed to encourage growth and the inclusion of new storage technologies.

On 2 December 2021, AEMC issued new rules aimed at cutting costs and logistical hurdles for large-scale storage projects and hybrids. The rules introduce a new participant category, the Integrated Resource Provider, which is aimed at accommodating storage and hybrid systems in a flexible and technology-neutral way. Small-scale storage is also able to participate in the market more easily through aggregation agreements. The new rules also allow hybrid systems to be used to store and self-consume power generated behind the system's grid connection point, allowing owners to reduce costs.

AEMC has also announced the introduction of two new ancillary market services into the NEM that are well suited for battery storage: the "very fast raise" service and the "very fast lower" service, which will operate more rapidly than existing grid frequency control services in response to the locally sensed frequency of the grid network in order to arrest a rise or fall in frequency respectively. This new fast frequency response market is due to commence in 2023.

While these reforms remove regulatory barriers and provide energy storage proponents with more certainty and revenue opportunities, concerns still remain. Network charging (including the "double-charging" of network charges from drawing and supplying energy from and to the grid) and how network prices should be set for storage and other large flexible loads remain a challenge for energy storage developers. It is vital that energy storage developers are supported and incentivised in order to provide AEMO with the support it requires to maintain the security of the NEM as it transitions and takes up more renewable energy. It is understood that AEMO intends to take steps to address some of these issues under future rule change proposals.

96 https://www.energy-storage.news/australian-energy-market-commission-adapting-for-a-future-increasingly-reliant-on-energy-storage/
97 https://aemo.com.au/-/media/files/major-publications/isp/2022/draft-2022-integrated-system-plan.pdf?la=en

14 Australia

GOVERNMENT / INVESTMENT SUPPORT

Australian governments offer a range of financial incentives to encourage private sector investment into electricity storage. The schemes vary from direct subsidies/grants to underwriting the investment through debt or equity support. Some schemes use a mix of approaches.

Australian Federal Government Support

The Australian Federal Government funds two key renewable energy investment agencies: (i) the Australian Renewable Energy Agency (ARENA); and (ii) the Clean Energy Finance Corporation (CEFC).

ARENA was established in 2012 to fund research, development and the commercialization of renewable technology. ARENA has subsequently invested AUD$1.7 billion in over 550 projects, including various energy storage projects, with a combined value of AUD 6.9 billion.

The CEFC was launched in 2012 as a government-owned green bank to promote investment in clean energy through debt and equity financing (as opposed to grants). CEFC finance of around AUD 8 billion has supported around 200 large-scale projects and 18,000 smaller scale projects, including energy storage projects.

In addition, ARENA and the CEFC jointly manage the Clean Energy Innovation Fund, which provides debt and equity for clean energy projects at the early stage of development, providing them with vital growth capital.

In October 2019, the CEFC was also mandated to administer the newly announced AUD 1 billion Grid Reliability Fund to encourage private investment in new energy generation, storage and transmission projects to balance the grid and ensure sufficient reliable generation capacity is available to meet periods of high demand. Eligible investments include energy storage projects, including pumped hydro and batteries.

State Government Support

State Governments have also been active in providing support to pilot and utility-scale projects across Australia. For example:

- In South Australia, the State Government contracted for network support services from the now 150MW (194 MWh) Hornsdale Power Reserve.
- In Victoria, the State Government (in conjunction with ARENA) provided AUD 50 million of funding to deliver 55MW of power (80MWh of storage), through the rollout of two utility-scale battery storage projects in the state.
- In New South Wales, the State Government has committed to building four new large-scale batteries under its ‘Emerging Renewables’ program.
- In Queensland, under the Powering Queensland plan, the State Government conducted a reverse auction for up to 100MW of energy storage, which included utility-scale battery storage.
- In Western Australian, the State Government is tendering for a 100MW battery.

In Tasmania, the State Government (in conjunction with ARENA) is supporting Hydro Tasmania’s Battery of the Nation initiative, which is about identifying future development opportunities for hydropower system expansion, including the potential redevelopment of the Tarraleah hydropower scheme and a pumped hydro project at Lake Cethana.

MARKET FEATURES

The national energy storage sector has been quite successful in recent years, with a wide range of projects springing up despite regulatory challenges and limited opportunities to obtain revenue other than through the merchant market. Privately funded large-scale projects have been unusual, although that appears to be changing with work progressing on the country’s largest privately funded battery, a 150MW system located at the former Hazelwood Power Station in the Latrobe Valley and funded by ENGIE and Macquarie’s Green Investment Group.

Large storage projects are also set to continue with developers announcing plans for an AUD 2.4 billion 1.2GW battery project at Kurri Kurri, north-west of Newcastle.

However, commercial and financial risks remain a significant challenge for the development of utility-scale battery storage projects in Australia. There is considerable risk relating to forecast revenue, and although some level of risk is very normal for any infrastructure projects exposed to a market price, battery storage revenue appears to be particularly challenging from a price risk perspective. This is primarily because the markets on which utility-scale battery storage projects rely for revenue are generally small and vulnerable to the impact of new technologies, and have limited appetite for contracting revenue, particularly for extended periods of time.

14 Australia

The following table sets out owners of the utility-scale battery energy storage projects (above 10 MW) that were in operation as at the start of 2021, together with details of the project owner and technology/ battery manufacturer.

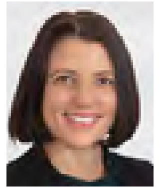
Project	Owner	Location	Operational	Technology / Size
Hornsdale Power Reserve	Neoen	Hornsdale, SA	2017	Tesla 150MW/194MWh
Ballarat	AusNet	Ballarat, Vic	2019	Fluence 30MW/30MWh
Mount Newman	Alinta	Newman, WA	2018	Kokam 30MW/11.4MWh
Dalrymple North	ElectraNet	Yorke Peninsula, SA	2018	Samsung 30MW/8MWh
Gannawarra	Edify Energy	Kerang, Vic	2019	Tesla 25MW/50MWh
Lake Bonney	Infigen	Mt Gambier, SA	2019	Tesla 25MW/52MWh
Agnew Gold Mine	EDL	Leinster, WA	2020	13MW/4MWh

The following table sets out the utility-scale battery energy storage projects (10MW and above) that were under construction as at the start of 2021. Note, there are a number of other projects in development with a capacity of less than 10MW.

Project	Owner	Location	Operational[98]	Technology / Size
Victorian Big Battery	Neoen	Moorabool, Vic	2021	Tesla 350MW/450MWh
Torrens Island	AGL	Torrens Island, SA	2023	N/A 250MW/250MWh
Wandoan South BESS	Vena Energy	Wandoan South, Qld	2021	Doosan 100MW/150MWh
Wallgrove Grid Battery	Transgrid	Wallgrove, NSW	2021	Tesla 52MW/78MWh
New England Solar Farm Battery	UPC/AC Renewables Australia	Uralla, NSW	2022	N/A 50MW/60MWh
Koodaideri Mine Solar Farm	Rio Tinto	Tom Price, WA	2022	N/A 45MW/12MWh
Bulgana Green Power Hub	Neoen	Stawell, Vic	2021	Tesla 20MW/12MWh

Utility-scale energy storage is due to play a vital role in creating a flexible and reliable energy system and supporting the continued deployment of renewable energy across Australia. The mix and extent of energy storage are likely to change over time, from rapid response batteries to long-duration storage (e.g. pumped hydro). Currently, the energy market in Australia does not fully recognize the value of energy storage, and as such we are not seeing the necessary levels of private investment. There has been significant progress in this context, including the introduction of the AEMC's recent reforms targeted at the integration of batteries into the NEM and the availability of government funding for utility-scale battery projects as outlined above. However, accelerating market reforms and further government support remains critical to the continued and increased deployment of battery storage. As the cost of energy storage continues to decrease, like with renewable energy, the level of support required from the government will start to fall away.

The integration of batteries into virtual power plants (VPPs) is also set to have a critical impact on the renewable energy transition and the deployment of utility-scale energy storage.



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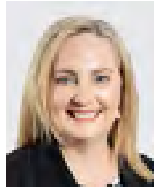

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15 Brazil

15 Brazil

Brazil is recognized for its abundant natural resources, with an extensive number of hydrographic basins, maritime coasts and rural properties. These qualifications make Brazil a country capable of producing a large volume of energy via several sources: hydroelectric, thermoelectric, wind farms and solar plants. Historically though, Brazil's energy matrix has been predominantly based on hydroelectric plants.[99]

The energy matrix is also rapidly changing with solar PV and wind representing almost 60% of new power projects under construction in Brazil and almost 85% in planning stages. Despite challenging economic conditions, Brazil still added 3.1GW of solar PV and 2.3GW of wind capacity in 2020.[100] This strong growth is expected to continue into 2022.

In view of such changes and due to the intermittency of solar and wind power, updating the regulatory framework to accommodate energy storage and facilitate its development stands out. This sets Brazil apart from some other countries in Latin America that have less need for front-of-the meter energy storage and where new solar PV and wind is less attractive due to high competitiveness with hydropower generation.

REGULATORY OUTLINE

The Brazilian regulatory framework does not prohibit the use of new energy storage solutions, but there are currently no specific regulations on the matter. However, the Brazilian authorities have shown interest in deepening the discussions on energy storage regulation, in particular regarding the use of batteries in front-of-the meter systems.

By the end of 2020, the Brazilian Energy Agency (ANEEL) published Call for Contributions (*Tomada de Subsídios*) No. 11/2020.[101] Its' goal was to obtain contributions and recommendations for the introduction of storage systems in the Brazilian energy sector from a regulatory perspective.

Among the main aspects to be addressed by ANEEL are: (i) the regulatory concept to characterize energy storage resources; (ii) which technologies and configurations will be regulated by the agency; (iii) measures to ensure competitiveness among the players and technologies; and (iv) which players (distribution, transmission and generation companies) will be allowed to use storage solutions. Another fundamental question is whether the stored energy would be used as capacity reserve or traded in the spot market.

Apart from all of the regulatory aspects mentioned above, perhaps the main barrier for the use of storage systems in Brazil is the cost of implementation. According to the Energy Research Company (EPE),[102] among the several forms of energy storage, electrochemical batteries are the main candidates for use in the Brazilian energy sector. On the other hand, the 2030 Ten Year Energy Expansion Plan (*Plano Decenal de Expansão de Energia 2030*), published in 2020 by the EPE, concludes that the use of batteries is unfeasible from a financial perspective, mainly due to the high cost of importing them. Another factor to be considered in the development of storage solutions in Brazil is taxation. Taxes may have a relevant impact on the transactions involving batteries, in particular those levied on the services and the power purchase and sale.

Accordingly, certain tax benefits and a revenue increase mechanism for effectiveness achieved by players from the energy sector through the use of storage solutions are under discussion within the Brazilian regulatory agenda.

The deadline for contributions under Call for Contributions No. 11/2020 ended in March 2021 and many sectors of the market have contributed positively to the initiative, from Brazilian associations and universities to major market players (e.g. China Three Gorges, CPFL (part of State Grid Corporation of China group, Honeywell, Huawei, Schneider Electric and SPIC).

In November 2021, ANEEL authorized energy transmission company ISA CTEEP to include the costs of its battery storage project as an additional charge in its annual permitted revenue. This is the first authorization of this kind. ISA CTEEP's project is the first large scale battery storage project, will be implemented on the coast of the State of Sao Paulo and was recommended by the EPE and the Brazilian Ministry of Mines and Energy.

It is also important to point out that Bill of Law No. 5.829/19, already approved by the House of Representatives and currently undergoing approval in the Federal Senate, establishes the legal framework for distributed generation and takes into account the possibility of distributed generators using batteries (although it does not establish rules and conditions for their use).

MARKET FEATURES

With the strong growth of solar PV and wind capacity in Brazil it seems only a matter of time until the need for new energy storage becomes apparent, a conclusion that the Brazilian government appears to have accepted as discussions with stakeholders on the regulatory framework continue.

At present, even without enabling regulation or government support, certain projects in Brazil have already begun implementing storage solutions with battery technology. With the issuance of the regulatory framework on the matter, it is expected that Brazilian players will move strongly towards adopting and implementing energy storage solutions.

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*Trench Rossi Watanabe and Baker McKenzie have executed a strategic cooperation agreement for consulting on foreign law.

99 According to a survey by the Brazilian Energy Agency (ANEEL), around 58% of the energy produced in Brazil comes from hydroelectric plants
100 REN21: Renewables 2021 Global Status Report
101 Technical Note No. 094/2020-SRG/ANEEL
102 Entity linked to the Brazilian Ministry of Mines and Energy that carries out studies and researches to support the planning of the energy sector

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The Colombian power industry is very well structured and stable in terms of its governing regulations, the interaction between different authorities, and the protection of private interests and investments. It is very interesting to note that activities in the different segments of the power industry (generation, storage and trading, mainly) have been performed freely since 1994, with no need to obtain specific concessions or operating permits from the government, which limits the scope of its own activities to monitor compliance with compulsory regulations, normally focusing on matters related to residential public utility services (power supply) and the rights of end consumers.

When deals in the power industry take place between private parties, in equal conditions, and none of the parties is a "regulated user" in essence (i.e. a residential user), the negotiation of the terms of the relevant deal are to be set freely, with virtually no restrictions.

This translates to the Colombian power industry being very flexible and functioning very well, from the perspective of private investors. Furthermore, the fact that the power market in general is managed by a specialised entity (XM) with exclusive devotion to such administration, is very relevant and valuable, considering that such specialisation allows for the actual administration of the system to be smooth and function properly.

In terms of power storage, and while Colombian government has expressly manifested its intention to incentivize the development of this kind of projects for purposes of mitigating the intermittency of solar and wind power, and serving as an essential part of generation plants based on those sources, a regulation doing so is still pending to be issued. As a first step, the government has already regulated and launched public bidding processes for the allocation of rights to build and operate power storage systems, but these are specifically and exclusively devoted to mitigate insufficiencies in the transmission infrastructure, as explained further below. In consequence, although there is still a long road ahead, the Colombian government has issued clear signals that it will move in the direction of stimulating and prioritizing power storage projects for general purposes.

REGULATORY OUTLINE

From 2018, the Colombian government started exploring the possibility of incorporating power storage systems to the national grid. For such purposes, the regulator ("CREG", for its acronym in Spanish[103]) acknowledged that power storage systems (through batteries or otherwise) can be used for various purposes, to respond to different needs of the power generation and transportation infrastructure. Some of the multiple services that can be rendered by power storage systems, as acknowledged by CREG in a white paper[104] that preceded the regulation currently in force, are: (i) the flattening of load curves; (ii) the postponement of the commissioning of new generation capacity; (iii) spinning reserve services; (iv) voltage level control; (v) black-start support; (vi) the displacement of network investments; (vii) network congestion relief; and (viii) the improvement of quality indicators.

Without prejudice to the abovementioned acknowledgement of the multiple uses that power storage systems may have (and leaving a door open for new regulation to be enacted in the future, to incorporate power storage systems for other uses and purposes), in 2019 the Colombian government decided to take the first step towards the incorporation of battery power storage systems (BESS) to the national grid, for the sole purpose of rendering a service to the transmission network (grid) itself. Such service has to do with the mitigation of existing problems that result from the lack or insufficiency of power transmission networks in light of, among other situations, (i) the delays in the construction and commissioning of new transmission infrastructure, and (ii) the need to guarantee sufficient available capacity for new generation projects to connect to the grid and transport their relevant power.

The result of this effort was the enactment of Resolution 098 (**BESS Resolution**) by CREG in 2019, which set the regulatory conditions required for the installation and commissioning of BESS to be connected to the national grid (at different tension levels) for the specific purpose mentioned above.

The regulatory conditions of the installation and commissioning of BESS to be connected to the grid, as defined under the BESS Resolution, include the following: (i) a definition of the process of recommendation of projects, based on the identification of specific needs that call for satisfaction;[105] (ii) a definition of the persons allowed by the regulation to participate in these kinds of projects; (iii) the design of mechanisms to accomplish compliance, by the relevant projects, with specific technical requirements and construction and commissioning schedules; and (iv) a definition of the treatment to be given to the power used and delivered through the BESS.

From a technical standpoint, a BESS is defined as *"the installation of groups of batteries, with their respective connection, cut and protection equipment, which are used for the temporal storage of power and its subsequent delivery to the system. The electronic interface and required measurement equipment are also deemed part of the BESS."*

The BESS Resolution[106] refers to the "minimum efficiency of a BESS", and defines the term as: "the efficiency of the full cycle of a BESS refers to the amount of power that the BESS can restore to the electric system compared to the amount of power that it takes from it; both amounts measured at the point of connection of the BESS to the SIN"[107].

103 *Comisión de Regulación de Energía y Gas*
104 Document CREG 064, dated August 30, 2019.
105 Pursuant to the BESS Resolution, the analysis and recommendation of situations or cases calling for the installation of BESS should correspond to UPME, as the governmental agency in charge of preparing the national expansion plans. The initial identification of these cases, however, can come from any agent, as well as UPME itself.
106 Which was amended through Resolution 070, 2021 by CREG.
107 Resolution 098, 2019. Article 3.

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From a regulatory standpoint, there is currently a new project of resolution, subject to public consultation (Resolution 074, 2021 by CREG), which intends to define the quality requirements of the service for BESS to be built and operated based on the BESS Resolution.

GOVERNMENT / INVESTMENT SUPPORT

Pursuant to the BESS Resolution, as well as Resolution 181313, 2002 by the Colombian Ministry of Mines and Energy ("MME"), the Colombian government, through its Mining and Energy Planning Unit (UPME, for its acronym in Spanish) is currently entitled to launch public tender processes (*convocatorias públicas* **"Tenders"**) to award private parties the right to build and operate BESS for the purposes defined in the regulation, and subject to previously identifying a specific need to be addressed, regarding a particular transmission network that is lacking or insufficient in a certain region of the country.

To participate in the Tenders, the participating private parties (agents) are required to file proposals, consisting of (i) a technical offer and (ii) an economic offer. Technical offers shall correspond to the specific project subject to the Tender, and shall comply with the grid's quality and reliability criteria, also containing a detailed schedule for each of the project construction stages. All proposals should be accompanied by bid bonds (*garantías de seriedad de la oferta*), as set forth in the relevant Tender documents.

The companies awarded the right to build and operate BESS as a result of a Tender are remunerated with a consideration known as the *Expected Annual Income* (IAE, for its acronym in Spanish), payable monthly during the whole term of the respective payment period (as defined by UPME for each specific BESS project, under its respective Tender documents). This IAE is proposed directly by each of the companies that participate in the Tenders, through the submission of their respective economic offers. The company that proposes a lesser IAE value is awarded the relevant right to build and operate the BESS.

The first successfully completed Tender, UPME STR 01-2021, was launched by UPME on June, 2021, and aimed at mitigating the insufficiency of power transmission networks in the department of Atlántico. Under this Tender, the right to build and operate the relevant BESS was awarded to Canadian Solar,[108] which participated through the Colombian simplified corporation Canadian Solar Energy Colombia S.A.S and subsequently created a separate subsidiary called SAEB La Arenosa S.A.S. E.S.P., in the form of a public utility company. Thus, the current beneficiary of the formal award of the construction and operation rights, as well as the right to receive the IAE (as acknowledgement by CREG), for a payment period of 15 years, is SAEB La Arenosa S.A.S. E.S.P. The amount of the IAE to be received annually (through monthly installments) by SAEB La Arenosa S.A.S. E.S.P. is approximately USD 2,783,783.[109] Pursuant to the BESS Resolution, the entity responsible for paying the IAE is the market administrator, XM S.A. E.S.P., through a department known as the liquidator and manager of accounts (LAC, for its acronym in Spanish).

MARKET FEATURES

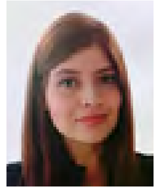
Investors and developers interested in undertaking BESS projects in Colombia, based on the BESS Resolution currently in force, benefit from a very stable regulatory framework that aims to protect their relevant rights, including their right to receive the IAE as compensation during the entire payment period defined in each case under the relevant Tender documents (regarding the first Tender already awarded, this period is of 15 years). Thus, there is no risk of investors awarded a Tender being deprived of their governmentally awarded rights, based on the assumption that they remain compliant with the applicable legal and regulatory obligations.

Furthermore, the fact that, under the regulation currently in force, BESS can only be awarded by the government, through public bidding processes (the Tenders), serves as a competitive advantage because the possibility to participate is not reserved to the "incumbents", understood as agents already operating in the sector and having the de-facto advantage of controlling the market.

As the source of payment of the IAE corresponds to the price of the power, payable by the end users of the public utility (the cost of a BESS being transferred to the regulatory tariff for that purpose), there is stability and certainty in connection with the payment of such IAE to the private entities entitled to receive it.

It is essential to acknowledge and highlight the importance of the BESS Resolution as a first step in the process of incorporating BESS into Colombia's electricity matrix, considering the multiple advantages and uses of BESS. CREG, as regulator, is expected to create new market opportunities to build, operate and use BESS for purposes that differ from the sole mitigation of risks associated with lacking or deficient transmission networks, and this serves as one of the primary outstanding challenges.

An additional challenge is that related to the application of tax, customs and accounting benefits stemming from Law 1715, 2014 (**"Renewables Law"**) to BESS developed in Colombia. As of the date of preparation of this document, UPME has acknowledged that the abovementioned tax, customs and accounting benefits would be applicable to BESS only to the extent such BESS are complementary to generation projects based on renewable energy sources, and thus, BESS destined solely to for the mitigation of risks associated with lacking or deficient transmission networks would in principle not be able to apply the same benefits. Therefore, there is room for improvement associated with a potential amendment of the rules governing the matter, so as to make the development of BESS more profitable within the country.



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108 The set of other agents that participated in this Tender include Engie and Terpel.
109COP 10,300,000,000 converted at an average exchange rate of COP 3,700 = 1 USD.

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