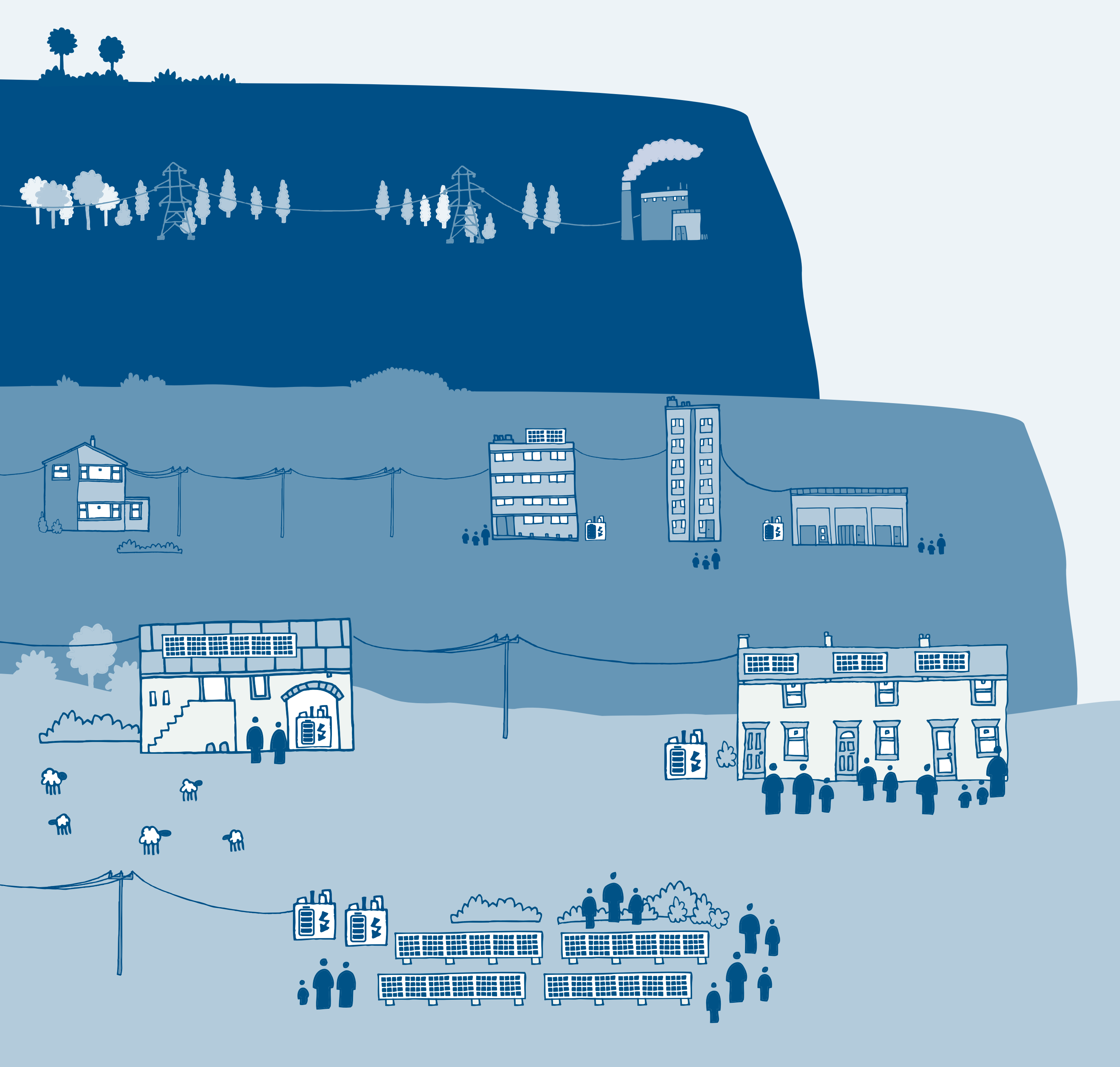
The voice of the networks



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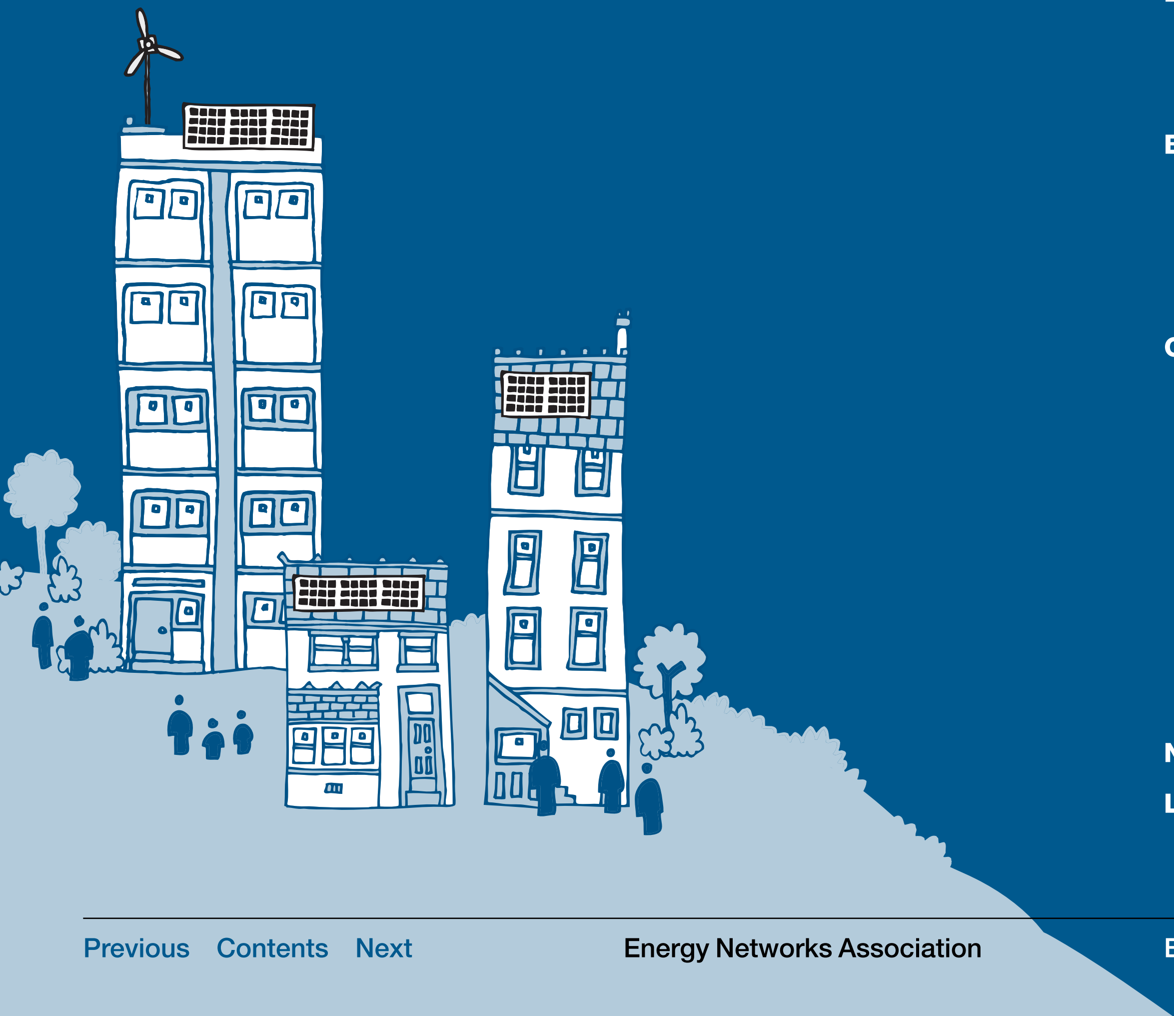
Energy Networks Association

Electricity storage guide for communities and independent developers

regensw delivering sustainable energy

Energy Networks Association Electricity storage guide for communities and independent developers



Contents

Background

Who is this guide for?

This guide is aimed at community energy groups and independent developers looking to develop electricity storage projects, who want to know how to connect to the electricity network.

This document is an introduction to the area of electricity storage and refers to more detailed content where appropriate.

What is ENA?

Energy Networks Association (ENA) represents the 'wires and pipes' transmission and Distribution Network Operators (DNO) for gas and electricity in the UK and Ireland. Our members control and maintain the critical national infrastructure that delivers these vital services into our homes and businesses. ENA's overriding goals are to promote the UK and Ireland energy networks ensuring our networks are the safest, most reliable, most efficient and sustainable in the world (See Figure 1).

ENA and the DNOs are keen to make connecting electricity storage to their networks as straightforward as possible, which is why we have worked with Regen SW to produce this guide. Regen is an independent not-for-profit organisation that uses its expertise to work with industry, communities and the public sector to revolutionise the way we generate, supply and use energy.

1. Scottish & Southern Electricity Networks
2. SP Energy Networks
3. Northern Ireland Electricity Networks
4. Electricity North West – Bringing energy to your door
5. Northern Powergrid
6. SP Energy Networks
7. Western Power Distribution – Serving the Midlands, South West and Wales
8. UK Power Networks – Delivering your electricity
9. Scottish & Southern Electricity Networks
10. ESB Networks

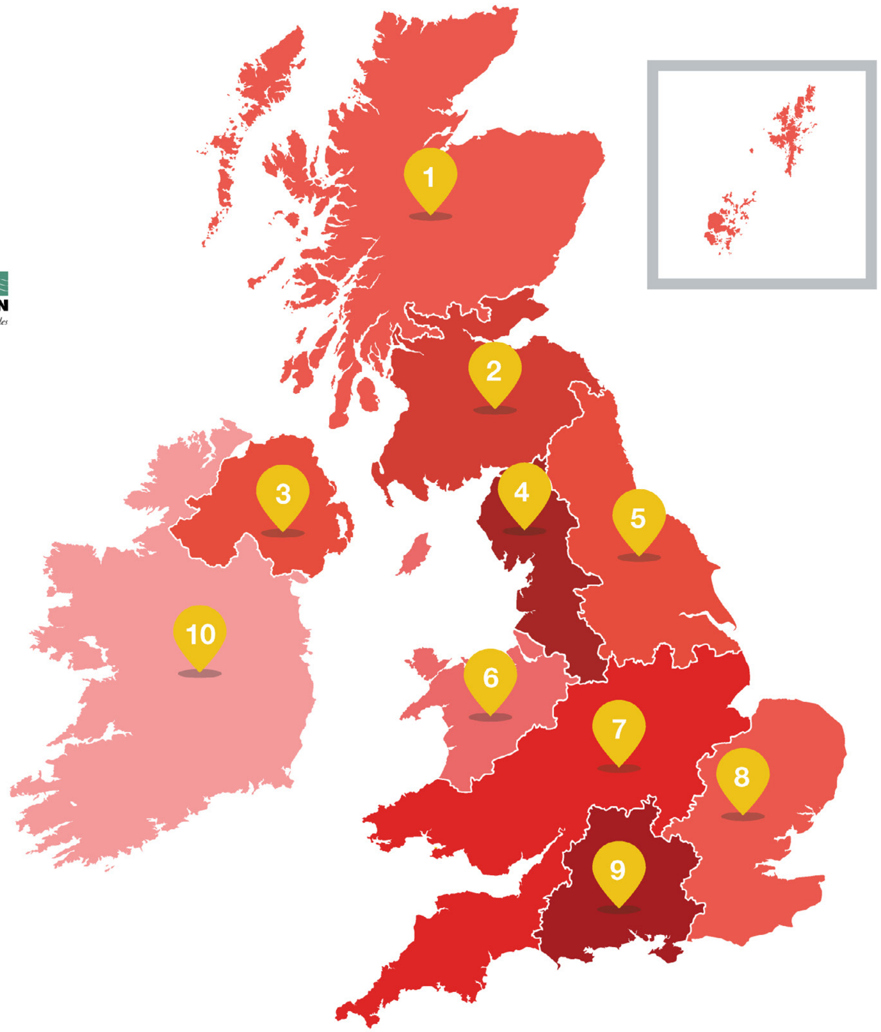


Figure 1: Map of ENA electricity Distribution Network Operator members

If you are not aware which DNO manages the network at the location of your project, use the ENA postcode search here.

Introduction to the electricity network

Historically, electricity flows from the power stations into the transmission network, run by the National Grid, which transports electricity over long distances at a high voltage (275 kV or 400 kV in England and Wales) (132 kV, 275 kV or 400 kV in Scotland).

It then flows into the distribution network, run by Distribution Network Operators (DNOs), to users, such as homes and businesses. The voltage is reduced in the distribution network to be able to supply electricity ready for use in consumers' homes; from 132 kV down to 230 V in England and Wales, and from 33 kV down to 230 V in Scotland.

In recent years the nature of the energy system has changed with more generation, including renewable energy, now being connected at a local level directly to the distribution network. Smaller generators connect at the distribution level, referred to as distributed generation or DG. The major generators connect at the transmission level.

The role of the distribution network is changing. The following factors are putting the network under pressure:

> **Variable generation** - more variable sources of generation from the rapid growth of renewable distributed generation.

> **Lack of capacity** - some areas of the network are at capacity, with new generation connections becoming more expensive and taking considerable time.

> **Decarbonisation of the electricity network** - more variable renewable energy generation will need to connect to the network to decarbonise our energy system over the coming years to meet our national carbon targets.

> **Decommissioning of power stations** - older coal and nuclear generation is being turned off, making the margin between peak winter demand and supply tighter than it has been before.

> **Increasing demand** - more of our transport and heat demand is due to be added to the electricity network via electric vehicles and heat pumps.

A smart and flexible network is needed to help avoid expensive reinforcement and balance demand and supply at the lowest cost.

How our energy system meets these challenges will shape the future electricity network and the investment in infrastructure that will be required. One answer would be to simply invest in new generation and network capacity. However this would be an expensive approach which would lead to higher consumer bills over time. A better way would be to combine infrastructure investment with greater flexibility, innovation and smarter system technology which would enable the UK to make more efficient use of the electricity network. This would enable the electricity system to exploit cheaper forms of generation while at the same time providing energy security and helping to meet the UK's decarbonisation targets.

The National Infrastructure Commission (NIC) report on smart power stated that the benefits to consumers of a smart system could be £3-8 billion a year in 2030[1]. In response to the recommendations of this report the Government committed to, 'lay the foundations of a smart power revolution'. The framework for this system has been discussed in the smart, flexible energy system call for evidence from the Department of Business Energy and Industrial Strategy (BEIS) and Ofgem[2].

The investment in new generation capacity and network reinforcement will therefore need to be balanced with the opportunity to support flexibility and innovation in the energy system including for example the use of electricity storage, demand side response, interconnectors and local energy networks.

Given the scale of the energy network revolution required, government and regulators have signalled their intent to remove barriers to the progression of both of these options.

1 National Infrastructure Commission report on smart power https://www.gov.uk/government/publications/smart-power-a-national-infrastructure-commission-report
2 BEIS and Ofgem call for evidence on the smart, flexible energy system https://www.gov.uk/government/consultations/call-for-evidence-a-smart-flexible-energy-system

Introduction to the electricity network

Evolution from DNO to DSO

The role of a DNO has traditionally been passive and reactive. In a smart and flexible energy network DNOs will need to take a more active role in managing their networks and move towards becoming Distribution Systems Operators (DSOs).

Essentially this means that more aspects of the electricity network will be managed at a regional and local level. For example, this would include responsibility for:

> Balancing of demand and supply of electricity at the distribution level

> Providing and obtaining flexibility services from the market

> Supporting local energy markets and microgrids

> Much closer interaction with National Grid

> More monitoring, automation and control of network assets at a local level

> Enabling more generation and other customers to connect at a reasonable cost.

The evolution towards DSO has already started and is likely to accelerate. For this transition to be possible, DNOs will need to work much more closely and proactively with local electricity generators, high energy users and electricity storage providers.

This transition will itself create opportunities for electricity storage providers as DSO's procure additional flexibility and balancing services and create an important new market for electricity storage.

It is therefore essential that electricity storage providers and DNOs have a close working relationship and fully appreciate their mutual requirements, and their network impacts.

Getting connected to the network

Getting your project connected and exporting your electricity to the network has become more of a challenge.

In some areas network capacity has become difficult to access due to the high levels of distributed generation already on the network and in the queue to connect[3]. DNOs are working hard to allow more customers to connect to their network in response to the Quicker and More Efficient Connections publication from Ofgem[4].

The introduction of flexible connections is one method that has allowed more generation to connect to the network.

These connection types limit the ability to export electricity to the network at certain times. Active Network Management (ANM) is a particular type of flexible connection that is being rolled out in certain areas.

In ANM the DNO starts to act like a DSO, by using more monitoring and control equipment to manage the amount of capacity and demand on the network at any time. For more information visit the ENA flexible connections webpage.

Engaging communities in network innovation

The ENA hosted two national events looking at engaging communities in network innovation.

Communities have a valuable position as a trusted local organisation can provide a useful partner for consumer engagement.

Many communities have already developed their own renewable energy projects which can also be incorporated into an innovation project.

A guide has been produced which explores how DNOs can positively engage local communities in innovation and how communities can get themselves into the best position to grasp the opportunity. For more information read the rough guide to engaging communities in network innovation. [Hyperlink TBC]

A large number of innovation projects have been initiated and completed that relate to community energy, in a broad range of sectors (see Table 1).

For a full list of all the innovation projects from DNOs use the ENA Smarter Networks Portal.

3 The 'queue' represents projects that have accepted or been offered connections to the network by a DNO. Many of these projects are likely to be completed, but some are not. Reclaiming this capacity could allow more projects to connect to the network.

4 Ofgem Quicker and More Efficient Connections publication https://www.ofgem.gov.uk/publications-and-updates/quicker-and-more-efficient-connections-next-steps-0

Table 1: DNO innovation projects relating to community energy

Project	Duration	Aims	Overview	Findings
SoLa Bristol Partners: Western Power Distribution, Siemens, Bristol City Council, University of Bath, Knowle West Media Centre	2011 - 2016	To address the issues associated with the impact of solar PV on the low voltage network using battery storage and variable tariffs.	26 homes, one office and five schools in north west Bristol participated in the trial. Solar PV panels, batteries and a control system were installed into properties. A direct current (DC) electricity system was installed in the homes and a tablet PC used to provide information on energy usage and savings Participants made use of a smart tariff so they could sell excess energy from the battery back to the network at peak hours, gaining an income.	Higher levels of distributed generation needed to be cost-effective for the DNO The main benefits of the project were for the supplier and communities. Battery storage systems need to be designed to fit the customer demand profile. The benefits of electricity outage back-up from storage can be at odds with the financial benefit of discharging at peak times.
Power Saving Challenge Partners: Electricity North West, National Energy Action, Stockport Council, Stockport homes, Impact research	2013 - 2015	To reduce the overall and peak demand to avoid network reinforcement.	Consumers were encouraged to reduce their demand relative to the previous year with incentives, online forums, and events. The development of the challenge with community groups was shown to build trust.	The average reduction in demand was over 4 per cent (compared to baseline). Household demand were generally more flexible than expected.
Distributed storage and solar study (DS3) Partners: Northern Powergrid, Moixa, Energise Barnsley	2016 – 2019 (ongoing)	To investigate the use of residential electricity storage to avoid network upgrade costs associated with solar PV installations and reduce winter peak demand.	40 electricity storage devices will be installed to see if there is an impact on the network at the substation level. Data collected could be used to determine whether it would be possible to incorporate the presence and impact of electricity storage when assessing future network applications.	Project completion in 2019.

Table 1: DNO innovation projects relating to community energy (continued)

Project	Duration	Aims	Overview	Findings
Accelerating Renewable Connections (ARC) Partners: SP Energy Networks (SPEN), Community Energy Scotland, Smarter Grids Solutions, University of Strathclyde	2012 - 2016	To increase the number of renewable generation connections, by offering flexible connections and engaging communities.	Using Active Network Management (ANM) connections more renewable generation can be connected faster and at a cheaper cost, while avoiding reinforcement costs. Communities will be able to develop their projects and benefit from more revenue as a result.	New design improvement to the ANM connection process Communities can help drive new projects Community engagement and active involvement gives an additional driver for the completion of projects and will facilitate delivery of projects within timescale.
Energywise (also known as Vulnerable Customers and Energy Efficiency) Partners: UK Power Networks (UKPN), Tower Hamlet Homes, Poplar HARCA, Bromley by Bow Centre, University College London, National Energy Action, Element Energy, CAG Consultants, Institute for Sustainability	2014 - 2017	To look at ways of reducing residential energy usage via smart meters, energy efficient lighting, an ecoKettle and changing behaviour in vulnerable and fuel poor customers.	Face-to-face communication and support. A trusted local organisation with field officers recruited participants, with an impressive sign up rate of 40 per cent mainly via door-to-door contact. An initial high sign up rate was followed by higher than predicted dropout rate.	Project completion in 2017.

Electricity storage

Energy storage allows the shifting of energy delivery from a time when it is less valuable, to a time when it is more valuable either to the consumer or to the network.

Energy storage encompasses a whole range of technologies. Broadly they can be classified as chemical, electrical, thermal, electrochemical and mechanical. All have various benefits and drawbacks which need to be taken into account when assessing a potential project.

The focus of this document is on the storage of electricity, as we are discussing how to connect to the electricity network. There are numerous heat storage products and models available.

Electricity storage has a different set of technical characteristics and definitions in comparison with more established generation technologies:

> **Electricity storage has a power rating (MW)** – the power rating is the peak power a storage device can deliver.

> **Energy capacity (MWh)** - how much energy the device can store and delivery over time.

> **Cycle or round trip efficiency (%)** – this is the ratio between the amount of power put in to a storage device and the amount you get back out. There are normally some losses in this process, which vary depending on the technology.

> **Lifetime (years or charge-discharge cycles)** – the length of time the electricity storage project lasts. This is technology specific and varies considerably depending on how the storage device is used.

> **Response time (milliseconds to minutes)** – how fast the electricity storage can react to a signal and start exporting/importing to the network.

Both the power rating and energy capacity dictate how long and at what rate the electricity storage project can export to the network or import to the device.

The way in which the electricity storage device is used can have an impact on its lifetime.

A given electricity storage project will need to be designed to maximise a set of revenue opportunities available, which are discussed in the next section.

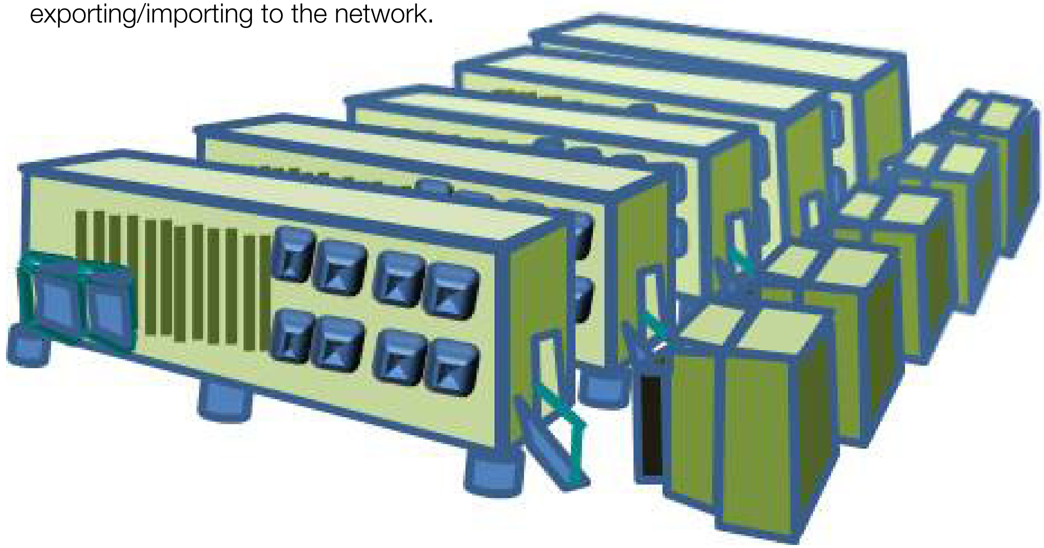


Figure 2: Illustration of a large container-based electricity storage project

Applications for electricity storage

It is beyond the scope of this document to list and explain all the applications of electricity storage. In general terms electricity storage can provide three types of service:

> **Response** - the ability to respond quickly (milliseconds – minutes) to a signal (e.g. Enhanced Frequency Response[5] and Firm Frequency Response[6]).

> **Reserve** - storage of energy to be used at a time when it is required. From a simple back-up capability or providing the capacity at a larger scale (e.g. Short Term Operating Reserve[7] and Capacity Markets[8]).

> **Price and time shift** - storing energy to be used at times of higher price/cost periods. This allows users to benefit from the difference in the price of energy between peak and off-peak (such as price arbitrage[9]), avoid peak transmission and distribution costs and/or to recover energy that would be lost due to the network or other constraints.This has the potential to enable additional generation to be connected to a network.

Within each of these types of service there a number of potential revenue streams that vary in value. In order to make an electricity storage project commercially viable the revenue streams may well need to be 'stacked'.

The challenge is to find the right combination of revenues that fit with the regulatory and technical requirements. This can be a difficult task as not all revenue streams can be combined with others and the regulatory environment is under review.

The potential models for community energy and their 'stacked' revenue streams are covered on page 12. Other models also have potential[10].

5 **Enhanced Frequency Response (EFR) is a fast response (sub-second) service for electricity storage projects to supply to National Grid.** http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx
6 **Firm Frequency Response (FFR) is another fast (seconds) response service to maintain the frequency of the network for National Grid** http://www2.nationalgrid.com/uk/services/balancing-services/frequency-response/firm-frequency-response/
7 **Short Term Operating Reserve (STOR) is a slow (minutes) reserve service, that requires output for a minimum 2 hour timeframe for National Grid** http://www2.nationalgrid.com/uk/services/balancing-services/reserve-services/short-term-operating-reserve/
8 The Capacity Market is a mechanism to deliver capacity at times of peak demand or stress https://www.emrdeliverybody.com/cm/home.aspx
9 Price arbitrage is where you import energy at a low price and export it back to the network at a higher price
10 Energy storage - towards a commercial model (2nd edition) https://www.regensw.co.uk/storage-towards-a-commercial-model

The electricity storage market

Electricity storage is not a new phenomenon in the UK. The Dinorwig pumped hydro facility in Gwynedd, Wales has been operational since 1984. The facility is 1.72 GW capacity and is used by National Grid to balance the network.

At the large scale (GWs), electricity storage has previously been provided by pumped hydro solutions. Finding new sites for these projects can be challenging. Compressed Air Electricity storage (CAES) may be an additional technology option and there are a number of projects proposed in the UK.

At the smaller, distribution scale the recent surge in interest for electricity storage has been driven by a rapid reduction in the manufacturing costs of lithium-ion batteries, from the growth of the electric vehicle market. However, the electricity storage market is moving quickly and other electrochemical technology types are due to become widely available.

Electricity storage on the network

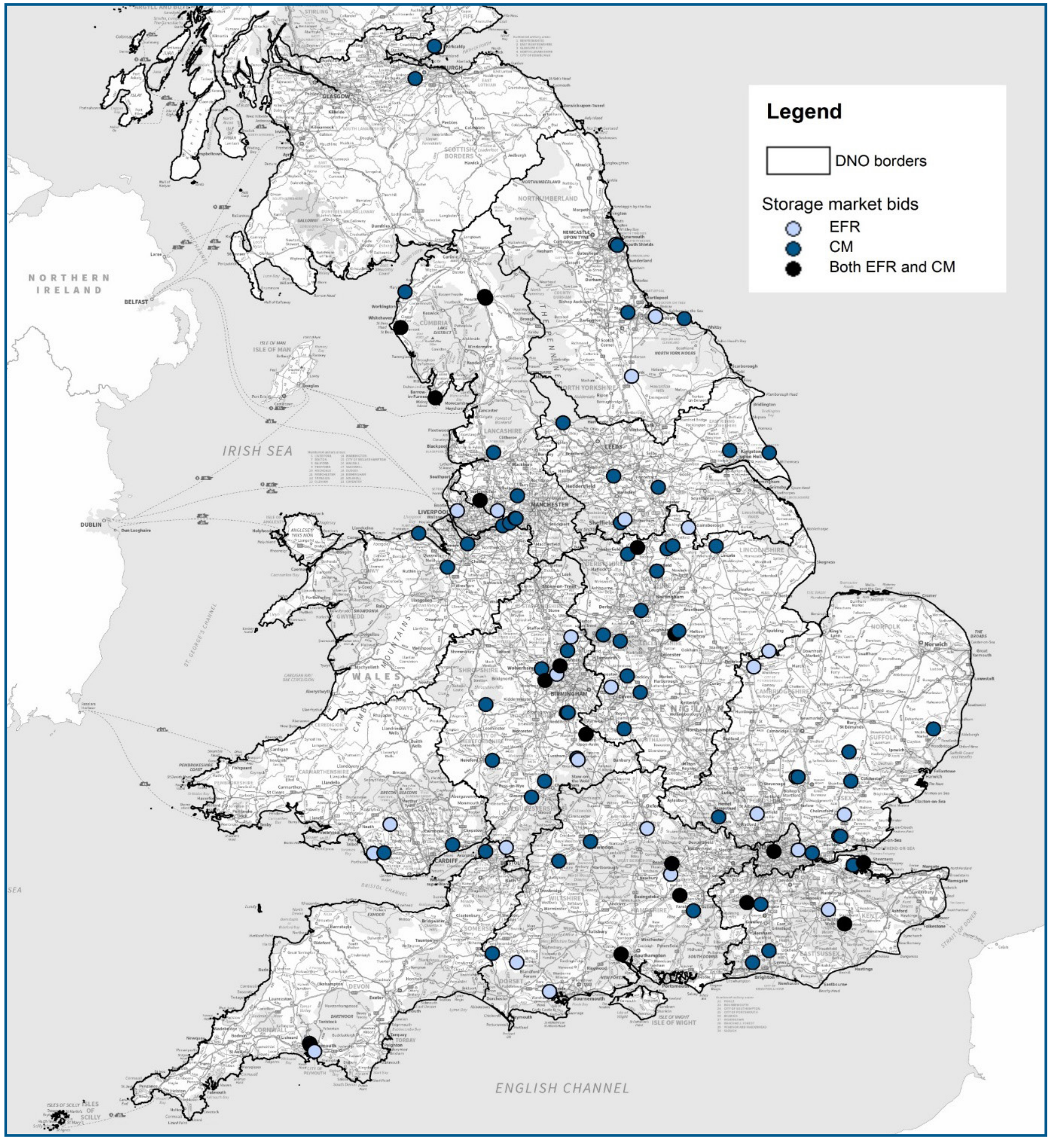
There are approximately 30 operational electricity storage projects installed in the UK[11]. There is currently very little data available on the number of domestic and small scale installations, so this assessment is conservative. In terms of capacity 78% is pumped hydro electricity storage. A growing number of battery electricity storage projects have been developed. Many are located in remote island or microgrid locations and associated with innovation projects.

The first large scale commercial projects are starting to be commissioned. The recent 200 MW Enhanced Frequency Response tender and interest in the Capacity Market, both run by National Grid, initiated a large number of applications for network connections for electricity storage projects (see Figure 3). This has had a considerable impact across the DNOs with 19 GW of applications received[12].

To put that into perspective, Hinkley Point C nuclear power station is due to be 3.2 GW when completed. A very low proportion (approx. 3%) of the applications have accepted the connection offered. This low take up of connection offers is not good for the sector as those applying are not accepting the terms offered and the DNOs have to deal with lots of unnecessary applications. This issue was highlighted in the smart, flexible energy system call for evidence.

11 US Department for Energy global electricity storage database http://www.energystorageexchange.org/projects
12 **BEIS/Ofgem call for evidence** https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/567006/Smart_Flexibility_Energy_-_Call_for_Evidence.pdf

Figure 3: Map of the location of different bids for the Enhanced Frequency Response (EFR) and Capacity Market (CM) tenders from National Grid



Electricity storage - models for domestic and community energy

At the domestic[13] and community scale the electricity storage market is at an early stage of development in the UK. A number of potential models for electricity storage exist that will become more attractive as costs continue to fall and changes to the regulatory regime occur.

The below models are chosen as the most relevant to the community energy sector. There are many others available.

Domestic microgeneration and electricity storage

Below we discuss some of the key design considerations at the domestic scale and then move on to the business model emerging. In the majority of cases this is likely to be a battery device twinned with solar PV (or another microgeneration technology) in a domestic setting.

Households are an important part of a smart and flexible network. Electricity storage will allow more variety in the way they can consume and generate energy. This could lead to more balancing of demand and supply at a local level.

The market for domestic microgeneration and electricity storage

There are two main markets for electricity storage at the domestic scale. Firstly, new domestic installations linking microgeneration[14] with electricity storage. Secondly, the 850,000 existing microgeneration installations offer a potential opportunity for the installation of electricity storage. It is recognised that the financial benefit of installing electricity storage, for most domestic and community consumers is low at present. However, as electricity storage costs continue to fall and with the introduction of time of use tariffs, it is expected that small scale storage could become commonplace.

Generator 'own use'

The electricity storage installation will increase the 'own use' of the electricity generated by microgeneration, which means less is imported from the network, saving the costs associated. This self-reliance and increase in self-consumption has been noted as a strong driver for those early movers who have already installed electricity storage.

Price arbitrage/peak shaving

As defined earlier, one of the main price/time shift services that can be provided by electricity storage is price arbitrage – using a storage device to import energy at a low price and export it back to the network at a higher price.

This is related to peak shaving, where the high costs of electricity at peaks periods are avoided by using energy from electricity storage at those times.

These revenue streams are currently only available at the non-domestic scale. With the introduction of smart meters across the UK (due to be offered to all households by 2020), more variable time of use tariffs[15] for our electricity will follow and allow the benefits of price arbitrage and peak shaving to be passed on to domestic consumers.

Payments from aggregators[16] for use of domestic electricity storage could become a significant revenue stream for owners in the near future. See the next section for more detail.

Table 2: Revenue streams associated with domestic microgeneration and electricity storage

Domestic microgeneration and electricity storage	
Current revenues	Increased 'own use'
Potential revenues	Peak shaving
	Price arbitrage
	Payment from aggregator

The domestic microgeneration and electricity storage model is a market with large growth potential. The continued reduction of electricity storage costs and the introduction of smart meters and time of use tariffs, will enable further deployment.

13 When discussing domestic and non-domestic classifications we are referring here to the type of electricity consumer.

14 Microgeneration is the term given to electricity and heat generation equipment of the smallest capacity (up to 50 kW for electricity and 45 kW for heat). In terms of electricity generation the most popular technology at this scale has been solar PV. Lower numbers of hydro and wind have also been installed.

15 Time of use tariffs – a variable tariff per unit (p/kWh) depending on the time of day. The introduction of smart meters allows for more variable pricing for our electricity. Economy 7 (and 10) tariffs are the main time of use tariffs currently available and offer a peak and off peak tariff rate.

16 Aggregators collect multiple electricity storage installations together. They install control systems so that they can use these aggregated installations at the same time and sell these services.

Domestic microgeneration and electricity storage (continued)

Aggregation of domestic microgeneration and electricity storage

The grouping together, or aggregation of electricity storage with local generation, provides an opportunity to unlock more revenue streams and make best use of electricity storage. This requires communication and control systems to be fitted to the electricity storage devices and a platform to collate the different installations together.

Aggregators already pay electricity storage owners for use of their devices at certain times. For example, in the UK the Moixa Gridshare offers £50-£75 per annum for the ability to utilise one of their own installed batteries[17]. In the Netherlands Eneco CrowdNett are paying €450 per annum for five years for use of 30% of a Tesla Powerwall[18]. These offers are likely to develop and become more widely available as the markets for network services mature and regulatory barriers are removed.

Community energy groups could become the aggregators themselves, or partner with other aggregators to sell flexibility services to the market. It may be possible to access the higher value response type services, by contracting with other companies providing these services to National Grid or DNOs. The current terms of these services would have to change to allow this market to be initiated.

Moixa's Gridshare in the UK and the Sonnen community[19] in Germany, show the early stages of this market developing. As the transition from DNO to DSO occurs, more localised services will be required to balance and manage the network. Distributed electricity storage at the domestic and non-domestic scale aggregated together is well placed to provide these services.

In summary aggregation of electricity storage with other generation provides a better model, with a broader range of revenues (see Table 3), compared to a single domestic installation. The community energy sector could act as an aggregator or partner with others, to help bring together and engage people in this evolving market.

Table 3: Revenue streams associated with aggregation of electricity storage and generation at the community scale.

Aggregation of electricity storage and generation	
Current revenues	Increased 'own use'
Potential revenues	Peak shaving
	Price arbitrage
	Response services (via partner)

Connecting electricity storage at the domestic scale to the network

Once you have identified a potential model for electricity storage you may need to connect it to the network. The process for doing so at the domestic scale depends on the size of the system.

This can be as simple as a form to fill out post installation all the way up to the need for a full application to your DNO (with a response within 45 to 65 days depending on scale). Many installations require a more complicated (EREC G59) connection (see page 23), often with the need for witnessing by a DNO representative, which can increase the cost and time of an installation.

At the moment there is no central registry of electricity storage projects in the UK and there is no certification scheme, like the Microgeneration Certification Scheme (MCS), for storage in the same way that there is for solar PV and other renewable generation technologies. ENA and DNOs will be recommending that such a registration scheme is established but in the meantime it is essential that installers notify their DNO of all electricity storage installations.

Skip to page 19 for more detail on the sizing and the associated connection pathway for you to follow.

Page 16 relates to larger electricity storage projects.

17 Moixa Gridshare offer http://www.moixa.com/products/#GridShare
18 Eneco CrowdNett Tesla Powerwall offer https://www.eneco.nl/actie/crowdnett/
19 Sonnen Community https://www.sonnenbatterie.de/en/sonnencommunity

Other models for electricity storage

The domestic electricity storage market is steadily growing. The markets for larger scale electricity storage installations are more mature and some of the revenue streams have been operational for some time.

In this section we summarise some of the potential models available. Please note these models are simplified and there may be variations that can be applied.

Response service

As discussed on page 9 there are a number of response services that electricity storage installations can provide. They are normally rapid (sub-second to seconds) and delivered over a short time frame (5 to 30 mins).

The Enhanced Frequency Response[20] service tendered by National Grid is one example of this service. This is likely to be provided by a large electricity storage installation (10-20 MW power rating and 6-10 MWh energy capacity), situated on a brownfield site (e.g. an industrial estate) with good network capacity available (see Figure 3 for example locations).

In addition this model can access the capacity market[21] in certain situations. The response service model has seen considerable commercial interest.

High energy user 'behind the meter'

A 'behind the meter' electricity storage installation, refers to an project on the consumer side of the electricity meter. In this case this would be located with a high energy user, such as industrial manufacturers, data centres or hospitals.

This model is based on using electricity storage to avoid higher energy consumption costs at peak periods. The addition or integration of other on-site generation can help enhance this model

As mentioned in the domestic models for electricity storage price arbitrage and peak shaving are potential revenues for electricity storage, which can be more significant at the non-domestic scale (particularly those with a network connection more than 100 kW).

Reducing network costs

The cost of the network is charged to generators and demand users. The half-hourly charges for these payments is complex, but the charges are particularly high during times of peak demand on the network.[22] Electricity storage projects can be used to avoid these times of peak demand and assist the network by exporting/importing energy during these times (gaining a revenue in some instances). This revenue stream is not fixed and varies depending on the location and at what level you connect to the network.

20 Enhanced Frequency Response (EFR) is a fast response (sub-second) service for electricity storage projects to supply to National Grid. http://www2.nationalgrid.com/Enhanced-Frequency-Response.aspx
21 The Capacity Market is a mechanism to deliver capacity at times of peak demand or stress https://www.emrdeliverybody.com/cm/home.aspx
22 Network charging for a flexible future https://www.regensw.co.uk/network-charging-for-flexible-future

Other models for electricity storage (continued)

Generator network curtailment

When new renewable generation (such as solar PV or hydro) is located with a high energy user other revenues can become important. As discussed previously, the network is under strain and it can be difficult to get a new connection offer in some areas.

Flexible connections[22] are available in a number of specific zones at present depending on the DNO. They are due to become more widely available in the near future.

A generator with a flexible connection is likely to be unable to export the electricity they generate to the network at certain times and/or only up to certain limit.

This excess energy generation is a potential revenue stream, we term 'generator network curtailment' that electricity storage could utilise.

Storing energy at times when the network is at capacity and the generator cannot export and releasing this energy to the network when the flexible connection allows. This revenue stream is reliant on the use of a flexible connection type.

If generation is included in the high energy user example, then as described in the domestic electricity storage model, increased 'own use' of the energy generated is an additional revenue stream.

Table 4: Revenue streams associated with response service and high energy user 'behind the meter'.

	Response service	High energy user 'behind the meter'
Current revenues	Enhanced Frequency Response and/or Firm Frequency Response	Reduction of network charges
	Capacity Market	Capacity Market
		Price arbitrage/peak shaving
Potential revenues		Generator network curtailment
		Increased generator 'own use'

For more detail refer to the Regen paper Electricity storage – towards a commercial model.

The high energy user 'behind the meter' model could be an area of considerable potential growth for electricity storage projects.

There is likely to be changes to the network charging arrangements. The inclusion of other generation increases the potential revenue streams on offer.

Connecting other models of electricity storage to the network

Connecting electricity storage to the network is a more challenging process at the non-domestic scale. The response service model in particular requires a large amount of network capacity.

In the next section we go through the potential ways of identifying if there is any network capacity in a given location. The following section then gives more detail on the sizing and the associated connection pathway for you to follow.

You must notify your DNO of all electricity storage installations.

If you are not aware which DNO manages the network at the location of your project, use ENA postcode search here.

[22] ENA flexible connections http://www.energynetworks.org/electricity/futures/flexible-connections.html

Before applying for a network connection

Electricity storage is currently treated as generation under the licencing conditions of Electricity Act 1989[23]. As such, DNOs treat an electricity storage application to get a connection to the network as generation. In many cases an electricity storage project will need to export and import energy from the network.

Impact of electricity storage on the network

How your electricity storage project will impact on the network will depend on the way in which the storage device is used, its "mode of operation", this will in turn depend on the business model and revenue streams underlying the electricity storage project.

It could well be that your electricity storage project is intended to harness lower cost electricity produced during periods of peak generation and export this energy during periods of peak demand.

In which case your storage project will generally help network balancing. However this cannot be assumed, and at this stage DNO's have taken a precautionary approach before offering electricity storage network connection agreements.

Those projects which are willing to use certain modes of operation and accept limits to their network connection, may find more opportunities to connect to the network.

Electricity storage project applicants need to provide as much information to the DNO during the network connection application process as possible, particularly in relation to the mode of operation.

Your connection offer will be based on the information you provide. If limited information is forthcoming it may mean your connection offer is not as favourable and your project is less likely to be viable.

DNO's are however working to better understand how electricity storage will be used. As more storage projects are deployed, DNO's will be better able to model and anticipate network impacts.

Please provide your DNO as much information on the intended use, known as mode of operation, of your electricity storage project as possible.

[23] This could change in response to the BEIS/Ofgem call for evidence https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/567006/Smart_Flexibility_Energy_-_Call_for_Evidence.pdf

Before applying for a network connection

Consult your DNO generation capacity map

In places, the electricity network is now constrained or at capacity due to the amount of distributed generation that has been connected. It is still possible to get an electricity connection, but it might take longer and be at a higher price due to the need to modify or reinforce the network.

All DNOs have developed a generation capacity map to give an indication of the network capacity issues in your area (see Table 5). Some DNOs have also provided a demand capacity map for their area.

Both are important for electricity storage as the DNO will assess the impact of an application on the capacity in the network.

This information should only be used as an initial indication for the potential capacity at any project site. Capacity maps vary considerably among the DNOs, but are useful at the initial stages of an application.

Table 5: Links to DNO generation capacity maps

Hyperlink to generation capacity maps	Hyperlink to demand capacity maps
electricity north west	
Northern Ireland Electricity Networks	
NORTHERN POWERGRID	NORTHERN POWERGRID
SP ENERGY NETWORKS	
Scottish & Southern Electricity Networks	Scottish & Southern Electricity Networks
UK Power Networks	UK Power Networks
WESTERN POWER DISTRIBUTION Serving the Midlands, South West and Wales	

Before applying for a network connection

Find a local connection surgery and contact your local DNO representative

Your DNO will have a number of local representatives that respond to connection applications. You may have already contacted them in relation to other projects. They have the latest information and are well placed to advise on a potential electricity storage application.

There could be an opportunity to meet your local representatives at a connection surgery (see Table 6). Alternatively a specific meeting or phone call with a DNO representative can be arranged.

Table 6: Links to connection surgery information for each DNO

Click logo for link to connection surgery webpage information
electricity north west
NORTHERN POWERGRID
SP ENERGY NETWORKS
Scottish & Southern Electricity Networks
UK Power Networks
WESTERN POWER DISTRIBUTION Serving the Midlands, South West and Wales

Connecting storage to the electricity network

This section takes you through the process of how to connect an electricity storage project to the network. As electricity storage is currently defined as generation, it follows the same connection pathway that many are familiar with. There are some notable differences.

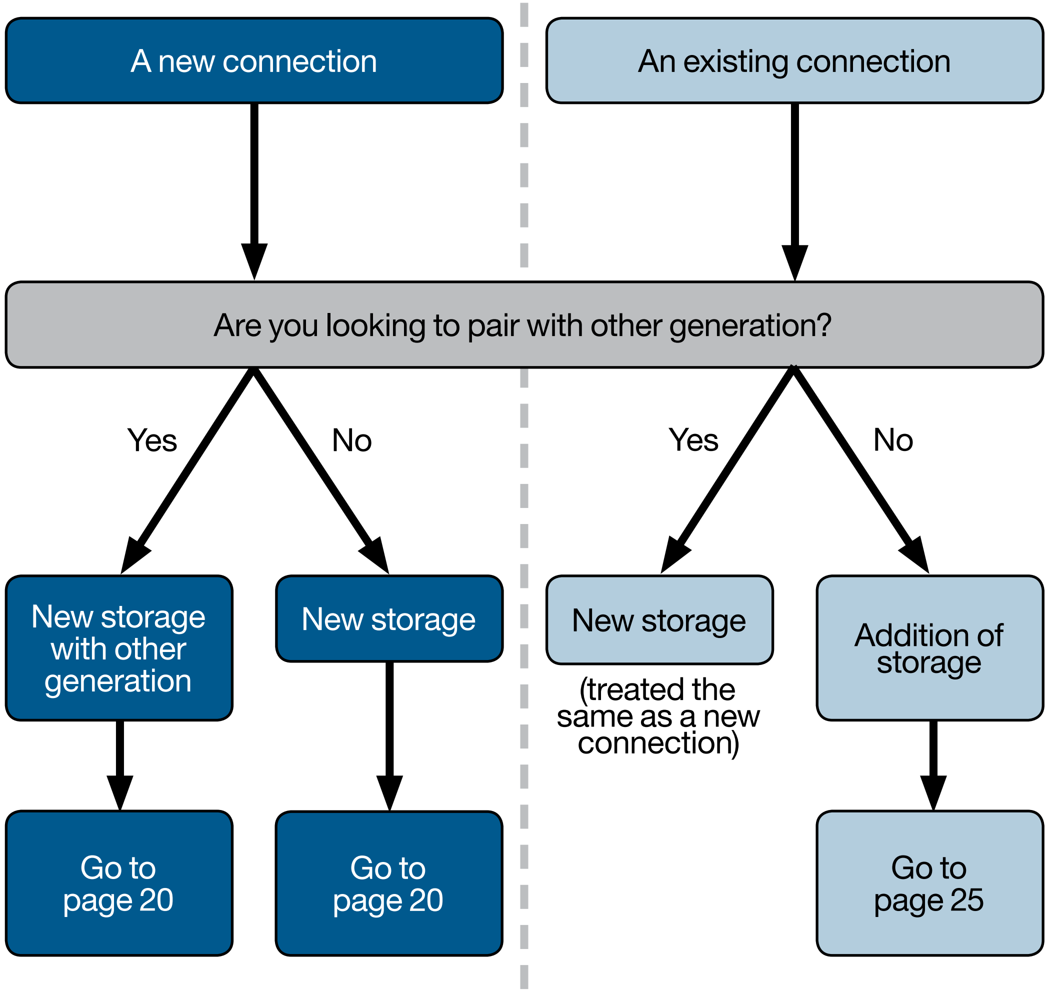
In addition to the correct generation connection pathway and the associated application forms described in the following sections, ENA has developed a form[24] for the additional information required for an electricity storage application (see page 24).

A new or existing connection?

Following the scoping work for larger installations, mentioned in the previous section to identify if there is network capacity for the electricity storage project in your area, you need to categorise what type of connection you are looking for (See Figure 4).

The first stage is to identify if your electricity storage project will utilise a new or existing network connection. Once this is established, then you need to know if you are looking to pair the electricity storage with other forms of generation (for example solar PV).

Figure 4: Flow diagram of different types of electricity storage connection



[24] Energy storage Further Information Request http://www.energynetworks.org/electricity/futures/energy-storage/energy-storage-further-information-request.html

Connecting storage to the electricity network

Sizing

The application route and specifications for connecting to the network is dependent on the size of the connection required. This is determined by the total aggregated capacity of the project if for a new electricity storage project.

If the application is for new electricity storage connection with other generation technologies, the total combined capacity should be used.

You will be applying from a single phase or three phase supply of electricity. A typical house has a single phase, whereas larger houses, flats and commercial properties require three phase as they need more power.

There are two sizing cut-off points:

1) 16 Ampere per phase or less:

- > 3.68 kW or less connected to single phase
- > 11.04 kW or less connected to three phase

2) 75 Ampere per phase or less:

- > 17 kW or less connected to single phase
- > 50 kW or less connected to three phase

You need to understand which size category refers to your application in order to identify the correct application process to follow.

Engineering Classification

The sizing cut-off points refer to two different Engineering Recommendations (EREC) that specify requirements that need to be met in order to connect to the network:

EREC G83 for generators that are:

- > Small-Scale Embedded Generation (SSEG) i.e. rated up to and including 16 A per phase
- > Type tested and installed in accordance with the latest version of EREC G83 (G83/2 from 1 December 2012)

EREC G59:

- > Rated above 16 A per phase or that do not meet the requirements of EREC G83
- > Type tested and installed in accordance with the latest version of EREC G59 (G59/3-2 from 17 August 2015)

Continue to Figure 5 referring to the information on this page

EREC G100

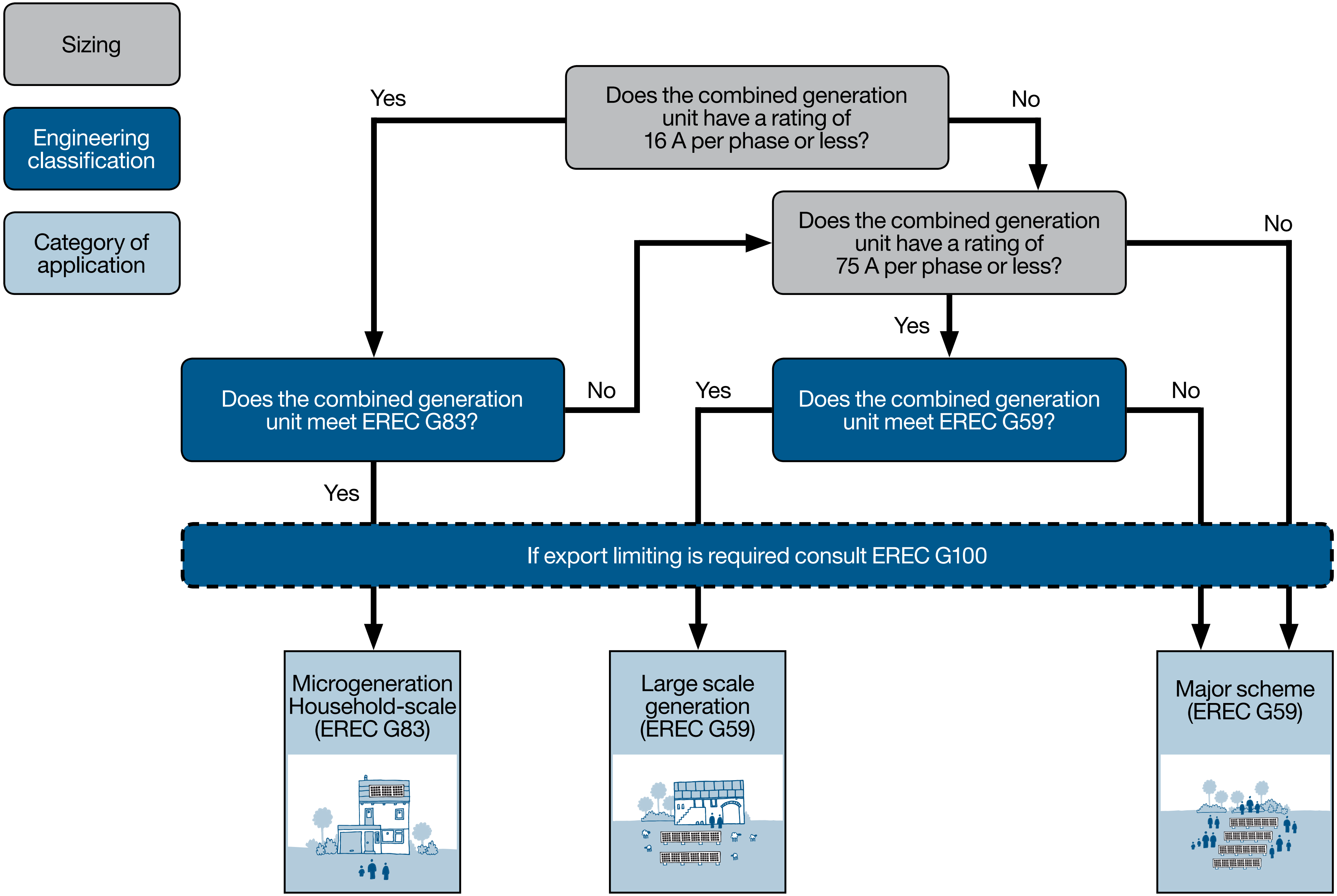
EREC G100 is different from EREC G83 and G59.

If a new generator is looking to export to the network, but there is insufficient capacity available and the reinforcement required to connect them is too costly or long term, then an export limiting scheme could be a solution. The export or import capacity is set at limit for the generator to adhere to.

At the time of writing there was no type tested equipment that meets the requirements of EREC G100, so witnessing of an installation is required in all cases. This can add expense and time on to an installation.

EREC G100 should be applied in combination with EREC G83 and EREC G59.

Figure 5: Flow diagram of a generation network application pathway



Connecting storage to the electricity network Microgeneration (EREC G83)

Once you have decided that Microgeneration (EREC G83) applies to your project, there are some further questions to answer (see Figure 6).

If your electricity storage installation is in parallel with the network[25], then you need to continue following the process below and adhere to the correct regulations. If it is not parallel to the network then under the current regulatory regime you do not have to meet the requirements associated with EREC G83 or EREC G59.

You must notify your DNO of your electricity storage project in all instances.

If your electricity storage project is identified as microgeneration (EREC G83) then this is likely to be a household-scale installation.

The EREC G83 does not require you to notify your DNO ahead of the installation for a single new connection, however you (or your installer) must fill in and return a G83/2 Commissioning Confirmation Form along with an Operation Diagram to your DNO within 28 days.

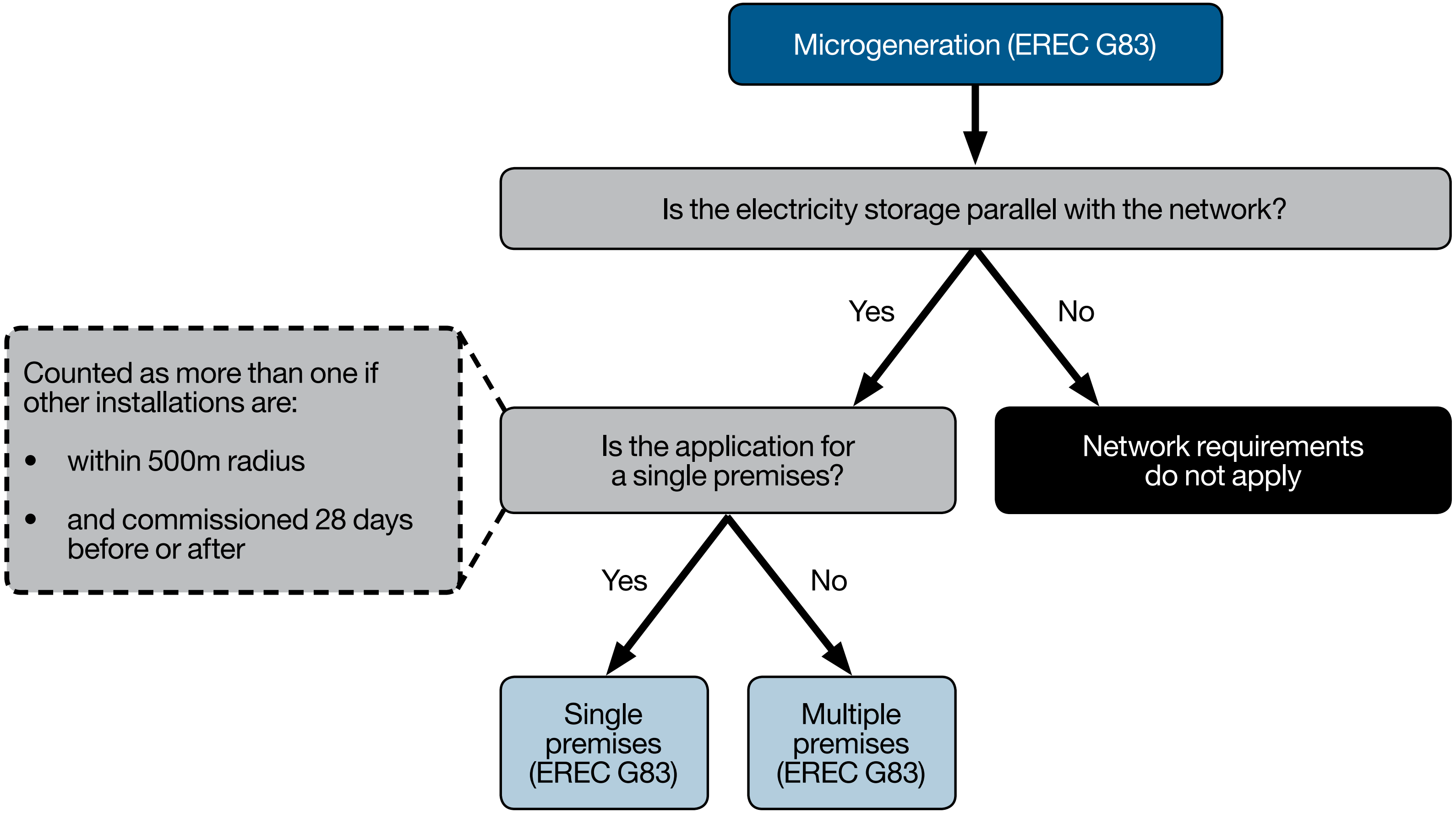
Your DNO will have details of their Microgeneration (EREC G83) application process on their website (see Table 7). Further information is available in ENA's connection guide - A Guide for connecting Domestic-Scale Type Tested Generation to the Distribution Network. Witnessing is not required for generation installations at the EREC G83 standard.

Multiple premises (EREC G83)

If you are intending to install generation on other premises within a 500 metre radius commissioned and within 28 days before and after your installation, you will need to apply to your DNO beforehand.

This is classed as generation on multiple premises which requires you to apply to your DNO for permission. Follow the ENA's connection guide - A Guide to Connecting Multiple Domestic-Scale Type Tested Generation to the Distribution Network.

Figure 6: Flow diagram of Microgeneration (EREC G83) decision process for electricity storage



[25] Parallel to the network in this instance refers to the use of . If an electricity storage device is not parallel and being used as alternative energy source in the household.

Connecting storage to the electricity network

Large scale generation and major schemes (EREC G59)

If your electricity storage project is larger than a household-scale or does not meet the EREC G83 requirements then it falls under the EREC G59 standards. EREC G59 is separated into two sections:

- Less than 50kW type tested systems. Further information is available in ENA's connection guide: [A Guide for connecting Type Tested Generation that falls under G59/3 and is 50kW or less 3-phase or 17 kW or less single phase to the Distribution Network]
- More than 50kW or non-type tested systems. Further information is available in ENA's connection guide: [A Guide for connecting Generation that falls under G59/3 to the Distribution Network]

More detailed information is available from your DNO (see Table 7).

Witnessing of electricity storage installations is currently required for:

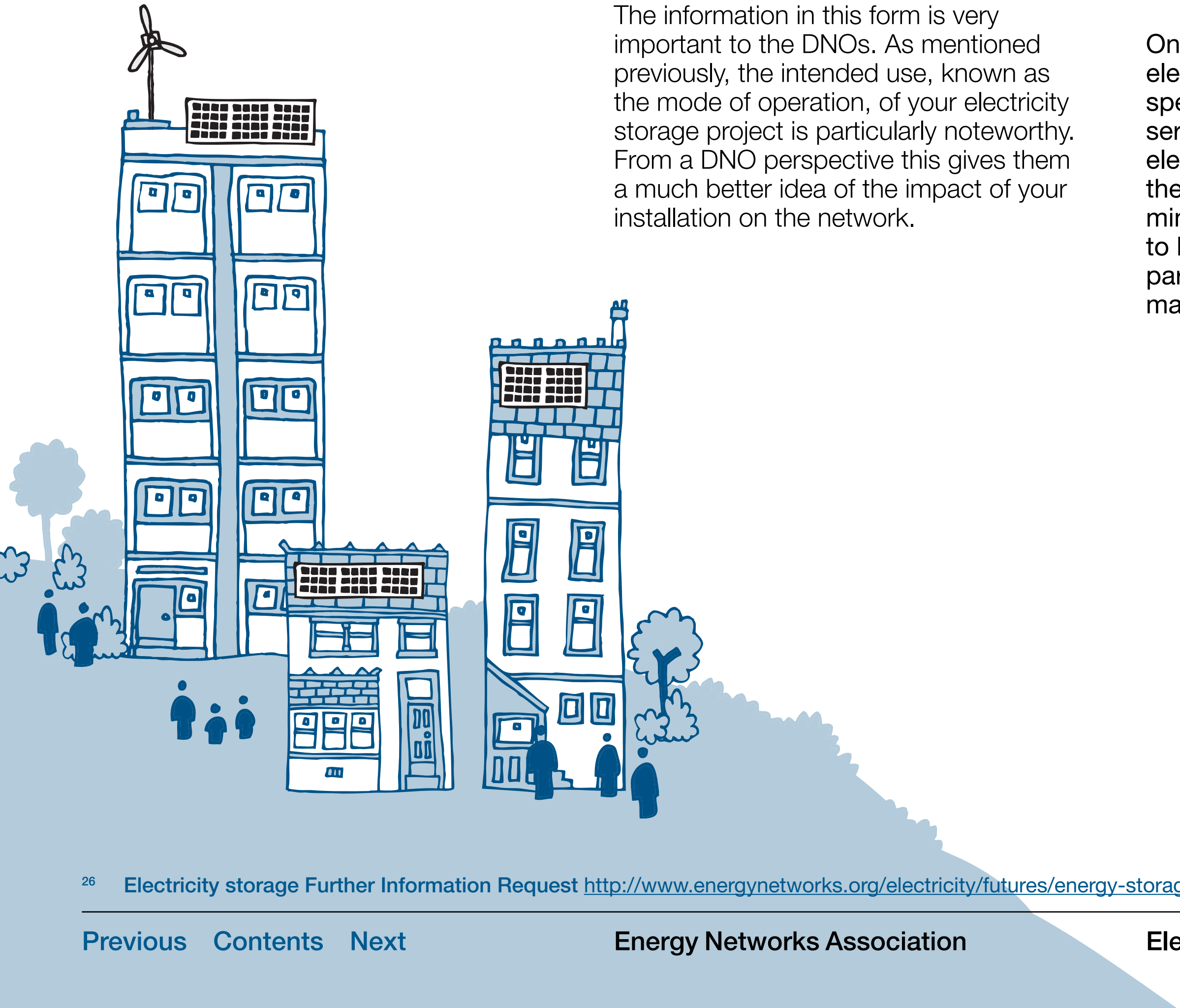
- Every G59 installation above 50kW (DNOs may choose to do so for installations below 50kW)
- Any installations that are looking to use an export limitation scheme and adhere to EREC G100 (unless manufacturers provide evidence that their scheme meets G100 requirements).

Flexible connections types, such as Active Network Management, are applicable for electricity storage projects under the current regulations. However a flexible connection could inhibit the ability of the project to access certain revenues.

In an ANM situation they are queued and constrained in the same way as other generation technologies. This has been noted in the smart, flexible power system call for evidence and may be reformed.

Table 7: Links to DNO webpages for generation connections

Click logo for link to DNO generation connection webpage	Click logo for link to DNO electricity storage webpage
electricity north west	
Northern Ireland Electricity Networks	
NORTHERN POWERGRID	NORTHERN POWERGRID
SP ENERGY NETWORKS	
Scottish & Southern Electricity Networks	
UK Power Networks	UK Power Networks
WESTERN POWER DISTRIBUTION Serving the Midlands, South West and Wales	



Electricity storage – additional information needed for an application

As well as the process described above all DNOs are using a standard ENA form[26] (or version of) for the additional information required for an electricity storage application.

The information in this form is very important to the DNOs. As mentioned previously, the intended use, known as the mode of operation, of your electricity storage project is particularly noteworthy. From a DNO perspective this gives them a much better idea of the impact of your installation on the network.

This contains a number of technical definitions for power:

> **Active power** – the actual amount of power being used by the load. Also known as real or actual power (MW).

> **Reactive power** – the amount of power not used to do work on the load. Also known as 'useless' or 'watt-less' power. Normally measured in Megavolt Amps Reactive (MVAR).

> **Apparent power** – the total power including reactive and active power in a circuit. Normally measured in Mega-Volt-Amps (MVA).

One of the unique characteristics of electricity storage is the ability to provide specific voltage/reactive power control services to the network. This means that electricity storage can be used to help the network perform more efficiently by minimising losses. This service is likely to become a valuable revenue stream, particularly as DNOs start entering the market.

A number of other technical definitions are used:

> **Ramp rate** – the rate that a generator changes its power output. Normally measured in Megawatts per second (MW/sec).

> **Power swing** – the total potential change in power export to power import. This is normally measured in Mega Watts (MW).

> **Security of supply (firm or non-firm connections)** – the type of connection you have will determine how your electricity storage project can operate. Particularly if there are constraints on the network.

[26] Electricity storage Further Information Request http://www.energynetworks.org/electricity/futures/energy-storage/energy-storage-further-information-request.html

Connecting storage to the electricity network

Addition of electricity storage to an existing connection offer

In comparison to other types of connections, electricity storage provides a different set of characteristics for DNOs to assess.

For example an electricity storage project can require an import and export connection.

This means that an existing connection offer for other technologies (e.g. solar PV) cannot be transferred to storage in the majority of cases, due to the following issues:

> Potential impact on other customers in the area waiting for a connection

> The amount and timing of the energy exported to the network is likely to change

> There is likely to be a need for import capacity

> The ramp rate[27] of storage is unlike other technologies

However, there are a number of circumstances where a so called 'material change' to an existing connection offer is possible if certain conditions are met. We are currently consulting on this area, so changes could occur in the near future to provide more certainty for the treatment of electricity storage projects[28].

Contact your DNO to find out more.

[27] The rate that a generator changes its capacity over time. Normally measured in Megawatts per second (MW/sec). A high ramp rate can have a big impact on the network.

[28] ENA consultation, Fair and Effective Management of DNO Connection Queues: Treatment of Changes to Connection Applications http://www.energynetworks.org/assets/files/news/consultation-responses/Consultation%20responses%202016/Fair%20and%20Effective%20Management%20of%20DNO%20Connection%20Queues%20Treating%20Changes%20within%20Applications.pdf

Next steps

Clarity of the commercial and regulatory arrangements for electricity storage, alongside further development of technical and installation standards, would support the growth of the sector.

At the domestic scale, the Renewable Energy Consumer Code (RECC)[29] and BRE National Solar Centre[30] have released documents covering the basics associated with the installation of batteries and solar PV. A more comprehensive code of practice for the installation of all electrical storage systems is under development, following on from the Institute Engineering and Technology (IET) technical briefing[31].

Electricity storage is set to play an important role in managing the challenges facing the electricity network. The market is poised for growth and an evolution of in the whole sstem frmaework will help it to meet its full potential. A number of ENA working groups have been tackling the issues associated with electricity storage for some time and will continue to do so.

We hope this guide provides a concise overview of electricity storage and the process for connecting a project to the network. The community energy sector has a vital role to play in the smart and flexible network, as a trusted local intermediary to consumers and other stakeholders. ENA is leading the transformation of the network we want to work with regulators and government to build the right conditions for electricity storage in our homes and communities to prosper.

29 RECC guidance on battery storage https://www.recc.org.uk/pdf/guidance-on-battery-storage.pdf
30 BRE Batteries and Solar Power: Guidance for domestic and small commercial consumers https://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/88031-BRE_Solar-Consumer-Guide-A4-12pp.pdf
31 IET Electrical energy storage: an introduction http://www.theiet.org/resources/standards/eesstb.cfm

List of key documents

ENA - Electricity storage Further Information Request
http://www.energynetworks.org/electricity/futures/energy-storage/energy-storage-further-information-request.html

ENA Connecting Community energy – a guide to getting a network connection
http://www.energynetworks.org/assets/files/news/publications/1500108_ENA_WPD_guide_AW_110416.pdf

IET Electrical Electricity storage: an introduction
http://www.theiet.org/resources/standards/eesstb.cfm

BRE Batteries and Solar Power: Guidance for domestic and small commercial consumers
https://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/88031-BRE_Solar-Consumer-Guide-A4-12pp.pdf

RECC guidance on battery storage
https://www.recc.org.uk/pdf/guidance-on-battery-storage.pdf

Regen – Electricity storage – towards a commercial model
https://www.regensw.co.uk/storage-towards-a-commercial-model

UK Power Networks – Engineering Design Standard EDS 08-5010 Electricity storage
http://library.ukpowernetworks.co.uk/library/en/g81/Design_and_Planning/Planning_and_Design/Documents/EDS+08-5010+Energy+Storage.pdf

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