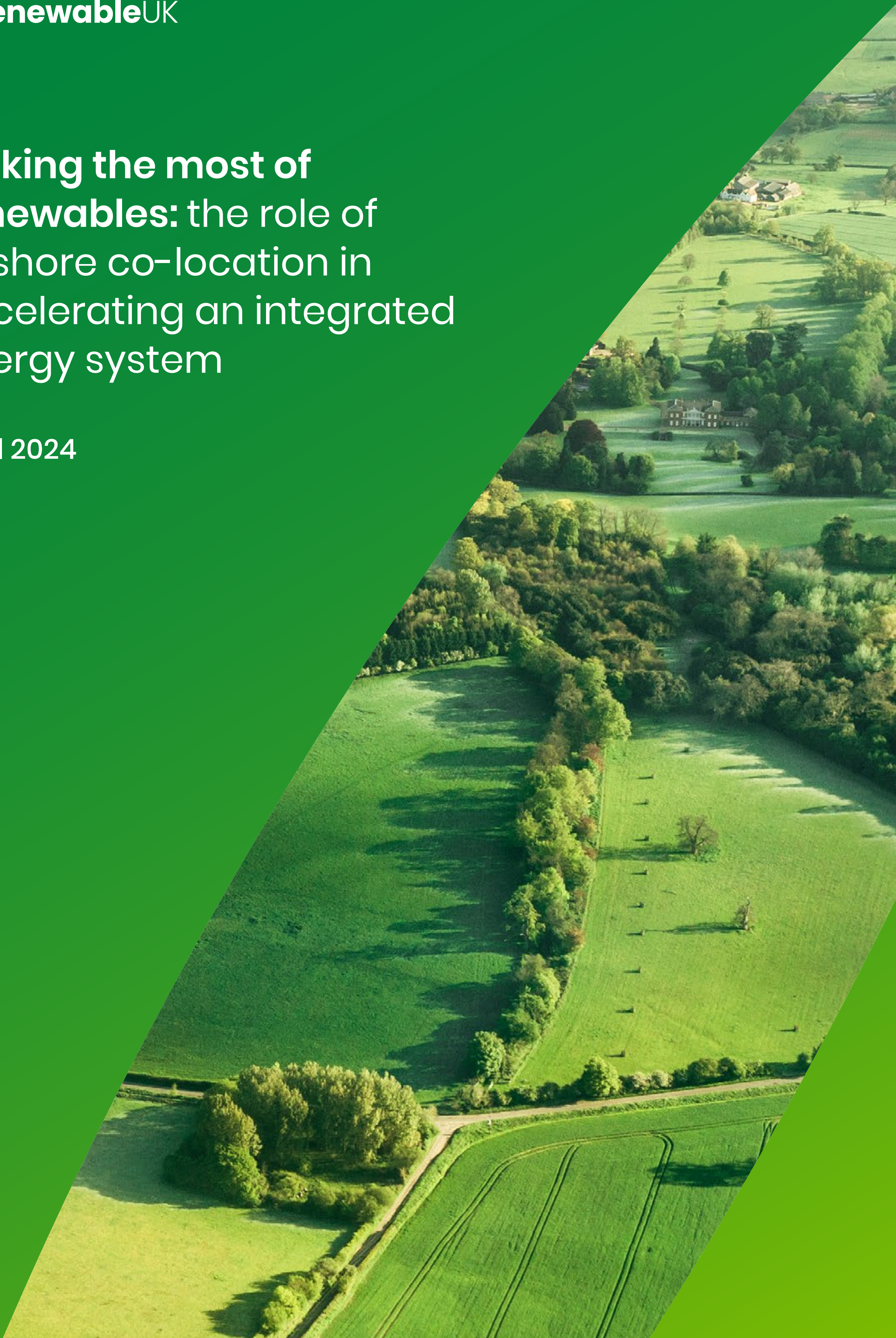
RenewableUK

Making the most of renewables: the role of onshore co-location in accelerating an integrated energy system

April 2024



1 Executive summary

The importance of enabling a modern, flexible and renewable energy system

The UK is targeting full decarbonisation of the electricity system by 2035[1] and to reach net zero by 2050. These commitments will not only ensure the UK moves away from high carbon, fossil fuel use in the power sector but also require widespread electrification across the economy. As the UK electricity supply is transitioning to a modern, decarbonised system an increasing amount will be provided by wind and solar energy as they are the cheapest forms of low carbon generation.

Greater levels of flexibility in the system such as energy storage will allow the UK to integrate renewables with significant savings by up to £16.7bn a year in 2050[2].

" Developers could take the opportunity to make efficient use of land and optimise the existing and future pipeline of assets by adding battery storage and even green hydrogen technologies to their sites."

Increasing the amount of renewables and flexibility from technologies like battery storage or green hydrogen within the UK energy mix requires either developing new sites or building out the capacity of existing sites. However, securing land or planning permission for new projects as well as connection to the grid is a long and costly process. Developers could take the opportunity to make efficient use of land and optimise the existing and future pipeline of assets by adding battery storage and even green hydrogen technologies to their sites. Being able to combine and co-locate various types of technologies behind an existing grid connection can expedite and lower the costs of developing new renewable generation capacity– at the same time as increasing the system's flexible capacity. Co-locating different technologies could bring value to both industry and consumers.

While co-location is of fundamental value to the industry – making efficient use of network capacity assets and available land, UK currently only has a small percentage of co-located onshore wind or solar with battery storage or hydrogen electrolyser (around 12% of all installations[3]). This is because policy and regulation are hindering the growth of such projects. Developers should be able to have the

1 DESNZ, Powering up Britain (March 2023)
2 The Carbon Trust, Flexibility in GB (2021)
3 RenewableUK Energy Pulse

option to include co-location in their projects and business plans as well as retrofit technologies like storage or green hydrogen easily and with confidence which will help improve overall system operation and security. Achieving a flexible system and unlocking the current barriers to co-location and greater operability from renewables will require a coordinated effort and a holistic strategy cutting across markets, grid, planning and technical (metering) barriers.

This paper is focused on onshore technologies[4] and will cover:

- The benefits and opportunities of co-location
- The barriers to deploying co-located projects
- Regulatory changes required to enable quicker and less burdensome deployment of co-located assets

Policy recommendations

The following regulatory changes should be overcome to enable quicker and less burdensome deployment of co-located assets:

No	Issue	Recommendation	Lead
	Grid challenges		
1	Co-location and hybridisation are not very well defined in policy and regulations in the UK, which is hindering the speed of deployment of co-located assets	We need consistent definition of co-location and hybridisation to be applied as we develop policies across network planning, network codes, system operability and market arrangements. It is helpful to have a clear definition of what a hybrid installation is from high level regulation to lower level, covering permitting and connection to the grid	DESNZ, NESO, Ofgem, consenting bodies
2	Connection queue practices disincentivise co-location at distribution level	Co-location projects at distribution level should not have to be sent to the back of the connection queue if co-locating does not alter the need for extra export capacity	DNOs, ENA
3	Lack of an adequate connection assessment process for co-located and hybrid sites	Consider putting in place adequate connection assessment procedures where flexibility is co-located with renewable generation connections	DNOs, TOs, NESO
4	Strategic Spatial Energy Plan driving a clear line of sight for co-location opportunities	A consolidated planning process for co-located assets (including underground hydrogen storage) should be prioritised as matter of urgency and consideration should be given to special exemptions for applications in, or in close proximity to, the UK industrial clusters and ports	NESO

[4] There are some additional challenges related to offshore wind co-location with flexible technologies which are not covered in this paper

No	Issue	Recommendation	Lead
	Grid challenges (continued)		
5	Lack of access to transparent and granular information to incentivise investment in co-location	Flexibility services need to provide adequate investment signals during the planning phase of large-scale renewable installations to co-optimise provision of these services for both new build and retrofit sites. NESO should consider identifying and quantifying net zero system need for key flexibility services in a more transparent and granular way than it does currently, so that developers can build provision of these services into their preliminary designs, land negotiations and planning applications	NESO
6	The TNUoS charging methodology does not adequately reflect co-located generation	Tailor network charging regimes to encourage co-location in key geographical areas to make efficient use of high-cost connections and reduce or minimise grid reinforcements	Ofgem, NESO industry
7	Lack of pragmatic grid compliance guidance from the NESO on associated with co-located sites	Develop and provide a comprehensive grid compliance guidance that extends to operational elements around different metering, forecasting and trading that can reflect all the different operational arrangements associated with co-location	NESO
£	**Market challenges**		
8	Lack of design approval process when retrofitting flexibility to Renewable Obligation accredited sites	Introduce design approval stage to Renewable Obligation process for retrofitting projects with flexibility such that accreditation is not jeopardised as long as project is built to pre-approved design	Ofgem, DESNZ
9	Lack of strong incentive under current CfD rules to participate in ancillary service markets	As part of REMA, government should continue to explore options to decouple output from CfD payment (such as deemed generation CfD') so that generators are encouraged to co-locate technologies that provide system services other than generation for the wholesale market	DESNZ
10	A lack of design approval process for co-location projects	LCCC needs to develop a formal design approval process for co-location projects where there is CfD generation	DESNZ, LCCC
11	The co-location guidance under the CfD scheme relies on certain code modifications and mechanisms that were not really designed for the use of secondary Balancing Mechanism Units, and were really envisaged more for demand-side response type activities	Further refine CfD co-location guidance and the use of secondary BMUs by non VLPs (Virtual Lead Parties)	DESNZ, Ofgem, LCCC, Elexon

No	Issue	Recommendation	Lead
	Market challenges (continued)		
12	Lack of appropriate definitions for hybrid sites within the Contracts for Difference scheme and the Capacity Market	Need to consider allowance of hybrid sites in the CfD with clear definition of roles on basis of perceived system benefit. This will require changes: definition of hybrid BMU (HyBMU) in the Balancing and Settlement Code and requirements for performance monitoring and metering The Capacity Market needs to be refined to include better definitions in place for hybrid CMU and design a comprehensive approach taking into account associated de-rating factors and connection capacity for co-located sites	DESNZ, Elexon
13	Policy alignment between CfD and other support schemes	Interaction and alignment with schemes such as the Hydrogen Production Business Model, the planned Hydrogen to Power business model and LDES support mechanism needs to be thought through to ensure co-location is permitted under those policy frameworks	DESNZ
	Planning and consenting challenges		
14	To enable onshore wind co-located sites to be developed in a streamlined manner, there needs to be a level-playing field for all related renewable energy technologies	Despite the recent changes to the NPPF in September 2023, onshore wind is still singled out in planning compared to other technologies and can only go through local planning authorities as it is exempt from the Nationally Significant Infrastructure Project (NSIP) planning regime unlike commercial scale solar. There are also different regimes for some flexibility assets across the devolved nations. We need authorities to help build awareness of these technologies with local planning authorities to reduce risk and allay some concerns to do with the planning process.	DLUHC, Central government
15	Lack of adequate resourcing of planning authorities and related bodies	Resourcing needs to be improved within the Planning Inspectorate and Local Authorities as well as in Statutory Nature Conservation Bodies (SNCBs) and all statutory consultees, to ensure planning applications are determined in a streamlined, accurate, and timely way for both standalone and co-located technologies	DLUHC, Central Government, PINS, Statutory consultees
16	Lack of planning guidance and outdated policies and statements	All planning regulations and guidelines need to be updated regularly. The recent report from the Electricity Transmission Commissioner has recommended that the National Planning Statements (NPS) need to be updated every 5 years	DESNZ, DLUHC, Central Government, Welsh Government, Scottish Government

No	Issue	Recommendation	Lead
	Planning and consenting challenges (continued)		
17	Strict planning requirements do not apply to existing onshore wind farms or to repowering and life extension of sites. Planning policy should evolve to alleviate current ambiguity around co-location projects and include an approach to differentiate between low and high impact projects which are planned to be co-located to repowering and life extension of existing sites	Appropriate provisions should be made so that retrofitting low impact storage technologies to an existing site is considered part of a material amendment to existing permission and can be considered under Section 73B of the Act accordingly	DESNZ, DLUHC
18	There is a lack of clarity for bringing forward green hydrogen elements of a wider project (i.e. co-location) where that wider project involves a Nationally Significant Infrastructure Project (NSIP). Currently it seems only battery storage is included in the "Associated Development" definition while green hydrogen is not. It is unclear whether a co-located green hydrogen production facility can be included in the same planning application as a site's renewable generators (e.g. solar, wind farm), or whether in fact it requires a separate, stand-alone application to the planning authorities	The review of the NPPF should ensure, at a minimum, that specific reference is made to green hydrogen equivalent to that made for other renewable energy technologies, including reference to the potential for green hydrogen co-location. Department of Levelling Up, Housing and Communities (DLUHC) should update Guidance on NSIP Associated Development to facilitate decarbonisation projects, confirming that green hydrogen production may be an associated development where multiple energy generation projects are proposed or where pipeline meet the NSIP criteria but need the production facility to be built to be utilised for green hydrogen purposes	DESNZ; DLUHC; Central and each devolved government
	Technical challenges		
19	Standardisation in DC electrical power (from technologies like wind, solar and storage) is still in its infancy. The UK has yet to make progress on developing effective solutions on how DC power is metered, calibrated and supportive standards (e.g. power quality metrics) and code compliance in this space is missing	Technical work is needed to develop compliance in the codes for wider standardisation of DC electrical power. Development of metering policy and technical specification which allows for the development of DC coupled co-located projects in the UK	DESNZ, Elexon, BSI, industry
20	REGOs cannot be issued on DC meter readings from DC co-located projects as a result of lack of supportive metering standards being in place	Further work will need to be undertaken by industry and Ofgem to develop a technical solution and produce guidance which is suitable for DC coupled sites	Ofgem, industry

2 Defining co-location

“Co-location is not a well-defined term in the UK. It refers to the process of developing multiple different generation projects (including energy storage) or combining different technology types at the same grid connection point.”

Despite not being a new concept, co-location is not a well-defined term in the UK. In this paper, we define co-location as *the process of developing multiple generation projects (including energy storage) or when combining different technology types at the same grid connection point* (e.g. onshore wind with solar, battery storage or green hydrogen). Currently, battery storage is the core technology driving co-location of different technology types due to its scalability, however pairing with solar, green hydrogen or other longer duration electricity storage technologies is of increasing industry interest.

Co-location of multiple technologies (also referred to as energy parks), is aimed at increasing the flexibility of energy supply and maximising the value from the expensive grid connection and land. Co-location and hybridisation (or hybrid assets) are often used interchangeably even though representing two similar but operationally different concepts. Co-located assets could be geographically close together with some sharing of land and infrastructure (e.g. a grid connection and access to the network). They can have many different metering schemes within a single site for different purposes. Partially co-located sites usually have separate metering, substation or grid connection agreement[5]. The majority of the UK co-located sites currently are partially co-located projects.

Hybridisation usually involves sharing of grid infrastructure (e.g. shared substation or use of inverters) between a mix of generation assets all connected to a single metering point which also identifies the ownership boundary with the network operator. Hybrid assets can also be separated into two categories: those which are fully integrated and those which are partially integrated operationally.

Partially integrated hybrid sites usually have fixed export limits for each component (e.g. solar or battery storage) and sub-metering arrangements that allow for each co-located technology to have its own offtake agreement. Fully integrated hybrid sites have a single grid connection with overall export limit that can be dynamically allocated to each of the site components. Fully integrated hybrids can operate as a single commercial entity and are able to optimise what they provide and when they provide it (operating under priority dispatch for the technologies involved). Fully integrated hybrid assets are

[5] Natural Power, The business case for hybrid projects (2023)

inseparable as it is not possible to implement metering separation of different technology types.

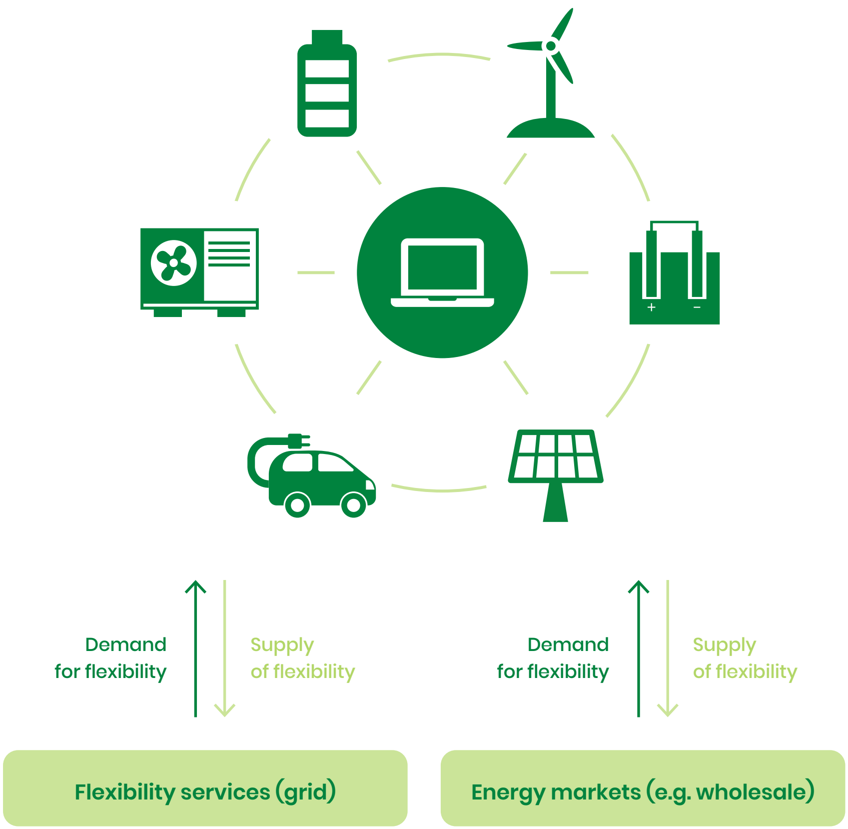
Another closely related concept to co-location of multiple technologies is Virtual Power Plants (virtual co-location), which are defined as networks of demand and multiple small-scale generation or storage assets that are pooled together to supply energy. Typically, each device is geographically spread with no sharing of grid infrastructure, but is operationally and commercially connected "virtually" and traded in the market. Virtual Power Plants allow for optimisation of trading and scheduling of dispatch of energy supply across a portfolio of smaller assets like wind, solar, hydro power, battery storage or demand-side assets. The control of this type of arrangement is very coarse and the aggregator has to factor this in. The value of this is typically not about optimised grid connections and more about pooling resource to allow it to access flexibility revenue streams.

This paper will focus on partially co-located projects (which we refer to as co-location) as well as hybrid assets (both partially integrated and fully integrated hybrids). The diagrams on the next page have been developed as a representative of the different levels of co-location. It should be noted that the technologies involved are illustrative examples and will vary from project to project in practice.

Level of co-location	Shared elements	Separate elements
Virtual Power Plant (virtual co-location)	No sharing of physical assets or infrastructure. Operationally and commercially connected virtually and traded in the market as a larger entity	All technologies, part of a Virtual Power Plant are geographically distant
Partially co-located	Limited shared components such as sharing a grid connection and access to the network	Have separate metering, substation or grid connection agreement
Partially integrated hybrid	Sharing of grid infrastructure (e.g. shared substation or use of inverters). Have single grid connection with fixed export limits for each component (e.g. solar or battery storage). Shared land, roads, operational activities, Biodiversity Net Gain considerations	Sub-metering arrangements that allow for each co-located technology to have its own offtake agreement
Fully integrated hybrid	Sharing of grid infrastructure (e.g. shared substation or use of inverters). Single grid connection with overall export limit that can be dynamically allocated to each of the site components. Shared land, roads, operational activities, Biodiversity Net Gain considerations	Inseparable. Able to optimise what they provide and when they provide it and can be operated as a single commercial entity

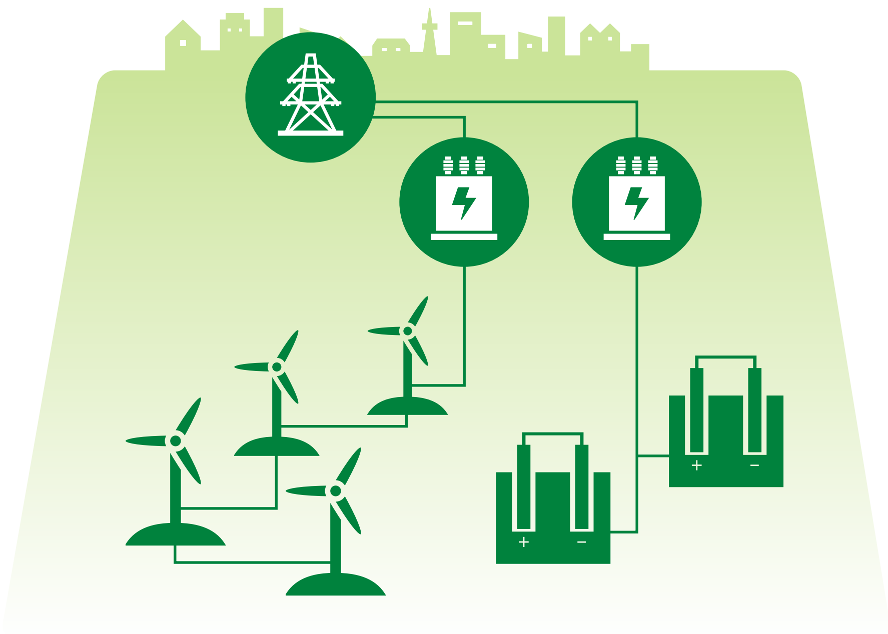
Virtual Power Plants (virtual co-location)

No sharing of physical assets or infrastructure. Operationally and commercially connected virtually and traded in the market as a larger entity.

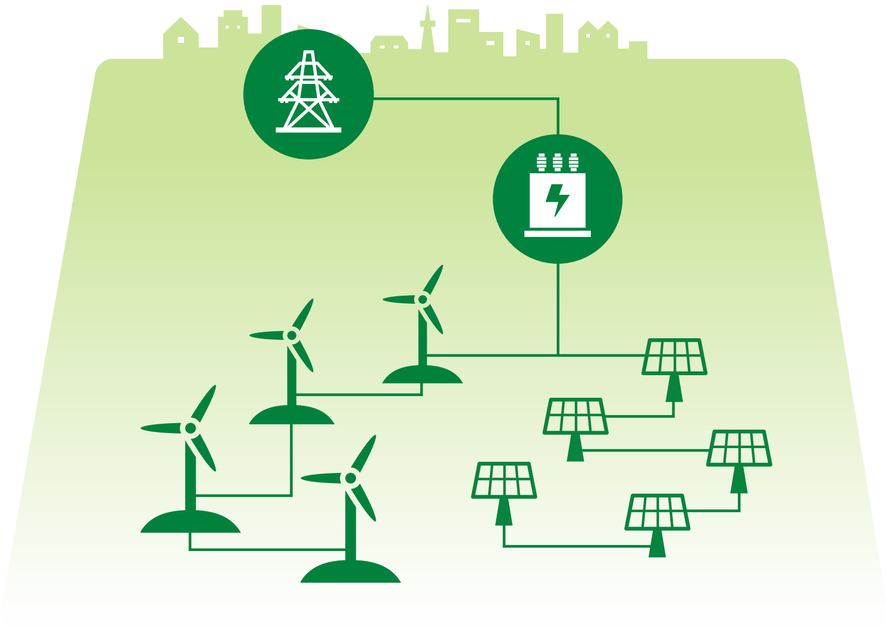


Partially co-located

Limited shared components. Have separate metering, substation or grid connection agreement.

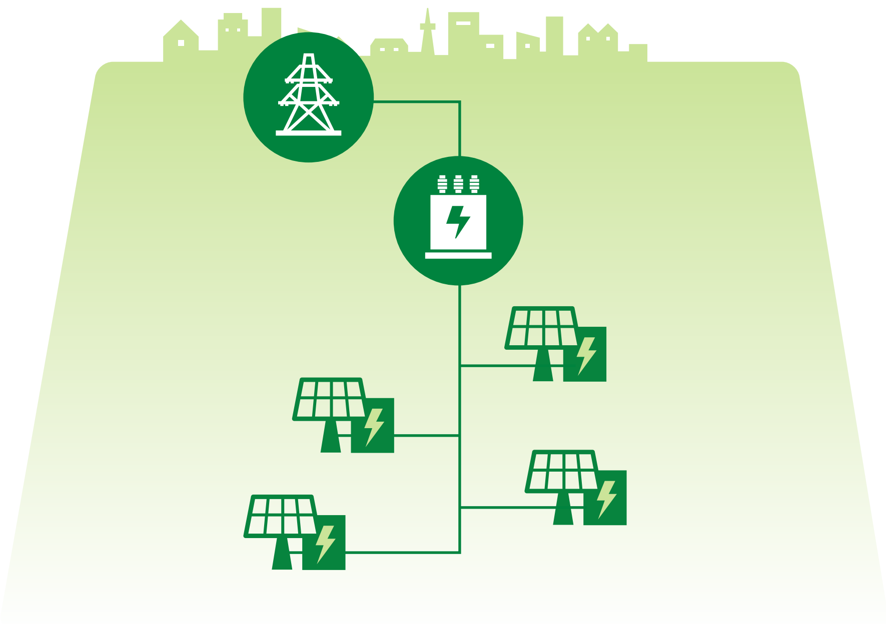


Partially integrated hybrid



Sharing of grid infrastructure (e.g. shared substation or use of inverters). Have single grid connection with fixed export limits for each component. Sub-metering arrangements that allow for each co-located technology to have its own offtake agreement.

Fully integrated hybrid



Sharing of grid infrastructure (e.g. shared substation or use of inverters). Single grid connection with overall export limit that can be dynamically allocated to each of the site components.

3 Benefits and opportunities

Developing co-located or hybrid assets is a more complex process compared to developing standalone sites. However, co-located and hybrid projects can present several benefits and opportunities to developers and consumers[6, 7]:

- Combining onshore wind, solar PV and battery energy storage assets at a single location can create value-added systems compared to standalone applications with asset characteristics better aligned to conventional fossil fuel generation sources. Integrating wind and solar at a site yields a **more stable and manageable power output over time** with less ramping issues and instantaneous peaks than pure wind or solar plants.

- **Lower the cost of renewables** by sharing and reutilising existing infrastructure and land, thereby reducing both the capital and operational cost of the shared assets. Combining storage with renewable generation allows for developers to harvest synergies within the planning and leasing process as well as the operation and maintenance of the energy park which could lead to lower development, capital and operation expenses. Co-location of solar with battery storage may lead to 50% reduction in the battery balance of system costs (shared foundations, access routes etc), and fixed costs (operation and maintenance, land lease, business rates etc.) due to the use of a shared grid connection point[8].

- As access to the grid has become more competitive – and connection queues are lengthening - the significance of maximising the utility of a project's grid connection is becoming increasingly important. Co-location of multiple complementary generation and storage technologies and demand offer the opportunity to make **more efficient use of grid capacity** by optimising the use of the network (depending on the technologies co-located and other factors such as the correlation of renewable output to system flexibilty needs). A benefit of sharing grid connections is the reduction of additional cable corridors delivered in the connection of new projects. Co-locating technologies to an existing operational renewable site

6 Weightmans and Cornwall Insight, Co-location co-location co-location (December 2022)
7 WindEurope, Renewable Hybrid Power Plants: Exploring the benefits and market opportunities (July 2019)
8 Aurora Energy Research, The economics of merchant solar co-located with battery storage systems (September 2019)

(e.g. adding storage to a solar or a wind farm) could also speed up the time to connect to the grid compared to a standalone storage development. Standalone storage assets currently face a delay to connect to the grid beyond 2030, while co-locating to an existing site **minimises the need for more costly grid capacity** which leads to **reduced infrastructure investment costs**.

- National planning policy requirements in England are a major barrier to development of new onshore renewable generation. Extending and/or repowering projects to **make use of land available** as well as the high level of public acceptance nurtured in that location is an important opportunity for bringing more onshore wind online. Land is more efficiently used since the installed capacity and energy output per square meter of used land increases with co-located as well as hybrid sites.

- Combining multiple assets behind a single connection point also provides an opportunity to load shift generation output or **avoid grid curtailment** during times of high renewable generation, particularly in the cases when energy can be moved directly from generation to storage (e.g. in a DC coupled sites[9]). Hybridisation of generation and demand assets helps the grid by relieving the constraints on the network, **ultimately lowering the overall balancing costs** paid by consumers and boosting overall system reliability. Alongside maximising the revenue of the generation asset, a storage asset can also participate in wholesale trading, ancillary services, the balancing mechanism, and the Capacity Market. In 2022, around 80-85% of battery storage revenues came from ancillary services. However, industry expects that the battery storage revenue stack will gradually shift towards balancing and wholesale trading. For this application a hybrid asset might have an advantage over a standalone asset which will still need to charge from the grid.[10]

- Hybridisation also provide benefits to **manage merchant revenue risk for generators** and avoiding risks due to forecast uncertainty. Co-locating renewables with green hydrogen in particular also allows to mitigate the effects of price cannibalisation in a merchant scenario. Older renewable sites under the Renewable Obligation scheme will need to prepare to operate under a more merchant world, where they would increasingly be exposed to the effects of wholesale prices. Following recent rule changes, CfD assets are not guaranteed revenue when wholesale prices remain negative for 6 hours or more. Hybridisation allows for a firmer energy profile in terms of dispatching power in the market; it is no longer just about how many MWhs are being fed into the grid – we need to understand and optimise when these MWhs are being injected.

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[9] For explanation on DC coupled sites, please go to pg 29

[10] Natural Power, The business case for hybrid projects (2023)

4 Barriers to deployment

Grid challenges

- Connection queue
- Centralised Strategic Network Planning
- Network charging
- Grid compliance

Market barriers

- Renewable Obligation
- Contracts for Difference
- Capacity Market

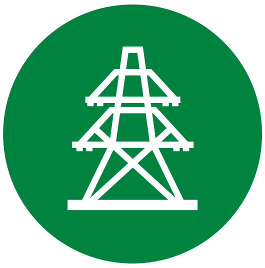
Planning & consenting challenges

- Planning process
- Retrofitting
- Green Hydrogen

Technical barriers

- Metering

Grid challenges



One of the key benefits to co-locating different onshore technologies is maximising the utility of the project's grid connection. This sections details some of the existing grid challenges which developers need to overcome when making co-location decisions.

Connection queue

It is widely recognised that the current connections process is no longer fit for purpose. The current process was designed to connect small numbers of large fossil fuel generators every year and has not kept up with the changes we are seeing in the energy sector. Between 2018 and 2022 the volume of new application offers provided per year grew tenfold, and the volume of offers sent out in the first quarter of 2023 alone exceeded the total volume in 2022. The ultimate result of this has been that there is over 420GW[11] as of December 2023 of projects waiting to connect to the transmission system, with offers for new projects often giving dates in the late 2030s for connection. The pipeline of projects waiting to connect to the transmission network has been growing, with over 500GW[12] as of time of writing; there is still more waiting to connect to the distribution network. In particular, battery storage has risen from having zero capacity in the queue in 2017/18 to 97GW today[13]. DESNZ and Ofgem published a network Connections Action Plan in November 2023 to deal with issues in the connections queue. It will represent a key milestone in the next phase of connections reform and set the direction for future action.

- **Connection queue practices disincentivise co-location at distribution level** — When considering co-locating storage to projects which have secured a grid connection, developers could be faced with the risk of losing their place on the connection queue even if

[11] National Grid ESO, Connections Reform: Final Recommendations Report (December 2023)
[12] National Grid TEC register (March, 2024)
[13] RenewableUK EnergyPulse: Energy Storage (December 2023)

there is no need to increase the export capacity from the site. This is because distribution network companies carry out connection reassessment process on impacts on network fault limit and additional import capacity from the site. The addition of storage next to the renewable asset will require both import and export capacity from the grid connection point. Co-location with flexibility assets are not additional capacity injected into the grid but will regulate and help the network at the point of connection - the inclusion of a second technology should not imply a full reopening of a connection agreement but an update of existing one, in those cases in which hybridisation takes place in an existing site where there is no need to increase the overall export capacity from the connection. **Co-location projects at distribution level should not have to be sent to the back of the connection queue if co-locating does not alter the need for extra export capacity.**

- **Adequate connection assessment process for co-located and hybrid sites** - batteries are not additional capacity injected into the grid but assets that can help to regulate the system. Therefore, no additional reinforcements or investments, such as new or upgraded transformers, should be required. These requirements increase the cost of the hybrid projects and make them unfeasible from a techno-economic perspective. A careful consideration should be made whether the addition of storage co-located with renewables will have any negative impact on higher or lower voltages of the network or in fact help to alleviate thermal constraints in the area. There is a licence condition[14] which places obligations to network companies to ensure whole system coordination in planning and operating the grid, however there is still a gulf between cooperation and a single whole system network treatment. An adequate connection assessment process for co-located and hybrid sites can address the shortcomings of the current approach and consider the whole system benefit from co-location (in addition to local benefit). **Consider putting in place adequate connection assessment procedures where flexibility is co-located with renewable generation connections**.

Centralised Strategic Network Planning

The move to Centralised Strategic Network Planning is welcomed and will help provide clarity and certainty to network companies, developers and the public on where and why new network investment is needed. National Grid ESO published the transitional Centralised Strategic Network Plan (tCSNP), "Beyond 2030" in March 2024, which set out the network requirements for a decarbonised grid. As National

[14] Standard licence condition D17/7A (Electricity Act 1989) places obligations on DNOs and TOs to ensure coordination and cooperation in planning and operating the whole electricity system.

Grid ESO evolves into the National Energy System Operator (NESO), the tCSNP will begin to take into account other energy networks such as hydrogen and other gasses.

Beyond this, the Electricity Networks Commissioner, Nick Winser, has recommended that the NESO produce a Strategic Spatial Energy Plan, which would map out Government energy targets spatially across the UK. This would help inform the tCSNP as well as the National Policy Statement (NPS) and further unlock the potential for investment ahead of need for grid projects, allowing a 'plug-and-play' approach for new generation, as well as helping prospective developers better understand where grid capacity will be available to site new projects.

- **Strategic Spatial Energy Plan driving a clear line of sight** - We need a Strategic Spatial Energy Plan which will prioritise the geographical spread of assets needed to meet 2050 targets. A consolidated planning process for co-located assets (including underground hydrogen storage) should be prioritised as matter of urgency and consideration should be given to special exemptions for applications in, or in close proximity to, the UK industrial clusters and ports.

- **Lack of transparent and granular information access to incentivise investment in co-location** - alongside optimal strategic grid investment, network companies need to indicate areas where the additional flexibility from standalone flexibility assets and co-location of multiple technologies like storage, hydrogen or solar with onshore wind could help alleviate future network issues. Flexibility services and improving dispatchability from renewable generation cannot always be an afterthought in renewable investments, although retrofitting is always an option, it generally proves to be unviable for offshore wind investments compared to onshore renewable investments. Flexibility services need to provide adequate investment signals during the planning phase of large-scale renewable installations to co-optimise provision of these services for both new build and retrofit sites. NESO should look to provide an operational flexibility requirement (both locational and temporal) for developers to consider in their design process. Access to transparent and granular information on flexibility requirements will reduce investment risk and DEVEX costs as well as ensuring high value to the system projects get deployed. It could also enable asset operators to retrofit existing assets and support life extension of projects, helping to address regional operational requirements. This could be provided as an extension to the existing System Operability Framework (SOF). **NESO should consider identifying and quantifying net zero system need for key flexibility services in a more transparent and granular way than it does currently, so that developers can build provision of these services into their preliminary designs, land negotiations and planning applications.**

Network charging

Co-location could be most beneficial in key geographical areas where constraint costs are high and require expensive grid reinforcements. Co-location would help make more efficient use of high-cost connections and bring forward connections in these areas that face significant delay to energisation (thereby putting investment at risk).

- **The TNUoS charging methodology does not adequately reflect co-located generation** - TNUOS charges still apply even if the co-located asset i.e. storage or hydrogen electrolyser is in very close proximity to generation where it offtakes most of its power but situated in front of the meter. These costs should not be the reason for a negative business case for co-location. More generally the test should always be around unfair advantage compared to two separately connected sites in the same location. We need to tailor network charging regimes to encourage co-location in key geographical areas to make efficient use of high-cost connections and reduce or postpone grid reinforcements.

Grid compliance

Currently there is a lack of pragmatic guidance being available from the NESO on grid compliance associated with co-located sites. We see the need to **develop and provide a comprehensive grid compliance guidance that extends to operational elements around different metering, forecasting and trading that can reflect all the different operational arrangements associated with co-location**. This should include provisions for separate Balancing Mechanism Unit (BMU) arrangement for co-located sites with grid compliance options for combined efficiency. In particular, it will be beneficial to develop grid compliance guidance that can provide greater clarity on: the suitability in combining technologies within a single site, expectations around operational awareness of co-located BMUs for the system operator and how dynamic signals should be formed when the site is co-located with multiple BMUs.

Market barriers

Established market arrangements like Contracts for Difference, Renewable Obligation and the Capacity Market were not initially designed with co-location in mind. The CfD, the RO and the Capacity Market haven't evolved significantly in the way that could value flexibility provided by co-location of renewable assets with storage or hydrogen. Current market arrangements could also hinder decisions to co-locate if appropriate provisions are not put in place to remove these barriers.

Renewable Obligation

The Renewable Obligation (RO) is a key support mechanism for renewable energy generation. In 2022, ROCs were issued based on 78.0 TWh of renewable generation, equivalent to 29.5% of the UK electricity supply market. These ROCs act as an additional revenue stream for renewable generators and have been an important driver of investment into UK renewable energy. The scheme closed to all new generating capacity in 2017. As older wind farms are coming to the end of their 20-year ROC subsidy period in the coming years decisions around life extension and repowering, including co-location will play an important role.

- **Lack of design approval process when retrofitting flexibility to accredited sites** - retrofitting of energy storage and other flexible technologies to RO accredited generators is currently undertaken 'at-risk'. As the RO scheme administrator, Ofgem does not confirm enduring accreditation until after retrofit is completed[15]. The real challenge lies in the timing of the re-accreditation, where Ofgem will only assess RO re-accreditation applications once the site has been altered (for instance once the hydrogen electrolyser has been

[15] Ofgem, Guidance for generators: Co-location of electricity storage and hydrogen production under the RO, FIT, REGO and SEG (March 2023)

built). There is no process for Ofgem to provide a minded-to opinion based on the detailed desktop study of the amendments prior to Final Investment Decision (FID) for the installation of the co-located asset. This provides a significant challenge to meeting FID, which is required prior to the build of the electrolyser or battery, as the RO accreditation for the whole RO accredited site is deemed 'at risk' by the developer until Ofgem have assessed the changes to the site. **We believe the solution would be for Ofgem to provide a minded-to position on RO re-accreditation based on a desktop study of the amendments to a RO site at the pre-FID stage**. We need to create a design approval process as part of RO re-accreditation for retrofitting projects which will grant a pre-approval of the to retrofit RO projects with flexible technologies in a way that accreditation is not jeopardised as long as project is built to pre-approved design.

Contracts for Difference

The Contracts for Difference (CfD) scheme was introduced in 2015 and replaced the RO as the main support mechanism for new renewable energy generation. Developers are paid a flat (indexed) rate for the electricity they produce over a 15-year period. This flat price is the 'strike price' which generators are paid per MWh. If the 'reference price' (a measure of the average market price for electricity in the GB market) falls below the strike price the government pays the difference; if the reference price is higher the generator pays the difference back.

The efficacy of the CfD scheme has been undermined by some key challenges recently, most notably unsustainable Administrative Srike Prices that do not reflect recent macroeconomic conditions such as higher cost of capital and rising supply chain costs. The CfD as currently designed also incentivises generators to maximise their output regardless of system stress and network constraints. CfD generators must also take on the volume risk of being asked to curtail generation during times of system stress (supply outpaces demand, or grid constraints), without compensation if stress events result in negative prices for a period over 6 hours and no compensation for any negative price period under some CfD contracts. As renewable generation capacity increases, it is likely this risk will be exacerbated. DESNZ has made progress on 2021 Smart Systems and Flexibility Plan to reform the CfD and enhance the system integration of CfD generation as well as more recently with the proposals to introduce hybrid metering arrangements in the latest CfD Allocation Round 7 (AR7) consultation[16].

[16] DESNZ, Proposed amendments to Contracts for Difference for Allocation Round 7 and future rounds (January 2024)

- **Lack of strong incentive to participate in ancillary service markets** - the current approach and focus on assets to maximise output regardless of system stress and network constraints actively disincentivises development of hybrid installations and their participation in ancillary service markets. Potential changes to CfD market arrangements in the future, will have an impact on the financing and operability expenses of projects (such as additional investment in enabling technology to participate in grid services or respond to locational operability and flexibility signals provided by the system operator). This will most likely need provisions to be explored in the CfD to decouple output from CfD payment to accommodate such projects with a comprehensive and quantified impact assessment needed to identify the benefits and any potential risks of such a change. As part of REMA, government should continue to explore options to decouple output from CfD payment (such as deemed generation CfD) so that generators are encouraged to co-locate technologies that provide system services other than generation for the wholesale market.

- **A lack of design approval process for co-location projects** - since its introduction, a CfD co-location guidance has been produced with the scheme administrators – the Low Carbon Contract Company (LCCC) which has made good progress in addressing strict requirements, particularly metering. The proposals in the AR7 consultation are very promising and will encourage the use of digital metering solutions in line with the needs of the industry and will go some way to address the challenge of co-located storage assets importing power from the grid. DESNZ, LCCC and Elexon need to continue to collaborate with industry to make the use of digital metering solutions a reality. However, it is likely a wide range of metering arrangements and models will be put forward. LCCC needs to have the authority to advise project developers early in the process that their co-location projects will be compliant under the CfD rules. This will greatly reduce developer risk and DEVEX costs. **There is a strong case for LCCC to develop a formal design approval process for co-location projects where there is CfD generation**.

- **Further refine CfD co-location guidance and the use of secondary BMUs by non VLPs** – although there is an updated guidance for co-location under the CfD scheme[17], this relies on certain code modifications and mechanisms that were not really designed for this purpose, and were really envisaged more for demand-side response type activities. For example, it relies on the use of Secondary BMUs which can only be registered by Virtual Lead Parties (VLPs). This limits

[17] LCCC, Co-location Generator Guidance (May 2023)

the use of this arrangement by non VLP market participants and further work is needed to better accommodate grid-connected CfD projects with co-located assets in the form of **further refining the CfD co-location guidance and the use of secondary BMUs by non VLPs (Virtual Lead Parties)**.

- **Hybrid asset participation in multiple schemes faces challenges** - currently, cumulation of multiple subsidies is not allowed as per the Subsidy Control Act 2022. The current rules require the amount of energy generated by each technology to be clearly established. As a result, any wind or solar plant which has a CfD agreement, for example, cannot enter a Capacity Market agreement at the same time. This will be a barrier to hybridisation if the hybrid unit wants to participate in multiple schemes and are not metered separately.

- **Lack of appropriate definitions for hybrid sites** – the industry will require options and a flexible regulatory framework through which to innovate. We welcome the current approach taken by DESNZ and wider stakeholders to remove the barriers on the use of secondary BMUs and sub-metering for co-located sites outlined in the CfD AR7 consultation, which provides enough confidence that developers could still choose to co-locate technologies and have the option to co-locate and use separate metering and separate BMUs still available. However, the current CfD guidance still does not permit for a storage asset to import power from the grid if that asset shares a BMU with the CfD generator. Co-location is permitted if both generation and storage have separate BMUs. Managing two or more BMUs could result in administrative challenges for hybrid sites which could be solved by developing appropriate definitions within the Balancing Mechanism for hybrid assets. The BM is seen as an essential mechanism for unlocking and valuing flexibility and its role can be improved by a number of different measures such as allowing more participants to access the Balancing Mechanism (BM) as well as putting in place provisions so that hybrid renewable assets can avoid the need to curtail as much as possible. Such measures should help to optimise the dispatch of renewables on a more dynamic basis and support the operation of a net zero grid. Allowance of hybrid sites in the CfD with clear definition of roles on the basis of perceived system benefit will require further provisions to be explored such as **introducing a definition of hybrid BMU in the Balancing and Settlement Code and associated development of requirements for performance monitoring and metering which are currently not in place**.

- **Policy alignment between CfD and other support schemes** – aligning the CfD with the Hydrogen Production Business Model (HPBM) support scheme is needed to provide certainty to the industry that co-located projects where the generation is CfD-backed, and the electrolysis is within the HPBM scheme, are permitted under both regulatory frameworks. There may be some additional challenges with the pricing requirements for the HPBM (which requires a spot price) and the CfD (which uses the day ahead reference price). **Interaction and alignment with schemes such as the Hydrogen Production Business Model, the planned H2P business model and LDES support mechanism needs to be thought through to ensure co-location is permitted under those policy frameworks**.

Capacity Market

The Capacity Market (CM) was introduced in 2014 to manage security of electricity supply and safeguard against the possibility of future blackouts. Renewable generation was initially unable to participate in the CM until legislation was amended in 2019. CM participants take part in two capacity auctions each year (a year ahead (T-1) and four years ahead (T-4) auctions) where successful bidders are awarded Capacity Agreements which confirm their CM obligation and the payments they are entitled to receive. These payments are made to ensure CM participants are available to respond in a scenario where there is significant risk of a System Stress Event occurring.

- **Lack of hybrid assets definition in the Capacity Market** - the CM does not have appropriate definitions for hybrid CMU (HyCMU) or defined de-rating factors for hybrid sites. DESNZ has also recently decided to make changes to connection capacity for co-located sites participating in the CM and cap the unit capacities at the grid connection level of TEC or MEC rather than the nameplate capacity of the site. Capping the co-located sites connection capacity at the site level of TEC or MEC seems to be a step backwards in promoting co-location compared to the current arrangements as it will incentivise only one of the multi-unit site assets to participate in future actions. **Going forward the CM needs to be refined to include better definition for hybrid assets with definitions put in place for hybrid CMU (in line with the Subsidy Control Act 2022) and design a comprehensive approach taking into account associated de-rating factors and the connection capacity for hybrid sites.**

Planning and consenting challenges

Making the most of available land and space is another key driver behind developers' decisions on co-location. However, harvesting synergies within the planning and leasing process for co-located assets could be challenging with a number of regulatory hurdles that developers still need to overcome.

In England, renewable developments benefit from the National Planning Practice Guidance (NPPG) on renewable energy generation, which provides guidance on how the policies and principles detailed within the National Policy Statement (NPS) and the National Planning Policy Framework (NPPF) apply in practice, and how key planning and environmental considerations should be dealt with, including matters such as site selection. Wales, Northern Ireland and Scotland have their own equivalent planning policies and guidance documents.

The British Energy Security Strategy (BESS) suggests that government is supportive of solar generation that is co-located with other functions (for example, agriculture, onshore wind generation, or storage) to maximise the efficiency of land use. However, there is no mention of onshore wind co-located projects in planning policy. As a result, an enabling framework within planning policy for co-located renewable energy projects may be beneficial. Although, there is a risk that a combined co-located planning application process may halt the development of any technology. For example, if there is a preference for one particular technology over another, then an application may face complications, and even refusal, when seeking development consent.

- **A plan-led approach for co-located sites** – greater national planning policy provision and support for the co-location of renewable energy technologies on existing or new onshore wind energy sites, to maximise the opportunity for delivering greater efficiencies and reduced intermittency, and contributing towards rapid decarbonisation of electricity generation across the UK. National policy in support of co-location with relevant supporting guidance is needed as a priority to enable planning authorities to transpose this policy within emerging development plans and relevant local planning guidance. Planning for this type of co-location could be facilitated through a plan-led approach, as has been developed via non-statutory guidance with the Development Framework for the Hagshaw Energy Cluster - Planning for Net Zero, in Scotland[18]. Central to achieving this is the requirement for collaboration between developers, landowners, the wider community, and local planning authorities.

There are several other issues that persist across the consenting process for all technologies, both standalone and co-located:

- **Different planning regimes for different technologies** – to enable onshore wind co-located sites to be developed in a streamlined manner, there needs to be a level-playing field for all related renewable energy technologies. Currently, planning policy discourages developers from building onshore wind in England. In 2013, a Written Ministerial Statement led to the implementation of a footnote within the NPPF and has acted as a de-facto ban for onshore wind development in England ever since. Despite the recent changes to the NPPF in September 2023, onshore wind is still singled-out in planning compared to other technologies and can only go through local planning authorities as it is exempt from the Nationally Significant Infrastructure Project (NSIP) planning regime unlike commercial scale solar. There are also different regimes for some flexibility assets across the devolved nations. For example, in England and Wales, The Town and Country Planning Act includes flexibility assets such as long duration energy storage (LDES), whereas in Scotland LDES is considered as a generation technology therefore it requires a development consent order (DCO). This adds additional time to the process and differences may mean an unlevel playfield between jurisdictions. Flexibility assets such as LDES and some types of battery storage technology are relatively new and projects are innovating – we need DESNZ to help build awareness of these technologies with local planning authorities to reduce risk and allay some concerns to do with the planning process.

- **A lack of planning resource** – resourcing needs to be improved through both bringing in additional resource and upskilling the current workforce within the Planning Inspectorate and Local Authorities as well as in Statutory Nature Conservation Bodies (SNCBs) and all statutory consultees, to ensure planning applications are determined in a streamlined, accurate, and timely way for both standalone and co-located technologies. Industry strongly recommend that increases in revenue from planning fees are ring-fenced to ensure that funds are not used to cover shortfalls in other areas of Local Authorities'

[18] www.thehagshawenergycluster.co.uk

budgets. Industry is supportive of the proposals to increase fees related to planning applications provided that local authorities and the Planning Inspectorate can deliver a high-quality consenting process, that is time effective, streamlined, and transparent. The only way to ensure this is to increase resourcing to a level that would support this. Planning fees could be raised to a proportionate cost recovery level, but if Government continue to resist ring-fencing such fees to enable delivery, they will require to find other funding to improve resourcing.

- **Outdated planning policies and statements** – it is important that all planning regulations and guidelines are updated regularly. For example, the recent report from the Electricity Transmission Commissioner has recommended that the National Planning Statements (NPS) need to be updated every 5 years and support wider government policy.

Retrofitting technologies to existing sites

Currently, strict planning requirements do not apply to existing onshore wind farms or to repowering and life extension of sites. Co-location with operational onshore wind generation as well as solar technologies is a good opportunity to bring more renewable generation to the system.

The lack of clarity on how a co-located project needs to be processed through planning and permitting increases the risk of an application being refused, and therefore constitutes a potential barrier. Involved planning authorities do not have guidance on how to proceed and thus projects are analysed in a very different way depending on the authority or even the person in charge. This typically results in longer timings and developers not being able to properly prepare the permitting process and anticipate authorities' requests. When retrofitting storage to existing sites developers need to submit a new planning application (e.g. S36 in Scotland). If developers had to follow the standard 50MW + Scottish energy consenting unit route, then this is likely to put developers off. To maximise the opportunity of installing battery storage on existing sites (or sites with existing consent) we would need a simplified process to make it quicker and less risky. We recommend that planning policy should evolve to alleviate current ambiguity around co-location projects and include an approach to differentiate between low and high impact projects which are planned to be co-located to repowering and life extension of existing sites.

- Low impact storage projects are smaller in size and their impact on the environment. We see the need to develop appropriate provisions for low impact storage projects (such as battery storage) co-locating with existing sites so that there are means to reduce the quantity of surveys and documentation needed to be provided for the application to be approved. Current rules require low impact projects co-locating within the existing site boundary to submit a new planning application. Appropriate provisions should be made so that retrofitting low impact storage technologies to existing sites is considered as part of a material amendment to the existing permission and can be considered under Section 73B of the Act accordingly.

- High impact storage projects are larger in size and their impact on the environment, for example a long duration storage project. The business case for high impact co-located project needs to be laid out at project inception and part of the preliminary designs, land negotiations and planning application.

Green hydrogen

Both standalone and co-located green hydrogen projects involve multiple components which interact with several planning bodies and different regulatory regimes. Due to the nascent stage of the industry, the current planning and permitting regime has not yet evolved sufficiently for this technology which could significantly impede the growth and success of a UK-based hydrogen economy. To accelerate the deployment of green hydrogen projects across the UK; simpler, faster and more predicable processes are required.

- **The NPPG does not reference green hydrogen, leaving the local planning authorities with little direction** - The lack of guidance for planning decisions relating to green hydrogen introduces risks; leading to potential unnecessary restrictions and controls being put in place.

- **There is a lack of clarity for bringing forward green hydrogen elements of a wider project (i.e. co-location) where that wider project involves a Nationally Significant Infrastructure Project (NSIP)** - Currently it seems only battery storage is included in the "Associated Development" definition while green hydrogen is not. It is not clear that the green hydrogen site will be able to be considered as an "Associated Development" given that it can be a means and end to itself; and hydrogen production is not itself currently able to be a NSIP. Moreover, it is unclear whether a co-located green hydrogen production facility can be included in the same planning application as a site's renewable generators (e.g. solar, wind farm), or whether in fact it requires a separate, stand-alone application to the planning authorities. In such instances the green hydrogen production facility is likely to be a key aspect of the generating plant's route to market and therefore certainty is required. Within the current policy and guidance void on green hydrogen its production is considered an industrial process in planning terms, it is not considered as electricity generation and as such follows the relevant TCPA process for industrial use. Depending upon its scale it could also be COMAH regulated and also require an application for Hazardous Substance Consent.

- **Projects are forced between two consenting regimes in some instances** - The Whitelee project, for example, was initially presented for EIA screening under the Electricity Act as a single project, comprising of an electrolyser, solar and battery storage. After much discussion it was deemed that neither the Scottish Government nor the council could determine the project as a whole. This was because the hydrogen production element was not electricity generation and could not be determined under the Electricity Act, and the solar and battery components exceeded 50MW and therefore could not be determined by the Council as part of the project. The result was the project being split over two consenting regimes which significantly hampered process.

- **The review of the NPPF should ensure, at a minimum, that specific reference is made to green hydrogen equivalent to that made for other renewable energy technologies, including reference to the potential for green hydrogen co-location. Department of Levelling Up, Housing and Communities (DLUHC) should update Guidance on NSIP Associated Development to facilitate decarbonisation projects, confirming that green hydrogen production may be an associated development where multiple energy generation projects are proposed or where pipeline meet the NSIP criteria but need the production facility to be built to be utilised for green hydrogen purposes.**

Technical barriers

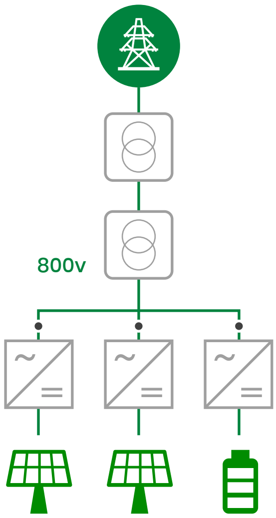
The current metering provisions haven't yet evolved to a level to provide greater certainty in terms of standardisation or have kept pace with innovative methods of digital metering such as DC coupled hybrid systems. The lack of appropriate standards in this space is a technical barrier which still need to be addressed to allow for a less burdensome development of DC coupled hybrid systems.

The generation, storage and use of DC electrical power is set to grow in the electricity grid with the transition to renewable technologies like wind, solar, battery storage and electric vehicles; all of which rely on DC (direct current). Technically integrated DC coupled co-location systems rely on shared configuration of power equipment between two generation technologies (e.g. shared use of inverters). Such configuration treats DC coupled co-located projects as fully integrated single machines - hybrid assets.

Most utility scale solar and storage co-located systems are AC coupled with separate inverters for each of the assets. AC coupled co-location offers the benefit of operating the assets independently. The use of AC coupled systems is highly standardised in the UK with settlement and billing regulations predicated on the use of AC meters. The alternative to AC coupled co-location is DC coupled which relies on shared use of inverters. The key advantages of DC coupling are cost saving and being able to store clipping energy losses (these occur when storage can soak up renewable generation which will otherwise be wasted due to the capacity of the inverter). DC coupling is a less common configuration as it is more challenging in terms of technical and commercial separation of the assets.

AC Coupled

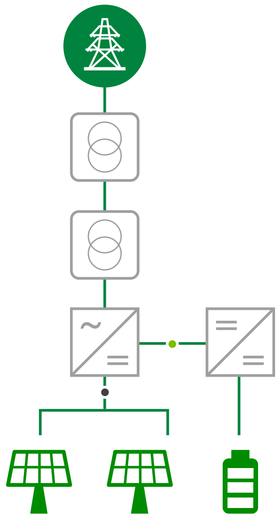
- Both solar and battery have their dedicated inverters converting from DC to AC
- Less cost-efficient option to DC coupled
- Metering: To separately meter solar and battery energy flows AC meters are sufficient



● AC Meter
● DC Meter

DC Coupled

- Solar and battery share the same inverter
- For the battery only a DC-DC converter is required (cheaper than inverter)
- More cost-efficient system design
- Metering: To separately meter solar and battery energy flows DC meters are required
- On the AC side it cannot be differentiated between solar and storage



Metering

Standardisation in DC electrical power (from technologies like wind, solar and storage) is still in its infancy. The UK has yet to make progress on developing effective solutions on how DC power is metered, calibrated and supportive standards (e.g. power quality metrics) and code compliance in this space is missing.

- **Lack of appropriate REGOs guidance on the use of DC meters** - there is a lack of guidance from Ofgem that can reassure the industry that REGOs can be issued on DC meter readings from DC co-located projects as a result of lack of supportive metering standards being in place. For a typical site with AC metering assuring accuracy of metered volumes will be straightforward, since an AC settlement meter would be Measurement Instrument Directive (MID) compliant and so accuracy can easily be demonstrated with normal test certificates. Ofgem is not able to use metered volumes from DC meters that record the solar generation (independently of battery storage metering volumes) and means of evidencing that these are sufficiently accurate as there are currently no DC-meters accredited. However, it is possible for DC coupled generators to be able to demonstrate metered volumes are accurate to Ofgem in other ways, not exclusively just by having an MID compliant meter – for example sharing other internal commissioning test results or data flows for which a technical solution could be provided in the guidance issued by Ofgem. The lack of clarity on DC co-located projects eligibility to receive REGOs presents a barrier to further development of DC co-located hybrid projects in the UK. Further work will need to be taken by industry and Ofgem to develop a technical solution and produce guidance which is suitable for DC coupled sites.

- **Lack of supportive DC metering standards** - In May 2023 an updated CfD co-location guidance included new provisions for DC co-located projects. The CfD has relaxed condition 31.F so that battery storage can be co-located at CfD sites with associated DC meters. The update to the CfD co-location guidance confirmed that the CfD will be settled, and payments calculated at the point of generation in either AC or DC, although it may be subject to differencing or aggregation rules. However, even with these changes Elexon protocol testing code of practice leans towards the use of AC meters rather than DC meters for settlement and billing. Although code compliance for a DC meter is possible through Elexon CoP 11, considerations should be made to make DC meters more widely available. Technical work is needed to develop compliance in the codes for wider standardisation of DC electrical power. **We need to see development of metering policy and technical specification which allows for the development of DC coupled co-located projects in the UK.**