Guidance on the connection of energy storage devices to Western Power Distribution's Distribution System

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

V2 March 2018

Guidance on the connection of Energy Storage devices to Western Power Distribution's Distribution System

1. Introduction

1.1 Renewable technologies such as wind and solar have made a significant contribution toward the UK's Government commitment to moving to a low-carbon economy and to meet carbon reduction and renewable energy targets. These technologies are tried and tested however the proliferation of distributed generation connecting to the distribution system has presented challenges to transmission and distribution network operators in their role of ensuring the electricity system is balanced and operating within technical limits.

1.2 The uptake of generation capability has meant that Distribution Network Operators (DNOs) like WPD now on many occasions have to reinforce the existing network to provide additional capacity, or alternatively, introduce operating constraints on the connecting generator. Reinforcement work can be costly and introduce lengthy delays to connection times.

1.3 Renewable technologies like wind and solar are known as intermittent generation and are reliant on favourable weather conditions. This means that they may generate at a time when no additional power is required on the system and conversely are unable to generate at times when additional power is required.

1.4 Energy storage is not a new technology but its impact has been limited largely due to high manufacturing costs. These costs have fallen over recent years and energy storage is now playing an increasing role in the UK's energy market. Helped by various incentives, the number of connection applications has risen sharply. As at May 2017 WPD had over 2,000MVA of energy storage either connected, committed or offered across its distribution areas.

1.5 The fall in manufacturing costs has meant that energy storage is now not only viable at a larger scale but also for smaller installations including domestic premises thus providing the home owner with the opportunity to optimise the use of electricity within the home.

1.6 This guidance document sets out WPDs views on the role energy storage has to play in the development of our distribution system and help us move towards becoming a Distribution System Operator (DSO) by taking a more active role in managing our network. We have also provided information outlining our current application processes for connecting energy storage.

2. The need for a flexible system

2.1 In November 2016, BEIS and Ofgem issued a joint call for evidence around *'A Smart, Flexible Energy System'*. The document set out their views on the need for change to meet new demands on the energy system. The role of storage and aggregators, demand side response (DSR) for industrial and commercial consumers, and network and system operation are all seen as priorities in the drive to provide a more flexible system and improve the balance of energy generation and consumption.

2.2 The use of advanced energy storage technology is seen as the key to increasing flexibility in the system. In simple terms, it can allow the capture of generated energy when it is supplemental to needs, so that it can be stored and released at times when it is needed, for example, at times of peak demand. It provides the ability to instantaneously balance power supply and demand. It can also support power quality management by controlling voltage and frequency when required under emergency conditions.

2.3 At a smaller scale the use of energy storage at a local level can reduce costs and support local energy markets and microgrids. The Electricity Networks Association (ENA) has issued an Energy Storage Guide for Communities and Independent Developers that provides valuable information in this area. Click here to view the guidance document.

2.4 There are numerous benefits associated with energy storage, these include;

- Additional revenue for generators in the form of increased energy sales and payments for ancillary services
- Deferment in the reinforcement of both transmission and distribution system assets that would otherwise be required to provide additional capacity
- Potential benefits for the end user in the form of reduced energy bills
- Provision of system stability during electricity outages

Because of this, we believe energy storage will have a significant part to play in our efforts to improve system flexibility.

3. The role of energy storage

3.1 There are a number of roles that energy storage can play and we understand that developers will want to maximise the revenue stream opportunities available to them. Some of the service areas that can provide a benefit and are open to the developer are listed below.

Response: The ability to respond quickly (milliseconds – minutes) to grid, frequency and/or price signals. Potential applications include the provision of ancillary network services such as frequency response and voltage support.

Reserve: The fundamental property of energy storage that enables the storage of energy to be used at a time when it is required. From a simple back-up capability for use as an

alternative source of energy, to large scale capacity reserve and Short Term Operating Reserve (STOR).

Price and time shift: The capability to shift energy from lower to higher price/cost periods. A more sophisticated application of both reserve and response functions, allowing energy users and suppliers to take advantage of price variance (price arbitrage), avoid peak transmission and distribution costs and/or to recover energy that would be lost due to network or other constraints.

3.2 The basis upon which a developer may participate in any of the above services will differ. Examples of these are given below.

Short Term Operating Reserve (STOR): STOR is a service for the provision of additional active power from generation and/or demand reduction. NGET will contract for this service as a means of utilising reserved power at certain times of day when actual demand is higher than forecast or perhaps due to plant unavailability.

Capacity Markets: Operators can try to secure a capacity agreement through an auction process to win the right to earn a steady revenue stream in return for delivering energy at times of system stress.

Frequency Response: Operators can provide a service to NGET that enables them to monitor the frequency of the network. Enhanced Frequency Response is the ability for a generator to respond to a signal from NGET in milliseconds. Firm Frequency Response is similar but requires a response in seconds rather than milliseconds. Both of these services can be procured through a tender process.

The above applications are generally only open to larger generation projects.

Price Arbitrage: Users can benefit through 'Price Arbitrage' which allows them to import energy at off-peak times for a low price and export it back on to the network for a higher price. They can also utilise that stored energy at times of peak demand thus avoiding higher costs (peak shaving). This has as additional benefit in that it can enable additional generation to connect to the network that might otherwise necessitate reinforcement work. This will become more viable with the introduction of Smart Meters (due to complete by 2020) and utilisation of 'time of use' tariffs.

3.3 Developers may decide a single benefit approach is not cost effective therefore combining two or more services (stacking) could make a more viable proposition. Combining services however, can bring its own problems in terms of having to ensure they are technically and operationally compatible. Some of the services that can be fulfilled by an energy storage scheme may require additional conditions of connection – i.e. a higher security of supply or increased availability of import and export capacity compared to a conventional distribution connection.

3.4 Energy storage at a domestic level is still in its infancy but as manufacturing costs continue to drop the opportunity to install an energy storage capability will increase. This is particularly attractive where a generation capability such as a solar panel installation is already in-situ.

4. The development of the energy storage market

4.1 The energy storage market is developing rapidly and may well focus on different areas in the future as developers look to maximise revenue streams and refine business models. The market has been dominated by tendering based scenarios such as Enhanced Frequency Response and T4 Capacity Market auctions.

4.2 As the market develops we may see a widening of the initial focus on frequency response, Capacity Market, DSR. We expect that energy storage projects will target other grid and network services such as commercial and industrial (C&I) applications, domestic and small scale energy storage and also co-location with generation and aggregation. We anticipate the deployment of energy storage could evolve as shown below.

Wave 1 - Led by response services (Now-2020)

- Focus on grid and network services (including frequency response & DSR)
- First applications for C&I 'behind the meter' models and co-location
- Domestic and community scale early adopters.

Wave 2 - Co-location business models become viable (Early 2020's)

- Market for C&I high energy users/generators grows rapidly
- Co-location projects with solar PV and wind become viable
- The domestic and community storage market expands.

Wave 3 – Market expansion and new business models (Mid/Late 2020's)

- Price arbitrage and new trading platforms develop
- Storage enables local supply markets, private wire and virtual markets
- Domestic electricity storage becomes common
- Most new solar and wind farms now include electricity storage to harness low marginal cost energy and price arbitrage
- Heat storage and electricity storage are increasingly integrated

5. Assessing opportunities for connection

5.1 Before making an application it may be desirable to find the optimal location to connect an energy storage facility to WPDs distribution system. There will be a number of factors which affect the location of energy storage projects. These include:

- Access to the grid (specifically 132kV and 33 kV substations)
- Proximity to C&I energy demand
- Proximity to new and existing solar PV
- Proximity to other existing generation plant
- Availability of low cost and accessible land space

5.2 WPD has a number of facilities available to help a developer assess the potential to connect some form of energy storage to our distribution system.

Network Capacity Map: provides an indication of the networks capability to connect large-scale developments to major substations. It identifies areas of the network where a connection is more likely to be achieved without significant reinforcement.

DG EHV Heat Maps: provide an overview of our EHV networks (33kV and above), highlighting those circuits that are operating at or near their limits. Constraints are shown as either 'thermal' or 'voltage'

Generation Capacity Register: lists generators connected at 11kV and above that:

- are connected to our network (connected)
- have accepted offers to connect to our network (accepted but not yet connected)
- have received offers to connect to our network (offered but not yet accepted)

Long Term Development Statements: are compiled to assist current and future users to identify and assess opportunities available to them for making new or additional use of our distribution system. There is a Statement covering each of our four licenced areas and each one provides an overview of the design and operation of the network, together with data on the 132kV, 66kV, 33kV system and the transformation level down to 11kV.

DataPortal2: is an on-line application that provides access to both our mapping systems and downloadable data sets. Using this tool it is possible to access WPDs record maps and network diagrams and to query WPD assets for attribution, such as conductor type, operating voltage and feeding substation.

For further information regarding these information tools please click here

6. Applying for a connection

6.1 Energy storage is considered to be a generator when producing power and a demand when absorbing power (e.g. charging) and the application process will reflect this.

6.2 Once you have decided what type of energy storage model you wish to install you will need to notify us. The method and timing of notification will vary according to the size of the energy storage project.

6.3 For WPD to be able to assess the potential impact of an energy storage system on the network it is important that the applicant provides as much information as possible in terms of the technical characteristics and operating mode of the equipment. Attributes include the power rating (kW/MW) and energy capacity which determine how long and at what rate the equipment will import from and export to the network.

6.4 The dynamic requirements of the equipment are also important. We need to understand ramp rates and power swings. Equipment that is required to respond to a signal in milliseconds (e.g. enhanced frequency response) can impose more onerous problems on the network and restrict the ability to connect without undertaking reinforcement. We need to be able to assess for this.

6.5 Where more than one form of generation capability is installed (typically where battery storage is to be incorporated into a domestic dwelling that already has PV panels) it should be noted that the aggregate capacity of the generation to be considered is the sum of the capacities of each individual system. These capacities are based on the inverter/converter ratings where such equipment is installed. For the avoidance of doubt, the aggregate rating is not the export capacity. As an example, if a battery storage converter is connected on the ac side of a PV inverter then the aggregate capacity of the generation would be the PV inverter rating + the rating of the converter. If the equipment is connected on the dc side of a PV inverter the aggregate capacity of the generation would be the PV inverter as this restricts the output from both the PV and battery systems. Where the aggregate capacity exceeds 16A per phase, the installation must comply with the requirements of Engineering Recommendation G59.

6.6 Small Scale Energy Storage – connecting in accordance with G83/2

6.7 Any energy storage system utilising type tested equipment rated up to 16A (3.68kW) per phase must comply with ENA Engineering Recommendation G83/2, as amended from time to time.

6.8 Before investing in any form of energy storage system a property owner should seek professional advice from a qualified installer who will ensure the installation meets current UK standards and best practice recommendations. All installations must comply with relevant British Standards and Codes of Practice.

6.9 You can connect G83/2 compliant equipment on a 'fit and inform' basis but you must notify us of any connection of a source of energy which may be connected in parallel with our network no later than 28 days (inclusive of the day of commissioning), after commissioning the source using the Commissioning Confirmation form and enclosing an operational diagram.

6.10 We will assess the information provided and either, acknowledge the commissioning and operation of the energy storage system or, where the data is incomplete or unsatisfactory, we will request further information. Please note, where satisfactory data is not provided we can give notice to disconnect the energy storage system until we are satisfied that the provisions of G83/2 are met.

6.11 Please ensure you obtain a copy of our acknowledgment from the Installer for your own records.

6.12 If you want to connect multiple energy storage systems to separate premises in a close geographic area (a 500metre radius) you must contact us at an early planning stage, prior to commissioning the units, so that we can assess the impact they have on our network. Click here to view the G83/2 Application Form. You will need our consent to connection before proceeding.

6.13 Large Scale Energy Storage – connecting in accordance with G59/3

6.14 Any energy storage system utilising non-type tested equipment or equipment rated at 16A per phase and above must comply with ENA Engineering Recommendation G59/3.

6.15 Aggregate capacity up to 32A per phase: You may not install an energy storage system with a rating greater then 16A per phase without our prior agreement. However, for energy storage systems with an aggregate capacity up to 32A per phase whereby:

- the individual capacity of the generation and battery storage devices are less than 16A per phase;
- the export capacity will be limited to a maximum of 16A per phase via an export limiting device that is compliant with ERG100;
- both the generation and battery storage devices will be connected via ERG83 type tested invertors; and
- the generation and battery storage devices will be prevented from operating in island mode, i.e. when there is no mains supply,

then a Fast-Track application form may be completed. Under the Fast-Track process we will endeavour to give approval to connect within 10 days of receiving a complete application. More information and the Fast-Track application form can be found here.

6.16 Aggregate capacity up to 75A per phase: For energy storage systems rated up to 75A (17kW single phase/50kW three phase) that are type tested and do not fall into the Fast Track process a simplified application form is available. Click here to view the Simplified Application form. You must contact us in advance of commissioning the energy storage system (ideally at your earliest opportunity) and provide full details so that we may establish whether or not certain requirements of G83/2 can be applied.

6.16 Aggregate capacity above 75A per phase: A person wishing to install an energy storage system rated above 75A (17kW single phase/50kW three phase) or any other energy storage system that is not type tested should complete the standard ENA application form. Click here to view the application form.

6.17 In order that we can assess the full impact of an energy storage system on the distribution system the applicant must complete an additional form; the 'Further Information Request'. This form requires the applicant to provide information relating to the specific storage technology and operating mode (including ramp rates/power swing). Click here to view the Further Information Request form.

6.18 Please note, if you are looking to add energy storage to an existing demand or generation connection you must still follow the same process as for new connections even where there is no increase in export capacity requirements. We may also need to inform National Grid Electricity Transmission of any relevant generation under the Statement of Works process. Click here for further information on our Statement of Works process.

6.19 Click here to find further information relating to the use of application and commissioning confirmation forms and Electricity Network Association guidance documents.

7. Assessment and Alternative connections

7.1 Any installation connected in accordance with ER G59/3 will require a level of assessment to understand the impact on the distribution system. Adding an energy storage system to a new or existing premises could alter the operational characteristics of the site and/or introduce power quality issues such as rapid voltage changes (including step change in voltage), flicker and harmonics. There could also be earthing and/or fault level implications.

7.2 We will carry out studies to assess the power flow, voltage rise, step change and fault level impact on the distribution system.

7.3 You must decide on the level of security you require. A 'firm' connection will provide additional security but may come at a cost. 'Unfirm' connections with no back-feed provision will be cheaper but could be disconnected from the distribution system and unable to import or export energy for the duration of a network fault.

7.4 We must ensure compliance with all relevant Engineering Recommendations including ER P2/6 relating to system security. The level of security a developer is prepared to accept depends on individual circumstances. Currently developers may request an exemption from P2/6 in terms of single customer demand (i.e. no need to apply an N-1 condition). WPD must however, ensure continued compliance with Group Demand requirements.

7.5 Where there is insufficient capacity available on the distribution system and reinforcement is required the developer may consider the use of an export limiting device in order to constrain export capacity. Any such device must comply with the requirements of Engineering Recommendation G100. The installer will be required to provide an additional 'Export Limitation Scheme' application form. Click <here> to view the form.

7.6 Under certain circumstances WPD may be able to provide a 'curtailed' connection that would mean that a developer could avoid high reinforcement costs by agreeing to a connection that may be constrained to a lower capacity (or zero capacity) at certain times. This is possible via the use of 'Active Network Management' and/or 'soft-intertrip' schemes. A developer will need to consider the implications of loss of revenue streams at times of curtailment. Click here for further information on alternative connections.

8. Connection Offers

8.1 On completion of the assessment we will forward a Connection Offer to you setting out the terms and conditions including any specific operational requirements upon which you may connect the energy storage system to our distribution system.

8.2 We have an obligation to provide you with a Connection Offer within prescribed timescales under the Electricity (Connections Standards of Performance) Regulations 2010. These timescales vary according to the voltage of connection to the distribution system but we will endeavour to exceed these Standards at all times.

8.3 If physical works are required to enable the connection of the energy storage system our Connection Offer will include a charge for undertaking the works. Some of these works may be undertaken by an accredited independent connection provider. Click here to find more information on Competition in Connections.

8.4 You will have 90 days to accept our Connection Offer and if you do we will contact you to agree dates to undertake the works.

8.5 Where there are multiple applications to connect to the same section of the network your offer may become interactive with other offers. In these circumstances your ability to accept our connection offer will be affected by the interactivity process and outcomes. For further information, Click here to view our interactivity guide.

8.6 We will also require you to enter in to a Connection Agreement that will set out the enduring rights and obligations of both parties following connection and energisation.

9. Charging for reinforcement

9.1 Unlike most conventional generation, (e.g. PV or wind) energy storage schemes have operating characteristics that merit special consideration. They generally have both a significant generation (export) and demand (import) requirement.

9.2 Where reinforcement of our distribution system is required we will apportion the costs between ourselves and the customer according to the rules set out under our Statement of Methodology and Charges for Connection to WPD's Electricity Distribution System. There is no specific definition for energy storage within regulatory frameworks, however current thinking is that it should be treated as generation.

9.3 Whilst an energy storage may be considered as generation the cost apportionment calculation will be driven according to whether the reinforcement is required to accommodate the import or export capacity on the distribution system. We will apply the following methodology:

i) If reinforcement is required solely to accommodate the generation capability then cost apportionment will be calculated based upon the required export capacity.

ii) If reinforcement is required solely to accommodate the demand capability then cost apportionment will be calculated based upon the required import capacity.

iii) If reinforcement is required to accommodate both the generation and demand capability then cost apportionment will be calculated based upon whichever of the import or export capcity is greater.

iv) If it is necessary to reinforce one part of the distribution system to accommodate the generation capability and a different part of the distribution system to accommodate

the demand capability then cost apportionment will be calculated separately according to import and export capacity requirements.

9.4 A person connecting smaller energy storage systems, in accordance with ERG83 may be deemed, subject to eligibility, as a Relevant Customer in accordance with Standard Licence Condition 13C. In circumstances where the reinforcement costs are caused by a Relevant Customer WPD will fully fund the reinforcement work.

9.5 Further information relating to the apportionment of costs and eligibility criteria for applying non-chargeable reinforcement can be found under WPD's Statement of Methodology and Charges for Connection to WPD's Electricity Distribution System. Click here to view WPDs charging statements.

10. Looking ahead

10.1 There is still some uncertainty surrounding the future for energy storage although it is clear it will have a role to play. Conclusions drawn from the BEIS/Ofgem Call for Evidence will undoubtedly inform ongoing strategy although regulatory change may be required if it is to meet its full potential. There are also a number of active ENA Workstream Groups whose role it is to look at developing areas such as, transmission/distribution interface processes, transition to Distribution System Operator (DSO), charging principles and improving customer communication/experiences.

10.2 WPD will continue to explore the potential to use energy storage to help it balance the distribution system in its role as a DSO. We will also investigate opportunities to provide and obtain flexibility services from the market.

10.3 Energy storage projects will currently need to wait behind other committed generation schemes in any queue to connect to the distribution system even where the storage scheme could relieve system constraints. There is an expectancy that if DNOs can demonstrate that other customers within a connection queue can benefit from storage connecting earlier it should be promoted. In tandem with the ENA Workstreams we will explore the capability to do this.

11. Further information

11.1 Further information concerning many of the topics covered above is available from our website: www.westernpower.co.uk