FINANCING

Utility Scale Battery Storage Assets

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Contents

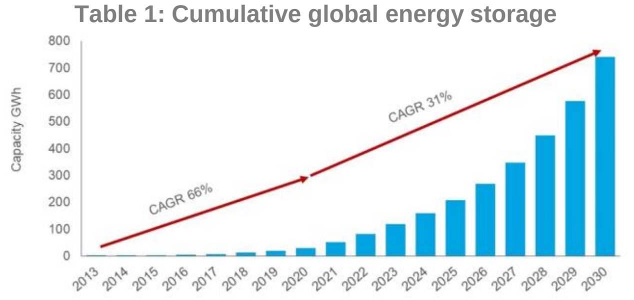
Introduction

The European energy sector has gone through fundamental changes with rapid growth of renewable and sustainable solutions across all industries, responding to a growing pressure from governments to achieve ambitious carbon neutrality targets.

The need for large scale development of battery storage assets has become a hot topic mostly since the 2015 United Nations Climate Change Conference in Paris where nations committed to support a rapid and global transition to renewable energy technologies. Since then, the European Commission has notably placed the offshore wind industry and more broadly renewable energy at the core of its EU Green Deal strategy to support its target of net zero emissions of greenhouse gases by 2050. At each country level, national polices have contributed to facilitate (or limit) the development and the competitiveness of energy storage assets through the implementation of specific market design rules and dedicated support schemes for batteries. Nevertheless a few hurdles still remain.

The ambitious targets are expected to be met by increasing wind and solar generation capacity and its weight in the energy mix. An analysis published by the International Renewable Energy Agency (IRENA) estimates that by 2050 over 80% of the world's electricity supply could be generated from renewable sources, with solar PV and wind power accounting for 52% of total production. As these intermittent sources of electricity generation gradually replace baseload fossil fuel plants (which offer flexibility and stability to grid operators) the importance of batteries grows. Both large scale battery storage and behind-the-meter solutions (including Electric Vehicles), will be important to enable this change, providing services essential to reduce the supply and demand imbalances that arise from increased intermittent energy sources. Researches show that the global energy storage capacity is expected to grow at a compound annual growth rate of 31% in the coming decade and will hit 741 GWh of cumulative capacity by 2030.

Table 1: Cumulative global energy storage



Source: Wood Mackenzie

In this context, the use of battery storage will also be important for countries with less developed interconnection capacity, as it is partially the case for the UK for example compared to other European countries, which explained why storage deployment has particularly accelerated in this country over recent years.

Role of batteries and prospects

Battery electricity storage will play a key role in the world's transition to a low carbon emission energy mix, by storing surplus energy and releasing it, rapidly, when the sun is not shining or the wind is not blowing.

Table 2: Energy Storage Technologies

ELECTRO CHEMICAL ENERGY STORAGE	**Lithium-Ion Batteries**	A battery based on charge and discharge reactions from a lithiated metal oxide cathode and a graphite anode. This battery technology is used in a wide variety of applications, notably for Electric Vehicles.
	Sodium-Sulphur battery	A molten-salt battery made up of sodium (Na) and sulphur (S) that operates at high temperature ranges and is primarily suitable for >4-hour duration applications.
	Redox Flow Batteries	A battery in which energy storage in the electrolyte tanks is separated from power generation in stacks. The stacks consist of positive and negative electrode compartments divided by a separator or an ion exchange membrane through which ions pass to complete the electrochemical reactions.
MECHANICAL ENERGY STORAGE	**Pumped Hydro Storage (PHS)**	PHS is a technology that stores energy by pumping water from a lower to a higher reservoir and then releasing it back through the connection, passing through a turbine(s), which generates electricity. This technology is typically used for grid-scale storage.
	Flywheels	A storage system that relies on kinetic energy from rotor spinning through a "nearly frictionless enclosure" that can provide short-term power through inertia.
	Compress Air (CAS)	This energy storage system is based on using electricity to compress air and store it in underground caverns. The air is released when needed and passed through a turbine to generate electricity.
ELECTRICAL ENERGY STORAGE	**Supercapacitors**	Supercapacitors store energy at the double layer of each electrode separated by a dielectric and can discharge energy instantaneously.
	Superconducting Magnetic Energy Storage (SMES)	Superconducting magnetic energy storage devices (SMES) store electricity in a magnetic field generated by current flowing through a superconducting coil.
CHEMICAL ENERGY STORAGE	**Hydrogen**	Hydrogen energy storage technologies are based on the chemical conversion of electricity into hydrogen. Electrolysis is used to split water (H2O) into its constituent elements, Hydrogen (H2) and Oxygen (O2).
THERMAL ENERGY STORAGE	**Molten Salt**	This technology involves heating the molten salt by the concentration and reflection of solar energy in concentrating solar power (CSP) plants. Molten salt is a non-flammable and non-toxic mixture of 60% sodium nitrate and 40% potassium nitrate.

Source: World Energy Council and (2020) and US Department of Energy (2019)

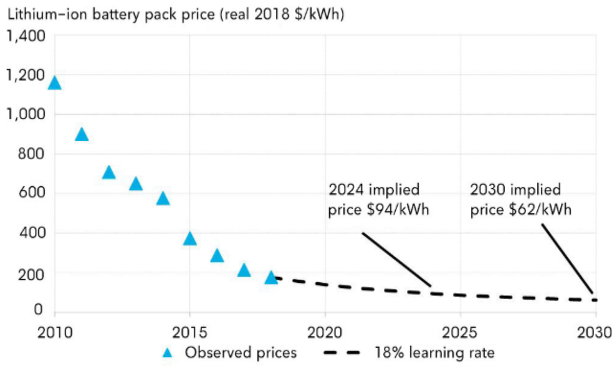
Currently a plethora of technologies is available, each characterized by specific features and advantages which make them suitable for different applications and to compete, on performance and costs, in different market segments. As of today, the available categories of storage technologies can be either chemical (e.g. hydrogen) (refer to the article published by MUFG in July 2020)[1], electrical (e.g. capacitors), electrochemical (e.g. batteries), thermal (e.g. molten salt) or mechanical (e.g. pumped hydro). (Please refer to Table 2 and Annex 1 for more details).

[1] https://www.mufgemea.com/images/mufg/Future_of_Hydrogen_May_2020.pdf

The need for energy storage is not a new concept. Pumped hydro storage technology was the first large scale storage solution developed to shift the electricity supply from times of low demand to times of high demand and reduce generation costs. This technology currently dominates electricity storage capacity, estimated at around 96% in total in 2017. Pumped hydro is a well proven concept and will continue to play a part in storage. Nevertheless the rapid growth of other sources of electricity storage is expected to reduce its share by 50% by 2030.

Amongst the various alternative technologies available for battery storage, Lithium-ion ("Li-ion") is perhaps the most well-known, notably due to its role with Electric Vehicles ("EV"). As of 2017, Li-ion batteries accounted for the largest share (59%) of total operational installed capacity of electro-chemical batteries, and 90% of the large scale battery storage additions. The manufacturing capacity of lithium-ion batteries has scaled from 14 GWh in 2010 to 285 GWh in early 2019 and is on track to reach 777 GWh by 2026. This is compared to Sodium-based batteries the second largest technology having an 8% share. Unlike pumped hydro storage, batteries are flexible in terms of location and scale: there are no specific geological requirements for the storage site and the size of units is scalable, with capacity ranging from around a few megawatt-hours (MWh) to hundreds of MWh.

Table 3: Li-ion battery price outlook



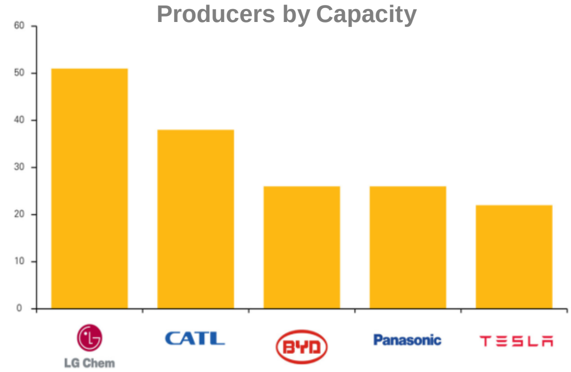
Source: BloombergNEF

One of the drivers of the Li-ion batteries market growth has been the decrease of manufactory costs, from over $3,000/kWh in 1990 to under $200/kWh by 2016 (National Infrastructure Commission, 2016) and $176/kWh (on average) in 2018. This trend is expected to continue and some analysis indicates that the average installed costs of systems could fall to $94/kWh by 2024 and $62/kWh by 2030, driven by optimisation of manufacturing facilities and economies of scale from mass production required to meet the increased demand from electric vehicles.

The envisaged growth in the renewable generation installed capacity will also impact the demand for Li-ion batteries. Li-ion batteries have a shorter response time, as compared to other technologies (such as sodium sulphur and redox flow batteries) which make them more adequate to mitigate short period power fluctuations connected to the renewable sources. A second element contributing to this growth will be the expected improvement in performance. Some experts envisage that the calendar life of Li-ion batteries will increase by 50% by 2030, while the number of full cycles possible could potentially increase by as much as 90%.

The recent announcement of a $1.6bn financing raised by the Swedish battery firm Northvolt to build two lithium-ion battery cell gigafactories in Europe is an additional step toward achieving this goal.

Table 4: Top 5 Lithium ion Battery Producers by Capacity



Source: Benchmark Mineral Intelligence

Additionally Tesla is about to finalise the construction of a fourth Gigafactory which, upon completion (expected in 2021), will be located in Germany and be its first in Europe and the most advanced high-volume electric vehicle production plant in the world. Tesla Gigafactories have been developed to support Tesla's projected vehicle demand which could not be satisfied by the worldwide supply of lithium-ion batteries. The economies of scale help lower the cost of the batteries, and consequently the vehicles themselves.

Actions required for large scale development of battery storage

Whilst the development of large-scale battery storage assets appears fundamental to support the renewable energy transition and the achievement of ambitious decarbonisation targets, some barriers to investment are still to be overcome.

One sizeable obstacle relates to regulatory frameworks and the challenge of securing long-term contracts providing stable revenue streams. For historical reasons, revenue streams for storage assets were designed to suit conventional generation, whereas storage projects have different characteristics. Indeed, conventional plants often provide generation as well flexibility services, with generation being the core revenue source. This contrasts with storage for which flexibility is the driver of all revenues. Also, this element represents a key difference when comparing with solar and wind projects that have historically been financed (largely from non-recourse debt) based on long term guaranteed revenues through Feed-in-Tariff (FiT), Contracts for Difference (CfD) or Renewables Obligation (RO) subsidies.

At present, the main revenue streams for battery projects lie in electricity trading arbitrage and ancillary services. The term “ancillary services” encompasses roles that allow grid operators to deliver a reliable electricity system and comprises for instance Enhanced Frequency Response, Firm Frequency Response, Fast Reserve, Capacity Mechanism and Triads in the UK (please refer to the Appendix 2 for more details on these revenues). These are often based on short term contracts which require frequent re-tendering and expose these projects to market price fluctuation. Nevertheless, one important advantage offered to energy storage systems is the opportunity for “stacking services,” i.e. leveraging the same equipment, system, or process to deliver multiple benefits that maximise revenues. Nevertheless it should be noted that the combination of these streams (called revenue stacking), although possible, can be difficult to achieve from a timing, contractual or technical perspective.

Hence, the variable and volatile nature of the revenues generated from batteries make these assets less suitable to be financed via Project Finance debt which needs to rely on the stability and predictability of cash flow generated by the asset, having no or limited recourse to the sponsors.

On the other hand, from an equity investors perspective, increasing the certainty of the revenue stream by entering into longer term power purchase agreements might be seen as limiting upside and consequently equity returns.

Another challenge, particularly for Li-ion batteries, is that as costs are expected to drop significantly over the next 10 years, a key concern for financiers and investors relates to the competitive environment for these assets are typically based on short term auctioned contracts. Over time, these projects may become stranded as they struggle to compete against improved and less expensive technologies.

To overcome these barriers, changes in regulation may be required. Flexible technologies like batteries will form part of the UK’s smarter electricity grid, supporting the integration of more low-carbon power, heat and transport technologies, which it is estimated could save the UK energy system up to £40 billion by 2050. Conscious of the role played by batteries in balancing the UK’s electricity system during reduction in demand during the COVID-19 pandemic (c.20% of typical levels), the UK Government has recently introduced changes that will boost the ability for subsidy-free renewable power projects to be built in England and Wales by removing barriers for storage projects above 50MW in England and 350MW in Wales. As a result, developers of most electricity storage technologies (excluding pumped hydro) will receive permission to progress projects over 50MW in 8-16 weeks (versus 1-2 years previously). Indeed, the old framework typically meant that developers limited project to 49MW in order to avoid the onerous planning requirements.

Battery Storage in Project Financing

Historically, project financing has played a central role in the large scale development of energy projects, especially in the renewables space. This can notably be explained in light of the high leverage offered by these financing structures on a non-recourse or limited recourse basis which limits the equity requirement and thus boosts the Equity Internal Rate of Return (Equity IRR). Nevertheless, in order to gain access to project financing, developers, with the support of the Regulators, need to create the market conditions that mitigates the risks for lenders.

Considering the situation as of today, two options have been explored: (i) the structuring of hybrid financing mixing project financing and corporate financing and (ii) co-locating batteries with renewable projects.

Hybrid Structure

The revenue structure of battery storage provides limited fixed revenues, which limits the debt capacity of a project to be raised on a non-recourse basis.

One solution MUFG has explored with investors is a hybrid financing consisting of a project financing debt partially guaranteed by the sponsors. In this structure, sponsors would effectively guarantee the re-tendering risk to increase the leverage. However, to test the benefits of this hybrid structure, a developer would notably have to take into consideration all costs associated with project financing which might make this option uneconomical if the debt capacity remains limited. Also, some revenues cannot be added to other types of revenues and asking the project to enter into long term fixed price contracts might exclude the asset from participating in more remunerative contracts and dilute value for investors.

In some jurisdictions the energy dispatch regime is not transparent and/or comprehensive and renewables projects benefit from priority of dispatch while battery storage assets do not. To limit the volume risk for battery projects when the dispatch rules are not clear and/or the volumes are controlled by the capacity purchaser/grid operator it would be key to explore the possibility to put in place warranty arrangements.

Another hurdle to the non-recourse financing of the battery projects is the uncertainty on the evolution of the operational and maintenance cost over the life of the assets. Whilst the technical knowledge of batteries is improving, a key area remains understanding how the assets perform over time, the optimal utilisation regime and the impact on asset life. Indeed, as many battery storage assets remain relatively new in terms of deployment, coupled with a numerous technologies creating difficulties for investors and lenders to identify an appropriate base case.

Key Risks to be considered in Project Financing Battery Storage Assets

- Construction risk
- Technology risks
- Regulatory risk and alignment of regimes
- Operational risks
- Incentive mechanisms
- Market risks
- Counterparty risks

In order to be successful in raising project financing, projects will need to benefit from a solid insurance package and long term warranties, protecting lenders against defects and low performance, similar to the ones which are typically offered for wind or solar assets. Also, the expertise and track record of developers and technology providers would be a strong focus for the lenders, in addition to certification by well-known technical advisors/agencies.

The Future of Co-Located Battery Storage Assets

Electricity storage, ranging from Li-ion batteries to cryogenic systems and compressed air, are a key enabler of a modern low-cost and low-carbon power system particularly when they are located alongside renewable power projects like wind and solar.

Nevertheless, one of the major barriers to retrospectively fitting a battery to a renewable project in the UK has been the lack of clarity as to whether the existing renewable project would lose the renewable benefits it was entitled to.

The introduction of the battery asset in the finance perimeter of a wind or solar project has not been pushed by developers. We understand that the rationale behind their hesitation to introduce batteries is the concern that lenders might apply a discount on the cash flow available for debt service to factor in the uncertainties linked to revenue stacking of the battery asset and charge higher margins to reflect the increased risk perceived.

Despite these barriers, the combination of renewable energy projects with battery storage technologies looks promising around the world. As energy storage enables the project developer to “internally hedge” the risk of curtailment or low or even negative power prices in times of abundant supply or network restraints.

We have seen a battery project in Australia installed alongside a solar farm and to be operated under long term battery storage Service Agreement. The operator/offtaker is entitled to full operational rights as they relate to charge and discharge decisions, in exchange for a fixed payment. Under this structure, the operator/offtaker benefits from the full flexibility and value of the asset, also taking the market risks which are expected to be managed as part of a broader and diversified portfolio.

Conclusion and Outlook

The battery storage market is very dynamic with the development of many technologies such as cryogenic or compressed air, with Li-ion remaining at the centre of the attention as it is likely to dominate the EV market. This success has been driven by rapidly decreasing manufacturing costs which, nevertheless, remain high and has therefore limited economic applications to off-grid markets, transport and, increasingly, behind-the-meter uses. Costs will need to continue falling in order to compete head to head with alternative technologies such as pumped hydro storage or sodium based batteries. In this respect, some experts expect the costs for battery storage to decline as dramatically as they did for solar panels, but whether this becomes a reality remains to be seen.

However some researches show that there are still some progresses to be made to allow battery storage solutions to reach their full potential. All stakeholders in the sector, including regulators and developers, need to align their objectives. Market design needs to evolve to enable the access for new storage service opportunities. In order to enact these changes, studies concluded that developers and policy makers should engage with all the different actors involved, share information, promote research and development and focus on energy storage as an “affordable and deeper” decarbonisation option.

As alluded to in our article on Hydrogen published in July 2020, battery storage is a valuable addition to the energy mix and the transition to a net zero carbon emission economy. Nevertheless in order to flourish at large scale, battery projects will need to secure contracted revenue stream(s) rather than being reliant on the market price for power in order to raise financing against large scale energy storage projects.

We note that governments are mindful of the role that the battery assets could play in meeting low carbon emission targets. Notably, energy storage has played a key role in balancing the UK’s electricity system during the COVID-19 pandemic, ensuring an efficient utilisation of the energy produced. The UK government has recently relaxed planning legislation to facilitate construction of large batteries to store renewable energy from solar and wind farms across the UK. The move could allow for over 100 large-scale batteries to be built across the country, trebling the amount already in operation. South Korea, Italy, and other nations are increasing the availability of financial incentives for storage investment. This reflects the growing awareness of policymakers of the range of benefits battery storage can deliver throughout the electricity value chain.

At MUFG we have been following the development in battery storage market very closely over the past few years and we believe that it will become an important element of the energy mix globally and a key driver in the decarbonisation of the energy production. We expect to see more and more battery storage assets raising project financing as part of a portfolio of generation assets. Nevertheless, some challenges remain to allow standalone battery storage to raise non-recourse financing and we believe that changes in the regulatory framework will be necessary, notably to offer more stable and predictable revenue streams on a long term basis. Until then, we view these assets as good candidates for equity investors willing to hedge their portfolio and able to maximise the value of a battery with a strong expertise in managing the flexible revenue sources.

Highlights

- The ambitious targets of net zero emissions of greenhouse gases by 2050 set by the United Nations Climate Change Conference in Paris are expected to be met by increasing wind and solar generation capacity and their weight in the energy mix.
- Battery electricity storage will play a key role in the world's transition to a low carbon emission energy mix, by storing surplus energy and releasing it, rapidly, when the sun is not shining or the wind is not blowing.
- Energy storage is not a new concept and mechanical solutions, such as pumped hydro, are already well deployed. Meeting the low targets will require the growth of other storage technologies, such as Lithium-ion (Li-ion) are growing rapidly.
- Energy storage capacity may increase with a CAGR of 31% in the coming 10 years and will hit 741 GWh of cumulative capacity by 2030.
- While the benefits of energy storage are clear to the energy community, some investment barriers to the large scale deployment are still to overcome. One sizeable obstacle relates to regulatory framework and the challenge of securing long-term contracts providing stable revenue streams.
- We note that governments are mindful of the role that the battery assets could play in meeting low carbon emission targets. Some governments have notably started to relax planning legislation to facilitate construction of large batteries to store renewable energy.
- At MUFG, we expect to see more and more battery storage assets raising project financing as part of a portfolio of generation assets in the coming years.

Appendix 1: Main energy storage technologies

Technology		Maturity	Efficiency	Response Time	Lifetimes Years	Discharge time	Environ-mental Impact	Current Main Applications
ELECTRO-CHEMICAL ENERGY STORAGE	**Lithium-Ion Batteries**	Commercia-lised	85-95%	ms-secs	5-15	min-hr	Moderate	*Power quality*, arbitrage, RES integration, back up, voltage regulation, network stabilization and expansion, peak shaving*, time shifting*, load leveling*, end-user services*
	Sodium-Sulphur battery	Commercia-lised	80-90%	ms	10-15	s-hr	Moderate	
	Redox Flow Batteries	Early - Commercialised	60-85%	ms	5-10	s-hr	Moderate	*Arbitrage, RES integration, back up, voltage regulation*
MECHANI-CAL ENERGY STORAGE	**Pumped Hydro Storage (PHS)**	Mature	75-85%	sec-mins	40-60	1-24hs+	Large	*Network expansion, peak shaving*, time shifting*, arbitrage, load leveling**
	Flywheels	Early Commercialised	93-95%	ms-secs	15+	ms-15min	Almost none	*Power quality*, RES integration, back up*
	Compress Air (CAS)	Mature	70-89%	mins	20-40	1-24hs+	Large	*Peak shaving*, time shifting*, arbitrage, load leveling**
ELECTRICAL ENERGY STORAGE	**Supercapacitors**	Developing	90-95%	ms	20+	ms-60 min	None	*Power quality**
	Superconducting Magnetic Energy Storage (SMES)	Developing	95-98%	<100ms	20+	ms- 8s	Moderate	*Power quality*, RES integration, network stabilization*

CHEMICAL ENERGY STORAGE	**Hydrogen**	Demonstr a-tion	35-55%	secs	5-30	1-24hr +	Dependen t of H2 productio n method	*RES integration*
THERMAL ENERGY STORAGE	**Molten Salt**	Mature	80-90%	mins	30	min-hr	Moderate	*Energy arbitrage*

*__Power quality__ (Use energy storage to provide a high level of power quality above and beyond what the system offers (e.g. critical load) to some customers); **Peak shaving** (Refers to leveling out peaks in electricity use by industrial and commercial power consumers); **Time shifting** (Energy time shift involves storing energy during low price times, and discharging during high price times); **Load leveling** (Load leveling usually involves storing power during periods of light loading on the system and delivering it during periods of high demand)

Source: World Energy Council and (2020)

Appendix 2: Examples of revenues streams for Battery Storage assets in the UK

Revenue Stream	Description
Enhanced Frequency Response(EFR)	System frequency is a continuously changing variable that is determined and controlled by the second-by-second balance between system demand and total generation. EFR is a fast frequency response product which helps manage frequency, requiring a full response in less than a second.
Firm Frequency Response(FFR)	A monthly electronically tendered service through which National Grid procures energy that can respond within 30 seconds.
Fast Reserve	A monthly tendered market designed to procure large blocks of reserve energy of 50MW to respond within 2 minutes.
Short Term Operating Reserve (STOR)	An important source of reserve energy for National Grid. Procured via 3 tenders throughout each year, a response time of up to 20 minutes is required
Capacity Mechanism	The capacity mechanism is a catch-all term for the auctions for the Capacity Market that National Grid runs to guarantee capacity for any given year. The Capacity Market is one of the main building blocks in the UK Government's Electricity Market Reform (EMR) programme
Triad Avoidance	Reducing consumption at periods where peak winter national demand is forecast, in order to proportionally reduce TNUoS (Transmission Network Use of System) charge.
Wholesale markets arbitrage	Price arbitrage: buying energy cheap on the wholesale energy markets, and then selling when prices are higher.

References

IRENA. (2017) Electricity Storage and Renewables: Costs and Markets to 2030.
http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf

IRENA. (2019) Utility-Scale Batteries: Innovation Landscape Brief.
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Utility-scale-batteries_2019.pdf

European Commission - N° ENER C2/2015-410 Support to R&D strategy for battery based energy storage, Battery Promoting Strategies in Selected Member States – June 2018
https://ec.europa.eu/energy/sites/ener/files/policy_analysis_-_battery_promoting_policies_in_selected_member_states.pdf

Joint Research Center (JRC). (2018) Li-ion batteries for mobility and stationary storage applications, Scenarios for costs and market growth.
https://ec.europa.eu/jrc/en/science-update/lithium-ion-batteries-mobility-and-storage-applications

National Infrastructure Commission. (2016) Smart Power.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf

GE Renewable Energy to integrate UK's first DC-Coupled Battery Energy Storage System at Wykes's Chelveston Renewable Energy Wind-Solar Park, 27 August 2020
https://www.ge.com/news/press-releases/ge-renewable-energy-integrate-uks-first-dc-coupled-battery-energy-storage-system

World Energy Council, Five Steps To Energy Storage, Innovation Insight Brief | 2020,
https://www.worldenergy.org/assets/downloads/Five_steps_to_energy_storage_v301.pdf

Hydro Wires, U.S: department of Energy, Energy Storage Technology and Cost Characterization Report, July 2019
https://www.energy.gov/sites/prod/files/2019/07/f65/Storage%20Cost%20and%20Performance%20Characterization%20Report_Final.pdf

Benckmark Mineral Intelligenge, Who is winning the global lithium ion battery arms race?, January 2019
https://www.benchmarkminerals.com/who-is-winning-the-global-lithium-ion-battery-arms-race

Global energy storage capacity to grow at CAGR of 31% to 2030
https://www.woodmac.com/press-releases/global-energy-storage-capacity-to-grow-at-cagr-of-31-to-2030/

A Behind the Scenes Take on Lithium-ion Battery Prices, 5 March 2019
https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

Everoze, Cracking the Code, a guide to energy storage revenue streams and how to derisk them, July 2016
http://solar-media.s3.amazonaws.com/assets/Storage_Cracking_the_code__1_.pdf