PRIVATE CAPITAL REAL ESTATE | INFRASTRUCTURE INVESTMENT

Investing in battery energy storage systems (BESS)

Opportunities and challenges for grid-scale projects

MACFARLANES

With escalating power demands from AI, data centres and high demand technologies, along with challenges surrounding electrification of energy networks, grid resilience and the emerging prevalence of renewable (but intermittent) supplies, grid-scale BESS are expected to become an integral part of our generating infrastructure.[1] It is forecast that cumulative global energy storage capacity may reach 2 terawatts (7.3 terawatt-hours) in 2035, an eightfold increase on 2025 levels.[2]

In this article, we consider the opportunities and challenges for new grid-scale BESS projects.

Energy storage projects

BESS are rechargeable battery devices that enable energy, particularly from renewables like solar and wind, to be stored and later released when demand for power is called upon. Lithium-ion batteries, the predominant grid-scale technology, have to date had a typical duration of one to four hours when discharging at maximum capacity. As demand for "long-duration energy storage" (LDES) grows, and regulatory incentives are introduced to support investment in such infrastructure, batteries are currently being developed with a duration of upwards of eight hours.

Other different types of LDES project, notably pumped hydroelectric, a mature, established technology, or newer, emerging ones, such as hydrogen storage, can store much larger amounts of energy than current BESS, however these technologies are highly complex to deploy. BESS, on the other hand, is scalable, modular and, with its relatively efficient conversion rate and fast response times (milliseconds), is especially suited to grid stabilization, short-term power fluctuations and smoothing out intermittent renewable outputs.

Uncertainty about public policy has in the past impeded BESS investment, including "double charging" and whether BESS was a hybrid of both an "end-consumer", when importing electricity for storage, and "generator", when discharging it, and so may be exposed to additional network cost. However, governments have taken steps to alleviate concerns, with the UK legislating for electricity storage to be expressly treated as a subset of electricity generation for regulatory licensing purposes.

Opportunity/challenge 1: integration with renewables

BESS projects are commonly configured either:

- to provide independent, "standalone", grid-connected services, not tied to a specific generator or end-user, known as "front of the meter" (FTM) projects; or
- as "co-located" projects, typically sitting alongside a renewable generation plant, operating "behind the meter" (BTM) and therefore allowing stored power to be consumed on-site, with both activities often also sharing grid connection access.

Co-located BESS facilities are important for achieving national governments' decarbonisation targets. For example, the UK's "Clean Power 2030 Action Plan" expects "23-27 GW of battery storage to be needed by 2030 to support clean power", compared to the 4.5 GW of battery storage capacity recorded on publication in late 2024.[3]

Output from renewable plants, like solar PV and windfarms, is unpredictable. By storing the excess electricity that renewables plants produce when the sun shines or wind blows and releasing it at a later point, when needed by customers or demand from them is higher, BESS can effectively balance the supply issues connected to these intermittent energy sources.

By co-locating BESS with renewable assets, developers may be better able to:

- negate or mitigate any issues associated with network capacity constraints (including grid upgrades and connection delays) by sharing a single or an existing grid connection. This can expedite project completion and reduce overall grid fees and any pressure on the distribution or transmission network operators;
- anticipate future operational risks and revenue streams, including smoothing intermittent renewable supplies, avoiding "imbalance costs" (which may be imposed by network operators due to failure to deliver agreed electricity output levels promised to the grid), and "arbitraging" market price fluctuations; and
- jointly coordinate the effective use of land rights and key operational infrastructure, such as shared cabling and transformers.

Issues that need careful consideration when co-locating BESS and renewables assets include, for example, assessing any requirements for revised planning permissions for such combined uses, or any implications for a renewable plant's own direct customers that might require their consent or any renegotiation of any existing corporate power purchase agreements (PPAs). Co-location has in the past raised other concerns for investors, including whether adding BESS with renewables could compromise any regulatory subsidy support the latter may benefit from (for example, in the UK, renewable obligation certificates (ROCs), or contracts for difference (CfD)), but reassurance from relevant authorities has been given recently, including how to manage this in practice (e.g., if deploying separate metering).

[1] Financial Times: How mega batteries are unlocking an energy revolution

[2] Global Energy Storage Boom: Three Things to Know | BloombergNEF

[3] Clean Power 2030 Action Plan: A new era of clean electricity – main report - GOV.UK

> We expect 23-27GW of battery storage to be needed by 2030 to support clean power, a very significant level of increase ... [with] the majority of this increase to come from grid-scale batteries
>
> UK Government's Clean Power 2030 Action Plan

Opportunity/challenge 2: revenue stacking

From a commercial perspective, the distinguishing feature of developing BESS projects, either standalone or co-located, is the opportunity for a single project to pursue revenues from multiple, diverse sources, so-called "revenue stacking". The availability of revenues will depend on the scale of the BESS project, whether it has access to the grid, the status of the local electricity markets and the compatibility of these various potentially competing demands for the project's services. Just as important is the risk appetite that different stakeholders, notably project lenders, may have for future revenue streams where these are linked to more volatile energy market pricing or which have short contract durations.

The main types of business models for combining BESS revenue streams comprise:

- **energy price arbitrage** (buy low/sell high), deploying strategies such as "time-of-use/load shifting", where a battery may charge during off-peak low tariff hours and discharges during peak demand periods;
- **ancillary services**, supporting grid stability and reliability, involving, for example, "frequency regulation", "voltage control", and "spinning reserves"; and
- **capacity market payments** (contracted power availability), which offer longer term, predictable revenues, earned by providing reliable, on-demand capacity to the grid, usually through competitive auctions.

Market location is a significant factor in the architecture of revenue stacking. Industry commentary has highlighted that in the UK and various European jurisdictions, for example, while ancillary services have traditionally offered stable revenues, as more BESS capacity comes online, certain markets have become saturated and margins have been eroded. Energy price arbitrage is currently considered by many commentators to be the most scalable market opportunity for BESS projects, with increased renewable penetration creating a more volatile, and accordingly potentially more profitable, pricing environment, including when trading on "day-ahead" and "intra-day" markets. Dynamic strategic planning is therefore essential, insofar as BESS projects seek to optimise arbitrage gains and maintain capacity for grid services.

However, for BESS projects there may be tension between different kinds of stakeholders, with project lenders having concerns about over-exposure to market price risks, and investor expectations about the levels of return.

Increasingly, for merchant-focused projects, BESS developers are procuring and entering into third party optimisation agreements with third party specialists (optimizers), including utility companies and specialist technology-driven consultancies and trading firms, who offer outsourcing services to maximise revenue streams, including profit sharing and guaranteed minimum income arrangements.

Alongside revenue stacking, offtake contracts, often in the form of "tolling agreements", provide predictable and longer term revenue flows and help "de-risk" the project, making it more "bankable" for project financing purposes. Entered into with a counterparty providing guaranteed payments for rights to control the BESS project's stored output and dispatch, these arrangements replace or supplement more volatile merchant-only pricing strategies. Such agreements can be structured as either physical or virtual (derivatives based) arrangements:

- **physical toll**: an arrangement where a third party (toller) pays a fixed fee for the right to physically control the charging and discharging of the BESS, taking on merchant risk while the asset owner retains ownership;
- **virtual toll**: a financial arrangement where the owner retains operational control of the asset whilst the toller receives the economic benefit (or loss) from the BESS's operations without having physical dispatch control, with settlements calculated as if they made the dispatch;
- **firmed PPA**: a PPA that pairs intermittent renewable generation (such as solar or wind) with a BESS to deliver a more predictable, dispatchable power profile to the offtaker; and
- **revenue share/swap**: a commercial structure where the BESS owner retains full operational control of the asset but agrees to share a portion of its merchant revenues with a counterparty, often in exchange for a floor price or minimum guaranteed payment to reduce volatility.

Opportunity/challenge 3: project development

Developing BESS installations, whether standalone, co-located with renewables, or built to provide back-up power for energy-intensive users (for example, hyperscale data centres), involves complex technical risks and supply chain considerations, and there is no standard procurement model for their design and build. Due to the specialised nature of BESS projects, a more integrated, "full wrap", engineering, procurement and construction (EPC) contract is often preferred by stakeholders, whereby a single party, usually an experienced developer in this sector, is appointed to manage its design, engage with the various technology suppliers and sub-contractors, and oversee the site development. A number of jurisdictions are increasingly seeing a move towards split contracting regimes, and it is common to see such arrangements involving a battery supply agreement with one provider and a separate "balance of plant" agreement with another.

The kinds of risks and considerations that arise when procuring, constructing and operating BESS, given the material up-front capital costs of delivering these assets and the importance for investment plans of then ensuring stable and reliable, long-term performance, include:

- the need to engage premium manufacturers and components suppliers;
- the sequencing of development works, which will require early considerations of project timescales and milestone dates. The interface between when the BESS plant is due to be built and when any grid connection is secured will be particularly critical, and the time that may be required for an independent connection provider to lay the connection route will need to be factored in, as will long lead-in times for the purchase of components. Given the potential for significant delays to project completion, developers and providers will want to build in commercially acceptable limits on the liquidated damages they will be exposed to in the event of such delay;
- complying with requirements for obtaining operator approvals, including an electricity generating licence (unless an exemption may apply for smaller projects), and grid codes and technical standards;
- obtaining the benefit of adequate warranties from battery manufacturers and suppliers, and setting appropriate KPIs and securing performance guarantees and expert support for ongoing operational maintenance, for example under "long-term service agreements" (LTSAs) with specialist providers, including to address critical issues with respect to key performance metrics, such as "round-trip efficiency" (i.e. percentage of energy dispatched compared to that used for charging, for which lithium-ion batteries score highly), as well as capacity retention levels, and planning for future degradation and augmentation of equipment and outputs;
- maintaining robust fire safety controls and emergency response systems, including in order to mitigate the risk of any major "thermal runaway" incident associated with rapid overheating in lithium-ion batteries, albeit such incidents are rare;
- reliance on digital controls for continuing to operate large-scale BESS and management of software obsolescence risks and any cybersecurity threats;
- data sharing, intellectual property and related matters: where BESS projects increasingly rely on such sophisticated digital controls, optimisation algorithms and real-time performance monitoring systems, careful attention must be paid to the ownership and licensing of proprietary software and the operational data generated by such systems. From an intellectual property perspective, developers and operators should clearly delineate data "ownership" rights, particularly where third-party optimisers or equipment suppliers retain access to performance data for their own product development or benchmarking purposes. Competition law considerations may also arise where data sharing arrangements between BESS operators, optimisers and grid operators could facilitate coordination on pricing strategies or market behaviours, particularly where markets may become more concentrated or ancillary services markets experience saturation;
- where BESS services are intended for customers in other national jurisdictions (in particular, within the EU, which is increasingly standardising energy markets), clear understanding of the legal and regulatory position is needed, including under market harmonisation and cross-border trading reforms; and
- given the various challenges described above, management of any disputes which may arise during the construction and operational phases. Contracts on BESS projects typically include dispute escalation provisions such as a requirement for senior representatives to meet and/or to engage in mediation prior to commencing formal proceedings, in order to encourage early and cost-effective resolution. Clear definition of the performance and testing requirements for a project, interfaces between the responsibilities of those involved in delivery, and the contractual consequences of underperformance will all help to reduce the risk of such disputes.

Opportunity/challenge 4: private capital and project financing

The Energy Transitions Commission, a global coalition of leaders from across the energy landscape, has estimated that achieving net-zero by 2050 will require an average annual investment of $3.5tn globally between 2021 and 2050. Securing this investment will require access to a full suite of financing products and structures.

Traditionally, securing finance for BESS projects has been difficult. Whilst battery technology is not new, its track record in the renewables ecosystem is less proven than that of renewable heavyweights such as solar PV and windfarms. When compared to these established renewable energy projects, which are typically backed by long-term PPAs with creditworthy offtakers, BESS projects achieve more fragmented revenue streams, have different operational and technical risks, and are subject to newer and evolving regulation, presenting challenges for these projects as they look to achieve bankability and secure finance. However, notwithstanding this, confidence in the sector is growing, fuelled by increased demand for grid-scale BESS and substantial government support.

Traditional renewable energy financings have typically relied upon contracted revenue streams that span the life of the project, typically 10-20 years or more, to provide project lenders with the predictable cashflows that they require to underwrite debt. By contrast, BESS revenue models, which are centred on energy price arbitrage, ancillary services, and capacity market participation, tend to involve offtake arrangements of shorter duration and thereby suffer greater exposure to wholesale market volatility. Whilst this is improving as revenue stacking allows BESS projects to hedge against financial poor performance and strengthen long-term revenue predictability (see Opportunity/challenge 2: revenue stacking), lenders must still balance merchant risk with the need for sufficient revenue certainty to support debt service coverage ratios.

Case study

Thorpe Marsh BESS project[4]

As projects are increasingly finding ways to strengthen long-term revenue predictability, the sector is attracting growing interest from both traditional lenders and private capital, particularly from infrastructure funds and specialist energy lenders seeking exposure to the energy transition. Indeed, at the end of 2025 US-based fund manager EIG Partners joined the UK's National Wealth Fund in making a £445m equity investment in the Thorpe Marsh BESS project in Yorkshire, the UK's flagship BESS project, alongside debt facilities of £594m from a club of international lenders (ABN Amro, China Minsheng, CIBC, Deutsche Bank, Investec, MUFG, NatWest, Nord LB, Santander, Siemens, SMBC, SocGen and Standard Chartered).

Thorpe Marsh BESS is one of the largest standalone BESS projects in Europe and is designed to store power from North Sea wind farms, supporting the UK's renewable energy goal of shifting to a clean power system by 2030. Key to securing the required investment was the revenue predictability provided by long-term offtake agreements with EDF, Octopus Energy, and Statkraft which cover c.80% of the capacity of the project, and a 15-year UK Government capacity market contract. These arrangements provide predictable cash flows and support accurate forecasting, reducing the risk that the project will not perform.

The capital intensity of BESS projects further shapes financing considerations. Whilst costs are falling (driven by competition among battery suppliers) grid-scale BESS projects require substantial upfront investment in equipment, grid connection infrastructure, and site development, with relatively long payback periods. This high initial capital outlay, coupled with revenue profile uncertainties, has led to the development of various financing and investment structures.

Whilst in the UK, the market generally relies on direct, traditional project finance, equity investment from infrastructure funds, and, increasingly, investment from government-backed sources such as the National Wealth Fund, the choice of financing for a project depends on various factors such as project size, revenue certainty, sponsor creditworthiness, availability of tax incentives, regulatory environment, and lender appetite for technology and merchant risk, and includes:

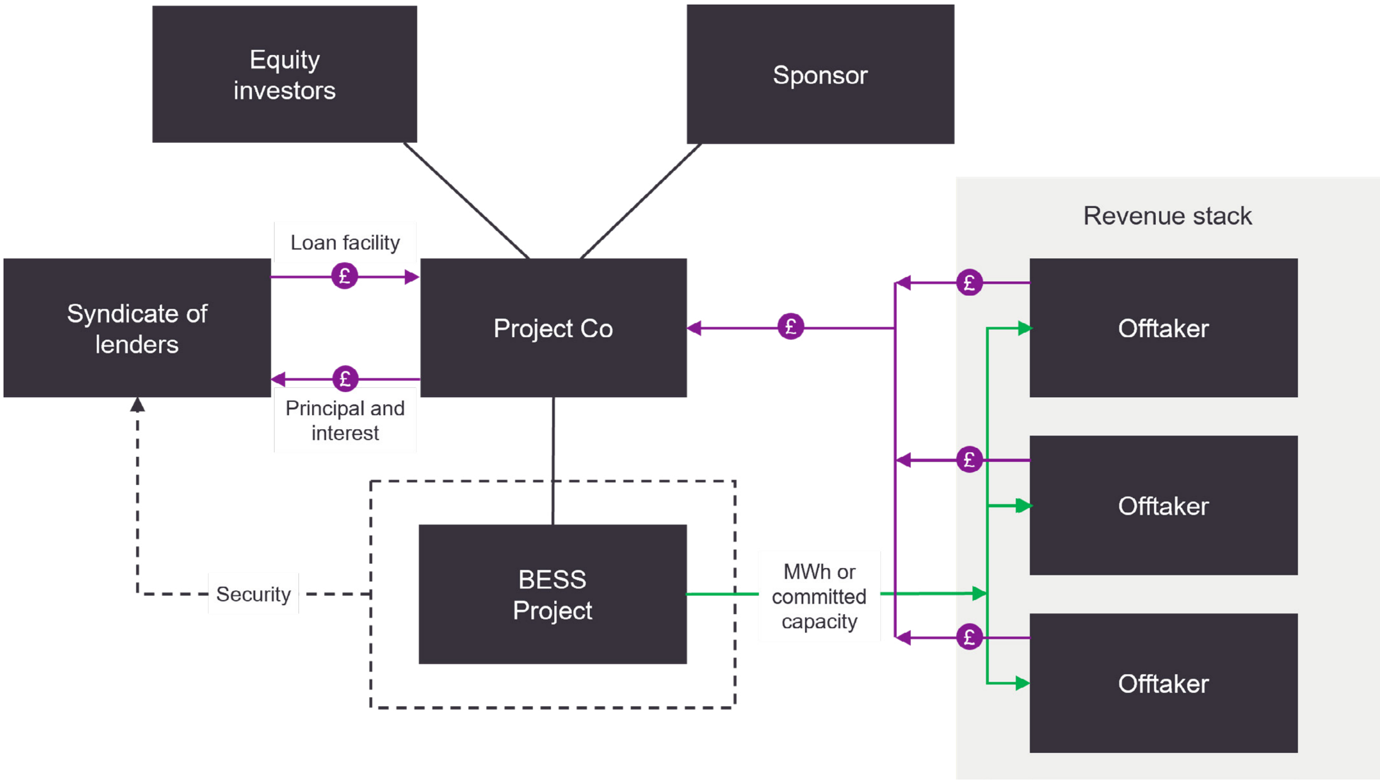
- **Corporate balance sheet funding**: traditionally the financing needs of BESS projects were funded off the balance sheet of the project sponsor, with full recourse to the sponsor's assets and creditworthiness. Whilst often used by smaller or early stage projects, the market has largely shifted away from reliance on corporate balance sheet funding for larger scale projects.
- **Non-recourse project finance**: today, non-recourse project finance is the usual "go-to" for larger, standalone BESS projects or those co-located with renewable generation. Debt is secured solely against the project's assets and future cash flows, with no (or limited) recourse to the sponsor's balance sheet (see Figure 1: Example funds flow).
- **Tax equity financing**: predominantly used in the United States, tax equity investors provide capital in exchange for tax benefits and a share of project returns.
- **Portfolio or Holdco financing**: increasingly common as developers scale up, multiple BESS assets are aggregated into a single holding company or portfolio structure in order to provide more stable, risk-adjusted returns than a single project. Debt is raised at portfolio level, benefiting from diversification of revenue streams, geographic spread, and reduced risk.
- **Blended finance**: typically employed in less mature markets as a means to improve bankability and attract private sector participation, public capital is inserted as first-loss capital or as a guarantee for BESS projects.

It is also vital that owners and operators understand how their transactions are treated for tax purposes and the different VAT treatments that apply to their different revenue streams. Suppliers, customers and projects may well be located in different territories and supplies of both land and electricity can potentially trigger obligations to register and account for VAT outside a business's home territory. Understanding how relevant tax authorities treat the supplies in question (which may be the subject of some inconsistency as tax authority policy evolves to keep up with new technologies) and having in place robust systems to track and meet the business's VAT compliance obligations, will be essential.

> "While the growth of the BESS sector has been market-driven in recent times, with a sharp fall in battery prices, it is increasingly benefiting from more supportive regulatory frameworks and may be an attractive sustainable investment opportunity

[4] National Wealth Fund News

Figure 1: Example funds flow



Opportunity/challenge 5: private capital and sustainable investments

BESS can make a substantial contribution to climate change mitigation by enabling renewable integration and displacing fossil fuel peaking capacity. Hence, it could be an attractive investment prospect for private capital funds disclosing as Article 9 or 8+ under the EU's Sustainable Finance Disclosure Regulation (SFDR), which make investments in sustainable investments. Additionally, other private capital funds, not disclosing under SFDR but otherwise having an impact strategy, could also be attracted to the positive benefits the investment opportunities may pose.

Some of these funds will also be seeking EU Taxonomy alignment, which requires an investment to align with the list of sustainable activities and EU criteria. This depends on the activity, its use case and technical parameters, but storage of electricity is in principle capable of satisfying the "substantial contribution criteria" for climate change mitigation.

However, supply chain diligence and corporate governance remain a key issue for investors, including, for example, to demonstrate compliance with the EU's minimum safeguards and Do No Significant Harm (DNSH) criteria. This entails having robust human rights and anti-corruption controls across mining, processing and manufacturing of battery materials, alongside responsible end-of-use plans, as well as credible evidence on hazardous substances, fire risk, noise, biodiversity and waste handling.

Additionally, from an SFDR and EU taxonomy alignment perspective, funds often struggle with data availability, particularly for lifecycle greenhouse gas metrics and waste indicators. Managers often need negotiated information rights from operators and other third parties which can be difficult to obtain in practice.

If supply chain diligence and stewardship requirements can be met, reducing operational, legal and reputational risk, and the other tests for the various fund-specific criteria are satisfied on a defensible, data backed and evidenced basis, managers may have access to broader pools of LP capital targeting SFDR Article 8+/9 allocations and of those looking to invest in the energy transition, making BESS an attractive sustainable investment prospect for private capital funds across a range of strategies.

Conclusion and regulatory outlook

As grid-scale BESS becomes integral to power generation infrastructure, while its growth has largely been market-driven, it is increasingly benefiting from more supportive regulatory frameworks. Recent policy reforms in the UK, for example, have focused on clearing grid connection backlogs, prioritising the "readiness" and "strategic importance" of applicants, which will benefit sectors like BESS.

Significantly, the UK Government recently introduced a "cap and floor" regime for LDES, which guarantees minimum revenues (covering investment costs) while protecting consumers with a maximum revenue limit, with any profits exceeding such cap being shared. The scheme targets storage technologies capable of discharging for at least eight hours, with the first application window opening in 2025. Ofgem has confirmed that 77 LDES projects have cleared the scheme's "eligibility" hurdle, with lithium-ion BESS dominating this list. Final approvals are expected by summer of 2026.[5]

Looking ahead, the bankability of BESS projects is expected to improve as revenue certainty mechanisms become more standardised and maturing regulatory frameworks provide greater predictability. Careful due diligence and specialist legal and technical advice on business project configuration, revenue stack composition, offtake and optimisation arrangements, technology risk, and the evolving regulatory position, will continue to be essential to successfully developing and investing in these increasingly important infrastructure assets.

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[5] Long Duration Electricity Storage (LDES) window 1 eligibility assessment outcome | Ofgem

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