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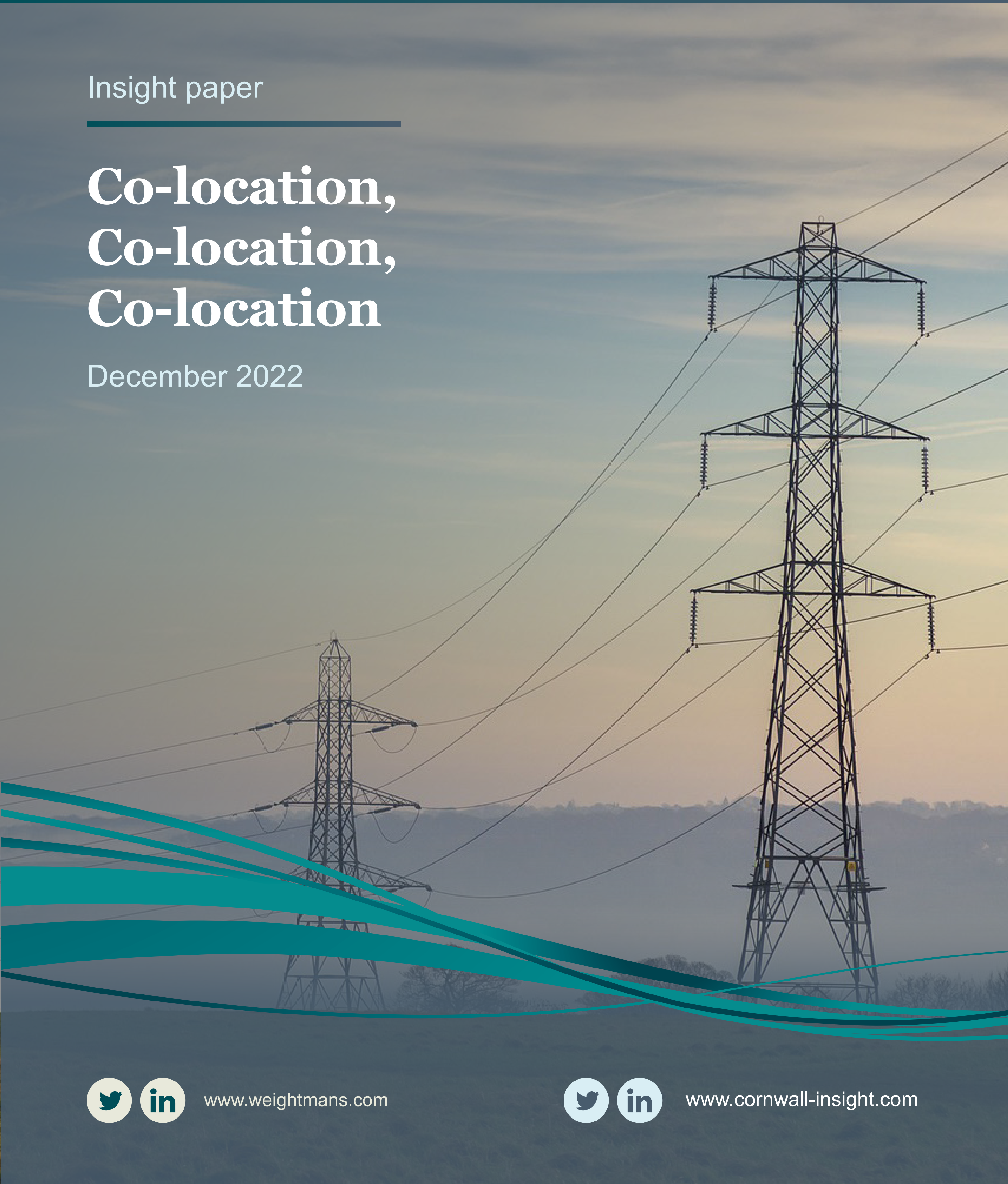

Insight paper

Co-location, Co-location, Co-location

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About Cornwall Insight

Getting to grips with the intricacies embedded in energy and water markets can be a daunting task.

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For more information about us and our services contact us at 01603 604400 or enquiries@cornwall-insight.com.

About Weightmans

Weightmans is delighted to have collaborated with Cornwall Insight on the production of this report on the co-location of energy assets.

As our energy system transitions to one with ever greater reliance on renewable power generation, with the intermittency and need for flexibility that comes with it, there will be increasing focus on how we can maximise the capacity and efficiency of those renewable assets. Co-location is expected to have a significant role to play in the optimisation of our energy assets, and this report provides a useful analysis of the opportunities and challenges associated with co-location.

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Our national energy team works closely with organisations involved in the energy sector, including large utilities, project developers, investors and funders, new energy services companies, and major energy consumers.

We have a deep understanding of this fast-moving sector, including the complex regulatory framework, and have notable expertise in energy generation projects, energy storage projects, low-carbon heating projects, decarbonisation projects, and waste and resources. Our dedicated national team of renewables, decarbonisation, and sustainability lawyers are experts in their field, and have the capabilities and strength in depth to facilitate the delivery of renewables projects across the full range of technologies.

Please get in touch, and we should be happy to assist you with your energy project needs.

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Acknowledgements

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The polls shown in Figures 5, 9, 11 & 15 were conducted as part of a joint Cornwall Insight and Weightmans webinar on co-location presented on 20 July 2022.

Co-location, co-location, co-location

Executive summary

As the UK transitions to net zero, the energy generation mix will become increasingly dominated by intermittent renewable generators, thus promoting a need for greater flexibility within the energy system. Setting up a new site, especially for storage assets, is currently a long and often costly process. Co-location is where multiple renewable generation or storage assets share a grid connection and by co-locating a new asset with a pre-existing one, the set-up process can be made both cheaper and faster. Whilst this report focuses primarily on the co-location of multiple generation or storage assets, the co-location of generation with demand is also discussed in the context of electric vehicle charging infrastructure and low-carbon hydrogen production.

Key benefits

Co-location can provide a range of benefits to renewable generators and developers, with the key benefits as follows:

Cost savings – Both capital and operational costs can be reduced by sharing existing infrastructure and land. Combining storage and generation assets allows more effective utilisation of connected grid capacity.

Faster grid connection – Currently, a stand-alone storage asset faces a wait for a grid connection beyond 2030, whereas co-location allows assets to come on-line much earlier by utilising an existing grid connection.

Revenue stacking – Storage assets can be used to avoid curtailment of renewable generation assets or to load shift generation output from times when capture prices are low, or negative, to peak times when capture prices are high. Alongside maximising the revenue of the generation asset, a storage asset can also participate in wholesale arbitrage, grid flexibility services, the balancing mechanism, and the capacity market.

Planning permission – Currently the national planning policy requirements in England present a major barrier for new onshore renewable generation. But the policy hurdles do not apply to existing sites, and so co-location of a new asset with an existing one presents a valuable opportunity to bring more onshore renewable generation on-line.

Challenges to overcome

Despite these benefits to co-locating, there are still some challenges that need to be overcome to unlock the investment potential of co-location:

Price certainty – For co-location, all the assets should be financially viable on their own and the business case for co-location needs to be made clear. One of the assets

is likely to be constrained as a result of co-location, so the benefits need to outweigh the cost of this constraint.

Optimisation – Linked to the price certainty, co-located assets require careful optimisation to produce the most lucrative energy output profile that is in line with the contractual mechanisms of the site. Similarly, the ratio of generation capacity to export capacity needs to be optimised for the characteristics of a co-located site, to maximise efficiency.

Insurance – There is concern in the insurance community regarding the fire risk of battery storage, with clearer guidelines and standardisation in operating procedures needed to build confidence and encourage insurers.

Outlook

Looking forward, there is a large pipeline of co-located assets set to come online across the next decade, with an increasing trend of large-scale energy parks, which combine several of the co-location types discussed in this report behind one grid connection, and district energy networks, where large-scale property developments are designed in tandem with the provision of low-carbon energy and heat. As more co-located sites are established, there will be more of a blueprint available for best practice solutions, helping to overcome the challenges of price certainty and optimisation. Corporate and hybrid power purchase agreements could both provide valuable routes to market for co-location in the future.

Chapter 1:
Background and types of co-location

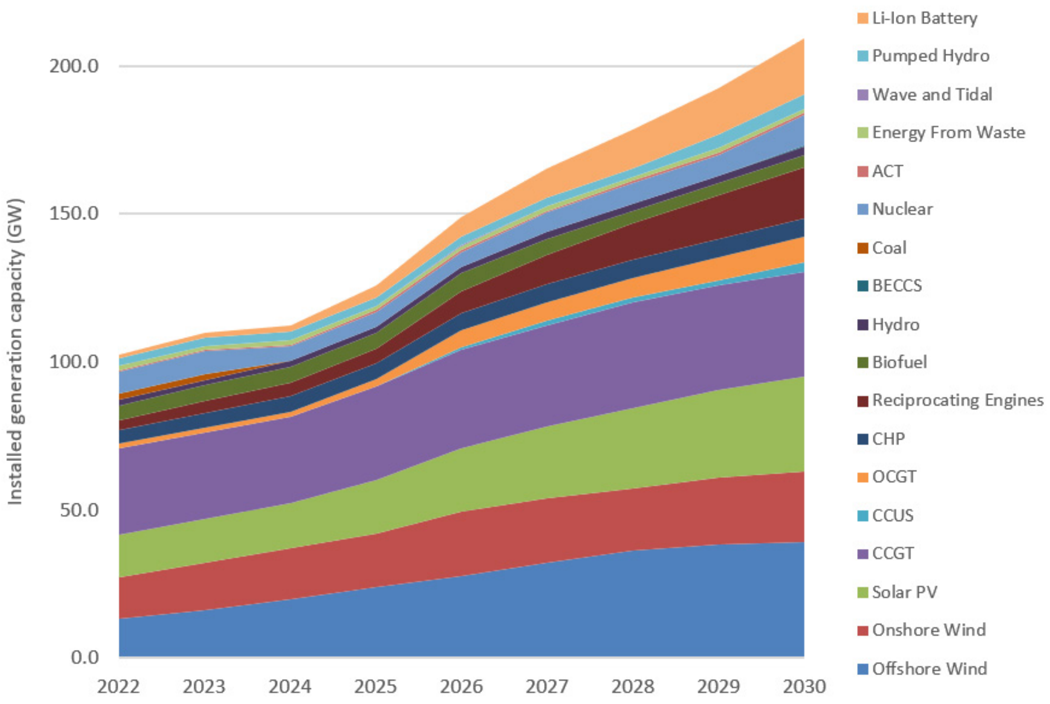
1.1. Background to the net zero transition

In June 2019, the UK government committed to reaching net zero by 2050[1], whereby the amount of greenhouse gases released is lower than, or equal to, the amount removed from the atmosphere. This transition to net zero is crucial to meeting the global commitment to the Paris Agreement, adopted in 2015, a legally binding treaty to limit global warming to below two degrees. Achieving this transition will require action from across the economy and energy market ecosystem.

1.2. Energy market ecosystem

In the UK there is an increasing amount of renewable energy technologies entering the energy generation mix in the coming decade (Figure 1). As more renewables enter the generation mix, the intermittency of energy generation is increased and there is therefore a need for greater flexibility. Increasing the amount of renewable generation and flexibility within the UK energy mix requires either developing new sites or building out the capacity of existing sites. Getting the land and associated planning permissions for a new site, alongside establishing a connection to the grid, is currently a long and often costly process in the UK. Therefore, being able to add a new generation or storage asset behind an existing grid connection can both expedite and bring down the costs of developing the UK's renewable generation capacity.

Figure 1: Forecasted UK generation capacity mix until 2030.

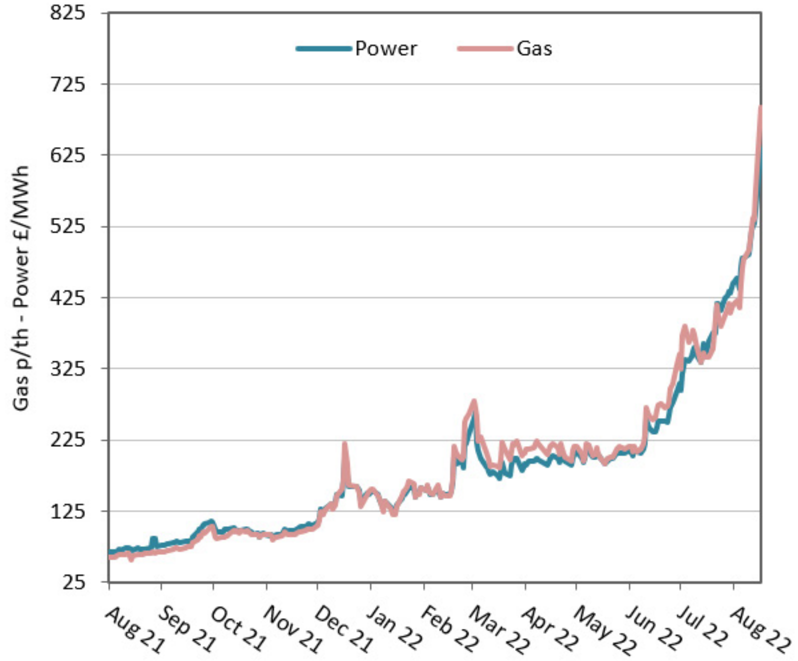


Source: Cornwall Insight Benchmark Power Curve

1 UK becomes first major economy to pass net zero emissions law - GOV.UK

The need for cheap, renewable energy generation has been further promoted by the recent high and volatile wholesale gas and electricity prices (Figure 2). High demand for gas in Europe following the covid-19 pandemic, combined with supply shortages as a result of the Russian invasion of Ukraine have resulted in exceptionally high gas prices, which, as the marginal power generator, have driven up the cost of electricity in the UK. Increasing the generation capacity from renewables with little or no associated fuel cost can reduce the dependence on gas and thus help bring down the cost of power.

Figure 2: UK gas and power prices for August 2021 to August 2022



Source: Cornwall Insight Daily Pricing Bulletin

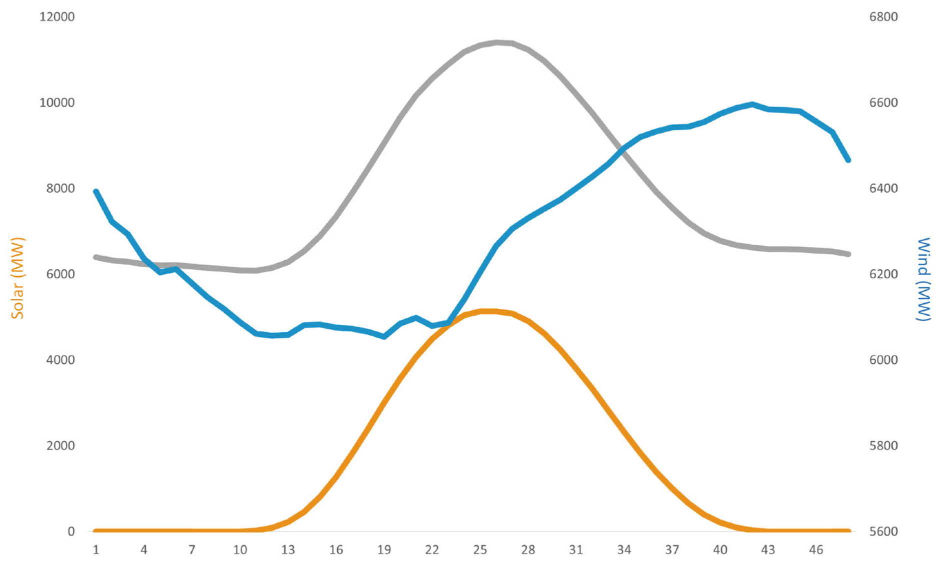
1.3. Co-location

Co-location is a very general term and can come in a variety of forms. This report will focus on the co-location of multiple generation or storage assets with a single grid connection. Co-location is aimed at increasing the flexibility of energy supply and maximising the value from expensive grid connections and land. This report will discuss a series of different forms of co-location before considering the benefits and challenges and what the investment landscape looks like going forward. The co-located assets sharing a grid connection can be metered separately or together. They can also either share the same land or be in different locations (within a relatively small radius) but connected via private infrastructure. All assets can be owned by a single company or by separate companies.

1.4. Multiple generation assets

One of the most straightforward types of co-location is the combination of multiple generation assets. The most common global version of this is the combination of solar PV and onshore wind, with a UK example being the 5MW solar and 3.6 MW onshore wind Parc Cynog site owned by European Energy[2]. The combination of solar PV and onshore wind is able to produce a firmer, although less predictable, energy generation profile, with solar and wind generation peaking at different times of day and different seasons (Figure 3). In the UK, a solely solar PV asset tends to generate <1,000 full-load hours a year[3], whereas a co-located solar PV and onshore wind asset can generate around 4,000 full-load hours a year[4].

Figure 3: UK solar, wind, and combined (solar + wind) half hourly energy generation on 15 June 2022.



Source: Elexon

Solar PV and onshore wind can either be co-located by separately installed turbines and solar panels that share a grid connection or by integrating the two. Integration removes the need for the solar inverter and improves the efficiency of the turbine converter. However, it also comes with the limitation of potential shading of the solar panels from the turbine blades and constraints based on the available space.

Combining multiple generation assets increases the difficulty in correctly sizing the grid connection for the site. The two assets are rarely going to both be outputting 100% and so a grid connection for the full capacity of both assets would largely be underutilised. But identifying the optimal ratio between grid connection size and maximum generation capacity is challenging compared to optimising for a single generation type.

Other than the co-location of solar PV and onshore wind, there are more novel generation asset combinations being explored. An example of this is the collaboration between Shearwater Energy and NuScale at Wylfa in North Wales looking to combine offshore wind generation with a small modular nuclear reactor[5]. The aim of this project is to replicate the performance characteristics of a large thermal power station.

2 Renewables Now
3 BEIS
4 Fasihi et al., 2016
5 Shearwater Energy

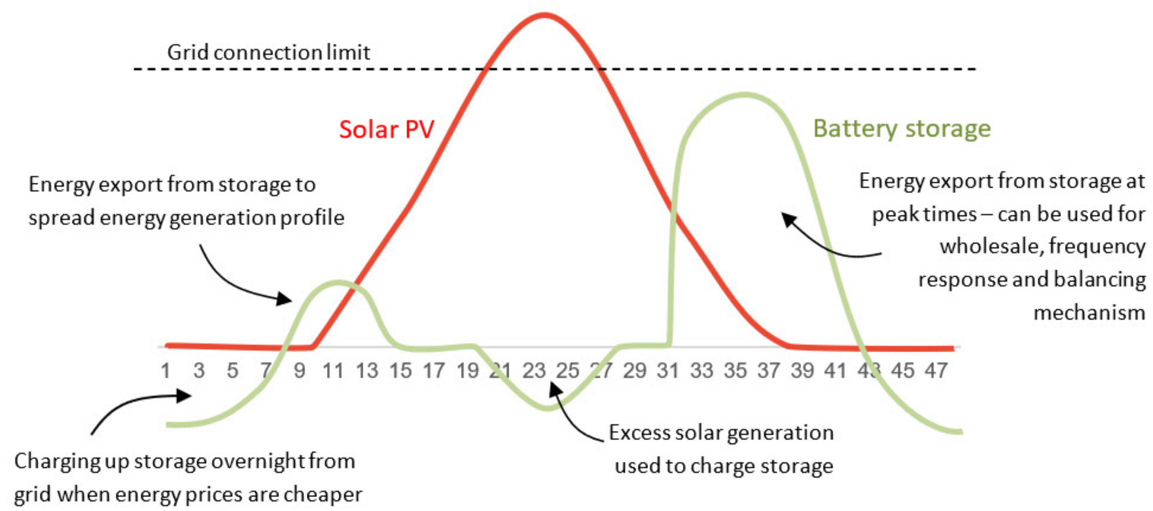
1.5. Inclusion of batteries

The most explored co-location option is the addition of battery storage to a generation asset, with Nick Fothergill, Partner at Weightmans, stating that with the increasing roll-out of intermittent renewable generation there are "clear advantages to increased deployment of energy storage assets". Adding battery storage to a generation asset gains better value from the existing grid connection and saves on cost and time associated with setting up a standalone battery asset. Co-located battery storage assets are able to access more revenue streams (Figure 4) but are at risk of potential clashes with the generation asset, limiting the batteries' access to these revenue streams. A co-located battery storage asset benefits from lower costs and quicker connection to the grid, but in return it likely has to accept slightly lower revenues than a standalone battery.

The co-located battery can be charged either from the renewable generation asset or from the grid and used for peak shaving, arbitrage, creating a firmer energy output profile, or grid services.

Peak shaving utilises the battery to avoid curtailment of output due to grid constraints, by charging the battery with output that would otherwise be lost and exporting at an unconstrained time. Arbitrage is import and storage of energy when it is cheap and export when energy prices are higher. Arbitrage is usually targeted to release the stored energy onto the wholesale market during peak times when maximum price spread is achieved. This can be either energy imported from the grid or from the renewable energy generator. Roberto Castiglioni, Co-founder and CEO at energy transition strategic advisor Ikigai Group, argues that, with the exception of curtailed renewable output due to grid constraints or other particular circumstances, there is no business case in the UK for charging the battery from the renewable generation asset instead of from the grid, especially from solar generation. Adam McKenzie, Director of Trading at Arenko Group, a technology platform provider to the energy market, added that arbitrage of the renewable output could also be beneficial when the prices for renewable energy output are negative.

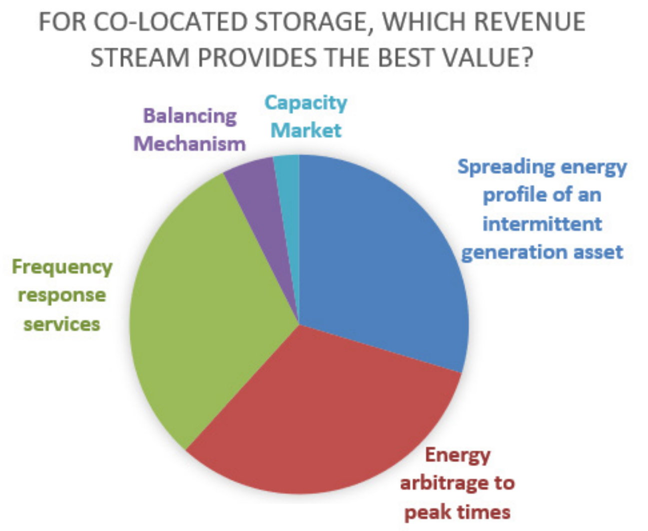
Figure 4: Schematic of co-located solar PV and battery storage assets indicating potential revenue opportunities across a day.



Source: Cornwall Insight

Being able to create a firmer energy output profile, or a profile better matched to demand, was identified by market experts[6] as a key revenue stream for co-located battery storage, alongside arbitrage and grid flexibility services (Figure 5). Lev Gurdenli, Partner at Weightmans, added that "by smoothing out the generation profile and offering more of a baseload profile" the output could be more attractive to "offtakers looking to enter long-term power purchase agreements".

Figure 5: Poll responses from 81 participants.



Source: Cornwall Insight

The main grid services that a co-located, or stand-alone, storage asset can provide are the frequency response services (dynamic containment, dynamic regulation and dynamic moderation). Battery storage can also be used for the balancing mechanism and the capacity market, but as seen in Figure 5, market experts surveyed by Cornwall Insight see other options, such as frequency response services and energy arbitrage, as more valuable. The three frequency response services are designed to balance deviations away from 50.0Hz (Figure 6), with dynamic regulation and moderation acting within a ±0.2Hz pre-fault window and dynamic containment acting in the ±0.2-0.5Hz post-fault window.

The decreasing inertia of the UK's energy generation mix as more renewable technologies are incorporated has increased the need for the fast acting (<10 seconds) frequency response services that can be provided by battery storage. Currently, dynamic containment provides the best value revenue stream for storage assets (Figure 7). However, this looks set to change with the latest Cornwall Insight flexibility forecast, published in July 2022, indicating that the price available for dynamic containment services is set to substantially decrease by the mid-2020s as more battery capacity comes on-line and with increasing penetration of higher inertia low-carbon technologies (e.g., new nuclear, carbon capture use and storage, and bioenergy with carbon capture and storage).

6 A poll of attendees was conducted as part of a joint Cornwall Insight and Weightmans webinar on co-location presented on 20 July 2022.

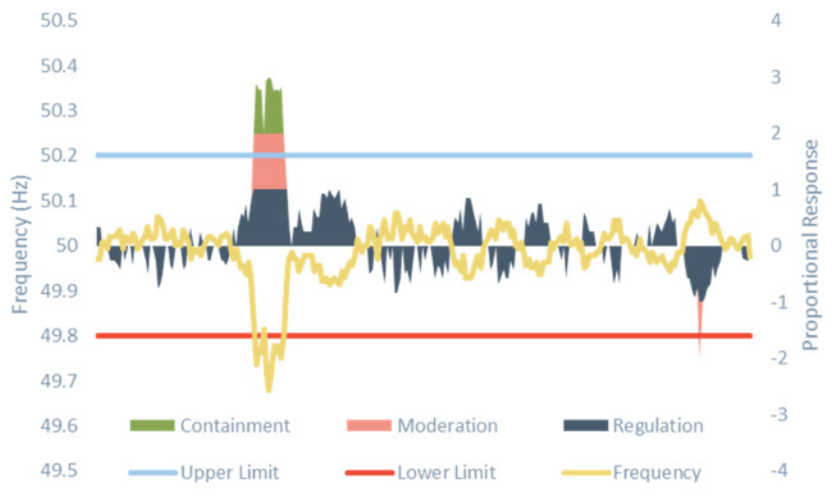
Box 1: Frequency response services

Dynamic Regulation – designed to slowly correct continuous, but small (< ±0.2 Hz) frequency deviations. Aiming to continuously regulate frequency around 50 Hz.

Dynamic Moderation – designed to rapidly regulate sudden small deviations in frequency (< ±0.2 Hz). A quick acting service for deviations at the edge of the operational range.

Dynamic Containment – designed to operate after a significant frequency deviation (e.g., post-fault) to recover frequency deviations of ±0.2-0.5 Hz.

Figure 6: Roles of Dynamic Regulation, Moderation and Containment in managing grid frequency.



Source: Cornwall Insight

Figure 7: June 2022 revenues for frequency response services.

Service	June 2022 revenue (£/kW)
Dynamic Containment Low	19.77
Dynamic Containment High	1.84
Dynamic Regulation Low	3.63
Dynamic Regulation High	4.91
Dynamic Moderation Low	0.24
Dynamic Moderation High	0.43

Source: Cornwall Insight Flexibility Markets Report

The balancing mechanism provides a way for National Grid to balance the supply and demand of electricity by asking for more or less energy from capacity providers. Battery storage can participate in this mechanism, but would need to be registered through a supplier as a balancing mechanism unit and/or a generation/storage asset. The volatility and uncertainty in the balancing mechanism means that prices can be much higher than the wholesale market but with less guarantee of revenue. Participation in the balancing mechanism can occur alongside trading in the wholesale market, as long as there is sufficient storage capacity. However, participation in the balancing mechanism would also change how a battery would operate in the market for future half-hourly settlement.

The capacity market provides long term contracts to ensure that power is available during periods of grid stress if called upon by the National Grid. Capacity is procured through auctions held four years (T-4) and one year (T-1) ahead of delivery and the latest auction prices (February 2022) were £30.59/kW/yr and £75/kW/yr, for T-4 and T-1 respectively. Battery storage can be included in the capacity market alongside participating in other markets and for a co-located battery storage asset would have its de-rating[7] capacity factor calculated as a combination of the available technologies on site. The capacity market is a relatively low risk revenue stream for battery storage and will have less of an impact on optimisation strategy due to the nature of a battery storage asset.

1.6. Electric vehicle charging infrastructure (EVCI)

With the UK Government's target of ending the sale of new petrol and diesel cars by 2030, and the surging uptake in electric vehicles (EVs) – year-to-date sales of EVs in August 2022 up 149% on year-to-date EV sales in August 2021[8] – there is a clear need for the roll-out of extensive EVCI. Within this roll-out there are three main use cases where the co-location of a generation and/or storage asset alongside the EVCI could provide a valuable addition: motorway service areas (MSAs), fleets, and workplaces.

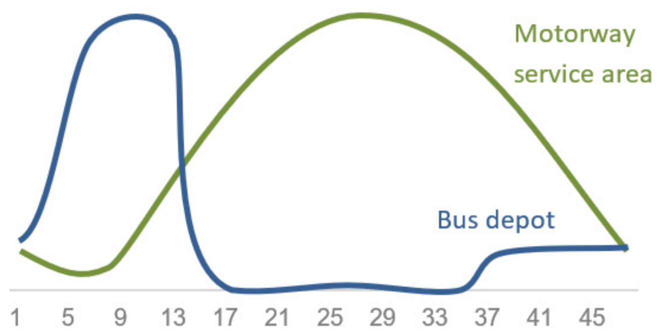
MSAs are an area where the provision of EV chargepoints, especially rapid chargepoints, will be crucial to the scale-up of UK EV usage. The expected charging profile for a MSA (Figure 8) shows energy requirements peaking in the middle of the day, and as such the inclusion of solar panels could clearly help reduce the amount of energy required to be imported from the grid. Likewise, battery storage could be used, as previously discussed, to import energy from the grid during the night when electricity prices are cheap before discharging to support EV charging during peak periods. Nick Fothergill, Weightmans, notes that the high demand for charging that will increasingly fall on MSAs highlights the need to maximise both capacity and efficiency of charging infrastructure. With Lev Gurdenli, Weightmans, adding that MSAs are likely to be the only EVCI use case that can take advantage of large-scale generation asset co-location, due to the space constraints.

For fleet charging, the exact charge profile will be influenced by the characteristics of the fleet, with the example of a bus depot charging profile given in Figure 8. For this

7 The percentage capacity that an asset is run at to avoid deterioration or failure of the asset.
8 SMMT

bus depot example, the bulk of the charging occurs overnight and therefore, unlike with MSAs, a solar PV asset would not alone support the EVCI. However, combining a storage and generation asset could be used similarly to as discussed in section 1.5, but with the energy demand (the EV charging) now co-located alongside the supply.

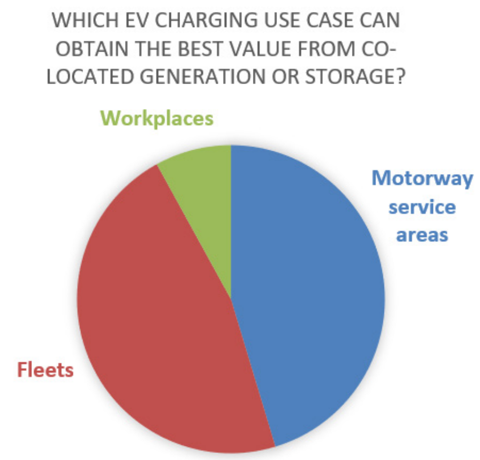
Figure 8: Schematic daily EV charging profiles for a motorway service area and a bus depot.



Source: Cornwall Insight

The third use case for co-location of storage and/or generation with EVCI is workplace charging. This option is the least explored at present, and a survey of market experts[9] indicated that this is viewed as the least likely use case to benefit from co-location (Figure 9). This lack of uptake is likely due to the high capital costs and space requirements associated with installing generation or storage assets in a workplace setting. The recently launched Papilio 3 from 3ti[10] is an example of EVCI targeted at workplace charging. Rentable and mobile EV charging apparatus could help bring down the upfront costs and lessen the requirements for installation planning permission.

Figure 9: Poll responses from 75 participants.



Source: Cornwall Insight

Across all three of these EVCI use cases, it is likely that, where possible, EVs will also be used for vehicle-to-grid services. This would require a sufficient charge profile, such that the EV is still available and fully charged at the required time, and

9 A poll of attendees was conducted as part of a joint Cornwall Insight and Weightmans webinar on co-location presented on 20 July 2022.
10 SMMT

so is most likely to be of benefit to fleets where timing and charge requirements are easier to predict.

An example of an alternative EVCI use case are the Energy Superhubs being set up by Pivot Power[11], with the Energy Superhub Oxford[12] currently operational and using battery storage, in combination with the National Grid transmission system, to provide EV charging for both private and fleet vehicles. Lev Gurdenli, Weightmans, points out that in this set up the EVCI and battery storage have separate ownership, which has the advantage that EV charging operators don't have to be experts in battery storage infrastructure, and vice versa.

1.7. Low-carbon hydrogen production

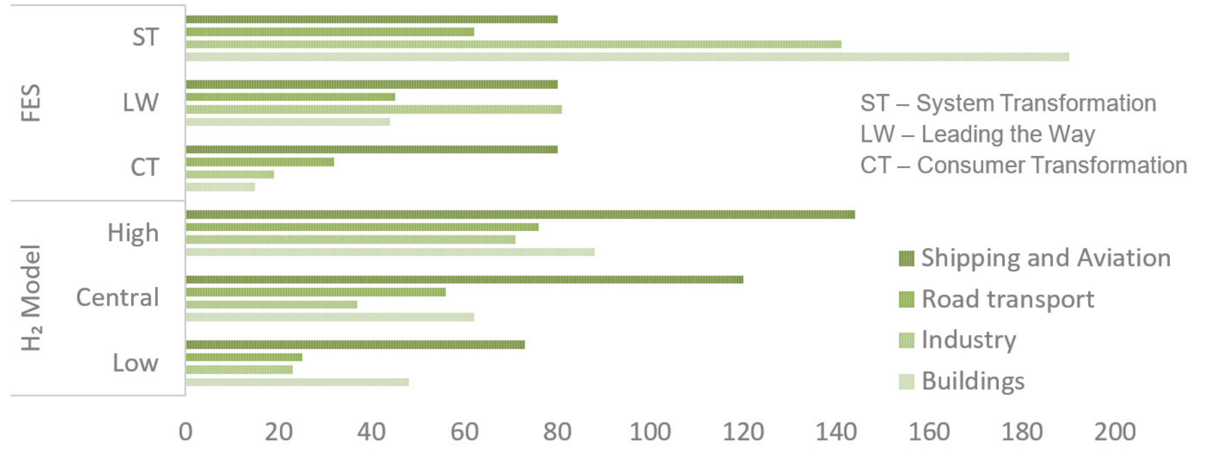
Part of the UK's Energy Security Strategy, a document published by the UK government in April 2022, included the target of 10GW of low-carbon hydrogen production by 2030, with at least 50% as 'green' hydrogen, generated by electrolysis from renewable electricity. Some of the major barriers to developing the UK's low-carbon hydrogen economy have been identified as the high cost of hydrogen production and uncertainty in the offtakers[13].

Co-locating low-carbon hydrogen production with a renewable generation asset and a demand centre can help to bring down the price by reducing the transport and storage costs, as well as giving more certainty in offtake. Additionally, if the entire output of a renewable generation asset is used to produce hydrogen, then the renewable asset can essentially be built off-grid, massively reducing the costs as there is no need to pay for a grid connection. Forecasting by the National Grid ESO and Cornwall Insight both indicate that heavy industry and shipping and aviation are key use cases for low-carbon hydrogen in the UK (Figure 10), with Weightmans' Lev Gurdenli highlighting that shipping, aviation and heavy goods vehicles could present more of a use case because they are harder to electrify. Industrial clusters and transport hubs can therefore provide valuable use cases for low-carbon hydrogen, with market experts[14] identifying them as the two areas with the most potential for co-located hydrogen production (Figure 11).

Low-carbon hydrogen can also be utilised as a long duration storage mechanism, with Weightmans' Lev Gurdenli stating that it can provide a valuable opportunity for seasonal storage. Roberto Castiglioni, Ikigai Group, adds that in the case of Scottish onshore/offshore wind generation, grid constraints often result in generation curtailment, but using this excess energy to produce hydrogen would avoid the energy being wasted and allow the generator to be "competitive on the price of hydrogen because the opportunity cost is extremely low".

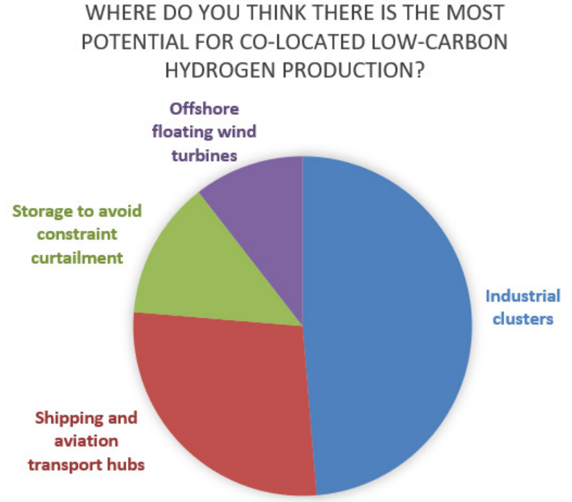
11 Pivot Power
12 Energy Superhub Oxford
13 Low-carbon hydrogen: hype or reality?
14 A poll of attendees was conducted as part of a joint Cornwall Insight and Weightmans webinar on co-location presented on 20 July 2022.

Figure 10: Forecast low-carbon hydrogen usage (TWh) across a series of sectors and future scenarios.



Source: Cornwall Insight, National Grid ESO

Figure 11: Poll responses from 76 participants.



Source: Cornwall Insight

As the UK develops its offshore wind capacity there is increasing focus on the installation of floating, rather than fixed base, wind turbines. By combining floating offshore wind energy generation with production of low-carbon hydrogen, which can then be shipped back to shore, the costs of constructing and installing lengthy export cables, alongside associated marine planning permissions can be avoided. An example of this co-location of floating offshore wind and low-carbon hydrogen production is the ERM Dolphyn project[15], aiming to come on-line in the mid to late 2020s.

Weightmans' Lev Gurdenli notes that an area that still needs developing/clarifying for low-carbon hydrogen is the legal framework, and "in particular the treatment of hydrogen gas within our existing networks" and "the network charges for the use of hydrogen on the gas network". These concerns are not unique to co-located low-carbon hydrogen but a more mature market in this space will require proper clarification of the regulations and legal frameworks surrounding it.

15 ERM

Chapter 2: Benefits of co-location

2.1. Lower costs

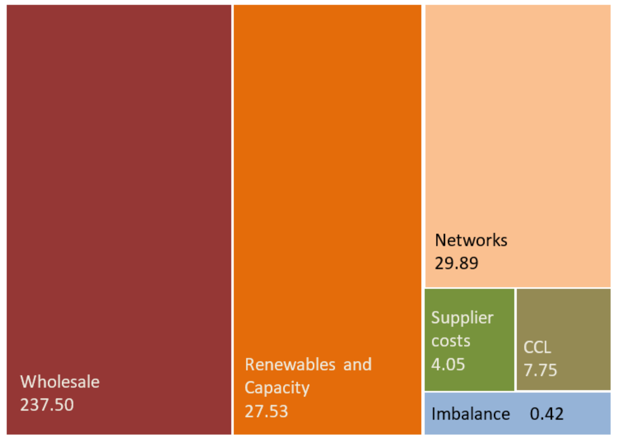
The primary benefit to co-location is the cost savings that can be made, with these savings coming in several areas. The first area is the reduced capital and operational costs by using existing infrastructure and land that would otherwise be un-utilised, with Adam McKenzie, Arenko Group, pointing out that, in particular, onshore wind farms have a lot of spare land that could be used to incorporate solar panels or battery storage assets, and Nick Fothergill, Weightmans, adding that the nature of batteries as self-contained and with a relatively small land footprint makes them particularly easy to deploy on existing sites. Planning and leasing costs can therefore be reduced by combining multiple assets on one site.

Similarly, as mentioned in sections 1.4 and 1.5, intermittent energy generation results in there being spare grid connection capacity, which could be taken advantage of by an additional asset, especially flexible storage assets. Nick Fothergill, Weightmans, notes that because grid connection cost is based on capacity, rather than how much power travels through it, there are grid connection cost saving opportunities for co-locating assets. These cost savings are available in scenarios where a second asset is being added to an existing one, and in scenarios where the co-location of multiple assets is planned from the outset. Roberto Castiglioni, Ikigai Group, noted that when setting up a co-located (i.e., infrastructure sharing) storage and generation asset from scratch, the storage component could take the full cost of the upfront capital for the grid connection to subsidise the generation asset and allow it to be more competitive.

An additional related benefit to adding a new asset to an existing one is quicker connection to the grid, through the pre-existing asset connection, than if the new asset was set up as a stand-alone. The speed of grid connection through co-location is a particular benefit for battery storage, with Iona Penman, Energy Market Regulation Manager at Arenko Group, highlighting that, at present, for stand-alone battery storage projects “the majority of connection dates offered by the Electricity System Operator go beyond 2030”.

Another area where operational savings can be made is through the co-location of generation with demand and the corresponding reduction in costs for importing energy. Figure 12 gives a breakdown of the cost of power for an average large non-domestic consumer (totalling ~£303/MWh) in 2022-23. At the extreme end, by utilising energy that is produced on-site or connected via dedicated infrastructure (a private wire arrangement) a saving of up to £297/MWh is achieved, with only the fixed charge for connection to the distribution network remaining. It should be noted that from 2023-24 the Targeted Charging Review will introduce an additional fixed Transmission Network Use of System charge, reducing the available savings for a private wire arrangement.

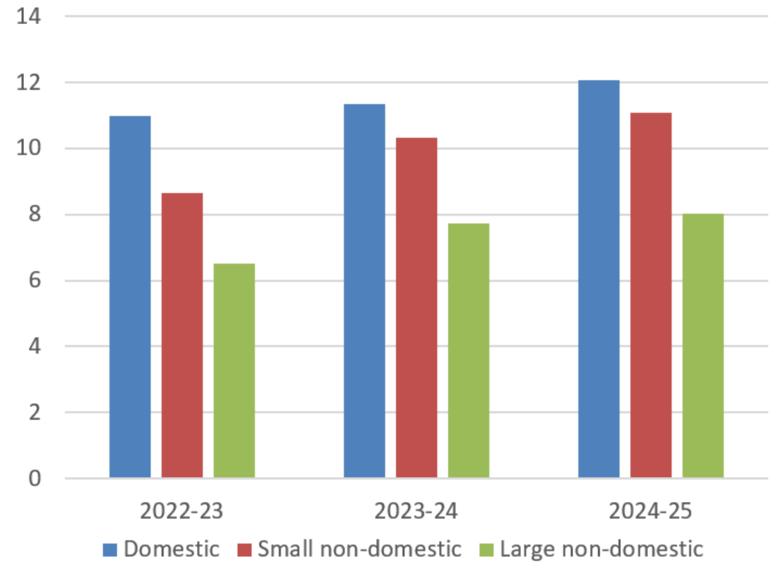
Figure 12: Breakdown of total cost of power for an average large non-domestic consumer in 2022-23



Source: Cornwall Insight

The co-location of generation and demand can help protect against high wholesale prices and the forecasted rises in non-commodity costs (Figure 13), and for this report is considered in the specific contexts of EVCI and low-carbon hydrogen production. For EVCI, MSAs are a specific area where substantial cost savings can be achieved by co-locating generation on site due to the high estimated costs (up to £600mn) required to install the network capacity needed to meet the predicted EV charging demand by 2035.

Figure 13: Forecast non-commodity costs for electricity (p/kWh)



Source: Cornwall Insight Third Party Charges Forecast

For low-carbon hydrogen production Ross Driver, Director at sustainability-led alternative assets investment manager Foresight, identified the ability to offtake as a key driver for the market. With the high costs of transporting hydrogen currently, locating low-carbon hydrogen production with demand brings down the costs and provides greater certainty of offtake. As shown in Figure 11, industrial clusters are considered by market experts to have the most potential as a co-located offtaker of low-carbon hydrogen, with shipping and aviation transport hubs as the next most attractive option.

Licensing a generation or storage asset can also reduce non-commodity costs, with exemption from final consumption levies (Figure 14). This exemption only applies to power which is taken from the public network for later export, not for supply to a private wire customer. Private wire storage assets can still avoid the final consumption levies, but only if the metering can prove that the exemption is not being applied to power exported to private wire end users.

Figure 14: Forecast nominal final consumption levies for a large non-domestic customer (p/kWh)

Component	2022-23	2023-24	2024-25
Renewables Obligation (RO)	2.596	2.509	2.507
Feed-in Tariffs (FiT)	0.731	0.730	0.735
Contracts for Difference (CfDs)	-0.892	0.045	0.340
Capacity Market (CM)	0.317	0.352	0.384

Source: Cornwall Insight Third Party Charges Forecast

2.2. Planning requirements

Not only can co-location help to bring down the costs associated with setting up a new generation or storage asset but can also reduce the difficulties that would be associated with obtaining the planning permission if setting up the new asset as a stand-alone. Lee Gordon, Partner and Head of Planning & Infrastructure at Weightmans, notes that national planning policy in England is one of the main barriers to promoting new onshore renewable generation schemes (e.g., onshore wind and solar). Gordon adds that there has been a huge fall in new onshore wind developments in recent years due to both the need for a local authority to identify a region as suitable for wind energy in a developmental plan, and the requirement for the proposal to have the 'backing' of the local community. Because these planning policies do not apply to existing onshore wind farms, or applications for re-powering existing turbines, co-location with existing generation assets is an important opportunity for bringing more onshore wind on-line.

2.3. Revenue stacking

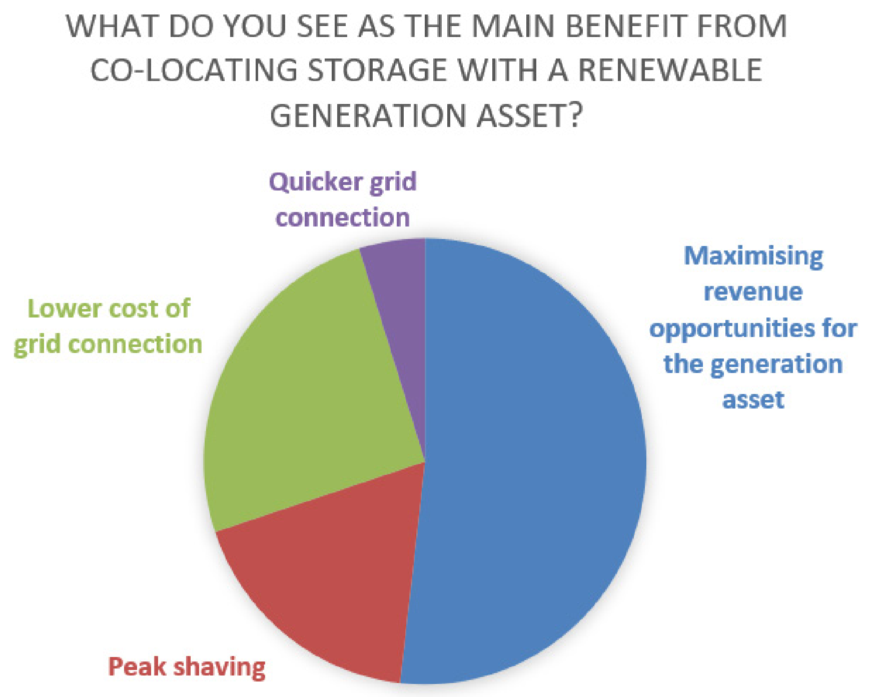
As well as the cost savings that can be made from co-location, by combining a battery with either generation assets or EVCI there is the potential for accessing multiple different revenue streams and revenue stacking. A poll of market experts[16] shows that the ability for batteries to be used to maximise revenue opportunities for an existing generation asset is considered the main benefit to co-locating battery storage with generation (Figure 15).

16 A poll of attendees was conducted as part of a joint Cornwall Insight and Weightmans webinar on co-location presented on 20 July 2022.

As discussed in section 1.5, a co-located battery can be charged from a generation asset for peak shaving to avoid grid curtailment or for arbitrage to get a better export price for the energy generated. However, these benefits are situation-specific and co-located battery storage is more commonly charged from the grid and used for wholesale arbitrage or grid services. As with a stand-alone battery, the grid services provide the major revenue streams, with Adam McKay, Senior Trader at Arenko Group, saying that "dynamic containment trumps all at present" and "significantly inflated spreads in wholesale power values would need to be realised to outcompete the dynamic containment prices at present". However, as more battery storage comes on-line the frequency response services will become saturated and the available price is forecast to drop considerably. In this context, a co-located or stand-alone battery asset could get more of its revenue from wholesale arbitrage or entering the balancing mechanism.

Whilst both stand-alone and co-located battery storage can access all these different revenue streams, a benefit to co-located storage is that it can be combined alongside generation to create export profiles better matched to demand profiles from offtakers. On the other hand, a co-located battery will likely have less optionality in the market, and therefore lower revenues than if it was a stand-alone asset. Foresight's Ross Driver notes that the aim for a co-location project is for the "generation asset to be able to operate as effectively as possible and then the battery storage has the flexibility to move into the other ancillary markets, creating additional revenue stacks". For generation assets co-located with EVCI there is the potential to trade in the wholesale market any energy that is excess to the demands from the EV charging.

Figure 15: Poll responses from 83 participants.



Source: Cornwall Insight

Chapter 3: Overcoming challenges

3.1. Optimisation and price certainty

Currently the biggest challenge to greater uptake and investor confidence in co-location is how to best optimise the different assets and the price certainty of the revenue streams. It is important that both assets are financially viable in their own right and that the business case for their co-location is clear. With Weightmans' Nick Fothergill noting that co-location will not be viable for all projects, and the site-specific features need to be analysed and weighed-up before an investment decision can be made. Is the business case focused on avoiding grid curtailment or arbitrage of renewable generation? Or is the business case treating the two assets separately whilst taking advantage of the cost savings discussed in section 2.1?

Foresight's Ross Driver notes that stacking individual business cases will likely place "a constraint on one or other of the assets" and that "examples of pure co-location where it is fully optimised are few and far between". Adam McKenzie, Arenko Group, adds that the optimisation strategy is dependent on the contractual mechanisms in place and therefore which asset has priority usage of the network connection and whether that changes at different points in time. Lev Gurdenli, Weightmans, notes that the legal and contractual structures for co-located assets are more complex for sites where a new asset is being retrofitted to an existing one, which already has its own funding structures and legal and contractual framework behind it.

Peak times when the network is most constrained are periods with the most chance of the different assets curtailing each other, and careful consideration is needed by developers as to whether the potential curtailment of an asset is outweighed by the cost benefits of the co-location. Iona Penman, Arenko Group, identified "economies of scale" where "the larger the shared connection, the higher the battery revenues" for co-located assets. According to an industry expert, the target markets for a storage asset need considering when setting up the asset, with "fast cycling batteries better suited to flexibility services".

Part of the optimisation of co-located assets involves identifying the ideal ratio of generation capacity to export capacity for co-located assets according to Liam Kelly, Chief Operating Officer at investor and developer Green Switch Capital, to avoid building assets that can't export or underutilising the available grid connection capacity. Similarly, Roberto Castiglioni, Ikigai Group, notes that with the inclusion of battery storage connected to the generation portfolio there is a lot more flexibility in the export profiles that can be generated and therefore more clarity is needed from offtakers as to what the most profitable profile is for trading. There are also potential concerns from investors over whether renewable energy subsidy schemes are impacted by the co-location of assets. Under the Contracts for Difference (CfD) subsidy scheme, storage units can be co-located with generation assets but there are strict requirements required, especially on the metering side[17].

17 LCCC

3.2. Metering and regulations

As well as the complexities in how best to optimise and maximise revenues from co-located assets, there are also multiple metering and regulatory criteria that need to be considered as part of the optimisation. The first consideration is the licensing set-up, with small generation assets exempt from a licence but storage assets benefiting from avoiding final consumption levies (Figure 14) if licensed. This can therefore result in a co-located site with a mixture of licensed and un-licensed assets. A storage asset being added to an existing generation site will require registered import capacity to charge from the grid, rather than being purely parasitic on the generation asset. However, Foresight's Ross Driver notes that import capacity is not available for every site with export capacity.

Another consideration is the set-up of the metering, with the arrangement and technical specifications of the meters affecting what services the storage asset, in particular, is able to provide. The metering complexity is further complicated when part of a private wire arrangement, where the metering needs to be set up to distinguish between export from a storage asset to the grid and to the private wire end user. Cynthia Grainger, Strategic Account Manager at independent energy data platform Origami Energy, suggests that more stringent requirements for the positioning and technology of meters installed by developers could result in a more robust metering system for operators of co-located sites.

3.3. Insurance concerns

From an insurance perspective, one of the major concerns with co-located assets is the fire risk from batteries. Robert Gardner, Renewable Energy and Power Lead for GB Retail at insurance advisor WTW, notes that "if there's a problem, small losses are unlikely" and adds that, especially for smaller sites, the "insurance premium generated is relatively small compared to the potential for an insurance loss", which is not conducive to encouraging insurers. This concern is not unique to co-located assets but can be exacerbated by the risk of a battery fire to other non-battery assets, especially in scenarios where the batteries are interspersed amongst generation assets.

Insurers are often "wary of relying on NFPA 855[18] as the complete solution" for fire prevention and protection, according to WTW's Robert Gardner. Gardner adds that clearer guidelines and standardisation are required around the minimum levels of fire protection, as well as more data on battery performance available from developers to allow insurers to be "collaborators, not competitors". Part of these standards will likely include insurance engineering reports detailing the minimum spacing of batteries and other electrical equipment (e.g., transformers, inverters etc.) to reduce the domino-effect of any fires.

An additional complexity for insuring co-located assets is asset ownership and the sharing of infrastructure, especially the grid connection. The grid connection infrastructure is often owned by a third party and the lack of redundancy options

18 National Fire Protection Association – Standard for the Installation of Stationary Energy Storage Systems

if there is any problem with the grid connection is a concern for insurers and underwriters. The fewer parties involved in a co-located site, the less complexities and potential for gaps between insurance policies.

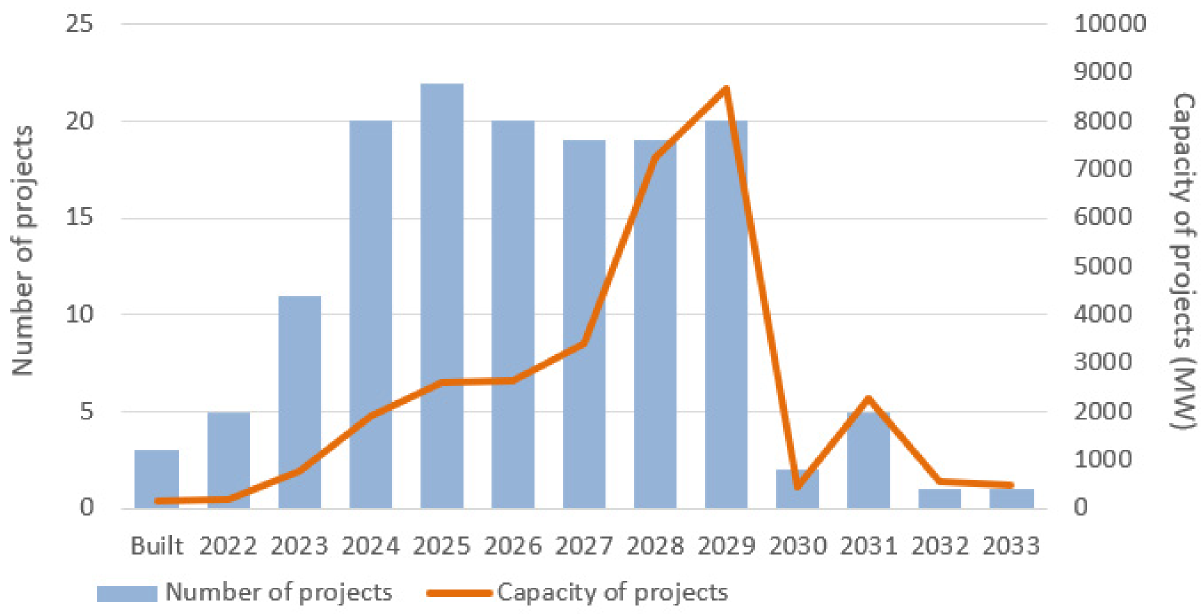
3.4. Planning permission

As outlined in section 2.2, one of the benefits to co-location is the reduction in planning permission hurdles compared to setting up a stand-alone onshore renewable generation asset. However, these planning hurdles still present a major barrier to setting up sites that are co-located from the outset, rather than sites where co-location is being set up with an existing asset. In particular, Lee Gordon, Weightmans, notes that investor confidence in solar assets has been substantially dented by the recent suggestions from the UK Government that the definition of the “best and most versatile” agricultural land will be broadened to include the lower grade 3b land, significantly raising the planning hurdles required for the majority of sites in England. Gordon adds that the recent backlash from industry regarding the billions worth of investment this change could cost, alongside the impacts on net zero targets, could prevent the change in definition from making its way into national planning policy.

Chapter 4: Outlook for the future

Overall, there are numerous cost savings achieved by co-location of generation assets, storage assets and end-user demand, as well as a range of available revenue streams that assets can be utilised for. However, this versatility adds complexity in identifying the optimal way to trade the assets, which can dent investor confidence. The business case for co-location is evolving very quickly and requires highly flexible trading capability to stay on top of, especially given the amount of changes coming to the markets in the coming months and years. As more generators and suppliers set up co-located sites (Figure 16) there will likely be improved clarity on which business cases work, which helps build investor confidence. A key consideration, given that co-locating assets places a constraint on one or other of the assets, is whether the cost and time benefits outweigh the losses from that constraint.

Figure 16: Number and capacity (MW) of co-located renewable projects per year on the National Grid Transmission Entry Capacity (TEC) register, as of 12 September 2022



Source: Cornwall Insight, National Grid TEC register

In order to develop confidence in co-location, more engagement is needed from both offtakers and the grid operator. Given the complexity in optimising a co-located site, increased engagement from energy offtakers regarding which energy generation profiles can be traded most profitably is crucial to developing co-location business cases, with aggregators likely playing an important role in this process. More engagement is needed between the grid operator and developers to allow collaboration in identifying where grid reinforcements are needed and getting developers and generators involved in making those grid upgrades, with Liam Kelly, Green Switch Capital, concerned that the grid are placing "extortionate numbers on grid offers", which are killing off new projects. As well as greater engagement on grid reinforcements there also needs to be better modelling of batteries and the role they can play in supporting the grid. According to Francesca Putzu, Junior Data Scientist at Arenko Group, storage assets are currently assumed to be "exporting over a constraint, and thus worsening it", triggering the need for reinforcement work.

There is also a trend emerging in the market to set up energy parks, where a large grid connection is used to connect a series of generators and storage assets as part of one large installation. An example of one of these is the Chelveston Renewable Energy Park, which houses ~26 MW of onshore wind capacity, 120 MW of solar PV capacity (with half dedicated to low-carbon hydrogen generation and battery storage), 20 MW of battery storage, and 10 MW of low-carbon hydrogen production capacity for heavy vehicles[19]. These energy parks allow more generation to connect to the grid than would be possible if all connected independently but also come with increased complexity for optimising.

Similarly to the energy parks, Lev Gurdenli, Weightmans, has seen increasing interest in district energy networks, where large scale property developments (houses, offices etc.) are set up with low-carbon energy and heat infrastructure installed from the outset. Gurdenli adds that these developments often combine renewable generation assets, such as solar PV, located either on site (e.g., rooftops) or on adjacent land, with battery storage and EVCI "to optimise the supply of low-carbon energy to residents".

4.1. A role for power purchase agreements?

Power purchase agreements (PPAs) are currently in place for over 70% of UK renewable energy generation capacity, according to the latest Cornwall Insight PPA Market Share report (August 2022), and could provide a route to market for co-located assets. PPAs can be set up for assets that are subsidy funded or for assets that are merchant financed and can be generation or storage assets. The only subsidy pathway available to renewable projects in the UK currently is the CfD scheme, but the view from industry experts is that co-located sites are more likely to be run subsidy free. PPAs provide a long-term route to market and agreed revenue stream for up to 10 years. However, the high wholesale energy prices currently mean there is more value in remaining trading in the wholesale energy market than locking in to a PPA at present, although these high prices are not expected to continue indefinitely.

Over the last year, roughly half of the capacity in subsidy free PPAs is in Corporate PPAs (CPPAs) where a business is the end user for the generated energy. From 6 April 2022, mandatory disclosures of climate-related financial information for over 1,300 of the UKs largest businesses has strengthened the importance of decarbonising for corporates. Alongside the mandatory disclosures there are also valuable reputational benefits to committing to, and meeting, net zero targets, with climate change a key issue among consumers, citizens, and investors. High and volatile wholesale energy prices provide further incentive to potentially lock-in long

19 Chelveston Renewable Energy Park

term energy prices through a CPPA. Co-located sites are seeing some interest from businesses in setting up CPPAs, with a co-located combination of assets allowing for a firmer energy profile or a better match to a demand profile. However, the greater versatility in co-located sites likely results in higher premiums for their output and so the question remains around whether corporates are willing to pay those premiums for the additional flexibility in the profile.

An alternative to a CPPA for a co-located site is a hybrid PPA where the assets are co-optimised within the PPA structure. There are relatively few examples of hybrid PPAs currently, with Statkraft and Habitat some of the leading players in this field, but there is the potential for hybrid PPAs to provide an important route to market in the future for co-located sites. Negotiating a contract for a hybrid PPA is more complicated than treating the assets as stand-alone and setting up separate routes to market for each asset. However, the ability of co-located sites to guarantee more output and meet both peak and baseload energy requirements allow operators of co-located sites to get a better price for their energy output. Weightmans' Lev Gurdenli mentions that one potential structuring of a hybrid PPA route to market involves an optimiser being granted control of multiple co-located assets and paying a minimum 'floor' payment to the asset owner(s). Any revenues beyond this floor payment can then be shared between the optimiser and the asset owner(s). Gurdenli further notes that this structure allows for the share of revenues between parties to be flexed, alongside the level of floor payment, depending on the risk appetites involved.

As part of the Autumn Statement, published on 17 November 2022, from 1 January 2023 (until 31 March 2028) groups generating over a 100GWh electricity per year from renewable, nuclear, or biomass sources will be subject to the Energy Generator Levy[20]. The Energy Generator Levy will impose a 45% 'windfall' tax on within scope electricity priced above £75/MWh, and so looks likely to damage investor confidence in renewables. However, both electricity generated as part of a CfD and electricity provided by battery storage will not be included under the Energy Generator Levy, and so this 'windfall' tax could result in a greater focus on these routes to market.

4.2. Conclusions

Overall there are a range of key benefits available to renewable generators and developers from co-location. Primary among these are the substantial cost and time savings that can be made from adding a new asset to an existing site, compared to setting up a new standalone site. The co-location of storage and generation assets also provides an increased number of available revenue streams, with storage assets able to load shift generation output or prevent grid curtailment, as well as participating in wholesale arbitrage, grid flexibility services etc.

Despite these benefits to co-location there are also some challenges that, whilst not insurmountable, need careful consideration when setting up a co-located site. The main challenges faced by co-location relate to the risk of the assets curtailing each other and the challenges associated with optimising energy output and revenue from multiple different assets. This is further complicated by the need to navigate existing contractual frameworks when retrofitting a new asset to an existing site. Another

20 Energy Generator Levy

challenge are the concerns of the insurance community on the fire risks presented by battery storage, with clearer guidelines and standardisation of operating procedures key to building insurer confidence.

The outlook for co-location looks positive, with a large pipeline of projects due to come online throughout this decade. There is also an increasing trend in large-scale energy park and district energy network projects, as well as more diverse routes to market provided by hybrid and corporate PPAs, increasing the opportunities for co-location.

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