Has 2021 changed the outlook for battery storage investment?

2022

Contents

Executive summary

2021 was a landmark year for battery storage, with pipeline capacity reaching over 20GW.

Record high day-ahead and balancing prices, driven by tightening gas supply and system margins, together with new frequency response products resulted in significant profits and fuelled investor appetite for storage. This is from both a commercial perspective and a renewed certainty that batteries have a key role to play on the road to net zero. Meanwhile, the optimiser market boomed, giving simple routes to market for battery owners, lowering the barrier to entry for investment. Platforms, such as LCP Enact, allowed owners and investors to compare the performance of optimisers through leaderboards and deep dive into their trading strategy, which has further increased confidence in this space.

But do batteries remain investible over the long-term?

There is no doubt that battery storage has a key role to play on the route to Net Zero, to handle an increasingly intermittent system. However, there's also very little doubt that the battery market is experiencing a boom at the moment and whilst there are many factors that affect returns, cannibalisation of revenues as a result of over-build versus the fundamental requirement for storage is a growing risk.

In this report, we take an in-depth look at the fundamentals of the key revenue streams available to batteries, including energy arbitrage, balancing, frequency response and capacity provision. We discuss how we believe these revenue streams will evolve over time, how susceptible they are to cannibalisation and how this impacts the 'sweet spot' of battery duration to build.

We also note two key changes for securing financing for assets that were reiterated over 2021: that **volatility** is a core component of the revenue stack and must be bankable, rather than being treated as a cherry on top, and that **securing finance** for assets using curves should now firmly be considered a remnant of the past (for all technologies but particularly batteries). There are too many uncertainties within a given scenario to provide a general power curve of any use given how variable captured prices and revenue stacking opportunities are. Even asset specific projections have a great deal of uncertainty, requiring a more sophisticated approach, which we discuss in this report.

We conclude that while there are a range of uncertainties facing battery storage, and investors must be aware of how the market will change significantly over the asset's lifetime, we remain cautiously optimistic about the potential for battery storage in GB.

1

Batteries were well placed to capitalise on record energy prices

Energy prices were a dominant headline in 2021. A backdrop of rising gas prices and tighter margins saw: day-ahead prices reaching **over £1,800/MWh**, balancing prices reaching **over £4,000/MWh**, the 10 most expensive days in the balancing mechanism ever observed all falling within a few months, nearly 30 suppliers exiting the market and Ofgem raising the price cap by 54%. At the same time wind power was curtailed on 54% of days, over 2.3TWh of wind energy in total, mainly due to network constraints. This low-cost clean energy could have been stored, used to power over half a million homes and reduce household bills.

While the news was poor reading for consumers, these events provided a clear signal of how battery storage is able to capitalise on volatile market conditions at times of system stress. Their ability to store power and shift load will allow a greater deployment of renewable energy onto the system aiding the transition to net zero.

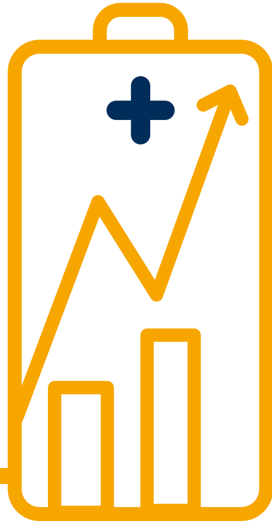
Longer duration storage is required and we are seeing a shift in the market at the moment towards batteries with a duration of 2 hours or more. These have a greater ability to capitalise on volatile intraday price spreads and benefit from being less heavily de-rated in the Capacity Market (CM) than shorter duration batteries. In this report, we look back at 2018 through to 2021 and compare the revenue stacks for both 1-hour and 2-hour duration batteries and quantify the greater returns longer duration batteries can provide.

2

System margins remain tight but additional storage could significantly reduce balancing costs

Faster than anticipated nuclear closures (Dungeness B and Hunterston B), upcoming closure of coal plant (Drax – 1.3GW, West Burton A - 2GW) and the continuing loss of the Calon CCGTs (2.2GW) mean that system margins remain tight and energy prices volatile. With limited options **scarcity** has become a significant factor in determining bid and offer prices in the Balancing Mechanism (BM). Balancing costs soared in 2021, adding an additional **£860m** to the consumer bill vs the costs of 2020, and has sparked NGESO to launch a review into the BM.

However with an extensive battery pipeline the scarcity rent apparent in the BM could be significantly reduced. In this report we explore just how much storage capacity is required to meet GB's balancing requirements and how at risk from cannibalisation storage revenues in the balancing market are.



3

Frequency products proved lucrative but hybrid approaches of entering both frequency and energy markets can yield greater returns

Decarbonisation of the power sector is gathering pace following the COP26 conference, with the UK government committing to Net Zero in the GB power sector by 2035. The system will become increasingly dependent upon intermittent generation and must operate with much **lower levels of inertia** than seen in previous years. With its ability to respond quickly, to sudden changes in frequency in either direction, battery storage has a crucial role to play in securing the power system and enabling this transition.

Prices for Dynamic Containment (DC), the first of a new set of frequency response products aimed at securing the future system, remained high, at the price cap of £17/MW/h, across the majority of 2021 as the market remained undersupplied. During this time however, we observed some optimisers occasionally foregoing secure frequency revenues to chase more lucrative energy market opportunities, and those that did were able to outperform the market. Later in the year prices dropped following revisions to the volume requirement and enabling of bidding for shorter duration 4-hour contracts (or EFA blocks), allowing batteries to enter both frequency and energy markets on the same day, but remained lucrative at £13/MW/h on average.

Whilst attractive, a frequency only strategy can be sub-optimal. In this report we show the importance of following a hybrid approach **optimising across both frequency and energy** markets.

4

Co-location a viable option with grid connections at a premium

Finding spare firm grid connection capacity is becoming increasingly challenging. It is therefore important to make the best use of it to maximise returns. A common business case is co-location, siting solar PV with battery storage and **saving on the connection costs** that would otherwise be incurred. There are two key questions: what is the optimal capacity ratio of solar to battery for a given connection and what impact is there on revenues due to being unable to export fully from both assets simultaneously.

5

Capacity Mechanism provides bankable long-term revenues for investors

3.3GW (1.03GW derated) of new battery storage capacity **cleared** in the Capacity Market (CM) T-4 auction for delivery in 2025-26, at a record price of **£30.59/kW-yr** (derated). This included over 1.6GW (0.65GW derated) of new build 2-hour battery storage, signalling a shift to longer durations. Whilst CM revenues are typically lower than those in other markets (even with this record price) they provide a bankable long-term return for investors in new build battery assets.

7 lessons from 2021 (continued)

6

Leaderboards gave greater transparency on storage market strategies, but don't tell the full story

Interest grew in the LCP Enact leaderboard to benchmark storage optimisers and assets. The leaderboard allows users to quickly identify the relative scales of returns optimisers were achieving and the types of strategies employed (frequency only, price arbitrage only or a hybrid of these).

Leaderboards are a tempting way to bring together a vast amount of data into a simple ranking, however as we discuss in this blog, they can only show so much. They cannot show revenues only visible to the optimiser, such as intraday optimisation, forward hedging or buying back of a position. As such we strongly believe leaderboards should be taken with a pinch of salt, particularly as **revenue opportunities and trading strategies become more complex** in the future.

It will be crucial to go 'beyond the leaderboard' and identify how and why assets operated as they did.

7

Generalised power curves became irrelevant given unprecedented market volatility

The market changed fundamentally in 2021 and those using generalised power curves for both near-term trading and hedging and long-term investments were caught out. Short-term scarcity, a changing capacity mix and multiple pathways to reach net zero by 2035 mean that past behaviour is not a good indicator for future revenues.

As an example, whilst the **frequency of low and zero priced periods increases as renewable capacity grows**, this excess power can not only be stored by batteries but also be transported by interconnection to foreign markets or converted into hydrogen by electrolysers. Levels of interconnection, the pace of decarbonisation in foreign markets and the proliferation and support of a hydrogen economy and other forms of long-duration storage will impact the amount of low price periods and price spreads overall.

With output from wind being so variable a single scenario cannot capture the range of possible outcomes. Stochastic modelling, taking into account weather variability across GB and overall demand uncertainty is required to assess the most likely range of returns.

Impacts to single markets will result in a shifts in trading and investment strategies as operators look at the opportunity costs of participating in other marketplaces. Routes to reaching net zero vary with competing factors such as a centralised versus decentralised grid, the role of hydrogen and electrolysis versus gas-fired generation with carbon capture and storage, levels of nuclear and interconnector capacity, all yielding differing outcomes.

Fundamental modelling of the electricity market is required to reflect these complexities.

Arbitraging the market

Batteries make money in energy markets by shifting energy from low to high price periods. The greater the difference in prices the larger the profit for a battery. Whilst batteries can charge and discharge multiple times a day, the high levels of cycling will impact the performance and lifetime of the asset. Typically, battery cells require replacement after 6,000 – 10,000 full cycles. A strategy involving high levels of cycling may yield greater profits in the short-term but limit the expected lifetime of the battery.

We consider the markets batteries are likely to engage in intraday price arbitrage, the wholesale day-ahead and intraday markets, and the Balancing Mechanism (BM).

A battery will set its initial running profile at the day-ahead stage based on the day-ahead price shape, charging when the wholesale price is at its lowest and discharging when the price is highest. Consideration is needed for the outturn Balancing Services Use of System (BSUoS) charge, which differs from half-hour to half-hour and batteries pay when discharging. National Grid ESO (NGESO) uses this charge to recover balancing costs and, given the current record highs, an accurate forecast is key to fully maximising revenues.

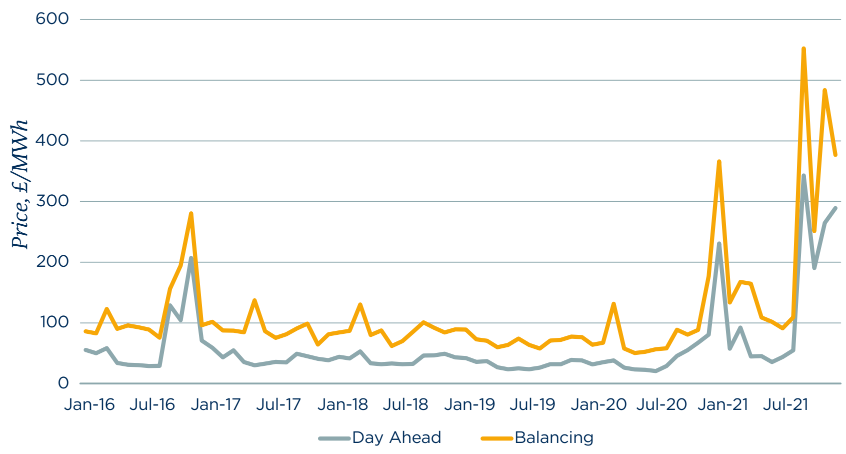
There are then two opportunities to re-dispatch, firstly in the intraday wholesale energy market taking advantage of price movements due to changes in demand and generation forecasts, and secondly in the BM.

Through the BM NGESO issues instructions, accepting bids and offers from participants, to turn down and up power to resolve the Net Imbalance Volume (NIV) to ensure supply meets demand in real time. Batteries can adopt 'NIV chasing' approaches to arbitrage the BM.

Price spreads over the last year have been especially attractive (as shown on the chart), with high gas prices and tight system margins leading to high intraday spreads.

> *Spreads in the balancing mechanism have been extremely high and volatile, with cashout prices over the peak of the day reaching as high as £4000/MWh*

Intraday price spread (monthly average)



We expect spreads to fall from these levels as gas prices return to more normal levels in the coming years and more competition enters the market. [Ofgem's recent open letter] addressing high balancing costs may apply some pressure on generators but so far prices following its publication remain high.

But in the longer term, as the system continues to decarbonise, wholesale and balancing prices are likely to become more volatile. During periods of high wind or solar output prices will become very low, and when there is sufficient low carbon generation to cover demand day-ahead prices are likely to drop to zero[1] and BM prices to negative levels (assuming no further changes to market rules). Conversely, in low wind periods prices are likely to be driven higher as flexible units are required and will need to recover start costs over fewer periods.

A shift to a system driven by wind patterns will mean less predictable running profiles for the flexible fleet. In addition, as high and low wind periods can last many hours (or even days), there will be greater arbitrage opportunities for storage with longer durations. **We are already seeing a shift in focus from 1-hour to 2-hour duration systems, and we would expect this trend to continue.**

Above all, the changing nature of the system means that valuing market volatility is not just a cherry on top of an asset's 'fixed' revenue streams but is a core piece of the puzzle, and understanding how 'bankable' volatility is, and how sensitive it might be to different market forces, is crucial.

[1] The new Contracts for Difference (CfD) rules mean wind and solar plant procured from Allocation Round 4 (AR4) onwards are unwilling to bid below zero, as they cannot receive support payments when day-ahead prices are negative.

Battery Trading Strategies

The individual trading strategies of batteries vary from unit to unit, but a key factor in each one's approach will be its duration – a measure of its energy storage capacity in terms of the number of hours of full discharge that a battery is able to store.

Historically, most battery capacity has been reserved for frequency response, with batteries being able to fulfil the stringent technical requirements of the Dynamic Containment market (and before it Enhanced Frequency Response). Since the actions required are not required over a long period of time, shorter (1-hour or less) duration batteries are typically used for this. However, as we see more battery units competing directly in the wholesale and balancing markets, 1-hour duration units tend not to have enough storage capacity to take advantage of the longer streaks of high and low prices. This gives **significant advantages to longer duration 2-hour batteries**, that possibly outweigh their greater installation costs.

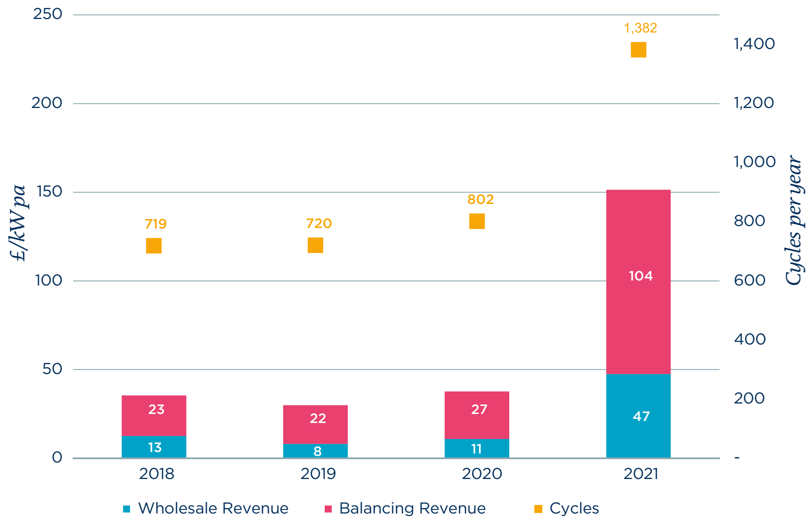
To demonstrate this, we explore the potential wholesale and balancing revenues of a 50MW unit, based on historic prices from 2018-2021, modelled using the LCP Battery Optimisation Model.

We assume that all of the battery's capacity enters these energy markets, and assume there is no impact from other competition (i.e. using the historical prices as they were). We model both 1-hour and 2-hour durations and assume a round trip efficiency of 90%, depth of discharge of 95% and an availability of 96%. We assume that the batteries only cycle to capture a minimum level of return, to avoid wear and tear, aiming to target roughly 2 cycles a day on average (though cycle more in 2021 when returns are much higher).

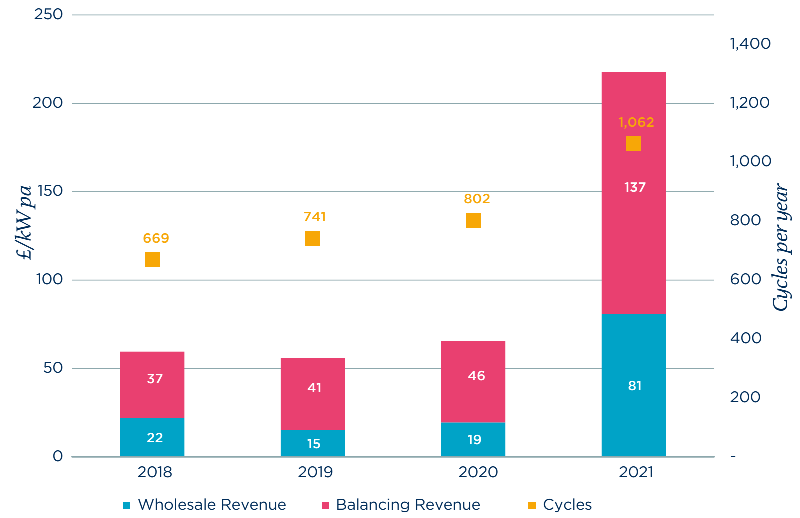
As would be expected, the extreme prices we have seen across 2021 have resulted in greater price spreads leading to greater battery revenues in both the balancing and wholesale market. Due to the greater level of volatility the total number of cycles increases for both units with the 1-hour battery cycling well over three times a day.

Across the 2018 to 2020 period the 2-hour battery averages **£60/kW** pa and the 1-hour battery **£34/kW** pa. The 2-hour battery is able to capture longer paystreaks, arbitraging the highest and second highest priced hours of the day, to make almost but not quite double the revenue of the 1-hour battery. Lower cycling rates reduce the level of degradation to the battery extending asset life and delaying the need to refurbish the site with replacement cells.

1-hour battery revenues



2-hour battery revenues



Balancing the system – how much battery storage is needed?

Currently, gas generation provides the vast majority of BM volume (78% of energy action volume in 2021), making the market particularly exposed to high gas prices. This has meant there has been the potential for large profits for battery storage in the BM recently, with intraday spreads of over £1,500/MWh.

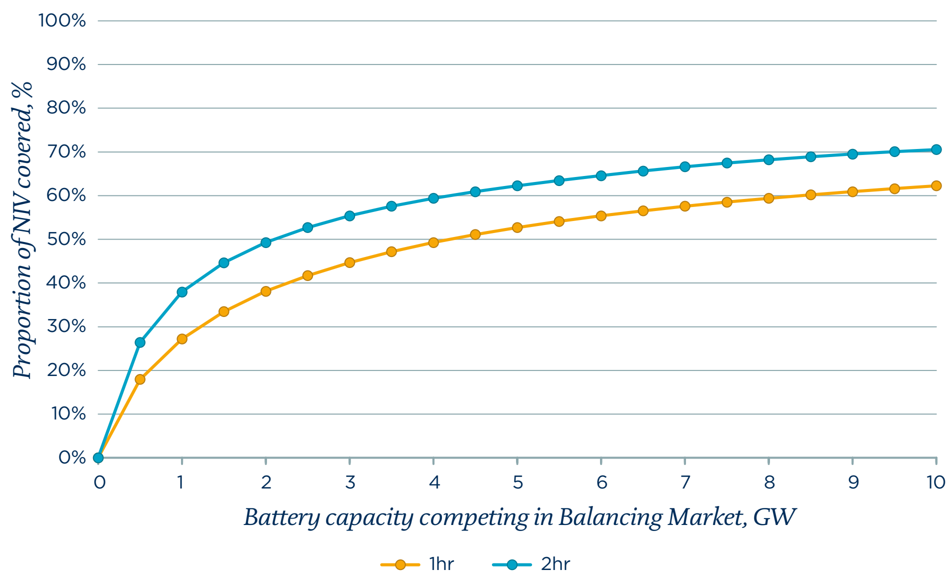
However as more battery storage enters the market, the amount of volume that each unit can expect to satisfy will reduce. On top of that, as other units aim to charge at low prices and discharge at high, the price spreads seen each day will begin to shrink. **Competition and the impact of cannibalisation** of price spreads is important when assessing future revenues.

With the 2025/26 T-4 auction seeing over 3.3GW of battery storage capacity clear, the competition is going to dramatically increase. For context, only 1.7GW prequalified for the previous T-4 with just under 700MW clearing. The impact this will have on the BM and the margins available will depend on the proportion of NIV that the total storage capacity is able to cover. If the storage capacity alone can cover the entirety of the imbalance volume, then we would expect storage actions to reduce balancing spreads down to that of the wholesale market, reducing the profits available.

To gauge at which point storage could saturate the BM we used the LCP Battery Optimisation Model to model the proportion of NIV that could have been satisfied by varying durations and volumes of storage if solely acting for that purpose (ignoring price). We have used the historic NIV data from 2018-2021 to perform the analysis. While normally a large proportion of storage capacity would be reserved for the wholesale market or frequency response, here we are modelling units as submitting their entire capacity into balancing alone. The chart to the right shows the results for fleets comprised fully of 1-hour and 2-hour duration batteries.

4GW of battery storage competing the Balancing Mechanism (BM) could cover more than 50% of the total Net Imbalance Volume (NIV)

Proportion of NIV potentially fulfilled by storage



From these results, if we had 4GW of battery capacity that was solely competing in the BM, we could see storage covering more than **50% of total NIV** while averaging less than 1 cycle per day. This will reduce the BM (and ultimately the consumers) exposure to high gas prices, but will also supress the margins achievable for battery storage. However, if this amount was increased to 10GW, battery storage could only cover around 70% of NIV, leaving the remainder to be covered by other types of flexible generation and/or demand-side response.

This analysis is relatively simplistic. NIVs in the future may grow larger as the wind fleet increases significantly, and batteries will operate to arbitrage prices rather than reduce imbalance volumes. However, it highlights the potential role that batteries can play in the BM, and also the potential risk to battery storage's BM revenues from cannibalisation. It will be important for battery storage investors and operators to assess the full range of revenue streams available, and to factor the impacts of competition in each of these markets into their revenue forecasts.

Frequency response

Until now, the vast majority of battery storage capacity has been allocated to providing Frequency Response. Battery storage's fast response times and ability to be on standby to provide flexibility in both directions without incurring significant cost mean they are ideally suited to these markets. However, Frequency Response markets are relatively shallow and we expect that they will become saturated this year.

National Grid ESO (NGESO) has been rolling out new Frequency Response products and will continue the roll-out of the new product suite in 2022 whilst phasing out all legacy services apart from Mandatory Frequency Response (MFR).

Dynamic Containment (DC) is the newest service and has provided lucrative revenues to battery storage assets over the past year. It requires participants to provide power in under one second when the frequency deviates from 50Hz by more than 0.2Hz. Initially introduced as a low frequency (DC LF) service in October 2020 a corresponding high frequency (DC HF) service was added in September 2021.

Procurement rules have recently changed from a pay-as-bid auction for 24-hour contracts to a pay-as-clear auction for 4-hour (EFA block) contracts, and the flat price cap of £17/MW/h has been revised to vary by EFA block. The requirement is set by the largest single generation loss on the system and level of forecast inertia.

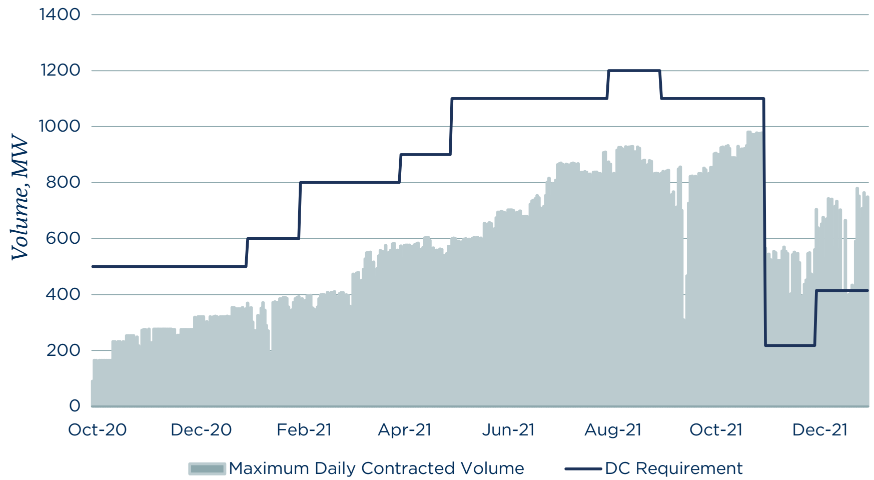
Increased competition will likely lead to a fall in DC LF clearing prices as the level of returns becomes consistent with those from the energy markets.

The DC LF service has historically been undersubscribed, with prices being set at the price cap. With NGESO's median requirement for the next year of c. 600MW and maximum requirement of 1600MW, DC LF is set to become oversubscribed this year. This increased competition will likely lead to a fall in DC LF clearing prices as the level of returns becomes consistent with those from the energy markets (as this represents the opportunity cost of holding capacity out of energy markets to provide frequency response) – unless power prices remain at elevated levels.

In the DC HF service, the volume requirement is set by the single largest demand loss which will be the North Sea Link (NSL) interconnector once it reaches full capacity of 1400MW, with a requirement for the top quartile of hours in April 2022 of 1GW forecast by NGESO. As participation in the auction has increased clearing prices have reduced falling from £12/MW/h in November 2021 to £2/MW/h in December.

The legacy **Enhanced Frequency Response (EFR)** service, where participants respond in under one second when the frequency deviates from 50Hz by more than 0.05Hz and receive a payment of £7-12/MW/h, comes to an end in April 2022. These providers will enter the DC market adding 200MW of further competition.

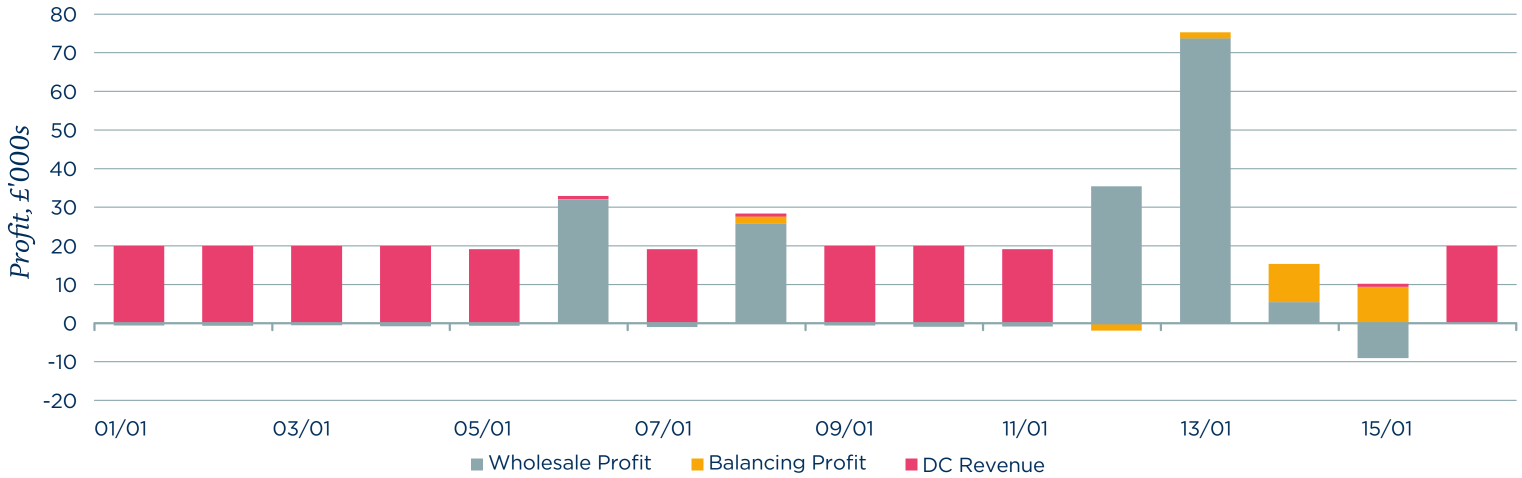
Low Frequency Dynamic Containment Volumes



Frequency response continued

Whilst DC revenues have been lucrative, opportunities in the day ahead and balancing markets can be greater. A hybrid approach, picking between energy and frequency markets, is likely to be necessary going forward, and yield higher returns than a frequency only approach.

a) Plant profits for a single battery asset in the first two weeks of 2021 as shown on [LCP Enact](), where exiting Dynamic Containment and chasing wholesale allowed for greater returns.



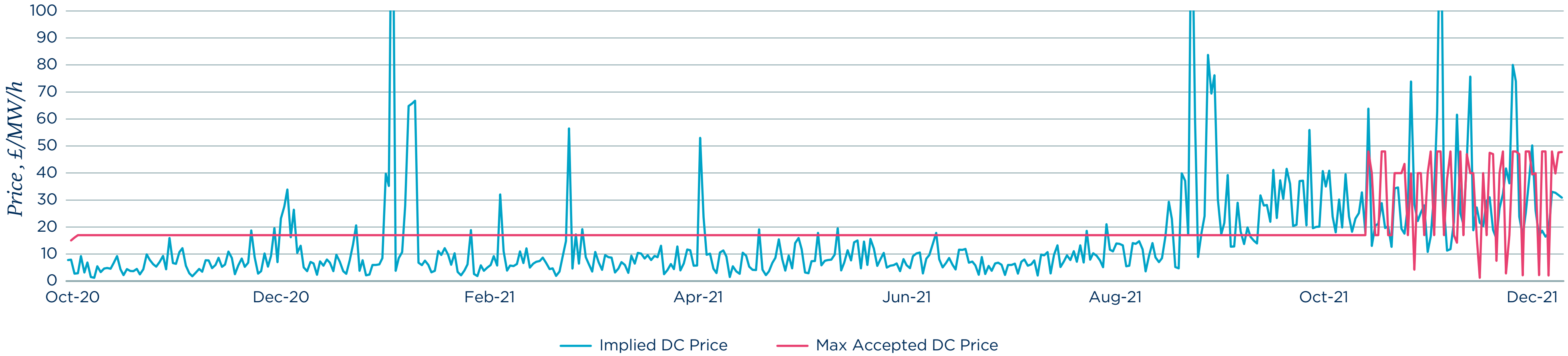
b) The leaderboard for January 2021, where the assets who also participated in wholesale and balancing were able to outperform the DC only strategy.

		Profit (£)						Profit (£/MW/h)					
Capacity (MW)	Max FPN (MW)	Net	Balancing	Wholesale	DC	FFR	STOR	Net	Balancing	Wholesale	DC	FFR	STOR
49.0 (-49.0)	49	671,151	21,427	150,217	499,506	-	-	18.41	0.59	4.12	13.7	-	-
41.6 (-41.6)	36	558,698	-3,206	76,791	485,112	-	-	18.03	-0.1	2.48	15.65	-	-
50.6 (-51.3)	49	613,295	-	-6,093	619,387	-	-	16.31	-	-0.16	16.47	-	-
7.1 (-7.1)	7	82,010	2,129	48,695	18,445	12,741	-	15.48	0.4	9.19	3.48	2.41	-
20.0 (-20.0)	20	225,811	19,022	58,583	148,206	-	-	15.18	1.28	3.94	9.96	-	-
50.0 (-50.0)	10	455,485	-	64,705	-	390,780	-	12.24	-	1.74	-	10.5	-
4.0 (-4.0)	3	33,641	-	-1,288	-	34,929	-	11.3	-	-0.43	-	11.74	-
49.0 (-49.0)	49	278,786	-	-1,255	-	280,041	-	7.65	-	-0.03	-	7.68	-
49.0 (-20.3)	19	246,161	-	21,353	224,808	-	-	6.75	-	0.59	6.17	-	-
10.0 (-10.0)	-	49,130	-	-	49,130	-	-	6.6	-	-	6.6	-	-
49.0 (-0.8)	16	197,398	29,121	168,277	-	-	-	5.41	0.8	4.62	-	-	-
49.0 (-7.4)	2	86,162	579	-97	85,680	-	-	2.36	0.02	-	2.35	-	-

Though DC prices (at least up until November 2021) were set to the cap of £17/MW/hr, we can estimate what they would have been if the cap was not in place and the market was not undersubscribed.

We have calculated an implied DC price, based on the lost opportunity of entering the energy markets, for a one-hour battery. During the DC price cap period the DC market often gave the greatest returns. However there were periods where energy markets would have provided far higher profits. From September 2021 energy market revenues regularly exceeded those from DC until changes to the requirements and the price cap (increased to £48/MW/hr at peak) at which times DC prices began to equalise.

Implied DC price (daily average)



The pre-fault **Dynamic Regulation (DR)** and **Dynamic Moderation (DM)** services launch in March and April 2022 respectively. Unlike DC these are symmetric services requiring providers to both increase and decrease output to maintain frequency at 50Hz within ±0.2Hz boundary.

- DM respond within one second, sustain response for at least 30 mins
- DR respond within ten seconds, sustain response for at least 60 mins

The total market size for pre-fault response is expected to fall following their introduction due to the increased efficiency of the new services. Legacy auctions for Firm Frequency Response (FFR) will be phased out, the weekly FFR auction trial having already ended in November 2021 with the monthly FFR auctions to follow.

Mandatory Frequency Response (MFR) will remain within the NGESO toolkit until DC, DR and DM are able to be procured intraday.

Co-location

One option available to battery storage developers is co-location with other types of generation. With grid connection capacity at a premium, making the best use of this capacity and spreading connection costs over a larger revenue base becomes increasingly important.

Co-locating battery storage with solar PV is the most common business case. It is particularly attractive because solar uses a relatively small proportion of the grid capacity and battery storage can optimise its operation against this profile. The key trade-off (relative to locating the two assets separately) is whether the savings from the sharing of grid connection costs outweigh the revenues lost from both assets being unable to export at the same time during times of high market prices.

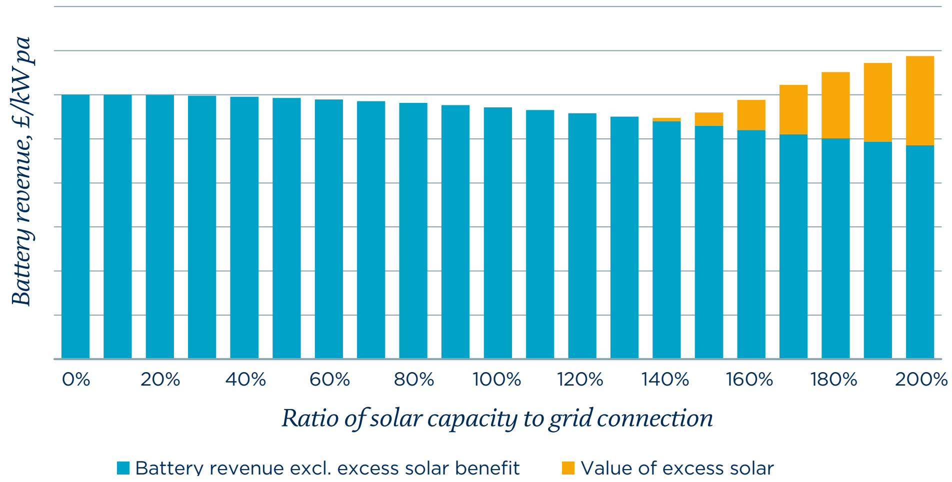
Key considerations for developers will include:

- How the solar capacity should be sized. It is potentially desirable to over-size relative to the export capacity more than in a standalone system due to excess solar generation being utilised by charging the battery.
- Understanding the level of revenue cannibalisation (between the co-located solar and battery) and if the trade-off result in a net benefit relative to two standalone systems.

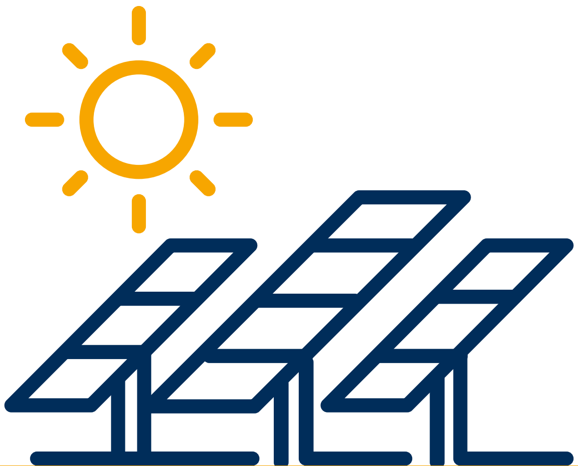
The outlook on both of the above two points improves as solar penetration in the wider market increases, and market prices are depressed when solar output is high, meaning the co-located battery can charge when the solar PV is generating.

The following chart shows an example of how the revenues for a battery change given a fixed battery and connection capacity. As solar capacity is increased from zero we initially see a slight dip in battery revenues as the battery is forced to charge and discharge sub-optimally. There is then a rise when solar capacity becomes 40% greater than that of the battery and grid connection as solar generation that would otherwise be curtailed is able to be stored and exported for a net gain. The 'sweet spot' then depends on the additional fixed OpEx and CapEx incurred due to the oversizing for the particular site considered.

Illustrative example: Impact of solar capacity sizing on co-located battery revenues



For co-located assets sited behind-the-meter with onsite demand there are further advantages in being able to reduce exposure to non-commodity charges. For example, storing solar generation through the middle of the day and exporting over the peak of the day reducing the total red-band charge incurred.



Capacity Market

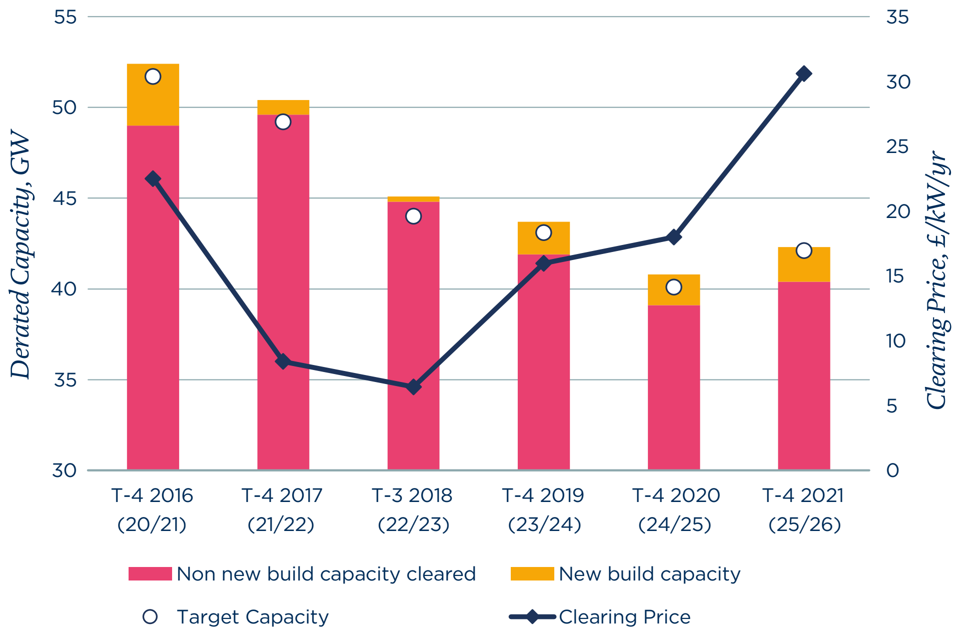
Despite the record recent clearing prices, capacity revenues remain a relatively small slice of the pie for a battery storage asset's overall revenues, with limited duration systems heavily derated in the GB Capacity Market (CM). However, as the focus shifts from shorter one-hour duration systems to longer duration systems with higher derating factors, the CM becomes much more important. The CM is also the only real "bankable" revenue stream for battery storage, with 15-year contracts available for new build.

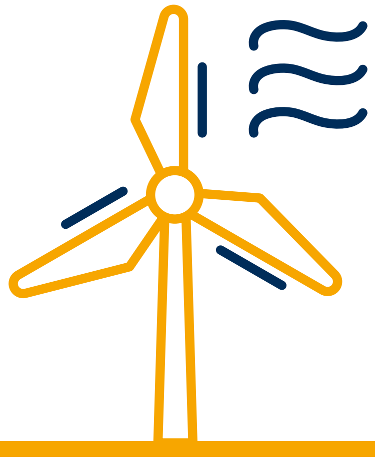
We are also seeing some very high clearing prices in recent year ahead ("T-1") auctions, with £45/kW/yr for this winter and the auction for next winter clearing at the price cap of £75/kW/yr due to an undersupply. But these outcomes are very volatile, the T-1 auction for 2020/21 cleared at only £1/kW/yr. The T-1 auctions are partly used to plug the gap where more capacity is needed than was anticipated at the T-4 stage, due to capacity drop-outs or higher than expected demand. Uncertainty in the energy market may mean we continue to see volatile prices at these T-1 auctions.

In the longer term, derating factors for limited duration storage are likely to continue to fall as more of this capacity type enters the market. This is because system stress events become more likely to be caused by storage itself (running out of charge during longer stress events), and stress events will in theory become longer (but less frequent) as periods of very low wind become the driving factor for stress events.

Counteracting this, we expect the T-4 CM clearing prices to remain relatively healthy, and unlikely to show a repeat of <£10/kW/yr seen a couple of years ago. This is because new capacity will be required to fill the gap as the older plants close, and demand starts to increase due to electrification. Most of the new capacity being added is not "firm" – interconnection, wind, solar and limited duration storage. So in the longer term as demand grows there will be a need for firm capacity with low run hours (i.e. backup peaking capacity) and high levels of "missing money", which will set higher prices.

Capacity Market Results





In summary

Interest in batteries is high. They are a relatively easy to deploy technology which can operate across multiple markets, have shown fantastic returns for investors, and have a compelling story for their future growth. The need for storage is set to grow as the system decarbonises and becomes more reliant on renewable generation. However it is important to consider how the fundamentals of these markets will change over time, and how susceptible they are to oversupply and the cannibalisation of their revenues. In performing this analysis, general power curves are of no use, and detailed fundamental modelling is required that considers the many pathways to net zero and how these may impact the differing revenue stacks for battery storage.

Here's our view on how each market could change in the future:

Arbitrage – With price spreads forecast to remain wide as the system continues to decarbonise the future is positive for price arbitrage strategies. The frequency and duration of low and zero price periods will grow as renewable penetration increases, and longer duration batteries are required to take full advantage of these opportunities.

Balancing – The balancing market is relatively shallow compared to the wholesale market. Whilst the level of imbalance will grow with increasing renewable capacity, it is more at risk of cannibalisation due to increased competition from battery and other flexibility providers. The amount of storage to saturate the balancing market is much less than current pipeline capacity and will act to suppress future revenues.

Frequency Response – The DC market is set to become over-supplied, and whilst new opportunities in the form of DR and DM are set to be introduced, volume requirements for these services will typically be small in the near term. Storage owners and optimisers will need to look at operating their assets across multiple markets, adopting hybrid strategies, to maximise returns.

Capacity Market – Clearing prices will be supported in the short term due to the faster than anticipated closure of nuclear units, closure of coal sites and absence of the Calon CCGT units. Longer duration storage, with their higher de-rating factors, are better placed to capitalise on these revenues.

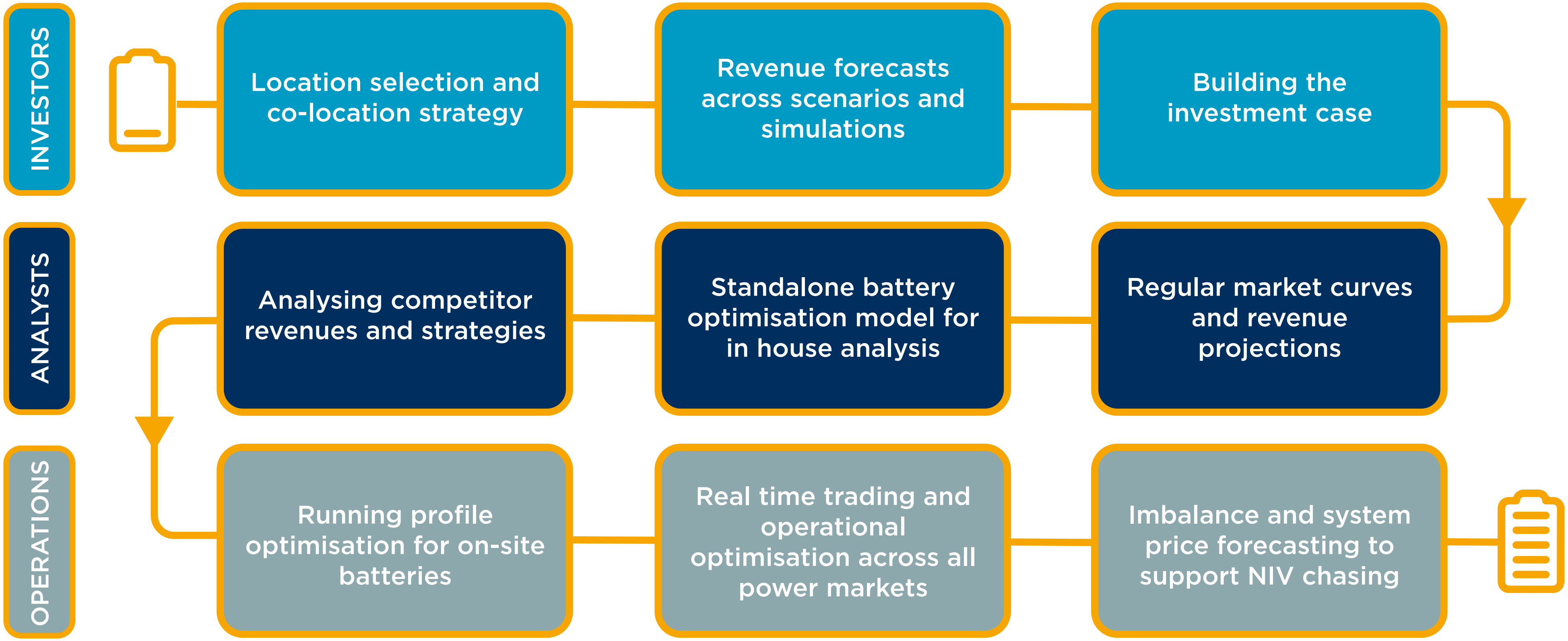
Our view

We have begun to see a shift in trading and investment strategies away from short duration batteries focusing exclusively on ancillary markets to longer duration batteries and more dynamic strategies shifting between wholesale, balancing and ancillary market opportunities. Whilst leaderboards are useful in bringing together and ranking the performance of assets across multiple markets they do not tell the full story as revenue opportunities and trading strategies are becoming more complex. Investors should be prepared to dig deeper when using these to assess the performance of traders and optimisers.

We remain cautiously optimistic about the investment case for battery storage in GB. These must be considered on a case by case basis to determine how the balance of factors that feed into a battery's revenue stack will evolve, but on the path to net zero batteries present an exciting opportunity for investors to capitalise on an emerging and complex market.

How we can help

Understanding the revenue stack for battery storage assets in an ever-changing regulatory and competitive backdrop has never been more complex. LCP's modelling framework has been used extensively by industry and key decision makers for over a decade in understanding the revenue potential for assets across markets and how markets will evolve. Our work includes providing the UK Government with its primary long-term energy forecasting models, providing the modelling National Grid ESO uses to set the capacity market deratings, and supporting £1bn+ M&A transactions.

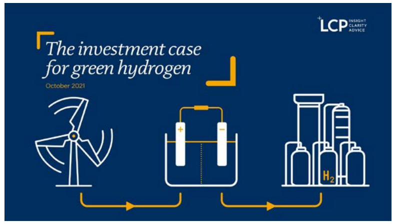


Top picks from LCP Energy and beyond

Our webinar

Has 2021 changed the outlook for battery storage investment?

Thought leadership



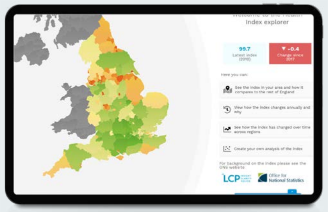
The investment case for green hydrogen

Net zero power without breaking the bank

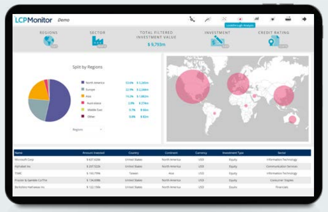
Aligning the Stars: Asset owners and energy investment toward Net Zero

Our technology & analytics

Our technology & analytics capabilities help clients solve complex problems across a range of industries.



Health



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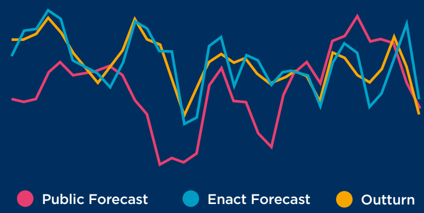
LCP Enact

Helping traders, analysts and managers navigate an increasingly competitive market with ease, make better decisions, and monitor performance.



The Energy Current

Explore our free Enact-powered data visualiser to see what's happening right now in the energy market.

Contact us

Understanding the revenue stack for battery storage assets in an ever-changing regulatory and competitive backdrop has never been more complex. If you would like to hear how we help our clients with their battery assets, from investor due diligence to real time trading, get in touch with us.

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