Solar PV and Battery Storage Colocation
Thought Leadership Series – Part 4

This ITPEnergised insights series examines the techno-economics of solar PV and battery storage colocation projects in the GB (Great Britain) market. The series is arranged with an introduction to battery storage first, then builds from this in the remainder of the series to discuss the key value drivers of additionally including solar PV with battery storage in colocation (*figures are illustrative*).

Part 1 – Battery Storage and Energy Arbitrage
Part 2 – Introducing the Techno-Economics of Solar PV and Battery Storage Colocation Projects
Part 3 – Impact of Wholesale Price Volatility on Solar PV and Battery Colocation Techno-Economics
Part 4 – Key Drivers of Solar PV and Battery Colocation Techno-Economics

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As well as impact investing, developer/ owners of solar PV and battery colocation projects try to define what the commercial strategy and risk-return appetite of a colocation project is from the outset. This could be to generate a higher proportion of returns through a solar PV farm PPA or CfD revenue stream with a smaller capacity battery bringing in a smaller proportion of merchant or uncontracted revenues. Alternatively, some investors may have a larger risk appetite and choose to generate half of the returns through a solar PV farm PPA or CfD revenue stream with a battery sized to capture the remaining half as merchant revenues. Some investors may choose to increase the ratio of battery to solar PV capacity further still. This serves to capture the increasing volatility in the markets and may help to balance potentially lacklustre CfD / PPAs that do not fully capture the extrinsic value of stress events. A colocated battery also supports the continuous need to balance the intermittency of renewable generation in both energy and power quality terms at the point of connection. Colocation also offers potential downside mitigation as a physical hedge to grid constraints and price cannibalisation. The associated techno-economics of colocation projects and optimisation are however complex to analyse and model.

In our analysis of colocation projects, we have made several key learnings. These can shift value towards the solar PV farm, implying more solar PV capacity and less battery storage capacity in the colocation total capacity, and vice versa. Some of the drivers that improve solar PV economics include, but are not limited to:

- **A lower solar PV nominal discount rate** improves NPV;
- **Higher future solar PV PPA/ CfD pricing** increases revenues and returns;
- **Annual, seasonal, monthly, daily variations in solar irradiance levels** with higher irradiance years improving annual cashflows and overall economics;
- **Higher wholesale power pricing** will drive higher returns for merchant solar PV projects with an uncontracted route to market such as a merchant project, a partially merchant project or for periods of a project with a merchant nose or tail;
- **Lower solar PV capex and its capex learning curve** reduces the cost base and improves returns;
- **DC:AC ratio** where the DC capacity drives the solar PV capex and the AC capacity drives the energy exported to the grid and therefore the capacity size under optimum conditions; and
- **Location** will drive a variety of energy yields.

Similarly, the colocation optimisation is subject to drivers that can shift value towards the battery storage, implying more battery storage capacity and less solar PV capacity in the colocation total capacity, with some of the key drivers including:

- **The shape and volumes of solar PV irradiation** is a location effect and is one of the drivers of colocation component sizing of the solar PV farm and battery capacity and duration;
- **The volatility of wholesale power prices** has an impact on battery storage economics. Wholesale power pricing in higher volatility years increases the battery NPV, colocation NPV benefit and increases the optimum battery storage capacity as a ratio of the solar PV capacity. We expect the range of colocation NPV benefit to stay positive for longer in the 2022 wholesale power price case versus the 2021 wholesale power price case for a wider range of battery storage capacities for example;
- **We assume that the pricing of charging energy from the solar PV project is captured by the battery free of charge** when generating above the grid connection capacity. We do not treat the two projects as two separate SPVs so we do not adjust for separate economic boundary conditions other than the ability to use asymmetrical, or different, discount rates. If the lowest daily wholesale power market prices were used instead of free of charge approach the battery storage economics reduce materially;
- **A lower battery nominal discount rate** – symmetrical discount rates can be used but this may depend on the developer/ owner's risk appetite – a higher battery nominal discount rate will push the economics in favour of adding more solar PV capacity and reduce the battery capacity within the colocation project itself from an NPV optimisation basis;
- **Higher battery duration** although this is a trade off with battery capex as the number of battery cells increase proportionally to duration;
- **The specific revenue stream assumptions** relating to non-wholesale power arbitrage revenues such as the balancing mechanism, ancillary services (e.g. frequency response) and capacity mechanism together form the remainder of the revenue streams for the battery and available from independent market curve providers and energy aggregators;
- **Higher volatility of wholesale power price forecasts** increases the frequency of higher quality energy arbitrage opportunities and therefore improve the battery economics;
- **The number of cycles** per day is a trade-off to battery life with more cycling reducing battery life;

- **A higher degree of local grid constraints** may improve the economics for a colocation project;
- **Battery proximity to other larger volumes of intermittent generation** including but not limited to solar PV, onshore wind, offshore wind, large scale heat pumps for industrial applications, EV charging networks and factories with batch production;
- **Reducing battery capex and cell refresh capex forecasts** i.e. a strong EPC learning curve where capex is forecasted to reduce materially over time with an increasing number of non-China domiciled gigafactories versus competition for supply chain from other similar competing products e.g. the global proliferation of EVs;
- **Minimal supply chain competition** with electric vehicle supply chain would help battery capex and therefore battery economics; and
- **Additionally for transmission connected colocation projects, Transmission Network Use of System (TNUoS) charges** will apply and for some combinations of technologies in different Generation Zones can either increase or reduce TNUoS charges versus a standalone solar PV project.

Whilst colocation optimisation can be focussed on the upside economics, colocation can also be about downside risk mitigation. Battery storage can potentially act as a physical hedge against increasing cannibalisation of wholesale power price when there is excess solar PV and/ or wind as conditions approach Net Zero and periods of coincident low demand. A colocated battery in this situation can time shift energy, and therefore and importantly value, into higher priced periods. This might be applicable if the colocation project is fully merchant, partially merchant or has a merchant nose or tail. In terms of the bigger picture, both standalone and colocated battery storage are vital to the energy transition to net zero. They are readily available and affordable technology today that help to balance the grid in energy and power quality terms as thermal generators are removed from the system.

Battery storage can also help diversify the revenue streams with potential upside from a strongly growing balancing market in addition to a solar PV contracted PPA or CfD. We note that the National Grid Balancing Market (BM) has grown approximately 4x from c £1billion in 2019 to c £4billion in 2022 but intermittent renewables did not grow at that same rate.

The colocation optimisation sizing configuration comes down to both analysing the impact of reasonable assumptions about the future but also your fundamental beliefs of how the market will evolve when approaching net zero end state conditions. ITPEnergised is here to help you navigate this complex techno-economic landscape.

To find out how we can help you with your colocation projects and portfolios:

- **Optimise the size your colocation project with corresponding techno economic KPIs;**
- **Support your colocation grid connection;**
- **Carry out solar PV energy yield assessments;**
- **Support environmental permitting; and**
- **Provide accompanying due diligence services,**

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