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ENERGY STORAGE CONSULTANTS

STORAGE BUSINESS MODELS IN THE GB MARKET

A report to Elexon

July 2014

STORAGE BUSINESS MODELS IN THE GB MARKET

Contact details

Name	Email	Telephone
Simon Bradbury	Simon.bradbury@poyry.com	01865812239
Anthony Price	aprice@swanbarton.co.uk	01666840948

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EXECUTIVE SUMMARY

Context

The GB market is undergoing transformation in response to decarbonisation goals. The generation mix is changing as the penetration of low carbon generation technologies, such as wind and solar, increases. At the same time, electricity demand is also evolving. Greater electrification of heat and transport will increase overall demand, while the advance of 'smart' technologies has the potential to change patterns of consumption.

The conventional model of large scale, controllable, thermal generation operating to meet predictable patterns of demand no longer holds. Instead, the future market has increased need for flexibility on both the supply and demand sides to manage:

- the unpredictability and variability of intermittent generation from autonomous sources such as wind and solar; and
- more variable patterns of consumption.

Storage offers one possible source of flexibility, absorbing or releasing energy to smooth intermittent generation patterns and demand variability. It can also help to manage the implications of potentially more variable patterns of consumption for the grid, offering an alternative to conventional network reinforcement.

The role of storage in the GB electricity system is, therefore, expected to increase as the system decarbonises and smart solutions develop.

Potential for storage

When considering growth in storage potential, several manufacturers, developers and commentators endorse the ambition of an additional "2000MW by 2020" and have individual potential pipelines that can contribute to this. The ambition is based on a number of studies, which indicate system savings arising from installation of a minimum of 2000MW[1]. These studies also point to further growth beyond 2020, as summarised in Figure 1, with storage capacity potentially reaching 20GW in 2050 on average across a range of future potential scenarios.

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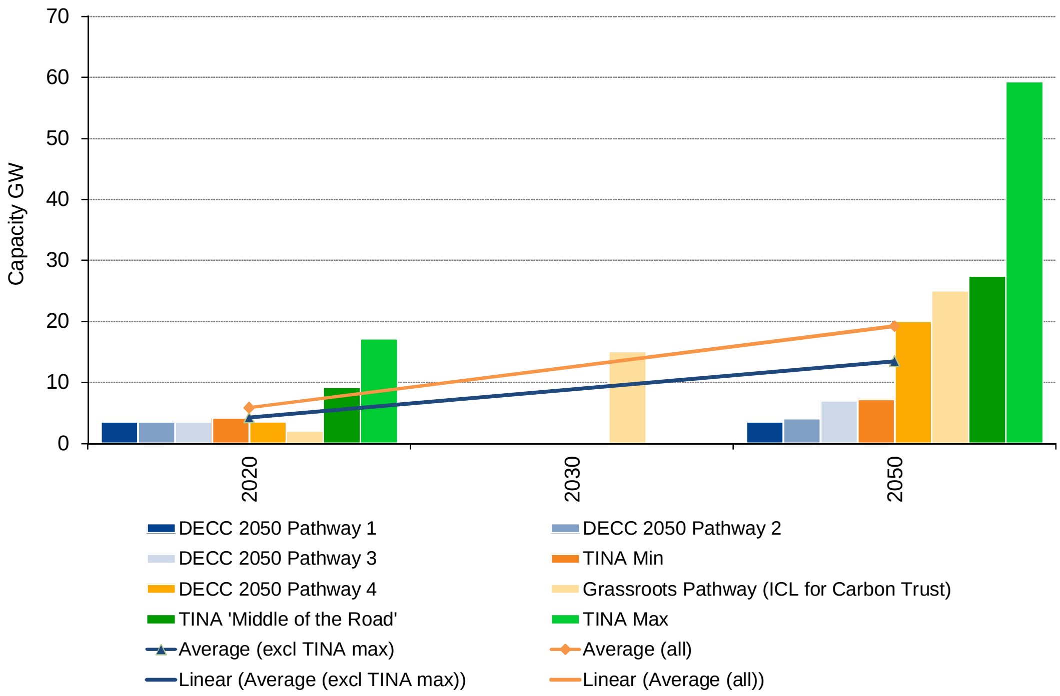
[1] 'Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future', Imperial College report The Carbon Trust, June 2012.

Figure 1 – Potential storage deployment pathways



Sources: DECC, Imperial College, The Carbon Trust

If the 2020 ambition is delivered, this would increase the quantity of installed storage capacity from around 3GW at present to around 5GW by 2020, with further growth potential thereafter. While existing storage is largely provided by large scale, centralised pumped storage assets, the incremental capacity is likely to be provided by different types of assets. Consumer led and distributed storage assets have the potential to make up a significant proportion of new storage capacity deployment. Such assets are small scale and are unlikely to participate directly within the trading arrangements and may not feed into half-hourly settlement. As such, the scale and, importantly, nature of potential growth in storage deployment could have important implications for trading and settlement.

Implications for trading and settlement

If the anticipated incremental storage capacity consists of approximately 500MW of user led projects, 1000MW at the distribution grid level and 500MW of centralised installations, Table 1 provides an indication of potential future capacity and associated traded volume assuming two cycles per day and a ratio of 1.25:1 for charging relative to discharge. The gross traded volume (taking the absolute value of imports and exports into account) in 2020 linked to this capacity is around 8.2TWh/year. The net effect on the wholesale market is consumption of around 1TWh/year. These figures compare to gross traded volume of around 5TWh/year and net volume of 1TWh/year across the existing First Hydro assets, based on operation from 2011 to 2013.

Table 1 – Potential deployment and traded volume

	Existing	Expected new capacity by 2020	Total in 2020	Volume traded / year *
User led, consumer or small scale community storage		~ 500 MW 1000 MWh	500 MW 1000 MWh	~0.8TWh
Distributed storage		~ 1000 MW 3000 MWh	1000 MW 3000 MWh	~1.6TWh
Centralised	3000 MW	~ 500 MW	3500 MW 28000 MWh	~5.7TWh

* - based on two cycles per day.

There is scope for variation in these potential volumes if the frequency of cycling varies or if the import to export ratio differs from that assumed. If, for example, cycling of user and distributed storage doubles, the gross traded volume linked to storage increases to around 10.7TWh.

The implication is that increased deployment of storage capacity to the levels envisaged by 2020 could have a significant impact on traded volumes within the wholesale market and its settlement:

- gross traded volume linked to storage capacity and operation envisaged in Table 1 equates to over 2% of annual demand[2];
- if this capacity were to operate on a losses and spill approach, the net flows equate to 0.3% of annual demand[2], with a monetary value of approximately £60m/year[3]; and
- just under 1TWh/year linked to user-led projects may continue to fall below the radar of half-hourly settlement, creating imbalance risks for suppliers linked to these sites.

There is potential for these impacts to grow in time if penetration increases beyond 2020. If 20GW of storage capacity is delivered by 2050, as indicated by the studies referred to above, and operates as envisaged in Table 1, gross traded volumes linked to this capacity could reach ~33TWh/year or around 9.5% of current annual demand. Substantial expansion of non-grid scale or 'grid-edge' projects could result in more significant implications if it is not visible to settlement or the wholesale market more generally.

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[2] Based on 350TWh annual demand.

[3] If priced at a wholesale price of £60/MWh.

Business models

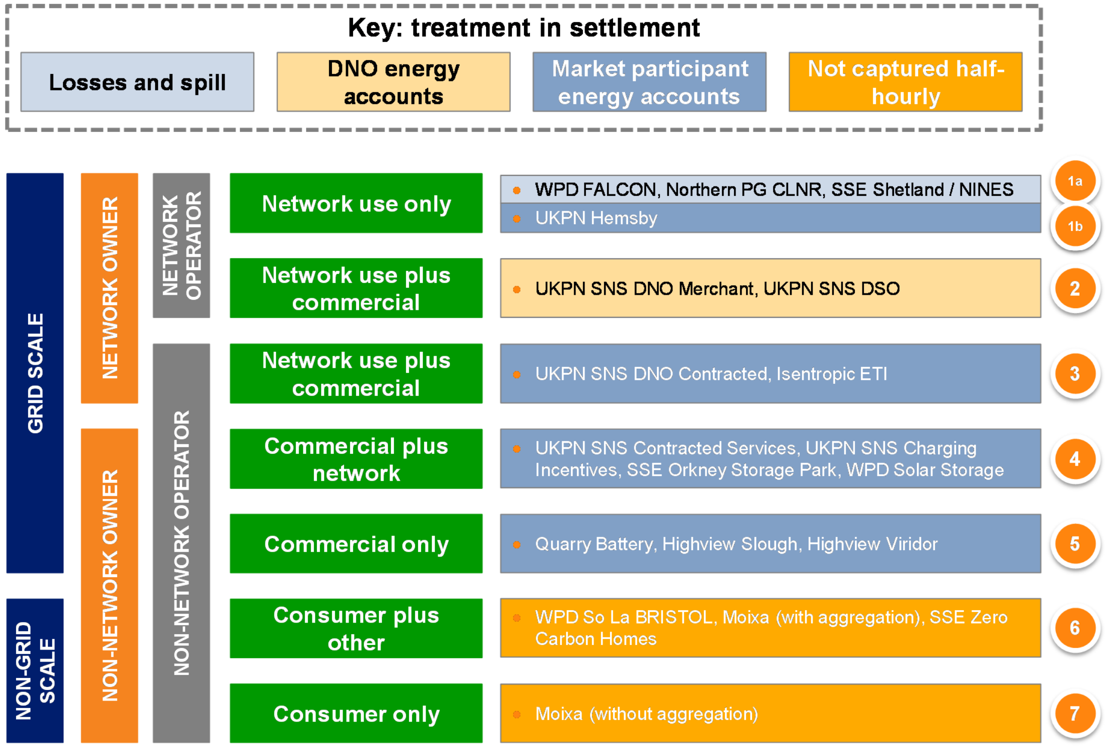
Delivering future deployment of storage projects requires viable business models that allow investors to earn sufficient revenue to cover investment costs and also make a return on that investment. That a storage device can be used for multiple applications increases its potential sources of value. But it also means that the business case is multi-layered and so relies upon being able to access multiple revenue streams. This:

- introduces complexity from a practical and operational perspective;
- may require the involvement of multiple stakeholders across whom value must be shared; and
- may face challenges within the current regulatory framework.

Discussions with stakeholders highlight that business models vary across projects by scale, owner, operator and application/applications. A range of storage projects are being progressed now, in many cases supported by innovation funding schemes such as the Low Carbon Network Fund (LCNF). These projects indicate a variety of potential business models under which future deployment of storage could be progressed. By considering ongoing/prospective projects and through discussion with stakeholders, we have identified several distinct business models and modes of interaction with settlement. The resultant mapping is shown in Figure 2, which highlights that the business models considered can interact with settlement in four potential ways:

- **losses/spill**: energy inflows and outflows are treated as network losses and spill and not metered from the perspective of settlement;
- **settled on half-hourly basis in DNO energy account**: energy inflows and outflows are included directly in the energy account of a distribution network operator;
- **settled on half-hourly basis in market participant energy account**: energy inflows and outflows are included directly in the energy account of the owner/operator or another trading party with whom the storage asset has contractual arrangements; and
- **not settled on half-hourly basis**: energy inflows and outflows ultimately feed through into energy accounts following reconciliation process but are not settled on a half-hourly basis.

Figure 2 – Business models and interaction with settlement



Our summary assessment of the four methods of interaction with settlement is as follows:

- **Losses and spill**: this is not tenable beyond initial demonstration projects because (a) it imposes costs on other market participants as the net inflow/outflow position is picked up in losses and (b) it effectively precludes provision of services to the market and so removes a potential value stream for storage assets which may compromise business cases for future applications for which multiple value streams are likely to be necessary.
- **DNO energy accounts**: the current regulatory framework precludes distribution businesses from participating in the market which means that this option is not possible at present. DNO trading could be accommodated within central settlement in principle using the standard market participant model or the National Grid model for its role as System Operator. However, this must be preceded by changes to the regulatory and legal framework to revise the role of distribution businesses. Without such changes, it is not feasible for DNOs to operate energy accounts.
- **Market participant energy accounts**: this appears to be the most likely model for grid-scale storage assets in the short/medium term. It allows network owned assets to provide market-oriented services via contractual arrangements with a third party who already has trading functionality and energy accounts under BSC. Given likely scale of distribution-led assets of up to ~10MW, the asset is likely to be included in Supplier Volume Allocation (SVA) within a supplier/aggregator portfolio. Non-DNO owned assets can be included under CVA (Central Volume Allocation) or SVA routes depending upon scale and the status of the owner (i.e. direct or indirect market participant). There is scope for commercial arrangements between parties to be enhanced, however.

- **Not captured half-hourly**: this is the default situation for small-scale storage that is off-grid or grid-edge, with operation effectively invisible to the market and half-hourly settlement. This approach can continue to operate, but as deployment of such assets increases the impact of the lack of visibility increases, for suppliers in particular, and the full flexibility of the assets may not be captured by the market. Visibility could be improved through commercial arrangements between the user and their supplier and/or by extending the scope of half-hourly metering to cover sites with small scale storage.

Therefore, the 'losses and spill' approach is not desirable with higher deployment and 'DNO energy account' solutions are not feasible under the current regulatory framework.

DNO owned storage assets must have contractual arrangements in place with a market participant to allow inflows/outflows to be settled and also to offer market services, meaning that they need to be included within the energy accounts of a market participant. Non-DNO owned grid scale storage assets will also be included in the energy account of either the owner/operator or that of a third party with whom the owner/operator has a contractual relationship.

Non-grid scale or 'grid edge' storage can continue to fall below the radar of half-hourly settlement, as at present, and operate. But this will become a more significant issue for the market as deployment increases. Suppliers may want to take steps to improve visibility of such assets within settlement arrangements. Asset owners/developers, are likely to seek better access to the wholesale market in order to capture value. If not harnessed, this resource could have a disruptive impact on the market. Therefore, drivers for change on this front may come from several sides.

Regulatory and commercial issues

There are a number of regulatory and commercial barriers that affect deployment of storage within the GB market. Based on discussions with stakeholders active in storage developments, it is clear that there is a hierarchy of barriers and issues linked to the settlement and trading arrangements are on the second tier of priority.

Higher profile issues within the regulatory and commercial frameworks include:

- **Classification of storage**: electricity storage is not recognised as either an activity or asset class in the GB regulatory frameworks. Instead, the default is for storage to be treated as generation. This and the generation licensing regime constrain ownership and operation of storage by DNOs and influence sizing decisions.
- **Capacity market**: the capacity market being developed as part of the Electricity Market Reform process has the potential to be a valuable revenue stream for storage. But if the final design retains a potentially open-ended load following obligation (or penalty exposure), this market becomes less viable for storage.
- **Balancing services**: contracts for provision of reserve services to National Grid tend to be of short-term nature and so do not provide long-term certainty for potential investors. Services also tend to be defined on historical requirements which may not fit new technologies or evolving system requirements, although National Grid has made some services (such as STOR) more accessible to non-conventional providers.
- **Technology costs**: perceived costs of storage, or at least the initial capital cost, are high and without volumes of scale and replication as a minimum, costs will not fall. There is some circularity in this, and correspondents suggested that a market subsidy or incentive would support the initial deployment and encourage lowering of technology prices. Stakeholders consider that, on the assumption that storage is

needed in the longer term at scale and on an economic basis, support is needed in the short-term through the maturation/cost reduction phase.

The specifics of the settlement and trading arrangements attract less attention from stakeholders as the issues outlined above take priority. But there are aspects of the settlement and trading arrangements that influence storage business models:

- **Cashout arrangements**: the cashout arrangements are an important driver of value. By attaching a cost to imbalance, they place a value on flexible and reliable capacity, such as storage, that can be used to balance positions. However, the current methodology dampens cashout prices, weakening the signals and incentives that they provide. This situation looks set to change however, as Ofgem has proposed a switch to single, marginal cashout prices[4]. This will make cashout prices sharper and improve incentives for investments in flexible capacity.
- **Profiling**: continued use of customer profiles for sites with sub-100kW metering systems that have small scale storage means that the operation of such assets will remain invisible to the market in terms of settlement until well after the event. If instead the scope of half-hourly metering is extended to cover sites with small scale storage, visibility of these assets within the market will improve as may the ability of the assets to offer flexibility to the market.

Key messages

The role of storage in the GB electricity system is expected to increase as the system decarbonises and smart solutions develop. Consequently, gross traded volumes linked to storage operation will increase, potentially reaching levels in the region of 8TWh/year if the ambition of an additional “2000MW by 2020” is achieved.

Future business models for grid-scale projects rely on capturing revenue from multiple value streams, which necessitates interface with the markets. The most likely route for inclusion of such projects within the settlement arrangements is within a market participant’s energy account, either their own or that of a third party (with the latter the only option for DNO owned assets). Small-scale off-grid storage projects are currently invisible to settlement until well after the event. This arrangement can continue but as deployment of such projects increases, this will become a more significant issue for suppliers serving sites that have onsite storage. It may also restrict the ability for such assets to realise value from the wholesale market. Both factors are likely to be drivers for change creating pressure for better integration of such assets within the market.

There are a number of regulatory and commercial barriers that affect deployment of storage within the GB market. The most pressing relate to the wider regulatory framework, including the classification of storage and its storage to participate in capacity and balancing services markets.

The trading and settlement arrangements can be modified in some ways. Progressing Ofgem’s proposed reforms to the cashout arrangements will improve the business case for storage, while considering extending the scope of half-hourly metering to sites with small-scale storage will improve the robustness of the arrangements to potential growth in this area and improve access to the market for such assets. However, issues relating to the broader regulatory framework are more significant and should be the primary focus for attention.

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[4] https://www.ofgem.gov.uk/publications-and-updates/electricity-balancing-significant-code-review-final-policy-decision

Actions for Elexon

There is scope for Elexon to influence the role and inclusion of storage within the wholesale market. Elexon can:

- steer the modification process relating to:
  - cashout reform, with the proposal for sharper imbalance prices enhancing potential value to storage assets;
  - the extension of half-hourly metering instead of consumer profiles for sites with small scale storage in order to include the flows linked to such sites in settlement in a more timely manner;
- develop reference material to support parties considering operation of storage in the wholesale market or its inclusion within a portfolio, such as:
  - developing BSC Guidance Notes for storage, such as those that exist for embedded generation and interconnectors;
  - creating a 'Storage' reference section on the elexon.co.uk website;
- support innovation projects that are seeking to deploy of storage to consider how it can impact upon and be included within the trading and settlement arrangements. The RIIO-ED1 business plans highlight a number of storage projects planned for the 2015-23 price control period:
  - **UKPN**: HV connected Electrical Energy Storage (EES) (2015-17)[5]; and
  - **Scottish Power Energy Networks**: demonstration project (2017-19) and building business case (2020-23)[6];
- support quantification and/or modelling of the potential expansion and impact of 'grid-edge' storage on the system to understand its effects, considering the following:
  - how could penetration of small-scale storage devices in homes (e.g. in electronics, vehicles) grow in the coming years?
  - when will volumes of potential storage resource available from these assets become significant?
  - how can this resource be used/managed on the system as part of wider smarter energy solutions (storage, DSR, local energy)?
  - if not harnessed, what are the implications for imbalance linked to variability of demand that such devices could cause?

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[5] http://library.ukpowernetworks.co.uk/library/en/RIIO/Main_Business_Plan_Documents_and_Annexes/UKPN_Innovation_Strategy.pdf.

[6] http://www.spenergynetworks.com/userfiles/file/201403_SPEN_InnovationStrategy_MH.pdf

1. INTRODUCTION

1.1 Context of report and scope of work

The GB market is undergoing transformation in response to decarbonisation goals. The generation mix is changing as the penetration of low carbon generation technologies, such as wind and solar, increases, while older mid-merit coal and gas plants are retiring prompted, in many cases, by the Large Combustion Plant Directive (LCPD) and the Industrial Emissions Directive (IED). At the same time, electricity demand is also evolving. Greater electrification of heat and transport will increase overall demand, while the advance of ‘smart’ technologies has the potential to change patterns of consumption.

The conventional model of large scale, controllable, thermal generation operating to meet predictable patterns of demand no longer holds. Instead, the future market has increased need for flexibility on both the supply and demand sides (and indeed any distinction between the two will become less apparent) to manage:

- the unpredictability and variability of intermittent generation from autonomous sources such as wind and solar; and
- more variable patterns of consumption.

Storage offers one possible source of flexibility, absorbing or releasing energy to smooth intermittent generation patterns and demand variability. It can also help to manage the implications of potentially more variable patterns of consumption for the grid, offering an alternative to conventional network reinforcement.

The role of storage in the GB electricity system is, therefore, expected to increase as the system decarbonises and smart solutions develop. A range of storage projects are being progressed now, in many cases supported by innovation funding schemes such as the Low Carbon Network Fund (LCNF). These projects indicate a variety of potential business models under which future deployment of storage could be progressed. The viability of these business models, beyond demonstration projects, is heavily influenced by the regulatory framework and market arrangements, including the trading arrangements embodied within the Balancing and Settlement Code (BSC).

Pöyry Management Consulting (hereafter referred to as “Pöyry”) has, with Swanbarton Limited, been commissioned by Elexon to examine different business models for storage deployment and their interactions with the trading and settlement arrangements. This will help to inform whether enhancements can be made to the trading arrangements to facilitate these business models for storage deployment.

The content of this report has been informed through discussions with a range of stakeholders active in relation to storage, including storage developers and distribution network owners.

1.2 Structure of this report

The report is structured as follows:

- Section 2 provides a view of the drivers for storage, the current technologies and possible trajectories for future deployment;
- Section 3 describes the business models which would be applicable for storage and identifies the challenges/issues within the current market arrangements;
- Section 4 outlines the barriers to storage deployment, including BSC issues; and
- Section 5 sets out messages and recommendations for next steps.

2. DRIVERS AND POTENTIAL FOR INCREASED STORAGE DEPLOYMENT

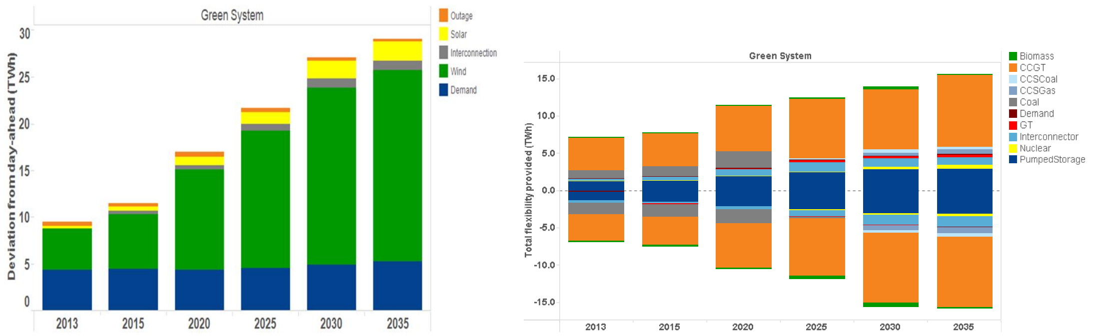
The potential role of storage within the GB electricity sector is increasing. In this section, we provide a view of the drivers for storage. We also describe the current technologies and their potential applications and mode of operation for embedded storage.

2.1 Drivers for storage

The UK is committed to decarbonisation. The Government has set legally binding targets to cut emissions, not just to comply with the EU 2020 targets (delivery of renewable targets), but also to tackle climate change in the longer term. The Climate Change Act 2008 sets a long term target of an 80% reduction by 2050. Wind and solar capacity as well as electrification of heat and transport are likely to play a key role in this decarbonisation process.

Output from wind and solar is inherently variable, and difficult to forecast accurately. As shown in Figure 3 (left hand chart), a substantial growth in intermittent renewable generation will lead to a growth and variability in forecast error – as wind and solar generation cannot be forecasted perfectly.

Figure 3[7] – Forecast error and requirement for flexibility



Source: Pöyry Management Consulting

As a result, greater flexibility will be needed to manage the unpredictability and variability of intermittent generation (wind and solar) and new plants will be needed to replace the existing thermal capacity which is being shut down through the LCPD and the IED. The greater requirement for flexibility is also shown in Figure 3 (right hand chart).

This flexibility could be provided through four sources: flexible generation, interconnection, demand side response and electricity storage. These options and their flexibility potential from an energy balancing perspective are illustrated in Figure 4. In addition, storage also offers an alternative to traditional network reinforcement in response to the implications of changing patterns of consumption on the grid.

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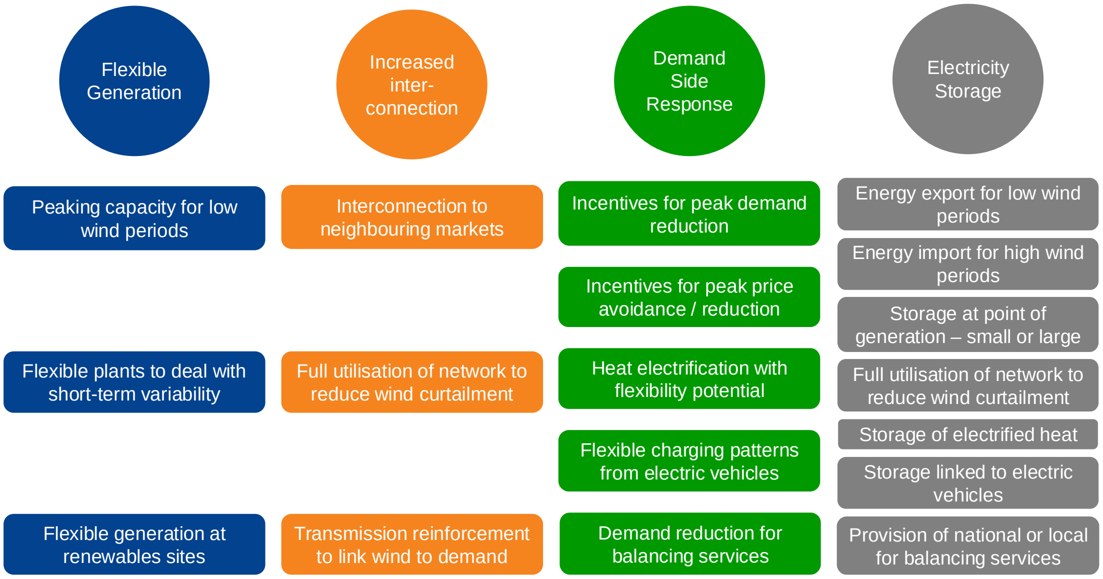
[7] A scenario aligned with the Government's aspirations in relation to renewable targets and decarbonisation.

Figure 4 – Sources of flexibility



Source: Pöyry Management Consulting

The drivers for new network connected storage installations are the need to drive down costs, increase revenues and margins for power market participants (whether consumers, suppliers, generators or network operators) and to meet softer targets such as overcoming technical constraints, meeting environmental obligations or even simply to test new technologies.

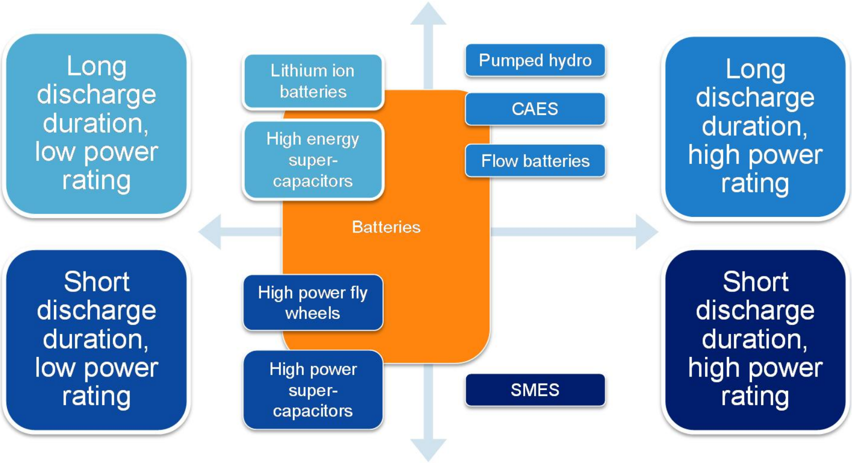
The business case for storage as a source of flexibility and/or an alternative to traditional network reinforcement depends upon its ability to extract value from these applications. Its ability to do so depends to a large extent on the market and regulatory structure that frames the electricity market. It is still not clear whether there will be a single business model and hence ownership and operational style, or whether a number of alternatives will come forward.

A single business model is likely if there is a significant incentive (such as a particular tariff or contract model) that provides a major proportion of either the initial capital or the ongoing revenue. The comparisons with support for new technologies in the renewable sector indicate that such subsidies tend to group business proposals into a limited number of business models. Given the absence of subsidies for storage, it is more likely that there will be a range of business models, and operational styles for storage in the short to medium term. We consider different business models in Section 3, after first exploring the range of storage technologies and their applications.

2.2 Storage technologies

The term ‘energy storage’ encompasses a wide range of technologies with diverse capabilities. Storage cannot be considered as a single, uniform concept. The diversity of different storage technologies in terms of power rating and discharge duration is shown in Figure 5. The range spans from super-capacitors which have low power rating and short discharge duration through to pumped storage hydro which has high power rating and long discharge duration.

Figure 5 – Mapping storage technologies to characteristics



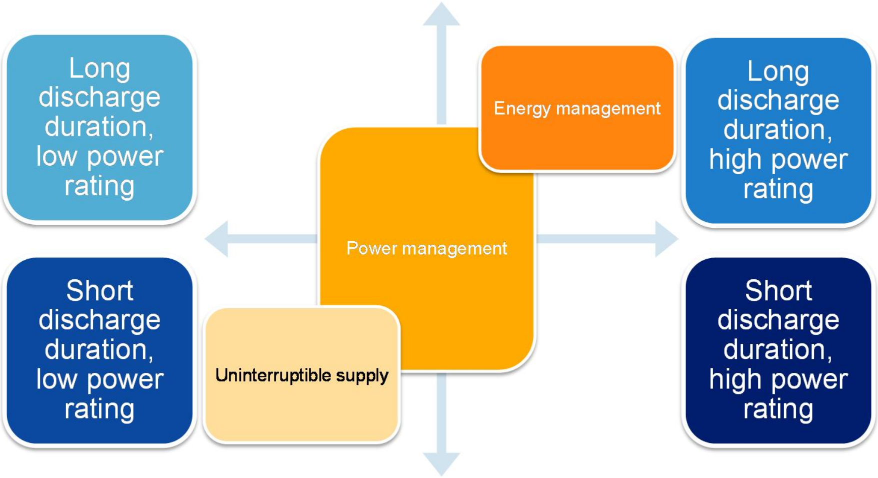
Source: Pöyry Management Consulting

This diversity means different technologies lend themselves to different applications and so a range of potential business models can be explored. Possible applications include:

- uninterruptible power supply: the provision of services to end-users to provide security and quality of electricity supplies;
- power management: the provision of services to distribution and transmission network operators to deliver system stability, manage peak load and provide balancing services; and
- energy management: bulk energy trading.

Figure 6 maps different storage options to different applications. This highlights that different technologies can provide a number of applications and are dependent upon different and often multiple sources for their revenue. The sources of revenue include regulated sources, coming from regulated businesses or directly from regulatory arrangements, and from non-regulated or market arrangements.

Figure 6 – Mapping applications to services



Source: Pöyry Management Consulting

2.3 Current status of storage in GB

In terms of grid or network connected storage that is currently installed on the system, the greatest contribution is made by pumped hydro, installed by the CEGB and the two Scottish Electricity Boards, and now in private ownership. Other storage is provided by a number of installations of varying types, and with a variety of points of connection and applications.

The most significant part of the privately owned and connected cohort is associated with uninterruptible power supplies (UPS). These systems may be series or parallel connected. Series connected systems provide continuous power when the network supply fails, and are usually not able to provide power back into the network. Parallel connected UPS, along with their associated standby generators are able to feed power back into the network. This “hidden” source of electricity storage would be able to participate in various services and the energy market if it was in receipt of the right price signals. Typical installations are in the size range of 100kW up to +20MW and estimates of the total UPS capacity in the UK exceed 4GW.[8]

A number of storage projects have been/are being carried out under the funding programmes of the Low Carbon Network Fund (and previous Ofgem initiatives), the DECC Innovation Fund and by funding agencies such as the ETI. A list of relevant projects is provided in the ENA Smarter Networks Portal.[9]

2.4 Factors affecting nature of future growth of electricity storage

2.4.1 Asset size

Potential asset size depends upon application. Grid-scale assets up to 10MW in size are appropriate for storage projects with a specific DNO need. Issues with lack of suitable points of connection at distribution level indicate that storage may not have the easy journey that was expected five years ago, due in part to the significant take up of renewable generation. Grid-scale assets in range 5MW to 100MW are possible for projects with a primarily commercial focus. The potential for larger grid-scale projects is constrained by the generation licence regime and requirement to be licensed above 100MW. Consumer scale projects in 1-2kWh range are gaining traction and cumulatively have potential, when aggregated, to dwarf other technologies.

2.4.2 Technology type

While technology type is a significant factor, the evidence from discussions with stakeholders, and anecdotal evidence from developers generally, is that most developers (whether DNO or private developers) are likely to be technology neutral in their procurement. However, technology neutrality is not an easy statement to abide by, as clearly many applications are heavily dependent on the technical parameters of the type of storage that is chosen. Under these circumstances, a stance of manufacturer neutrality may be considered appropriate. The obvious exception is that of the pumped hydro and

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[8] A special case for electricity storage is the 50 MW flywheel installed at the Culham Laboratory. This has a very small energy capacity and is used to avoid local overloading of the network when a large discharge is required for fusion experiments. Such installations are outside the scope of this report.

[9] http://www.smarternetworks.org/Index.aspx?Site=ed

CAES developers, where ownership of a particular site and proprietary expertise is strategically important in their business plan.

2.4.3 Niche application

As highlighted previously, the common theme for storage is to look for multiple income streams, but even so, the most likely development areas are where there is a specific niche. Examples of this can be found based on:

- geography: such as sites for distribution reinforcement, where costs of alternatives are high – for example sites such as Leighton Buzzard, Orkney;
- topography: such as North Wales where a pumped hydro developer has identified a site with potential for lower cost development;
- constraint: including Orkney, and other sites with a high proportion of wind or solar generation; and
- co-location with other facilities: for example, linking storage with on-site generation can allow an operator to obtain low cost shape to match demand to supply, or conversely to remove peak demand from a highly variable load.

An emerging case is that of balancing services and ancillary services, where providers are examining the business case for early adoption of storage as a lower cost alternative to the provision of frequency services or reserves. The niche interest here is likely to be based on first mover advantage in a new market.

2.5 The potential scale of future storage deployment

Several manufacturers, developers and commentators endorse the additional "2000MW by 2020" ambition and have individual potential pipelines that can contribute to this. The ambition is based on a number of studies which indicate system savings arising from installation of a minimum of 2000MW[10]. On the 11kV system, there are estimates of potential for 2GW by 2040[11], with a trajectory of around 200MW by 2020 and 1GW by 2030 (which provides opportunities for smaller scale projects to be developed, with lower project risk).

However, there is circularity because deployment is reliant upon the market arrangements and the signals and opportunities for value realisation that it provides. Unless potential market value crystallises, or some other form of financial incentive is available, deployment will be restricted to the high value, niche applications. Possible business models are discussed on Section 3.

In this context, there are a number of potential trajectories for future storage deployment. Figure 7 shows trajectories based on the following sources:

- DECC 2050 Pathways[12];
- Imperial College report for The Carbon Trust; and
- Technology Innovation Needs Assessment (TINA) report[13].

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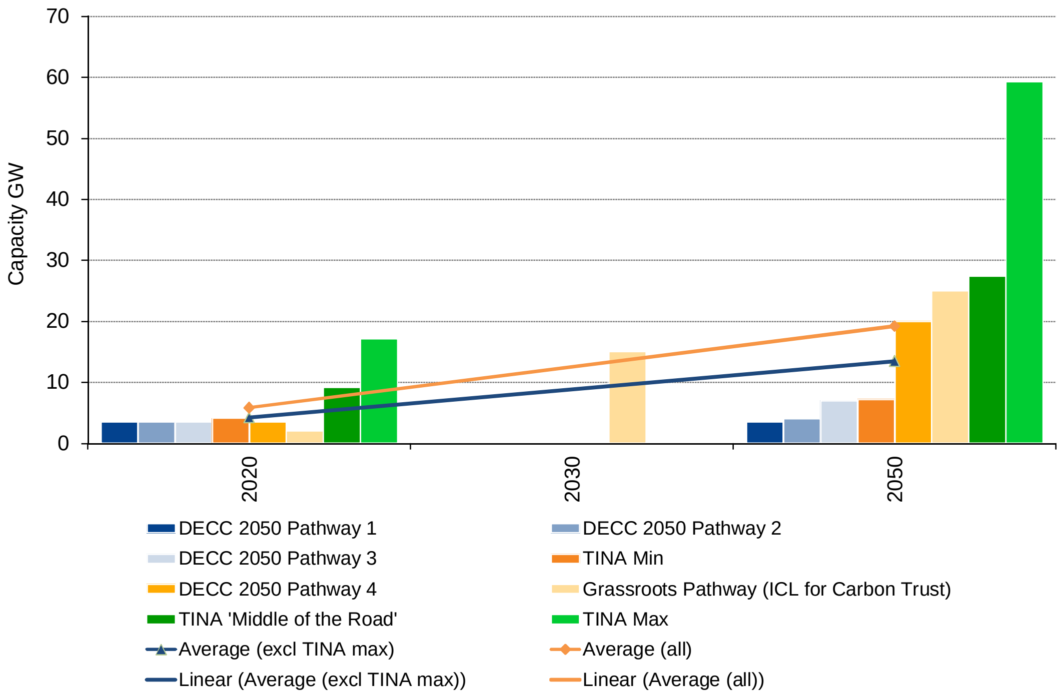
[10] 'Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future', Imperial College report The Carbon Trust, June 2012.

[11] UKPN Smarter Network Storage business case submission.

[12] http://2050-calculator-tool.decc.gov.uk/pathways/

Figure 7 – Potential storage deployment pathways



Sources: DECC, Imperial College, The Carbon Trust

The indications provided by these sources are as follows:

- **DECC pathways**: reflect scope for growth up to 20GW by 2050 from around 3GW today.
- **TINA study**: produces a broad range of possible deployment to 2050 of between 7.2GW and 59GW, with 27GW the central estimate. The equivalent range in 2020 is between 4GW and 17GW. At the top end, figures tend to be distorted by industry expectation of low cost storage. The lower end numbers are likely to be more realistic, reflecting the importance of a strong commercial framework; and
- **Imperial College study:** suggests deployment of 25GW by 2050.

An industry view, based on a combination of intention from key suppliers and extrapolation of interest from early adopters suggests approximately 500MW would be user led, at the consumer and community level, nearly 1000MW at the distributed level[14] (either by DNO or with DNO services as a primary or supporting installation) and 500MW as centralised installations, made up of new small scale pumped hydro and compressed air to be installed by 2020.

Taking these potential deployment figures as a basis, Table 2 provides an indication of potential future capacity and associated traded volume assuming two cycles per day and

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[13] Technology Innovation Needs Assessment, Electricity Networks and Storage Summary Report, August 2012.

[14] Probably connected at 11 kV and 33 kV. Installations at 132 kV are considered centralised assets as their trading will be within the GSP allocation.

a ratio of 1.25:1 for charging relative to discharge. The gross traded volume (taking the absolute value of imports and exports into account) in 2020 linked to this capacity is around 8.2TWh/year. The net effect on the wholesale market is consumption of around 1TWh/year. These figures compare to gross traded volume of around 5TWh/year and net volume of 1TWh/year across the existing First Hydro assets, based on operation from 2011 to 2013.

There is scope for variation in these potential volumes if the frequency of cycling varies and if the import to export ratio differs from that assumed. If, for example, cycling of user and distributed storage doubles, the gross traded volume linked to storage increases to around 10.7TWh. The implication is that increased deployment of storage capacity to the levels envisaged by 2020 could have a significant impact on traded volumes within the wholesale market.

Table 2 – Potential deployment and traded volume

	Existing	**Expected new capacity by 2020**	**Total in 2020**	**Volume traded / year ***
User led, consumer or small scale community storage		~ 500 MW 1000 MWh	500 MW 1000 MWh	~0.8TWh
Distributed storage		~ 1000 MW 3000 MWh	1000 MW 3000 MWh	~1.6TWh
Centralised	3000 MW	~ 500 MW	3500 MW 28000 MWh	~5.7TWh

* - based on two cycles per day.

The implication is that increased deployment of storage capacity to the levels envisaged by 2020 could have a significant impact on traded volumes within the wholesale market and its settlement:

- gross traded volume linked to storage capacity and operation envisaged in Table 2 equates to over 2% of annual demand[15];
- if this capacity were to operate on a losses and spill approach, the net flows equate to 0.3% of annual demand[2], with a monetary value of approximately £60m/year[16]; and
- just under 1TWh/year linked to user-led projects may continue to fall below the radar of half-hourly settlement, creating imbalance risks for suppliers linked to these sites.

There is potential for these impacts to grow in time if penetration increases beyond 2020. If 20GW of storage capacity is delivered by 2050, as indicated by the studies referred to above, and operates as envisaged in Table 2, gross traded volumes linked to this capacity could reach ~33TWh/year or around 9.5% of current annual demand. Substantial expansion of non-grid scale projects could result in more significant implications if it is not visible to settlement or the wholesale market more generally.

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[15] Based on 350TWh annual demand.

[16] If priced at a wholesale price of £60/MWh.

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3. BUSINESS MODELS FOR STORAGE AND INTERACTIONS WITH SETTLEMENT

Delivering future deployment of storage projects requires viable business models that allow investors to earn sufficient revenue to cover investment costs and also make a return on that investment. That a storage device can be used for multiple applications increases its potential sources of value. But it also means that the business case is multi-layered and so relies upon being able to access multiple revenue streams. This:

- introduces complexity from a practical and operational perspective;
- may require the involvement of multiple stakeholders across whom value must be shared; and
- may face challenges within the current regulatory framework.

In this section, we outline business models that have or are being used in current demonstrations or that have been raised as potential options for adoption in the context of future projects and consider their implications for settlement. Our description of the business models is based on our interpretation.

3.1 Overview of business models and settlement interactions

By considering the approaches being taken or considered in ongoing/prospective projects, we have identified several permutations of settlement interactions that apply across the business models considered. The following sections discuss in more detail a selection of the business models and their interaction with settlement[17].

In Figure 8, we present an overview of these permutations and identify projects that we consider to sit within each category based on our assessment. This makes the following distinctions:

- **scale**: grid scale or non-grid scale;
- **owner**: network owner or non-network owner;
- **operator**: network operator or non-network operator; and
- **application**: network use only, network use plus commercial uses, commercial use only, consumer use plus other or consumer use only.

These business models interact with settlement in the following ways, as summarised in Figure 9:

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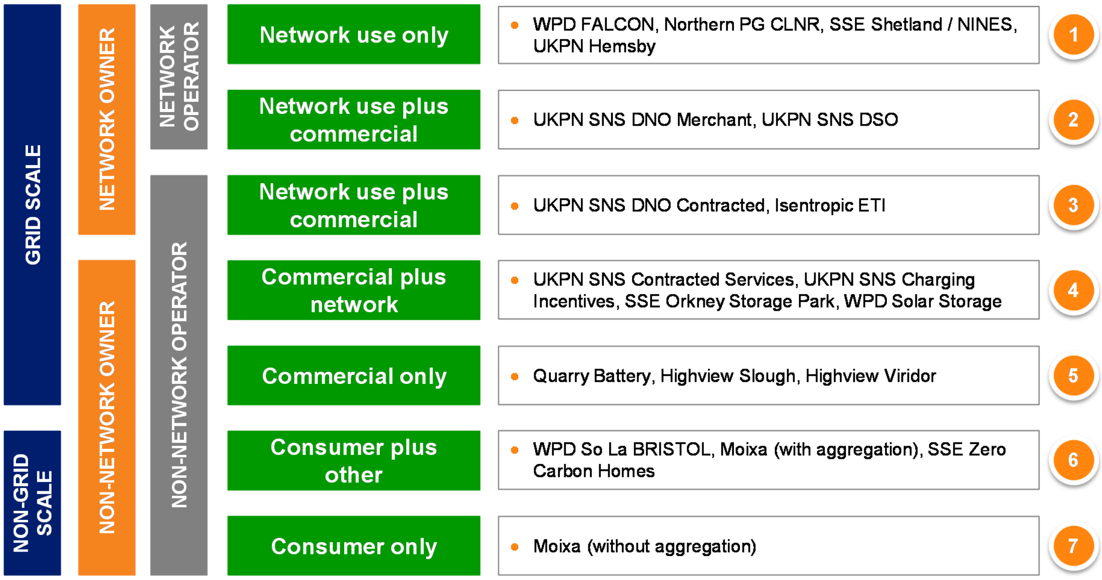
[17] The selection shown are identified from a review of demonstration projects in receipt of some form of innovation funding (such as the Innovation Funding Incentive and the Low Carbon Network Fund) as well as commercial propositions being considered or developed. Some of these projects focus on technical proof of concept or feasibility and commercial arrangements are not considered (e.g. SSEPD's 'Application of Storage & Demand Side Management' IFI project, UKPN's 'Application of Storage & Demand Side Management' IFI project, REDT's 'Vanadium Redox Flow Battery' Energy Storage Technology Demonstration Competition project). Others are desktop or modelling studies which, again, are not focused on commercial issues (e.g. SSEPD's 'Cryogenic Storage Technology Review' IFI project, SPEN's 'Energy Storage Devices for Distribution Networks' IFI project, SPEN's 'Energy Storage Project' IFI project).

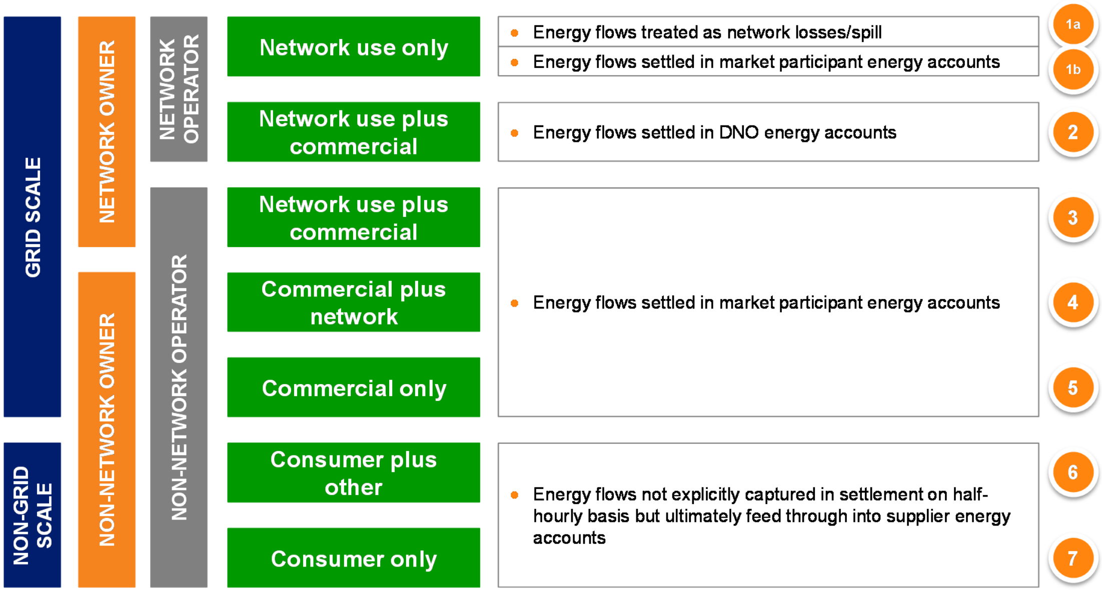
- **losses/spill**: energy inflows and outflows are treated as network losses and spill and not metered from the perspective of settlement;
- **settled on half-hourly basis in DNO energy account**: energy inflows and outflows are included directly in the energy account of a distribution network operator;
- **settled on half-hourly basis in market participant energy account**: energy inflows and outflows are included directly in the energy account of the owner/operator or another trading party with whom the storage asset has contractual arrangements; and
- **not settled on half-hourly basis**: energy inflows and outflows ultimately feed through into energy accounts following reconciliation process but are not settled on a half-hourly basis.

Figure 8 – Business model mapping



GRID SCALE	NETWORK OWNER	NETWORK OPERATOR	Network use only	WPD FALCON, Northern PG CLNR, SSE Shetland / NINES, UKPN Hemsby	1
			Network use plus commercial	UKPN SNS DNO Merchant, UKPN SNS DSO	2
		NON-NETWORK OPERATOR	Network use plus commercial	UKPN SNS DNO Contracted, Isentropic ETI	3
	NON-NETWORK OWNER		Commercial plus network	UKPN SNS Contracted Services, UKPN SNS Charging Incentives, SSE Orkney Storage Park, WPD Solar Storage	4
			Commercial only	Quarry Battery, Highview Slough, Highview Viridor	5
NON-GRID SCALE			Consumer plus other	WPD So La BRISTOL, Moixa (with aggregation), SSE Zero Carbon Homes	6
			Consumer only	Moixa (without aggregation)	7

Figure 9 – Business model interactions with settlement



The following sections discuss in more detail a selection of the business models and their interaction with settlement.

3.2 Framework for considering business models

Business models will vary across projects depending upon scale, owner, operator and application/applications. In order to present different business models in a consistent manner and so aid comparison, we have adopted the framework shown in Figure 10.

Figure 10 – Business model description framework

Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

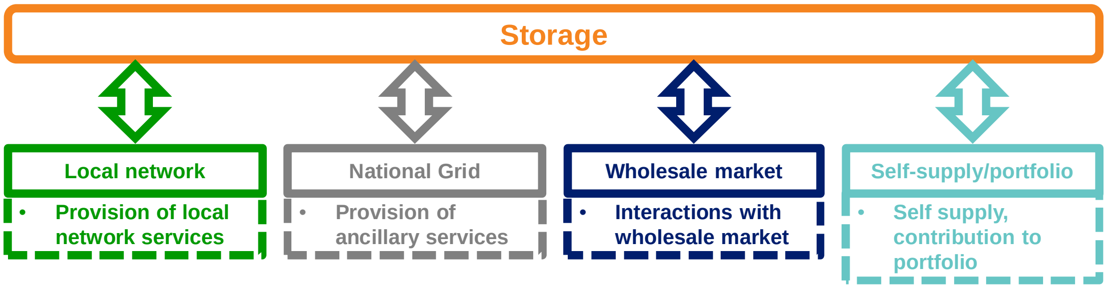
This captures how different models vary in terms of:

- **scale**: whether the underlying technology is grid-scale (connected to transmission or distribution systems) or non-grid-scale (at end-user premises or within communities) and whether the technology is at a single site or across multiple sites;
- **ownership**: who owns the asset ranging from network businesses, through market participants, to end users or communities;
- **operation**: who operates the asset across the same range of actors;
- **application**: whether the asset is applied to address national or local issues and what these applications are across the following:
  - reinforcement substitute: alternative to conventional network asset investment;
  - energy management: bulk energy trading and arbitrage;
  - system services: provision of balancing services such as reserve and response to National Grid and also services to distribution operators to manage peak load and voltage support;
  - intermittency management: smoothing variable generation patterns from wind and solar;
  - uninterruptible supply: providing non-grid power to users to enhance energy security resilience; and
  - lower costs to consumers: reducing exposure to costs of grid power consumption.

In some cases, projects/business models span several categories and we reflect this in our description of the models by highlighting multiple boxes as applicable and varying shading to reflect relative importance.

To complement this and consider how business models interact with different elements of the value chain, we also consider each of the models against the framework shown in Figure 11.

Figure 11 – Value chain interactions



3.3 Energy flows treated as network losses/spill

A number of the existing demonstration projects have focused upon ‘proof of concept’ for the application of storage as an alternative to conventional distribution network reinforcement and management options. Storage assets are typically owned by DNOs and operated by them on the basis that they are distribution system assets.

The value of storage in this context stems from benefits to the DNO in terms of:

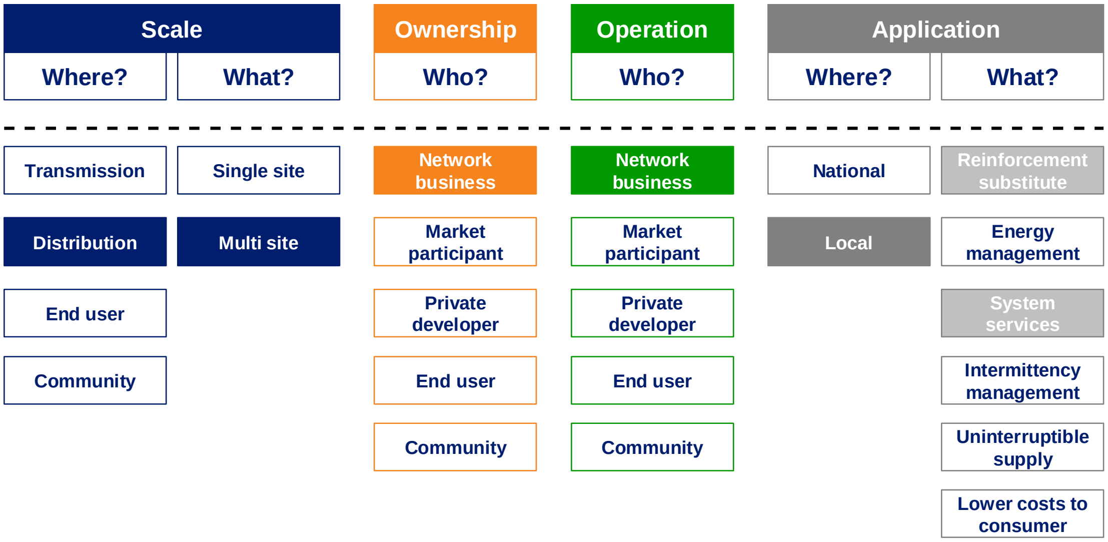
- avoided or delayed reinforcement capital expenditure;
- its ability to contribute to management of peak system demand; and
- as a tool for maintaining voltage and power quality.

As the projects tend to be proof of concept demonstrations, access to revenue from alternative sources such as wholesale market participation and provision of services to National Grid does not tend to feature in the business case. Furthermore, as the assets are typically small scale and there is limited cumulative scale across projects, energy flows associated with operation of the storage asset are often not explicitly metered for the purpose of energy settlement. Instead, inflows and outlfows are treated as losses and spill and within distribution losses. This influences line loss factors and so the extent to which consumption and generation volumes are scaled to reflect distribution losses.

3.3.1 Case study: Northern Powergrid, Customer Led Network Revolution

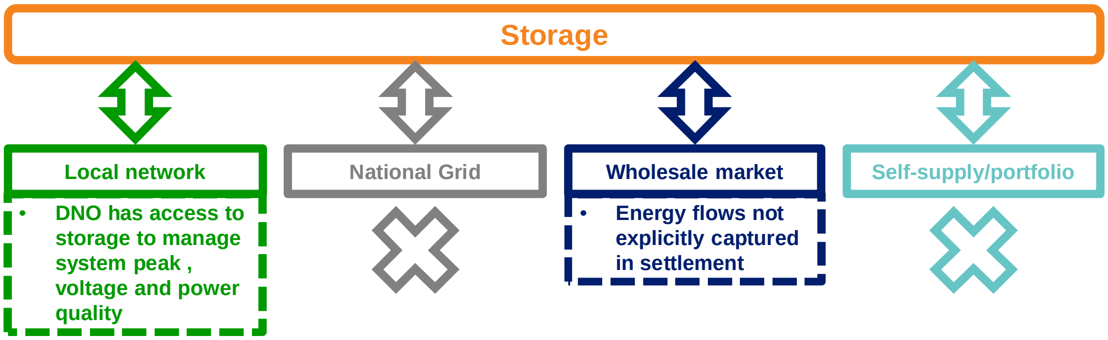
As part of the Customer Led Network Revolution (CLNR) LCNF project, Northern Powergrid has installed six batteries (the largest of which is 5MWh) at different points across its network. The assets support the operation of the system, including the management of peak demand and voltage control, and also offer an alternative to traditional network reinforcement. The energy inflows and outflows linked to operation of storage are not explicitly captured for purposes of settlement and are included within distribution losses. The business model overview and its interactions with value sources are shown in Figure 12 and Figure 13 respectively.

Figure 12 – Northern Powergrid CLNR: business model overview



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 13 – Northern Powergrid CLNR: interactions with sources of value



- DNO has access to storage to manage system peak , voltage and power quality

- Energy flows not explicitly captured in settlement

Other projects with similar characteristics in terms of interactions with settlement are:

- **1MW Shetland NaS Battery/ Northern Isles New Energy Solutions (NINES), SSEPD**: the initial LCNF Tier 1 project and the following Integrated Plan for Shetland include connection of a battery to Lerwick power station to reduce peak demand on the station and to support network management on Shetland. The initial focus was on the technical capability of the battery to support the system on Shetland.

- **Low Voltage (LV) Network Connected Energy Storage, SSEPD**: the objective of the project was to explore the practicalities and costs of installing storage facilities on the LV network. The main objective was to inform and de-risk the larger scale deployment of street batteries. As a technical feasibility trial, commercial arrangements and treatment of power flows within settlement were not the focus.
- **Demonstration of Distribution Scale Energy Storage, WPD**: the focus is to demonstrate the technical potential of pumped heat energy storage on the distribution system. It involves connection of a 1.4MW storage device provided by Isentropic to a primary substation on part of the WPD network for use by WPD in its operation of the system.
- **Flexible Approaches for Low Carbon Optimised Networks (FALCON), WPD**: FALCON is trialling six alternative techniques to conventional reinforcement. Four are engineering focused and two are commercial. Deployment of storage, in the form of batteries at substations, is one of the engineering trials. The focus of this aspect of the trials is principally on technical capabilities.

3.3.2 Issues

There are two principal issues with this model which affect its use for further deployment beyond the ‘proof of concept’ phase:

- the viability of a commercial business case based on network only use, without access to other sources of value; and
- the implications on other market participants.

Treating energy inflows/outflows as losses restricts the ability for the storage asset to be used for more market-oriented purposes, such as trading within the wholesale market or providing balancing services to National Grid. Unless flows are explicitly metered, delivery of such services cannot be verified or remunerated. Therefore, this treatment removes access to potential revenue stream options which may be needed to make the business case viable beyond the demonstration phase. In effect, adopting a losses/spill approach restricts revenue realisation potential and will serve to dampen future deployment of storage where additional value beyond network application is needed.

The losses/spill approach also affects other parties, as their metered volumes are adjusted to take account of distribution losses. But as the deployment of storage under this type of business model is relatively small, does this really matter? At present, it is probably fair to say that the impact on market participants is minor. However, the effects will become more pronounced if deployment under this approach does increase. This can be illustrated by considering inflows and outflows linked to the First Hydro pumped storage assets over recent years.

Based on metered data for the First Hydro assets over recent years, net annual flows across 2GW capacity have been around -1TWh/year. 1TWh is roughly 0.3% of annual demand (based on 350TWh demand). If this is valued at a wholesale price of £60/MWh, it has a monetary value of £60m/year. If this is representative for other storage capacity, every 100MW of additional storage under losses/spill treatment has a monetary impact of £3m/year. This is a significant value, suggesting that this approach is not viable beyond demonstrations of concept.

A further question regarding this approach is its compatibility, beyond proof of concept phases, with some elements of 3rd Energy Package which states that:

‘Each distribution system operator shall procure the energy it uses to cover energy losses and reserve capacity in its system according to transparent, non-discriminatory and market based procedures, whenever it has such a function’ (Article 25.3).

This can be interpreted as a requirement for explicit metering and accounting within the settlement processes, supported by trading activity to manage imports and exports.

3.3.3 Summary

The losses/spill approach appears unlikely to persist beyond initial demonstrations given its impact on business case viability for commercial projects and, in the event that it does gain momentum, the negative implications on the positions of market participants. Therefore, as larger scale storage projects are deployed and cumulative scale increases, this approach becomes less tenable.

If this approach is to remain an option for DNOs, consideration could be given to the following in order to limit its impact on market participants:

- a project specific threshold under which storage assets can be classed a distribution assets and so be treated as losses/spill; and
- a cumulative threshold per DNO for the overall quantity of storage assets that can be treated as losses/spill.

However, this may be counter-productive if it incentivises smaller projects and/or restricted deployment, when there are enhanced benefits from larger scale projects and more extensive deployment.

3.4 Energy flows settled in DNO energy accounts

Further potential business models open up if the role of the DNO within the market is revised and extended beyond conventional distribution business activities. If DNOs are able to take a more active role, trading energy and offering balancing services, then additional sources of value become available to the DNO beyond application of storage for network purposes only. In order to capture benefits from trade and balancing services provision, inflows and outflows from storage assets must be explicitly considered in settlement.

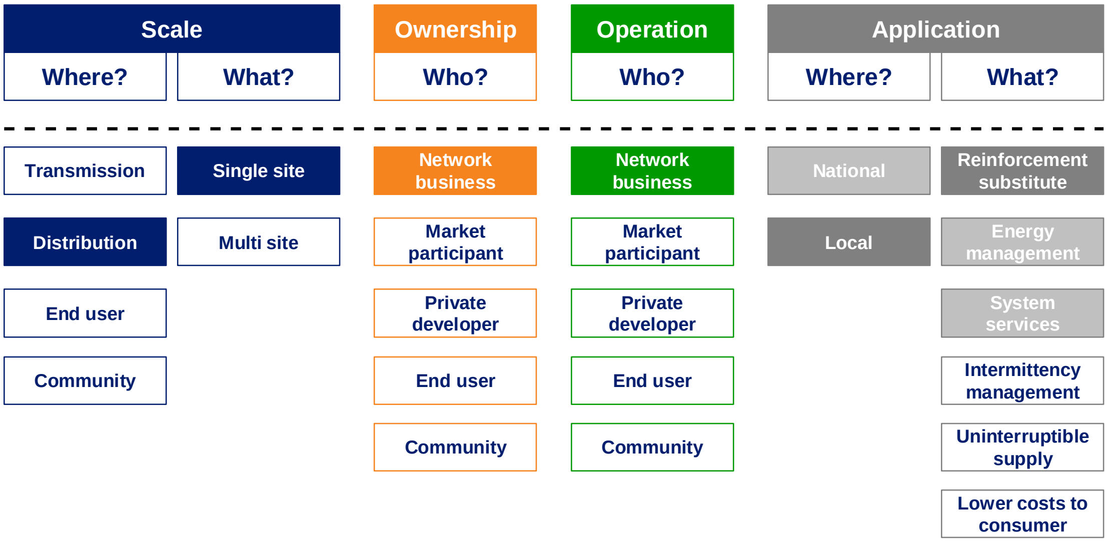
3.4.1 Case study: UKPN SNS Merchant DNO and DSO

UKPN’s Smarter Network Storage project, which centres on the installation of a 6MW/10MWh lithium ion battery in Leighton Buzzard, identifies two potential business models that revise the role of DNOs within the market relative to conventional distribution business activities:

- **DNO merchant**: the DNO has full operational control of storage assets and can monetise additional value streams directly through wholesale market trading and balancing service provision.
- **DSO**: again, the DNO has full operational control of storage assets on its system and has a Distribution System Operator (DSO) role, coordinating portfolios of flexible assets for application on its distribution system and the wider system.

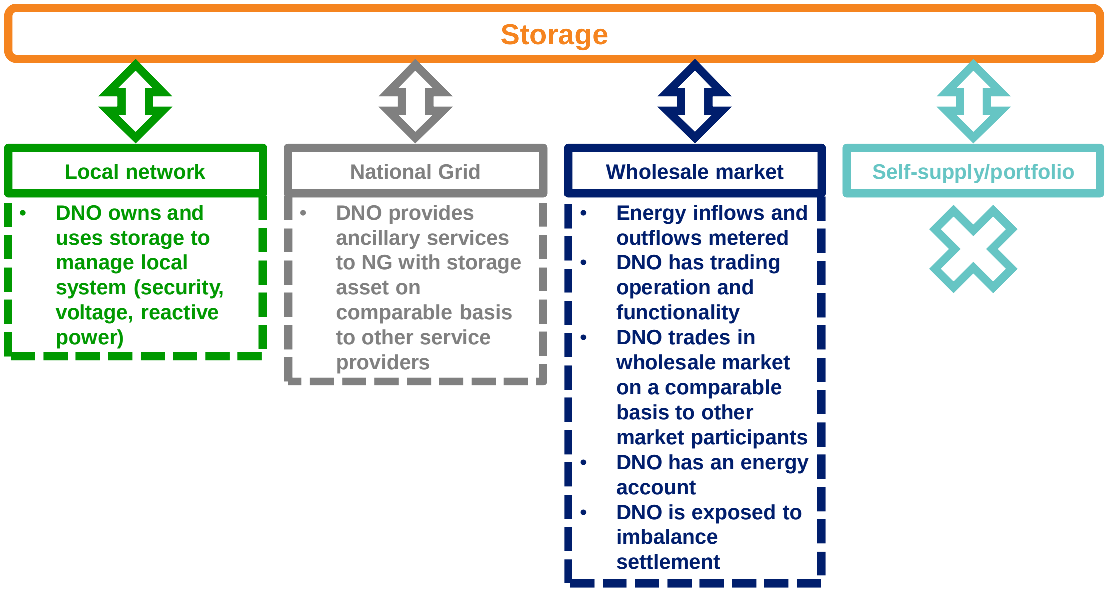
Under both models, therefore, the DNO owns and operates the storage asset and value is realised through a combination of reinforcement substitution, energy management and the provision of system services, as illustrated in Figure 14.

Figure 14 – UKPN SNS Merchant DNO and DSO: business model overview



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 15 – UKPN SNS Merchant DNO: interactions with sources of value



Storage

Local network

- DNO owns and uses storage to manage local system (security, voltage, reactive power)

National Grid

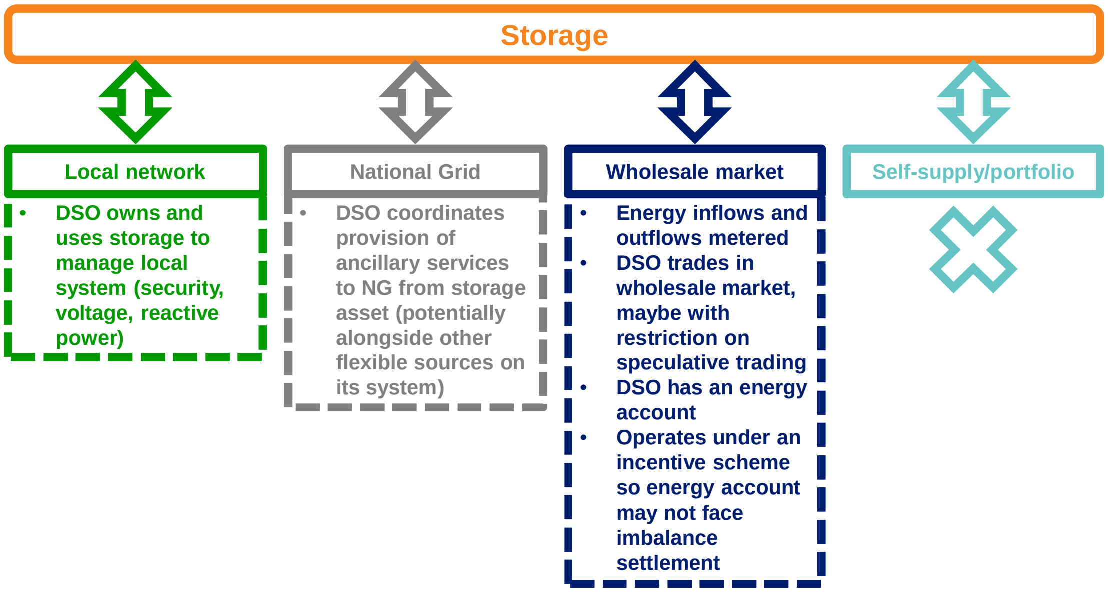
- DNO provides ancillary services to NG with storage asset on comparable basis to other service providers

Wholesale market

- Energy inflows and outflows metered
- DNO has trading operation and functionality
- DNO trades in wholesale market on a comparable basis to other market participants
- DNO has an energy account
- DNO is exposed to imbalance settlement

Self-supply/portfolio

Figure 16 – UKPN SNS DSO: interactions with sources of value



Local network

- DSO owns and uses storage to manage local system (security, voltage, reactive power)

National Grid

- DSO coordinates provision of ancillary services to NG from storage asset (potentially alongside other flexible sources on its system)

Wholesale market

- Energy inflows and outflows metered
- DSO trades in wholesale market, maybe with restriction on speculative trading
- DSO has an energy account
- Operates under an incentive scheme so energy account may not face imbalance settlement

The interaction between the DNO and the wider wholesale market does differ between these models, as shown by comparing Figure 15 and Figure 16. In both cases, energy inflows and outflows are metered and the DNO has trading functionality. However, the framework within which trade occurs differs. Under the DNO Merchant case, the DNO trades like any other market participant through an energy account which faces exposure to imbalance settlement. Under the DSO case, trade may be restricted to prevent non-speculative trading and the DNO's energy account may not be exposed to imbalance settlement. This is a comparable framework to that of National Grid in its role as Transmission System Operator.

At present, the SNS project is the only demonstration that considers either of these more active roles for distribution businesses.

3.4.2 Issues

Neither of these models is possible within the current regulatory and legal framework. The current framework places several restrictions on the ability for DNO's to operate and earn revenue from storage assets:

- **Treatment of storage as generation**: storage is not explicitly categorised as an activity within the electricity sector and is treated as a class of generation by default. As part of the privatisation and liberalisation process, distribution licence holders are prohibited from holding generation or supply licences, in order to maintain operational independence between these activities. There is some latitude for distribution licence holders to own storage assets, however, as a class exemption for 'small generators'[18]

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[18] The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001'. A generator can be exemptible as a small generator if output to the total system (GB transmission system and all distribution systems) is less than 10MW, or if output to the total system is less than 50MW and the declared net capacity of the power station is less than 100MW.

exists, meaning that storage projects which fall below the specified size threshold are exempt from the requirement to hold a generation licence. De minimis business restrictions[19] do limit this potential. These restrictions mean that turnover from and investment in non-distribution activities must not exceed 2.5% of DNO business revenue or licensee's share capital respectively. This is a relatively loose constraint at present, but in time it could become binding and so restrict deployment.

- **Obligation not to distort competition in supply and generation**: the distribution licence requires the licensee to avoid distortion of competition in generation or supply activities[20]. This is generally interpreted as a block on DNO trading. This compromises both the DNO Merchant and DSO business models and implies that, under the current regulatory arrangements, a third party needs to be involved to trade energy inflows and outflows on behalf of the DNO.

These issues, in particular the latter, mean that both DNO Merchant and DSO business models are not practicable within the current regulatory arrangements. Action is required from Ofgem to make these options possible (if considered appropriate) through revisions to the regulatory framework to enable DNO trading and/or DSO activities to occur. Getting an appropriate regulatory underpinning is the fundamental first step for these models.

On the assumption that the regulatory foundation is revised to allow these models, the settlement arrangements can be modified relatively straightforwardly. DNOs are already signatories to the BSC, but they do not have energy accounts. Accounts can be set up through existing administrative processes. For the DNO Merchant model, the energy accounts could be settled for imbalance just like other market participants. For the DSO model, the accounts may not necessarily be exposed to imbalance payments and instead treated similarly to National Grid's accounts (potentially alongside an incentive scheme elsewhere within the regulatory framework).

Finally, these business models require organisational change within the DNOs as undertaking trading is a departure from the conventional range of distribution business activities, requiring different functionality and in-house expertise. Transitioning to DNO Merchant or DSO is a significant undertaking for conventional DNO businesses and so this represents a possible step down the line rather than in short/medium-term. In any event, it needs to be preceded by or occur alongside enabling revisions to the regulatory framework referred to above.

3.4.3 Summary

In order to be feasible options, the DNO Merchant and DSO business models first require enabling amendments to the regulatory framework surrounding distribution business activity to allow DNOs to trade. This requires action from Ofgem. If the regulatory framework changes appropriately, then DNOs can hold energy accounts and be included within the settlement arrangements in a manner consistent with either general market participants or with National Grid. Therefore, these models can be incorporated within settlement arrangement relatively easily, but they require other regulatory changes as a primary step.

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[19] Standard Condition 29: Restriction of activity and financial ring-fencing of the Distribution Business.

[20] Standard Condition 4.1.

3.5 Energy flows settled in market participant energy accounts

The models that settle energy flows in market participant energy accounts can be split into two categories:

- grid scale assets under ownership of a network business, for which flows must be handled in a third party energy account with supporting contractual arrangements between the DNO and the third party; and
- grid scale assets under ownership of a non-network business, for which there is no need for energy flows to be handled by a third party.

3.5.1 Grid scale assets under ownership of a network business

To avoid issues relating to potential distortion of generation and supply through DNO trading (as discussed in the context of DNO Merchant and DSO models), energy trading activity to manage inflows and outflows can be handled by a third party supported by contractual arrangements between the DNO and this third party.

3.5.1.1 Case study: UKPN Hemsby (Demonstrating the benefits of Short-term Discharge Energy Storage on an 11kV Distribution Network)

UKPN's Hemsby project involves a 200kWh lithium ion battery installed at a substation site, used to support the management of the 11kV network. The asset is owned and operated by UKPN. But it has contractual arrangements in place with a third party, who is an active market participant, to buy energy inflows and sell energy outflows linked to the storage device. These flows are incorporated into the energy accounts of the third party and so are included within the settlement arrangements.

Figure 17 and Figure 18 provide the business model overview and highlight interactions with different values sources respectively. The model is the same as that of Northern Powergrid discussed in Section 3.3, with the exception of the interaction with the wholesale market and settlement.

Figure 17 – UKPN Hemsby: business model overview

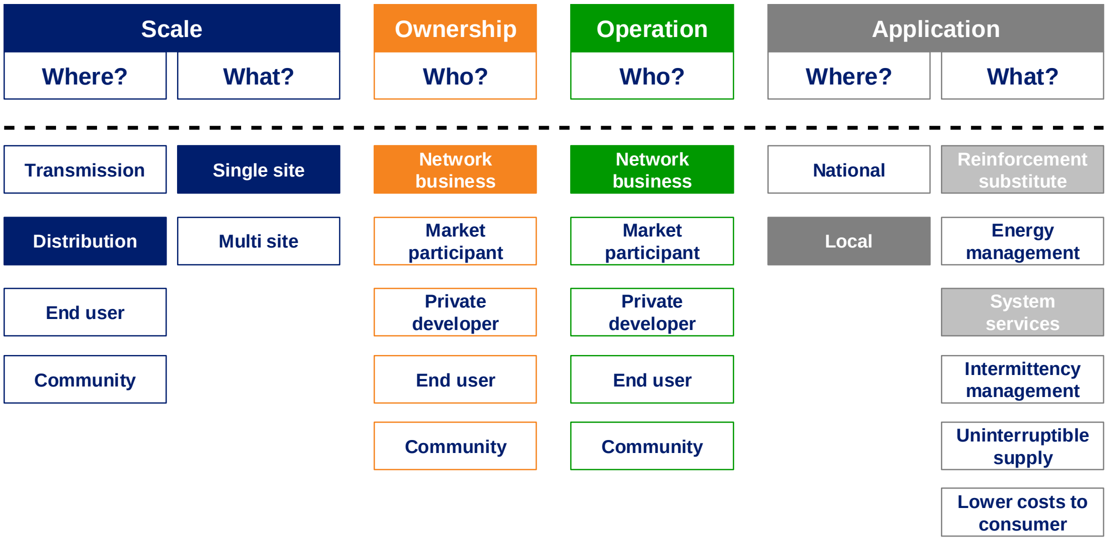
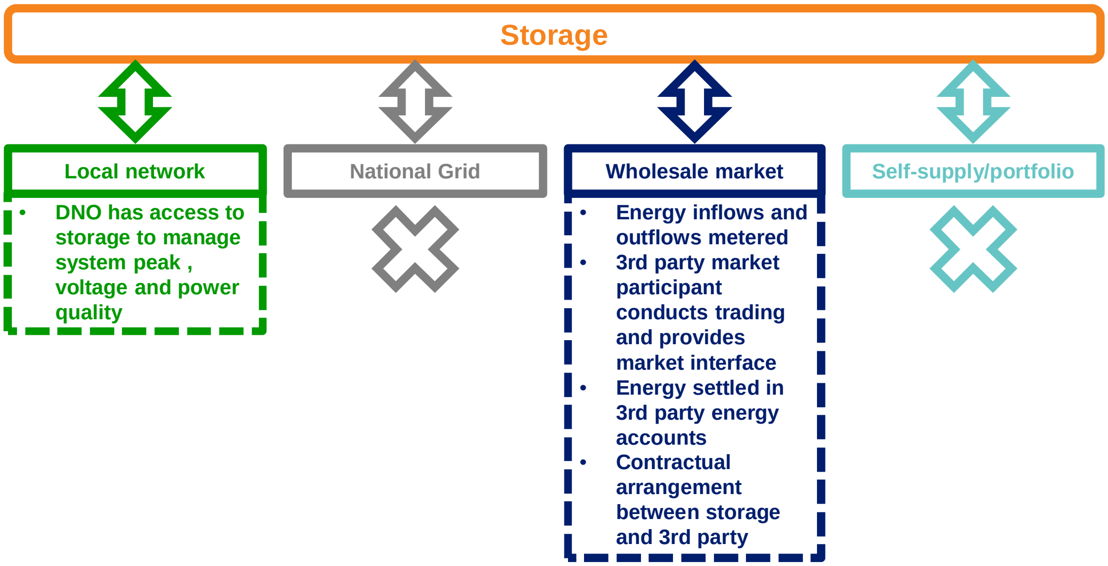


Figure 18 – UKPN Hemsby: interactions with sources of value



Local network:

- DNO has access to storage to manage system peak , voltage and power quality

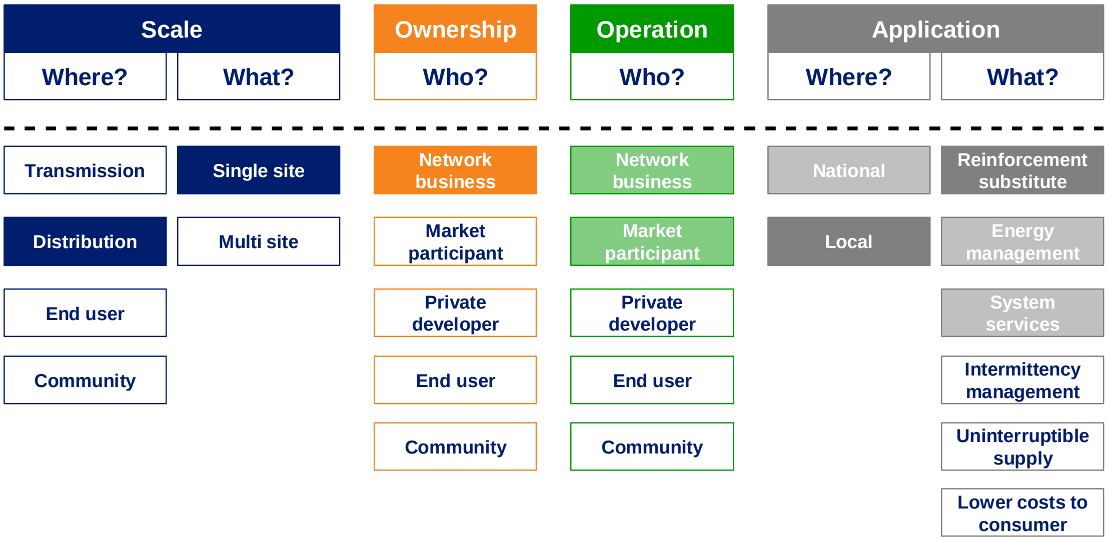
Wholesale market:

- Energy inflows and outflows metered
- 3rd party market participant conducts trading and provides market interface
- Energy settled in 3rd party energy accounts
- Contractual arrangement between storage and 3rd party

3.5.1.2 *Case study: UKPN SNS DNO Contracted*

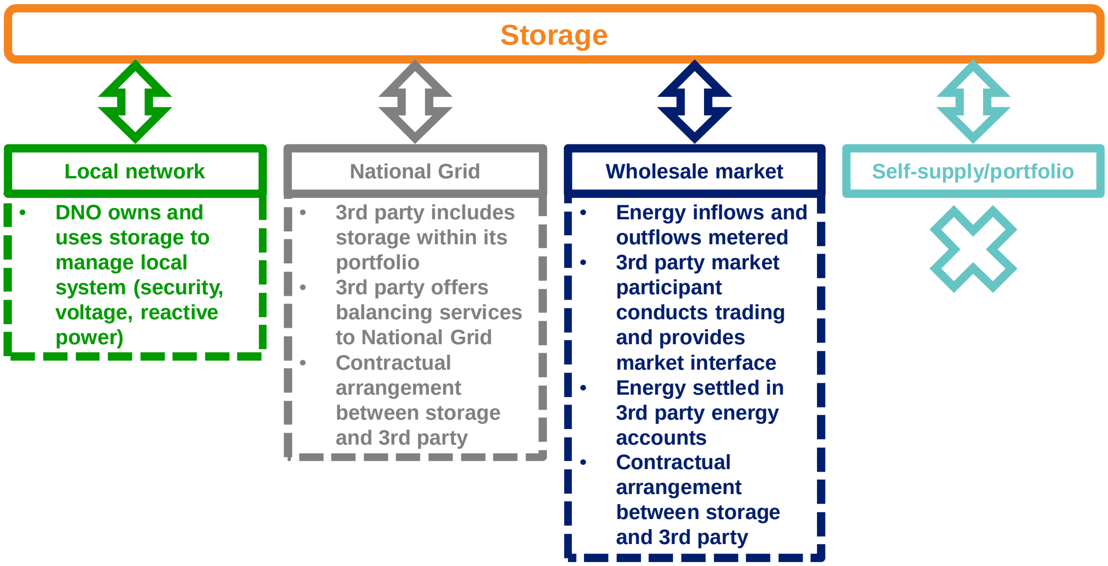
The DNO Contracted approach is another business model variant raised in the context of UKPN's SNS project. Under this model, the DNO owns the asset and uses it for network purposes in specific windows. However, operation of the asset outside these windows is managed by a third party who has a long-term contract for use of the asset for commercial purposes. A business model overview is provided in Figure 19, while Figure 20 highlights interactions with different values sources. This highlights that, while the DNO owns the asset, the energy flows linked to its operation are handled by a third party under contractual arrangements.

Figure 19 – UKPN SNS DNO Contracted: business model overview



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 20 – UKPN SNS DNO Contracted: interactions with sources of value



Local network

- DNO owns and uses storage to manage local system (security, voltage, reactive power)

National Grid

- 3rd party includes storage within its portfolio
- 3rd party offers balancing services to National Grid
- Contractual arrangement between storage and 3rd party

Wholesale market

- Energy inflows and outflows metered
- 3rd party market participant conducts trading and provides market interface
- Energy settled in 3rd party energy accounts
- Contractual arrangement between storage and 3rd party

Self-supply/portfolio

3.5.1.3 Issues

Involving a third party handle the energy flows seems a necessity under the current regulatory framework in order to ensure that the DNO does not distort competition. This additional contractual interface potentially increases the complexity of the business case and requires each party to make a return from the operation of the asset in order to make the arrangement worthwhile. However, there are no standard commercial terms between a storage asset and a supplier/offtaker – standard contracts assume that a party is a generator or a consumer, rather than both. There is additionally a concern that terms offered for supply and offtake in demonstration phases are not viable in the longer-term.

3.5.2 Grid scale assets under ownership of a non-network business

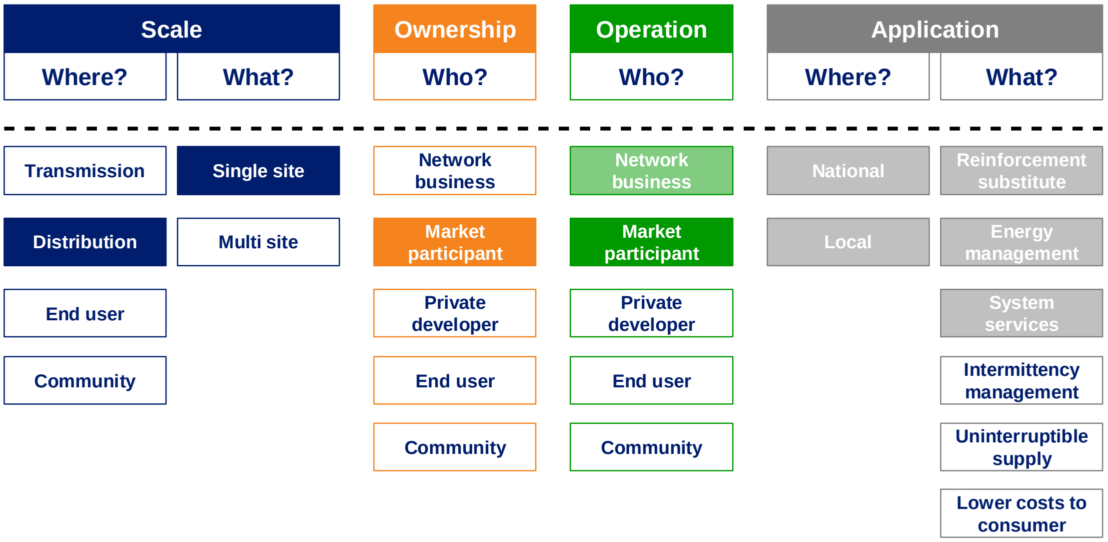
If storage assets are owned by non-network entities, then the requirement to contract via a third party does not exist (although this remains an option). Here, accessing commercial revenue streams is a central component of the business case which requires participation in the wholesale market either directly (through own energy account) or indirectly (through another party's energy account). Under either route, the energy flows are captured within settlement arrangements.

3.5.2.1 Case study: UKPN SNS Contracted Services

Under the Contracted Services model, the DNO contracts with the storage owner for provision of local network services but otherwise the owner has operational control of the asset. The owner's focus is on realising value from commercial revenue streams, whilst also capturing value through the contract with the DNO for provision of local network services.

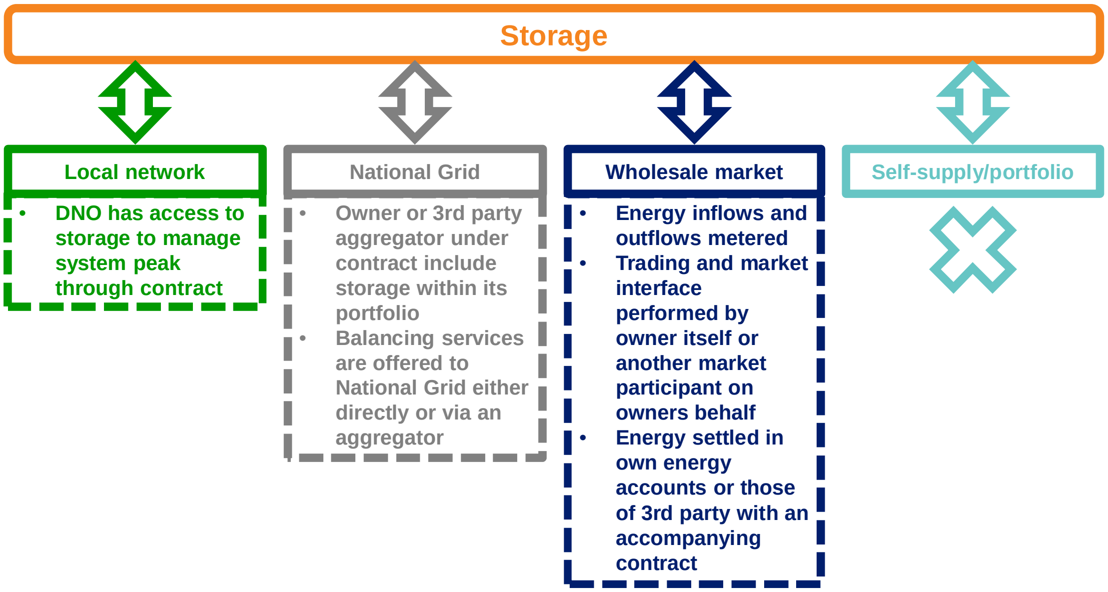
A business model overview is provided in Figure 21, while Figure 22 highlights interactions with different values sources. Again, the energy flows linked to operation of the storage assets are included in an energy account. This can be either the energy account of the operator or of a third party that it has contracted with.

Figure 21 – UKPN SNS Contracted Services: business model overview



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 22 – UKPN SNS Contracted Services: interactions with sources of value



Local network

- DNO has access to storage to manage system peak through contract

National Grid

- Owner or 3rd party aggregator under contract include storage within its portfolio
- Balancing services are offered to National Grid either directly or via an aggregator

Wholesale market

- Energy inflows and outflows metered
- Trading and market interface performed by owner itself or another market participant on owners behalf
- Energy settled in own energy accounts or those of 3rd party with an accompanying contract

Self-supply/portfolio

3.5.2.2 Case study: UKPN SNS Charging Incentives

The Charging Incentives model entails a different relationship between the DNO and the storage provider. Rather than contracting with the storage owner directly, the DNO instead creates incentives through distribution charging arrangements for storage to connect in a location that is useful for the distribution network. If the incentives are sufficient, the expectation is that storage will be delivered and will deliver system benefits without a direct contractual arrangement with the DNO.

A business model overview is provided in Figure 23, while Figure 24 highlights interactions with different values sources. Again, the energy flows linked to operation of the storage assets are included in an energy account. This can be either the energy account of the operator or of a third party that it has contracted with.

Figure 23 – UKPN SNS Charging Incentives: business model overview

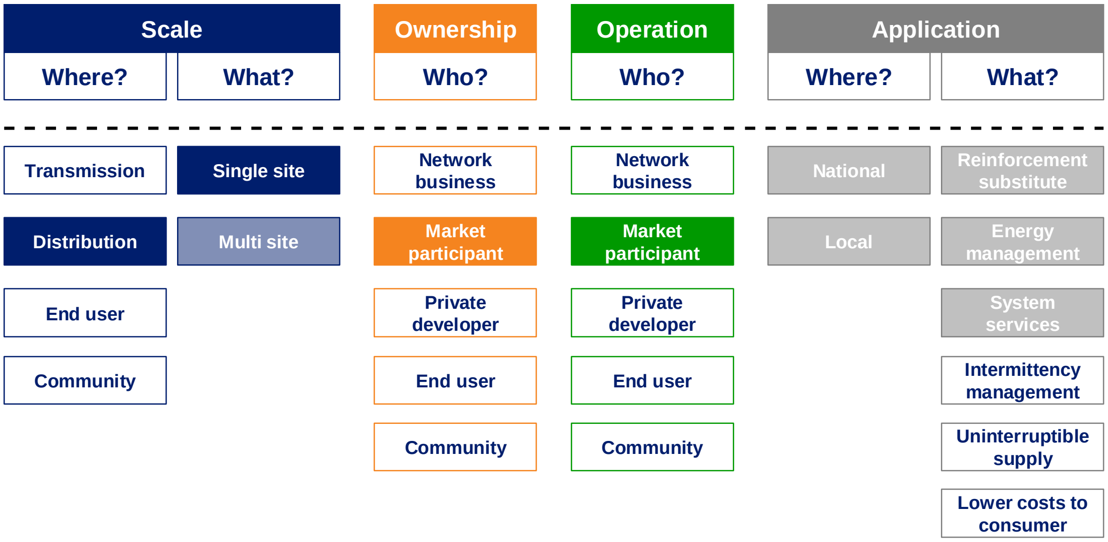
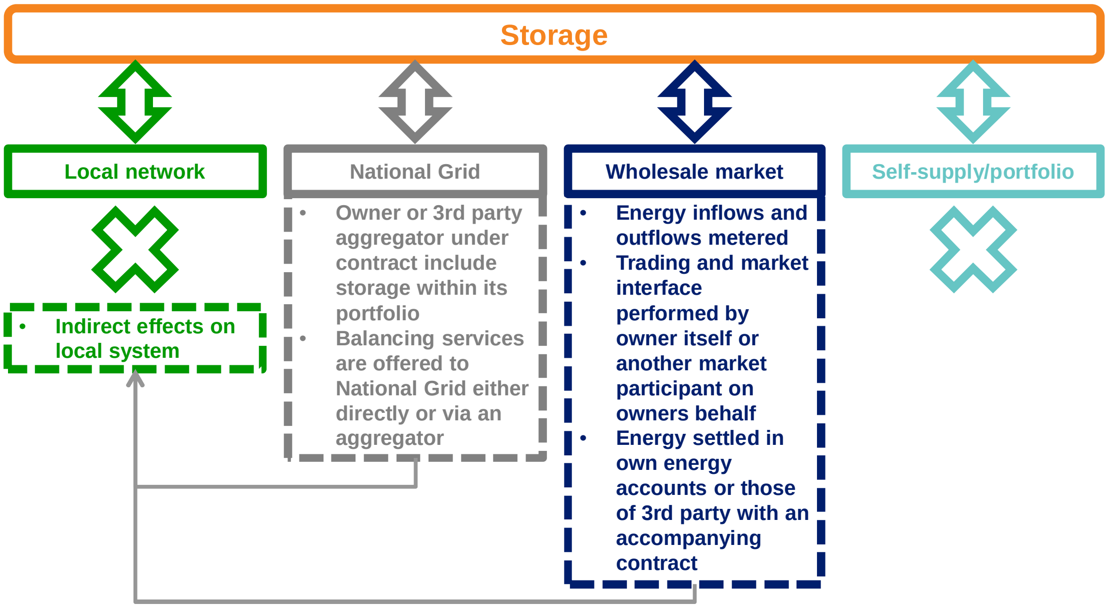


Figure 24 – UKPN SNS Charging Incentives: interactions with sources of value



3.5.2.3 Case study: SSE Orkney Energy Storage Park

The first phase of the Orkney Energy Storage Project sought to create commercial incentives for third parties to locate on a constrained part of the distribution network. The route for creating the incentive was via a contract tailored to facilitate the management of network constraints. Therefore, this has similarities with both the DNO Contracted and Charging Incentives models under the SNS project.

The principle behind business case for storage in this model relies on the owner being able to access revenue from a range of sources. This requires explicit metering and, from a settlement perspective, inclusion of all energy flows linked to the operation of storage in the energy account of the storage owner or a third party on its behalf.

3.5.2.4 *Case study: Quarry Battery*

The most advanced Quarry Battery project is a 49.9MW, 600MWh pumped storage hydro facility. It is being developed privately for operation in the wholesale and ancillary service markets. It is likely to be operated by a market participant either as part of its own portfolio or on behalf of the owner under contractual arrangements. Therefore, energy flows are explicitly captured in the energy accounts of a market participant for purposes of settlement.

Figure 25 and Figure 26 provide the business model overview and highlight interactions with different values sources respectively.

Figure 25 – Quarry Battery: business model overview

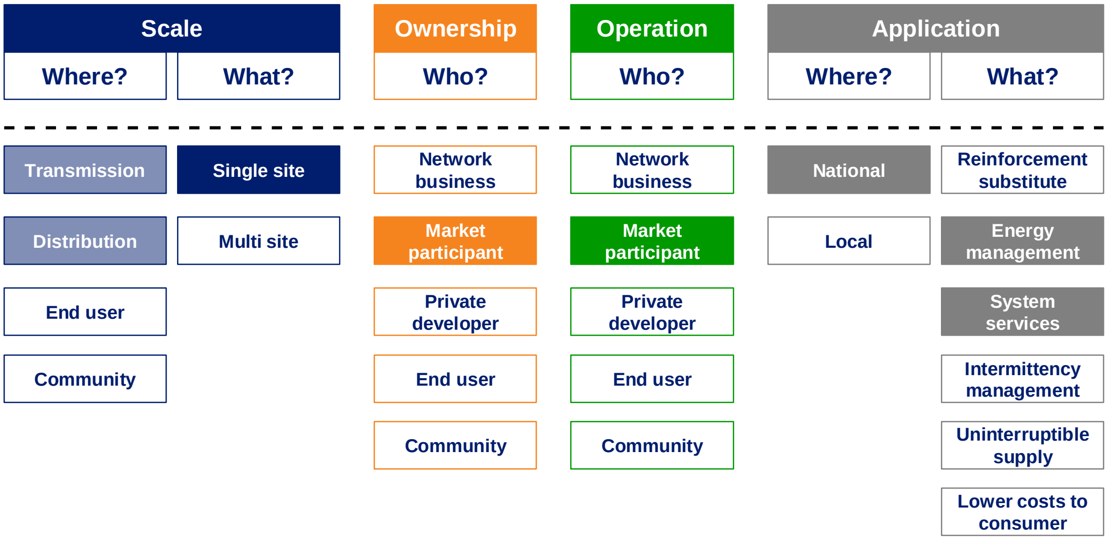
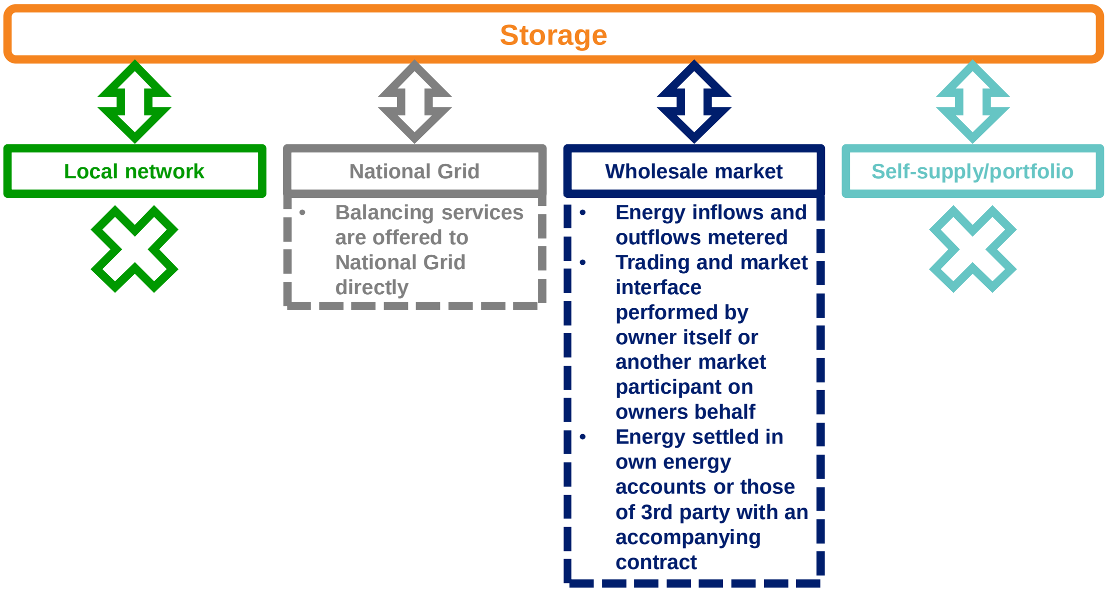


Figure 26 – Quarry Battery: interactions with sources of value

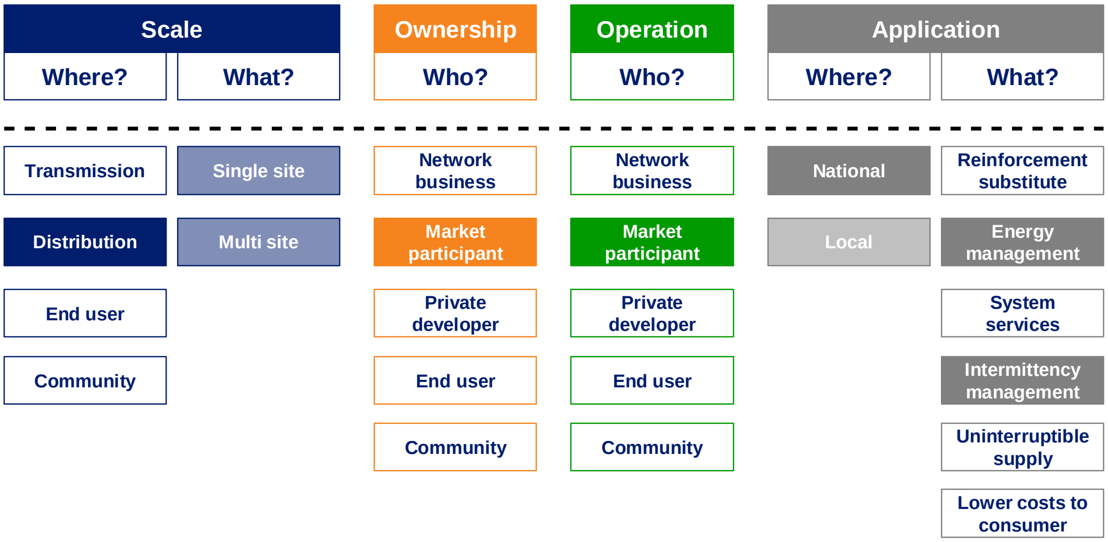


3.5.2.5 *Case study: WPD Solar Storage*

WPD's Solar Storage project focuses on the integration of battery storage with intermittent solar generation with multiple potential applications, some purely commercial to the benefit of the operator of the combined storage and solar assets and others network related. Commercial uses include shifting delivery of solar generation output from midday to peak consumption periods when higher wholesale prices can be realised and allowing more generation than physical connection capacity with surplus being stored and released at a later time. Network related services include managing peak and trough demand situations, voltage control and power quality management. So the potential applications for storage are varied including energy and intermittency management for the solar generation operator plus provision of network services and an alternative to network reinforcement.

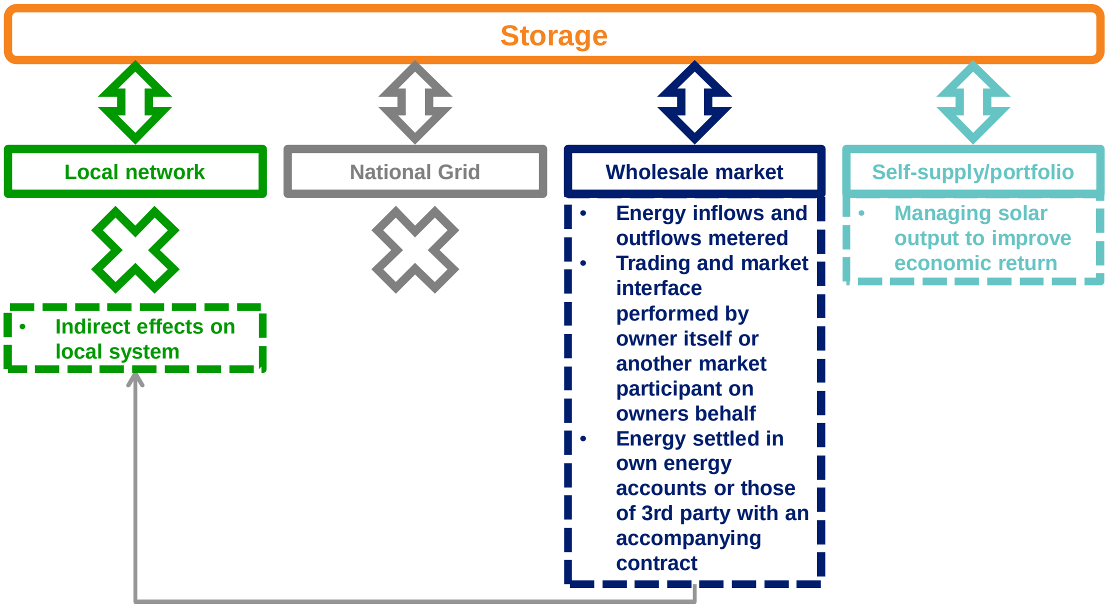
Figure 27 and Figure 28 provide the business model overview and highlight interactions with different values sources respectively for the use cases that provide value to the operator. Figure 29 and Figure 30 provide the same overview focusing on the use cases that provide value to the operator. While shown separately here to highlight different sources of value from different applications, operator value and DNO value uses will co-exist. The mix of use cases employed will depend on value potential from different applications, which is likely to evolve over time. In order to capture value from the broad range of potential uses, particularly the commercial uses which require market interaction, and also from the underlying solar generation output, the energy flows linked to the integrated assets will need to be captured within an energy account (either that of a third party or the solar/storage operator itself).

Figure 27 – Solar Storage: business model overview – operator value



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 28 – Solar Storage: interactions with sources of value – operator value

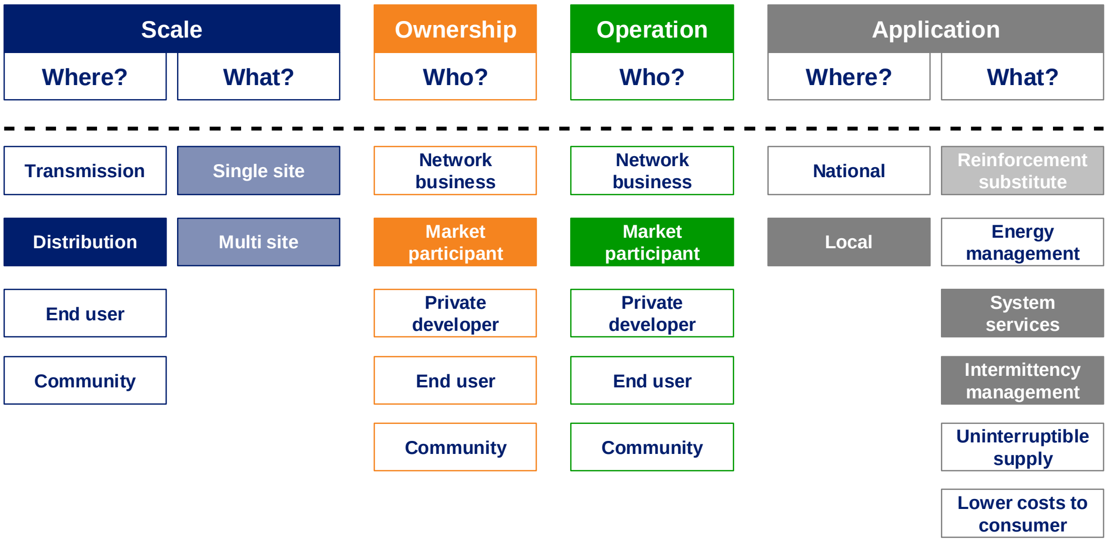


- Indirect effects on local system

- Energy inflows and outflows metered
- Trading and market interface performed by owner itself or another market participant on owners behalf
- Energy settled in own energy accounts or those of 3rd party with an accompanying contract

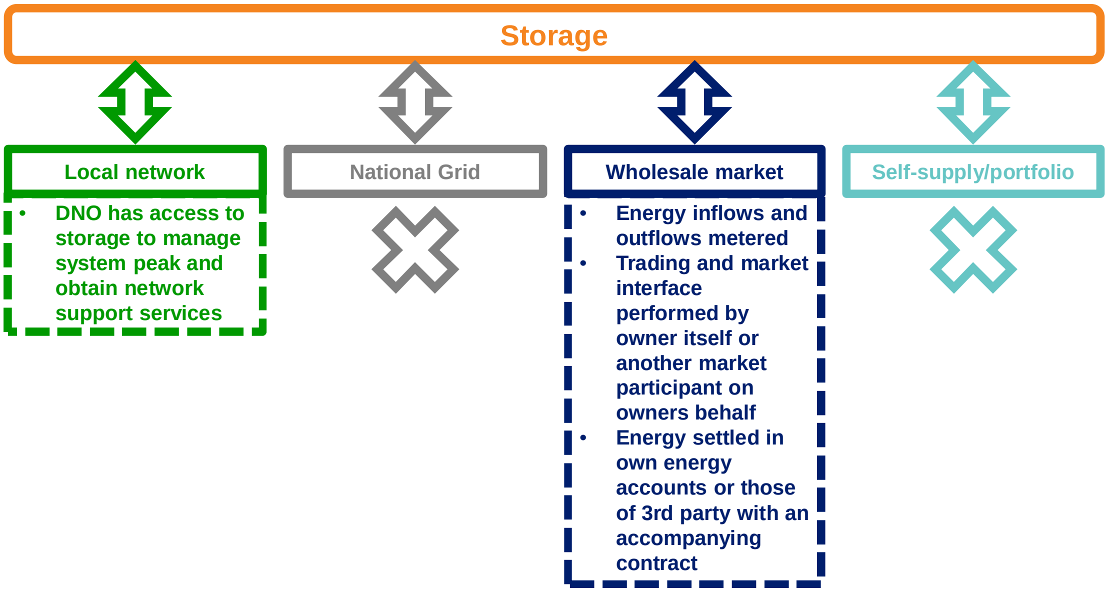
- Managing solar output to improve economic return

Figure 29 – Solar Storage: business model overview – DNO value



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 30 – Solar Storage: interactions with sources of value – DNO value



Storage

Local network

- DNO has access to storage to manage system peak and obtain network support services

National Grid

Wholesale market

- Energy inflows and outflows metered
- Trading and market interface performed by owner itself or another market participant on owners behalf
- Energy settled in own energy accounts or those of 3rd party with an accompanying contract

Self-supply/portfolio

3.5.2.6 *Issues*

These models place clear emphasis on storage being able to participate in wholesale and ancillary services markets. For this, flows need to be metered to enable service provision verification and to account appropriately for energy inflows/outflows. Indeed, these models rely on being able to interact with the wholesale market to be viable. Developers are progressing commercial projects that will be integrated within the settlement arrangements.

3.5.3 Summary

Explicit inclusion of energy inflows/outflows associated with storage operation within market participant energy accounts is the most likely model for grid-scale storage assets in the short/medium term. It avoids the shortcomings of the losses/spill approach that has been adopted in some early demonstration projects and is feasible within the current regulatory framework, unlike solutions involving DNO energy accounts.

The approach allows network owned assets to provide market-oriented services via contractual arrangements with a third party who already has trading functionality and energy accounts under BSC. Given likely scale of distribution-led assets of up to ~10MW, the asset is likely to be included in SVA within a supplier/aggregator portfolio

Non-DNO owned assets can be included under CVA or SVA routes depending upon scale and the status of the owner (i.e. direct or indirect market participant)

Where third party contracting is in place, there is an indication that the commercial terms for inflows and outflows could be improved, however. This is not helped by lack of standard contract formats for storage – existing contracts assume a party is either generation or demand, not both, and so bespoke arrangements need to be developed.

3.6 Energy flows not captured on half-hourly basis

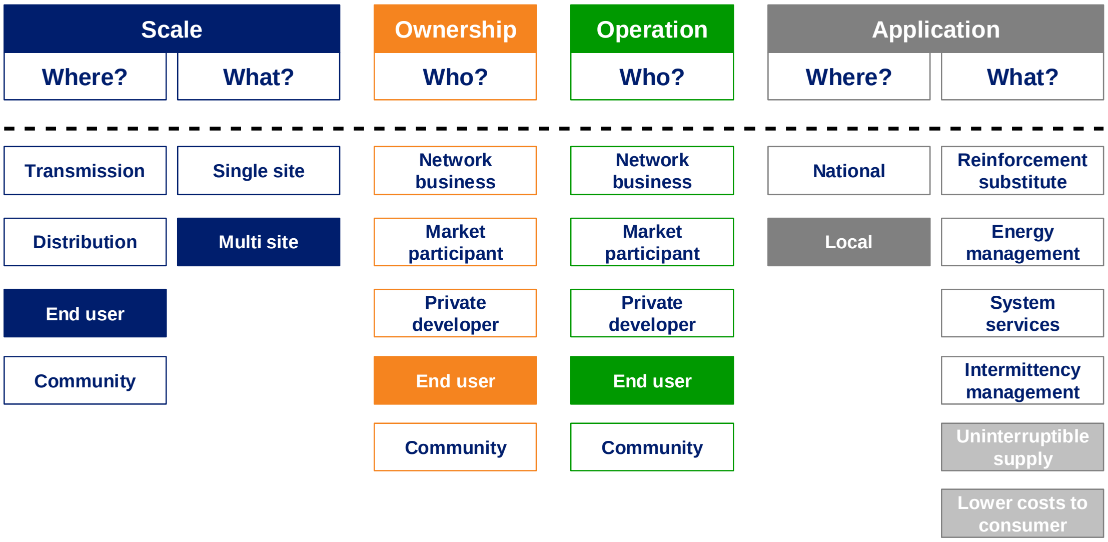
In addition to grid-scale storage projects, there is also growth in non-grid scale projects such as those installed in domestic or commercial premises. These assets can operate individually serving the premises at which they are installed or they can be aggregated to act collectively offering the potential for interaction with the wider market.

3.6.1 Case study: Moixa

Moixa offers smart energy systems that can incorporate batteries, smart meters and microgeneration, operating through a smart DC network. The solution enables users to power electronics and lighting from off-grid or off-peak energy supplies. The MASLOW battery can be charged at off-peak times and the stored energy used at peak, reducing exposure to the costs of grid supplied electricity. If the system also harnesses microgeneration (e.g. solar panels), usage of grid-supplied energy and associated costs can be reduced further.

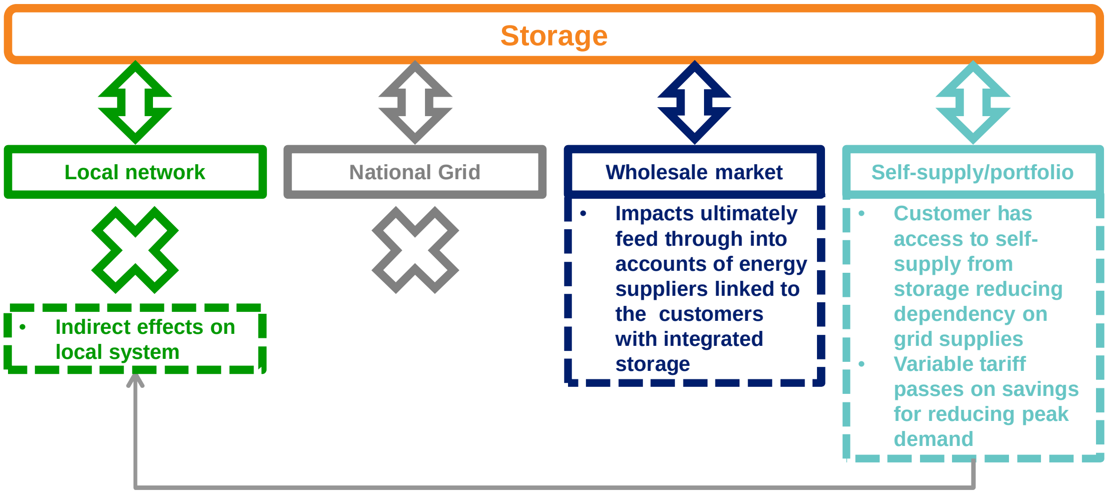
If the Moixa systems are operated by users in isolation (i.e. not aggregated), the business model focuses on delivering benefits to the end user in terms of reduced grid-supplied energy costs and enhanced resilience. There is no explicit linkage between the storage assets and the wider market. Altered patterns of consumption that result from operation of the Moixa systems will ultimately, following the reconciliation process when meter readings for these non-half-hourly consumers are obtained, feed into the energy accounts of the suppliers that serve the users in question. If these systems are deployed at scale and their operation is effectively invisible to the market, suppliers linked to the users will have to carry the uncertainty/imbalance risk associated with operation of the storage assets. In addition, there will be knock-on implications for operation of distribution systems in areas with a concentration of deployment. This business model and its interactions with different value streams are shown in Figure 31 and Figure 32 respectively.

Figure 31 – Moixa (no aggregation): business model overview



Scale		Ownership	Operation	Application	
Where?	What?	Who?	Who?	Where?	What?
Transmission	Single site	Network business	Network business	National	Reinforcement substitute
Distribution	Multi site	Market participant	Market participant	Local	Energy management
End user		Private developer	Private developer		System services
Community		End user	End user		Intermittency management
		Community	Community		Uninterruptible supply
					Lower costs to consumer

Figure 32 – Moixa (no aggregation): interactions with sources of value



- Indirect effects on local system

- Impacts ultimately feed through into accounts of energy suppliers linked to the customers with integrated storage

- Customer has access to self-supply from storage reducing dependency on grid supplies
- Variable tariff passes on savings for reducing peak demand

There is the potential for Moixa systems to be aggregated into a combined distributed energy resource. The responsible aggregator can then offer services to National Grid and potentially also to the local grid. To do this, metering, communications and IT infrastructure will need to be in place between the storage assets and the aggregator. But for central settlement purposes, the individual premises are likely to remain non-half hourly metered. This means that the changes to consumption patterns delivered through aggregation will remain invisible to the relevant suppliers that serve the end users and to the market until after the event.

The revised business model including aggregation and its interactions with different value streams are shown in Figure 33 and Figure 34 respectively.

Figure 33 – Moixa aggregation: business model overview

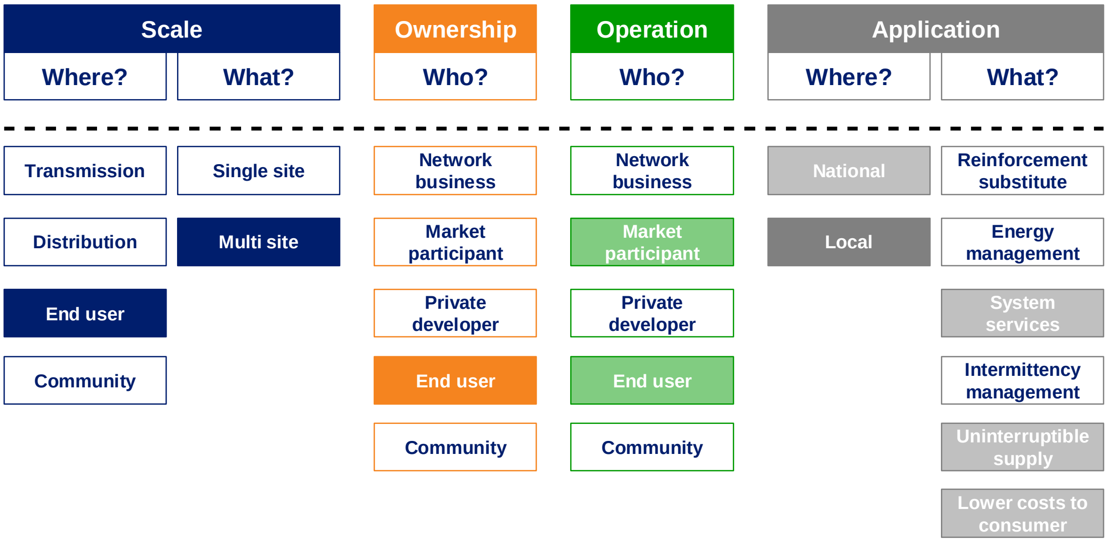
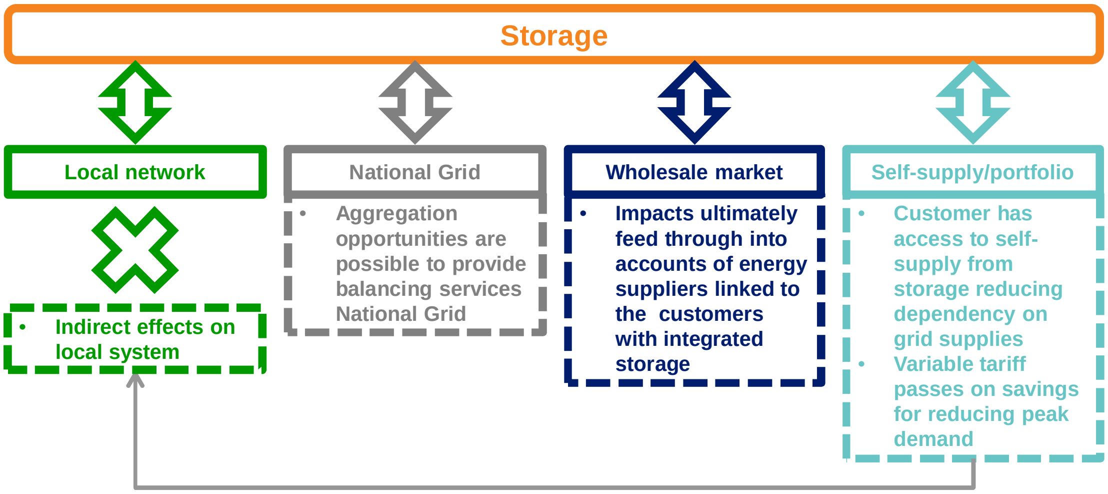


Figure 34 – Moixa aggregation: interactions with sources of value



- Indirect effects on local system

- Aggregation opportunities are possible to provide balancing services National Grid

- Impacts ultimately feed through into accounts of energy suppliers linked to the customers with integrated storage

- Customer has access to self-supply from storage reducing dependency on grid supplies
- Variable tariff passes on savings for reducing peak demand

Other projects with similar characteristics in terms of business model and interactions with settlement are:

- **So La BRISTOL, WPD**: the BRISTOL (Buildings, Renewables and Integrated Storage, with Tariffs to Overcome network Limitations) project considers the role for battery storage, alongside demand response and DC networks, as an efficient alternative to conventional network reinforcement to accommodate increased low carbon generation. It couples battery storage installation in homes/small businesses with variable tariffs and integrated network control to support network operation (e.g. reducing peak load, providing voltage control, reducing network harmonics) and allow consumers to reduce energy demand.

3.6.2 Issues

Both variants of the Moixa approach have implications for other parties, notably suppliers linked to the end users, because the storage assets are not likely to be picked up in half-hourly settlement given their size. Instead, suppliers serving these users will initially be settled using estimated consumption profiles until meter readings become available through the reconciliation process. This creates uncertainty and imbalance risk exposure for suppliers.

This can be managed if the aggregator and supplier roles are under a common umbrella, as the supplier then has full visibility of the assets and the ability to operate them within its portfolio. This approach also enables benefits of storage for supplier balancing (in addition to system balancing) to be realised.

The situation could further be improved by reducing use of consumer profiles within settlement and instead increasing the use of half-hourly metering for sites with small scale storage. In time, this could help to enable such sites to access the markets directly.

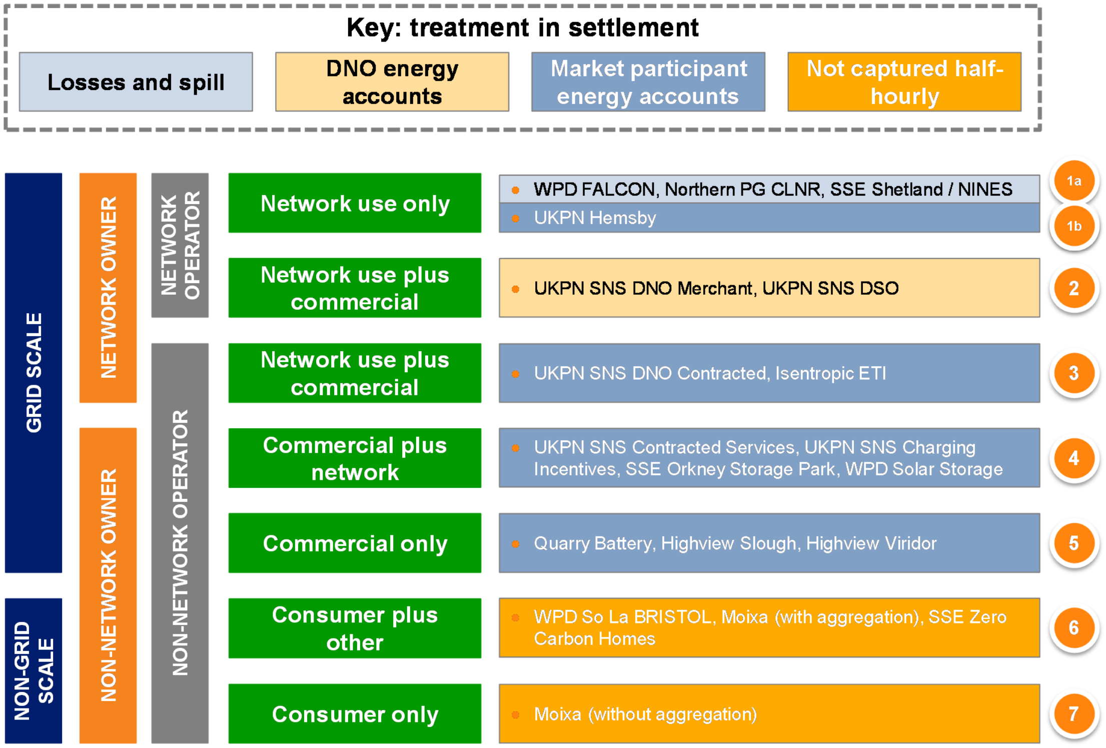
3.6.3 Summary

Both variants of the Moixa approach can work within the current market arrangements. However, the storage assets and their operation are invisible to the market in terms of settlement until well after the event creating potential imbalance exposure for suppliers. The lack of visibility could be addressed through commercial arrangements between the user and their supplier and/or by extending the scope of half-hourly metering to cover sites with small scale storage. In addition to improving visibility, this may enable the flexibility of these assets to be better integrated within the market.

3.7 Conclusions

Business models will vary across projects depending upon scale, owner, operator and application/applications. By considering ongoing/prospective projects, we have identified several distinct business models and modes of interaction with settlement. The resultant mapping is shown in Figure 35, which highlights that the business models considered can interact with settlement in four potential ways.

Figure 35 – Business models and interaction with settlement



Our summary assessment of the four methods of interaction with settlement is as follows:

- **Losses and spill**: this is not tenable beyond initial demonstration projects because (a) it imposes costs on other market participants as the net inflow/outflow position is picked up in losses and (b) it effectively precludes provision of services to the market and so removes a potential value stream for storage assets which may compromise business cases for future applications for which multiple value streams are likely to be necessary.
- **DNO energy accounts**: the current regulatory framework precludes distribution businesses from participating in the market which means that this option is not possible at present. DNO trading could be accommodated within central settlement in principle using the standard market participant model or the National Grid model for its role as System Operator. However, this must be preceded by changes to the regulatory and legal framework to revise the role of distribution businesses. Without such changes, it is not feasible for DNOs to operate energy accounts.
- **Market participant energy accounts**: this appears to be the most likely model for grid-scale storage assets in the short/medium term. It allows network owned assets to provide market-oriented services via contractual arrangements with a third party

who already has trading functionality and energy accounts under BSC. Given likely scale of distribution-led assets of up to ~10MW, the asset is likely to be included in SVA within a supplier/aggregator portfolio. Non-DNO owned assets can be included under CVA or SVA routes depending upon scale and the status of the owner (i.e. direct or indirect market participant). There is scope for commercial arrangements between parties to be enhanced, however.

- **Not captured half-hourly**: this is the default situation for small-scale storage that is off-grid, with operation effectively invisible to the market and half-hourly settlement. This approach can continue to operate, but as deployment of such assets increases the impact of the lack of visibility increases, for suppliers in particular, and the full flexibility of the assets may not be captured by the market. Visibility could be improved through commercial arrangements between the user/aggregator and their supplier and/or by extending the scope of half-hourly metering to cover sites with small scale storage.

Therefore, the ‘losses and spill’ approach is not desirable with higher deployment and ‘DNO energy account’ solutions is not feasible under the current regulatory framework.

DNO owned storage assets must have contractual arrangements in place with a market participant to allow inflows/outflows to be settled and also to offer market services, meaning that they need to be included within the energy accounts of a market participant. Non-DNO grid scale storage assets will also be included in either the operators own energy account or that of a third party.

Non-grid scale storage can continue to fall below the radar of half-hourly settlement, as at present, and operate. But this will become a more significant issue for the market as deployment increases. Suppliers, in particular, may want to take steps to improve visibility of such assets within settlement arrangements while developers/owners of smaller-scale devices may seek better access to the wholesale market in order to capture value.

4. REGULATORY AND COMMERCIAL ISSUES AFFECTING STORAGE DEPLOYMENT

There are a number of regulatory and commercial barriers that affect deployment of storage within the GB market. Based on discussions with stakeholders active in storage developments, it is clear that there is a hierarchy of barriers and issues linked to the settlement and trading arrangements are on the second tier of priority.

4.1 Wider regulatory and commercial framework

4.1.1 Classification of storage

Electricity storage is not recognised as either an activity or asset class in the GB regulatory frameworks. Instead, the default is for storage to be treated as generation. This imposes constraints on ownership and operation, which affect distribution business led investments in storage in particular.

Distribution licence holders are prohibited from holding generation or supply licences to ensure operational independence. It is possible to develop storage assets that are sized below the thresholds for licensing and so be exempt from the need to hold a generation licence. Assets to serve distribution network requirements are likely to be below the threshold and so licence exemption provides a route for DNOs to develop storage assets (noting the need for a third party market participant to manage inflows and outflows). Non-network owner developers do not face the same restriction, but the licence exemption arrangements can influence storage asset sizing decisions.

The consideration of licensing has many side effects, ranging from impact on planning and consenting, through to payment of use of system charges and grid code compliance. For example, a licensed generator may be able to install storage on an existing operational site as a permitted developer, whereas an independent operator would need separate planning and consents.

A storage plant may also be required to pay TUOS charges for both generation and demand. Within the existing TUOS charging regime a storage asset in a generation rich region would typically be charging (that is be a demand customer) at times of high generation and vice versa for demand, it has to pay costs to reflect the abundance of generation. This tends to inhibit development of storage where it might have greatest impact.

Further distortions are caused by storage assets being sized to be below thresholds such as 50MW, in order to avoid the additional market costs of joining the BSC.

4.1.2 Capacity market participation

The capacity market being developed as part of the Electricity Market Reform process has the potential to be a valuable revenue stream for storage. The intention is for storage to participate on a comparable basis to other technologies. But certain elements of the design proposals presented in October 2013[21] influence the ability of storage to participate.

Of most significance is the nature of the obligation associated with capacity contracts. The October 2013 proposals require capacity contract holders to deliver energy in line with their underlying capacity obligation in system stress periods. Failure to do so will result in a penalty. But a stress period does not have a defined time period, making the obligation open-ended. This creates issues for storage given limitations on discharge duration, which increases risk of penalty exposure and so reduces the viability for storage to hold capacity contracts.

The capacity market rules have been evolving since October 2013 and DECC is aware of this issue. There is, therefore, the potential for revised arrangements in the final capacity market rules. But if storage participation is restricted by virtue of the rules, this will affect individual business cases and represent a missed opportunity for the market.

4.1.3 Balancing service requirements and procurement timescales

In Section 3.7, we conclude that the most likely and relevant business model is an energy market participant. The main barrier here is institutional, reflecting the nature of the energy market and its relative uncertainty. Because the storage plant will be trading on volatility, and volatility is difficult to predict, it is likely that long term contracts for energy trading will not be available. This will tend to lower the value of storage as it increases the cost of capital and so makes project investment much less secure.

Contracts from the SO for reserve services such as frequency, fast reserve and STOR tend to be of short term nature and so do not provide the financial certainty that an investor prefers. They also tend to be defined based on historical system needs and the technical characteristics of generating technologies that have traditionally been on the system. This risks overlooking changing system needs and the ability of new technologies to offer services[22].

Counter to this argument is an issue that as cash out prices become more extreme, the need for suppliers to balance their purchases against sales becomes more acute, and so there is a view that storage would become more essential, as a physical embodiment of a financial hedge against imbalance prices. This would increase trades in the Balancing Mechanism, and may be the more appropriate home for storage than the long-term ancillary services market.

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[21] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249565/capacity_market_rules_consultation_draft.pdf

[22] This approach is changing, however. National Grid has opened up the Short-term Operating Reserve (STOR) market to non-Balancing Mechanism providers and aggregated resources over recent years. Consideration is also being given to opening up the fast reserve market in a similar manner. In addition, National Grid has also suggested revisions to the firm frequency response service, including the introduction of a week-ahead tender and potential for aggregation. Such initiatives improve the potential for storage to participate in these markets by modifying service provider requirements and making procurement timescales more compatible with operational timescales.

4.1.4 Costs

During discussions with stakeholders, many commented on the costs of energy storage, and the impact on commercial development. The overall opinion is that perceived costs of storage, or at least the initial capital cost, are high and without volumes of scale and replication as a minimum, costs will not fall. There is some circularity in this, and correspondents suggested that a market subsidy or incentive would support the initial deployment and encourage lowering of technology prices.

One stakeholder who had detailed knowledge of procurement of energy storage technology commented on the competitive position between suppliers, and how there had been noticeable falls in costs in more recent projects. Lithium ion batteries were most cost competitive for their particular application.

Another stakeholder with current experience of battery technology drew attention to the volume of batteries that were installed for non-grid applications, such as in mobility scooters. The storage deployed in mobility applications dwarfed that in current grid applications, or even the mainstream EV sector, and this was likely to lead to ongoing cost reductions.

Our own analysis of costs highlights the following areas of importance:

- initial capital cost of the technology medium, which varies widely by technology;
- system integration costs for the power conversion system are reasonably well developed and relatively low cost, but the costs for software control, especially when algorithmic control is included can drive costs up significantly;
- installation and costs of connection are often overlooked, but are significant; and
- energy storage systems based on mechanical methods, such as cryogenics, compressed air or pumped hydro have longer lifetimes, and so lower through life cost.

For bulk applications, or for a large storage project that might be suitable for distribution deferral or reinforcement, typical costs and annualised income to repay capital at 8.5 % discount rate are shown in Table 3.

Table 3 – Technology costs and income requirements

Technology	Rating	Cap Ex	Lifetime	Required income
Lithium ion battery	10 MW, 2 h discharge	£18.5m	15	£2.2m
Lead acid battery	10 MW, 4 h discharge	£50m	15	£4.8m
NAS battery	10 MW, 6h discharge	£40m	15	£6.0m
Cryogenic system	10 MW, 4 h discharge	£17m	30	£1.5m

Guideline income for provision of reserve services such as STOR provided by National Grid indicates possible revenue of £50,000/MW/year. STOR is therefore able to provide about one quarter to one third of the annual income for an energy storage plant, demonstrating the need for a multiplicity of services to value storage correctly. However, contracting for a range of services, at different times of the day and year is complex and uncertain, and this lack of certainty for the income stream depresses the value of storage in the market place, especially when compared to the certainty of returns offered by support for low carbon generation technologies through the Renewables Obligation or, looking forward, Contract for Difference Feed-in Tariffs. This leads to calls for support for storage in the short-term through maturation/cost reduction phases, on the assumption that storage is needed at scale in the longer-term.

4.2 Settlement and trading arrangements issues

4.2.1 Cashout arrangements

The cashout arrangements influence the value that storage assets can realise through the market. By attaching a cost to imbalance, they place a value on flexible and reliable capacity, such as storage, that can be used to balance positions. However, the current methodology dampens cashout prices, weakening the signals and incentives that they provide.

The current 'main' imbalance price is a weighted average of the 500MWh most expensive energy trades needed to balance the system. This dampens cashout prices, as the averaging process reduces the impact of more expensive balancing actions and dampens the signals that they create for parties to balance their positions.

In addition, the method for including STOR within cashout prices has a dampening effect. Utilisation fees feed into the calculations, but the prices are fixed in the tender process, well in advance of potential delivery, meaning that they cannot reflect the underlying supply/demand fundamentals and system tightness in real-time. Also, availability payments are included through a Buy Price Adjuster (BPA), which is an imperfect proxy for when reserve is actually used and valued most.

This situation looks set to change however. Through its Electricity Balancing Significant Code Review[23], Ofgem has proposed a package of cashout reforms including:

- making cash-out prices more marginal by reducing (in phases over several years) the volume of actions on which the cash-out price is based or 1MWh (a 'fully marginal' cash-out price); and
- improving pricing of reserve by using a Reserve Scarcity Pricing function.

Ofgem has directed National Grid to raise BSC modification proposals to implement its proposed package of reforms. If implemented at the end of the modification process, these changes will make cashout prices sharper and improve incentives for investments in flexible capacity, such as storage. Stakeholders confirmed the importance of this modification for future deployment ambitions.

4.2.2 Profiling

Currently, SVA metered data is settled half hourly if the metering system is 100kW or greater or it is settled non-half hourly if the metering system is below 100kW. Sites with non-half-hourly meters are settled using generic consumer profiles pending receipt of meter reads throughout the reconciliation process. There are eight consumer profiles;

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[23] https://www.ofgem.gov.uk/publications-and-updates/electricity-balancing-significant-code-review-final-policy-decision

profiles 1 and 2 are for domestic premises and profiles 3 to 8 are for non-domestic premises. As highlighted in Section 3.6, the use of consumer profiles for small-scale sites with storage means that their impact is invisible to the market in terms of settlement until well after the event.

As smart meter technology is rolled out, options open up for migrating non-half hourly metered sites to half hourly metering rather than continued reliance on profiles. This could include premises with onsite storage. This would improve visibility of these assets to the market and also potentially enable them to offer flexibility to the market.

SmartestEnergy raised modification proposal P272 in order to require that SVA metering systems that fall within profile classes 5 to 8 be settled using half-hourly metered volumes where the appropriate metering technology is installed. This modification is now with the Authority for decision, although the Panel recommended rejection. Nevertheless, there appears to be merit in considering further the potential for extending the scope of half-hourly metering to cover sites with small scale storage.

4.2.3 Contractual arrangements

Discussions with stakeholders highlighted that there are no standard form of contract or commercial terms for arrangements between a storage asset and a supplier/offtaker. Existing contracts assume that a party is a generator or a consumer, rather than both. This means that bespoke contractual arrangements need to be developed whenever parties wish to formalise an agreement. This increases the administrative burden and makes comparison of alternative offers (if available) difficult. There is, therefore, scope for development of standard contracts that can work as a basis for agreements involving storage counterparties.

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5. KEY MESSAGES AND ACTIONS

5.1 Key messages

The role of storage in the GB electricity system is expected to increase as the system decarbonises and smart solutions develop, with a range of stakeholders endorsing the ambition of an additional “2000MW by 2020” backed by a pipeline of potential projects. If this ambition is achieved, gross traded volume linked to storage assets collectively in 2020 could be in the region of 8TWh/year assuming two cycles per day and a ratio of 1.25:1 for charging relative to discharge. This could, therefore, have a significant impact on traded volumes within the wholesale market. Substantial expansion of non-grid scale projects could result in more significant implications for settlement.

Delivering future deployment of storage projects requires viable business models. As a storage device can be used for multiple applications, it has several potential sources of value. This means that the business case typically relies upon being able to access multiple revenue streams, including capturing revenues from wholesale and balancing services markets. This means that the assets will need to interface with the market in order to make business models work.

Based on discussions with stakeholders and our own assessment, our appraisal of modes of interaction between business models and settlement is as follows:

- **Losses and spill**: this is not tenable beyond initial demonstration projects.
- **DNO energy accounts**: the current regulatory framework precludes distribution businesses from participating in the market, so this option is not possible.
- **Market participant energy accounts**: inclusion through SVA within a market participant’s energy account is the most likely model for both network owned and non-network owned grid-scale storage assets.
- **Not captured half-hourly**: this is the default situation for small-scale, off-grid storage, with operation effectively invisible to the market and half-hourly settlement. This approach can continue to operate, but as deployment of such assets increases the impact of the lack of visibility increases, with growing impact for settlement. Suppliers, in particular, may want to take steps to improve visibility of such assets within settlement arrangements Asset owners/developers, are also likely to seek better access to the wholesale market in order to capture value. If not harnessed, this resource could have a disruptive impact on the market. Therefore, drivers for change on this front may come from several sides.

There are a number of regulatory and commercial barriers that affect deployment of storage within the GB market. Based on discussions with stakeholders active in storage developments, it is clear that there is a hierarchy of barriers and issues linked to the settlement and trading arrangements are on the second tier of priority.

Wider issues include the classification (or absence of classification) for storage within the regulatory framework and ability for storage to participate in capacity and balancing services markets. Focusing on the trading and settlement arrangements, there is scope for improvement including the following:

- progressing proposed reforms to the cashout arrangements will aid storage business cases;

- extending the scope of half-hourly metering to sites with small-scale storage will improve visibility and enable these assets to participate in the markets; and
- developing standard forms of contract that fit storage will ease contractual arrangements.

However, there are higher priority issues to resolve within the broader regulatory framework that are more significant than issues linked to settlement and trading arrangements specifically.

5.2 Actions for Elexon

Nevertheless, there is scope for Elexon to influence the role and inclusion of storage within the wholesale market. Elexon can:

- steer the modification process relating to:
  - cashout reform, with the proposal for sharper imbalance prices enhancing potential value to storage assets;
  - the extension of half-hourly metering instead of consumer profiles for sites with small scale storage in order to include the flows linked to such sites in settlement in a more timely manner;
- develop reference material to support parties considering operation of storage in the wholesale market or its inclusion within a portfolio, such as:
  - developing BSC Guidance Notes for storage, such as those that exist for embedded generation and interconnectors;
  - creating a ‘Storage’ reference section on the elexon.co.uk website;
- support innovation projects that are seeking to deploy of storage to consider how it can impact upon and be included within the trading and settlement arrangements. The RIIO-ED1 business plans highlight a number of storage projects planned for the 2015-23 price control period:
  - **UKPN**: HV connected Electrical Energy Storage (EES) (2015-17)[24]; and
  - **Scottish Power Energy Networks**: demonstration project (2017-19) and building business case (2020-23)[25].
- support quantification and/or modelling of the potential expansion and impact of ‘grid-edge’ storage on the system to understand its effects, considering the following:
  - how could penetration of small-scale storage devices in homes (e.g. in electronics, vehicles) grow in the coming years?
  - when will volumes of potential storage resource available from these assets become significant?
  - how can this resource be used/managed on the system as part of wider smarter energy solutions (storage, DSR, local energy)?
  - if not harnessed, what are the implications for imbalance linked to variability of demand that such devices could cause?

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[24] http://library.ukpowernetworks.co.uk/library/en/RIIO/Main_Business_Plan_Documents_and_Annexes/UKPN_Innovation_Strategy.pdf.

[25] http://www.spenergynetworks.com/userfiles/file/201403_SPEN_InnovationStrategy_MH.pdf

ANNEX A – QUALITY AND DOCUMENT CONTROL

Quality control Report's unique identifier: **2014/374**

Role	Name	Date
Author(s):	Simon Bradbury Anthony Price	July 2014
Approved by:	Mike Wilks	July 2014
QC review by:	Beverly King	July 2014

Document control

Version no.	Unique id.	Principal changes	Date
v1_0	2014/374		July 2014

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Pöyry Management Consulting
King Charles House
Park End Street
Oxford, OX1 1JD
UK

Tel: +44 (0)1865 722660
Fax: +44 (0)1865 722988
www.poyry.co.uk
E-mail: consulting.energy.uk@poyry.com

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Pöyry Management Consulting (UK) Ltd, Registered in England No. 2573801
King Charles House, Park End Street, Oxford OX1 1JD, UK