Battery Storage Guidance Note 1: Battery Storage Planning.

Energy Institute, August 2019

ISBN 978 1 78725 122 9

Battery storage guidance note 1:
Battery storage planning

energy institute

BATTERY STORAGE GUIDANCE NOTE 1: BATTERY STORAGE PLANNING

First edition

August 2019

Published by
Energy Institute, London
The Energy Institute is a professional membership body incorporated by Royal Charter 2003
Registered charity number 1097899

The Energy Institute (EI) is the chartered professional membership body for the energy industry, supporting over 20 000 individuals working in or studying energy and 200 energy companies worldwide. The EI provides learning and networking opportunities to support professional development, as well as professional recognition and technical and scientific knowledge resources on energy in all its forms and applications.

The EI's purpose is to develop and disseminate knowledge, skills and good practice towards a safe, secure and sustainable energy system. In fulfilling this mission, the EI addresses the depth and breadth of the energy sector, from fuels and fuels distribution to health and safety, sustainability and the environment. It also informs policy by providing a platform for debate and scientifically-sound information on energy issues.

The EI is licensed by:

– the Engineering Council to award Chartered, Incorporated and Engineering Technician status, and
– the Society for the Environment to award Chartered Environmentalist status.

It also offers its own Chartered Energy Engineer, Chartered Petroleum Engineer, and Chartered Energy Manager titles.

A registered charity, the EI serves society with independence, professionalism and a wealth of expertise in all energy matters.

This publication has been produced as a result of work carried out within the Technical Team of the EI, funded by the EI's Technical Partners. The EI's Technical Work Programme provides industry with cost-effective, value-adding knowledge on key current and future issues affecting those operating in the energy sector, both in the UK and internationally.

For further information, please visit [redacted]

The EI gratefully acknowledges the financial contributions towards the scientific and technical programme from the following companies:

BP Exploration Operating Co Ltd
BP Oil UK Ltd
Centrica
Chevron North Sea Ltd
Chevron Products Company
Chrysaor
CLH
ConocoPhillips Ltd
DCC Energy
EDF Energy
ENI
E. ON UK
Equinor
ExxonMobil International Ltd
Innogy
Kuwait Petroleum International Ltd
Nexen CNOOC
Ørsted
Perenco
Phillips 66
Qatar Petroleum
Repsol Sinopec
RWE npower
Saudi Aramco
Scottish Power
SGS
Shell UK Oil Products Limited
Shell U.K. Exploration and Production Ltd
SSE
TAQA Bratani
Total E&P UK Limited
Total UK Limited
Tullow Oil
Uniper
Valero
Vattenfall
Vitol Energy
Woodside
World Fuel Services

However, it should be noted that the above organisations have not all been directly involved in the development of this publication, nor do they necessarily endorse its content.

ISBN 978 1 78725 122 9

Published by the Energy Institute

Hard copy and electronic access to EI and IP publications is available via our website, [redacted]
Documents can be purchased online as downloadable pdfs or on an annual subscription for single users and companies.
For more information, contact the EI Publications Team.
e: [redacted]

CONTENTS

LIST OF FIGURES AND TABLES

ACKNOWLEDGEMENTS

Battery storage guidance note 1: Battery storage planning was developed by Anthony Price (Swanbarton) on behalf of the EI Energy Storage Working Group. During this work the working group consisted of the following individuals:

Jacob Allinson	RWE
Jonathan Buston	HSL
Victor Craig	SSE
Joseph Dunn	Scottish Power
Frank Gordon (Vice-Chair)	Renewable Energy Association
Stuart King (Chair)	Energy Institute
Lee Reed	Centrica

The EI thanks the following contributors who reviewed the project deliverables:

Christophe Banos	EDF Renewables
Hannah Clapham	BEIS
Scott Drinkell	Greenergy
Ed Jamieson	RWE
Adrien Lebrun	Pivot Power

Affiliations are correct at the time of contribution.

FOREWORD

Battery storage is expected to play an important role in the energy transition, allowing the storage of electrical energy from renewables for later use, and helping to balance grid load. At the time of publication, 4.8GW of battery storage has been given planning consent in the UK, but a further 12GW may be needed by 2021. Given the importance that battery storage has on the future energy mix, and the (expected) increasing need for operating companies to plan future battery storage installations, and for local authorities to review and approve plans, industry sees the need for 'just in time' guidance addressing this.

This publication provides guidance covering various aspects of planning a battery storage facility. It provides an overview of battery types, planning regulations in the UK, and information on safety issues that should be considered during planning and risk assessments. It is intended to be concise and reflect current practice and knowledge in this fast-changing sector.

The guidance is intended for:

- operating companies, to help plan and assess risk, and
- local authorities, to help them ask the right questions when making planning decisions.

The information contained in this document is provided for general information purposes only. Whilst the EI and the contributors have applied reasonable care in developing this publication, no representations or warranties, expressed or implied, are made by the EI or any of the contributors concerning the applicability, suitability, accuracy or completeness of the information contained herein, and the EI and the contributors accept no responsibility whatsoever for the use of this information. Neither the EI nor any of the contributors shall be liable in any way for any liability, loss, cost or damage incurred as a result of the receipt or use of the information contained herein.

The EI welcomes feedback on its publications. Feedback or suggested revisions should be submitted to:

Technical Department
Energy Institute
61 New Cavendish Street
London, W1G 7AR
e [redacted]

1 INTRODUCTION

Our electricity networks currently operate on a 'just in time basis' as electricity generation must continually match electricity demand (including losses through inefficiencies). Power system planners and system operators have several options to balance supply and demand. The ability to store electricity and release it later provides a useful technical and commercial tool to assist balancing.

Electricity can be stored in many ways including:

– electrochemical solutions such as batteries;
– pumped hydroelectric storage, and
– mechanical flywheels.

This guidance note considers planning for battery energy storage only. Some other storage systems share similar characteristics and the methodology of this note may be extended to other technologies, such as supercapacitors and electrolyser/fuel cell combinations.

The focus of this guidance note is network connected mid-scale and larger scale installations with a suggested minimum threshold of 500 kW or 250 kWh. The note covers the current interest in the many types of lithium-ion cells but also includes important aspects of other commercial battery types including lead acid, flow batteries and high temperature batteries. There are many large-scale battery systems already installed and operating; this guide is written with reference to these existing examples.

This note excludes planning for small scale domestic battery energy storage applications and battery storage in mobile applications, such as electric vehicles and other transport applications. Developers, operators and installers of small- and mid-size electrical energy storage systems will find useful information in other publications, including the Institution of Engineering and Technology (IET) *Code of practice for electrical energy storage systems*.

1.1 AUDIENCE

This publication provides guidance to site owners and developers planning to build battery energy storage, and to local authorities and others who have responsibility for granting planning permission or other consent. It is intended to help all audiences understand the risks and mitigations that should be in place.

It should prompt informed and relevant risk assessments for site owners and developers and contains information that should be examined by planning authorities before granting permission.

While care has been taken to provide accurate and up-to-date information, this document is for guidance only and users are recommended to take professional advice in the development or assessment of any project.

2 BATTERY ENERGY STORAGE TYPES

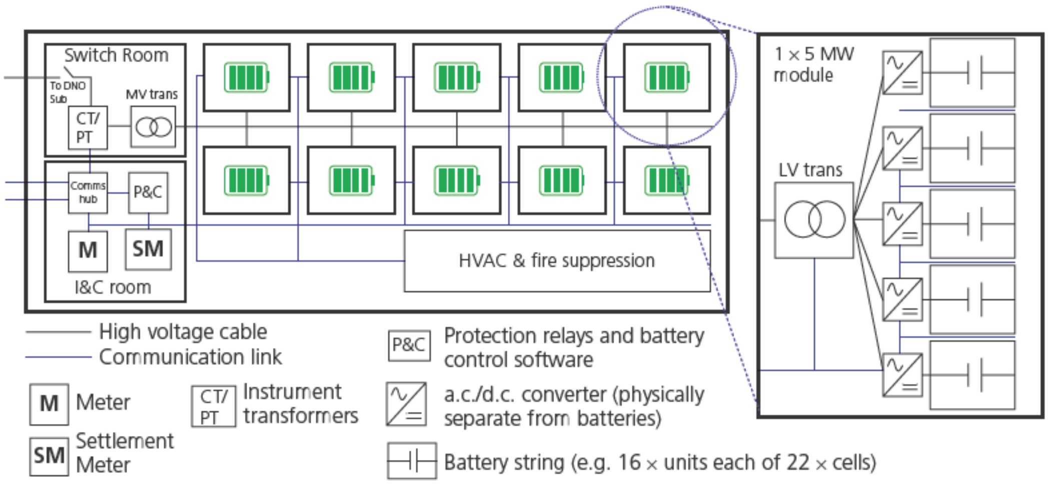

Figure 1: Typical components within a grid scale battery installation

2.1 WHAT IS A BATTERY?

In common use, a battery refers to an electrochemical device which supplies electrical energy. A primary battery converts electrochemical energy to electrical energy. The precise terminology, used for example in international standards, is that a battery is one or more electrochemical cells.

An electrochemical cell converts electrochemical energy to d.c. Two or more cells arranged in series or parallel form a battery. A cell or battery may require a cell or battery management system (BMS) to ensure safety and reliability. A secondary (or rechargeable) battery is a reversible device that converts electrochemical energy to electrical energy and vice versa. In this document, the term battery, unless otherwise stated, refers to a secondary battery.

2.2 WHAT IS A BATTERY STORAGE SYSTEM?

A battery energy storage system includes a BMS, and often a power conversion system (PCS) for conversion of d.c. to a.c. and vice versa. A battery energy storage system, especially for large-scale installations, may include many other components, such as transformers, switchgear, PCSs, battery management, heating or cooling as well as fire management, suppression or firefighting, and other safety or security, equipment.

2.3 TYPES OF BATTERIES IN USE

The lead acid battery has been for many years the predominant type of electrochemistry used for large-scale electricity storage, both in the UK and worldwide. Lead acid is relatively low cost, is nearly completely recyclable and has a well-established history.

The lithium-ion family of batteries has been commercially available for more than 20 years. The common secondary battery types that are used for commercial mid-scale and large-scale storage systems, presently and expected over the next five years, are shown in Table 1.

Other battery types include nickel cadmium, which is not currently used for environmental reasons, and nickel metal chloride which has ceased large-scale commercial production. Many new battery technologies (including aluminium ion, lithium sulfur) are under development, but are not expected to be in widespread use during the lifetime of this document.

The specific chemistry of the battery is important for the planning process because the chemicals released in the event of an accident will determine the level and nature of the risk and how it must be mitigated. For example, it is not sufficient to simply state 'lithium-ion' in the planning application, as each type has widely different characteristics, particularly with regard to fire resistance, fire and explosion propagation, performance, efficiency and resilience to ambient conditions.

All battery types require some form of BMS to ensure safety and reliability during operation. In general, batteries should not be overcharged or over-discharged. For some systems the BMS needs to monitor individual modules or cells to prevent thermal runaway and consequential catastrophic failure. The BMS should be of high integrity and is often provided with third-party certification.

Table 1: Battery chemistry types

Type	Examples	Description	Characteristics	Applications
Lithium-ion (Li-ion)	Several battery types exist including: – Lithium nickel manganese cobalt (NMC or MNC) – Lithium cobalt oxide ($LiCoO_2$) – Lithium iron phosphate ($LiFePO_4$) – Lithium ion manganese oxide battery ($LiMn_2O_4$, Li_2MnO_3, or LMO)	A cell where the lithium ion moves from a carbon-based electrode to a metal oxide electrode through an electrolyte of a lithium salt in a solvent. Cells can be cylindrical, prismatic or pouch type, enabling different physical arrangements. Each chemistry type has different performance characteristics and so there are different consequences in the event of failure Many installations use NMC. LFP has a lower energy density but is regarded as safer than the other chemistry types.	Different battery types can be designed for optimum power density, physical footprint, degradation, fire resistance etc. reasonably robust to high and regular charge cycling. The choice of format and arrangement impacts energy and power density and options for cooling. Catastrophic failure can lead to fire or explosion and release of toxic materials.	Ideal for short duration (~ 1 hour), high power applications, but recent cost reductions show that longer durations can be cost-competitive against other technologies.
Lead Acid	$PbSO_4$	Lead and lead sulfate electrodes with electrolyte sulphuric acid, either as liquid or as a gel. Several variations including flooded, valve regulated, gel type and bipolar.	Low cost, long proven history, Largely recyclable. Low power density and toxic materials. Explosion risk if overcharged due to build-up of hydrogen.	Suitable for a variety of grid applications.
Flow batteries	Many different types using different electrolytes including vanadium flow battery (V/V) and zinc bromide (Zn Br) flow battery.	Electrolytes are stored outside the electrochemical cell, and flow through the cell during the charging and discharging process.	Low performance degradation of performance from charge/discharge cycling. Low fire risk.	Generally suitable for longer durations of up to 8 hrs.
High temperature	Sodium sulfur (NaS)	Sodium and sulfur electrodes separated by a ceramic electrolyte	High energy and power density. Cell temperature of approx. 300 °C mitigated by insulation. Performance not affected by ambient temperature.	Suitable for a variety of grid applications.

Figure 2: A standalone 250 kW 500 kWh ZnBr battery system

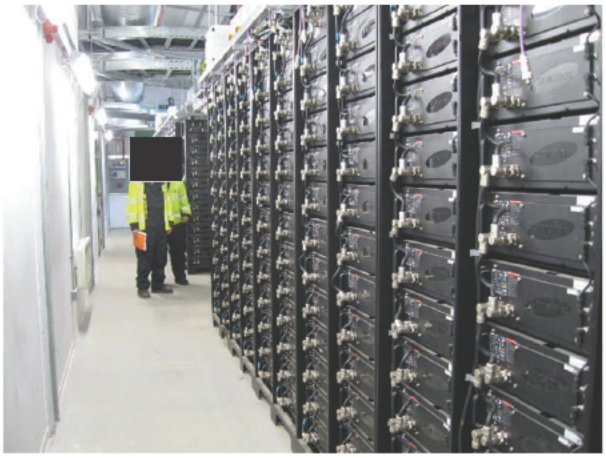

Figure 3: The inside of a 6 MW, 10 MWh lithium-ion battery system operated by UK Power Networks at Leighton Buzzard

Figure 4: A multi container lithium-ion battery storage project

3 NAVIGATING THE PLANNING REGIME – A UK EXAMPLE

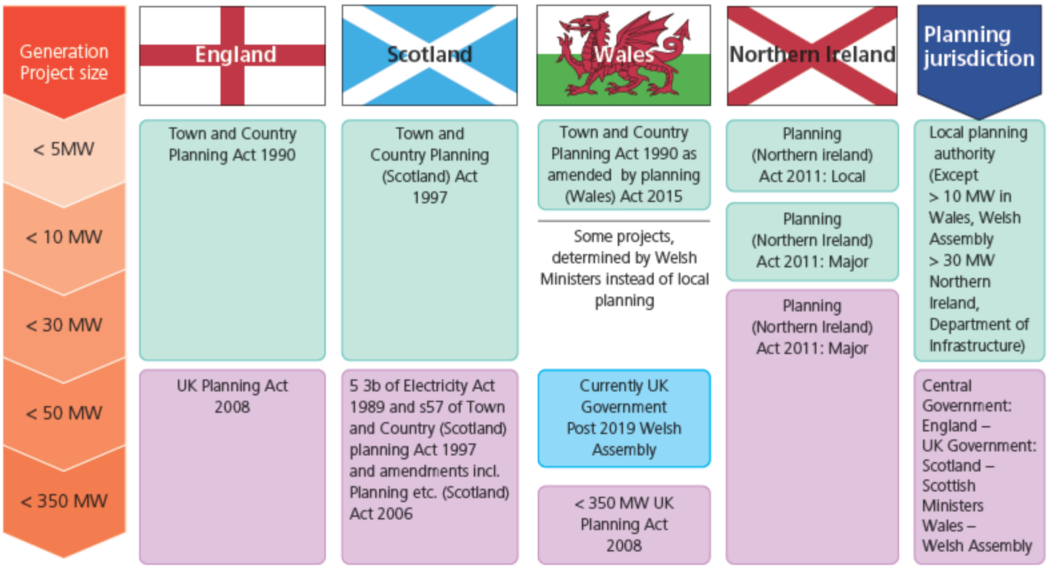

Figure 5: UK planning regime for generation projects (at a glance)

All development is subject to compliance with planning legislation (Department of Local Government and Communities, *Plain English guide to the planning system*), although there are many exemptions that can be applied. There are also different regulations that cover specific circumstances, such as National Parks or developments of a hazardous nature. It is important to identify which planning regime would apply to a specific energy storage project. Although there may be some similarities between projects, care should be taken to comply not only with the planning legislation, but also to ensure that a risk analysis covers the whole system development.

3.1 THE PLANNING BACKGROUND

Planning processes are highly sensitive to the legal jurisdictions covering the project location. These may be national, regional or local laws, under the federal, county/state or municipal authority. Most likely there will be a mixture of all of these, covering different aspects. This guide is written using example storage projects in the UK, but clearly developers must adhere to relevant local process and therefore enlisting local expertise is highly recommended. An early task is to identify the authority having jurisdiction for the project in the area where the project is to be located and to understand their requirements. Even within the UK, there are significant variations in the planning and consenting procedures and care is required to ensure compliance with legislation and regulation.

Many development projects in England and Wales are authorised under the Town and Country Planning Act 1990 (TCPA). However certain projects are consented using alternative authorisation. Developments in the electricity industry are often covered under the Electricity Act 1989, which gives development rights to companies which hold a generation, transmission or distribution licence. This exemption is often used to authorise minor changes to power stations, substations and the like, subject to limitations, restricting the height of any new structures to less than 9 m and excluding substantial changes to the overall site.

New installations are required to either seek planning approval through the TCPA process, or, for larger generation installations, to apply using the process under the Planning Act 2008 (PA). Electricity storage is considered to be generation. The planning treatment for generation projects varies in accordance with the generating capacity of the project. In England, generation projects below 50 MW are determined by the local planning authority (LPA) and projects above 50 MW are determined by the Planning Inspectorate advising the Secretary of State under the Planning Act 2008. There are variations in the thresholds for projects in Wales, Scotland and Northern Ireland. Some larger energy storage sites might require new overhead transmission lines, for which the relevant planning legislation is determined by voltage[1]. As the threshold for consent by the LPA is 50 MW for generation projects, in recent years this has determined the upper capacity limit for storage projects.

In many cases, the planning legislation is yet to catch up with the development of new technology. For example, the TCPA use-class definition (The Town and Country Planning (Use Classes) Order 1987 No. 764) does not yet define a specific class that covers energy storage. Some applications have been made either under B1 (light industrial), B2 (general industrial) or B8 (industrial storage and distribution centres). In the case of B8, applicants have reasonably argued that electricity storage comes under the umbrella of general industrial storage. B8 is also most appropriate when the battery is an uninterruptable power supply (UPS) for a data centre. Many planners have treated standalone energy storage as *sui generis* (in a class of its own) which slows the planning process down; more so because referees will usually be unfamiliar with energy storage technology.

In the UK, The Department for Business, Energy and Industrial Strategy (BEIS) has stated that storage projects should be considered as a subset of generation. This means that development consent is required for storage projects above 50 MW[2], indicating that many storage projects have been treated for planning applications as if they are a generation project. At the time of writing, changes to the licensing regime for electrical energy storage are being considered by The Office of Gas and Electricity Markets (Ofgem) (Ofgem, *Upgrading our energy system: Smart systems and flexibility plan*) and the implications are not yet known. It is not clear whether co-locating storage with an existing generation plant (such as solar or wind) increases the output capacity of the project. The main area of uncertainty is the procedure for deciding whether the project is below or above the current 50 MW threshold which refers larger projects to the planning Authority. Both developers and planners will be aware that this threshold does not necessarily represent a boundary between what is and is not visually or environmentally acceptable and that the situation can change in the future.

Different procedures apply in Scotland, Wales and Northern Ireland:

In Scotland, the devolved administration authorises generation projects over 50 MW whilst those below 50 MW are sent to the relevant LPA. However, the planning legislation is specific to Scotland: the Town and Country Planning (Scotland) Act 1997 and the Planning etc. (Scotland) Act 2006.

1 Lines of 132 kV and above are deemed a Nationally Significant Infrastructure Project and covered by the Planning Act 2008, others are covered by the Electricity Act 1989.

2 At the time of publication, the UK government is conducting consultation as to whether to retain the 50MW NSIP capacity threshold that applies to standalone storage projects, but to place projects under local planning control where the capacity threshold is reached through composite projects including storage and another form of generation. In the UK, a statutory consultation is now underway covering changes to electricity licensing for electricity storage.

In Wales, onshore projects up to 10 MW are covered by the UK TCPA 1990 and are administered by the relevant LPA. Currently, any project between 10 and 50 MW is also covered by the UK TCPA but is judged a 'development of national significance' (DNS) and so is assessed by the Welsh Assembly rather than the LPA. Projects over 50 MW are deemed 'nationally significant infrastructure projects' (NSIP) and so administered by the UK government. However, following the devolutionary Wales Act 2017, the threshold for NSIP will be raised from 50 MW to 350 MW from 2019 onwards. Thus, after this date, any project above 10 MW but below 350 MW is deemed a DNS and will be administered by the Welsh Assembly.

Northern Ireland uses a three-tier approach introduced by the Planning (Northern Ireland) Act 2011 that determines whether jurisdiction lies with either:

- the LPA – in Northern Ireland the LPA is the local council, or
- the central Northern Irish Assembly, specifically its Department of Infrastructure.

According to categories specified by the Planning (Development Management) Regulations 2015, any project below 5 MW is classed as a 'local' development and presided over by the LPA. Projects between 5 MW and 30 MW are classed as 'major': they remain the LPA's decision, but must be subject to a pre-application consultation with the local community, commensurate with project size and complexity. Any project exceeding 30 MW is deemed of regional significance. It still must undergo a suitable public consultation, but is adjudicated by the Department of Infrastructure.

The Ofgem Tier 2 Low Carbon Networks Fund (LCNF) project *Smarter Network Storage 2013–2016* lead by UKPN involved design and operation of 6 MW/10 MWh lithium-ion battery in Leighton Buzzard, UK. The publicly available project reports, particularly, SNS1.2 *Design and planning considerations for large-scale distribution-connected energy storage* include much about the planning process for large-scale storage projects.

Different legislation applies in other countries, and prevailing attitudes to energy storage may affect the planning process. For example, in Australia the recent draft standard DR AS/NZS 5139:2017 dramatically restricts deployment of lithium-ion in buildings because of fire safety concerns. There can be restrictive planning procedures at a more local level. For example, New York City, in the USA, restricts the deployment of grid scale battery storage due to concerns of the New York Fire Department over of the use of lithium-ion batteries in areas of high population density.

4 WHAT SHOULD BE CONSIDERED DURING RISK ASSESSMENT AND PLANNING APPLICATIONS?

This section includes various aspects that should be considered by site owners when risk assessing and planning a battery storage facility, and by LPAs when reviewing planning applications.

4.1 SITE SELECTION

- **Location of the battery:** a basic appreciation of the site, including the battery and the PCS, switchgear, transformers, metering and the like. The site appreciation should consider any restrictions applying to the site, both within the allocated area, or outside the fence line. Abnormal events, for example flooding risk, can create significant hazards and it may be necessary to raise batteries and other equipment above ground level for this reason[3]. The project also includes work up to the point of connection to the electrical network, and any additional works required outside the site boundary. If the project is to be co-located with other renewable assets, such as a solar or wind installation, the area for the site appreciation should be increased.
- **The choice of the type of structure** to house the batteries and ancillary equipment has multiple implications for the planning and consenting process. To date, most large battery storage projects have either been housed in purpose-designed buildings or ISO-style shipping containers (ISO 668:2013). ISO container projects are quick to build, often low cost and are inherently modular. Access to individual containers (unless containers are extensively stacked) offers the option to increase the energy or power of the project later if this option is included in the original design. Adequately spaced containers may mitigate overall fire risk. However, containers have a larger net physical footprint and are perceived to have more adverse visual impact than an existing or new building. Building projects can be designed to fit the surroundings and thus planning permission may be easier to obtain. Some projects have been developed in low-cost, barn-like structures on agricultural sites. Changing the use of an existing farm building does not normally require planning permission, although developers should always check with the LPA. Regulations and legal requirements must be checked before considering installation of new equipment in an existing building.
- **Capacity of the required electrical network connection, voltage at point of connection and timescale for connection:** grid connection timescales vary; they heavily depend on status and forward evolution of the local network and can be in excess of 18 months. Larger projects may affect the transmission network, directly or indirectly, and so require the distribution company to liaise with the system operator. The applicant should provide the status of the connection application to the relevant network operator(s) and demonstrate how connection timescales will be managed.

3 A battery project at Leighton Buzzard was installed in a building raised on stilts to allow flood waters to pass safely underneath.

4.2 ISSUES FOR DESIGN AND PLANNING APPLICATIONS

- **Site access for construction, maintenance and decommissioning:** the size and weight of the installation can be significant, for example lithium-ion batteries can have mass in excess of 6 tonnes per MWh.
- **Site security**: for example, prevention of theft or vandalism. The project type (free standing, installed in shipping containers or similar enclosures, or installed in an existing or new building) will impact on installation, maintenance, relocation, visual appearance, safety and noise.
- **On-site vehicular parking** for the construction phase and ongoing maintenance access and facility staff.
- **Ownership of the land** and any third-party rights to the land, including public access.
- **Noise** (see 4.5).
- **Visual impact and its management**: multi-MW energy installation will be physically large and its visual impact will need to be considered in the planning process:
  - A 10 MW (5 MWh) battery storage project's approximate footprint is 750 m^2. A 100 MW (100 MWh) lithium-ion project's approximate footprint is 10 000 m^2. A 50 MW (300 MWh) sodium sulfur system has a footprint of 14 000 m^2.
  - Container-based projects are usually housed within standard (8 ft 6 in high), high cube (9 ft 6 in high) or modified ISO containers and may be stacked but, due to spacing and access requirements, may cover twice as much area as a building project.
  - The point of connection to the electricity grid will also have some impact on the planning for the project. A cable joint connection underground would have little visual impact unlike a tie-in to an overhead line or a tower. Connection to 132 kV and above require sub-stations (sometimes loop-in – loop-out) requiring significant equipment.
  - Some battery projects will be located on brownfield or greyfield sites where a new development will have a positive visual impact. Project developers can mitigate their visual impact for example by planting shrubs and trees around the perimeter.

4.3 SPECIFIC ENERGY STORAGE CONSIDERATIONS

- **Battery energy storage may be used for single or multiple purposes.** Planning applications require the applicant to describe how the intended development will be used. The use(s) of the energy storage may also determine the rateable value of the project with implications on the project's rate of return.
- **Power and energy rating** which impact on layout, requirements for network connection, and its intended and alternative applications. The connection application to the distribution network operator needs to be carefully aligned with the future operation profile of the battery. Crucial elements to consider are:
  - connection voltage (important for the power rating of the battery);
  - both import and export ratings (MW). In general, symmetric capacities are recommended;

– ramp rate (MW/sec) to indicate the speed of response the network will have to expect, and
– power swing (MW).

Any constraints indicated by the distribution network operator in their grid connection offer should be carefully assessed by the developer to ensure they would not affect the battery storage business case.

– **Choice of battery technology and specific chemistry:** the Control of Substances Hazardous to Health Regulations 2002 (COSHH) cover the use of substances hazardous to health. The choice of energy storage type, in conjunction with its location, may determine the requirement for environmental impact assessment (EIA)[4], integrated pollution prevention and control (IPPC)[5] or variations, accounting not only for the energy storage medium, but also for the rest of the plant and its interactions with other adjoining or adjacent installations. For example, the presence of fuel tanks or chemical stores could, in combination, take an installation over a threshold limit set by the Control of Major Accident Hazards (COMAH) Regulations, Dangerous Substances (Notification and Marking of Sites) Regulations 1990 (NAMOS)[6], and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulations. Developers should calculate the total mass of active materials on the sites and refer to the limits given in the legislation. Because battery storage involves chemical/electrochemical reactions, the materials in the charged and uncharged states should be considered. Some battery systems produce hydrogen at certain points in the charge cycle and this possibility should be included in the analysis. Developers should also check that in the event of a fire, explosion or other event, the total mass of released by-product materials is below the threshold limits. Compliance with the Batteries Directives (see references) and associated legislation and regulations which cover the import, use and recycling of the batteries is essential. There is also legislation covering the transport of batteries[7] and removal of waste batteries. This may influence the choice of route and selection of carrier for the delivery of batteries.
– **Choice of supporting equipment**, often referred to as the balance of plant. Consideration should be given to any size and noise implications and the chemical hazards associated with the balance of plant.
– The application should also consider associated **civil engineering or building works** associated with the electrical connection, such as cable trenches, cable ways, bunding and blast walls for transformers.

4 In the UK, covered by The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 No. 572, UK Parliament, available at http://www.legislation.gov.uk/uksi/2017/571/introduction/made

5 In England and Wales: European Community (EC) Directive 2008/1/EC1 on Integrated Pollution Prevention and Control (the IPPC Directive), since superseded by Directive 2010/75/EU, [redacted]

In Scotland: The Pollution Prevention and Control (Scotland) Regulations 2012, No. 360 Scottish Parliament, available at http://www.legislation.gov.uk/ssi/2012/360/contents/made,

In Northern Ireland: The Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013, No. 160, available at http://www.legislation.gov.uk/nisr/2013/160/contents/made

6 This includes the notification of sites holding over 25 tonnes of lithium-ion chemistry batteries

7 For example UN 3090 is for lithium-ion batteries. Trained drivers are required for the transport of hazardous goods such as batteries.

4.4 CONSTRUCTION CONSIDERATIONS

- **Compliance with the Construction, Design and Maintenance Regulations (CDM):** by law, CDM regulations require all projects where construction work will last longer than 30 days, where there are more than 20 workers at a time or more than 500-person days, to notify the Health and Safety Executive (HSE). Irrespective of this, it is good practice for all involved in a battery project to comply with the spirit of the CDM and ensure that an adequate management plan is in place to cover the design construction, operation, maintenance and decommissioning of the project. Because the operation and maintenance of a battery project will be dependent on its use and duty cycle, it is important, and a legal requirement, that the application of the battery system, and any changes in its applications, are defined at the beginning of the process and recorded in the project file.
- **Site access during construction** (equipment delivery, construction equipment access): impact on a given locality is very site-specific and is affected by rural or urban locations and by the existence (or otherwise) of communication routes (roads, rail, seaports). The amount of civil works required will depend upon ground quality and the type of building works required will depend upon options to reuse existing facilities if these are available.
- **Use of building materials:** comparisons should be made between indoor versus outdoor insulations and the quality of the building fabric on a brownfield site (resistance to wind, rain, water or noise).
- **Noise and other disruption:** the project will necessitate extra vehicles and so frequency and time-of-day of deliveries should be considered in relation to extra traffic, disruption and noise. Consideration of construction and installation works practices in relation to time-of-day (working hours) and number of working days (including working at weekends) should be made, as well as considering provision of storage of materials during construction.
- **Construction timescales:** time required for construction and installation works will clearly vary with the scale, rating and complexity of a project. But often many elements are pre-constructed in containers with the main impact being on the roads, cranage, storage and site operatives. Typically, a 5 MW battery energy storage plant may take four to six months to build and a larger 50 MW system may take eight to 12 months.

4.5 OPERATIONAL CONSIDERATIONS

- **Noise from electrical equipment and cooling:** although battery storage systems do not contain significant moving parts, battery PCSs emit a whine due to fast electrical switching, flow batteries require pumps, and various items of plant will require fans for active cooling. For example, a forced-air-cooled 1 MW PCS could have a sound level up to 75 dBA (average value at 1 m from object). This 'base value' could easily change (up or down) due to an alternative cooling medium. Similarly, other ancillary systems (particularly transformers) can vary in noise output due to the cooling design adopted (natural or forced, air, oil or water) and have the characteristic 100 Hz hum. A baseline noise survey must be carried out before planning so that any additional noise when operational can be objectively measured.

- **Harmonic current emissions** associated with power inverter systems may have operational impacts on the plant itself as well as on other plant and equipment in the area. This will be considered in the application for network connection and is covered in the Energy Networks Association (ENA) Engineering Recommendation G5/4-1.
- **Heating and cooling:** the source of air or water for heating and cooling is important as it impacts on the condition of the system. Sites close to the coast may have high salinity air which would be detrimental to the system. The discharge of cooling air should take into account neighbouring areas.
- **Maintenance requirements:** the developer should consider how to provide maintenance over the operational lifetime. This includes the possible need for storage of materials or equipment onsite, the need for site access for specialist equipment, and the possibility of replacing large modules (e.g. containers).
- **Fire safety and emergency procedures:** the developer, owner and operator should prepare a fires safety and emergency plan which will contain, but not be limited to, the ingress and egress routes to buildings, access routes for emergency vehicles, fire management and compliance with fire safety legislation[8].

4.6 FIRE RISKS

The UK's Regulatory Reform (Fire Safety) Order 2005 places the burden of fire safety on the owner and operator of an installation. The fire and rescue services are not obliged to give consent or agreement as to the safety of an installation. If an installation does not have an adequate fire safety plan and precautions, the responsible owners or operators will be prosecuted. This has implications for landlords who have leased space to energy storage operators as well as the Directors of the ultimate holding companies operating storage.

The fire risk from a battery installation covers damage to the energy storage medium, as well as the ancillary equipment, and the buildings or containers. Fire could start in the energy storage medium itself (such as the battery) or it could be started elsewhere and then spread to any other combustible materials (including the battery). Additional hazards could include fire spreading to other parts of the same installation or adjacent property. For example, a fire on a battery installed on a power station or industrial site could spread to fuel tanks. The hazards from fires are complex, and need to include the effects of flame, heat, smoke and products of combustion on the installation and other properties.

Fire engineers can model the impact of fire on an installation, considering a range of possible ignition scenarios and the local environment and the modelling will support and inform the development of the fire protection safety case. This is dependent on the provision of accurate information from battery manufacturers concerning maximum allowable temperatures before fire propagation can be assumed to occur and the heat released by a burning battery.

The response to a fire on a battery storage project will differ, depending on the battery chemistry, the site location and local environment and method of installation. For small installations it may be prudent to let the fire burn itself out, but for larger installations fire quenching using an extinguishing material will be a better course of action. The products of combustion and the effect of water or other extinguishing materials on battery and other electrical materials must be assessed.

8 In the UK, *The Regulatory Reform (Fire Safety) Order 2005*, No. 1541, UK Parliament, available at http://www.legislation.gov.uk/uksi/2005/1541/contents/made

The fire and safety plan should include a means for containment of water, or other materials used for extinguishing the fire, but avoiding run off into the local environment. The standards for lead acid battery rooms include sufficient primary and secondary bunding to contain battery electrolyte and this is recommended practice for flow battery systems.

4.7 INTENDED APPLICATIONS, ASSET LIFE AND ENVIRONMENTAL IMPACT

A battery energy storage plant might be used for one or more applications, and the applications may have a significant impact on the project's asset life and its environmental impact. As an example, from a related industry, a small generator installed for back-up power or peaking power may only be expected to run in exceptional circumstances, and so may be granted planning consent on the basis of a limited number of running hours each year.

Energy storage is an enabling technology and can be used for many applications, both connected to, and separated from, the power network. A battery energy storage plant can be placed in the following operational states:

– **Shutdown:** the system is disconnected and there is no power flow in or out and the battery system will need to be moved to a standby state before use. (Note that this may be different for different battery types and some systems may be able to go from shutdown to standby or operational in seconds or less. Other systems may require cooling or heating systems to be started, fans or pumps to be started as well as control systems to boot up.
– **Standby:** the battery is able to be charged or discharged promptly. In this state, cooling and heating may be required, pumps and fans may be operational, meaning that noise and emissions will be occurring, even if there is no charge or discharge taking place.
– **Operational:** the battery is charging or discharging. Note that battery storage can be fast to operate and moving from charge to discharge can be close to instantaneous, and so the battery can be used for regulating frequency on a cycle-by-cycle basis.

The main applications currently considered for a battery energy storage system are:

– **Dynamic frequency regulation** – discharging or charging power to or from the network to maintain system frequency on a continuous basis.
– **Static frequency regulation** – discharging or charging power to or from the network to maintain system frequency when the frequency changes outside set limits. This means that the battery is expected to be in standby mode for most of the time.
– **Reserve** – discharging or charging power over longer time periods when for example there is insufficient generating power.
– **Energy trading** – importing and exporting power, often on a continuous basis, to take advantage of energy price differences between time periods, to timeshift the output from renewable generation or to reduce demand at peak periods to reduce network connection charges. This can also include participation in capacity markets and the balancing mechanism.

An owner/operator seeking to maximise the financial benefit of a battery system may need to move between services as the market conditions change. Planning and consenting authorities do not normally consider the commercial viability of projects, but they should be aware of the constantly changing market-place in the provision of services to the electricity transmission network operator and the distribution network operators and that the services provided by these installations will certainly change during the lifetime of the asset.

The operational duties of the battery will affect the battery's lifetime to a greater or lesser extent depending on the battery type. In general terms, the more discharge/charge cycles that a battery undergoes, the more the overall performance is degraded and the lifetime is reduced. For some battery types, such as vanadium flow systems, this is not regarded as an issue, but for other types, including lead acid and some lithium systems, this decline in performance can result in a reduction in lifetime and require early replacement or decommissioning.

The planning or consenting authority may wish to consider the impact of the number of running hours on the broader environment and local area, and include assessments of noise, emissions, repairs and maintenance which will all be proportional to the operating profile of the system.

Emissions include hydrogen and other gases from certain battery types, heat, which may be dissipated through air cooling or water cooling and will arise as a by-product of battery operation. Batteries, BMSs, PCSs and transformers all need to be maintained within an appropriate operating temperature and fans, pumps and other electro / mechanical devices may be required.

4.8 HYBRID INSTALLATIONS

The term hybrid installations could refer to either a project with multi technology energy storage mediums or a project where energy storage is combined with another energy installation such as wind or solar generation.

A hybrid multi technology energy storage project should be considered for planning and consenting purposes as both two separate storage types, each with its own characteristics under planning guidance, and also in combination. The risk and hazard analysis should consider what impact an event on one part of the site would have on the other – for example whether a fire or explosion in battery type A would impact on battery type B or vice versa.

Many storage installations have been developed as standalone sites, but the trend is towards combined projects such as behind the meter demand or generation and with renewable, particularly photovoltaics (PV) solar or wind generation. These raise similar planning considerations – principally, care should be taken to ensure that the impact of the storage technology on the generation technology or vice versa has been properly considered.

Currently, generation projects are given permission or consent based on their net generation capacity. Recently, government publications (e.g. Ofgem, *Smart systems and flexibility plan: Upgrading our energy system*) consider storage projects to also be classified as generation. This may mean that adding storage to a renewable generation project moves the project out of the LPA jurisdiction into national planning. However, planning applications and decisions should always be taken with a complete assessment of risks and impacts, both of the facility itself and the surrounding environment.

5 COMPLIANCE WITH LEGISLATION AND STANDARDS

Legislation, including the Electricity at Work Regulations 1989 Act and the Health and Safety at Work etc Act is highly relevant in establishing the framework for planning and construction of projects. Adhering to the relevant standards provides reassurance of best practice and may be a requirement for insurance. There is a broad range of overlapping standards, so it is not possible to give an exhaustive list. Standards are being developed continuously so referencing up-to-date indexes is important. There are national standards and international standards: those adopted by the British Standards Institution (BSI), International Electrotechnical Commission (IEC), the European Committee for Electrotechnical Standardization (CENELEC), or the International Organization for Standardization (ISO) for example, are likely to be relevant. Where it exists, any harmonised international standard should take precedence. Some commercial[9] and not for profit organisations[10] also produce standards or codes of practice, often in advance of a national or international standard. In the UK, the ENA's Engineering Recommendations are requirements of the Grid Code or Distribution Code and so are legally enforceable requirements. Standards can be grouped by their subject matter, as shown in Tables 2–5:

Table 2: Standards concerning specific battery type

	Battery type				
Standard	**Lithium-ion**	**Lead-acid**	**Flow batteries**	**Nickel cadmium**	**High temperature**
BS EN 62281:2017, *Safety of primary and secondary lithium cells and batteries during transport*	X				
IEC 62619:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*	X				
IEEE P1679.2, Draft *Guide for the characterization and evaluation of sodium-beta batteries in stationary applications*					X
IEC 60896-22, *The technical requirements for stationary VRLA batteries*		X			

9 For example, DNVGL-RP-0043, *Safety, operation and performance of grid connected energy storage systems*, published by DNV as part of the GRIDSTOR project.

10 For example, Institute of Electrical and Electronics Engineers (IEEE), and Institution of Engineering and Technology (IET) produce standards or similar documents which are treated as *de facto* standards and are often considered as requirements by insurance companies.

Table 2: Standards concerning specific battery type (continued)

UL 1642, *Standard for lithium batteries*	X				
BS EN IEC 62485-2:2018, *Safety requirements for secondary batteries and battery installations*	X	X	X	X	X
CWA 50611:2013, *Flow batteries – Guidance on the specification, installation and operation*			X		
IEEE P2030.3, *Standard for test procedures for electric energy storage equipment and systems for electric power systems applications*	X	X	X	X	X

Table 3: Standards concerning energy storage systems

Name	**Description**
IEC 62933, *Electrical energy storage systems (EESS)*	Currently under development, published parts covered below.
IEC 60050-601:1985, *International electrotechnical vocabulary. Chapter 601: Generation, transmission and distribution of electricity – General*	Defines low voltage<1 kV, 1 kV < medium voltage < 30kV and high voltage > 30 kV.
IEC 62933-1, *Electrical energy storage (EES) systems – Part 1: Vocabulary*	Covers the detailed terminology within the standard. Notably a distinction is made between low voltage, medium voltage and high voltage Electrical energy storage systems (EESS) and residential EESS, commercial and industrial EESS and utility EESS. (See IEC 60050 for voltage level definitions).
IEC 62933-2-1 2018, *Electrical energy storage (EES) systems – Part 2–1: Unit parameters and testing methods – General specification*	This formally defines EESS parameters such as active and reactive power, round trip efficiency, expected service life etc., and formally sets out how to verify these parameters in testing.
IEC 62933-4-1, *Electrical energy storage (EES) systems – Part 4–1: Guidance on environmental issues – General specification*	Assesses the interaction of the EESS with the environment across its entire life-cycle and how adverse mutual effects on the EESS/environment may be considered and mitigated.
IEC 62933-5-2, *Electrical energy storage (EES) systems Part 5–2: Safety requirements for grid integrated EES systems – electrochemical based systems*	Covers risk assessment, identification and mitigation of hazards, across 5 unique EESS classes based on electrochemistry. Expected to be published in 2020.

Table 4: Standards concerning electrical installations

Name	**Description**
IEEE 1547, *Standard for interconnection and interoperability of distributed energy resources (DER) with associated electric power systems interfaces*	This covers all DER including Energy Storage Systems connected at distribution level, specifying detailed electrical performance characteristics such as active and reactive power and voltage control, protection, fault ride through, islanding, communication and testing and verification of the same.
IEEE 1584-2018, *Guide for performing arc-flash hazard calculations*	Guidance for performing arc-flash hazard calculations.
IEC 61936-1: 2010, *Power installations exceeding 1 kV a.c.- Part 1: Common rules*	A very general standard covering guidance for all common items of power system plant with regard to insulation, protection and safe clearances.
IEC 61000, *Electromagnetic compatibility (EMC)*	A family of standards specifying electromagnetic compatibility equipment in various environments. Relevant parts are 1–2 methodology, 6–2 (industrial environments) and 6–5 (substations).
IEC 61850, *Power utility automation*	Standard for communication protocols used in the automation of electricity substations. The basic standard focuses on secondary system communication architecture, but further modules exist for distributed energy resources and e-mobility.
BS 7671, *Requirements for electrical installations (IET wiring regulations)*	National standard in the UK for electrical installation and the safety of electrical wiring for installations below 1.5 kV d.c. and 1 kV a.c.
IEC 60364, *Electrical installations for buildings*	This IEC document closely mirrors BS 7671 but has minor variations to account for international practices.
ENA Engineering recommendation G83, *Recommendations for the connection of type tested small-scale embedded generators (up to 16A per phase) in parallel with low-voltage distribution systems* This will be replaced by G98, *Requirements for the connection of fully type tested micro-generators (up to and including 16 A per phase) in parallel with public low voltage distribution networks on or after 27 April 2019)*	Although not a storage standard *per se*, G83 in the UK applies to any generation equipment connected to the network that is less than 16 A per phase (i.e. 3.68 kW at 230 V).

Table 4: Standards concerning electrical installations (continued)

ENA Engineering recommendation G59, *Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators* This will be replaced by G99, *Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019*	Although not a storage standard *per se*, G59 in the UK applies to any generation equipment connected to the network with output greater than 16 A per phase (i.e. 3.68 kW at 230 V). Different sections of G59 apply depending on overall power – for example >50 kW must use G59 approved relays to de-energise equipment safely in the event of a grid outage.

Table 5: Standards concerning electrical networks

Name	Description
ENA Engineering recommendation P28, *Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom*	Defines in high detail permissible voltage dips and flicker caused by energisation of equipment connected to voltages up to and including 132 kV – nominally dips should not be more than 3%.
ENA Engineering recommendation P29, *Planning Limits for Voltage Unbalance in the United Kingdom*	Planning limits for the degree of voltage balance in a three-phase system. States that unbalance caused by individual loads should not be more than 1.3% but with short-term deviations < 1 minute up to 2% allowed. In aggregate, many loads are permitted a 2% unbalance.
ENA Engineering recommendation G5/4, *Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the United Kingdom*	Specifies planning for the maximum permissible harmonics at different voltage levels. Can be summarised as percentage total harmonic distortion (THD): 5% at and below 400 V, 4% up to 20 kV and 3% above 20kV.
ENA S36, *Procedure to identify and record "hot" substations*	Very high voltage substations can cause the potential of the local ground to temporally rise to dangerous levels in the event of an earth fault – in addition to obvious personal hazard this can interfere with telecoms equipment. This standard covers how to measure and record such hot sites.
ENA TS 41-36, *Distribution switchgear for service up to 38kV. (Cable and overhead conductor connected)*	The technical specification for distribution switchgear up to 36 kV, both cable and overhead line connected.
ENA TS 50-18, *Design and application of ancillary electrical equipment*	Covers earthing and protection of secondary power system equipment, e.g. current transformers.

6 RISK ASSESSMENT

There should be a full consideration of risks including, but not limited to, accidental or intentional damage and natural phenomena such as fire, weather (including snow and ice and access during bad weather), flooding, land subsidence, flora and fauna (including birds and mammals) and security. Note that risk assessment should be bidirectional – i.e. include both risks *to* the facility and *from* the facility. The planning process should assess the following risks and describe how the credible worst case has been mitigated. (Brief examples of mitigation are given here, but clearly applicants must adhere to the relevant legislation.)

Risk	**Reason**	**Example mitigation**
Construction site hazards	Construction related, working at height, manual handling	Adherence to CDM. Contractor risk assessment, adequate safety record and accreditation. Appropriate personal protective equipment (PPE).
Industrial site hazards	Slips, trips and falls, manual handling, chemical burns, electrocution, explosion	Undertake site risk assessment, ongoing safety training of site staff, appropriate PPE.
Weather: storm, snow and ice	Water ingress, freeze-thaw weathering, electrical short circuit	Ingress protection, antifreeze agents, power system protection, adequate system earthing, lightning surge suppression.
Subsidence and earthquake	Land may be unstable	Geological survey.
Flora and fauna	Effect on habitats, biotic weathering, animals or birds nesting, animals roaming onto site	Maintenance, adequate ingress protection.
Fire	Flammable materials	Fire breaks, adequate fire suppression, clear emergency egress and ingress routes. Fire safety drills.
Flood	Electrical short circuit, contamination of water supply	Flood defence, electrical plant raised above flood height.
Security	Vandalism, theft	CCTV monitoring, security alarms, adequate lighting.

7 DECOMMISSIONING

Good practice, as required to comply with the CDM, includes maintenance and decommissioning. Decommissioning is not simply a reversal of the construction process, as it will include consideration of disposal of waste materials, compliance with the EU Batteries Directives for recycling, and restoration of the land. The Batteries Directive creates a legal requirement for recycling rates, and within national legislation there are requirements that industrial batteries are returned to the distributor and sent to an approved battery treatment operator or an approved battery exporter for treatment and recycling. The lifting capability of any containers or battery enclosures should be checked prior to removal, and batteries and other equipment may need to be removed from the enclosures prior to lifting.

A project developer should include a statement on decommissioning and recycling of all equipment: the battery cells, containers, as well as the BMSs, ancillary equipment such as switchgear and transformers and return of the site to its original condition. Many contractors are used to dealing with the removal and repurposing or recycling of conventional electrical infrastructure because of the high scrap value content of transformers and switchgear. Currently, there are few systems in place for collection and treatment of advanced batteries, particularly those of the lithium-ion family. Because lithium battery systems currently have negative scrap value, it is important that the decommissioning plan is sufficiently well financed to cover the full costs of decommissioning and removal from site. There is uncertainty within the industry over the availability and suitability of recycling facilities which need to be available within the next 10 years.

ANNEX A
FURTHER READING AND REFERENCES

A.1 FURTHER READING

Baxter, R. *Energy storage: A nontechnical guide*

EA Technology, *A good practice guide on electrical energy storage*

Smarter Network Storage Project, *Design and planning considerations for large-scale distribution-connected energy storage (SNS1.2)*

US Department of Energy, Electric Power Research Institute, *Electricity storage handbook 2016*

A.2 REFERENCES

Regulations

Control of Substances Hazardous to Health Regulations 2002 No. 2677

Directive 2006/66/Ec of the European Parliament and of the council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC

Directive 2008/1/EC1 on Integrated Pollution Prevention and Control (the IPPC Directive)

Directive 2010/75/EU of the European Parliament and of the council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

Electricity Act, 1989 c. 29

Health and Safety at Work etc. Act 1974

Planning (Northern Ireland) Act 2011 c. 25, UK Parliament

Planning etc. (Scotland) Act 2006 asp 17, Scottish Parliament

Registration, evaluation, authorisation and restriction of chemicals, EC Regulation No 1907/2006

The batteries and accumulators (placing on the market) Regulations 2008, No. 2164, UK Parliament

The Construction (Design and Management) Regulations 2015, No. 51

The control of Major Accident Hazards Regulations 2015 No. 483

The Dangerous Substances (Notification and Marking of Sites) Regulations 1990

The Electricity at Work Regulations 1989 (SI 1989/635) (as amended)

The Planning (Development Management) Regulations (Northern Ireland) 2015 No. 71, UK Parliament

The Planning Act 2008 c. 29, UK Parliament

The Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013, No. 160

The Pollution Prevention and Control (Scotland) Regulations 2012, No. 360 Scottish Parliament

The Regulatory Reform (Fire Safety) Order 2005, No. 1541, UK Parliament

The Town and Country Planning (Environmental Impact Assessment) Regulations 2017 No. 572, UK Parliament

The Town and Country Planning (Use Classes) Order 1987 No. 764

The Wales Act 2017 c. 4, UK Parliament

The Waste Batteries and Accumulators Regulations 2009 No. 890, UK Parliament

Town and Country Planning (Scotland) Act 1997 c. 8, Scottish Parliament

Town and Country Planning Act, 1990 c. 8, UK Parliament

British Standards Institution (BSI) – https://www.bsigroup.com

BS 7671 *Requirements for electrical installations (IET wiring regulations)*

BS EN 62281:2017 *Safety of primary and secondary lithium cells and batteries during transport*

BS EN IEC 62485-2:2018 *Safety requirements for secondary batteries and battery installations*

Energy Networks Association (ENA) – http://www.energynetworks.org/

Engineering recommendation G5/4 *Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the United Kingdom*

Engineering recommendation G59 *Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators*

Engineering recommendation G83 *Recommendations for the connection of type tested small-scale embedded generators (up to 16A per phase) in parallel with low-voltage distribution systems*

Engineering recommendation G98 *Requirements for the connection of fully type tested micro-generators (up to and including 16 A per phase) in parallel with public low voltage distribution networks (replacing G83) on or after 27 April 2019)*

Engineering recommendation G99 *Requirements for the connection of generation equipment in parallel with public distribution networks (replacing G59) on or after 27 April 2019*

Engineering recommendation P28 *Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom*

Engineering recommendation P29 *Planning limits for voltage unbalance in the United Kingdom*

Recommendation G5/4 *Planning levels for harmonic voltage distortion of non-linear equipment*

S36 *Procedure to identify and record 'hot' substations*

TS 41-36 *Distribution switchgear for service up to 38kV. (Cable and overhead conductor connected)*

TS 50-18 *Design and application of ancillary electrical equipment*

Institute of Electrical and Electronics Engineers (IEEE) – [redacted]

IEEE P1679.2 *Draft: Guide for the characterization and evaluation of sodium-beta batteries in stationary applications*

IEEE 60896-22 *Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements*

IEEE P2030.3 *Standard for test procedures for electric energy storage equipment and systems for electric power systems applications*

IEEE 1547 *Standard for interconnection and interoperability of distributed energy resources (DER) with associated electric power systems interfaces*

IEEE 1584-2018 *Guide for performing arc-flash hazard calculations*

International Electrotechnical Commission (IEC) – [redacted]

IEC 60364 *Electrical installations for buildings*

IEC 60896-22 *The technical requirements for stationary VRLA batteries*

IEC 61000 *Electromagnetic compatibility (EMC)*

IEC 61850 *Power utility automation*

IEC 61936-1: 2010 *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC 62619:2017 *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

UK Government – https://www.gov.uk

Department of Local Government and Communities, *Plain English guide to the planning system*

Ofgem, *Upgrading our energy system: Smart systems and flexibility plan*

Batteries and accumulators (placing on the market) regulations: compliance and guidance

Electrical waste: retailer and distributer responsibility

Waste batteries: producer responsibility

Various authors

European Committee for Electrotechnical Standardization (CENELEC), CWA 50611:2013, *Flow batteries – Guidance on the specification, installation and operation*

DNVGL-RP-0043 *Safety, operation and performance of grid connected energy storage systems*, published by DNV as part of the GRIDSTOR project.

International Organization for Standardization (ISO), ISO 668:2013 *Series 1 freight containers – classification, dimensions and ratings*

Standards Australia, DR AS/NZS 5139:2017 *Electrical installations – Safety of battery systems for use with power conversion equipment*

The Institution of Engineering and Technology (IET), *Code of practice for electrical energy storage systems*

Underwriters Laboratory (UL) 1642 *Standard for lithium batteries*

ANNEX B
ABBREVIATIONS AND ACRONYMS

A	ampere
a.c.	alternating current
BEIS	The Department for Business, Energy and Industrial Strategy
BMS	battery management system
BSI	British Standards Institution
C	celsius
CDM	Construction, Design and Maintenance Regulations
CENELEC	European Committee for Electrotechnical Standardization
COMAH	Control of Major Accident Hazards Regulations
d.c.	direct current
dBA	A-weighted decibels
DER	distributed energy resources
DNS	development of national significance
EESS	Electrical energy storage system/s
EI	Energy Institute
EIA	Environmental Impact Assessment
ENA	Energy Networks Association
ft	foot/feet (unit of measurement)
HSE	Health and Safety Executive
HVAC	heating, ventilation, and air conditioning
Hz	hertz
IEC	International Electrotechnical Commission
IEEE	Electrical and Electronics Engineers
IET	Institution of Engineering and Technology
in	inch (unit of measurement)
IPPC	Integrated Pollution Prevention and Control
ISO	International Organization for Standardization
kV	kilovolt
LCNF	Low Carbon Networks Fund
$LiCoO_2$	lithium iron phosphate
Li-ion	lithium-ion
$LiMn_2O_4$, Li_2MnO_3, or LMO	lithium-ion manganese oxide battery
LPA	local planning authority
m	meter
MW	megawatt
MWh	megawatt-hour
NAMOS	Dangerous Substances (Notification and Marking of Sites) Regulations 1990
NaS	sodium sulfur
NMC/MNC	lithium nickel manganese cobalt
NSIP	nationally significant infrastructure projects
Ofgem	The Office of Gas and Electricity Markets
P&C	protection relays and battery control software
PA	*Planning Act 2008*
$PbSO_4$	lead acid

PCS	power conversion system
PPE	personal protective equipment
PV	photovoltaics
REACH	Registration, evaluation, authorisation and restriction of chemicals regulations
SM	settlement meter
TCPA	*Town and Country Planning Act 1990*
THD	total harmonic distortion
UPS	uninterruptable power supply
V	volt
V	vanadium (V/V all vanadium flow battery chemistry)
Zn Br	zinc bromide

This publication has been produced as a result of work carried out within the Technical Team of the Energy Institute (EI), funded by the EI's Technical Partners and other stakeholders. The EI's Technical Work Programme provides industry with cost effective, value adding knowledge on key current and future issues affecting those operating in the energy industry.

Energy Institute
61 New Cavendish Street
London W1G 7AR, UK

t: +44 (0) 20 7467 7100
[redacted]

9781787251229

ISBN 978 1 78725 122 9
Registered Charity Number: 1097899