

Smarter Network Storage - business model consultation



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Executive Summary

In December 2012, UK Power Networks was awarded £13.2 million of funding from Ofgem's Low Carbon Networks Fund (LCN Fund) for the Smarter Network Storage (SNS) Tier 2 project.

The Smarter Network Storage project will develop and utilise 6MW/10MWh of advanced electrical storage technology to support the local distribution network while exploring the potential commercial opportunities associated with providing balancing energy through the wholesale electricity markets, and ancillary services to the System Operator, and the extent to which multiple services can be provided simultaneously.

1. Consultation Scope

As part of this project, UK Power Networks is launching a Consultation on the viable business models for distribution scale Electrical Energy Storage (EES). We aim to demonstrate and test our thinking on the possible business models for energy storage, including the advantages and disadvantages of the options presented.

The purpose of this Consultation is to gather views from all interested parties on the possible business models for distribution connected EES as proposed by UK Power Networks. The Consultation also seeks assurance from stakeholders and subject matter experts that all significant cost and revenue streams have been accounted for in the business models. We are seeking views on the **micro-economic business model**: the business model for a particular installation of energy storage, from an investor or 'controlling entity' perspective. We are considering the suitability of the business models for **projects of a similar distribution-scale and of similar**

technology-type to SNS. This Consultation will complement existing studies on the macro-economic benefit of storage, such as those from Imperial College London¹ and the Energy Research Partnership², and will inform how these might be achieved in practice.

The key features of the technologies that this Consultation is applicable to are:

- **Technology:** Electrical energy storage including for example lead-acid, lithium-ion, flow and sodium sulphur batteries. Mechanical storage could also be applicable.
- **Size:** Generation capacity of between 1MW to 10MW, with storage capacity equivalent to between one and several hours of generation.
- **Location:** Distribution-network connected at EHV (Extra High Voltage) or HV (High Voltage). We have considered business cases for projects that are located at similar voltages in distribution networks.
- **Primary need:** The primary need is for mitigation of a distribution network constraint that would otherwise require reinforcement. This could be related to network security, statutory voltage limits or fault-levels. We consider cases where this is a major driver of the business case.
- **Technology and proposition maturity:** Future storage developments, from the first post-LCN Fund projects to a future world in which EES forms part of Business As Usual for DNOs.

The consultation closes on 30th September 2013. Interested parties should see Section 2.5 for a summary of questions and instructions on how to respond.

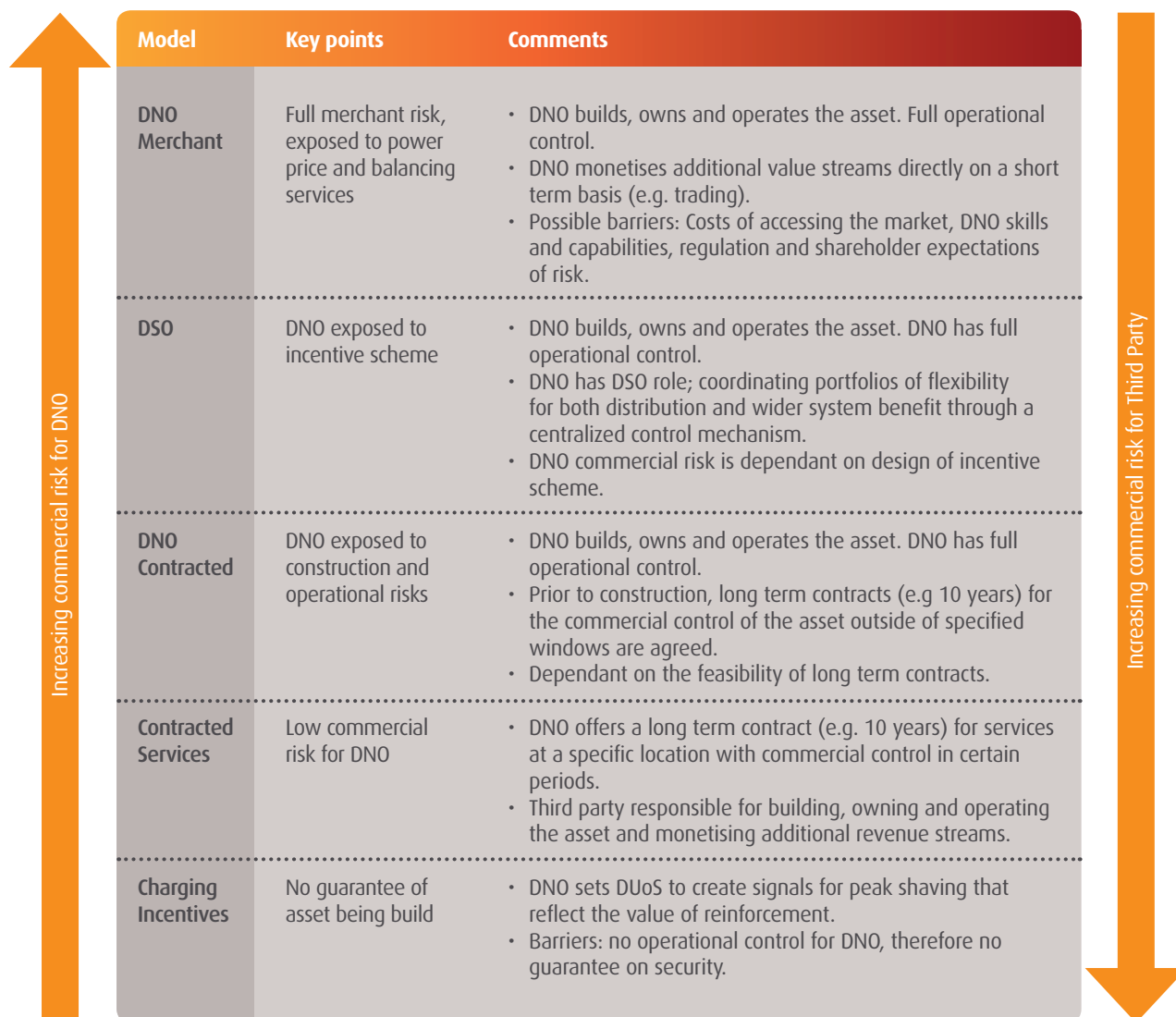
¹ Strategic Assessment of the Role and Value of Energy Storage Systems in the UK Low Carbon Energy Future, Energy Futures Lab, Imperial College, EDF UK R&D, 2012

² The future role of energy storage in the UK, Energy Research Partnership 2011

2. Business Models

We considered five broad categories of business model in Figure 1.

Figure 1 Business Model Key Features



Model	Key points	Comments
DNO Merchant	Full merchant risk, exposed to power price and balancing services	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. Full operational control. DNO monetises additional value streams directly on a short term basis (e.g. trading). Possible barriers: Costs of accessing the market, DNO skills and capabilities, regulation and shareholder expectations of risk.
DSO	DNO exposed to incentive scheme	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. DNO has full operational control. DNO has DSO role; coordinating portfolios of flexibility for both distribution and wider system benefit through a centralized control mechanism. DNO commercial risk is dependant on design of incentive scheme.
DNO Contracted	DNO exposed to construction and operational risks	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. DNO has full operational control. Prior to construction, long term contracts (e.g 10 years) for the commercial control of the asset outside of specified windows are agreed. Dependant on the feasibility of long term contracts.
Contracted Services	Low commercial risk for DNO	<ul style="list-style-type: none"> DNO offers a long term contract (e.g. 10 years) for services at a specific location with commercial control in certain periods. Third party responsible for building, owning and operating the asset and monetising additional revenue streams.
Charging Incentives	No guarantee of asset being build	<ul style="list-style-type: none"> DNO sets DUoS to create signals for peak shaving that reflect the value of reinforcement. Barriers: no operational control for DNO, therefore no guarantee on security.

In the **DNO Merchant** business model, the DNO takes full ownership and operation of the asset and is responsible for monetising the value from the wholesale electricity markets and ancillary services provided to the System Operator. The DNO does this directly in the relevant markets and there is no third party with a direct relationship to the asset.

Under a **DSO** model the DNO would own, operate and maintain the asset as part of a wider role of actively managing its network under a regulatory incentive scheme, akin to the role that National Grid plays at the transmission level. The DNO would also lead the development and construction of the asset, finance its construction and operation and then hold its full commercial control. The DNO would accrue all the project costs and benefits and there would be no direct third party involvement.

The **DNO Contracted** model differs from the DNO Merchant model due to the involvement of a third party to manage

the capacity of the asset when it is not required for security purposes. The DNO would still finance, maintain and operate the asset, but would dispatch for ancillary services at the instruction of a third party.

Under the **Contracted Services** model, the DNO runs a tender for third parties to build and operate storage at a specific site. The DNO makes a fixed annual payment in return for the distribution network services provided by the third party. The third party manages the capacity of the asset when it is not required for security purposes.

The **Charging Incentives** model is one under which the DNO ensures that the DUoS charging creates the right incentives in the location requiring reinforcement. Third parties may or may not respond to the incentives by building storage.

A summary of the potential advantages and disadvantages of each model is shown in Table 1.

Table 1 Business Model Advantages and Disadvantages Summary

Business model	Advantages	Disadvantages
DNO Merchant	<ul style="list-style-type: none"> • DNO has full operational control. • May be lower cost of financing if financed as a regulated asset (depending on risk sharing between DNO & Customers). 	<ul style="list-style-type: none"> • DNO requires new skills and capabilities to trade in the wholesale energy market and participate in procurement mechanisms for ancillary services. • May not be consistent with DNO shareholder expectations of risk.
Distribution System Operator (DSO)	<ul style="list-style-type: none"> • DNO has full operational control. • Specific incentives on DNO to manage costs of balancing the grid. • May be lower cost of financing if financed as a regulated asset (depending on risk sharing between DNO & consumers). 	<ul style="list-style-type: none"> • Regulatory regime not yet in place • Commercial risk remains with DNO and Customers.
DNO Contracted	<ul style="list-style-type: none"> • May be lower cost of financing if financed as a regulated asset (depending on risk sharing between DNO & Customers). • Commercial risk for DNO significantly decreased. • Third party may be better placed to manage commercial value streams. • Third party may be able to aggregate across multiple assets which increases scalability and overall system efficiency. 	<ul style="list-style-type: none"> • Complex tolling contract required (i.e. a services contract between the DNO and a third party). • Third party may heavily discount long term value of additional revenues.
Contracted Services	<ul style="list-style-type: none"> • Commercial risk for DNO significantly decreased. • Third party may be better placed to manage commercial value streams. • Third party may be able to aggregate across multiple assets which increases scalability and overall system efficiency. 	<ul style="list-style-type: none"> • DNO does not have direct operational control. • Complex tolling contract required. • Third party may heavily discount long term value of additional revenues.
Charging Incentives	<ul style="list-style-type: none"> • DNO (and Customers) takes no commercial risk. • Incentives based approach may be economically efficient. 	<ul style="list-style-type: none"> • No guarantee of storage being built. • No DNO control on asset being available for network security when required. • Third party exposed to annual changes to incentives.

After reviewing these models, we selected DNO Contracted and Contracted Services as the two lead business models for further consideration. The DNO Merchant model was excluded mainly because of the requirement for the DNO to build a trading capability and take wholesale market risk. The DSO model, while attractive in principle was excluded at this time because the underlying regulation that would define this model has yet to be developed and as such cannot be critically appraised. However, we recognise that a number of other LCNF projects may benefit from this kind of approach. As such, we do not rule out the possibility that this business model becomes more relevant in the future. The Charging Incentives model was excluded because it provides no guarantee of the storage being built or, once built, being available to provide network security.

3. Lead Business Models

Under the DNO Contracted model, the DNO would own the asset, whereas under Contracted Services it would be owned and operated by a third party.

The lead business models share a common concept of a long term contract between the DNO and a third party to share the risks and rewards from commercial opportunities that can be captured beyond the asset's primary role of providing network security. The terms for this tolling contract would need to give the third party the greatest freedom possible to optimise the value of additional value streams whilst ensuring that the DNO's security requirement is met.

Impact on network security

The DNO Contracted model gives the DNO direct control over the operation of the storage. The security provided by the Contracted Services model is dependent on the contractual obligations placed on the third party, and how it fulfils these obligations. Whilst not as direct as operational control, this model could provide sufficient security if the terms are well structured.

Impact on asset value, costs and risks

Both models depend on a well-structured tolling contract that gives as much availability to the third party as possible without compromising security. Both models place the optimisation of the value streams with a third party which is likely to have a more developed set of skills and capabilities to generate value from the storage without imposing high costs of trading, and depend on a third party's willingness to take long term risk on the additional value streams. However, under the DNO Contracted model there is more flexibility for the DNO to share some of this risk if the DNO can take some merchant exposure.

A relative advantage of the DNO Contracted model may be a lower cost of capital. However this may not persist as the deployment of storage increases and the risk profile of the utility changes. The DNO Contracted option creates the possibility of sharing the risk (and additional benefit) with Customers (if this was considered desirable for Customers), whereas this is not easily possible with the Contracted Services model.

Impact on wider benefits

Under both models, the tolling contract will need to clearly specify the terms on which capacity is made available. There is a risk that the full benefits for the GB system are not captured due to a lack of flexibility in these terms.

The DNO contracted model allows for competition between third parties in the provision of trading and aggregation. The third party has the ability to transfer their knowledge and expertise to develop projects in other DNO licence areas. Under the Contracted Services model, the third party can also transfer their experience of designing, building and operating other storage assets. Additionally, third parties that have a portfolio of assets in planning, construction or operation may have already established fairer value arrangements and

contracts with the providers of these design, procurement and building services.

Under both models, the DNO is able to set terms of the technology considered, to ensure that a low carbon solution is procured.

Future proofing of business model

Both models allow for aggregation of the dispatch of multiple assets by the third party. The Contracted Services model allows one third party to operate storage across multiple DNO licence areas.

From a regulatory perspective the DNO Contracted model could face barriers as the DNO approaches its present de minimis non-distribution activity limit, which is 2.5 per cent of the sum of the licensee's share capital, its share premium, and its consolidated reserves.

Based on our review of the lead models, both the DNO Contracted and Contracted Services appear to be feasible business models for distribution-connected storage. The key

barriers for these models are shared: the complexity of the tolling contract and the willingness of a third party to take long term risk on the additional value streams.

4. Investment Model Templates

We have also developed a template investment model for each of the two lead business models. These templates demonstrate how the business case for distribution-connected EES might be assessed. The investment model template illustrates the possible financing costs, operating models and revenue streams in each case, and enables comparisons across the business models for the same configuration of storage.

The Consultation responses will allow the project to update the investment model templates, and to understand the level of acceptance from potential buyers of services and the level of appetite from potential storage owners for the different business models. The investment model templates are a key tool in the project and one of the aims of the project is to populate and disseminate these with real cost and benefit figures based on experience from the operational trials.

1

Introduction



In December 2012, UK Power Networks was awarded £13.2 million of funding from Ofgem's Low Carbon Networks Fund (LCN Fund) for the Smarter Network Storage (SNS) Tier 2 project.

The Smarter Network Storage project will develop and utilise 6MW/10MWh of advanced electrical storage technology to support the local distribution network while exploring the potential commercial arrangements that will support overall system balancing and stability, the wholesale electricity markets and the viability in providing multiple services simultaneously. The project is differentiated from other storage demonstrations in that its aim is to undertake a range of commercial and technical innovations to explore and improve the economics of electrical energy storage when leveraged for full-system benefit, and how these additional value streams may support viable business models for storage in the future. The objective is to support the development of the storage industry to benefit network operators and customers, allowing storage to benefit an upgraded electricity system in a more sustainable and cost efficient way.

As part of this project, UK Power Networks is launching a consultation on the viable business models for distribution scale Electrical Energy Storage (EES). We aim to demonstrate and test our thinking on the possible business models for energy storage, including the advantages/disadvantages of the options. The Consultation also seeks assurance from stakeholders and subject matter experts that all significant cost and revenue streams have been accounted for in the business models.

We are also seeking feedback on a template investment model for two specific business models that we believe are the most likely to be suitable for distribution-connected storage. These models demonstrate how the business case for distribution-connected energy storage might be assessed for each business model. The template investment model illustrates the possible financing costs, operating models and revenue models for each business model.

1.1. What does UK Power Networks do?

UK Power Networks owns, operates and manages three of the fourteen regional electricity distribution networks in the UK. Our licensed distribution networks are in the East of England (Eastern Power Networks plc), London (London Power Networks plc) and the South East (South Eastern Power Networks plc). UK Power Networks is one of the largest Distribution Network Operators (DNOs) in the UK, covering an area of approximately 30,000km, extending from the Wash in the east, through London, to Littlehampton on the Sussex coast. Approximately eight million connected customers depend on us for their power.

1.2. The Smarter Network Storage Project

The SNS project will develop a 6MW/10MWh battery facility at Leighton Buzzard primary substation. This system will have the capability to generate 6MW for approximately 1.5 hours for each full charge and discharge cycle, and to change output level within a few seconds. This is intended to delay, or potentially avoid the requirement for traditional reinforcement to the distribution network as described below.

Leighton Buzzard substation comprises two 33/11kV 38MVA transformers fed by two 33kV overhead Lines (OHLs), each with a winter rating of 35.6 MVA. Network security of supply standard Engineering Recommendation P2/6 sets out the minimum demand that needs to be met following the loss of a circuit depending on the group demand. This requires a level of redundancy such that if one line were to fail, a certain proportion of group demand can still be met. At Leighton Buzzard, the site 'firm capacity' – defined as the maximum capacity available during an N-1 event – is currently restricted by the thermal rating of the 33kV OHL and is therefore 35.6 MVA.

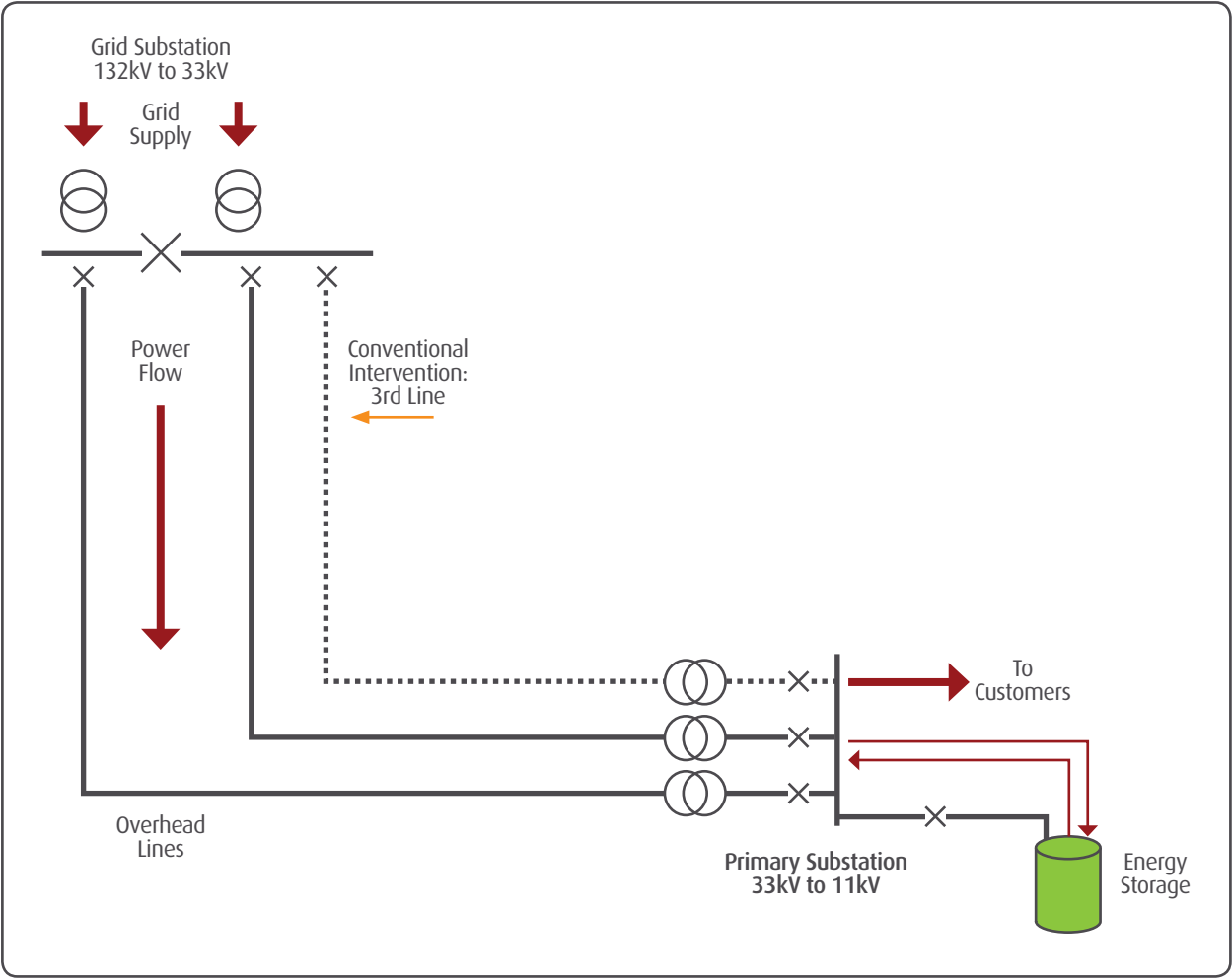
Peak demand at Leighton Buzzard has been above this firm capacity limit between 9 and 37 days in each of the last five years (typically during periods of very cold weather). The additional capacity required has been provided by transfer capacity from

neighbouring sections of the network. Peak demand at this location is forecast to continue to grow, and transfer capacity is limited at 2 MVA, meaning that limits may be breached in future years. This is a trigger for reinforcement of the network.

The conventional reinforcement option for Leighton Buzzard has been evaluated as a third 33kV circuit from Sundon Grid

to Leighton Buzzard primary substation, and a third 38 MVA transformer at Leighton Buzzard. This reinforcement would provide an additional 36 MVA of firm capacity at Leighton Buzzard, which is significantly above predicted requirements for the medium-long term. The traditional reinforcement option, and alternative approach using storage as described below, is shown in Figure 2.

Figure 2 Leighton Buzzard Reinforcement Options



An alternative to building a new circuit and transformer is to consider innovative solutions that will give UK Power Networks the ability to reduce (net) peak offtake at Leighton Buzzard to maintain demand below the firm capacity rating. This could take the form of embedded generation, Demand Side Response (DSR), or Electrical Energy Storage (EES), all of which could reduce the required offtake from the network at Leighton Buzzard. The reduction of peak demand could delay the need for traditional reinforcement for a number of years. This may be combined with incremental upgrades to the network (e.g. reconductoring of the existing overhead lines) to further delay or potentially avoid the need for traditional reinforcement.

Distribution connected storage is still a relatively new concept that attracts a set of “First of a Kind” costs that would not be accrued to other established technologies and solutions. These costs are expected to reduce in future with greater deployment of storage.

On the other hand, distributed storage can access a range of additional benefits not accessible to traditional reinforcement. The value of these additional benefits relative to the additional cost of storage governs whether storage is cost effective compared to the alternative traditional reinforcement options.

The aim of the SNS project is to explore how EES can fully maximise these ancillary benefits. These benefits are above and beyond the resolution of network constraints at Leighton Buzzard and can both improve the project economics and advance the use of storage as a cost-effective alternative to network reinforcement. These additional benefits could include:

- Provision of power quality services on the distribution network
- Provision of balancing energy to the market and ancillary services to the System Operator to reduce the costs of managing the GB transmission system with increasing proportions of intermittent renewables
- Reduction in requirement for peak generation capacity

The primary purpose of the storage asset is to provide network security, and additional benefits must be compatible with this requirement.

During the course of the SNS project, UK Power Networks will demonstrate:

1. Deployment and multi-purpose application of large-scale distribution-connected EES
2. Implementation of a Smart Optimisation & Control system in order to manage and optimise the storage flexibility
3. Innovative commercial arrangements to support the shared use of energy storage in providing wider system benefits, including standby reserve and managing frequency
4. Assessment and validation of the full value that storage can provide to DNOs and the wider system to support future business models for storage

This Consultation will primarily support the third of these objectives, as described in the following section.

1.3. Aims and Scope of the Consultation

The purpose of this Consultation is to gather views from interested parties on the possible business models for distribution connected EES as proposed by UK Power Networks. There are multiple different ownership and operating models that could evolve around EES. The SNS project aims to capture learning, demonstrate analysis and provide thought-leadership that will support the development of viable business models for future electricity storage projects at the distribution level.

Note that we are not consulting on the business model for the SNS project itself. The business model and commercial arrangements for the Leighton Buzzard EES facility reflect a variation of the ‘DNO Contracted’ business model, in which the DNO owns and operates the storage, as described later in this report. This approach has been designed to ensure learning

can be gained in relation to a wide range of future possible business models that may involve the storage being entirely managed, operated or even owned by different types of third-party organisation. Furthermore, this approach will ensure full transparency of the value generated from each service area and makes most effective use of existing business capability and operational experience across our project partners. This will not necessarily be typical of future storage and the scope is rather to consider the future business models for storage that are to be developed without LCN Fund support.

Business models

The scope of the business models consultation is defined as:

- **Micro-economic business model:** the business model for a particular installation of energy storage, from an investor or 'controlling entity' perspective. This will include all lifecycle and investment costs in detail and allow installations to be compared in terms of economic viability, and sensitivity analysis. Out of scope are 'non-bankable' societal benefits accruing to 'UK Plc', such as carbon emissions savings. These are relevant to the overall benefits case for storage and may influence the design of policy or regulation but do not directly contribute to revenues.
- **Suitable for energy storage projects of a similar distribution-scale and of similar technology-type to SNS:** in order to restrict the scope of discussions we will evaluate business models for projects similar to the SNS project in terms of scale and storage type. We note that there are a wide range of potential technologies, sizes and uses of storage on the distribution networks, some of which are being explored under other LCN Fund projects. Some of these are described in Box 1. UK Power Networks analysis has indicated that a reasonable estimate for the potential national capacity of sites similar to the SNS project is of the order of 2 GW by 2040³. There are a number of key features which will be common to these opportunities:
 - **Technology:** Electrical energy storage including for example lead-acid, lithium-ion, flow and sodium sulphur batteries. Mechanical storage, if scalable and at similar Technology Readiness Levels (TRLs) could also be applicable, such as some flywheel systems. Storage requiring specialist geological requirements, such as underground compressed-air, are out of scope due to the differing CAPEX and OPEX requirements.
 - **Size:** Generation capacity of between 1MW to 10MW, with storage capacity equivalent to between one and several hours of generation.
 - **Location:** Distribution-network connected at EHV or HV. We have considered business cases for projects that are located at similar voltages in distribution networks.
 - **Primary need:** the primary need is for mitigation of a distribution network constraint that would otherwise require network reinforcement. This could be related to network security, statutory voltage limits or fault-levels. We consider cases where this is a major driver of the business case.
 - **Technology and proposition maturity:** we are consulting on the business models for future storage developments, from the first post-LCN Fund projects to a future world in which EES forms part of business as usual for DNOs.

³ LCNF Full Submission Pro-Forma. Appendix G, Section 2
<http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/stlcnf/year3/smarter-network-storage/Documents1/SNS%20RE-Submission%20+%20Appendices%20Redacted.pdf>

Box 1 Storage on distribution networks

The range of scales and uses of storage on distribution networks ranges from domestic or street level battery technologies, up to megawatt scale storage that may be used to absorb excess embedded renewable generation (export constraint management) or meet peak demand in import constrained areas. Storage may also be installed for power quality management purposes.

Project Name	DNO	Location	Description
Demonstrating the benefits of short-term discharge energy storage on an 11kV distribution network	UKPN	Hemsby, Norfolk	UK Power Networks has installed a dynamic energy storage system (ESS) at Hemsby in Norfolk, in collaboration with ABB. The system is based on ABB's SVC Light product, combined with a Lithium-ion battery storage device and is located on an 11kV distribution network with some penetration of wind power (http://www.ukpowernetworks.co.uk/internet/en/innovation/documents/Hemsby_Progress_report%20Oct_2012_FINAL.pdf)
Shetland and the NINES project	SSEPD	Lerwick Power Station, Shetland	This Project involves installing a 1MWe connected battery at the Lerwick Power Station on Shetland. This Project will provide learning regarding the operation of the battery and its integration with local Demand Side Response to remove station peaks providing additional Demand capacity (in a similar way to managing a network load constraint). (http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/ftp/sse/Pages/index.aspx)
CHALVEY	SSEPD	Chalvey, Slough, Berkshire	This project seeks to understand the potential benefits, practicalities and costs of installing electrical energy storage (EES) connected via four quadrant power conversion systems (PCS) on the LV network. The main objective is to inform and de-risk the larger scale deployment of street batteries as detailed in the NTVV Tier 2 project. (http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/ftp/sse/Pages/index.aspx)

These three examples are shown to illustrate the range of possible storage applications and that the business models presented in this consultation while generic as far as is possible, may not be applicable to other storage projects.

We have reviewed a range of potential business models and made a qualitative assessment of these in order to select two models for further consideration. We have considered the details of how these two models would operate, and what the advantages, disadvantages and risks are of these models.

Investment model template

We have also developed a template investment model for each of the two lead business models. These templates demonstrate how the business case for distribution-connected EES might be assessed. The template investment model illustrates the possible financing costs, operating models and revenue models in each case, and enables comparisons across the business models for the same configuration of storage.

The investment templates are provided for illustration of the business models only. Although we have populated them with representative values as an aid to users to understand the workings of each model, we do not present these as a business case assessment for any particular EES project.

Timelines

Responses should be sent to:

SNSConsultation@ukpowernetworks.co.uk

by 30th September 2013. The Consultation process is shown schematically in the below diagram.

We are requesting responses from a broad range of interested parties with an interest in distribution-scale electricity storage. This may include, but is not limited to:

- Supply chain (e.g. manufacturers)
- Generation (renewable and conventional generators)
- Transmission (Transmission Owners and the GB System Operator)
- Distribution (Distribution Network Operators)
- Suppliers and aggregators
- Customers (e.g. Industrial, Community)
- Regulation (Ofgem)
- Government

We will review the responses and publish a summary along with our findings. The output of the Consultation will be used to inform the on-going SNS project. In particular we expect this to guide the further assessment of regulatory and commercial barriers and the assessment of the business case for distribution connected storage. Feedback on the template investment model will be incorporated into a version which will be populated throughout the project lifecycle as learning relating to the operational costs and value streams is validated during the trial phases.

1.4. The Value of Distribution Connected Electrical Energy Storage

An understanding of the business models for storage depends on an understanding of the value streams available to EES. For

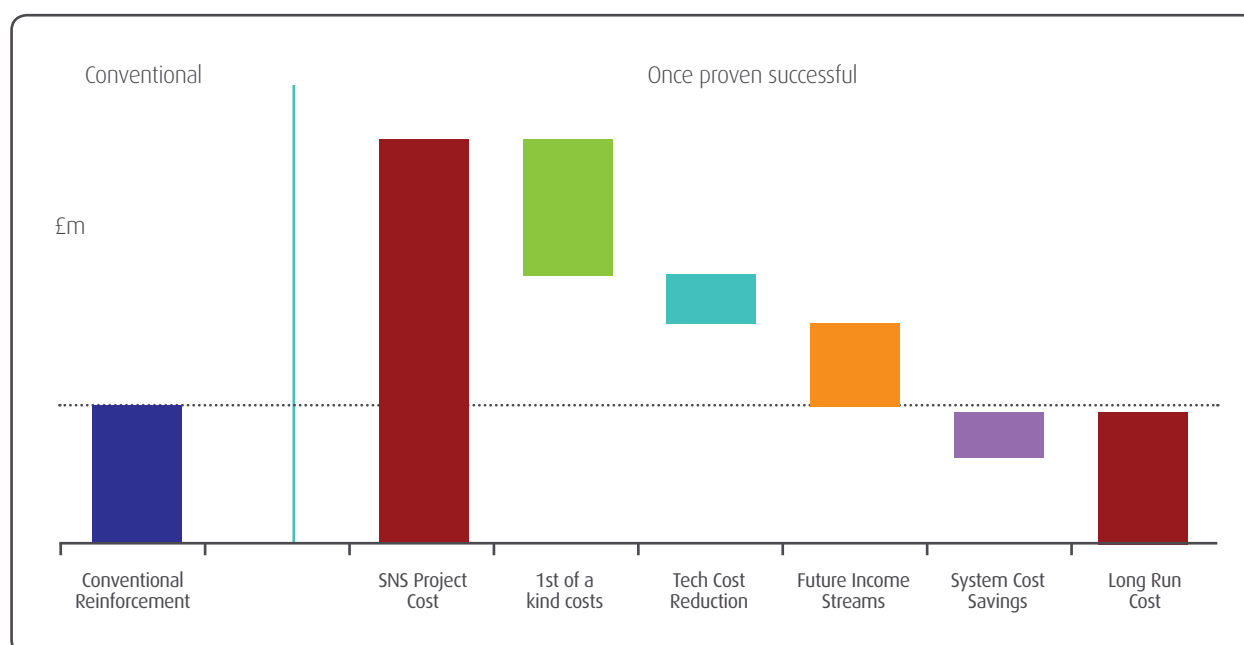


this analysis we focus on the monetisation of benefits to a particular project, rather than the wider economic and social benefits provided to the GB system as a whole (it is worth noting however in the particular case of the DSO the incentive is likely to have been set based on, and designed to achieve these wider economic and social benefits).

For the scope of distribution-scale EES under consideration, the “Needs Case” for storage is initiated by a distribution network requirement. Where flexibility in demand and/or generation would help to mitigate network constraints and potentially defer investment, then storage should be considered alongside

traditional reinforcement options. The business case is driven primarily by this constraint which could be related to network security, or, statutory voltage limits for example, whilst additional value streams increase the competitiveness of storage when considered alongside traditional reinforcement. This is shown schematically in Figure 3 where the current storage project cost is adjusted for future technology and system cost reductions, along with the expected ancillary revenue streams. This reduced cost is shown as the Long Run Cost. This is the net cost which can be compared to the cost of traditional reinforcement to appraise the future viability of storage projects.

Figure 3 Storage Project Schematic Cost Comparison



In the case of the SNS project, the storage is required to contribute to network security. The implication of the Needs Case is that storage must be available for security purposes when required, taking priority over all other uses. This is because the security provided by the storage asset cannot be provided by another storage asset or generator elsewhere on the network – it must be connected to the specific substation that requires support. There are alternative applications for distribution-connected EES other than to meet security obligations, for example the management of the output of embedded intermittent generation. In such cases the asset could be operated without restriction in a purely profit optimising manner.

Any additional value streams must be compatible with the security requirement. Given the nature of timing of the demand, it is highly probable that the storage will be required to provide security for only a small window when particularly high peak demand may occur. Currently this is likely to be timed close to the GB system peak demand, although this

could vary in future for areas with significant penetration of embedded generation behind the same constraint. For the Leighton Buzzard example, the asset is likely to be required for security only in winter months and only at peak times (e.g. 4-7pm). We define this period of time as the Secure Capacity Window. Outside of this window the storage can provide other services, subject to being in a state to provide security to the system at the start of the Secure Capacity Window. It may also be possible for some compatible services to be provided during the Secure Capacity Window itself. This is an area that the SNS project will investigate as to how this might work in practice.

Table 2 shows a list of the future income streams shown in the Storage Project Cost Breakup in Figure 3 above. Only some of these income streams have been considered in the SNS project and investment templates, a list of which is given in a following section (further detailed descriptions and discussions are included in Appendix 1).

Table 2 SNS Project Ancillary Benefits

Value stream	Final customer	Drivers of value	Value risks	Likely suitability
Local Security Provision of capacity at times of peak local demand	DNO	Avoided/delayed reinforcement cost	Technical performance of storage (availability)	Primary need
'Embedded Benefits' e.g. avoided demand TNUoS, avoided BSUoS, avoided losses	Supplier	Demand TNUoS, BSUoS, transmission losses	Only relevant when storage is exporting	Secondary value stream
Reactive Power Provision of reactive power to reduce losses	DNO. May also be opportunities on transmission network	Reduced losses and possible avoided reinforcement due to reactive power allowing more efficient use of network	Opportunities may be limited/specific	Opportunity specific
Voltage Support Provision to local network	DNO. May also be opportunities on transmission network	Possible value in specific locations e.g. with local renewable generation	Opportunities may be limited/specific	Opportunity specific
Firm Frequency Response (FFR) Managing the GB system frequency	TSO	Growth in FFR requirement due to size of largest loss on transmission system	Competing sources of FFR	Secondary value stream
Short Term Operating Reserve (STOR) Reserve for the GB system	TSO	Growth in STOR requirement due to intermittency	Competing sources of STOR	Secondary value stream
Energy Arbitrage Trading of wholesale power	Wholesale market/ Supplier	Power price shape & volatility	Lack of market liquidity	Secondary value stream
Capacity Payments	Generators or Energy providers	Design of capacity mechanism	Penalties for non-delivery	Potential future benefit

Table 2 SNS Project Ancillary Benefits

Value stream	Final customer	Drivers of value	Value risks	Likely suitability
Managing Intermittent Renewable Generation (Balancing Market Services) Absorbing excess renewable generation	Renewable generator or DNO	Growth in Intermittent generation	Requirement is unpredictable	Valuable if significant local embedded generation
Fast Reserve	TSO	Size of market for fast reserve	Competing sources	Limited to capacity > 50MW
Transmission Constraints	TSO	Transmission constraint in location of storage	Unlikely to be applicable unless aggregated	Not considered
Inertia Service Possible TSO service	TSO	May be increasingly required as amount of asynchronous generation increases	Competing sources	Potential future benefit
Responsive Flexibility Service Possible future TSO service	TSO	Possible future product to specifically reflect benefits provided by responsive storage or other sources of low-carbon flexibility	Product currently undefined	Potential future benefit
Distribution Losses Generation at peak reduces losses by more than increase when charging	DNO	Depends on incentive scheme. Benefit may accrue to DNO but not to storage directly		An ancillary benefit of operation of the asset – unlikely to drive dispatch. Not considered

The SNS project will focus on the value available from a subset of these value streams, which have been assessed as being the most significant in the current market and are compatible with the characteristics and likely operation of the storage asset envisaged.

- Local security
- Short Term Operating Reserve (STOR)
- Firm Frequency Response
- Energy Arbitrage

For the purposes of this Consultation and investment template we include two additional sets of value streams as being significant in the current market to complement those originally identified as core value streams;

- Embedded Benefits
- Capacity Payments.

We use these value streams as examples throughout this Consultation document and in the investment templates. However we recognise that other value streams mentioned above may become equally or more important in future, and so the investment template includes the ability to include other user-defined benefits.

1.5. The Potential Benefits of a Wider Rollout of Distribution Connected EES

UK Power Networks has modelled the potential number of typical storage deployments that could be applied to distribution

networks once EES is proven as an economic alternative solution to reinforcement. The analysis conservatively suggests around 2GW of distribution-connected storage capacity could be integrated into the system across GB by 2040⁴.

UK Power Networks has also calculated the present value of net benefits of this additional flexible capacity at a national level to be around £0.7bn, resulting from savings in distribution and transmission investment, value from supporting system balancing, displacement of peaking generation capacity and reduced costs of curtailment of low-carbon generation. These benefits assume that the storage is leveraged across only a limited number of applications simultaneously for short periods; although in practice it is expected that storage capacity could be much more flexible⁵.

As the integration of EES into the GB system increases so do the possible portfolio and scalability benefit to the project parties. For example, a third party (or indeed a DNO with an established energy trading capability) could actively manage and dispatch assets over a large spatial area, to firstly increase economies of scale and reduce operating costs, and secondly to increase their own system redundancies and improve their system efficiency (where increasing system redundancies refers to their ability to mitigate unavailability of individual assets by picking up lost generation across their asset portfolio). Similarly, an EES asset could be incorporated into a portfolio of intermittent generation assets, allowing the intermittent generators to discharge the asset to avoid costly energy imbalance charges.

⁴⁵ LCNF Full Submission Pro-Forma. Appendix G, Section 2

<http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/stlcnf/year3/smarter-network-storage/Documents1/SNS%20RE-Submission%20+%20Appendices%20Redacted.pdf>

1.6. How to Respond

Responses should be sent to

SNSConsultation@ukpowernetworks.co.uk
by 30th September 2013.

The questions that we invite interested parties to submit written evidence and analysis on are as follows:

SECTION 2 BUSINESS MODELS FOR STORAGE

1. Do you agree with the range of business models presented in Section 2.1?

- a. Are these business models and their variants representative of the range of plausible business models?
- b. Do you agree with the characterisations of each of these business models in their respective Sections 2.1.1 through to Section 2.1.5?

2. Do you agree with the choice of assessment criteria as described in Section 2.1?

- a. Are these the key assessment criteria that the business models should be compared against?
- b. Are there any additional advantages, disadvantages or barriers to any of the individual business models that have not been included?

3. Do you agree with the choice of the two lead models and the reasons for selecting these as described in the Qualitative Assessment Summary, Section 2.2?

- a. Are these options the most likely to be suitable for distribution-connected storage, or should one or more of the other business models (or variants of these) have been considered over the DNO Contracted and Contracted Services models?
- b. If so, which models should have been considered and why?

4. Do you agree with the range of four regulatory treatment scenarios presented in Section 2.3?

- a. Are there other scenarios that should be included?
- b. Are there inherent regulatory created limitations that have not been discussed?
- c. Are there additional advantages or disadvantages for each of these scenarios that should be considered?

SECTION 3 LEAD BUSINESS MODELS

5. Do you agree with the respective advantages and disadvantages of the two lead business models as described in the Section 3?

- a. Are there other limitations, barriers or features of these business models, or EES projects in general that have not been considered?
- b. Do either of these lead business models disproportionately favour one party over the other?

6. From your perspective, which of the two lead business models is most likely to be favoured?

SECTION 4 INVESTMENT MODEL TEMPLATE

7. Are there other technology parameters, costs or revenue streams that should have been considered in the investment model template?

- a. If so please give details

8. Do you agree with the interrelations of these ancillary services and their associated revenue streams?

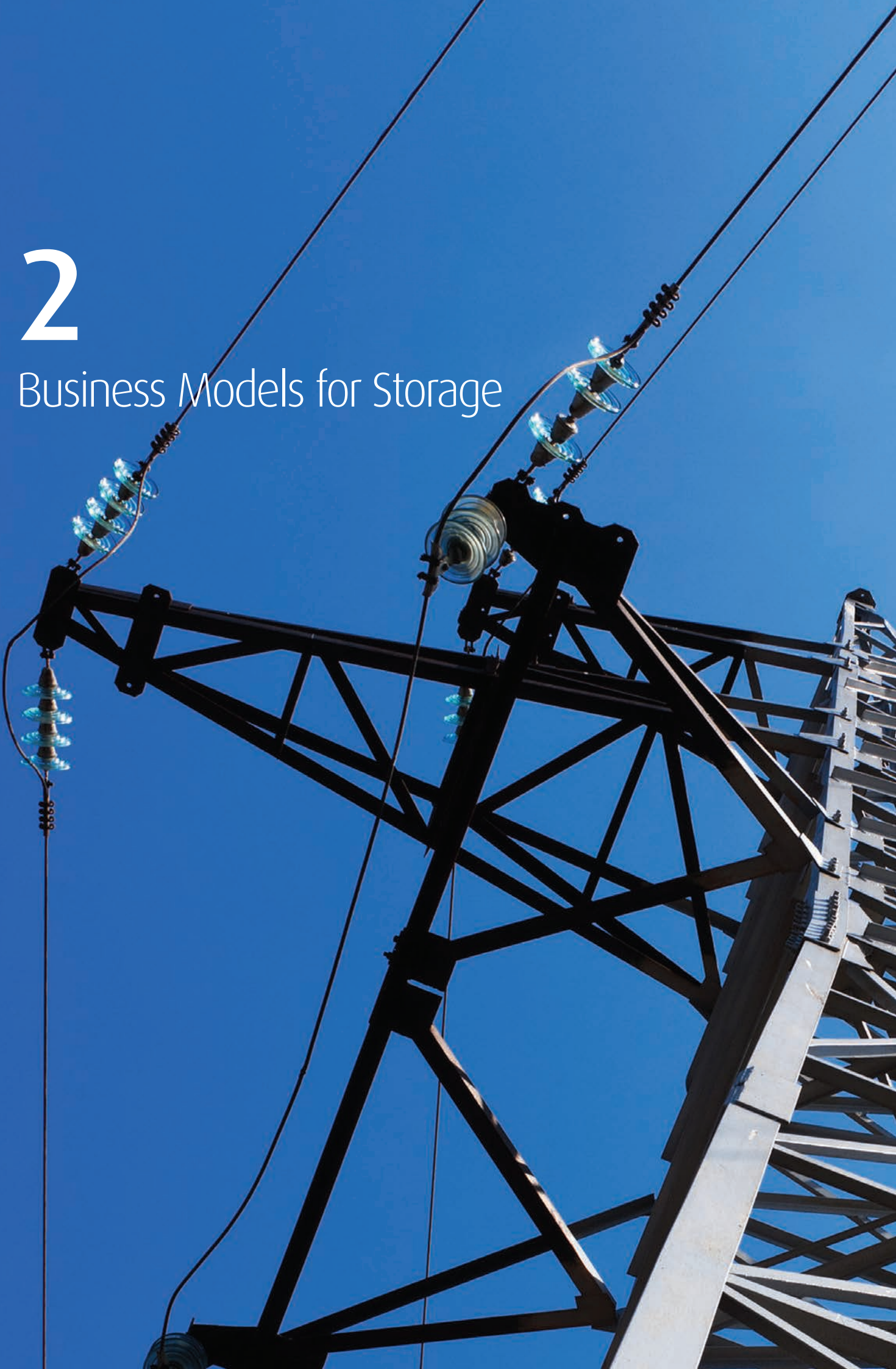
- a. Are there additional complexities in the dispatch of the asset to utilise these revenue streams that have not been considered? Are they all mutually exclusive or potentially dispatchable in unison, are there additional complexities in the knock-on effect to battery performance that have not been considered?

9. Do you agree with the stated assumptions and model limitations?

- a. Should any of these stated assumptions or limitations have been dealt with differently?

2

Business Models for Storage



In this section we describe a range of possible business models for distribution connected EES. Subsequently, we describe how we have selected and further developed two lead models for consultation.

The definition of a business model for our purposes covers the development, ownership, operation and maintenance, and marketing of services. The Consultation aims to develop models in line with the key questions in Figure 4.

There are a broad range of parties that could play a role in a distribution connected EES business model. The DNO has an

inherent role as the party responsible for the security need case. There are also a wide range of third parties from throughout the electricity value chain who could play a role in the business model. In describing the business models, we consider the relationship between the DNO and a single third party only. In reality, the third party could take the form of a joint venture or consortium, or aspects of the business model could be split between multiple third parties, as will be the case for the trials within the SNS project itself.

Figure 4 Consultation Questions

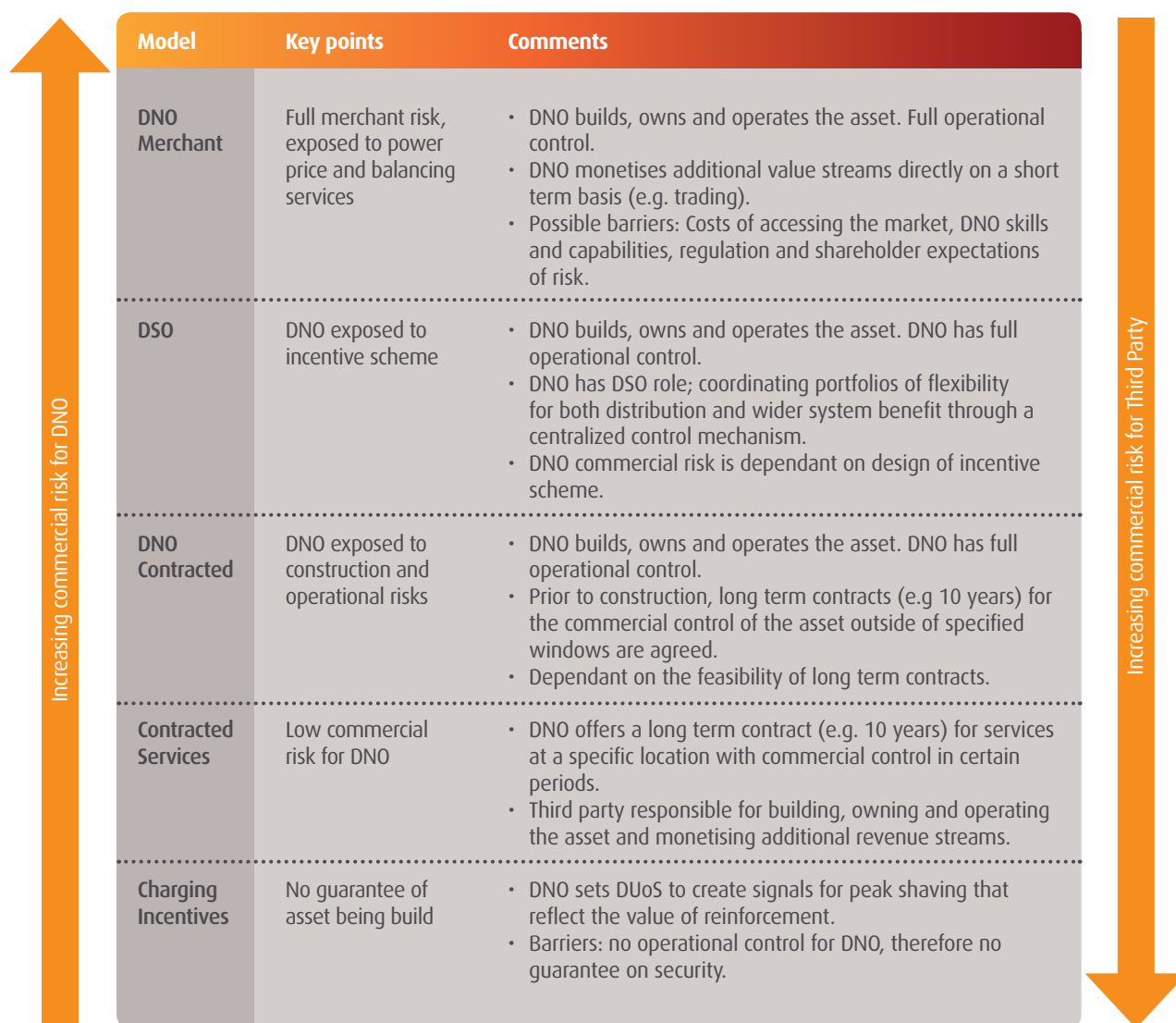
	Ownership	Commercial Operation	Market
Key Questions	Who should take risk on construction and operation of large scale storage (e.g. availability risk)?	Who should take the benefit and manage the risk associated with capturing the value of storage (i.e. market/operation risk)?	Which services and markets could the operators participate in and how do they complement/cannibalise each other?
Options	<div>DNO</div> <div>Energy traders/Aggregators</div> <div>Institutional Investors</div> <div>Industrial Customers</div> <div>Renewable Project Developers</div> <div>Private Equity</div> <div>Suppliers</div> <div>Community</div>		<div>Primary Services e.g.</div> <div>Security of Supply</div> <div>Secondary Services e.g.</div> <div>Embedded Benefits</div> <div>Firm Frequency Response</div> <div>STOR</div> <div>Energy Arbitrage</div> <div>Capacity Payments</div>

2.1. Business Models

We have selected a range of business models to illustrate the landscape of potential options. These are summarised at a high level in Figure 5. The five chosen business models range from a DNO merchant case where the DNO takes total operational control and no third party is involved, to a Charging Incentives

model where a third party builds the asset and the DNO has no commercial relationship with the storage other than a connection agreement. Between these extremes are models which involve a contractual relationship between the DNO and a third party.

Figure 5 Business Model Key Features



Model	Key points	Comments
DNO Merchant	Full merchant risk, exposed to power price and balancing services	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. Full operational control. DNO monetises additional value streams directly on a short term basis (e.g. trading). Possible barriers: Costs of accessing the market, DNO skills and capabilities, regulation and shareholder expectations of risk.
DSO	DNO exposed to incentive scheme	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. DNO has full operational control. DNO has DSO role; coordinating portfolios of flexibility for both distribution and wider system benefit through a centralized control mechanism. DNO commercial risk is dependant on design of incentive scheme.
DNO Contracted	DNO exposed to construction and operational risks	<ul style="list-style-type: none"> DNO builds, owns and operates the asset. DNO has full operational control. Prior to construction, long term contracts (e.g 10 years) for the commercial control of the asset outside of specified windows are agreed. Dependant on the feasibility of long term contracts.
Contracted Services	Low commercial risk for DNO	<ul style="list-style-type: none"> DNO offers a long term contract (e.g. 10 years) for services at a specific location with commercial control in certain periods. Third party responsible for building, owning and operating the asset and monetising additional revenue streams.
Charging Incentives	No guarantee of asset being build	<ul style="list-style-type: none"> DNO sets DUoS to create signals for peak shaving that reflect the value of reinforcement. Barriers: no operational control for DNO, therefore no guarantee on security.

In the following sections, each business model is first characterised according to its key exhibited features, namely storage development and construction, financing, ownership, operations and maintenance and commercial control. Second, each business model is assessed against a common set of qualitative criteria. The criteria aim to cover a broad spectrum of the aspects of an EES project on which the business model may have an impact.

The criteria are clustered within four broad themes – security, asset value costs and risks, wider benefits and future proof. The

list of criteria represents a high level view of the key business model considerations. The relative importance of the criteria may differ between interested parties. We have not attempted to rank these criteria. However we note that the DNO Control requirement is considered a primary factor because the provision of security to the local network is the driver of the Needs Case.

The common set of qualitative criteria that are to be used to assess the business models, along with their descriptions is shown in Table 3.

Table 3 Qualitative Assessment Criteria

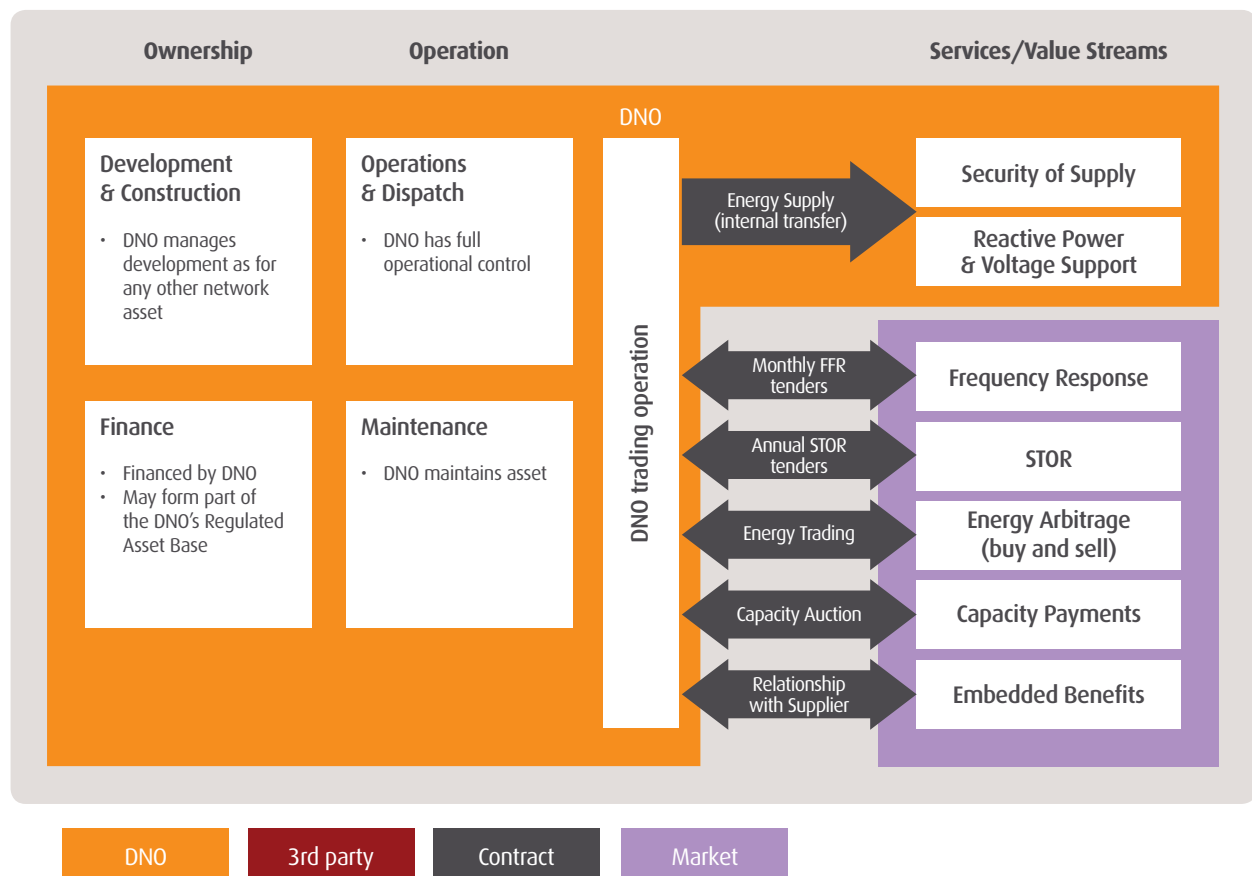
Grouping	Criteria	Criteria Description & Examples
Security	DNO Control	<ul style="list-style-type: none"> • Ensure that the asset is available for DNO security/constraint management purposes when required. • DNO confidence in asset availability.
Asset Value, Cost and Risks	Optimising Value of Asset	<ul style="list-style-type: none"> • Incentivise efficient usage of the asset. • Optimise viable value streams. • Ease of administration and avoidance of prohibitive costs of doing business.
	Risk Allocation	<ul style="list-style-type: none"> • Market risks allocated to party able to trade in the markets. • Construction risk allocated to parties with the appetite and ability to manage this. • Operations and maintenance by party with ability to manage this.
	Financing	<ul style="list-style-type: none"> • Enable access to low cost financing.
Wider Benefit	Optimising Value for System	<ul style="list-style-type: none"> • Optimise overall macro-economic and welfare benefits.
	Dynamic Efficiency	<ul style="list-style-type: none"> • Ability for innovation to occur on technology development and technology choice. • Ability for business model to evolve over time.
	Carbon Efficiency	<ul style="list-style-type: none"> • Incentivises and enables low carbon power system.
Future Proof	Scalability	<ul style="list-style-type: none"> • Ensure that business model is scalable and can evolve in response to changing values or value streams.
	Regulatory Compatibility	<ul style="list-style-type: none"> • Compatible with current market designs and current regulation. • Future proof against expectations of changes to market designs or regulation.
	Flexibility/Optionality	<ul style="list-style-type: none"> • Consistent with expectations of project life: interaction with potential future reinforcement. • Allows for the possibility of relocation of the storage asset to another part of the network.

2.1.1. DNO Merchant

In the DNO Merchant business model, the DNO takes full ownership and operation of the asset and is responsible for monetising the additional value streams. The DNO does this directly in the relevant markets and there is no third party with a direct relationship to the asset. Figure 6 below illustrates the key aspects of the business model.

The DNO would lead the development and construction of the storage facility, including all planning and consents. The asset would then be financed by the DNO on balance sheet, potentially as a regulated asset. This could be against a baseline of traditional reinforcement with DNO and Customers sharing the benefits and risks of any savings or cost overruns through a sharing factor.

Figure 6 DNO Merchant Model



A summary of the principal advantages and disadvantages of the model according to the common set of qualitative criteria is given in Table 4 (see Table 3 for descriptions of the assessment criteria).

Table 4 DNO Merchant Model Qualitative Assessment

Grouping	Criteria	Description
Security	DNO Control	<ul style="list-style-type: none"> DNO has full operational control.
Asset Value, Cost and Risks	Optimising Value of Asset	<ul style="list-style-type: none"> DNOs currently lack the experience, skills and capabilities to trade and risk manage the asset. The first of a kind cost of developing these capabilities will be high unless the DNO has a large portfolio of assets to spread the costs across. Until DNOs have developed the internal expertise there is a risk that the asset is utilised sub-optimally.
	Risk Allocation	<ul style="list-style-type: none"> DNO is required to take risk that value of residual revenue streams will not drive a saving when compared against traditional reinforcement, which is a significant departure from their business as usual. Risk allocation with Customers must be aligned with the proportion of regulatory financing Customers could share in additional captured value not previously available, depending on the proportion of regulatory financing.
	Financing	<ul style="list-style-type: none"> Financing as a regulated asset could reduce the cost of capital.
Wider Benefit	Optimising Value for System	<ul style="list-style-type: none"> For a single asset there is no aggregation therefore costs of trading will be high as a proportion of revenues. May be more suitable if DNO can develop multiple assets to spread costs of trading and accelerate development of internal expertise. Asset may be aggregated with assets of other DNOs in a joint trading organisation.
	Dynamic Efficiency	<ul style="list-style-type: none"> DNO has full control over the storage technology and can target the development of specific technologies if required. The business model would become more efficient as projects are rolled out and the DNO builds its internal trading and risk management expertise.
	Carbon Efficiency	<ul style="list-style-type: none"> Incentivises and enables low carbon power system.
Future Proof	Scalability	<ul style="list-style-type: none"> Can be scaled but would be limited by development of internal trading and risk management expertise.
	Regulatory Compatibility	<ul style="list-style-type: none"> There may be regulatory barriers to trading of power by DNO and the financing of the project as a regulated asset.
	Flexibility/Optionality	<ul style="list-style-type: none"> DNO has full control to relocate the asset to new constrained location if required.

Under the DNO Merchant model the DNO would have full operational control of the asset and therefore the ability to meet any security or constraint management obligations. The asset would be financed on the DNO's balance sheet as a regulated asset. There are a number of variations on the extent which Customers would fund the asset and take some of the risk around the returns, discussed in Section 2.3. A DNO is likely to have a lower Weighted Average Cost of Capital (WACC) than the majority of potential third parties. This may mean that the asset can be financed at lower cost (albeit with Customers taking some or all of the risk). However, the risk profile of the storage is higher than the rest of the DNO's business and creates exposure to new risks, and a significant portfolio of storage may increase the DNO's cost of funding. Therefore the DNO may assess the development using a marginal cost of capital implying a higher rate of return. This may depend on how much risk is shared with Customers.

The DNO Merchant model carries the greatest commercial risk for the DNO. The DNO would need to trade in the wholesale energy market and participate in procurement mechanisms for ancillary services (see Appendix 1 for a description of the possible ancillary revenue streams). The value that can be drawn from these ancillary services would be limited by the DNO's de-minimis threshold, which is 2.5 per cent of the sum of the licensee's share capital, its share premium, and its consolidated reserves.

A DNO trading and risk management operation would also be required. This would be a significant deviation from the core business of the DNO and would require additional set up and operational costs for the first of a kind project. These costs would be expected to decrease with increasing rollout of similar projects and the establishment of the DNOs internal trading and risk management expertise. DNOs could also

potentially aggregate the asset with other DNOs in a joint trading organization.

An additional complication would be how the asset is financed and operated within the DNO business. If the asset was a regulated asset to be fully financed by the Customers, but operated by the DNO there could be a misplaced incentive on the DNO to operate the asset's ancillary services in a profit optimising manner as they would not accrue any of this additional financial benefit. (The effect of the different financing options on price controls, along with the cost, risk and benefit sharing between the DNO, third party and Customers is discussed in detail in Section 2.3).

2.1.2. Distribution System Operator

Our definition of a Distribution System Operator (DSO) is discussed in Box 2. The DSO model for storage assumes a future world in which the necessary regulatory changes have been made. Under a DSO model the DNO might own, operate and maintain electrical energy storage as part of a wider role of actively managing its network, akin to the role that National Grid plays at the transmission level. Under this model the DSO might lead the development and construction of the asset, finance its construction and operation and then take full commercial control. The DNO would accrue all the project costs and benefits and there would be no direct third party involvement.

Alternatively the DSO might simply contract for services from electrical energy storage on an exclusive or priority basis. This is subtly different from the GB TSO model where the GB TSO does not own any generation or storage.

The DSO model can be considered as a variant of the DNO Merchant model, but with the addition of a new regulatory incentive regime to manage the risks associated with the value of the asset.

Box 2 Definition of a DSO

A Distribution System Operator (DSO) has access to a portfolio of responsive demand, storage and controllable generation assets that can be used to actively contribute to both distribution network and wider system operation. A DSO builds and operates a flexible network with the ability to control load flows. The combination of a highly flexible network and access to demand and generation response allows the DSO to contribute to the increasing challenge of encouraging demand to follow generation. This will become increasingly important as higher volumes of low carbon, zero marginal cost intermittent generation (such as wind and solar) become available to supply GB demand. However, changed demand profiles might also give rise to higher peak demands occurring when availability of low carbon generation is high. Moreover, in order to provide fast low-cost connections to renewable distributed generators, the use of interruptible connection arrangements, such as is being trialled through UK Power Networks' Flexible Plug & Play Networks project, might become more common, particularly for onshore wind generation in respect of which a typical load factor might be around 25%.

It follows that as well as helping to support the market, a DSO will also have to consider distribution network constraints and the opportunities for using commercial innovations such as demand side response (DSR) in order to reduce the requirement for network reinforcement. The DSO role could also entail closer interactions with the National Electricity Transmission System Operator (NETSO), such as a responsibility to assist with balancing at a national level and providing ancillary services such as reserve, frequency response, and voltage and reactive power management.

It follows that the DSO role is conceptually similar to the NETSO role under which National Grid manages balancing, reserve and constraints on the GB interconnected transmission system over time periods ranging from outage management planning timescales to second by second system frequency control. The NETSO balances the system using a range of mechanisms. These include:

- Ancillary and commercial services such as reactive power, frequency response and reserve services which the NETSO will contract for directly with the service providers;
- Contract notifications – whereby the NETSO can buy and sell electricity ahead of Gate Closure depending on whether there is expected to be a surplus or shortfall of generation; and
- The Balancing Mechanism whereby the SO instructs Balancing Mechanism Units to increase generation/reduce demand (acceptance of an Offer) or increase demand/reduce generation (acceptance of a Bid). Bid/Offer acceptances are made only following Gate Closure⁶.

National Grid is also responsible for ensuring that the GB interconnected system remains within safe operating limits and that the pattern of generation and demand is consistent with any system transmission related constraints (for example due to a planned outage of a circuit). Whilst National Grid will endeavour to coordinate network outages coincident with relevant generation outages in order to minimise constraint costs, it may be necessary to take actions (by entering into a Transmission Constraint Agreement, trading or taking actions in the Balancing Mechanism with generators, suppliers and large customers) to resolve constraints on the transmission system.

⁶ Note: whilst a Bid/Offer acceptance might move a generator or Supplier from their contracted position such that they are technically imbalanced, this does not affect their settlements (cash-out) position.

Box 2 Definition of a DSO

National Grid is incentivised on the procurement and utilisation of services to maintain the energy and system balance and other costs associated with operating the system. Users pay for the cost of these services and any incentivised payment/receipts through the Balancing Services Use of System (BSUoS) charge. The SO forecasts the costs at the start of a price control period, and Ofgem places incentives on the SO to keep costs within these forecasts. These charges are reconciled against actual costs so that the SO is not exposed to excessive over or underspend. For example, if the SO over or underspends against its forecast it is exposed to some of the extra cost or saving respectively, subject to a dead-band. The amount the SO is exposed to - the 'sharing factors' - were 25% for either overspend or underspend for the period 2011-2013⁷.

A DSO might take an active role in managing the distribution network through dispatching or curtailing electrical energy at different locations, for example through:

- curtailing or constraining-on generation (depending on whether the network is constrained for generator export or requires generator support due to loss of secure capacity);
- dispatch of electrical energy storage; or
- curtailment of demand through DSR contracts, curtailment of generation or use of storage) to minimise the cost of resolving constraints and ensuring network security.

The DNO regulatory framework does not explicitly provide for such market-based/relatively high risk solutions. It is designed for capital and operating expenditure that can be accurately forecast and then set as a baseline ex-ante allowance by Ofgem ahead of an applicable price control period. Moreover, there are currently limitations embedded in the DNO licence that limits the amount of generation or storage⁸ which they may own. The DNO does however have incentives to make efficiency savings through a cost-sharing mechanism whereby saved costs are shared with consumers but any overspend is only part funded by consumers. Some flexibility is provided through the use of uncertainty mechanisms⁹, which allow the DNO to alter its allowed expenditure during the price control period.

The DSO model may be most relevant in future as DNOs take a more active role in managing the distribution network, e.g. curtailment of embedded generation and dispatch of DSR. However it could also offer DNOs a mechanism through which to manage additional value streams of storage outside of the price control structure. It could also give Ofgem a number of levers to place incentives on the DNO to maximise the value streams to provide the most benefit for Customers.

⁷ Ofgem, 2011. National Grid Electricity Transmission System Operator Incentives from 1 April 2011

⁸ Existing storage is operated under Generation Licences, There is some current debate as to whether storage should be treated as generation for the purposes of the regulatory limitation on DNOs.

⁹ Uncertainty mechanisms can include indexing, volume drivers, triggers, logging-up provisions and re-openers.

It should be noted that while the DSO model is contingent on significant regulatory development, these developments are not necessarily required for distribution-scale EES projects. Under the Smart Grids Forum Workstream 6¹⁰, DECC, Ofgem and the industry are exploring the potential scope of the Distribution System Operator (DSO) role for DNOs. The initial view from the Smart Grids Forum is that a DSO model is not required for RII0-ED1. However distribution-connected EES built under RII0-ED1 may find itself operating under a DSO framework in future;

therefore forward compatibility with DSO-type arrangements should be a consideration.

The SNS project is intending to explore further these regulatory barriers following the first-of-a-kind trials of the storage facility for a range of value streams, which will be shared with DNOs and industry. A summary of the principal advantages and disadvantages of the model according to the common set of qualitative criteria is given in Table 5.

Table 5 DSO Model Qualitative Assessment

Grouping	Criteria	Description
Security	DNO Control	<ul style="list-style-type: none"> DNO has full operational control.
Asset value, cost and risks	Optimising Value of Asset	<ul style="list-style-type: none"> In a DSO world the DNO would actively manage the balancing of the network and would therefore be better placed to optimise the value of the asset than a present-day DNO An experienced third party aggregator might still be better placed to optimise the operation of the asset.
	Risk Allocation	<ul style="list-style-type: none"> If a regulated asset, DNO can share risks and benefits with Customers depending on the split of regulatory funding – a greater proportion of system value captured for customers. DSO role still at conceptual stage (WS6 of SGF).
	Financing	<ul style="list-style-type: none"> Financing as regulated asset could reduce the cost of capital. Customers could share in additional captured value not previously available, depending on the proportion of regulatory financing.
Wider benefit	Optimising Value for System	<ul style="list-style-type: none"> For DSO, may be additional incentives on power quality, losses etc. which can generate additional value.
	Dynamic Efficiency	<ul style="list-style-type: none"> DNO has full control over the storage technology and can target the development of specific technologies if required.
	Carbon Efficiency	<ul style="list-style-type: none"> Incentivises and enables low carbon power system.
Future proof	Scalability	<ul style="list-style-type: none"> Relevant in future as active network management by DNO develops, active assets increase, and regulations are developed. May be more appropriate when multiple actively managed assets are in place.
	Regulatory Compatibility	<ul style="list-style-type: none"> The model is reliant on future regulatory developments.
	Flexibility/Optionality	<ul style="list-style-type: none"> DNO control to relocate asset to new constrained location if required.

¹⁰ <http://www.ofgem.gov.uk/Networks/SGF/Pages/SGF.aspx>

Under a future DSO incentive scheme the DNO would still be incentivised to actively manage the distribution network to reduce costs. As such, the operation of the asset would already be a core function of the DNO's business, decreasing operational costs in setting up a trading and risk management business and increasing revenue efficiencies through already established expertise. Storage could be one of many technologies for enabling this, forming one part of a portfolio of active management technologies and systems with a greater wider system value.

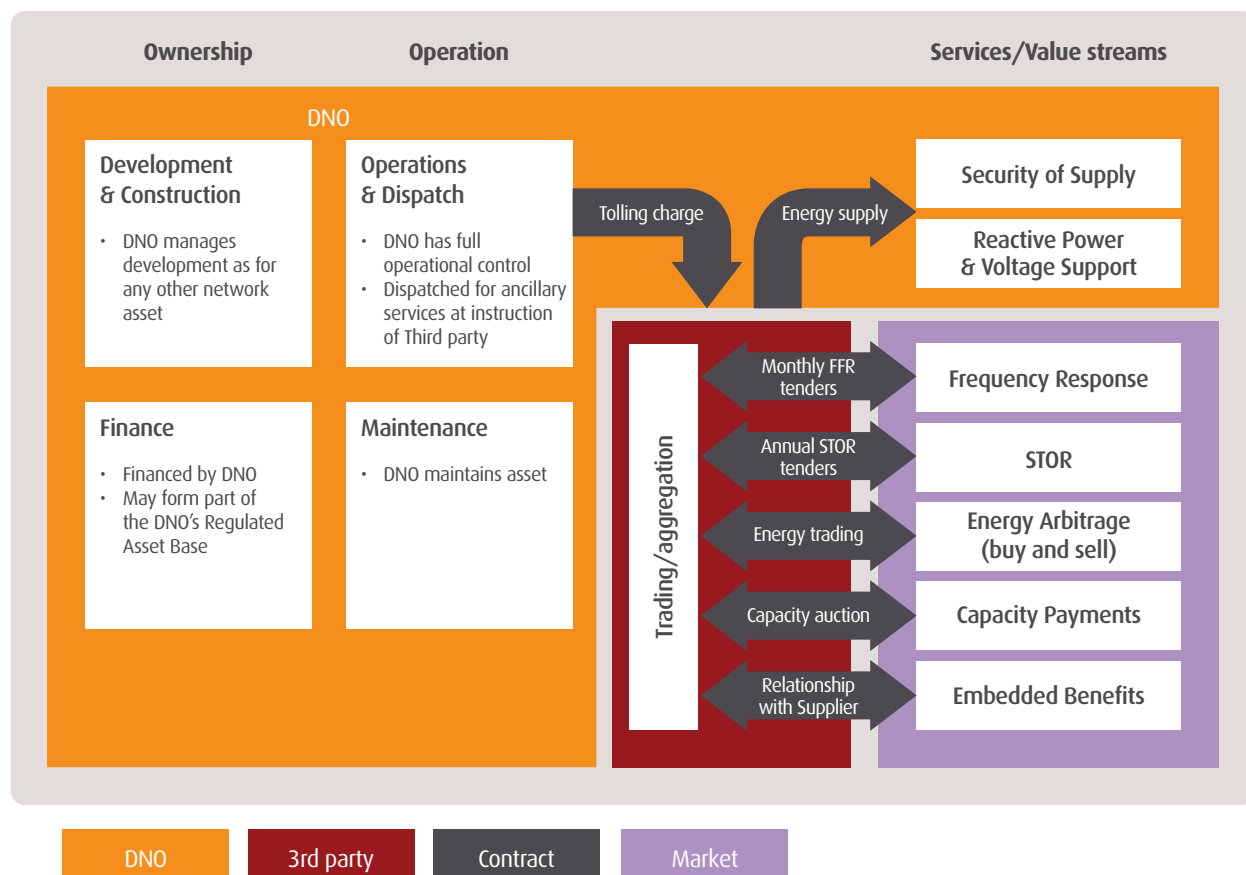
However, the obvious drawback of this model is that it is still very much a hypothetical case. Also, while the extent to which the DNO would need to carry the commercial risk of the asset's operation is unknown, it would still be greater than if the

asset's operation and the associated commercial risk were to be contracted to a third party (who would be expected to be able to better manage this risk). Also, while the balancing of the network would be a core part of the DNO's business under a DSO scenario, a specialist third party may still be better placed to operate and risk-manage the asset to ensure generated power and ancillary services achieve the maximum possible returns.

2.1.3. DNO Contracted

The DNO Contracted model differs from the DNO Merchant model due to the involvement of a third party to manage the capacity of the asset when it is not required for security purposes. The DNO would still finance, maintain and operate the asset, but would dispatch it for ancillary services at the instruction of a third party.

Figure 7 DNO Contracted Model



Under this model, the third party would enter into a long term capacity contract (ideally to the end of the operational life of the asset) where additional value would accrue to the DNO through fixed annual availability payments to the DNO, or some form of percentage pass-through of value. The DNO would therefore be in a position to make its investment decision by comparing the net present value of the availability payments under the long term capacity contracts against the incremental cost of storage over and above traditional reinforcement.

A summary of the principal advantages and disadvantages of the model according to the common set of qualitative criteria is given in Table 6.

The principal advantage of the DNO contracted model is that some, or all, of the risk around monetising the additional value streams is transferred away from the DNO. In view of the inherent uncertainty as to the long term value of additional revenue streams, the third party would be expected to bid at a discount to the long term expected value for this capacity. The extent of the risks will obviously determine the extent of the discount that it applies, which will in turn affect the likely viability of the investment from the DNO's perspective. A further advantage is that the DNO retains full operational control of the

asset, and is responsible for meeting the third party's dispatch instructions in the periods when the third party has commercial control of the asset, improving the overall DNO confidence in the availability of the capacity when required.

The disadvantage with the DNO Contracted model is that the terms of the third party's access to the capacity could be complex and need to be clearly defined prior to development of the asset. The ability to define the times at which the third party will have access to the asset is dependent on forecasting of the specific network constraint requirement, which is mainly dependent on the local network area and local demand growth which is largely uncertain (offset by any growth in embedded generation or DSR). Also, these contracted security requirement windows would aim to allow as much flexibility as possible for the monetization of additional value streams. As such, they would aim to use the smallest window that guarantees the DNO security requirements are met. However, there would be an inherent and largely unavoidable conservatism in these contracted security requirement windows, which would likely be long term coarse agreements with poor granularity for real time deviations of requirement. This would create a potential value loss to the revenue streams of the asset ancillary services.

Table 6 DNO Contracted Qualitative Assessment

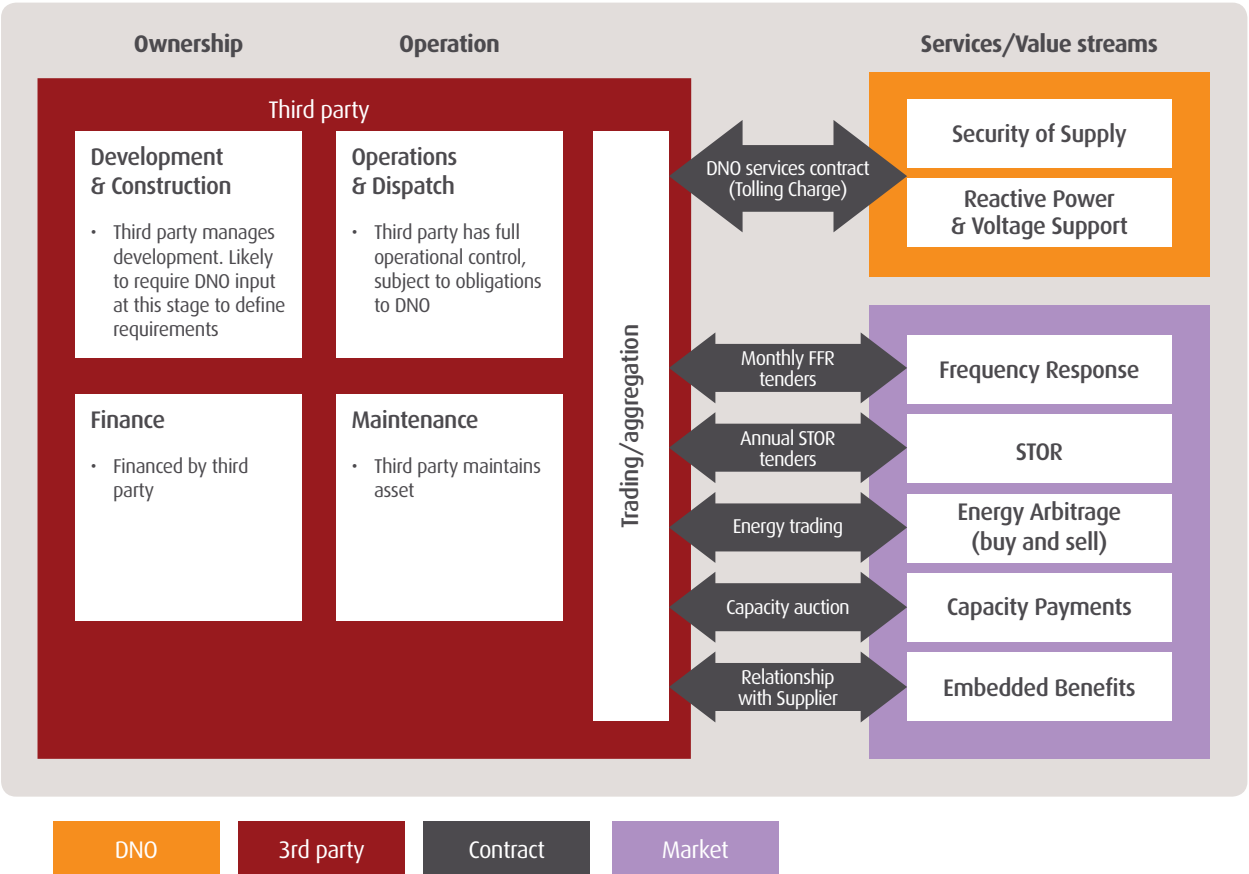
Grouping	Criteria	Description
Security	DNO Control	<ul style="list-style-type: none"> DNO has full operational control, and commercial control in defined security periods only. Possibility of complex contractual terms to ensure the most valuable services are available to third party whilst ensuring system security. Likely to be conservative Secure Capacity Windows with significant value losses (i.e. lost ancillary service benefits). Assumes that Secure Capacity Windows can be defined with enough certainty.
Asset Value, Cost and Risks	Optimising Value of Asset	<ul style="list-style-type: none"> Third party may heavily discount long term value of additional revenues, depending on the riskiness of these revenues. Third party expertise however would, in theory, ensure the asset is optimally utilised. The DNO would not be required to establish an energy trading and risk management function within their business.
	Risk Allocation	<ul style="list-style-type: none"> The DNO would pass some of the commercial risk to the third party, the extent of which would depend on the Secure Capacity Windows and tolling agreement between the two parties.
	Financing	<ul style="list-style-type: none"> Financing as a regulated asset could reduce the cost of capital. Customers share in additional captured value not previously available, depending on the proportion of regulatory financing.
Wider Benefit	Optimising Value for System	<ul style="list-style-type: none"> The terms of the tolling agreement could allow for the asset to be aggregated into a larger third party portfolio.
	Dynamic Efficiency	<ul style="list-style-type: none"> DNO has full control over the storage technology and can target the development of specific technologies if required. The business model would become more efficient as projects are rolled out and subject to the DNO establishing an internal trading and risk management expertise, the organic growth of these capabilities.
	Carbon Efficiency	<ul style="list-style-type: none"> Incentivises and enables low carbon power system.
Future Proof	Scalability	<ul style="list-style-type: none"> Third party may be able to aggregate across multiple assets which increases scalability.
	Regulatory Compatibility	<ul style="list-style-type: none"> There may be regulatory barriers to the financing of the project as a regulated asset. If the DNO was to carry some of the merchant exposure (a model variation), there may be regulatory barriers to trading of power by the DNO.
	Flexibility/Optionality	<ul style="list-style-type: none"> Optionality to re-locate asset may be restricted if not explicitly covered by terms of agreement with third party.

2.1.4. Contracted Services

Under this model, the DNO identifies the security requirement, or other network constraint for mitigation, selects the site and then runs an open tender for third parties to build and operate storage. The DNO sets technical requirements that must be

met, such as, the Secure Capacity Windows, the minimum exporting capacity and storage capacity of the asset. The DNO offers a fixed annual payment in return for the security services provided by the third party.

Figure 8 Contracted Services Model



Under the Contracted Services model the successful third party would lead the development and construction of the facility, including all consents and planning. The third party would then finance, own, operate and control the asset. The original tender agreement would guarantee them revenue streams across the expected life of the asset in return for meeting the DNO's security requirements. The third party would have

full commercial control of the asset and would receive tolling payments from the DNO combined with uncertain returns from additional value streams.

A summary of the principal advantages and disadvantages of the model according to the common set of qualitative criteria is given in Table 7 below.

Table 7 Contracted Services Model Qualitative Assessment

Grouping	Criteria	Description
Security	DNO Control	<ul style="list-style-type: none"> Third party has full control of the asset. DNO does not have operational control, or tangible assurance of safety or technical aspects.
Asset Value, Cost and Risks	Optimising Value of Asset	<ul style="list-style-type: none"> Possibility of contractual challenges in ensuring system security at best value. Third party may heavily discount long term value of additional revenues. Little existing appetite from third-parties while unproven.
	Risk Allocation	<ul style="list-style-type: none"> Full commercial risk with the third party. Limited initial investment by DNOs/Customers. Additional system value is not delivered to customers.
	Financing	<ul style="list-style-type: none"> Cost of capital may be higher than if financed by DNO.
Wider Benefit	Optimising Value for System	<ul style="list-style-type: none"> Asset can be aggregated into a larger Third Party portfolio.
	Dynamic Efficiency	<ul style="list-style-type: none"> Depending on the tender requirements, not necessarily promoting the development of energy storage above other solutions.
	Carbon Efficiency	<ul style="list-style-type: none"> DNO could still define the storage technology, or open up to all technologies. Incentivises and enables low carbon power system.
Future Proof	Scalability	<ul style="list-style-type: none"> Third party may be able to aggregate across multiple assets, which increases scalability.
	Regulatory Compatibility	<ul style="list-style-type: none"> Likely to face few regulatory barriers.
	Flexibility/Optionality	<ul style="list-style-type: none"> DNO optionality on relocation of asset is removed.

From the perspective of the DNO, the principal advantage of the Contracted Services model is that the construction, operational and commercial risk is removed or significantly decreased from the DNO Merchant and DNO Contracted models. The project's construction, operational and commercial risk is instead passed to a third party, who could have already established an expertise that would allow them to effectively manage this risk. The DNO also avoids the upfront capital cost of financing the asset, instead spreading this cost out over the lifetime of the asset as an annual tolling charge. The DNO also avoids having to establish an internal energy trading and risk management service which instead could be taken by an established function within the third party's business.

However, as the DNO passes control of the asset to a third party they also lose direct control of its operation. The DNO instead relies on the Third Party to provide the storage for security when required. This in itself adds a considerable project risk to the DNO with the chance that the third party would over utilise the asset to maximize their commercial benefits, thus failing to meet their security and constraint requirement obligations.

For the first projects, the risks associated may limit the number of potential providers and lead to a lack of competition in the near term. This may be compounded by the lack of understanding from the market as to the nature of the services required. There is a risk that the considerable upfront cost and commercial risk that would need to be carried by the third party would again limit the market size with the lack of suitable and interested third parties.

2.1.5. Charging Incentives

The Charging Incentives model is one under which the DNO ensures that the DUoS charging (for both generation and demand) creates the right incentives for decreases in (net) demand at peak times in the location requiring reinforcement. Third parties may or may not respond to the incentives by building storage (or equally by building embedded generation or with DSM, which are outside the scope of this consultation). The DNO has no control over how much capacity is built or what the technical capabilities are. The DNO also has no way to ensure that the capacity is available for security purposes when required. The DNO may therefore have to over-incentivise the third party in terms of the payment structure.

The third party would lead the development and construction of the storage facility with a technology option and location of their choice. The third party would own, finance, operate and maintain the asset, holding full commercial control of its operation. The DNO would hold no operational control of the asset and have no guarantee on security, but would set charging signals (such as negative DUoS or credits for generation during the 'Super Red' time period¹¹) for peak shaving that reflect the value of reinforcement. These signals would potentially need to react dynamically to system conditions, which is not currently the case.

A summary of the principal advantages and disadvantages of the model according to the common set of qualitative criteria is given in Table 8.

¹¹ Super Red time band is a seasonal time of day period determined by each DNO to reflect the time of system peak

Table 8 Charging Incentives Model Qualitative Assessment

Grouping	Criteria	Description
Security	DNO Control	<ul style="list-style-type: none"> Third party has full control of the asset and its operation. No operational control for DNO – no guarantee on security or that asset is built in optimal location or is built at all.
Asset Value, Cost and Risks	Optimising Value of Asset	<ul style="list-style-type: none"> Charging incentives may need to be very large. Third party may heavily discount long term value of additional revenues and of DUoS incentives. A market led solution could, in theory, produce the most economical solution. However this does not recognise the barriers and risks.
	Risk Allocation	<ul style="list-style-type: none"> All commercial risk is passed to the third party. No commercial risk to DNO or Customers.
	Financing	<ul style="list-style-type: none"> Cost of capital may be higher than for DNO.
Wider Benefit	Optimising Value for System	<ul style="list-style-type: none"> Third parties could aggregate the asset with others in a wider portfolio.
	Dynamic Efficiency	<ul style="list-style-type: none"> Allows most economic technology choice (not necessarily storage). Does not necessarily drive innovation in storage.
	Carbon Efficiency	<ul style="list-style-type: none"> There is no guarantee that a carbon efficient solution would be proposed by the third party.
Future Proof	Scalability	<ul style="list-style-type: none"> Appears to be easily scalable.
	Regulatory Compatibility	<ul style="list-style-type: none"> Likely to face few regulatory barriers.
	Flexibility/Optionality	<ul style="list-style-type: none"> DNO optionality on location of asset is removed. The Third Party has full control over the asset's location.

Under this model the DNO allows the market to define the most economic technology choice and location solution for the project. The DNO would carry none of the commercial risk, with all the project and commercial risk passed to a specialist third party (who would be expected to have the experience and capabilities to manage this risk).

However, with this market based solution there is a risk that third parties would not react to the price signals and the asset would not be built at all. If the storage asset were to be built it would be by a third party and the DNO would have no control of its location or technology choice, both of which might not be sufficient to meet the DNOs security requirements. Also, the DNO would have no control of the asset's operation and as such no guarantee that the asset would be available to provide the security required. This may be acceptable if there were a large number of small distributed assets supporting a single region, but is a barrier if security is based on a single asset.

Another consideration is that the changes to charging required to create the economic signals could add significant complexity to DUoS tariffs.

2.2. Qualitative Assessment Summary

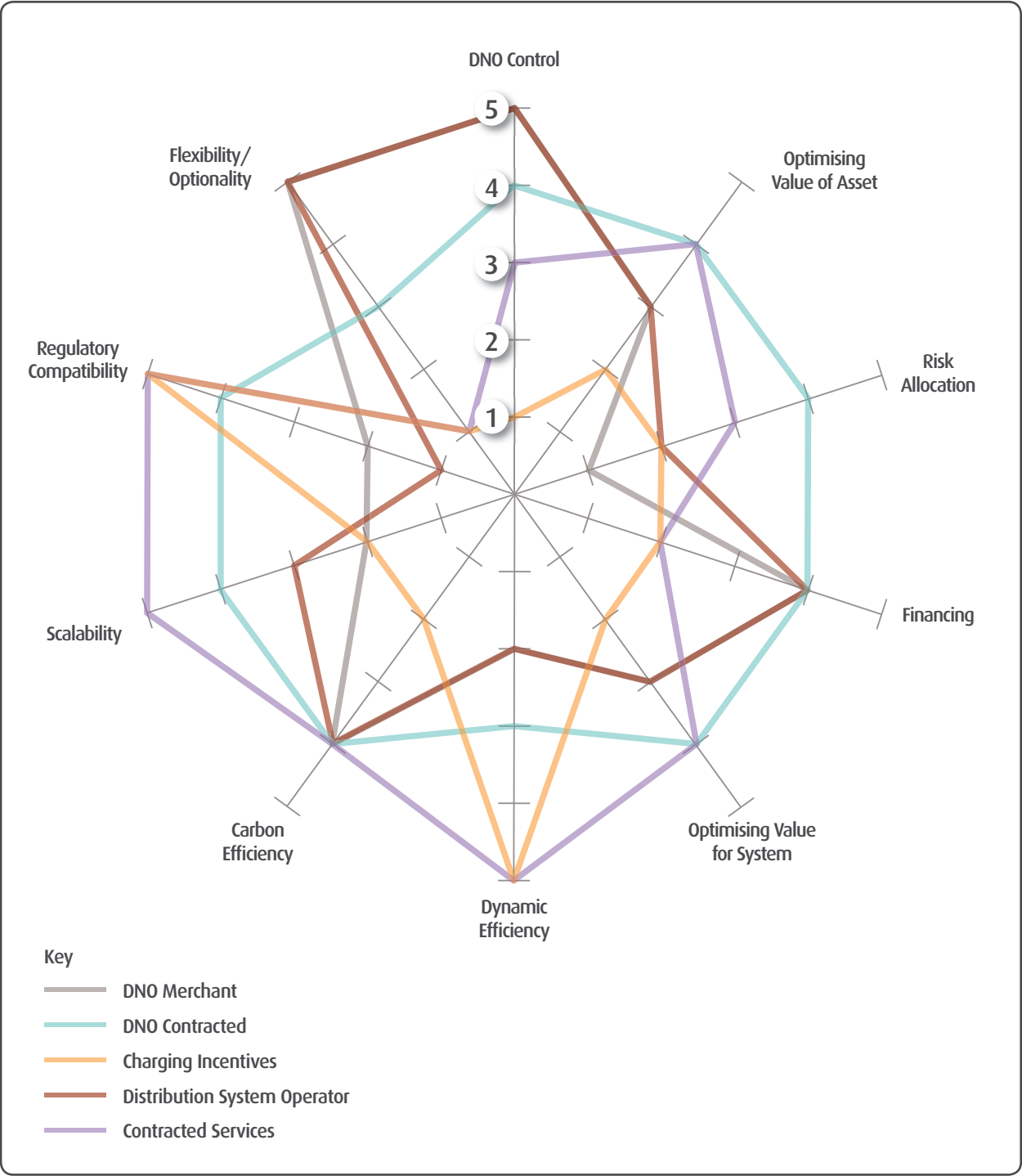
We have performed an assessment of the business models against the set of qualitative criteria presented in Table 3, and used this to aid the selection of two business models for further development. The list of criteria represents a high level view of the key business model considerations. We have not assigned weightings to the criteria as these would be highly subjective depending on stakeholder viewpoint. We invite interested parties to present their own views in this area.

We have scored each model against the criteria above. Each model is scored from 1 to 5 where 5 is the best score. The scoring is necessarily subjective but provides a common basis for discussion.

Table 9 Qualitative Scoring Matrix

	DNO Merchant	Distribution System Operator	DNO Contracted	Contracted Services	Charging Incentives	Comments
DNO Control	5	5	4	3	1	Highest score for models where DNO has full operational control.
Optimising Value of Asset	3	3	4	4	2	Assume third party better placed to optimise value than DNO.
Risk Allocation	1	2	4	3	2	Allocation of market risks is a key driver.
Financing	4	4	4	2	2	Assume DNO has lower cost of capital for storage investments.
Optimising Value for System	3	3	4	4	2	Assume that third party aggregation creates more value for system.
Dynamic Efficiency	2	2	3	5	5	Models which enable competition and technology neutrality score highly.
Carbon Efficiency	4	4	4	4	2	All score highly expect for Charging Incentives, where there is no guarantee that storage will be built.
Scalability	2	3	4	5	2	Assume DNO dominated models are less scalable.
Regulatory Compatibility	2	1	4	5	5	Assume that DNO licence conditions may limit DNO trading of power.
Flexibility/Optionality	5	5	3	1	1	Under DNO owned models, DNO keeps long term optionality to re-locate asset.

Figure 9 Qualitative Assessment Summary



The **DNO contracted** model scores consistently well across most metrics, due to the allocation of risks and responsibilities between the DNO and third party. It scores neutrally on dynamic efficiency because it does not encourage the open competition in technologies or models that the third party models allow. The flexibility/optionality for the DNO is restricted by the contractual relationship with the third party.

The **Contracted Services** model scores well on dynamic efficiency, scalability and regulatory compatibility, as a result of being third party owned. It scores poorly on flexibility/optionality for the DNO because the third party owns the asset and therefore redeployment of the asset may not be possible.

The remaining three models score poorly on specific areas. The **Charging Incentives** model offers the DNO no control over the assets technology choice, its location, or its operation to provide security or ancillary services. The Charging Incentives model as such does not guarantee the assets core function of meeting the DNOs security obligation would be met, and is therefore not considered further.

The **DNO Merchant** model scores poorly on risk allocation as the DNO retains the risk of monetizing the additional value streams.

While the DNO would have full control over the asset, they would be required to build an in-house energy trading and risk management capability to monetize these additional benefits. This in itself is a significant deviation from the DNOs core business and is a prohibitive up-front cost. There is also an increased risk that the project would lose the value of these ancillary benefits which are critical to the commercial viability of the project.

The **DSO** model scores poorly because the regulatory regime is yet to get beyond the earliest stages of discussion. This model will be of more interest in the future but for the current discussion it is relevant to explore the compatibility of other models with a future DSO world.

Based on this assessment the lead models selected for further consideration are the DNO Contracted and Contracted Services models.

2.3. Regulatory Treatment

With regards to the DNO’s price control, there are four different regulatory treatment options of interest across the five proposed business models. Apart from the models where the asset is financed by a third party, the DNO parent company has the option to finance the asset as a non-regulated or

Figure 10 Regulation Options

Regulatory Handling	Non-regulated	Regulated		
Project Cost Accrued to	Third Party	DNO Parent Company	DNO Parent Company and Consumer Split	Consumer
Relevant Models	<ul style="list-style-type: none">Contracted ServicesCharging Incentives	<ul style="list-style-type: none">DNO MerchantDSODNO Contracted	<ul style="list-style-type: none">DNO MerchantDSODNO Contracted	<ul style="list-style-type: none">DNO MerchantDSODNO Contracted

regulated asset. Furthermore, if the project was to be financed as a regulated asset the proportion that would be financed by the DNO parent company and Customers could also vary. This would in principle depend on the appropriate cost and benefit split to be carried by the DNO parent company and Customers.

This prompts two immediate questions, firstly what is the appropriate risk and corresponding cost and benefit that should be passed to Consumers for both the security benefit and the ancillary services. And secondly, how this cost (and annual revenues in particular) would be transferred to Customers through price controls or otherwise. We discuss the principles of the regulatory treatment, rather than seeking to consider how this may align with the emerging RIIO-ED1 arrangements¹².

Non-regulated & Third Party Financed Scenario

In the third party financed models there are few regulatory compatibility concerns as all commercial risk is passed to the third party. The DNO parent company would see the tolling charge as an operational cost which would be treated like any other under the price control.

We note that there is a variant under which the third party is in fact the non-regulated business arm of the DNO parent company. This would not preclude the DNO parent company from making use of an aggregator to manage the optimisation of the additional value streams. Under this variant the DNO's non-regulated business builds and operates the asset. Customers and the DNO's regulated business take no risk on the asset, assuming that a fixed transfer price is agreed for the value of the avoided reinforcement. The DNO's non-regulated business takes the risk and value of the additional value streams (variant of DNO Merchant), or contracts the capacity out to a third party (Variant of DNO Contracted).

DNO Parent Company Regulated Financed Scenario

In the second possible scenario where the asset is a regulated

asset financed on the DNO parent company's balance sheet the DNO parent company would carry the project costs and all the commercial risk. The regulated value of the asset under the price control would be the cost of offset traditional reinforcement. Customers would take no risk on the financial benefits from the assets additional services, which would accrue directly to the DNO parent company. In this regulated DNO parent company financed scenario the cost of security is passed to the Customers via appropriate price controls in a similar manner to typical network reinforcement costs.

Customer Regulated Financed Scenario

The third option is the opposite extreme of the regulated scenario, where the regulated value of the asset is the full capital cost of the asset. In this scenario Customers would see the security benefit and would also accrue the additional financial benefit from the ancillary revenue streams. This scenario creates a misalignment of incentives, with the DNO facing no direct incentive to operate the asset in a profit optimizing manner. If the asset were to be operated by the DNO, as is the case in the DNO Merchant model, there would be a misalignment of the project's cost and revenue structures where the benefit of operating the asset would not accrue to the party that would carry its operational cost, namely the DNO. (This excludes the possible reset of allowed revenues that might occur at price control review if the revenue generated by storage is significantly out of line with other DNOs)

This case also poses the question of how these additional benefits would be passed to the Customers under existing price control arrangements. The cost of the asset along with the benefit of the offset traditional reinforcement could be dealt with and passed to Customers via treatment as a regulated asset. The uncertain ancillary revenues over the life time of the asset would then offset the payments made by Customers.

¹² <http://www.ofgem.gov.uk/Networks/ElecDist/PriceCtrls/riio-ed1/consultations/Documents1/RIIOED1DecOverview.pdf>

Regulated & Split Customers DNO Parent Company Financed Scenario

The fourth financing option is for the asset to again be a regulated asset, but it is now split financed between the DNO parent company and Customers. In this case the DNO parent company, if it has operational control of the asset, is incentivised to operate the asset in a profit optimizing manner (the DNO parent company would accrue some of the financial benefits from the ancillary services, thus avoiding misplaced incentives). Customers would again see the security benefit, but the financial benefits of the ancillary revenue streams would now be split between the DNO parent company and Customers.

Across all the regulated cases the key is to align the costs and risks that Customers are taking with the benefits. It is clear that the DNO should take some exposure to the additional costs and revenues associated with the project, but there may be an argument for Customers to taking more or less of the benefits and corresponding risk.

We also note that storage assets do not have the typical long economic life of distribution assets. Most storage assets, such as batteries, would have a lifetime of 10-15 years for the energy storage medium and 30 years for the balance of plant. In comparison, most conventional distribution equipment has a lifetime of 30-50 years. Storage assets also differ from typical distribution assets as they provide positive revenues throughout the life of the asset. Therefore treatment as a typical regulated asset (with returns made over a 45 year assumed asset life) may not be well aligned with the true costs and revenues to the DNO of owning and operating storage.

2.4. Accounting Treatment

An additional project dynamic that varies between the different business models is the accounting treatment of the asset and its liabilities on the balance sheets of the project parties. Most notably, under accounting rules as outlined in the International Financial Standards as adopted in the European Union (EU-IFRS),

long term agreements for the economic output of specific assets (such as the tolling contract between the third party and the DNO) may in certain circumstances be categorised as a leasing agreement. If so, the liabilities of the asset may consolidate on the balance sheet of the party who issues dispatch instructions for the asset and carries the commercial risk, irrespective of who has ownership or operational control of the asset. Similarly, there may be an adverse effect on the credit rating of the project party who takes the asset and subsequent commercial risk, again irrespective of who controls or finances the asset.

The accounting treatment of the project's liabilities on the balance sheets of the respective project parties would depend on both the magnitude of, along with to whom the project's assets and liabilities accrued to. This asset liability split would be examined in the discounted cash flow of the specific project and would be tested according to the Financial Reporting Standard (FRS) 5. Careful consideration of the commercial structure would be required to ensure that the accounting treatment aligns with the intentions of the business model.

2.5. Consultation Questions

The questions that we invite interested parties to submit written evidence and analysis on are as follows:

1. Do you agree with the range of business models presented in Section 2.1?

- a. Are these business models and their variants representative of the range of plausible business models?
- b. Do you agree with the characterisations of each of these business models in their respective Sections 2.1.1 through to Section 2.1.5?

2. Do you agree with the choice of assessment criteria as described in Section 2.1?

- a. Are these the key assessment criteria that the business models should be compared against?

- b. Are there any additional advantages, disadvantages or barriers to any of the individual business models that have not been included?

3. Do you agree with the choice of the two lead models and the reasons for selecting these as described in the Qualitative Assessment Summary, Section 2.2?

- a. Are these options the most likely to be suitable for distribution-connected storage, or should one or more of the other business models (or variants of these) have been considered over the DNO Contracted and Contracted Services models?
- b. If so, which models should have been considered and why?

4. Do you agree with the range of four regulatory treatment scenarios presented in Section 2.3?

- a. Are there other scenarios that should be included?
- b. Are there inherent regulatory created limitations that have not been discussed?
- c. Are there additional advantages or disadvantages for each of these scenarios that should be considered?

3

Lead Business Models



In this section we outline two proposed lead business models to be assessed within the SNS project in more detail. We consider the project lifecycle, contractual arrangements, and possible barriers. Finally, we consider some possible variants of the models.

The DNO Contracted and Contracted Services models share a number of common features. They both require a third party to take some or all of the commercial risk on the long term value of the additional value streams, and require a contract that ensures that the DNO has primary access to the asset when it is required for security purposes, or other constraint management.

The key difference between the models is the ownership and operation of the asset, which lies with the DNO under DNO Contracted and the third party under Contracted Services.

3.1. DNO Contracted

The DNO Contracted model treats the storage as a distribution system asset and the development approach may in many ways be analogous to a traditional DNO investment, albeit with the further complexity of additional value streams and a contractual relationship with a third party.

This model is closest to that which will be demonstrated within the SNS project following commissioning of the storage facility.

Project development

The trigger for pre-development of the project is the identification of a need for reinforcement in a specific location to support the local network. The DNO would investigate the range of options available to it, which might include installation of new transformers and or lines, uprating of capacity of current infrastructure through incremental investments, and of non-transmission options such as EES and/or demand side response. If the DNO identifies EES as being the most technically and economically feasible option that is deliverable in the timescales required, it will initiate pre-development of the storage facility.

At an early stage in the development process, the DNO would initiate discussions with potential third parties to test the market for the storage tolling agreement. Assuming that the discussions indicate sufficient value in potential tolling payments, the DNO would select a third party and agree terms. This may involve bilateral negotiation, or a more formalised auction process.

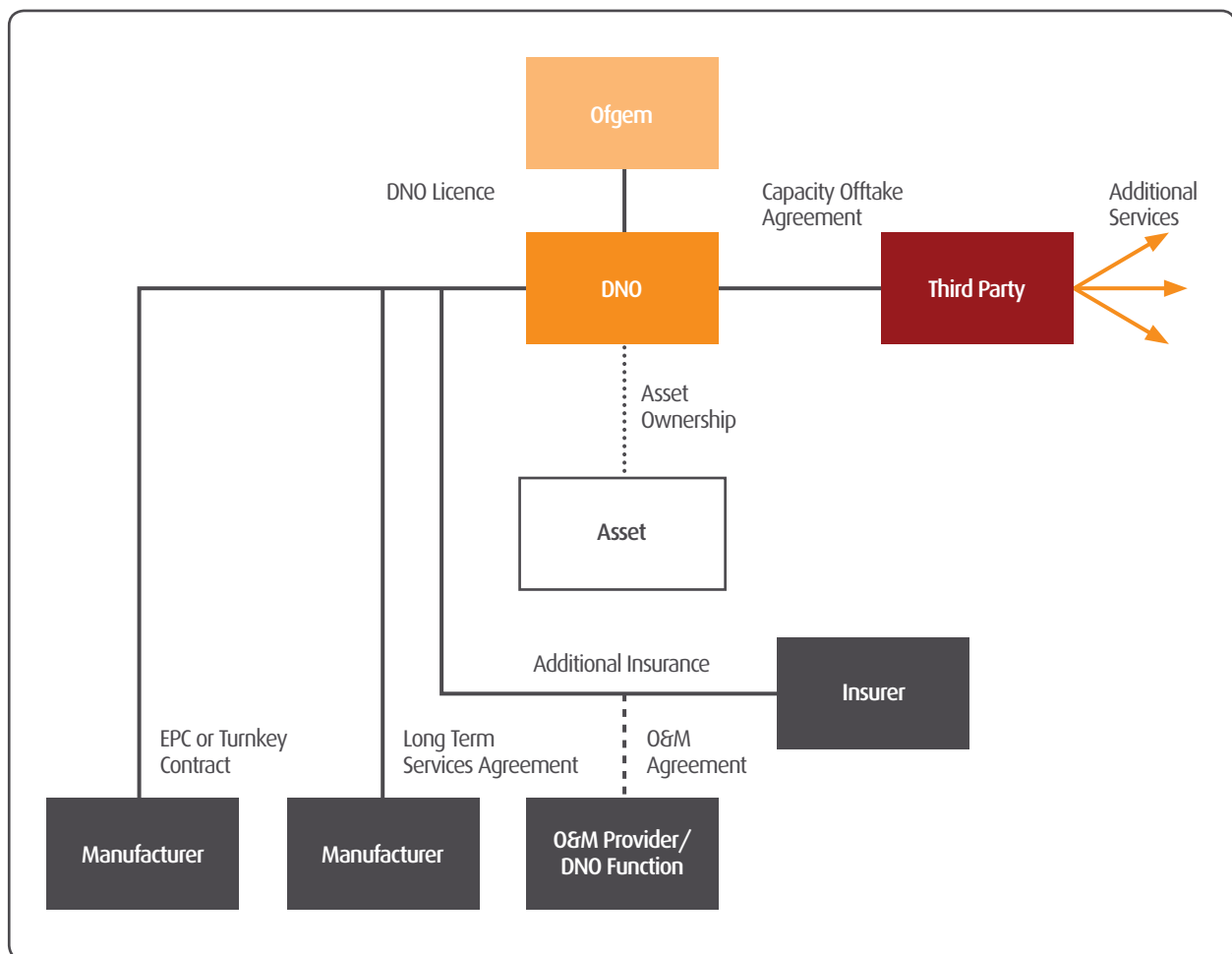
The asset would be built as a regulated asset under the rules of the price control in force at that point in time. The options for regulatory treatment are discussed in general terms in section 2.3.

Contracting structure

Figure 11 shows a possible ownership and contracting structure for the DNO Contracted model. The DNO would lead construction of the asset, contracting out for construction as required. The asset would be owned by the DNO as a regulated

distribution asset. Once operational, the maintenance strategy of the facility would fall to the DNO's Network Operations. The actual maintenance may be carried out by the DNO's field engineers directly, or contracted out to the manufacturer or a maintenance provider.

Figure 11 DNO Contracted: Contractual Structures



Note that it is assumed that no Connecting Construction Agreement (section 16 agreement, controlling the terms under which generator or demand connects to the network) is required, because the connection of the asset to the network is under the full control of the DNO, and operational control remains with the DNO so there is not a need to specify this in a connection agreement.

The capacity offtake agreement between the DNO and the third party defines the terms under which the capacity is released to the third party. The agreement gives the third party commercial control (tolling) of the asset outside of a specified set of Secure Capacity Windows. Under the simplest arrangement, these windows would be fixed in advance for the duration of the contract (e.g. 4-7pm on November – March weekdays). As the requirements might change across the life of the project the DNO would need to be conservative in defining these windows, which may reduce the value to the third party and therefore the payment to the DNO. In section 3.3 we explore the options to build flexibility into this contract. A condition of the contract would be the third party is obliged to make tolling instructions

that ensure the storage is at or above some pre-agreed charging level at the start of each security window (i.e. the third party must ensure that the storage device is at the agreed charging level at the start of each security window).

Depending on whether the DNO has secured a fixed capacity tolling contract for the entire economic lifetime of the asset, or whether a revenue share arrangement is established, the DNO may not hold any price or market risk associated with the value of the additional services. In either case, there may be some small exposure to the net cost of power bought and sold in the DNO's use (e.g. if a fault was to occur and the asset was required to export).

The DNO retains counterparty risk on the possibility of the third party defaulting. The DNO may require some form of collateral, security or guarantee as a contingency. The risk for the DNO is that it is left with no route to market, and with no revenue security. We assume that the counterparty risk that the third party takes is not a major consideration due to the typically high creditworthiness of DNOs.

Typical Contract Terms

While any tolling contract between the DNO and third party would be project specific, Table 10 gives a summary and examples of the expected headline contract terms that could

define the commercial elements of any tolling contract. A summary of how these terms could change as the business models evolve and the technology becomes established is given in Section 3.4.

Table 10 Example DNO Contract Tolling Agreement Headline Terms

Terms	Description
Secure Capacity Window	<ul style="list-style-type: none"> Fixed times that the asset is required for the DNO's security/constraint management purposes (e.g. 4-7pm daily from October to March)
Contract Tenure	<ul style="list-style-type: none"> Contract tenure (years)
Generation Capacity	<ul style="list-style-type: none"> The stored energy (MWh) that is required at the start of a Secure Capacity Window
Operational Constraints	<ul style="list-style-type: none"> The operational constraints outside of Secure Capacity Windows (e.g. depth of discharge (% of beginning of life capacity, response time (s))
Dispatch Notice	<ul style="list-style-type: none"> Third party's MWh availability/holding requirement for a given period for ancillary services Third party's MWh discharge for a given period if DNO is instructed by the third party to dispatch the asset for ancillary services
Tolling Charge	<ul style="list-style-type: none"> An annual fixed payment from the DNO to the third party (in £ or in £/MWh of availability)
Non-performance Penalties	<ul style="list-style-type: none"> A £/hr payment from the DNO to the third party if the third party's dispatch notices for availability and/or discharge are not met A £/hr payment from the third party to the DNO if the third party issues dispatch notices which are inconsistent with the Secure Capacity Window requirements (e.g. not enough energy stored at start of a Secure Capacity Window)

Decommissioning and terminal value

Throughout the project life, the DNO would regularly assess whether storage remains capable of fulfilling the security requirement, taking account of the useable capacity of the storage (after any degradation) and forecast demand growth. At the point at which the DNO forecasts that the storage will no longer be sufficient to fulfil the security requirement, the DNO will consider whether to renew or add to the storage capacity or to make alternative interventions including traditional reinforcement. If the DNO follows the traditional reinforcement option and the storage still has some usable economic life, it may be economic for the DNO to re-deploy the storage in another location. This could only occur within the contract duration if the option to relocate, along with any compensation for the temporary loss of availability, was written into the terms of the tolling contract.

Outside of the contract term, the DNO could relocate and aim to extend the contract with the third party.

Potential barriers to the DNO Contracted model

There are potential regulatory barriers to the ownership or operation of storage by DNOs, which we explore below. Workstream 6 (WS6) of the Smart Grids Forum (SGF)¹³ is considering these and UK Power Networks will conduct further work in this area in the course of the SNS project. Here we give an overview of our current understanding.

Generation licence

Storage is distinct from generation in that it both consumes and releases electricity (with the consumed amount being slightly higher due to losses in the charging cycle). However, storage such as the existing large scale transmission connected pumped storage at Dinorwig and Ffestiniog has been treated as generation for regulatory purposes. As such, the operators currently hold generation licenses. Therefore, the restriction

on the operation of generation by DNOs is a potential barrier as generation and distribution licenses are taken to be incompatible.

As network companies, DNOs are prevented from owning generation licences under the European Third Energy Package. However, under the GB regime there are generation licence exemptions for small generators in the Electricity Act. Effectively these allow a DNO to own generation up to 10MW in capacity. Storage providing distribution network reinforcement can typically be sized below this limit, and therefore this need not be a barrier, assuming that the limit is maintained at the 10MW level.

However the need for storage to be operated with a generation licence has not been validated. If storage was exempt from being considered generation and holding a generation licence this would simplify arrangements.

De Minimis Business restrictions

DNOs are restricted from conducting activity outside of distribution subject to a de minimis threshold¹⁴ of both;

- 2.5 per cent of the total turnover of distribution business; and
- 2.5 per cent of the sum of the licensee's share capital, its share premium, and its consolidated reserves.

In the DNO Contracted model we assume that storage does fall under the regulated distribution business. However, if this were not the case then the amount of ancillary revenue generated from storage owned by the DNOs could be subject to a cap. This would not be an issue until large numbers of storage projects had been developed.

Restrictions on DNOs buying and selling electricity

Under the DNO Contracted model, the DNO use of the storage

¹³ DNO ownership and operation of storage facilities.pdf (unpublished)

¹⁴ Ref to Standard Licence Condition 29

may consume and generate small amounts of electricity. Whilst there may be some restriction on the direct trading of electricity by DNO's, it seems that a supply agreement with the third party would circumvent this potential issue.

Disposal of assets

When the asset (storage technology and balance of plant) reaches its end of life the DNO would be required to decommission and dispose of the asset according to condition 26 "Disposal of Relevant Assets" of the Distribution License Conditions. This condition states that, in general, consent is given for assets without giving prior notice if the asset is obsolete, redundant or the disposal will not constitute the disposal of a legal (rather than an equitable) interest until the asset is obsolete or redundant. However this does not apply if;

- The value exceeds £200k in any regulatory year
- It does not apply in respect of a relevant asset that is obsolete, unless an appropriate replacement or alternative arrangement has been installed
- It does not apply if the disposal of the relevant asset constitutes a sale and leaseback arrangement
- It does not apply if the relevant asset is intended to remain in operational use but not under the operational control of the licensee and its value exceeds £20,000

At the end of life it is expected that the asset would still have some intrinsic operational value. For example, the storage

technology would expect to degrade past its functional limit in 10-12 years, but the balance of plant could operate for 30 years before replacement. Accordingly, the DNO may wish to replace the storage technology to further the operational life of the asset. Alternatively, they DNO may look to sell the asset to another party who would similarly use the intrinsic asset value to extend its operational lifetime.

If the asset and balance of plant have no further intrinsic operational value, the materials (and in the case of EES the storage medium in particular) and land would still have an intrinsic value that the DNO could monetize through the sale of the asset and property.

Other barriers

As we have already noted, the model may require complex contractual terms in order to ensure most valuable services are dispatched whilst ensuring system security. This complexity may also limit the potential for aggregation of the storage into a third party's portfolio of flexible assets, which may limit the value of the asset to the third party or increase the cost of managing it.

The future value of the additional revenue streams is inherently uncertain. Under a fixed annual payment, all market risk sits with the third party, which may lead a third party to heavily discount the future value of the revenues when evaluating a potential opportunity. Other variants where the DNO shares the risk may lead to lower discounts.

3.2. Contracted Services

The Contracted Services model treats the storage as a service provider to the DNO. It shares some similarity with the treatment for an embedded generator, with the addition of the provision of

capacity to the DNO within specific windows. Another example of a DNO-connected storage with a different primary purpose to UK Power Networks' SNS project is SSE Power Distribution's Orkney Energy Storage project¹⁵ described in Box 3.

Box 3 SSE Orkney project

The primary purpose of the SSE Orkney Project is to manage the intermittent generation of renewables on Orkney. This will be run as part of the Orkney Active Network Management, under which SSEPD has the ability to curtail renewable generation if required. In this case, the use of storage is an alternative to curtailment of renewables and therefore not specifically required for network security.

SSE has procured storage through a tender process, under which SSE will buy storage services from third party owner(s)/operator(s) under pre-agreed terms (analogous to the Contracted Services model). While there is a fundamental condition to make storage available to receive surplus power, a fundamental difference to the UK Power Networks SNS project is that the Orkney storage device is not required for distribution network security purposes.

¹⁵ <http://www.ssepd.co.uk/HaveYourSay/Innovation/Portfolio/OrkneyPhase1/>

Project development

As for the DNO Contracted model, the trigger for pre-development of the project is the identification of a need for reinforcement in a specific location to support the local network. If the DNO identifies EES as being the most technically and economically feasible option it will initiate a tender for the storage facility.

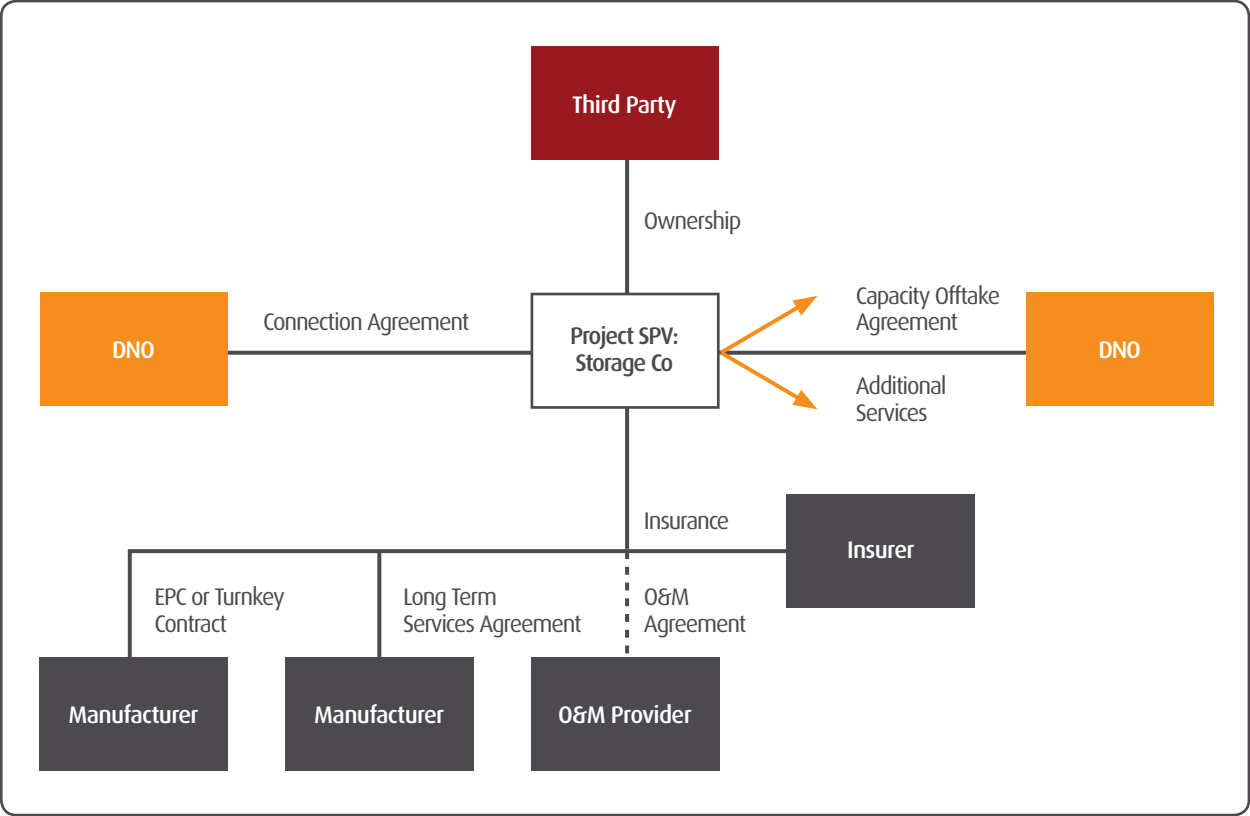
This tender will define the parameters of the service required by the DNO, including the exporting capacity (MW) and storage capacity (MWh), as well as the security windows in which the asset is required by the DNO. It would also identify the site for the asset and the start and end date of the security requirement.

Alternatively, the DNO could issue a technology neutral tender, open to DSR or embedded generation, however it may be difficult to compare availability on an equal footing. This might reduce the cost of the service to the DNO, however it could lead to less innovative, higher carbon emitting technologies being selected.

Contracting structure

Figure 12 shows a possible ownership and contracting structure for the Contracted Services model. The storage would be owned by the third party, either directly or through a Special Purpose Vehicle (SPV).

Figure 12 Contracted Services: Contractual Structures



To ensure that asset is built in a location that both meets the DNO's reinforcement requirements and can be optimally incorporated into the existing network, the DNO would identify the site on which the storage is to be built. However, whilst the DNO would identify the site the third party would be responsible for securing the necessary planning consents. We assume that the third party would be required to sign a connection agreement with DNO. This would most likely be based on a generation connection agreement, albeit with some adjustments to reflect the particular technical features of storage.

The capacity offtake agreement between the DNO and the third party would have a term equal to the anticipated economic life of the asset. It defines the windows in which the storage will be held available and at some minimum charge level. As the requirements might change across the life of the project the DNO would need to be conservative in defining these windows, which may increase the cost to the DNO. In section 3.3 we explore the options to build flexibility into this contract.

In this model the DNO does not take any market risk. This remains with the third party. The third party also takes risk on the availability and operational performance of the storage. This is likely to be reflected in lower terms offered to the DNO,

but countered by the incentives of more than one bidder who may be participating in a contract or auction.

The DNO is exposed to counterparty risk – in this case, the risk that the third party fails to provide the contracted services (either for isolated instances, or in the long term). In this case it is unlikely that the DNO will be able to replace the security provided by the asset at short notice and might incur significant costs in doing so. This is not as easily mitigated with financial guarantees as for the DNO Contracted model where the DNO is only exposed to a financial loss. This may be a barrier to the Contracted Services model, as discussed later in this section.

The third party is less exposed to counterparty risk because of the typical DNO creditworthiness and the limited alternatives available to the DNO in terms of security.

Typical Contract Terms

As in the DNO Contracted model, any tolling contract between the DNO and third party in a Contracted Services model would be project specific. However, Table 11 gives a summary and examples of the expected headline contract terms. Again, a summary of how these terms could change as the business models evolve and the technology becomes established is given in Section 3.4.

Table 11 Example Contracted Services Tolling Agreement Headline Terms

Terms	Description
Secure Capacity Window	<ul style="list-style-type: none"> Fixed times that the asset is required for the DNO's security/constraint management purposes (e.g. 4-7pm daily from October to March).
Contract Tenure	<ul style="list-style-type: none"> Contract tenure (years).
Generation Capacity	<ul style="list-style-type: none"> The stored energy (MWh) that is required at the start of a Secure Capacity Window.
Operational Constraints	<ul style="list-style-type: none"> The operational constraints during these Secure Capacity Windows (e.g. depth of discharge (% of beginning of life capacity, response time (s)).
Third Party Dispatch Notice	<ul style="list-style-type: none"> MWh discharge for a given period if asset is required to discharge for SoS obligations.
Tolling Charge	<ul style="list-style-type: none"> An annual fixed payment from the DNO to the third party (in £ or in £/MWh of availability).
Non-performance penalties	<ul style="list-style-type: none"> A £/hr payment from the third party to the DNO if the contracted Secure Capacity Window requirements are not met. A £/MWh payment from the third party to the DNO if the instructed discharge capacity is not met.

Decommissioning and terminal value

Under the Contracted Services model, the DNO may have little or no optionality on relocating the asset if the security requirement can no longer be met by the asset. Given the capital committed by the third party, it is likely to require a long term contract with a fixed price for the security provided. The third party is unlikely to relocate the asset unless this is a specific term in the contract which compensated the third party for the additional costs and risks incurred in this process as well as the loss of revenue.

Potential barriers to the Contracted Services model

A possible barrier to the Contract Services model is the lack of direct operational control of the storage by the DNO. This is a specific issue for EES required for network security purposes, and may not be an issue for other uses of EES outside of the scope of this Consultation.

One option is to put financial penalties on the third party if the storage is not made available in the required windows with the storage charged to a pre-specified level. The issue with this is that the impact on the DNO of not meeting a security requirement is not easily quantifiable, and any compensation value could be so high that it materially reduced the value that a third party assigns to the contract. Another option may be for the DNO to have direct override control of the asset; however this implies a level of oversight and intervention that is unusual in tolling contracts. Individual DNOs will need to evaluate their own attitude to this risk.

The probability that DNOs should assign to the availability of embedded generation is currently defined in ERP2/6. A review of these standards has been cited as a way of addressing the issue for storage, and SNS is expecting to deliver learning specifically relating to the contribution of storage to security of supply. A probability based approach to the availability of capacity is suitable where there are multiple small resources

which can all provide the same service. This is not true in the case of distribution-connected EES employed directly for network security. A potential outcome of a probability based approach might be to result in the DNO contracting for a greater capacity of storage than is required, without addressing the underlying issue.

Complexity

As we have already noted, the model may require complex contractual terms in order to ensure most valuable services are dispatched whilst ensuring system security. The level of complexity is likely to be similar to the DNO Contracted model. This complexity may also limit the potential for aggregation of the storage into a third party's portfolio of flexible assets, which may limit the value of the asset to the third party or increase the cost of managing it.

It may be more difficult for the DNO to make use of additional benefits, such as power quality control and power factor correction improvements from the power electronics of such storage technologies that have the capability.

3.3. Variants

There are many potential variations on the two lead models described above. Here we consider variants which separate ownership from operation, variations in contract length, and variants on the regulatory treatment of uncertainty.

Ownership variants

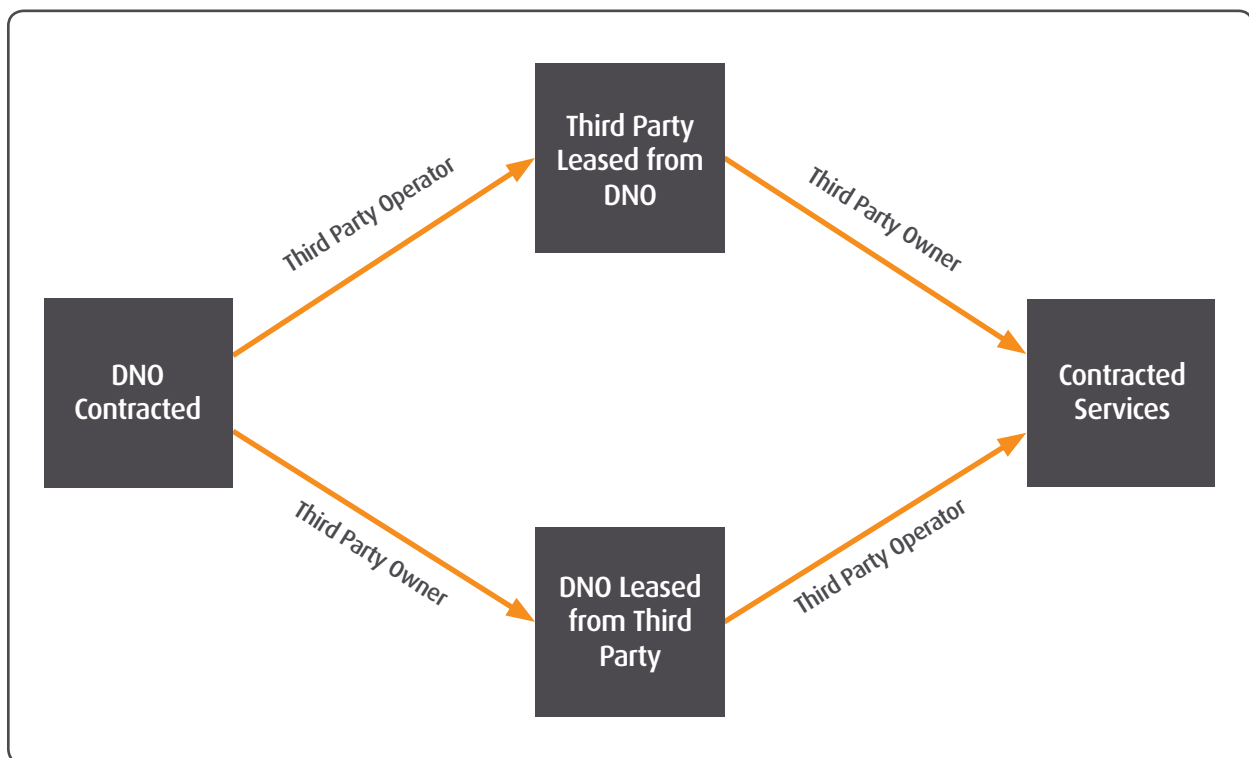
In the models described above we assume that the owner of the asset is also the operator. By separating these two functions we generate two new variants, shown in Figure 13.

- **Third party operator leased from DNO.** Under this model, the DNO builds the storage facility and then leases it to the third party to operate. Compared to the DNO Contracted model this removes control of the asset from the DNO. Compared to a Contracted Services model

it maintains the DNO's potential cost of capital benefit. However disposal of an operational asset by a DNO to another operator requires regulatory approval (Section 3.1).

- **DNO operator leased from third party.** Under this model, the third party builds the storage facility and then leases it to the DNO to operate. This model might be of merit in a case where the DNO required operational control of the asset for security purposes, but is restricted from asset ownership e.g. by regulatory restrictions.

Figure 13 DNO and Third Party Ownership Variants



Length of contract

For the lead models we have assumed that the tolling contract is for the expected economic life of the storage facility. For the DNO Contracted model, the impact of shortening the contract is to give the DNO more flexibility e.g. if demand growth is different from forecast. However, this leaves the DNO with the need to renegotiate the contract at a future point in time when the expected value of the additional revenue streams may be significantly higher or lower. A shorter contract may also be required if third parties are unwilling to take on a long term position.

Under the Contracted Services model, a shorter contract would be harder to enact because this would leave the third party with the risk of a stranded asset in future. Also once the asset is in place the DNO is the only Customers, therefore the third party will wish to lock in the full value of the security payments upfront before taking a final investment decision on the asset. Shorter contract periods may entail higher payments from the DNO across the shorter contract.

Sharing of benefits and risks with Customers

If storage is treated as any other distribution asset, the sharing of the risks and rewards of the asset would be shared according to the price control. However if the risks of storage were considered to be materially different from those for traditional distribution assets (e.g. due to technology risk, or market risk if the DNO is unable to secure a long term contract) then a separate uncertainty mechanism could be proposed. Under this approach, the DNO and Ofgem would agree a specific storage uncertainty mechanism in the DNO's price control. This could be specifically focused on the drivers of storage value that are beyond the DNO's control.

3.4. Secure Capacity Windows & Tolling Contract Terms

If the asset is to be commercially controlled by a third party (with or without operational control), as is the case in the two lead business models, the DNO and third party will need to

agree in advance the terms of the contracted Secure Capacity Windows and tolling contract terms. A summary of the expected headline contract terms for the two lead business models was given in Sections 3.1 & 3.2.

The Secure Capacity Windows would define the capacity and time that would be required by the DNO, with the balance of capacity and time being available to the third party to use the asset. An increase in time available to the third party is likely to increase the value of additional value streams, although this increase may be small if overriding restrictions remain. To ensure minimal value losses to the ancillary services the contracted Secure Capacity Windows should be carefully considered, balancing security of supply obligations while maximising the asset's utilisation. For example, one model is that the DNO has a right of override at any point, to ensure that security of supply requirements are met. However, this availability uncertainty for the third party is an additional risk that could result in increased commercial risk premiums.

Similarly, if the third party had operational control of the asset the DNO could include in the contract set diurnal Secure Capacity Windows that are to be available for the duration of the contract. This option would, however, likely result in significant ancillary service value losses as these Secure Capacity Windows would be unavoidably conservative, as was shown for the example terms of the lead business models in Sections 3.1 & 3.2.

An optimal scenario that could evolve as all parties become more familiar with the assets operation would be a dynamic reporting of the asset's Secure Capacity Windows at a day and month ahead frequency coupled with aggregation of the storage assets into a wider portfolio. This would limit the conservatism in the Secure Capacity Windows and ensure minimal ancillary revenue stream value losses. A summary of the alternatives to the tolling contract terms as penetration of EES assets increase, technology learning increase and the business models evolve is given in Table 12.

Table 12 Alternatives to Tolling Agreement Headline Terms

Terms	Tolling Contract Term Alternatives
Secure Capacity Window	<p>The Secure Capacity Windows are expected to be conservative to begin with, but with increased project learning would expect to be rationalised over time, for example;</p> <ul style="list-style-type: none"> • A minimum availability could be contracted in advance as a baseline. This could be reviewed at set periods over the project contract and rationalised where possible as all parties become more familiar with the asset's operation. • Forecasting and contracting of security requirements could increase in frequency to month, or week ahead reporting, allowing more active real-time control of the asset and avoiding unnecessary value losses. • The Secure Capacity Window could be aggregated for a number of assets across a wider storage portfolio.
Contract Tenure	<ul style="list-style-type: none"> • Contract tenures are presently limited by technology life-times, but as EES technologies improve so would the contract tenures expect to increase. • Short term rolling contracts may be favourable to some third parties. • Long term contracts across portfolios with asset replacements at the end of their technological life-time would also be possible and may also be favourable to other third parties.
Generation Capacity	<ul style="list-style-type: none"> • As with the Secure Capacity Windows, the reporting of the generation capacity could become more dynamic and reported closer to real time as project party's familiarity of the asset's operation improves. • Portfolio effects would increase the assets redundancy when discharging for ancillary services (i.e. risks of not meeting their obligation would be mitigated by capacity from other available assets). • The available generation capacity would increase, reducing ancillary revenue stream value losses.
Operational Constraints	<ul style="list-style-type: none"> • As technology performance improves, so would operational constraints be expected to be less onerous. • Again increasing the available generation capacity and reducing ancillary revenue stream value losses.
Third Party Dispatch Notice	<ul style="list-style-type: none"> • With increased project learning and economies of scale (as other assets are built) dispatch would be agreed closer to real time to avoid ancillary service value losses. • With portfolios dispatch notices could become area specific, allowing multiple storage assets to discharge in part (or in full) in unison.
Tolling Charges	<p>Alternative tolling charge arrangements could be used, such as;</p> <ul style="list-style-type: none"> • A payment indexed to the asset's ancillary revenues. • Discounts on the revenues of respective ancillary revenue streams (with or without a floor price).
Non-performance Penalties	<ul style="list-style-type: none"> • These non-performance penalties would not be expected to change over the project contract. • However, security of supply forecasting and technology performance would be expected to improve, along with the third party's ability to effectively manage the ancillary services, thus decreasing the likelihood of the third party accruing these punitive charges.

3.5. Comparison & Conclusions

Our review of the two lead business models presented for consultation suggests that both the DNO Contracted and Contracted Services models are viable models for distribution-connected storage. In the high level qualitative scoring, both models perform relatively well against most criteria.

The two lead models are compared below under the groupings from the qualitative assessment criteria.

Security

The DNO Contracted model gives the DNO robust confidence in availability through direct control over the operation of the storage, and can ensure that the third party instructions do not compromise the use of the storage to manage network constraints when required (assuming that the contractual obligations do not prevent this). The security provided by the Contracted Services model is dependent on the contractual obligations placed on the third party, and how it meets those obligations. Whilst not as direct as operational control, this model could provide sufficient security if the terms are well structured.

Asset value, cost and risks

Both models place the optimisation of the value streams with a third party which is likely to have a more developed set of skills and capabilities to generate value from the storage without imposing high costs of trading. Both models also depend on a well-structured tolling contract that gives as much availability to the third party as possible without compromising security.

Both models depend on a third party's willingness to take long term risk on the additional value streams. However, under the DNO Contracted model there is more flexibility for the DNO to share some of this risk if required, and if the DNO can take some merchant exposure.

A relative advantage of the DNO Contracted model may be a lower cost of capital. However this may not persist as the deployment of storage increases. The DNO Contracted option creates the possibility of sharing the risk and additional benefits with Customers (if this was considered desirable for Customers), whereas this is not easily possible with the Contracted Services model.

Wider benefits

Under both models, the tolling contract will clearly specify the terms on which capacity is made available. There is a risk that the full benefits for the GB system are not captured due to a lack of flexibility in these terms.

The DNO contracted model allows for competition between third parties in the provision of trading and aggregation. The third party has the ability to transfer the knowledge and expertise to develop projects in other DNO licence areas. Under the Contracted Services model, the third party can also transfer experience of building and operating storage, and there is the potential for further competition in the provision of these services.

Under both models, the DNO is able to set terms of the technology considered, to ensure that a low carbon solution is procured. It is likely that a Contracted Services model would be less prescriptive in terms of technology choice.

Future proof

Both models allow for aggregation across multiple assets by the third party; however this is limited by the restrictions imposed by the Secure Capacity Windows. A large number of storage assets with similar Secure Capacity Windows could be easily aggregated, but if these are all distinct this may be less effective. The Contracted Services model may be more scalable, with one third party able to operate and aggregate storage across multiple DNO licence areas.

From a regulatory perspective the DNO Contracted model could face barriers as the DNO approaches its present de minimis threshold for non-distribution activity.

The DNO Contracted model may allow the DNO flexibility in the long term location of the storage, with the ability to redeploy the asset to a new location (e.g. after full reinforcement at a current location). However, the DNO may require regulatory approval to dispose of the asset to a third party, which it might wish to do if the storage no longer had significant value in terms of network support and could not be economically redeployed. Under a Contracted Services model there would be no such restrictions but relocation of the asset to support the network in a different location would be more challenging.

Conclusions

Based on our review of the lead models, both the DNO Contracted and Contracted Services appear to be feasible

business models for distribution-connected storage. The key barriers for these models are shared: the complexity of the tolling contract, and the willingness of a third party to take long term risk on the additional value streams.

3.6. Consultation Questions

The questions that we invite interested parties to submit written evidence and analysis on are as follows:

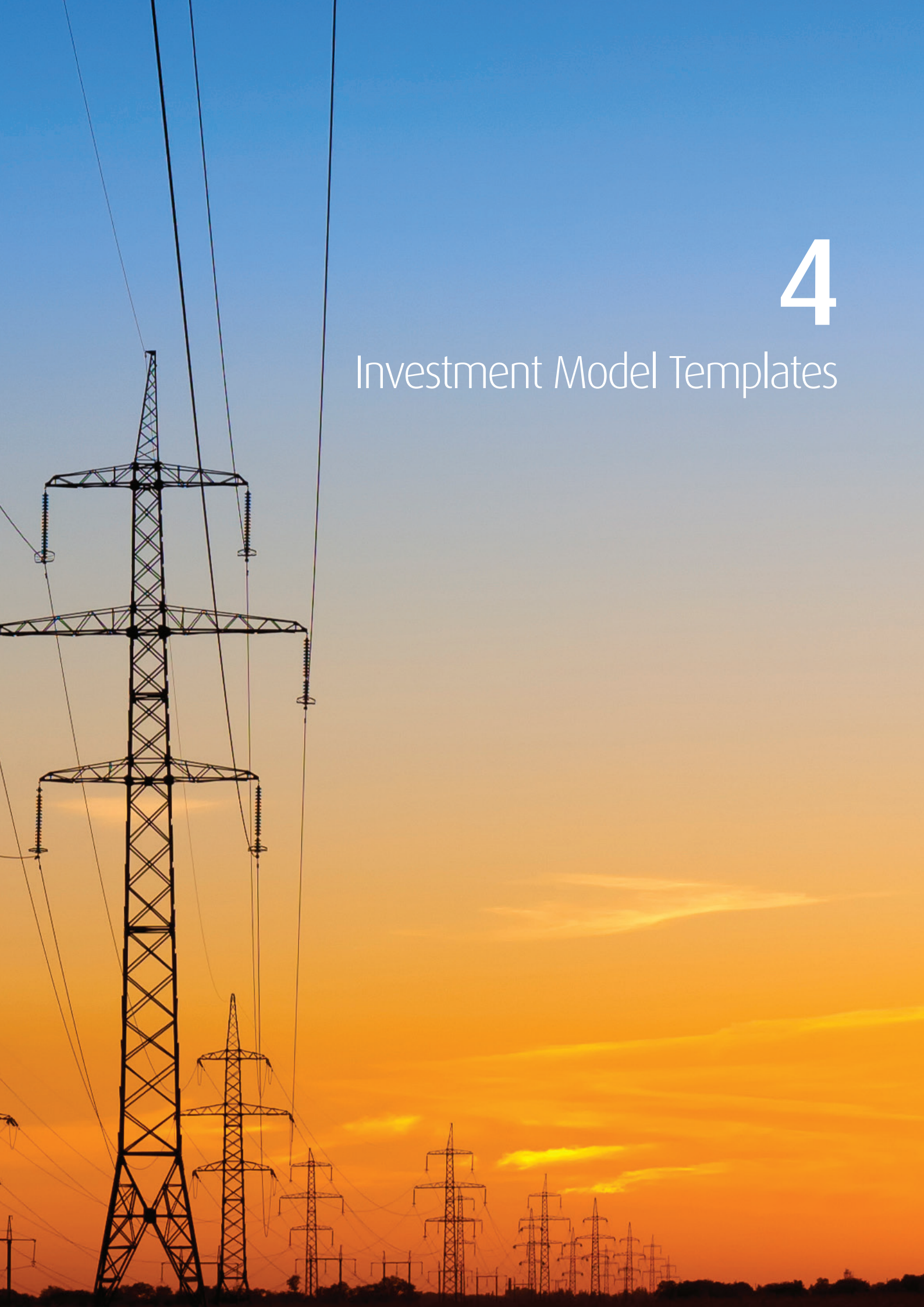
5. Do you agree with the respective advantages and disadvantages of the two lead business models as described in Section 3?

- a. Are there other limitations, barriers or features of these business models, or EES projects in general that have not been considered?
- b. Do either of these lead business models disproportionately favor one party over the other?

6. From your experience, which of the two lead business models is most likely to be favoured?

4

Investment Model Templates



To aid the Consultation process an investment model template describing possible business models for distribution-connected energy storage applications was developed. This investment model template is available from UK Power Networks and is being issued in conjunction with this Consultation document to allow further discussion and constructive feedback on the Consultation.

4.1. Template Introduction

The investment model template examines the investment cases for the two lead business models, namely the DNO Contracted and Contracted Services models. A third “Project Model” has been developed in the template as a party agnostic, hypothetical reference case model against which the investment models for the two lead business cases can be benchmarked.

The investment model template should be used by interested parties to further investigate the two lead business models described and characterised above. The investment model template firstly allows users to investigate in detail the magnitude and interrelations of cost, profit and risks as they accrue to the different project parties in the different business models.

Secondly, interested parties can input their own project parameters to explore these interrelations for their own project specific EES cases (the investment models are generic as far as is possible but are designed for projects falling within the scope of this Consultation as defined in Section 1.3). As direct comparisons can be made between the three business models users can then test the sensitivity of the indicative financial performance of their project. The project’s financial performance can be assessed further for the respective project parties for different input parameters across the three business models. For example, different life-time asset utilisation splits,

price projections and storage performance scenarios can be easily populated to show the sensitivity of the key performance indicators (for each project party) to these respective parameters. It should be noted that the model has been issued with default input parameters, but these are notional and should be updated with project specific values before users appraise and compare their own business cases.

Finally, the model calculates the feasible range of cumulative tolling charges between the DNO and Third Party that would give each of the project parties positive net present values (NPVs), effectively defining a max and min tolling charge that would still make the project profitable for both parties. The actual user defined tolling charge is then compared against this feasible range to assess if the profit/cost split is weighted towards one party or another (The tolling charge is the total charge made over the life time of the project by the third party to the DNO in the case of the DNO Contracted model, and from the DNO to the third party in the case of the Contracted Services mode (See Section 3.4 for a definition of tolling charge terms)).

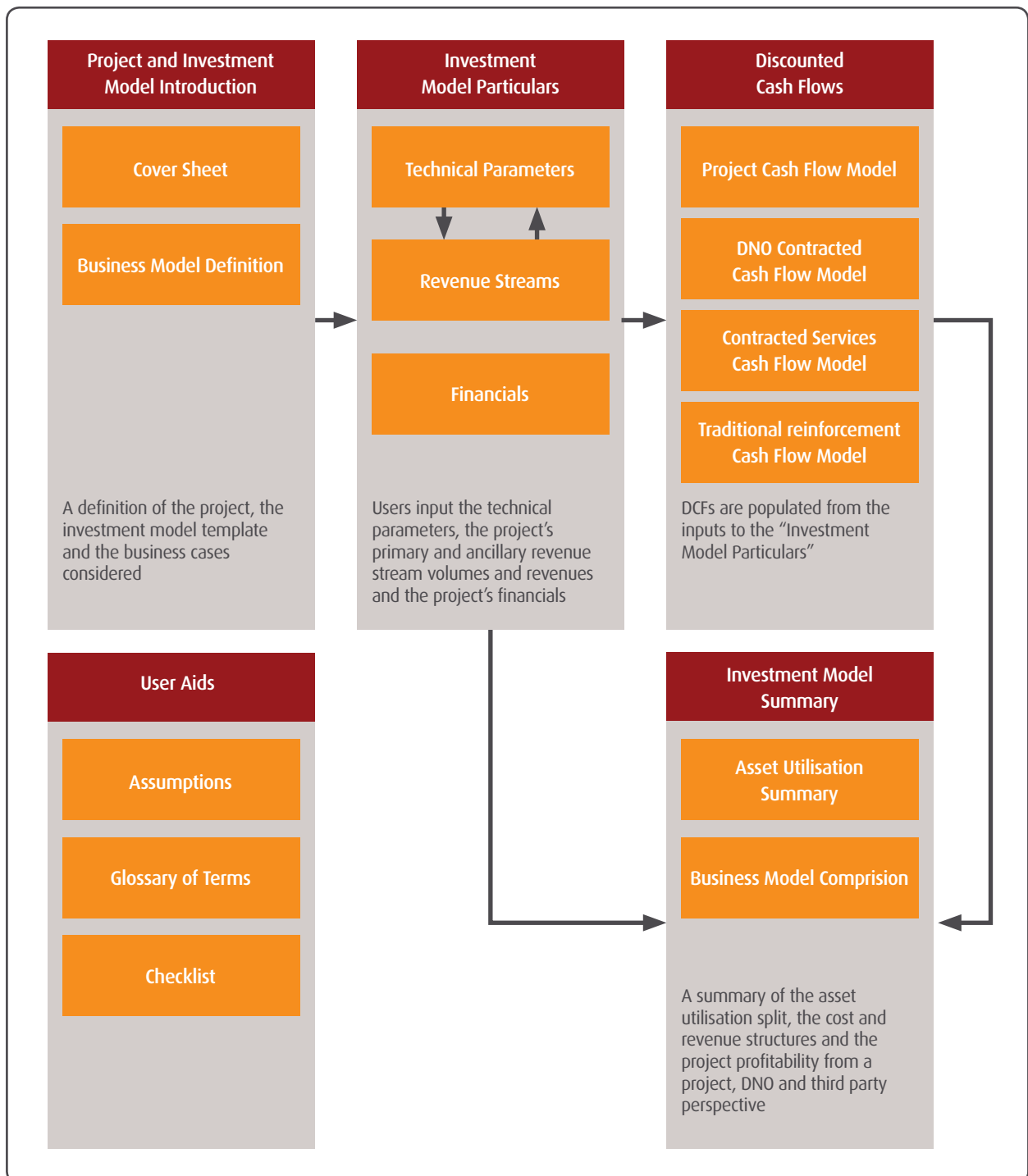
4.2. Model Specification

A summary of the model structure, the inputs parameters, calculations and outputs is given below. The main assumptions that were made when preparing the model along with its inherent limitations are also stated.

4.2.1. Structure

The investment model template is split into four main sections with supplementary user aids where applicable. A high-level summary of these four main sections along with their interrelations is given in the model schematic given in Figure 14.

Figure 14 Investment Model Template Schematic



The “Cover Sheet” and “Business Model Definition” sheets introduce the Consultation process and the characterisations of the three models explored in the template. Similarly, the “Assumptions”, “Glossary of Terms” and “Checklist” sheets define the main assumptions, the nomenclature used and a quality assurance (QA) check of the users’ inputs to the model.

Users are firstly asked to input the model parameters in the main body of the template. The model parameters comprise the technical particulars and the capital and operational costs in the “Tech Parameters” worksheet, the revenue streams in the “Revenue Streams” worksheet, and the financing options, gearing and debt terms in the “Financing” worksheet.

These inputs are then allocated as revenues and costs as they accrue to the respective project parties in three discounted cash flow (DCF) sheets. To disaggregate the cost and revenue splits for the project parties the DNO contracted and Contracted Services DCFs are further split into two separate DCFs for the DNO and third party respectively, giving 5 DCFs in total (1 for the Project Model and 2 each for the DNO Contracted and Contracted Services models). There is also a separate simple DCF model for the traditional reinforcement option, which is used as a counterfactual comparison.

The results of the model are then summarised in two output sheets. The technical performance of the asset and its utilisation split for the users’ input parameters are summarised in the “Asset Utilisation Smry” sheet. Then, a comparison of the financial performance and the net present values (NPVs) for the different project parties

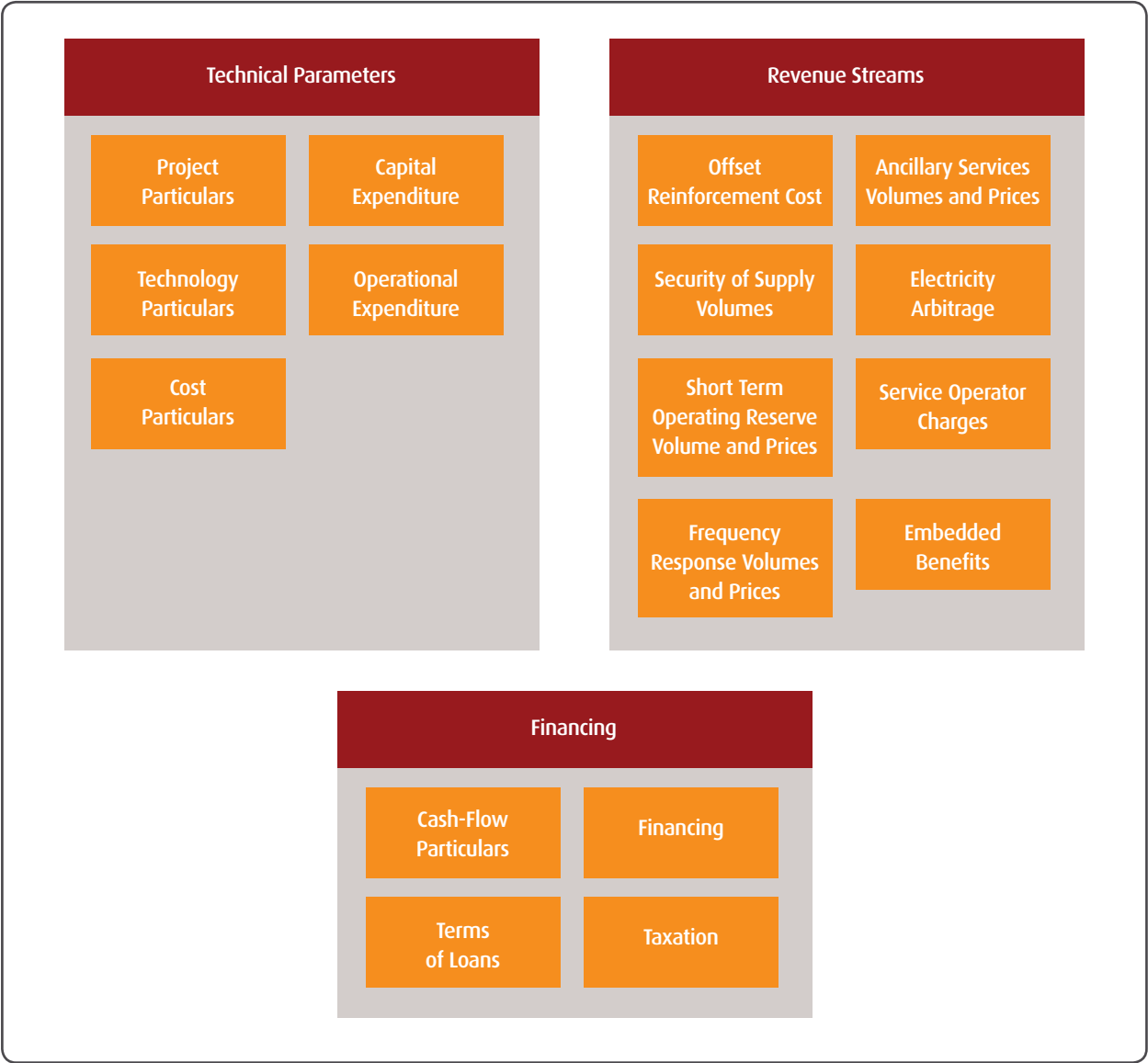
for the three business models is given in the “Business Model Comparison” sheet. This sheet also summarises the total costs and revenues as they accrue to the respective parties, along with the profitability of the different business models, once again split for the different project parties. The Business Model Comparison sheet also calculates the range of cumulative tolling charges for which all parties would have a positive NPV (i.e. the maximum and minimum total tolling charge that can flow between the DNO and the third party over the life time of the project for the project to still be profitable for both parties).

4.2.2. Inputs

A legend of the template’s cell types including the cells which users are required to input values for is given in the template cover sheet. For indicative purposes only these cells have been populated with notional values throughout the model as it is issued. These default values are not representative of any empirically based real case scenario and as such users should input their own project specific values (See Section 4.2.5).

A check list of the parameters that users are asked to input values for, along with the level of detail (or granularity) to which the users are asked to input for each of these parameters is given in the “Checklist” worksheet. The definitions of these parameters are included in the Glossary of Terms sheet for reference. Users are asked to complete this checklist to satisfy themselves that they have inputted their own parameters for each of these inputs before using the model to appraise and compare business cases. A high level summary of the model’s input categories are given in Figure 15.

Figure 15 Model Input Categories

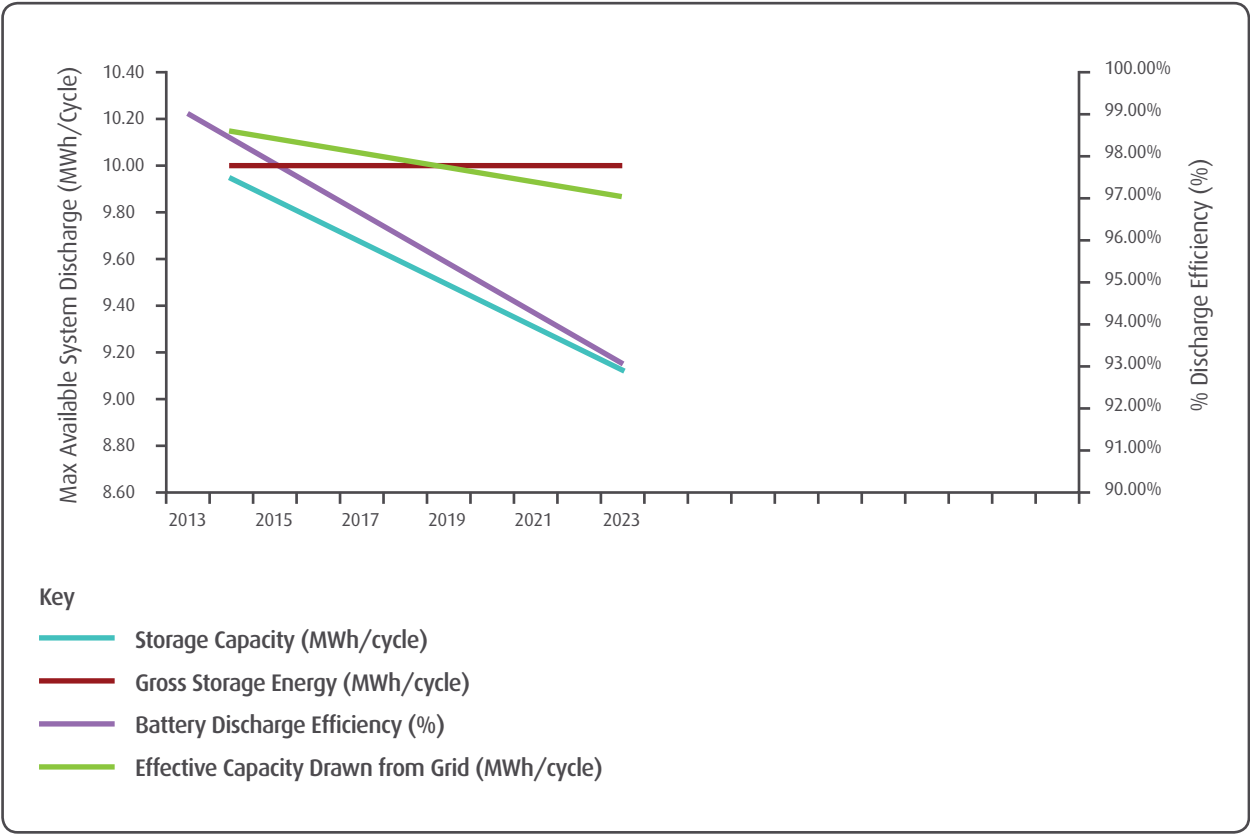


4.2.3. Calculations

Firstly, the inputs are used to calculate the net available capacity of the battery with respect to its charging volume and duration of discharge. The technology’s discharge coefficient, operational depths of discharge, system inefficiencies, and storage degradation are then used to calculate the overall system efficiency and the corresponding discharging volume and duration. A summary of the inefficiencies and their effect on the overall system efficiency is graphically shown in the Tech Parameters worksheet, an example of which is given in Figure 16. Technical unavailability is due to maintenance outages and unscheduled fault repairs. This may represent an estimate of

effort required or, in the case of the Contracted Services model or a maximum agreed level in the contract before penalties are activated. Balance of plant losses refer to the energy lost in the charge and discharge cycles and which is measured at the final point of connection to the DNO network, including losses in step-up and step-down transformers for example. Notwithstanding the fact that losses may be reduced elsewhere on the network as a result, the losses are included here in order to reduce the “name plate” capacity of the device to a level that is consistent with the revenue streams.

Figure 16 Generation Capacity and System Inefficiencies



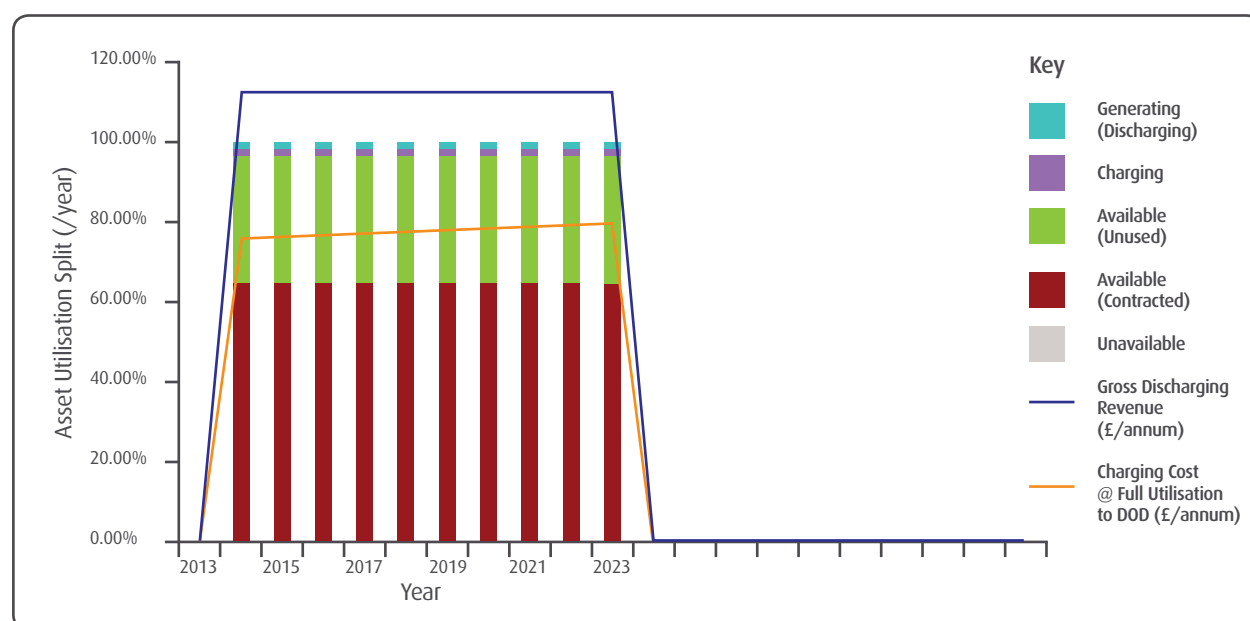
These revenue streams and their associated costs feed into the DCFs along with the project's CAPEX and OPEX, debt repayment costs and tax payments. The DCFs allow users to front load payments and index price inflation if necessary. As mentioned previously, DCFs are populated for the different project parties in the two lead business models to allow comparisons of the cost, profit and risk profiles across the project parties for the different business model options.

Figure 17 Asset Utilisation Split Summary

The investment template does not attempt to calculate the impact on the DNO's Regulatory Asset Value (RAV). We assume any incentive to favour storage over traditional reinforcement or vice versa would be neutralised under a well-designed price control.

A technical summary of the system's utilisation split is presented in the Asset Utilisation Summary worksheet. The asset's utilisation is split according to the system's availability, unavailability and charging time per year, along with the time that the system is both available but contracted and when it is exporting (discharging) for each of the revenue streams. The asset utilisation split is a function of the technical performance of the asset and the number of hours of utilisation that the user has inputted for each of the primary and ancillary services. An example of the graphical output of the model is shown in Figure 17.

Figure 17 Asset Utilisation Split Summary



The second output sheet, which is the “Business Model Comparison” sheet, firstly considers if the SNS option is more cost effective than traditional reinforcement. The model compares the unadjusted net present value of the storage option (the cost of storage) against the traditional reinforcement cost. An example output is shown in Figure 18 below;

The cumulative cash flows are then assessed for the projects’ overall commercial viability in the case of the Project model, and

for the commercial viability from the perspective of the differing project parties in the case of the DNO Contracted and Contracted Services models. For the DNO, the discounted cumulative cash flows are plotted against the offset reinforcement cost to check if the cumulative cash flow at project end (the NPV) is less than the offset reinforcement cost (similar to the first output above). For the third party, the cumulative discounted cash flows are plotted over the lifetime of the project to assess if the cumulative cash flow at the project end (the NPV) is positive as shown in Figure 19.

Figure 18 Traditional Reinforcement and Storage Option Cost Comparison (£)

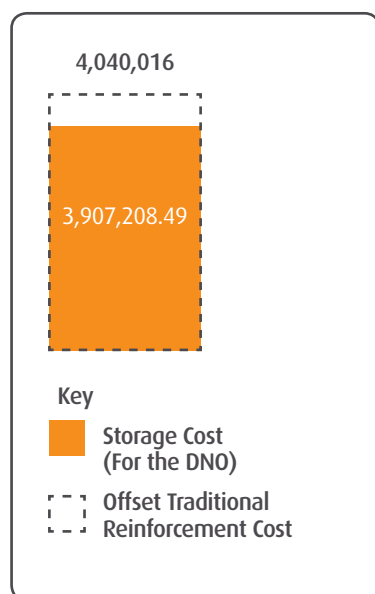
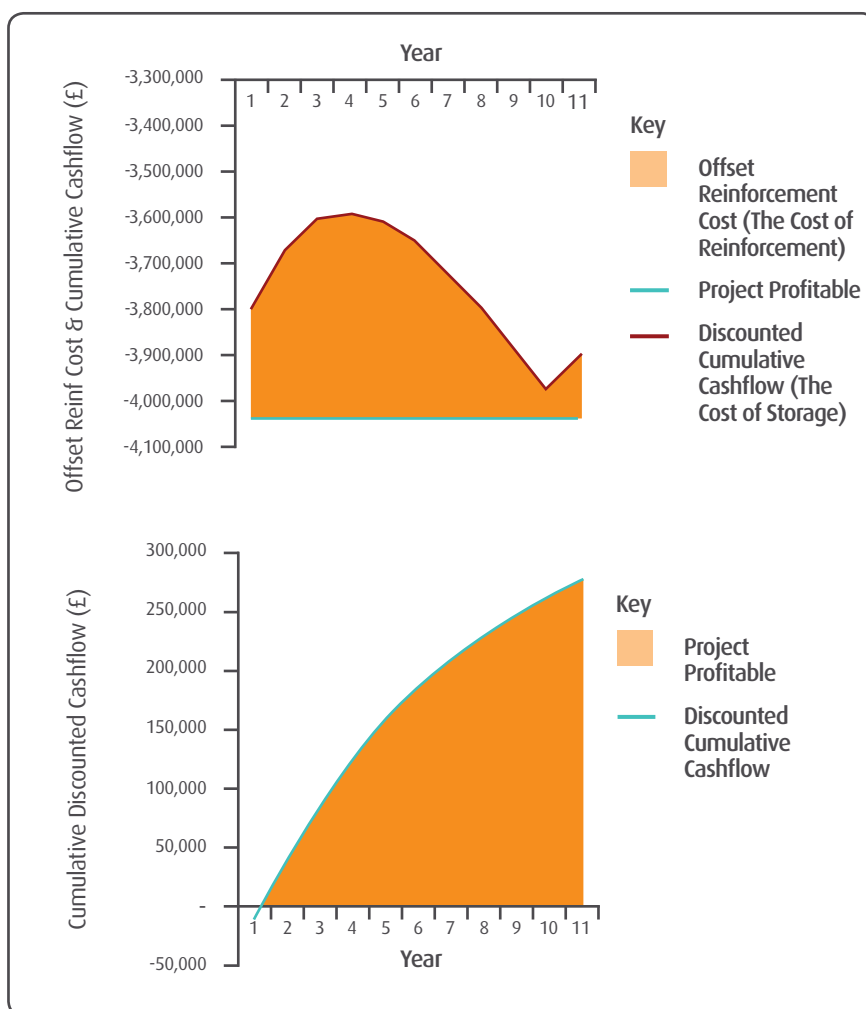


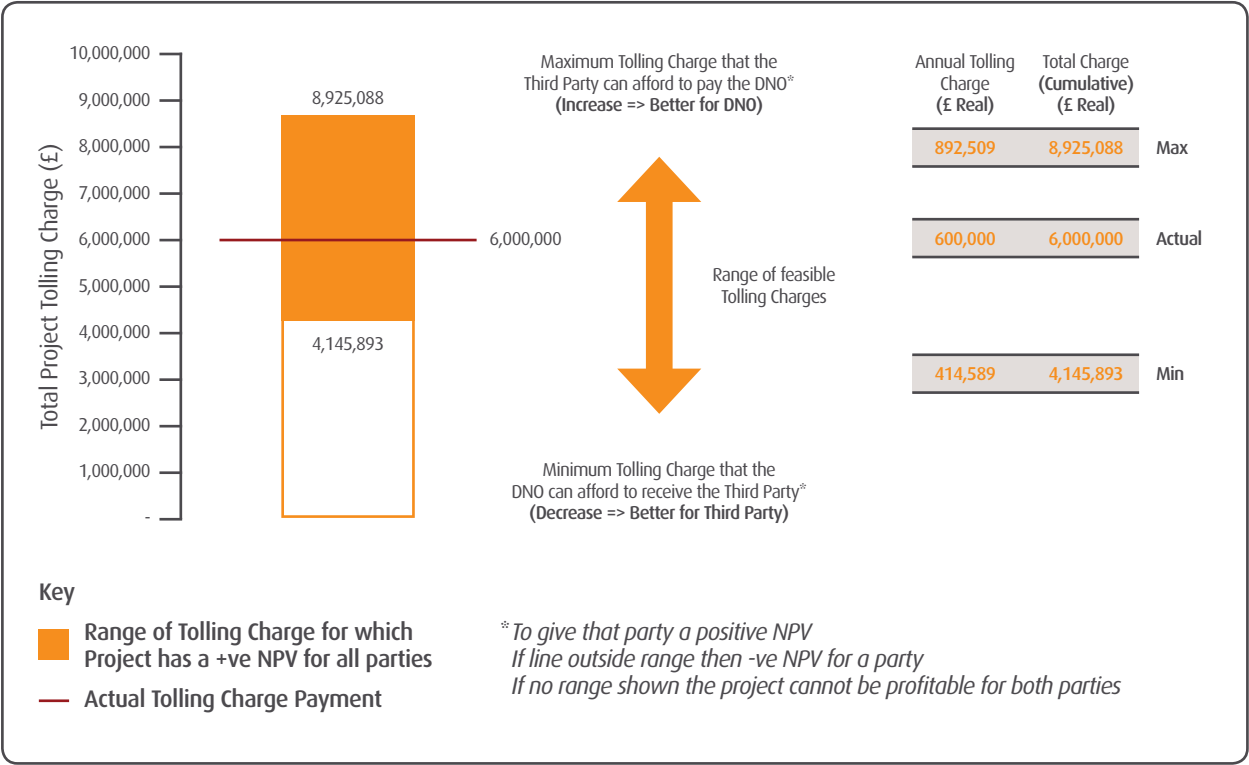
Figure 19 Project Profitability Checks



The Business Model Comparison sheet also allows users to run a macro that calculates the range of tolling charge that would give positive NPVs to all of the respective project parties (i.e. goal seeking the yearly tolling charge to find an NPV of zero). The tolling charge is the total charge made over the life time of the project by the third party to the DNO in the case of the DNO Contracted model, and from the DNO to the

third party in the case of the contracted services model. The actual tolling charge is then plotted on this range of feasible tolling charge to assess if the profit/cost split is weighted towards one party or another, or if the actual tolling charge is outside the feasible range (i.e. one of the parties has a negative NPV). A sample case for the DNO contracted model is given in Figure 20 below;

Figure 20 Range of Feasible Tolling Charges (Cumulative over life-time of project)



4.2.5. Assumptions

All technical, utilisation and price assumptions that are used in the model's calculations are inputted as model parameters by users. However, the following additional assumptions have been made in the investment model template;

1. **In the DNO Contracted Model (in addition to the model characterisation given in Sections 2 & 3);**
 - a. CAPEX is accrued to the DNO
 - b. OPEX is accrued to the DNO (with the exception of the "Control systems, trading & risk management" OPEX which accrues to the third party)
 - c. Embedded benefits (i.e. avoided TNUoS and BSUoS charges, and savings in transmission and distribution losses) are accrued to the third party
 - d. Capacity payments are accrued to the third party
 - e. The tolling charge is paid annually by the third party to the DNO and is a fixed sum that can be indexed and front-loaded if necessary
 - f. The DNO sees the benefit of the offset traditional reinforcement cost as a counterfactual
 - g. The impact on the DNO's Regulatory Asset Value (RAV) is not calculated.
2. **In the Contracted Services Model (in addition to the model characterisation given in Sections 2 & 3);**
 - a. CAPEX accrues to the third party
 - b. OPEX accrues to the third party
 - c. Embedded benefits (i.e. avoided TNUoS and BSUoS charges, and savings in transmission and distribution losses) are accrued to the third party
 - d. Capacity payments are accrued to the third party
 - e. The tolling charge is paid annually by the DNO to the third party is a fixed sum that can be indexed and front-loaded if necessary The DNO sees the benefit of the offset traditional reinforcement cost as a counterfactual.
3. **All values are real unless otherwise stated to be nominal (i.e. CAPEX, Tax and Debt in DCFs are nominal).**
4. **It is assumed that the DNO can transfer the incremental tax loss benefits internally, as such these are considered as a post EBITDA benefit in the DCF. This option can be switched off, in which case these benefits are accrued within the project.**
5. **The NPV of traditional reinforcement cost is separately calculated and then used as a counterfactual . Users are asked to input the CAPEX of the traditional reinforcement, and the terminal value at the end of the economic assessment period.**
6. **As the STOR service is typically contracted in two split diurnal periods it is possible that the asset is called during both of these periods. If this were the case the asset would need to charge during the day between these two cycles. Accordingly the electricity price for charging for use as STOR is the average day time price, as opposed to the off-peak night time low price for the rest of the ancillary services.**
7. **This model has been constructed for GB specific cases.**
8. **The reporting currency is assumed to be GBP Pound Sterling (£).**
9. **UK Corporate tax rates can be defined by the user, but have been assumed in the model to be as per the HMRC published figures (<http://www.hmrc.gov.uk/rates/corp.htm>).**
10. **The model assumes all senior debt drawn down at once in development start year.**
11. **The depreciation rate is as per; http://www.hmrc.gov.uk/capital_allowances/investmentschemes.htm General rates of capital allowances section (can be changed by user).**
12. **The model assumes a single charge/discharge rate for all services per day, therefore the model cannot differentiate for different charge/discharge rates for different services.**
13. **The model cannot be used retrospectively on projects commencing before 2013.**
14. **The max project lifetime allowed for in the model mechanics is 20yrs (input as 12yrs as a default).**
15. **Gearing ratios outside a 20-50% range give a user warning.**
16. **Years refer to financial years.**
17. **Self-discharge loss calculation assumes half of battery capacity stored per cycle.**

18. A single asset is considered in the model. Models may exhibit different characteristics if a portfolio were to be considered.
19. Constant and symmetrical charging and discharging across all services is assumed. This means simultaneous services cannot be modelled.

4.2.6. Limitations

The following limitations apply to the investment model template and should be considered by users before using it:

1. The investment model template is a learning aid issued for illustration and comparison purposes only. The template should not be used under any circumstances as the primary investment model for any EES project or otherwise.
2. While the investment model template has been prepared for a specific application type it is still inherently a generic investment model, and as such cannot account for every eventuality and permutation that may arise in specific EES projects.
3. For illustrative purposes the model as it is issued has been populated with default values for the model's input parameters. These default values are not based on empirical real case values and as such cannot be used to appraise project specific cases (The model has an in-built functionality to clear all these user defined inputs and to then check that the user has inputted values for all the required input parameters).
4. The default input financing terms (debt terms, discount rates, gearing and WACC) are indicative only and would need to be inputted by users.
5. The model uses a peak/offpeak spread for the value of energy arbitrage, and does not capture the full volatility of wholesale prices.

4.3. Business Model Insights

4.3.1. DNO Contracted Model

In the DNO Contracted model the DNO finances the construction of the asset and its annual operation, accruing the project CAPEX and

OPEX. The model allows the flexibility for the DNO to finance this through a mixture of debt and equity. The third party on the other hand would only accrue the annual costs required to operate the asset's ancillary services. These are described as "Control systems, trading & risk management" costs in the model. The third party would then instruct the DNO on the operation of the asset to and when to contract (or dispatch) the asset for ancillary services. The third party would accrue any revenue from the utilisation of the asset for these ancillary services. The third party would then return an annual tolling payment to the DNO as a payment for utilising the DNO's asset. The DNO also considers the offset traditional reinforcement cost when calculating their adjusted NPV.

Populating the investment model template with a range of notional values and scenarios allows users some useful insights into the differing interrelations of cost and revenues as they accrue to the project parties in the DNO Contracted model. Most notably, as the tolling charge in the DNO Contracted model does not contribute as large a proportion of the project cash flow as in the Contracted Services model, the NPV of the project is not as sensitive to the terms of the tolling charge agreement (i.e. there is a greater calculated range of possible tolling charges).

Also, the DNO Contracted model tends to give the third party a short payback but a lower NPV compared to the Contracted Services model (i.e. they do not accrue the CAPEX and OPEX costs and have minimal commercial risk).

In both models, there is an inherent and unavoidable constraint on revenue generation during the periods where the DNO requires the asset to be available for security of supply services, the Secure Capacity Windows.

4.3.2. Contracted Services

In the Contracted Services model the third party now finances the construction of the asset and its annual operation, accruing

the project CAPEX and OPEX. The third party would be expected to require some debt financing and would accrue these debt and interest repayments. The DNO would accrue none of the project's CAPEX or OPEX but instead would pass an annual tolling payment to the third party, now in the opposite direction to the DNO Contracted model. The third party, in addition to receiving this tolling charge payment from the DNO would also accrue the revenues from the ancillary benefits which it would dispatch the asset for. The third party also accrues any embedded benefits and capacity payments as they have full ownership and operational control of the asset. The DNO's cash flow is simpler than in the DNO contracted model with the tolling charge being their only cost, and the offset traditional reinforcement cost their only benefit.

Again, populating the template with notional values and scenarios allows users some useful insights. As the economic benefits of the offset traditional reinforcement cost does not accrue to the party who is making the investment, the third party, there is a need for a corresponding tolling payment to the third party. This, in the case of the DNO Contracted Model would be a payment from the DNO to the third party. While this does not differ in principle to the offtake agreement and payment in the DNO Contracted model, it is the value of this additional revenue stream to the overall investment case of the DNO and third party that is materially different (effectively, the tolling charge needs to cover the CAPEX when it accrues to the third party).

The corollary to this is that the DNO avoids the upfront expense of financing the asset, and spreads it over the lifetime of the project as tolling charge payments to the third party.

The Contracted Services Model gives a longer payback for the third Party than the DNO Contracted Model, but a larger NPV (i.e. they need to pay back the large project CAPEX and would expect larger financial benefits for carrying the project's commercial risk).

As in the DNO Contracted model there is again an inherent and unavoidable constraint on revenue generation during the periods where the DNO requires the asset to be available for security of supply services.

4.4. Consultation Questions

The questions that we invite interested parties to submit written evidence and analysis on are as follows:

7. **Are there other technology parameters, costs or revenue streams that should have been considered in the investment model template?**
 - a. If so please give details
8. **Do you agree with the interrelations of these ancillary services and their associated revenue streams?**
 - b. Are there additional complexities in the dispatch of the asset to utilise these revenue streams that haven't been considered? Are they all mutually exclusive or potentially dispatchable in unison, are there additional complexities in the knock-on effect to battery performance that have not been considered?
9. **Do you agree with the stated assumptions and model limitations?**
 - a. Should any of these stated assumptions or limitations have been dealt with differently?

The background of the entire page is a photograph showing the silhouettes of several high-voltage electrical transmission towers and power lines. The towers are lattice-structured and stretch across the frame from the bottom left towards the top right. The sky is a gradient of colors from a deep orange at the bottom to a pale blue at the top, indicating a sunset or sunrise. The power lines are thin and crisscross the sky. At the very bottom, there is a dark silhouette of a line of trees, possibly palm trees.

Appendix 1

The Value of Storage

Local Security of Supply (SOS)

When the storage asset is required to meet local SoS obligations the storage must be available with a set charge when called. It should be noted that the storage does not need to export in order to fulfill the security requirement, but the capacity must be available and the storage must have enough stored energy to cover the peak period if required. The storage asset will provide security if it is actively exporting. This could occur if there was additional value to exporting power (e.g. energy arbitrage). In this instance it will be important to ensure that the security requirement was met throughout the security requirement period. Similarly, depending on the storage asset type and its operation the constraint could also be relieved if the asset were to stop charging if it were being charged at the time of the constraint.

If a fault does occur on the local network at the time when peak demand exceeds firm capacity, the storage will be required to discharge until the demand drops to a secure level, the normal capacity is restored, or the storage is fully discharged. This would take precedence over all other uses.

Firm Frequency Response (FFR)

Frequency Response is the automatic provision of increased generation or demand reduction in response to a drop in system frequency. This can be further subdivided into three types of response:

- **Primary response** is defined as an initial increase of generation, with sustained output from 10 seconds to 30 seconds following a loss of 0.8Hz.
- **Secondary response** is defined as an increase in generation, in response to system frequency still being lower than target frequency, with sustained output from 30 seconds to 30 minutes for a loss of 0.5Hz.
- **High response** is defined as a decrease in generation, in response to system frequency being higher than target

frequency, which is achieved 10 seconds from the time of the Frequency change and is sustained thereafter.

The requirement for Frequency Response is created by demand forecasting uncertainty, the loss of generation from the system and increasing wind generation forecast uncertainty.

The type of Frequency Response which would be provided by the storage is Firm Frequency Response. Mandatory frequency response is an alternative market that is required to be provided under the Grid Code by all sufficiently large generators. An energy storage device is also eligible to provide Frequency Control by Demand Management (FCDM), which is aligned to providers of frequency response from demand Customers, but is also suitable for storage, and the bilateral contracts can be applied to both positive and negative response.

Short Term Operating Reserve (STOR)

STOR is one source of reserve for the GB System Operator, National Grid Electricity Transmission. Reserve is required for the following reasons:

- **Demand forecast errors:** Most end users of electricity do not need to provide any statement of their intended usage and so electricity demand is uncertain and actual demand is often quite different to forecast even quite close to real time.
- **Unexpected loss of thermal generation:** The largest infeed loss is currently the nuclear unit at Sizewell B. The larger capacity of the new nuclear stations once they come online will lead to an increase in STOR capacity.
- **Variable wind generation:** Output from wind capacity is inherently variable and unpredictable even close to real time. Therefore reserve is required to deal with situations where wind generation is lower than expected.

STOR is capacity that National Grid retains on stand-by that can be called on to export within four hours of instruction (with a

focus on <20min). The STOR service retains spare generation capacity on stand-by during certain hours of the day (typically periods when demand is changing rapidly). There are two categories of STOR:

- **Committed** providers must be available in all of the required availability windows in each season they are contracted.
- **Flexible** providers are not obliged to offer services in all availability windows and National Grid is not obliged to accept the service when offered.

STOR is open to both Balancing Mechanism (BM) participants (generally transmission connected generation from large power station sites) and non-BM participants (generally small transmission or distribution connected generation and demand). However BM participants must be 'committed' providers of STOR generation. Distribution scale storage would be most likely to be a non-BM flexible provider (although it may be possible to commit for certain STOR).

Energy Arbitrage

Energy arbitrage is the trading of wholesale electricity to benefit from the spreads between prices at different times. This typically involves buying power cheaply overnight and selling it at peak when prices are higher. As the volume of intermittent generation increases in future, the volatility in prices is likely to increase and timing of highest and lowest prices may be more variable.

Energy arbitrage requires the spread in prices to be great enough to offset the cost of lost power due to the efficiency of the cycle (charging and discharging the asset). Another consideration is that multiple charging cycles have an impact on the lifetime of the battery, which should be accounted for in the dispatch decision.

In theory distribution-connected EES could discharge over the peak period and still provide security, but this would require careful control to ensure that the remaining energy in the

storage is sufficient to cover expected and unforeseen changes in demand over the peak period.

Embedded Benefits

"Embedded generation" is electricity generation that is connected to the local distribution network rather than directly to the transmission network. Being embedded in the distribution network may allow parties to avoid various costs, which are termed "embedded benefits". The major categories of avoided costs associated with embedded generation are as follows:

- transmission losses
- distribution losses
- Transmission Network Use of System (TNUoS) charges, and
- Balancing Services Use of System (BSUoS) charges.

These embedded benefits may apply to some extent to distribution-connected storage. As the avoided costs associated with embedded generation often accrue directly to the supplier rather than the generator, embedded storage would need to negotiate with suppliers in order to realise actual embedded benefits.

Other DNO Services

The power control system associated with some EES technologies can provide useful secondary benefits of improved power factor and voltage support, reduced system losses, and power quality enhancement by means of the associated harmonic filters.

Capacity Payments

Under the Electricity Market Reform (EMR) programme, the UK Government is introducing legislation to provide for a future capacity mechanism. To mitigate the risks to security of supply, the Bill provides for new powers for the Secretary of State to introduce a CM to ensure there is enough capacity available to meet expected demand.

The Capacity Mechanism would pay providers of capacity such as generators, storage and Demand Side Management based on the results of a capacity auction. The first auction is planned for 2014 with delivery of capacity in the years 2018/19. It is proposed to hold early trial auctions in 2014 for delivery in 2016 which are targeted at DSM and storage.

Ancillary Service Exclusivity

In most cases the asset's ancillary services and security of supply obligations would be mutually exclusive (i.e. Ancillary services could not be used inside the Secure Capacity Windows). For example, STOR and energy arbitrage if used inside the capacity windows would adversely affect the assets capacity to meet its SoS obligation as both of these ancillary services necessitate the discharge of the asset's stored capacity. As discussed in

the Security of Supply Section, the asset would be required to discharge if a fault were to occur on the local network at the time when peak demand exceeds firm capacity.

However, while the terms of the capacity windows would define how the asset would be utilised it could be the case that for some of the ancillary services when specific storage technology types are used that the asset would not be required exclusively for provision of SoS. For example, in the case of firm frequency response the asset could provide a dual service, providing firm frequency response availability while not adversely affecting its capacity to meet its security of supply obligation. This is possible as the asset when used for firm frequency response is unlikely to be required to discharge significantly, due to the relatively short duration of operation.



