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Battery energy storage systems

Summary

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Summary

Battery energy storage systems (BESSs) use batteries, for example lithium-ion batteries, to store electricity at times when supply is higher than demand. They can then later release electricity when it is needed. BESSs are therefore important for "the replacement of fossil fuels with renewable energy".

The government set a legally binding target to reduce the UK's greenhouse gas emissions by 100% by 2050, compared with 1990 levels. This is known as the 'net zero target'. To meet this target, the government has set the aim of achieving "a fully decarbonised [...] power system by 2035".

Renewables, such as wind and solar power, rely on the weather to generate electricity. This means that they cannot adjust to demand from consumers as easily as fossil fuels and nuclear power can. Therefore, the government has said a decarbonised power system will need to be supported by technologies that can respond to fluctuations in supply and demand, including energy storage. The government expects demand for grid energy storage to rise to 10 gigawatt hours (GWh) by 2030 and 20 GWh by 2035.

What permissions do BESSs need?

Installing a grid-scale BESS requires planning consent. Planning is a devolved matter, and decision-making rules differ across the UK.

In England and Wales, decisions on BESSs (regardless of their capacity) are made by local planning authorities. In Scotland and Northern Ireland, BESSs require consent from either ministers or the planning authority depending on their storage capacity.

Depending on its capacity, a BESS may also require a generating licence to operate. Generating licences are issued by Ofgem in Great Britain or by the Utility Regulator in Northern Ireland.

Concerns about the safety of BESSs

Although safety incidents for BESSs are rare, a common concern about BESSs is the potential fire risk of lithium-ion batteries (PDF). Lithium-ion batteries can catch fire because of a process called "thermal runaway". It can occur, for example, if part of a battery is damaged.

Understanding of thermal runaway has improved in recent years, leading to more flame-resistant batteries. BESS sites can be also designed with safety features, such as fire suppression systems, to ensure their safety.

There is no reliable, publicly accessible record of the number of BESS fires that have occurred in the UK or elsewhere. There has been one documented incident of a BESS fire in the UK, when a battery system containers at a BESS site in Liverpool caught fire in September 2020 (PDF).

How is the safety of BESSs regulated?

There are no laws that govern the safety of BESSs specifically. However, individual batteries may have to adhere to product safety regulations, and grid-scale facilities may also have to comply with fire safety requirements and health and safety laws.

In response to concerns about the safety of BESSs, the government said BESSs were covered by "a robust regulatory framework". It published guidance in August 2023 which encourages developers and local planning authorities in England to consult their local fire and rescue service in preparing and deciding on planning applications for BESSs.

The government is also undertaking a review of batteries regulations and, as part of this review, is considering "safety risks associated with all batteries".

Barriers to the development of BESSs

The Commons Business and Trade Select Committee has raised concerns that the UK has "insufficient domestic manufacturing capacity" for batteries, and the Commons Foreign Affairs Select Committee has raised concerns that "the UK is almost completely dependent on imports for critical minerals", such as lithium, that are used in batteries.

The government set out how it intends to secure the UK's battery supply chain and improve the resilience of the UK's critical minerals supply in its UK battery strategy (November 2023) and critical minerals strategy (July 2022).

Barriers to the development of BESSs and other energy storage systems also include high upfront capital costs, uncertain revenue streams and delays to grid connections. In response to these concerns, the government published its action plan to accelerate grid connections in November 2023.

The government also recently consulted on proposals to enable investment in long duration storage.

1 Background: Targets and statistics

Battery energy storage systems (BESSs) can store electricity during times when supply is high and demand is low, then release electricity when it is needed.

BESSs can support the use of renewable energy technologies, such as wind and solar power, because they reduce the supply issues that are associated with their intermittency. They can store the electricity that is generated when, for example, the sun is shining and the wind is blowing, and release it later when consumers need it.[1] National Grid states that BESSs are "essential to speeding up the replacement of fossil fuels with renewable energy".[2]

This briefing focuses on grid-scale battery energy storage solutions. For further information about domestic batteries, see research commissioned by the government on domestic battery energy storage systems.

1.1 What are the government's targets for BESSs?

The Climate Change Act 2008 requires the UK Government to reduce UK greenhouse gas emissions by 80% compared to 1990 levels by 2050. In June 2019, the UK Government amended the 2008 Act to raise the 80% target to a 100% target by 2050.[3] This is referred to as the 'net zero target'.

The devolved administrations have also set targets to reduce their emissions to net zero compared to 1990 levels: Wales and Northern Ireland by 2050, and Scotland by 2045.[4]

For further information about the UK Government's net zero target, see the Library briefing on the UK's plans and progress to reach net zero by 2050.

Government strategies to reach net zero

The UK Government has set out how it intends to meet its net zero target in the Net Zero Strategy (October 2021), the British Energy Security Strategy (April 2022) and Powering Up Britain (March 2023). One of the ways in which

1 National Grid, Energy explained: What is battery storage?, undated [accessed 14 March 2024]
2 National Grid, What is battery storage?, undated [accessed 14 March 2024]
3 Climate Change Act 2008: The Climate Change Act 2008 (2050 Target Amendment) Order 2019
4 Welsh Government, Net Zero Wales, last updated December 2022; Climate Change Act (Northern Ireland) 2022; Climate Change (Scotland) Act 2009, as amended by the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019

the UK Government has proposed to reach net zero is by reducing the UK's reliance on fossil fuels and increasing its use of renewable energy sources, such as wind and solar power.

The government has set the aim to "fully decarbonise our power system" by 2035 (depending on supply security). Specifically, it said it aimed to increase offshore wind capacity to 50 gigawatts (GW) by 2030 and solar capacity to 70 GW by 2035.[5]

Role of battery energy storage

Renewables such as wind and solar power rely on the weather to generate electricity. This means that renewables cannot adjust to demand from consumers and businesses as easily as fossil fuels and nuclear power can.

Therefore, the government has said the decarbonised power system would need to be underpinned by technologies that can respond to fluctuations in supply and demand, including energy storage, gas with carbon capture and storage, and hydrogen.[6]

Energy storage systems store the energy that is produced when demand is lower than supply. The stored energy can then be released when there is little wind and sun to ensure the demand can always be met. This process of storing energy is also called "grid balancing".[7]

The government has not set specific targets regarding the capacity or number of BESSs in any of its strategies. In its 2022 British Energy Security Strategy, the government stated that it aimed to develop policy to enable investment in flexible energy storage technologies in 2024. This is yet to be published.

In November 2023, the government published the UK battery strategy. The strategy does not set specific targets for BESSs; however, it states that the government expects the demand for grid energy storage to rise to 10 gigawatt hours (GWh) by 2030 and 20 GWh by 2035. In the UK battery strategy, the government also highlights the importance of grid-scale BESSs to use energy more flexibly and decarbonise the energy system in a cost-effective way.[8]

5 Department for Energy Security and Net Zero (DESNZ) and Department for Business, Energy and Industrial Strategy (BEIS), Net Zero Strategy: Build Back Greener, last updated April 2022; DESNZ, Powering up Britain, last updated April 2023, p15

6 DESNZ and BEIS, Net Zero Strategy: Build Back Greener, last updated April 2022

7 The Royal Society, Large-scale electricity storage, September 2023; Department for Business and Trade (DBT), UK battery strategy, last updated December 2023, p25

8 DBT, UK battery strategy, last updated December 2023

1.2 What types of batteries are used in BESSs?

Energy storage systems for the grid must be able to accommodate daily and seasonal fluctuations in electricity demand.

Batteries are best suited for short-duration energy supply. This means that they can supply energy boosts to the grid for several hours. They are usually only used for short durations of energy supply because they are relatively expensive to install but are energy efficient (meaning that little charge is lost in the process of charging the battery).[9]

Other technologies, such as pumped hydroelectric storage and hydrogen storage, are typically used for long-duration energy storage. They can store very large amounts of energy that can then be discharged to the grid over days or weeks. However, more energy is used to charge them.[10]

Types of batteries used in BESSs

Lithium-ion batteries

Currently, lithium-ion batteries are the most common BESS being installed in the UK. According to a 2023 report by the research organisation, The Faraday Institution (PDF), lithium-ion batteries accounted for over 90% of grid-scale installations in the UK from 2020 to 2024.[11]

There are different types of lithium-ion batteries. They all follow the same principles in how they store energy (see box 1) but are made of different materials, have different costs, and can store different amounts of energy.

The two main types of lithium-ion batteries used for BESSs are lithium-iron-phosphate and nickel-manganese-cobalt. The Faraday Institution estimates that lithium-iron-phosphate batteries made around 60% of lithium-ion BESSs in the UK market in 2022 because of their lower cost and higher efficiency.[12]

1 How do lithium-ion batteries work?

A battery is a device that stores electrical energy as chemical energy that can be released on demand. Batteries can be rechargeable or non-rechargeable:

9 Bruno Cardenas and others, Short-, Medium-, and Long-Duration Energy Storage in a 100% Renewable Electricity Grid, Energies, Vol 14, 2021, 8524

10 DESNZ, Long duration electricity storage: scenario deployment analysis, January 2024

11 The Faraday Institution and Rho Motion, Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero (PDF), September 2023, p4

12 The Faraday Institution and Rho Motion, Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero (PDF), September 2023

- Non-rechargeable batteries are typically used in household devices such as torches.
- Rechargeable batteries can store and release energy many times. Rechargeable batteries, such as lithium-ion batteries, are used for applications that have greater energy demand such as mobile phones, electric vehicles and grid storage.

A lithium-ion battery stores energy by using electricity to release positively charged particles of lithium (lithium ions) from one side of the battery (the cathode) to the other (the anode). The lithium ions are stored in the anode when the battery is charged up. When electricity is needed, lithium ions move back to the cathode which discharges electricity to the device or grid.[13]

This process is repeated in a cycle of charging and discharging the battery.

Alternatives to lithium-ion batteries

Alternative batteries that can be used in BESS facilities include:

- Lead-acid batteries, a predecessor of lithium-ion, are relatively cheap and easy to recycle. However, they have a limited lifespan and store a low amount of energy-per-weight due to the high density of lead. They are therefore not commonly used anymore.[14]

- Flow batteries, also known as redox-flow batteries, are an emerging technology. They store energy in large tanks of liquid. The liquid is pumped into a battery to release the energy when required. Flow batteries can store energy for years and discharge energy over longer durations than lithium-ion batteries. They are also easy to maintain but, unlike lithium-ion batteries, are limited to grid-scale storage because of their size and weight.[15]

- Sodium-ion batteries work in a similar way to lithium-ion but use sodium ions instead of lithium ions. Sodium can be sourced from seawater, making it a cheaper raw material than lithium.[16] However, because sodium is heavier than lithium, sodium-ion batteries are expected to be more appropriate for grid storage than mobile storage. Although sodium-ion batteries are not used on a large scale yet, in its 2023 UK battery strategy, the government stated that it expects to deploy this technology in the next ten years.[17]

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13 United States Department of Energy, How Lithium-ion Batteries Work, February 2023; Australian Academy of Science, Lithium-ion batteries, undated [accessed 15 April 2024]

14 Xiayue Fan and others, Battery Technologies for Grid-Level Large-Scale Electrical Energy Storage, Transactions of Tianjin University, Vol 26, 2020, p92-103

15 ABC Science, Vanadium redox flow batteries, February 2023

16 The Faraday Institution, Sodium-ion Batteries: Inexpensive and Sustainable Energy Storage (PDF), May 2021

17 DBT, UK battery strategy, last updated December 2023

Other types of energy storage systems

Some examples of long-duration energy storage include:

- Pumped hydroelectric storage: Electricity is generated when water is released from a reservoir and travels downhill through a turbine. The water is pumped uphill during lower energy demand. According to the British Hydropower Association, the UK's pumped hydropower capacity was 2.8 GW or 32 GWh (see box 2 for an explanation of the difference).[18]

- Hydrogen storage: Excess electricity can be used to produce hydrogen by electrolysis. Hydrogen gas must be stored under very low temperatures and high pressures. Currently, there is one large-scale hydrogen storage site in the UK which has a capacity of 25 GWh. There are plans for three new sites which the government said could be operational by the late 2020s.[19]

- Compressed air storage: Electricity can used to compress air which is then stored at a high pressure. When the air expands to atmospheric pressure, it can be used to drive turbines to generate electricity. There are currently no compressed air energy storage systems in the UK.[20]

For further information about these energy storage systems, see the Royal Society's briefing on large-scale electricity storage and the Parliamentary Office of Science and Technology's (POST) note on longer duration energy storage.

2 What's the difference between watts and watt-hours?

A watt (W) and its multiples (such as megawatt, MW, and gigawatt, GW) are units of power. They measure the amount of energy generated or consumed per unit of time. Watts can be used to measure the installed capacity, that is, the maximum amount of power that a battery can generate at any particular time.

A watt-hour (Wh) is a unit of energy. It measures the total amount of energy that a battery or other energy storage systems can store and provide.

18 British Hydropower Association, Pumped Storage Hydro, undated [accessed 22 April 2024]

19 BEIS, Proposals for hydrogen transport and storage business models: Analytical annex, September 2022

20 The Royal Society, Large-scale electricity storage, September 2023

1.3 How many BESSs are there in the UK?

There is no definitive estimate of the number of operational BESS and their total capacity in the UK.

Industry estimates range from a total capacity of around 2.4 gigawatt (GW) to 3.5 GW in 2023. According to the government's renewable energy planning database, the total capacity of BESS as of January 2024 was 2 GW. However, this is likely an underestimate as facilities with a capacity below 1 megawatt (MW) that went through the planning system prior to 2021 were not recorded.

Industry estimates

Drawing on data from the Solar Media Market Research, which produces digital news and business intelligence on solar photovoltaics and battery storage technologies, the Solar Power Portal estimates that in 2023 there were 161 operational energy storage sites in the UK and these had a total capacity of 2.4 GW.[21] This data is also cited by the United States Department of Commerce and in a report on long-duration energy storage (PDF) by the House of Lords Science and Technology Select Committee.[22]

Information on how Solar Media Market Research obtained its data is not publicly available. There is also no publicly available information on which energy storage sites are recorded by Solar Media Market Research – for example, whether the database includes both BESSs and other types of energy storage or only energy storage sites of a certain size or capacity.

RenewableUK, a trade association for wind, wave and tidal power industries in the UK, estimated that, in December 2023, the total capacity of operational battery storage sites in the UK was 3.5 GW. RenewableUK further estimated that the capacity of projects under construction was 3.8 GW and the capacity of projects that had been granted consent but not yet constructed was 24.5 GW in December 2023.[23]

RenewableUK states that it relied on publicly available data for its estimate, but does not provide further information on how it collected the data.

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21 Record 800MWh of utility-scale storage added in 2022, Solar Power Portal, 2 February 2023 [accessed 18 April 2024]; 800MWh of utility-scale energy storage capacity added in the UK during 2022, Energy Storage News, 1 February 2023 [accessed 18 April 2024]

22 United States Department of Commerce, Country Commercial Guides: United Kingdom - Energy, last updated November 2023; Lords Science and Technology Committee, Long-duration energy storage: Get on with it (PDF), 13 March 2024, HL 68 2023-24, pp9-10

23 RenewableUK, Pipeline of UK energy storage projects grows by two-thirds over last 12 months, December 2023

Renewable energy planning database

Data on the number of BESSs is also available in the government's renewable energy planning database (REPD). The REPD tracks the progress of energy projects, including BESSs, through the planning system. Until 2021, the REPD only recorded projects with a capacity over 1 MW). Since 2021, it also includes projects with a capacity over 150 kilowatts (kW).[24] Therefore, BESSs that were going through the planning system before 2021 may not have been captured in the REPD.

According to the REPD, as of January 2024, there were 105 operational BESS in the UK, with a total capacity of at least 2 GW.[25] Of the operational BESSs recorded in the REPD, 56 were stand-alone storage facilities and 43 were co-located with renewable energy projects (such as solar and wind farms).

A further 596 BESSs recorded in the REPD have been given planning consent and are awaiting or under construction as of January 2024. Of these, 378 (63%) were stand-alone storage facilities and 210 (35%) were co-located with renewable energy projects.[26]

A small number of BESSs recorded in the REPD are also co-located with fossil fuel plants (14 in total in the UK, of which six are operational and eight are under or awaiting construction).

Number and capacity of operational BESSs and BESSs under/awaiting construction

	Co-located with renewable energy		Stand-alone storage		Co-located with fossil fuel plant	
	Number	Capacity	Number	Capacity	Number	Capacity
Operational	43	0.3 GW	56	1.6 GW	6	0.1 GW
Under/awaiting construction	210	1.9 GW	378	21.0 GW	8	0.5 GW

Notes: The 'under/awaiting construction' category includes one standalone storage facility that is finished but not yet operational.

Source: DESNZ, Renewable Energy Planning Database: Quarterly extract, Renewable Energy Planning Database (REPD): January 2024 (CSV), last updated 12 February 2024 [accessed 22 March 2024]

Most BESSs recorded in the REPD (that are operational or awaiting or under construction) are located in England: 85 operational BESSs and 445 BESSs that are awaiting or under construction. This is followed by Scotland where 15 operational BESS are located and 124 BESSs that are awaiting or under construction.

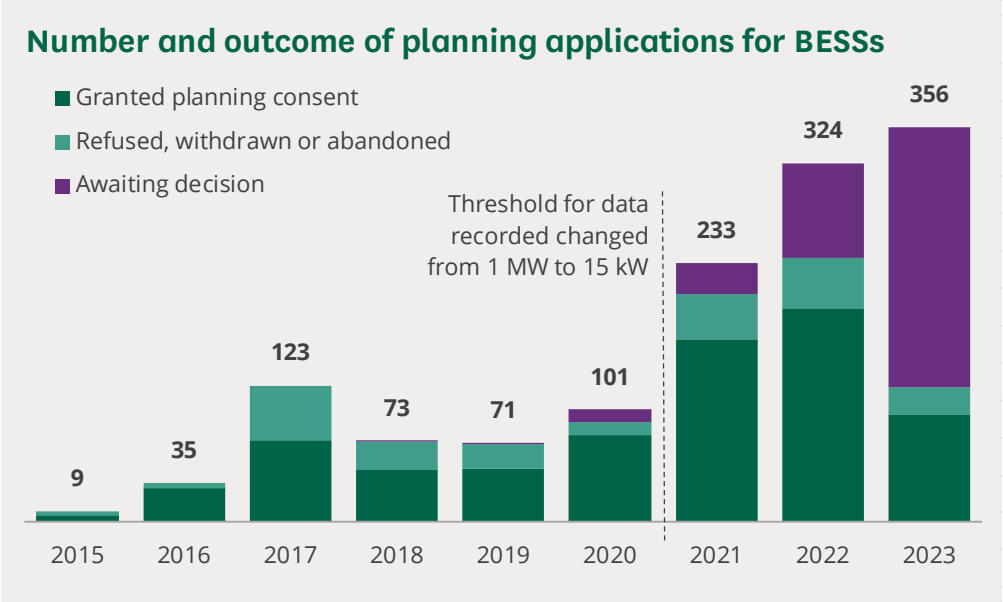
24 DESNZ, Renewable Energy Planning Database: Quarterly extract, last updated 12 February [accessed 22 March 2024]

25 However, data on the installed capacity for 18 of the 106 operational BESS in the UK is missing. This is therefore likely an underestimate of the total installed capacity of operational BESS in the UK.

26 DESNZ, Renewable Energy Planning Database: Quarterly extract, Renewable Energy Planning Database (REPD): January 2024 (CSV), last updated 12 February 2024 [accessed 22 March 2024]

The chart below shows the number of applications for BESSs that have been submitted for planning permission since 2015. The figures before and after 2021 cannot necessarily be compared, as the capacity threshold for recording projects in the REPD changed in 2021.

Of the applications submitted between 2015 and 2023 on which a decision has already been made, 77% were granted planning consent and 23% were refused consent, withdrawn or abandoned by developers. 362 applications for BESS that have been submitted are still awaiting a decision.



Source: DESNZ, Renewable Energy Planning Database: Quarterly extract, Renewable Energy Planning Database (REPD): January 2024 (CSV), last updated 12 February 2024 [accessed 22 March 2024]

2 What permissions do BESSs need?

The installation of a grid-scale battery energy storage system (BESS) requires planning consent. Planning is a devolved matter, and decision-making rules for planning consent for BESSs differ across the UK.

In England and Wales, decisions on BESSs (regardless of their capacity and size) are made local planning authorities. In Scotland and Northern Ireland, the size of a project will determine whether a BESS requires consent from ministers or the local planning authority.

Depending on its capacity, a BESS may also require a generating licence to operate. Generating licences are issued by the Office for Gas and Electricity Markets (Ofgem), the independent energy regulator for Great Britain, or the Utility Regulator in Northern Ireland.

2.1 Planning permission

England

Until 2020, energy storage systems with a generating capacity over 50 MW were classed as 'nationally significant infrastructure projects' (NSIP) under the Planning Act 2008. They required development consent from the Secretary of State for Business, Energy and Industrial Strategy (BEIS).[27] Energy storage systems with a generating capacity up to 50 MW required planning consent from the local planning authority.

Following two consultations,[28] the government decided to remove BESSs from the NSIP regime in 2020.[29] The government said the "time and cost of the NSIP regime is not proportionate to the planning impacts of these technologies". It also said the 50 MW threshold had distorted decisions about sizing, leading to a large number of facilities with a capacity of around 49 MW.[30]

The government explained that the role of energy storage in reaching its net zero target by 2050 had motivated it to remove BESSs from the NSIP regime:

> Electricity storage is a key technology in the transition to a smarter and more flexible energy system and will play an important role in helping to reduce

27 Part 3 of the Planning Act 2008

28 BEIS, The treatment of electricity storage within the planning system, October 2019; BEIS The planning system for electricity storage: Follow up consultation, last updated July 2020

29 Infrastructure Planning (Electricity Storage Facilities) Order 2020

30 Explanatory Memorandum to the Infrastructure Planning (Electricity Storage Facilities) Order 2020

> emissions to net-zero by 2050. These changes will make it simpler for large scale storage facilities to seek planning permission, helping to bring forward larger projects supporting more efficient grid balancing and management of intermittent renewable generation.[31]

All energy storage systems (except pumped hydro), regardless of their size and capacity, are now determined by local planning authorities in the first instance.[32]

How are planning applications decided?

A local planning authority will generally decide planning applications in line with its local plan which sets out its policies for the development and land use in its area. The local plan forms the basis for decision-making on planning applications unless 'material considerations' indicate otherwise.[33]

There is no set list of material considerations. One material consideration is the National Planning Policy Framework (last updated December 2023) which sets out the government's planning policies for England. It is supported by planning practice guidance on renewable and low-carbon energy.

The National Planning Policy Framework states that local planning authorities should generally grant planning permission to infrastructure associated with renewable and low-carbon developments, such as BESSs, if its impacts are or can be made acceptable. The government's planning practice guidance notes the potential benefits of BESSs "to use energy more flexibly and de-carbonise our energy system cost-effectively".[34]

Where should BESS be sited?

There are no specific policies for the siting of BESS. The National Planning Policy Framework advises local planning authorities to identify "suitable areas" for renewable energy developments and supporting infrastructure.

The planning practice guidance states that "there are no hard and fast rules" on how authorities should identify suitable areas. It advises local authorities to consider potential impacts of developments on the local environment and the views of local communities.[35]

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31 BEIS, The planning system for electricity storage: Follow up consultation, last updated July 2020

32 An applicant can appeal the refusal of permission or the non-determination of an application with the Planning Inspectorate, an executive agency of the Department for Levelling Up, Housing and Communities. The decisions of LPAs and the Planning Inspectorate can also be challenged in court.

33 Section 70(2) of the Town and Country Planning Act 1990; Section 38(6) of the Planning and Compulsory Purchase Act 2004

34 Department for Levelling Up, Housing and Communities (DLUHC), National Planning Policy Framework, last updated December 2023, para 163; DLUHC and Ministry of Housing, Communities and Local Government (MHCLG), Renewable and low carbon energy, last updated August 2023, para 32

35 DLUHC, National Planning Policy Framework, last updated December 2023, para 163; DLUHC and MHCLG, Renewable and low carbon energy, last updated August 2023, para 32

The National Planning Policy Framework guides all development away from the 'best and most versatile' agricultural land, that is, good to excellent-quality agricultural land. The framework also states that elements of many renewable energy projects are not "appropriate" development for green belt land.[36]

Who is consulted on planning applications?

Before deciding a planning application, a local authority must publicise the application to allow local residents and other interested parties to express their views on the proposed development.[37] A local authority must take these views into account when deciding a planning application.

In August 2023, the government updated its planning practice guidance to encourage developers and local planning authorities to consult their local fire and rescue service on planning applications for BESSs.[38] However, fire and rescue services are not statutory consultees, so local planning authorities are not required to consult them.

The government also updated its planning practice guidance to refer local planning authorities and developers to guidance on grid-scale BESS by the National Fire Chiefs Council (PDF). For further information on the guidance, see section 4.2 of this briefing.

Wales

Between 2015 and 2019, all energy storage systems with a capacity between 10 MW and 350 MW required consent from Welsh ministers under the Welsh Government' regime for 'developments of national significance'. BESSs in Wales with a capacity over 350 MW were governed by the UK Government's NSIP regime.[39]

In 2019, the Welsh Government changed planning rules so planning decisions on energy storage systems (except pumped hydro) with a capacity up to 350 MW were made by local planning authorities. In 2020, the UK Government removed energy storage (except pumped hydro) from the NSIP regime.[40] Therefore, planning decisions on all BESSs, regardless of their capacity, are now made by local planning authorities in Wales (as is the case in England).

36 DLUHC, National Planning Policy Framework, last updated December 2023, para 180; para 156

37 Articles 15 and 33 of the Town and Country Planning (Development Management Procedure) (England) Order 2015

38 DLUHC and MHCLG, Renewable and low carbon energy, last updated August 2023, paras 34-35

39 Section 19 of the Planning (Wales) Act 2015, which added section 62D to the Town and Country Planning Act 1990; Section 15 of the Planning Act 2008

40 Developments of National Significance (Specified Criteria, Fees and Fees for Deemed Applications) (Wales) (Amendment) Regulations 2019; Infrastructure Planning (Electricity Storage Facilities) Order 2020

How are planning applications decided?

Local planning authorities in Wales will decide planning applications for BESS in line with Future Wales (the Welsh Government's spatial plan), Planning Policy Wales (which sets out national planning policies), and relevant policies set out in the local development plan for the area.

Planning Policy Wales notes the importance of energy storage to manage the transition to a low-carbon economy, including to manage the intermittency of supply from renewable energy sources and to meet increases in demand from the electrification of heat and transport. Future Wales states there is "a need to consider large-scale energy storage [...] to provide grid balancing".[41]

Planning Policy Wales advises local planning authorities to "optimise energy storage" and support proposals for storage facilities "where possible".[42]

Scotland

In a letter to chief planning officers in 2020, the Scottish Government clarified that BESSs should be "treated as any other generating station" in Scotland.[43] This means that, depending on their capacity, BESS need either consent from planning authorities or from Scottish ministers:

- Planning authorities are responsible for determining applications for electricity generating stations with a capacity up to 50 MW.
- Scottish ministers are responsible for determining applications to construct and operate electricity generating stations with a capacity over 50 MW under section 36 of the Electricity Act 1989.
    - If they grant consent under section 36, Scottish ministers can also grant planning permission at the same time (so a developer does not need to make a separate planning application).[44]

How are planning applications decided?

Planning authorities and Scottish ministers will decide planning applications in line with the area's local development plan and the Scottish Government's National Planning Framework 4 (NPF4).

The NPF4 provides that planning authorities should support proposals for "all forms" of renewable and low-carbon technologies, including BESSs. However, it advises that they should ensure that proposals maximise economic impact

41 Welsh Government, Planning Policy Wales, last updated February 2024, para 5.7.12; Welsh Government, Future Wales: The National Plan 2040, February 2023, p99

42 Welsh Government, Planning Policy Wales, last updated February 2024, para 5.7.7; para 5.7.12

43 Scottish Government, Battery storage consents: Chief Planner letter August 2020, August 2020

44 Section 36 of the Electricity Act 1989; Section 57 of the Town and Country Planning (Scotland) Act 1997

and minimise certain other impacts (including on the surrounding landscape, the environment, and nearby communities).[45]

The NPF4 also states that planning authorities should place "significant weight" on the contribution of a development to renewable energy and greenhouse gas emissions targets.

Northern Ireland

In Northern Ireland, depending on their size, developments fall into one of three categories: 'local', 'major' or 'regionally significant'.

- Local and major developments are decided by the local planning authority.
- For regionally significant developments, applicants are required to consult Northern Ireland Department for Infrastructure. If the department decides that a development is "significant to the whole or a substantial part of Northern Ireland", it (rather than the local planning authority) will decide the planning application.
- For major and regionally significant developments, applicants must hold a pre-application consultation with the local community.[46]

In a letter to chief planning officers in 2020, the Department for Infrastructure said that it considered that "electricity storage development falls within the meaning of an 'electricity generating station' [...] for the purposes of planning in Northern Ireland".[47] Electricity generating stations with a capacity over 5 MW are major developments, and electricity generating stations with a capacity over 30 MW are classed as potentially regionally significant.

The decision to treat BESSs as electricity generating stations to decide whether they are local or major developments was challenged under judicial review. The court found that BESSs could not be considered to fall "wholly within" the class of electricity generating stations. Whether BESS are local or major developments will therefore depend on their site area exceeds one hectare.[48]

How are planning applications decided?

In determining planning applications, the Department for Infrastructure and local planning authorities in Northern Ireland are guided by the department's Strategic Planning Policy Statement and the Regional Development Strategy

45 Scottish Government, National Planning Framework 4, February 2023, Policy 11

46 Schedule of the Planning (Development Management) Regulations (Northern Ireland) 2015; Section 26 of the Planning Act (Northern Ireland) 2011

47 Department for Infrastructure, Seventh Chief Planner's Update issued to Councils, December 2020

48 ABO Wind NI Limited and Energia Renewables Company 1 Limited [2021] NIQB 96; Cleaver Fulton Rankin, BESS and the impact on the NI energy sector, undated [accessed 18 March 2024]

for Northern Ireland 2035. Neither contain specific policies for decision-making on BESS.

The Strategic Planning Policy Statement advises local planning authorities to support "development that generates energy from renewable resources" if the development will not result in "an unacceptable adverse impact" on other considerations (such as visual amenity, landscape character, public safety or residential amenity).[49] The Strategic Planning Policy Statement does not set out whether BESSs are considered a form of renewable energy development.

2.2 Generating licence from Ofgem

Under the Electricity Act 1989, certain activities, including the generation of electricity in Great Britain, require a licence from Ofgem (the independent energy regulator). Licensees must comply with Ofgem's industry codes and standards and license conditions.

In general, operators of BESSs that have a net capacity of more than 100 MW must hold a generating licence. Operators of BESSs that have a net capacity of less than 100 MW and that do not exceed 50 MW of power at any time are likely exempt from the requirement to hold a generating license.[50]

Until 2023, the Electricity Act 1989 included no specific definition of, or reference to, electricity storage. The government established a definition of electricity storage through the Energy Act 2023 and clarified that electricity storage, such as BESSs, is a distinct subset of generation within the Electricity Act 1989.[51]

Ofgem has treated electricity storage as a subset of electricity generation for regulation purposes since 2020.[52] The change made by the Energy Act 2023 formalises that approach. The government said the change removes "current ambiguities" and provides "clarity and certainty" on how electricity storage is treated within the existing and possible future frameworks.[53]

For further information about the changes introduced by the Energy Bill (now Act), see section 3.4 of the Library briefing, Energy Bill [HL] 2022-23, parts 4-6: Electricity and gas markets.

49 Department for Infrastructure, Strategic Planning Policy Statement, September 2015, para 6.224
50 Electricity (Class Exemptions from the Requirement for a Licence) Order 2001
51 Section 213 of the Energy Act 2023, which amended Section 4 of the Electricity Act 1989
52 Ofgem, Decision on clarifying the regulatory framework for electricity storage: Changes to the electricity generation licence, October 2020
53 Explanatory Notes to the Energy Bill 295 2022-23, para 48

Northern Ireland

Energy policy is a devolved matter in Northern Ireland. The Utility Regulator is responsible for issuing and enforcing licences to those who want to generate or supply electricity in Northern Ireland.[54]

Like Ofgem, the Utility Regulator treats BESSs as a type a generating station and expects them to obtain a generating licence.[55] In Northern Ireland, BESSs which do not exceed 10 MW of power at any point in time are exempt from the requirement to hold a generating license.[56]

[54] Northern Ireland Authority for Utility Regulation, Licence to supply electricity (Northern Ireland), undated [accessed 24 April 2024]

[55] Utility Regulator, Decision to grant an electricity generation licence to Belfast Energy Storage Company Limited, November 2021; Utility Regulator, Decision to grant an electricity generation licence for Heron Storage Limited, January 2023;

[56] Electricity (Class Exemptions from the Requirement for a Licence) Order (Northern Ireland) 2013

3 Concerns about the safety of BESSs

Although safety incidents for battery energy storage systems (BESSs) are rare, a common concern about the rollout of BESSs that use lithium-ion batteries is the potential fire risk.[57]

Concerns about the fire safety of BESSs have been raised in the UK Parliament on a number of occasions, for example, in debates on solar farms and battery storage in June 2022 and on lithium-ion battery storage facilities in July 2023.[58] Similar concerns about the fire safety of BESSs have also been raised in the Scottish Parliament on a number of occasions.[59]

This section of the briefing sets out the potential causes and consequences of fires at BESS facilities and the number of BESS fires that have occurred. It also discusses how the risk of fire can be minimised and how the safety of BESSs is regulated in the UK. Section 4 sets out the government's response to concerns about the safety of BESS.

3.1 Concerns about fire risks

The research organisation, The Faraday Institution, explains that lithium-ion battery fires are very rare. It notes that "even with billions of lithium-ion cells in circulation, there are very few safety incidents involving them". It estimates that only one in 40 million battery cells experience failure that results in fire.[60]

A scientific paper on the challenges for grid-scale battery energy storage explains that fires can occur at BESS facilities because they contain millions of battery cells. If one cell catches fire and is not shielded or insulated from the rest of the battery, it can cause adjacent cells to catch fire (sometimes called "thermal propagation").[61]

Potential causes of battery fires

Lithium-ion batteries can catch fire because of a process called "thermal runaway". A scientific review on the safety of lithium-ion batteries explains that thermal runaway occurs when part of a battery is damaged or has a

57 Gallagher, Fire risk at battery energy storage systems, August 2021

58 For example: HC Deb [Solar Farms and Battery Storage] 8 June 2022; HC Deb [Lithium-ion Battery Storage Facilities: Regulation] 4 July 2023; PQ HL7632 [Batteries: Fires] 3 May 2023

59 SP WA 7 February 2024, S6W-25333; SP WA 4 January 2024, S6W-24333

60 The Faraday Institution, Improving the Safety of Lithium-ion Battery Cells (PDF), July 2023

61 Huang Y and Li J, Key Challenges for Grid-Scale Lithium-Ion Battery Energy Storage [online via Wiley Online Library], Advanced Energy Materials, Vol 12, Issue 48, 2020

manufacturing fault. This causes the internal components of the battery to decompose, which produces heat. Higher temperatures can cause further decomposition, which in turn produces more heat. Without external cooling, this cycle can result in fire.[62]

The underlying causes of lithium-ion battery damage are stress or misuse. Examples of stress or misuse, which can result in thermal runaway and fire, include:

- Mechanical stress: Defects can be caused during manufacture or external damage (for example, damage caused by natural disasters).
- Thermal stress: If a battery is overheated (for example, due to an external fire), this can lead to fire.
- Electrical failure: A battery could be overcharged due to a fault in the battery management system (the electronic system that monitors and controls charging and discharging of the battery). This can result in too much energy being put into the battery.[63]

A study commissioned by the government notes that some batteries used in BESSs are 'second-life batteries' that were previously used in electric vehicles. The study highlights that second-life batteries could pose a greater risk than new batteries because they could have experienced damage or contain cells from different sources, which could result in electrical failure.[64]

Possible consequences of battery fires

Battery fires also can be difficult to extinguish because batteries contain a lot of fuel to sustain a fire. If on fire, they can also produce hydrogen and oxygen, which further fuels the fire. The build-up of gas and pressure during a battery fire can also lead to an explosion.

The gases produced are toxic, which can pose a risk to site workers and emergency responders if inhaled.[65] There are also concerns that toxic metals and chemicals can leach into the water used to fight the fire which could then end up in water systems, posing a risk to wildlife.[66]

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62 Yuqing Chen and others, A review of lithium-ion battery safety concerns, Journal of Energy Chemistry, August 2021, p83-99

63 The Faraday Institution, Improving the Safety of Lithium-ion Battery Cells (PDF), July 2023, p2; Huang Y and Li J, Key Challenges for Grid-Scale Lithium-Ion Battery Energy Storage [online via Wiley Online Library], Advanced Energy Materials, Vol 12, Issue 48, 2020

64 Office for Product Safety and Standards (OPSS), Safety of second life batteries in battery energy storage systems, January 2023

65 Jens Conzen and others, Lithium ion BESS hazards, Journal of Loss Prevention in the Process Industries, Vol 81, February 2023; OPSS, Safety of second life batteries in battery energy storage systems, January 2023, p22

66 Ian S. Mylenbusch and others, Hazards of lithium-ion BESS, mitigation strategies, minimum requirements, and best practices, American Institute of Chemical Engineers, June 2023

3.2 How many BESS fires have occurred?

Incidents in the UK

There has only been one documented incident of a BESS fire in the UK.

In September 2020, one of the three battery system containers at a BESS site in Liverpool caught fire.[67] An investigation by the Merseyside Fire and Rescue Service found the fire was the result of a failure of one of the batteries within the container which led to thermal runaway and a build-up of gas. This resulted in a fire and explosion that cause the container to warp and doors to blow off.[68]

A research paper on the incident by the Electric Power Research Institute (EPRI), an organisation based in the United States which conducts research on the generation, delivery, and use of electricity, notes that BESS design has improved since the Liverpool BESS was installed in 2018:

> Some newer system designs use smaller, modularized cabinets with a few racks of batteries. The system layout limits damage because of thermal runaway and allows a more targeted first responder approach in the event of a fire.[69]

Incidents in the rest of the world

There is no reliable, publicly accessible record of the number of BESS fires that have occurred elsewhere. An online database by EPRI estimates that (as of 17 April 2024) 85 BESS fires have occurred since 2011.[70] However, the EPRI database relies on news articles and does not verify their validity, so the list may not be accurate or exhaustive.

Many battery fires recorded in the EPRI database occurred in South Korea: it estimates 38 fires between 2017 and 2022.[71] The South Korean Ministry of Industry found that the fires were caused by errors during installation, a lack of protection from the environment and a lack of safety systems.[72]

Despite this number of fires, a report by EPRI states that the global failure rate for grid-scale BESSs has decreased significantly since 2018, from almost

67 Fire at 20MW UK battery storage plant in Liverpool, Energy Storage News, September 2020 [accessed 16 April 2024]
68 Merseyside Fire and Rescue Service, IIT Report Final redacted (PDF), February 2022, p3
69 Electric Power Research Institute (EPRI), Carnegie Road Energy Storage System Failure Response, Recovery, and Rebuild Lessons Learned, April 2023, p10
70 EPRI, BESS Failure Event Database, undated [accessed 10 April 2024]
71 EPRI, BESS Failure Event Database, undated [accessed 10 April 2024]
72 Jens Conzen and others, Lithium ion BESS hazards, Journal of Loss Prevention in the Process Industries, February 2023, 104932

10 failure events per GW of storage per year, to less than one failure event per GW per year since 2020.[73]

3.3 How can BESS fires be prevented?

A scientific review on lithium-ion batteries highlights that the understanding of thermal runaway has improved in recent years, leading to better and more flame-resistant battery designs.[74] Research has also found that batteries with lithium-iron-phosphate cathodes, which are safer than those with nickel-manganese-cobalt cathodes (see section 1.1), make up a greater percentage of the BESS market.[75]

A report by the Faraday Institution also notes that the next-generation of batteries used in BESSs (sodium-ion batteries and flow batteries) might be even safer than lithium-ion batteries because they are less prone to thermal runaway.[76]

In addition, BESSs have a battery management system to ensure they operate safely and efficiently. A battery management system will usually ensure that batteries are kept within their safe ranges of voltage, current and temperature.[77]

A scientific paper on the best practices for BESSs also notes that the design of the BESS facilities can also help ensure their safety. In BESS facilities, battery packs can be spaced out and have insulation between the cells to prevent the spread of fire.[78] BESSs can be also designed with safety features, for example, cooling systems, gas and fire detectors, fire control and suppression systems, explosion control and water supply for emergency services in case a fire does occur.[79]

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73 EPRI, Technology Innovation Spotlight: Lithium Ion Battery Fires in the News, October 2023, p2

74 Huang Y and Li J, Key Challenges for Grid-Scale Lithium-Ion Battery Energy Storage [online via Wiley Online Library], Advanced Energy Materials, Vol 12, Issue 48, 2020

75 The Faraday Institution and Rho Motion, Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero (PDF), September 2023, p47; Ian S. Mylenbusch and others, Hazards of lithium-ion BESS, mitigation strategies, minimum requirements, and best practices, American Institute of Chemical Engineers, June 2023

76 The Faraday Institution and Rho Motion, Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero (PDF), September 2023, p47

77 Volts Energies, BMS in Focus, March 2023; BEIS, Domestic battery energy storage systems, October 2020, p6

78 Ian S. Mylenbusch and others, Hazards of lithium-ion BESS, mitigation strategies, minimum requirements, and best practices, American Institute of Chemical Engineers, June 2023

79 Fire Industry Association, Guidance on Lithium-Ion Battery Fires, January 2021

4 How is the safety of BESSs regulated?

There are no laws that specifically govern the fire safety of battery energy storage systems (BESSs). Individual batteries may have to adhere to product safety regulations (see below), and the government has said grid-scale facilities may also have to comply with requirements out in the Fire Safety Order 2005 (which governs the fire safety of premises during operation and use).[80]

There is no guidance by the government or regulatory bodies on whether fire safety requirements set in building regulations (which govern the fire safety of buildings during construction) apply to grid-scale BESSs.[81]

A gap analysis report on health and safety standards for electricity storage technologies commissioned by the government (June 2020) also highlights that industry standards published by the British Standards Institute and other international bodies provide guidance how developers can ensure the safe installation and operation of BESSs.[82] There are no statutory provisions that require BESSs to adhere to industry standards, but they can help developers demonstrate compliance with the law.

4.1 Product safety

A study commissioned by the government noted that BESSs might use second-life lithium-ion batteries, for example, batteries that were previously used in electric vehicles or as domestic batteries. If second-life batteries are used in BESSs, the study notes that their safety likely falls under the scope of the UK General Product Safety Regulations 2005.[83]

Like all other products that are placed on the market and are intended for, or will likely be used by, consumers, domestic batteries and batteries used in electric vehicles must comply with the UK General Product Safety Regulations 2005. The 2005 Regulations require producers to ensure that products placed on the market in the UK are safe for consumers. Products must "not present

80 PQ 31536 [Batteries: Fire Prevention] 12 July 2021

81 North Yorkshire Fire & Rescue Service, Battery Energy Storage Systems, undated; Essex County Fire & Rescue Service, Fire service guidance for BESS developers, undated [accessed 18 March 2024]

82 DESNZ and BEIS, Electricity storage health and safety standards: Gap analysis, last updated August 2023

83 OPSS, Safety of second life batteries in battery energy storage systems, January 2023

any risk or only the minimum risks" compatible with their use "under normal or reasonably foreseeable conditions of use".[84]

For further information about the 2005 Regulations, see government guidance for Great Britain and separate guidance for Northern Ireland.

However, the study commissioned by the government also notes that "there was some uncertainty [...] in terms of the codes, standards and regulations" that govern the testing of second-life batteries, because the re-purposing batteries is "a nascent global market".[85] Further, if the batteries used in BESSs are not second-life batteries that were previously used in products covered by the UK General Product Safety Regulations 2005, it is likely that the batteries are outside the scope of the 2005 Regulations.

Government response to concerns about product safety

In response to concerns about the safety of lithium-ion batteries used in energy storage facilities, the government said that it considered BESSs to be covered by "a robust regulatory framework":

> Grid-scale lithium-ion battery energy storage systems are covered by a robust regulatory framework, which requires manufacturers to ensure that products are safe before they are placed on the market and installed correctly, and that any safety issues found after products are on the market or after installations are dealt with.[86]

In response to parliamentary questions in spring 2023, the government said it was undertaking a review of batteries regulations and, as part of this review, it will "consider safety risks associated with all batteries during their lifecycle, including safety concerns associated with lithium-ion batteries".[87]

The government also said it would consult on batteries regulations by the end of 2023.[88] In evidence provided to the Lords Environment and Climate Change Committee, the government said the consultation would be published in 2024. It said the consultation will cover the Batteries and Accumulators (Placing on the Market) Regulations 2008 and the Waste Batteries and Accumulators Regulations 2009.[89] At the time of publication of this briefing, a consultation has not yet been published.

84 Regulation 2 of the General Product Safety Regulations 2005

85 OPSS, Safety of second life batteries in battery energy storage systems, January 2023

86 HL Deb [Energy Bill [HL]] 28 March 2023, c240-241

87 PQ 182649 [Batteries: Storage] 25 April 2023; PQ HL7592 [Waste Management: Fires] 2 May 2023

88 PQ 182649 [Batteries: Storage] 25 April 2023; PQ HL7592 [Waste Management: Fires] 2 May 2023

89 Lords Environment and Climate Change Committee, Written evidence: EV strategy: Rapid recharge needed (PDF), November 2023, HL 51 2023-24, Ev ELV0144 [Department for Environment, Food and Rural Affairs, Defra]

3 Batteries regulations

- The Batteries and Accumulators (Placing on the Market) Regulations 2008 restrict the use of certain hazardous substances (namely mercury, cadmium, and lead) in batteries and require batteries to be labelled with a 'crossed out wheeled bin' symbol.
- The Waste Batteries and Accumulators Regulations 2009 require battery producers to take back, collect, and recycle automotive, waste industrial, and portable batteries. Retailers and distributors that sell at least 32 kg of portable batteries per year must also provide a take-back service.

For further information about the requirements the regulations place, see government guidance for manufacturers on placing batteries on the market and guidance on the collection, treatment and recycling of waste batteries.

Both the 2008 Regulations and the 2009 Regulations are derived from EU law but were retained and remain in place following the UK's exit from the EU.

The EU has since updated its Batteries Regulations. The updated regulations require stationary BESSs with a capacity greater than 2 kilowatts per hour to provide evidence that they have undergone certain safety tests, including for thermal runaway.[90] For further information, see information published by the European Commission on the Batteries Directive.

4.2 Fire safety

Fire safety during construction: Building regulations

Fire safety requirements for new buildings in England and Wales are set out in Part B of Schedule 1 of the Building Regulations 2010. Part B requires buildings to be designed and constructed to limit the spread of fire within and between buildings, to have systems that give early warning of fire, and to allow fire and rescue services to access a building and assist them in fighting a fire.[91]

Whether the fire safety requirements set out in building regulations apply to BESSs will depend on whether the modules (stacks of batteries) are housed in a building and, if they are housed in a building, whether the building is exempt:

90 Regulation (EU) 2023/1542 of the European Parliament and of the Council, 12 July 2023; European Commission, Batteries, undated [accessed 28 March 2024]

91 Part B of Schedule 1 of the Building Regulations 2010

- Regulation 2 states that building regulations apply to "any permanent or temporary building but not any other kind of structure or erection".

- Under Schedule 2, detached buildings are exempt from the building regulations if people do not normally enter them or they only enter intermittently to inspect or maintain plants or machinery.[92]

Fire safety requirements for new buildings in Scotland and Northern Ireland are set out in the Building (Scotland) Regulations 2004 and in the Building Regulations (Northern Ireland) 2012 respectively. In Scotland and Northern Ireland, detached buildings are also exempt if people do not usually enter them or only intermittently enter inspect or maintain plants or machinery.[93]

There is no guidance in any part of the UK on whether fire safety requirements set in building regulations apply to grid-scale BESSs. CROSS (Collaborative Reporting for Safer Structures), a body which is supported by the Institutions of Structural and Civil Engineers, states that "large-scale BESS are likely to be outside of the scope of ADB [Approved Document B]".[94] Approved Document B is published by the government to support Part B of the Building Regulations 2010 in England.

Fire safety during operation and use

The fire safety of non-domestic premises is governed during operation by the Regulatory Reform (Fire Safety) Order 2005 in England and Wales. The Order designates the person in control of a premises (for example, the employer in a workplace) as the 'responsible person' for fire safety. The responsible person does not have to be an individual; it can be an organisation.[95]

Responsible persons have two main duties under the Fire Safety Order:

- to carry out and regularly review fire risk assessments to identify what is needed to prevent fires and protect the people in and around a building (such as employees, visitors, and contractors) in the event of a fire.

- to put in place and maintain fire safety measure. Examples of fire safety measures include, "where reasonably necessary", fire detectors and alarms, fire suppression systems (such as sprinklers or gas extinguishing agents), and firefighting equipment (such as fire extinguishers).[96]

The Fire Safety Order imposes further duties on persons who are responsible for premises where 'dangerous substances' are present. There is no defined list of which substances are considered dangerous, but they include explosive

92 Regulation 2 of the Building Regulations 2010; Schedule 2 of the Building Regulations 2010

93 Schedule 1 of the Building (Scotland) Regulations 2004; Schedule 2 of the Building Regulations (Northern Ireland) 2012

94 Collaborative Reporting for Safer Structures, Battery Energy Storage System concerns, May 2023

95 Article 3 of the Regulatory Reform (Fire Safety) Order 2005; Home Office, A guide for persons with duties under fire safety legislation, September 2023, paras 2.2-2.23

96 Part 2 of the Regulatory Reform (Fire Safety) Order 2005

materials, flammable gases, and any other substances that create a risk as a result of their "physico-chemical or chemical properties".[97]

In premises where 'dangerous substances' are present, the Fire Safety Order also provides that responsible persons must eliminate or reduce related risks "so far as is reasonably practicable". Where they cannot eliminate risks, they must put in place measures to control these risks and mitigate the potentially detrimental effects of a fire. Responsible persons must also share information on their emergency procedures with local fire and rescue services so they can prepare their own response procedures and precautionary measures.[98]

The UK Government has indicated the Fire Safety Order applies to grid-scale BESSs.[99] However, it has not said whether lithium-ion or other batteries used in BESS are 'dangerous substances' for the purposes of the Fire Safety Order.

The fire safety of for non-domestic premises in Scotland and Northern Ireland is governed by the Fire Safety (Scotland) Regulations 2006 and the Fire Safety Regulations (Northern Ireland) 2010 respectively.

The Fire Safety Order is enforced by local fire and rescue services in England and Wales. For further information about their powers, see guidance on the enforcement of, and sanctions for non-compliance with the Fire Safety Order. Fire safety regulations in Scotland and Northern Ireland are enforced by the Scottish Fire and Rescue Service and Northern Ireland Fire and Rescue Service respectively.

4 Private Member's Bill by Maria Miller

In September 2022, Dame Maria Miller proposed a Ten-Minute Rule Bill on Lithium-Ion Battery Storage (Fire Safety and Environmental Permits).[100] A Ten-Minute Rule Bill is a Private Member's Bill which allows an MP to make their case for a new bill.

Dame Maria Miller expressed concern about the risk of thermal runaway and the potential environmental damage if contaminated water, used to put out a battery fire, were to seep into a watercourse. She said her bill would:

- make Environment Agency, the Health and Safety Executive (HSE) and local fire and rescue services statutory consultees on applications for industrial lithium-ion BESSs.
- require environmental permits for lithium-ion BESSs.

97 Article 2 of the Regulatory Reform (Fire Safety) Order 2005; Home Office, A guide for persons with duties under fire safety legislation, September 2023, paras 20.1-20.13

98 Article 12 of the Regulatory Reform (Fire Safety) Order 2005; Article 16 of the Regulatory Reform (Fire Safety) Order 2005

99 PQ 31536 [Batteries: Fire Prevention] 12 July 2021; PQ 31537 [Health and Safety: Batteries] 12 July 2021

100 HC Deb [Lithium-Ion Battery Storage (Fire Safety and Environmental Permits)] 7 September 2022

She said her bill would also extend regulations that govern the safety of hazardous and dangerous substances, including the Planning (Hazardous Substances) Regulations 2015 and the Control of Major Accident Hazards Regulations 2015, to industrial lithium-ion BESSs.

Unless a Ten-Minute Rule Bill is adopted or supported by the government, it is unlikely to proceed through all its stages in Parliament and become law. The Lithium-Ion Battery Storage (Fire Safety and Environmental Permits) Bill did not have a second reading and, therefore, did not progress further.

Dame Maria Miller has reiterated her concerns about BESSs since, including in debates on the regulation of lithium-ion BESS and on the Energy Bill.[101]

Government response to concerns about fire safety

In August 2023, in response to concerns about the fire safety of BESSs, the government updated its planning practice guidance to encourage developers and local planning authorities in England to consult their local fire and rescue service in preparing and deciding on planning applications for BESSs.[102]

Similar guidance has not been published by the devolved administrations.

The updated guidance also refers local planning authorities and developers to guidance on grid-scale BESS by the National Fire Chiefs Council (PDF). The guidance advises operators of BESSs to install "an effective and appropriate method" to detect faults and thermal runaway and fire suppression systems to prevent or limit spread of fire. The National Fire Chiefs Council also advises developers to consider designing their site to prevent of the spread of fire and to provide safe access and water supply for fire and rescue services.[103]

4.3 Health and safety

There are no specific health and safety laws relating to BESSs. However, they might be subject to general health and safety laws that impose obligations on all employers. Health and safety laws are enforced by the Health and Safety Executive (HSE) in Great Britain. In Northern Ireland, they are enforced by the Health and Safety Executive for Northern Ireland.

In response to parliamentary questions, the government explained which general health and safety laws apply to grid-scale BESSs in Great Britain:

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101 HC Deb [Lithium-ion Battery Storage Facilities: Regulation] 4 July 2023, c676; HC Deb [Energy Bill [Lords]] 9 May 2023, c283; HC Deb [Energy Bill [Lords]] 5 September 2023, c291

102 DLUHC and MHCLG, Renewable and low carbon energy, last updated August 2023, paras 34-35

103 National Fire Chiefs Council (NFCC), Grid Scale Battery Energy Storage System planning – Guidance for FRS (PDF), last updated October 2023

- The Management of Health and Safety at Work Regulations 1999 require employers to identify potential risks to employee health and safety and appropriately manage them. For further information on how employers should assess and manage risks, see guidance by the HSE.

- The Electricity at Work Regulations 1989 require all work activities that use or might be affected by electricity to be done safely. All foreseeable risks must also be assessed and minimised as far as possible. For further information, see the HSE's guidance on the 1989 Regulations.

- The Dangerous Substances and Explosive Atmospheres Regulations 2002 require employers to identify the risks posed by dangerous substances (which are substances that may be explosive, flammable or oxidising) in the workplace. Employers must put in place measures to remove risks to the safety of employees and others or, if it is not possible to fully remove risks, mitigate them and limit the effects of potential incidents involving the dangerous substances.[104]

Similar health and safety regulations exist in Northern Ireland.[105]

Government response

The government said the HSE considered the current regulatory framework to be "sufficient and suitably robust in relation to lithium-ion batteries".[106]

The government said it had set up an industry-led electricity storage health and safety governance group in 2018 to ensure "an appropriate, robust and future-proofed health and safety framework is sustained as [...] electricity storage deployment increases". In March 2023, the government said it was working with this group to develop guidance for grid-scale storage which would be "published this year".[107] At the time of writing, this guidance has not yet been published.

4.4 Which regimes do not apply to BESS?

Exclusion from the Control of Major Accident Hazard (COMAH) Regulations

The Control of Major Accident Hazards (COMAH) Regulations 2015 intend to prevent and mitigate the effects of major accidents involving dangerous

[104] PQ 31536 [Batteries: Fire Prevention] 12 July 2021; PQ 31537 [Health and Safety: Batteries] 12 July 2021

[105] Management of Health and Safety at Work Regulations (Northern Ireland) 2000; Electricity At Work Regulations (Northern Ireland) 1991; Dangerous Substances and Explosive Atmospheres Regulations (Northern Ireland) 2003

[106] PQ 31537 [Health and Safety: Batteries] 12 July 2021; HC Deb [Topical Questions] 27 February 2024, c126

[107] HL Deb [Energy Bill [HL]] 28 March 2023, c240-241

substances which can cause serious damage or harm to people and/or the environment. The 'dangerous' substances which are covered by the COMAH are set out in Schedule 1.[108]

If dangerous substances listed in Schedule 1 are kept or used on a site and meet a certain threshold, the COMAH requires site operators to take certain steps to prevent major accidents. They must notify the relevant 'competent authority' (usually, the HSE) of the details of their operation, prepare a major accidents prevention policy and develop a safety management system. For further information, see the HSE's guide to the COMAH.

The COMAH applies to Great Britain. Similar regulations apply in Northern Ireland, where they are enforced by the Health and Safety Executive for Northern Ireland.[109]

Government response

When asked why grid-scale lithium-ion BESSs are not covered by the COMAH, the government responded that lithium-ion batteries are articles rather than substances for the purposes of the COMAH. The government also said the HSE considered that "the current regulatory framework is sufficient and suitably robust":

> The Control of Major Accident Hazards Regulations 2015 (COMAH) apply to dangerous substances as classified by the Classification, Labelling and Packaging Regulations 2008. Lithium-ion batteries are considered to be articles, rather than substances, and are therefore outside of the scope of the COMAH.
>
> The Health and Safety Executive considers that the current regulatory framework is sufficient and suitably robust in relation to lithium-ion batteries and battery energy storage systems.[110]

Environmental permits

Under the Environmental Permitting (England and Wales) Regulations 2016, certain 'regulated facilities' (such as landfill sites, combustion plants and waste incinerators) require an environmental permit. In general, a permit is needed for activities that could pollute the air, water or land, increase flood risk, or adversely affect land drainage.[111]

For further information about which installations and activities require an environmental permit, see government guidance on environmental permitting and on the definition of 'regulated facilities'.

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108 Control of Major Accident Hazards (COMAH) Regulations 2015; HSE, Control Of Major Accident Hazards Regulations 2015, undated [accessed 16 April 2024]

109 Health and Safety Executive for Northern Ireland, Control of Major Accident Hazards Regulations, undated [accessed 16 April 2024]

110 PQ 29036 [Health and Safety: Batteries] 7 July 2021

111 Environmental Permitting (England and Wales) Regulations 2016; Defra, Environmental permitting guidance: Core guidance, last updated August 2020

Environmental permits are issued by the Environment Agency in England and Natural Resources Wales in Wales. A permit will set out which mandatory that operators have to comply with to protect the health of local communities and the local environment. The Environment Agency and Natural Resources Wales have powers to inspect regulated facilities to ensure operators comply with their permit. If they are not compliant, they can take enforcement action.

Similar regulations apply in Scotland and Northern Ireland.[112]

Government response

In response to a question in the House of Lords in May 2023, the government explained that BESS were not classed as 'installations' (one type of 'regulated facilities') for the purposes of environmental permitting regulations. It said it was "in discussions" with the Environment Agency "on the issue".[113]

In a debate in September 2023, the Parliamentary Under-Secretary of State for Energy Security and Net Zero, Andrew Bowie, acknowledged "the concerns surrounding the [...] environmental impact of battery energy storage at grid scale". He said that the government would consult on including BESSs in environmental permitting regulations "at the earliest opportunity".[114] At the time of publication of this briefing, a consultation has not yet been published.

[112] Scottish Environment Protection Agency, Environmental Authorisations (Scotland) Regulations 2018, undated [accessed 16 April 2024]; Northern Ireland (NI) Business Info, Introduction to environmental permits and licences, undated [accessed 16 April 2024]

[113] PQ HL7632 [Batteries: Fires] 3 May 2023; Environment Agency, Order Granting Development Consent for the West Burton Solar Project: Responses to the Examining Authority's Written Questions (PDF), last updated January 2024

[114] HC Deb [Energy Bill [Lords]] 5 September 2023, c322-323

5 Barriers to the development of BESSs

Barriers to the development of battery energy storage systems (BESSs) in the UK include a lack of manufacturing capacity for batteries in the UK and the UK's reliance on international markets for critical minerals that are used in batteries (such as lithium). Development might also be hindered by the cost of establishing BESSs and delays to grid connections.

5.1 Investment in, and funding for, BESSs

BESS companies and investors have reported difficult investment conditions in the UK because current market arrangements do not provide sufficient ways to earn revenue.[115]

In a report on long-duration energy storage (March 2024), the House of Lords Science and Technology Select Committee said the commercial development of long-duration energy storage required financial support because of high upfront capital costs and uncertain revenue streams:

> Long-duration storage facilities can take 7–10 years to build and require up-front capital investment. Developers need a clear business case, supporting infrastructure such as grid connections, and financial support in order to invest. [...] Commercial development of long-duration storage needs financial support mechanisms for investors due to high upfront capital costs, long lead times for planning approvals and construction, and uncertain revenue streams.[116]

In the report, the committee also expressed concern that a focus on lithium-ion storage projects meant that policymakers, investors and regulators had neglected the need for other longer-duration technologies.[117]

In a 2021 call for evidence, the government sought views on the barriers to deployment of large-scale and long-duration electricity storage and how these might be addressed. It found that high upfront capital costs, long build

[115] Energy Storage News, UK's battery storage assets subject to 'weak revenue environment', says Gresham House, 1 February 2024

[116] Lords Science and Technology Committee, Long-duration energy storage: Get on with it (PDF), 13 March 2024, HL 68 2023-24, p3-4

[117] Lords Science and Technology Committee, Long-duration energy storage: Get on with it (PDF), 13 March 2024, HL 68 2023-24, para 31

times, lack of a track record of the technology, lack of revenue certainty, and lack of market signals were some of the main barriers.[118]

Government actions

In its response to the call for evidence (August 2022), the government said that it would work with Ofgem, the energy regulator, to develop "an appropriate policy to enable investment in large-scale, long-duration electricity storage".

In January 2024, the government launched a consultation on proposals to enable investment in long duration electricity storage. The consultation sets out its plans to introduce a 'cap and floor' financial support mechanism to overcome investment barriers.[119] This would provide a guaranteed minimum revenue stream (the floor) and a limit on revenues (the cap) for long duration energy storage.[120] The consultation closed in March 2024, and the government is considering responses.

In 2021, the government launched a competition to support the development of innovative longer duration energy storage projects.[121] It provided over £69 million of capital funding to support a range of energy storage technologies (but not widely deployed technologies such as lithium-ion batteries) under two streams:

- Stream 1 of the competition was for actual demonstration projects that would be completed in March 2025. Successful projects in Stream 1 were announced in February 2021 and included a vanadium flow battery and a hydrogen storage project.

- Stream 2 of the competition was for prototype demonstration projects that would be completed in September 2024. Successful projects in Stream 2 included flow batteries and cooper/zinc batteries.[122]

In its UK battery strategy (November 2023), the government also highlighted that government-backed finance options "to help UK companies develop and scale their business" were available through the British Business Bank, the UK Infrastructure Bank and UK Export Finance.[123] For further information, see, for

118 BEIS, Facilitating the deployment of large-scale and long-duration electricity storage: call for evidence, last updated August 2022

119 DESNZ, Long duration electricity storage: Proposals to enable investment, January 2024

120 It would be a bespoke, short-medium term mechanism as the government's wider Review of Electricity Markey Arrangements (REMA) has ruled out a general cap and floor mechanism for renewable generation. For further information, see: DESNZ, Review of Electricity Market Arrangements: Second Consultation, March 2024

121 DESNZ and BEIS, Longer Duration Energy Storage Demonstration (LODES) competition, last updated April 2023

122 DESNZ and BEIS, Longer Duration Energy Storage Demonstration Programme: Successful projects, last updated April 2023

123 DBT, UK battery strategy, last updated December 2023

example, a strategy update on short duration battery energy storage systems published by the UK Infrastructure Bank (PDF) in September 2023.

5.2 Manufacturing capacity

In its report on batteries for electric vehicle manufacturing (November 2023), the Business and Trade Committee said that "the UK faces a gigafactory gap, because of insufficient domestic manufacturing capacity". Gigafactories are large-scale battery manufacturing sites that produce batteries mainly for the electric vehicle market but also for electrical storage applications.[124]

Most rechargeable batteries are currently manufactured in East Asia.[125] There is currently only one existing gigafactory in the UK, in Sunderland. It is owned by Envision AESC UK, part of a Chinese-owned battery technology company that is headquartered in Japan.[126]

In its report, the Business and Trade Committee called on the government to explain "how it will ensure the UK develops the capacity to build the battery supply needed [...] to achieve our targets for Net Zero". It recommended that the government offer more financial support, address skills gaps and identify sites for gigafactories to attract investors and encourage the development of gigafactories.[127]

In its response to the committee's report, the government pointed to its UK battery strategy (published in November 2023).[128] In the strategy, it said its aim was for the UK to "have a globally competitive battery supply chain that supports [...] the net zero transition" by 2030 and for the UK to become "a world leader in sustainable battery design and manufacture".[129]

There has been some recent investment in gigafactories in the UK. It includes:

- Envision AESC UK is building a second gigafactory in Sunderland which will have an initial capacity of 12 GWh.
- Tata Group announced in July 2023 that it would invest £4 billion in a gigafactory that is expected to commence production in 2026.[130]

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124 Business and Trade Committee, Batteries for electric vehicle manufacturing (PDF), 14 November 2023, HC 196 2023-24, pp3-5

125 DBT, UK battery strategy, last updated December 2023

126 Business and Trade Committee, Batteries for electric vehicle manufacturing (PDF), 14 November 2023, HC 196 2023-24, pp4-5

127 Business and Trade Committee, Batteries for electric vehicle manufacturing (PDF), 14 November 2023, HC 196 2023-24, pp4-5

128 DBT, Batteries for electric vehicle manufacturing: Government Response to the Committee's First Report of Session 2023-24 (PDF), 14 February 2024, HC 547 2023-24

129 DBT, UK battery strategy, last updated December 2023

130 Business and Trade Committee, Batteries for electric vehicle manufacturing (PDF), 14 November 2023, HC 196 2023-24, paras 18-22

5.3 Delays to grid connections

BESSs are connected to either the higher-voltage transmission system (132 kilovolts or above), which is operated mainly by National Grid ESO in Great Britain[131], or the lower-voltage distribution system (less than 132 kilovolts), which is operated by licensed distribution network operators (DNOs).[132]

The Energy Network Association is the trade association for energy networks in the UK. It is also responsible for ensuring connections are compliant with technical and legal requirements. Ofgem, the independent energy regulator, is responsible for ensuring that developers looking for a new connection to the grid receive good service at a fair price.[133]

Developers of all types of low-carbon energy infrastructure have reported long lead times for connection to the electricity transmission or distribution networks in Great Britain.

In January 2023, the head of hydrogen of the energy company Centrica told the then Business, Energy and Industrial Strategy (BEIS) Committee that, as a result of grid constraints, "hardly any more grid-scale batteries" could be put "on the network". The chief executive of Regen, a not-for-profit organisation which seeks to support the transition to net zero, told the BEIS Committee that there was a 15-year delay to putting renewable energy projects and batteries on the grid "in most parts of the country".[134]

In its UK battery strategy, the government also noted that respondents to its call for evidence had raised concerns that long lead times to accessing the grid could also have knock-on effects on the "cost of manufacturing in the UK and represent notable barriers to investment".[135]

Government actions

To address the issue of delays in grid connections, the government appointed Nick Winser as the UK's first Electricity Networks Commissioner in July 2022. In August 2023, Nick Winser published an independent report on accelerating

131 National Grid ESO are the electricity system operator for Great Britain. Under the Energy Act 2023, National Grid ESO will become the National Energy System Operator (NESO), a new independent public corporation responsible for planning Britain's electricity and gas networks and operating the electricity system, in summer 2024.

132 National Grid, Electricity Transmission: How can I connect?, undated [accessed 16 April 2024]

133 Energy Network Association (ENA), Connecting commercial generation to the electricity networks, undated [accessed 16 April 2024]; Ofgem, A guide to electricity distribution connections policy, April 2024

134 Business, Energy and Industrial Strategy (BEIS) Committee, Oral evidence: Decarbonisation of the power sector, 24 January 2023, HC 283 2022-23, Q215

135 DBT, UK battery strategy, last updated December 2023

electricity transmission network deployment. It out recommendations to half the connection time of new projects to around seven years.[136]

In response to the Nick Winser' report, the government and Ofgem published an action plan in November 2023. The government said that it aimed for "a significant majority of projects" to be connected to the transmission network by the date they requested and to reduce average delays projects from five years to six months. The government and Ofgem also said they would work with the electricity system operator and network companies to improve connections to the distribution network.[137]

Other steps to reduce grid connection delays include:

- In November 2023, Ofgem also announced a new policy to clear 'zombie projects' and cut waiting time for electricity grid connections. The policy ended the existing 'first-come, first-served' system and allowed stalled or speculative projects to be forced out of the connections queue.[138]
- National Grid ESO has a five-point plan to improve the connection process at the transmission level in the short term. In November 2023, National Grid ESO announced that the connection dates of 10 gigawatts of battery projects had been accelerated as part of this plan.[139]
- The Energy Network Association have set out plans to improve customer connections to the grid at distribution level. [140]

5.4 Critical minerals

The manufacture of batteries requires a reliable supply of a range of 'critical minerals' (such as lithium, cobalt, nickel and graphite). In a report on the role of critical minerals in clean energy transitions (May 2021), the International Energy Agency estimated that demand for minerals for grid-scale electricity storage would grow 30 times between 2020 and 2040.[141]

Supplies of critical materials can be from domestic or international markets.

The possibility of extracting lithium in Cornwall is currently being explored. In its report on batteries for electric vehicle manufacturing, the Business and

136 BEIS, New Electricity Networks Commissioner appointed to help ensure home-grown energy for Britain, July 2022; DESNZ, Accelerating electricity transmission network deployment: Electricity Networks Commissioner's recommendations, last updated August 2023

137 DESNZ and Ofgem, Electricity networks: Connections action plan, November 2023

138 Ofgem, Ofgem announces tough new policy to clear 'zombie projects' and cut waiting time for energy grid connection, November 2023

139 National Grid ESO, Our five-point plan, undated [accessed 16 April 2024]

140 ENA, Connecting to the networks, undated [accessed 18 April 2024]

141 International Energy Agency (IEA), The Role of Critical Minerals in Clean Energy Transitions, May 2021, p104

Trade Committee said nickel and cobalt were also found in the UK, but it was not clear whether they could be extracted "at a commercial scale".[142]

Other minerals needed to make batteries do not exist in the UK, however. In its report on critical mineral resilience (December 2023), the Foreign Affairs Committee noted that "the UK is almost completely dependent on imports for critical minerals and mineral products". It highlighted that China is currently the "dominant global player" in critical minerals supply chains.[143]

International markets can be subject to volatility and social, economic and geopolitical issues. In its critical minerals strategy, the government said that its reliance on international markets meant critical minerals were "vulnerable to market shocks, geopolitical events and logistical disruptions".[144]

Government actions

The government published a critical minerals strategy in July 2022. It said the strategy aimed to:

- maximise the UK's domestic supply of critical minerals (including through mining, refining and manufacturing) and accelerate the recovery, reuse and recycling of critical minerals in the UK.
- collaborate with international partners to diversify supply and improve the resilience of critical minerals supply to the UK.
- make international markets more transparent and responsible, including by boosting environmental, social and governance performance and reducing vulnerabilities.[145]

The government also established the Critical Minerals Intelligence Centre in July 2022 to support government and industry to mitigate risks to the supply of critical minerals, domestically and internationally. The centre is led by the British Geological Survey and supported by the government.

In March 2023, the government published an update to its critical minerals strategy (titled 'critical minerals refresh'). In the 'refresh', the government announced that it would:

- launch a Critical Minerals Task and Finish Group to investigate the critical mineral dependencies and vulnerabilities across UK industry sectors. The group published a report in December 2023 that assessed

142 Business and Trade Committee, Batteries for electric vehicle manufacturing (PDF), 14 November 2023, HC 196 2023-24, para 39

143 Foreign Affairs Committee, A rock and a hard place: Building critical mineral resilience (PDF), 15 December 2023, HC 371 2023-24, para 6

144 DBT and BEIS, UK Critical Minerals Strategy, last updated March 2023

145 DBT and BEIS, UK Critical Minerals Strategy, last updated March 2023

environmental, social, and governance risks and supply risks for critical materials across six sectors, including energy.[146]

- improve the UK's collaboration with international partners, including through partnerships with Canada and South Africa and engagement through the Minerals Security Partnership, International Energy Agency and the G7.[147]

In its report on critical mineral resilience (December 2023), the Foreign Affairs Committee raised concerns that the government's critical minerals strategy was "too broad to be helpful as a guide to industry". It also said the strategy did not "convey the sense of urgency and need for immediate, decisive action which is of paramount importance" to deliver the UK's net zero commitments and improve its resilience to global supply chains.[148]

The committee called on the government to set "specific targets for priority sectors", building on its critical minerals strategy and refresh. The committee also said a "detailed implementation plan" was needed.[149]

In its response to the committee's report, the government said its critical minerals strategy and refresh demonstrated its "commitment to improving the resilience of critical minerals supply chains".[150]

146 DBT, Task and Finish Group: Industry resilience for critical minerals, December 2023

147 DBT and BEIS, UK Critical Minerals Strategy, last updated March 2023

148 Foreign Affairs Committee, A rock and a hard place: Building critical mineral resilience (PDF), 15 December 2023, HC 371 2023-24, p3

149 Foreign Affairs Committee, A rock and a hard place: Building critical mineral resilience (PDF), 15 December 2023, HC 371 2023-24, paras 31-35

150 Foreign, Commonwealth and Development Office (FCDO), A rock and a hard place: Building critical mineral resilience: Government Response to the Committee's First Report (PDF), 8 March 2024, HC 583 2023-24

6 Further reading

Research on BESSs

- Parliamentary Office for Science and Technology (POST), Longer duration energy storage, December 2022
- Royal Society, Large-scale electricity storage, September 2023
- Faraday Institution and Rho Motion, Market and Technology Assessment of Grid-Scale Energy Storage (PDF), September 2023

Committee reports

- Business and Trade Committee, Batteries for electric vehicle manufacturing, November 2023
- Lords Science and Technology Committee, Long-duration energy storage, March 2024
- Lords Science and Technology Committee, Role of batteries and fuel cells in achieving Net Zero, July 2021

Government reports

- DBT, UK battery strategy, last updated December 2023
- DESNZ, Long duration electricity storage: Scenario deployment analysis, January 2024
- DESNZ and BEIS, Benefits of long-duration electricity storage, August 2022
- DESNZ and BEIS, Electricity storage health and safety standards: Gap analysis, last updated August 2023
- OPSS, Safety of second life batteries in battery energy storage systems, January 2023

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