Campaign to Protect Rural England
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Guidance for assessing planning applications for small-scale battery storage and backup generation facilities

Proposed location for a battery storage development at Lower Woodford, near Salisbury, viewed from Old Sarum.

CPRE Wiltshire
46 New Park Street, Devizes SN10 1DT
email: admin@cprewiltshire.org.uk

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www.cprewiltshire.org.uk

Preface

As Government encourages more generation of electricity from renewable sources, the National Grid is having to increase the number of facilities that can provide short-term supplies, so as to counteract the intermittency of renewable generation. This is being achieved partly by establishing contracts with organisations providing short-term backup generation and battery storage. This approach requires the building of new infrastructure to connect to the Grid and local distribution networks.

To date, new battery storage infrastructure has been created mainly as purpose-built 'barns' or as aggregations of large converted shipping containers with associated transmission equipment, known variously as Electricity Storage Schemes (ESSs) or Flexible Electricity Generation Facilities (FEGFs); new backup generation equipment has been housed similarly, with fuel-storage facilities in addition.

The *National Planning Policy Framework* (NPPF) and *Planning Practice Guidance* (PPG) give no specific guidance on assessing applications for these relatively new forms of development. The PPG section on *Renewable and Low-Carbon Energy*[1] discusses assessment of proposals for solar arrays and wind-turbine developments; but battery storage developments and backup generation facilities are not renewable or low-carbon developments, and their built forms have little in common with solar panels or wind turbines.

In assessing actual applications, members of the CPRE Wiltshire Branch recognised the need for a set of criteria that could be used consistently in balanced appraisal of proposals for battery storage and backup generation developments. Accordingly, with technical advice and scrutiny of technical accuracy from Howard P Johnson, CEng, MIET of HPJ Energy, Shiplake (formerly a senior manager with National Grid, System Operations Department), the Branch has produced the following adaptation and extension of the PPG section *Renewable and Low-Carbon Energy* to help its members assess planning applications for backup generation and battery storage.

[1] PPG Renewable and Low Carbon Energy - Paragraph: 007 Reference ID: 5-007-20140306

Acknowledgement

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About this guidance

This document is arranged in a way that mimics the national *Planning Practice Guidance* (PPG). There is no intrinsic structure to the presentation of information: the guidance is presented in stand-alone topic sections, designed to enable users to 'dip into' the document for information relevant to a particular query. There is some repetition of information, to minimise the need for cross referring between sections.

References to relevant sections of PPG and other sources are given at the ends of topic sections. A glossary of frequently used terms is provided immediately after the table of contents.

Battery storage technology is changing rapidly. Please let us know about any adjustments, additions, or withdrawals of information we should make in order to keep this guidance up-to-date. Future revision of the NPPF, and probably of PPG too, will also necessitate revision of this guidance in due course.

Contents

22. Can noise outweigh other planning concerns?

23. Can air quality/pollution be relevant to a planning decision for backup generation or battery storage?

24. How should heritage be taken into account in assessing backup generation and battery storage applications?

25. How should the decommissioning of backup generation and battery storage facilities be considered?

26. Who decides what weight to give to a material consideration?

Glossary

Backup generation

For the purposes of this document backup generation is defined as generation by diesel engines fuelled by either diesel or natural gas. Typically, individual units are of some three MW in size, but units are aggregated to form an overall capacity of up to 50MW. Such generation can start up and be operating at full output within minutes of being instructed and can provide reserve services to National Grid such as STOR.

Battery storage

Battery storage is an electricity storage solution that stores electricity by way of reversible chemical reactions within the battery storage medium. For battery storage, the round-trip losses are typically between 7% and 15% depending on the battery technology used.

Distribution Network Operator (DNO)

Distribution Network Operators (DNOs) are companies licensed to distribute electricity in Great Britain by the Office of Gas and Electricity Markets (Ofgem). There are 14 licensed distribution network operators (DNOs) in Britain and each is responsible for a regional distribution services area. Examples are Western Power Distribution and Scottish and Southern Electricity.

Frequency, frequency regulation, frequency synchronism

The UK's national electric power grid, the National Grid, transmits electrical energy from generating sources to end-users using alternating current (AC), which oscillates at a specific frequency (50 Hz for the UK). The system frequency must be maintained between 49.5Hz and 50.5Hz. A gap between electricity generation and demand causes the grid frequency to change. If demand is higher than supply, the frequency falls, leading to brownouts and blackouts; if supply exceeds demand, the frequency rises, potentially damaging the grid or the electric devices plugged into it. Frequency regulation is the constant second-by-second adjustment of power to maintain grid frequency around 50 Hz to ensure grid stability.

Reserve

At certain times of the day National Grid needs access to sources of extra electrical energy to be able to deal with actual demand being greater than forecast demand and/or unforeseen unavailability of generation. These additional electricity sources are referred to as providing “reserve” and can be provided by part-loaded conventional generation already running on the system or by stationary generation that can be started rapidly (within 20 minutes) on instruction from National Grid.

Response

National Grid needs access to electricity sources throughout the day that can vary output automatically so as to be able to deal with immediate generation losses (e.g. an instantaneous shutdown of a generator following an electrical fault). The amount of automatic response held on the system is determined by statistical methods by National Grid and is set at varying levels throughout the day. Power sources that operate automatically are referred to as providing “response” and currently comprise part-loaded conventional generation, pumped water storage, battery storage and contracted demand management.

Round-Trip Losses
There are round trip losses associated with converting electricity into a storage medium and then converting it back to electrical energy, as the conversion process has inherent inefficiencies. Round trip losses can range from 20% to only 7%, depending on the storage technology used.

Short Term Operating Reserve (STOR)
The amounts of part-loaded and stationary reserve required to be held on the system are determined by statistical methods by National Grid and are used to set the Short Term Operating Reserve (STOR) contract requirement for stationary reserve. STOR services are currently provided by backup generation, pumped water storage, battery storage and contracted demand management

Storage
Storage of electricity is defined as the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy in a controllable manner. This document discusses only battery storage, but other forms include hydro pump storage, flywheel storage, and salt cavern storage. All have “round trip losses” associated with the storage and recovery of the energy stored.

Technical Standards
There are a number of technical codes and standards that the transmission networks, distribution networks and generators are required to have in force and to comply with. These include the Grid Code, the System Operator Transmission Owner Code; the Distribution Code, the GB Security and Quality of Supply Standard and the Distribution System Planning Standard. These are augmented by a number of Engineering Recommendations that provide more detail by which the system is constructed and operated.

1 The need for backup generation and battery storage

Over the last decade, the mix of generation providing electricity to the National Grid has undergone a significant change as electricity production has moved to less carbon-intensive fuels and generation from renewable sources. Renewable sources are now providing over a quarter of all of the electricity used[2].

The output from most forms of renewable generation, unlike that from the conventional generation it is replacing, is intermittent. To manage this intermittency, National Grid is now having to carry increased amounts of “reserve” — a standby supply that can be held on stationary plant for long periods of the day, that can be generating at short notice for the periods when output from renewable sources has dropped.

An established technology that is well suited to provide reserve operation is backup generation (i.e. generation powered by diesel engines fuelled by either natural gas or diesel fuel). A technology that is being adapted to hold a reserve is battery storage.

In addition, National Grid is now also having to carry increased amounts of “response”. When a large generator at any location on the electricity system suddenly ceases to generate because of a fault, the frequency of the system may drop below required levels. Traditionally, to manage such events, a standby response supply has been held on part-loaded conventional generators. They automatically detect the frequency drop and increase output immediately. However, with fewer conventional generators now operating, alternative ways of holding response have had to be introduced. One type of technology that has been adapted to do this is battery storage.

National Grid needs to procure greater amounts of reserve and response now, and this need is set to increase into the future[3]. A wide range of service providers is responding to this opportunity by promoting the construction of new backup generation and battery storage facilities. From an economic and technical perspective, they are quick, cheap and reasonably suited to providing these services.

A fast and simple way to connect such facilities to the National Grid is to construct them in a rural setting and claim that they are needed locally to support the grid, thus avoiding the complications and costs of using an existing "brownfield" site in an industrial location.

In reality, unless the local distribution company has formally identified a need to reinforce local generation, there is no technical reason why these facilities need to be located in a rural setting. Contrary to popular belief, there is no practical benefit that such facilities give to restoring local electricity supplies following a fault or blackout of the local electricity system.

Furthermore, the emissions produced by backup generation can be environmentally significant when compared with those produced by other reserve sources because of the relatively poor efficiency of the diesel engines used for backup generation plant and the fuel used.

[2] Department for Business, Energy & Industrial Strategy – Digest of UK Energy Statistics, 2017
[3] National Grid – System Needs and Product Strategy Report, 2017

2 Who is responsible for the planning approval of energy developments?

Local planning authorities are responsible for control of renewable and low carbon energy development of 50MW or lower installed capacity (under the Town and Country Planning Act 1990). Renewable and low carbon developments over 50MW capacity are considered by the Secretary of State for Energy under the Planning Act 2008, and the local planning authority is a statutory consultee.

The NPPF explains that all communities have a responsibility to help increase the use and supply of green energy; but PPG emphasises[4] this does not mean that the need for renewable energy automatically overrides environmental protections and the planning concerns of local communities. As with other types of development, it is important that the planning concerns of local communities are properly heard in matters that directly affect them.

Whilst it may be appropriate from a national needs perspective for backup generation and battery storage facilities to be developed, it is not necessarily the case that communities have a responsibility to allow such facilities to be constructed in their locality, as these facilities do not in themselves increase the use and supply of green energy.

[4] PPG Renewable and Low Carbon Energy - Paragraph: 007 Reference ID: 5-007-20140306

3 Can suitable areas for battery storage and backup generation developments be identified?

There are no hard and fast rules about how suitable areas for battery storage and backup generation developments should be identified. However, in considering locations, local planning authorities should ensure they take into account the requirements of the technology and, critically, the potential impacts on the local environment, including cumulative impacts. The views of local communities likely to be affected should be listened to.

It is also important to set out the factors that should be taken into account when considering individual proposals in these areas. These factors may depend on the investigatory work underpinning the identified area. The following points may be of particular relevance when undertaking such investigation.

Whereas a wind turbine has to be located where the wind blows, and solar panels have to be located where the sun shines, the same limitation does not apply to battery storage, as the National Grid by its very purpose can transfer any surplus or deficit electricity to or from the battery storage facility even if its site is remote from the generating source.

As with battery storage, backup generation also can be sited at any location; it does not have to be near to the point of demand, as the National Grid can transfer any electricity provided by backup generation to that point when called upon to provide reserve.

Furthermore, the local distribution networks to which these facilities are connected are built and maintained in accordance with Regulatory Planning Standards. They are built to meet local demand without any backup generation or battery storage needing to be operated (except in rare and exceptional circumstances explicitly identified by the local Distribution Network Operator). The nearby presence of such facilities does not add to the electricity security of a local community; indeed, under major distribution network fault situations, they are automatically instructed to cease running on electricity safety grounds whilst the system is restored.

Therefore, though it may be appropriate from a national needs perspective for battery storage and backup generation facilities to be constructed on a site in a rural environment, to support the National Grid, there is no reason why they cannot be located away from that environment. The National Grid will transfer energy from them to where it is required when it is required.

4 Should a local planning authority strategy support backup generation and battery storage as renewable energy?

It should be noted that backup generation is not generation from a renewable source and is not a source of green energy. It provides alternative supplies when renewable generation output has dropped or when a conventional power station has broken down but, compared with all other forms of reserve generation (with the exception of coal), it is the most carbon-intensive form of generation.

It should be noted also that battery storage is not generation from a renewable source and is not a source of green energy. It facilitates the operation of a stable electricity system in that it both stores electricity when supplies are in surplus and discharges electricity (normally as reserve) when supplies are in deficit; but the energy a battery uses for charging may not necessarily derive from green energy sources. When the battery is being charged, it is likely that conventional gas-fired generation is also being run to provide stable supplies; if the battery was not being charged, it is possible the conventional generation would not be required. National Grid has yet to experience a time when the power system has been operated securely without the need for gas-fired generation, although there have been periods when demand has been met without coal-fired generation[5]

[5] National Grid Control Room, @NGControlRoom 10.11PM Apr 21, 2017

5 Should buffer zones for backup generation and battery storage developments be included in a local planning strategy?

Local planning authorities should not rule out otherwise acceptable energy developments through inflexible rules on buffer zones or separation distances. Other than when dealing with set-back distances for safety, distance of itself does not necessarily determine whether the impact of a proposal is unacceptable. Distance plays a part, but so does the local context, including factors such as topography, the local environment and near-by land uses.

6 What general planning considerations relate to backup generation and battery storage developments?

The scope of what can constitute a consideration material to determining backup generation and battery storage applications is very wide. The courts often do not indicate what cannot be a material consideration. However, in general they have taken the view that planning is concerned with land use in the public interest. The protection of purely private interests such as the impact of a development on the value of a neighbouring property or loss of private rights to light is not a material consideration.

Paragraphs 7 and 8 of the NPPF stress the three dimensions to sustainable development — economic, social, and environmental. They point out that these should not be considered in isolation, because they are mutually dependent: "To achieve sustainable development, economic, social, and environmental gains should be sought jointly and simultaneously through the planning system".

In considering a proposal for a backup generation or battery storage development, a local planning authority will need to take into account not only its potential contribution to the national electricity supply, but a full range of environmental, social, and economic factors. PPG, *Renewable and Low-Carbon energy,* makes an important general point[6]:

> the need for renewable or low carbon energy does not automatically override environmental protections.

The following lists of factors are based on the lists given in PPG, *Renewable and Low-Carbon Energy* for assessing applications for ground-mounted solar or wind turbine developments[7,8].

Environmental f*actors* a local planning authority will need to consider are:

- Encouraging the effective use of land by focusing large-scale backup generation and battery storage on previously developed and non-agricultural land, provided that it is not of high environmental value.

- Whether the proposed use of any agricultural land has been shown to be necessary, and poorer quality land has been used in preference to higher quality land.
- Whether the proposed backup generation and battery storage would be temporary structures, and planning conditions can be used to ensure that the installations are removed when no longer in use and the land is restored to its previous use.
- The proposal's likely effect on landscape and visual amenity (for detailed guidance see the Landscape Institute's *Guidelines for Landscape and Visual Impact Assessment*[9], especially chapters 4- 8 inclusive); for greenfield sites, whether the new industrial mass introduced by the proposed development can be accommodated comfortably within the rural character of the surrounding landscape.
- Whether the presence and operation of the new development will have any impact on neighbouring ecology and wildlife.
- What will be the effects of increased use of highways and public rights-of-way.

Important social factors will include:

- Whether receptors in nearby dwellings or on nearby footpaths will be affected by the visual impact of the proposed built development and any attempted screening with natural planting.
- The potential effect on leisure use of nearby amenities or tourist attractions.
- The need for, and impact of, security measures such as lights and fencing.
- Whether particular care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance, including the impact of proposals on views important to their setting. As the significance of a heritage asset derives not only from its physical presence, but also from its setting, careful consideration should be given to the impact of large scale developments on such assets. Depending on its scale, design and prominence, any backup generation or battery storage facility within the setting of a heritage asset may cause substantial harm to the significance of the asset.

Economic factors that will need to be considered include:

- Increase or decrease in local employment. After initial construction, impact on employment will be minimal, as only specialist contractors that serve similar backup and battery storage facilities nationwide will be needed to service the equipment infrequently.
- Energy-generating potential, which for both backup generation and battery storage facilities will NOT be dependent on the local topology, unlike wind and solar generation, but on the contracts for reserve and response services that are in place with National Grid. Reserve and response services are called upon to provide significant output only on infrequent occasions (for backup generation, operation for 300 hours per year (3.4%) is typical).

[6] PPG Renewable and Low Carbon Energy - Paragraph: 007 Reference ID: 5-007-20140306

[7] PPG Renewable and Low Carbon Energy - Paragraph: 013 Reference ID: 5-013-20150327
[8] PPG Renewable and Low Carbon Energy - Paragraph: 014 Reference ID: 5-014-20150618
[9] Landscape Institute, *Guidelines for Landscape and Visual Impact Assessment*, 3rd edition, 2013, 4.26

7 Siting: what factors relate to the National Grid?

Whilst it is appropriate from a national needs perspective for battery storage and backup generation to be constructed close to existing National Grid facilities, there is normally no reason from the perspective of a local distribution network or a renewable generation connection why these facilities cannot be located away from the rural environment.

Whereas a wind turbine has to be located where the wind blows, and solar panels have to be located where the sun shines, the same limitation does not apply to battery storage. The National Grid by its very purpose can transfer any surplus or deficit electricity to or from a battery storage facility even if it is remote from the wind turbine, solar panel or point of demand

As with battery storage, backup generation also can be sited at any location; it does not have to be near to the point of demand, as the National Grid can transfer any electricity provided by backup generation to that point when called upon to provide reserve.

As a consequence, National Grid does not have location-specific requirements within its procurement process for reserve provided by backup generation or for response provided by battery storage (although there is an expectation that such services will naturally be dispersed around the country. Also, there is a current desire for more reserve services closer to high demand areas, including South East England and Wales)[10].

[10] https://www.nationalgrid.com/uk/electricity/balancing-services/reserve-services/short-term-operating-reserve-stor?overview

8 Siting: what factors relate to the Local Distribution Network?

The local distribution networks to which backup generation and battery storage facilities are connected will have been built in accordance with regulatory Technical Standards. That means they will have been built to meet local demand without any local generation needing to operate within the local network. (Nationally, there are a few exceptions where backup generation or battery storage will be required for local system security reasons, but these will have been explicitly identified by the local DNO and be formally identified as being needed for this purpose under Engineering Recommendation P2/6)[11].

Even if there was a significant fault on the local distribution network, any backup generation or battery storage facilities would need to be disconnected (by network protection equipment[12]) immediately, on electricity safety grounds, to ensure they did not become “islanded” on an isolated part of the distribution network with local demand. This is because such facilities are unmanned and have no capability to operate autonomously to match output with the isolated demand, potentially causing local homes and businesses to suffer from high or low voltages. Such voltages would damage electrical equipment and preclude the local DNO from reconnecting the isolated part of the system because it might be out of frequency synchronism with the main system.

As a consequence, local backup generation and battery storage facilities do not add to the electricity security of the local community and are not needed from a local electrical supply point of view. Indeed, under local distribution network fault situations they may actually need to be disconnected until the system is restored by the DNO.

[11] http://www.dcode.org.uk/assets/uploads/ENA_ER_P2_Issue_6__2006_-1.pdf
[12] http://www.dcode.org.uk/assets/images/ENA_EREC_G59_Issue_3_Amendment_2_(2015).pdf

9 Siting: what factors need to be considered when battery storage is supporting local renewable generation?

On economic grounds there is sometimes a case to install a greater capacity of renewable generation (i.e. wind farm or solar farm generation) than the connecting circuits to the main 33kV substation can accommodate when the generation is at full output. Instead, a battery storage facility is located at the end of the connection closest to the renewable generation to take any excess electricity produced by the generation rather than limiting the generation. The stored electricity, less any round-trip losses, can then be discharged when the renewable generation output is below the maximum capacity of the connection. In this way all of the electrical energy produced by the renewable generation, less any round-trip losses, can be used.

In these situations, the initial cost of the battery storage, all of the round trip losses associated with the charging and discharging of the battery storage, and the cost of maintaining the battery storage facility over its lifetime (typically 25 years) may well be considerably higher than the cost of uprating the connection circuit when the renewable generation facility is constructed in the first place.

There may be an occasion when uprating the circuit is prohibitively expensive, justifying construction of a battery storage facility at the renewable generation wind farm end of the connection circuit, but this needs to be explicitly demonstrated in an application.

10 Siting: what factors relate to proximity to a substation?

As explained in section 8 of this Guidance *Siting: what factors relate to the Local Distribution Network*, there are only a few limited reasons under Engineering

Recommendation P2/6 where backup generation or battery storage might need to be located in a rural setting to support the local distribution network. But even then, there is generally no technical electrical reason why the facility cannot be located a number of miles distant from the substation which needs to be supported, perhaps in an existing redundant farm building, or in a new location where the visual and landscape impact of the facility will be less. Connection to the substation can be by either an underground cable and/or an overhead line (on light wooden poles for the voltages in question for these types of facilities).

Such facilities are estimated to have a design life of 25 years, so the cost of running underground cables or overhead lines to allow them to be located in alternative, more suitable locations should be included in any analysis of alternative sites.

11 Siting: what factors relate to the specific technology proposed?

Backup generation, whether fueled by gas oil (diesel) or natural gas, is mature technology. The only physical siting considerations related to technology would concern the building of the facility in the first place, delivery of fuel, and ease of occasional visiting by personnel to maintain the equipment. The equipment is not substantial in size, so is no more difficult to build and deliver to site than is a modern agricultural facility for handling animal food or waste or storing grain at harvest time. The delivery of fuel will be either by road tanker or by direct connection to the gas distribution system if a gas supply is nearby.

Backup generation will require cooling fans to be operating when the facility is running. That could be for a number of hours at a time when requested to run by National Grid. It would produce exhaust gas that could contain significant amounts of NOx and particulate emissions if no exhaust filtration equipment was included within the construction and, if fitted, was not properly maintained. The noise from such facilities can be minimal if acoustic sound insulation and baffling is included within the construction of the building that contains the combustion engines, and the speed of the cooling fans is limited so as to suppress noise as effectively as possible.

Storage is rapidly becoming important to the operation of the electricity system and a number of new technologies are being considered, but the technology that is currently predominant is battery storage. The advantage of battery storage is that it is modular, comprising batteries, inverter equipment and cooling fans that can be installed within shipping containers or within the frame of shipping containers (or similar sized structures). The larger the facility, the more modules, and the greater the number of shipping containers or frames of shipping containers.

The only physical siting considerations related to technology concern building the facility in the first place and ease of occasional visiting by personnel to maintain the equipment. The equipment is not substantial in size and can be handled as a container, so would be no more difficult to deliver to site than delivering the materials for the construction of a modern agricultural facility for handling animal food or waste or storing grain at harvest time.

Electricity Storage will require cooling fans and inverters to be operating when the facility is running. That could be continuously if providing response services to National Grid. The noise from such facilities can be minimal if acoustic sound insulation and baffling are included within the construction of the containers that house the batteries and inverters and the speed of the cooling fans is limited so as to suppress noise as effectively as possible.

12 Siting: what factors relate to the size of the facility proposed?

In England and Wales there is a break point in the Use of System charging structure, the Electricity Market Rules and the Grid Code at 50 MW, below which power stations are defined as Small Power Stations and the obligations for connection to the system are less onerous. At 50 MW output or below, Small Power Stations can connect to the 33 kV voltage level, with significant savings in cost when compared with the next voltage level up of 132 kV.

The majority of backup generation and battery storage facilities comprise of a number of units or modules that can be scaled up (to a maximum of 50 MW) to match the available capacity of the local distribution network to absorb the backup generation output or the battery storage output or input when the loading on the distribution system is at its maximum from other users of the network (i.e. customer demand and any other generation already installed on the system).

13 What will be the likely CO_2 emissions from a 50 MW backup generation facility providing short-term operating reserve?

Backup generation contracted with National Grid under a STOR contract to provide reserve is expected to generate infrequently. When called upon to operate, it will be required to be at full output within minutes of starting and will operate for no more than a few hours on each occasion.

For a backup generation facility of 50 MW capacity, the typical maximum total hours of operation that will be required for a STOR contract would be 300 hours per year. The total amount of electrical energy produced by such a plant would be 15,000 MWh.

A. To produce 15,000 MWh of electricity over a year, a typical backup generator fueled by diesel will emit **11,000 Tonnes** of CO_2;

B. To produce 15,000 MWh of electricity over a year, a typical backup generator fueled by natural gas will emit **7,500 Tonnes** of CO_2;

C. By comparison, to produce 15,000 MWh of electricity over a year, a typical conventional gas generator of modern design will emit **5,150 Tonnes** of CO_2.

Calculations A, B, C

For a typical backup generator fueled by diesel, operating at full load at an efficiency of 37% [13], with a fuel conversion of 0.272kg CO_2/kWh [14], the CO_2 emitted will be 0.735kg CO_2/kWh. Over a year the total amount of CO_2 emitted to deliver 15,000 MWh of electrical output will be 11,000 Tonnes.

For a typical backup generator fueled by natural gas, operating at full load at an efficiency of 37%, with a fuel conversion of 0.185kg CO_2/kWh, the CO_2 emitted will be 0.500kg CO_2/kWh. Therefore, over a year the total amount of CO_2 emitted to deliver 15,000 MWh of electrical output will be 7,500 Tonnes.

For a typical conventional gas fired generator of modern design operating at full load at an efficiency of 53.8% with a fuel conversion of 0.185kg CO_2/kWh, the CO_2 emitted will be 0.344kg CO_2/kWh. Over a year the amount of CO_2 emitted to deliver 15,000 MWh of reserve output will be 5,150 Tonnes.

[13] Wartsila - Combustion Engine vs Gas Turbine: Part Load Efficiency and Flexibility, 2016
[14] BEIS - Government emission conversion factors for greenhouse gas company reporting, 2016

14 What will be the likely CO2 emissions from a 50 MW battery storage facility providing short-term operating reserve?

There is little experience of how battery storage is used for reserve, as it is such a new technology. However, it is reasonable to assume that it will be used in a similar manner to how pumped water storage has been used over the past decade. That is, it is likely that it will charge when demand is lower, and discharge when reserve is needed.

A battery storage facility of 50 MW output may charge for 4 hours per day (a similar time to pumped water storage) so therefore may have a capacity of 200 MWh. Assuming 75% of the storage capacity is used each day (again using water storage as the guide) then over a day, 150 MWh of electrical energy will be discharged as reserve output. Over a hundred days, the total electrical energy delivered to the system will be 15,000 MWh.

A The total amount of $C0_2$ emissions associated with delivering 15,000MWh of electrical energy from a battery storage facility will be **4,000 Tonnes** of CO_2.

Calculation A

Typical "round trip" efficiencies of modern batteries are 93%[15] (from charged, to discharged, back to charged), typical power electronics inverter efficiencies are 97% rectifying and 97% inverting (when working at the high-power outputs associated with providing reserve)[16], thus the overall efficiency of the battery in providing reserve will be 87%.

If the battery is charged from the grid, the charging energy will be provided by the typical share of generation[17] of 21% nuclear generation, 42% conventional gas generation, 9% conventional coal generation, 25% renewable generation and 3% reserve generation.

The Battery will consume 17,000 MWh of electrical input to deliver 15,000 MWh of electrical output once charging losses are included. The CO_2 emissions produced will be 4,000 Tonnes. This will comprise 2,500 Tonnes from conventional gas generation (7,100 MWh at 0.344kg CO_2/kWh), 1,200 Tonnes from coal generation (1,500 MWh at 0.790kg CO_2/kWh[18], 300 Tonnes of CO_2 from other sources such as backup generation (500 MWh at 0.735kg CO_2/kWh); with the amount of CO_2 produced by both nuclear generation and renewable generation not being considered significant.

[15] Ashurst - Battery Storage: A charge future energy source issue 18, 2017
[16] Penn State University - Efficiency of Inverters EME 812 paper, 2017
[17] Department for Business, Energy & Industrial Strategy – Digest of UK Energy Statistics, 2017
[18] EMR white paper emissions performance standards impact assessment - 2011

15 What will be the likely CO_2 emissions from a 50 MW battery storage facility providing response services?

Over the past few years, battery storage as a new technology has started to be used to maintain a stable frequency by providing response. It works by monitoring the system frequency such that when the frequency drops, electrical energy is fed into the National Grid from the battery to help increase the frequency, and when the frequency rises, electrical energy is fed into the battery from the National Grid to help lower the frequency. Over a day, the energy taken out of the battery will equal the energy put into the battery plus any losses associated with the charging and discharging of the battery (caused by minor modulation in system frequency).

A The total amount of CO_2 emissions associated with a 50MW battery storage facility providing 12.5 MW of response continuously over a year will be **3,900 Tonnes** of CO_2

Calculation A

With a system standard deviation of frequency of 0.07 Hz and with the control system set at the standard Grid Code droop setting of 4% then the energy modulating in and out of a 50 MW battery every hour will be 1.25 MWh and over a year will be 10,950 MWh.

Typical "round trip" efficiencies of modern batteries are 93% (from charged, to discharged, back to charged), typical power electronics inverter efficiencies are 75% rectifying and 75% inverting (when working at the low-power outputs associated with response modulation), thus the overall efficiency of the battery in providing response will be 52%.

If the battery is charged from the grid, the charging energy will be provided by the typical share of generation of 21% nuclear generation, 42% conventional gas generation, 9% conventional coal generation, 25% renewable generation and 3% reserve generation.

The Battery will consume 16,650 MWh of electrical input as charging losses. The CO2 emissions produced will be 3,900 Tonnes. This will comprise of 2,440 Tonnes from conventional gas generation (6,940 MWh at 0.344kg CO2/kWh), 1,170 Tonnes from coal generation (1,450 MWh at 0.790kg CO2/kWh), 290 Tonnes of CO_2 from other sources such as backup generation (490 MWh at 0.735kg CO_2/kWh); with the amount of CO_2 produced by both nuclear generation and renewable generation not being considered significant.

16 What general consideration should be given to the NOx and particulate emission impacts of backup generation?

Backup generation will produce exhaust gas that can give rise to air pollutants, particularly oxides of nitrogen (NOx) and small particles of soot (particulate matter) if inadequate exhaust filtration equipment is included within the construction of the facility and if the exhaust filtration equipment is not properly maintained. This is particularly the case if the fuel used for the combustion engines is diesel fuel, for which, if the air pollutants are at typical or normal level, both nitrogen dioxide and small diesel soot particles can have very negative impacts on the health of citizens[19].

The proposed construction and design of any backup generation facility should be compliant with all relevant sections of the Medium Combustion Plant Directive[20] and any other regulations applicable to the use of diesel engines as the prime mover for "electrical generation".

Developers should demonstrate within their planning application how the design, construction and maintenance of the backup generation facility will be compliant with all NOx and particulate regulations applicable to the type of installation that is being proposed that are in force the time of the application.

[19] https://www.tandfonline.com/doi/abs/10.1080/10590500802494538
[20] http://ec.europa.eu/environment/industry/stationary/mcp.htm

17 What general consideration should be given to the landscape and visual impacts of backup generation and battery storage?

In general, the visual and landscape impacts of backup generation and battery storage developments should be assessed against the same criteria as are used in the assessments of all other types of development, following the guidance given in the Landscape Institute's Guidelines for Landscape and Visual Impact Assessment[21]. Particularly important general considerations include: direct and indirect effects, cumulative impacts, temporary and permanent impacts, the sensitivity of the landscape and visual resource, particularly sensitive skylines, and the magnitude or size of the predicted change.

Some landscapes may be more sensitive to certain types of change than others, and it should not be assumed that a landscape character area deemed sensitive to one type of change cannot accommodate another type of change. In assessing the impact on visual amenity, factors to consider include: establishing the area in which a proposed development may be visible, identifying key viewpoints, the people who experience the views, and the nature of the views.

The Historic England website provides information on undertaking historic landscape characterisation and how this relates to landscape character assessment.

[21] Landscape Institute, *Guidelines for Landscape and Visual Impact Assessment*, 3rd edition, 2013, 4.26

18 How should the cumulative landscape and visual impacts of backup generation and battery storage be assessed?

Cumulative landscape impacts and cumulative visual impacts are best considered separately[22]. The cumulative landscape impact is the effect of a proposed development on the fabric, character and quality of the landscape; it is concerned with the degree to which a proposed development will become a significant or defining characteristic of the landscape. Landscape character areas can form the basis for considering which technologies at which scale may be appropriate in

Cumulative visual impact concerns the degree to which proposed development will become a feature in particular views (or sequences of views), and the impact this has upon the people experiencing those views. Cumulative visual impacts may arise where two or more of the same type of renewable energy development will be visible from the same point or will be visible shortly after each other along the same journey. Hence, it should not be assumed that, just because no other sites will be visible from the proposed development site, the proposal will not create any cumulative impacts.

Particular attention should be paid to cumulative landscape and visual effects when use of agricultural land is changed to accommodate battery-storage installations: especially, as outlined in Guidelines for Landscape and Visual Impact Assessment, paragraph 7.17: "incremental change as a result of successive individual developments such that the combined landscape and visual effect is significant even though the individual effects may not be."

[22] PPG Renewable and Low Carbon Energy Paragraph: 022 Reference ID: 5-022-20140306

19 Would any 'mitigation' offered really reduce adverse landscape and visual effects or be "cosmetic landscape works'?

Backup generation and battery storage developments, especially those housed in converted shipping containers, on what has previously been agricultural land will introduce non-characteristic elements into an area, changing the content and character of the views available to people, and the over-all sense of visual amenity. As the Landscape Institute's *Guidelines for Landscape and Visual Impact Assessment* point out[23]:

> Sympathetic treatment of external areas can, in some circumstances, help the integration of a new development into the surrounding landscape, but measures that are simply added on to a scheme as 'cosmetic' landscape works, such as screen planting designed to reduce the negative effects of an otherwise fixed scheme design, are the least desirable.

'Screening' with plantings merely converts the external appearance of a new element in the landscape, and that only for the times of the year when the screening is in full leaf.

The scenic qualities of a landscape may be altered not only by adding new features but also by removing familiar ones. For example, removal of hedges may change a small-scale, intimate landscape into a large-scale open one, or introduction of new buildings or tall structures may alter open skylines[24].

The ideal strategy, says the Landscape Institute, " is one of prevention/avoidance"[25]. That will usually entail finding an alternative site, preferably on previously used land or in an area earmarked for industrial development.

Weight should be given to local attitudes to the landscape. Landscape may be valued by society for a variety of reasons, and there is no intrinsic hierarchy among the values attached to a location by different stakeholders. In the words of PPG, *Renewable and Low-Carbon energy*[26]:

> the need for renewable or low carbon energy does not automatically override environmental protections.

[23] Landscape Institute, *Guidelines for Landscape and Visual Impact Assessment,* 3rd edition 2013, 4.26
[24] Landscape Institute, op.cit., 4.24
[25] Landscape Institute, op.cit., 5.49
[26] PPG Renewable and Low Carbon Energy - Paragraph: 007 Reference ID: 5-007-20140306

20 What general considerations should be given to the noise impacts of backup generation and battery storage facilities?

Section 11 of the NPPF (Conserving and enhancing the natural environment) provides guidance on how noise produced by new developments should be considered. It expects the planning system to contribute to and enhance the natural and local environment by preventing new development from contributing to unacceptable levels of noise pollution.

It also expects[27] planning policies and decisions to aim to:

- avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of any new development;
- mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from any noise from the new development, including through the use of conditions; and
- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

It is against this framework that any application for a backup generation or battery storage facility should be assessed as a potential creator of noise pollution.

Backup generation will require cooling fans and reciprocating engines to be operating when the facility is running, which could be for a number of hours during the day if providing reserve services to National Grid. Battery storage also will require cooling fans and inverters to be operating when the facility is running, which could be continuously if providing response services to National Grid. The noise from both types of such facilities can be minimal if acoustic sound insulation and baffling are included within the construction of the building that contains the combustion engines and inverters, and the speed of the cooling fans is limited so as to suppress noise as effectively as possible.

Even where facilities are being proposed for sites in rural locations, designs will be expected to use acoustic sound insulation and baffling within the construction of the buildings that contain the combustion engines, inverters and slow-speed cooling fans, so that the facilities create no discernible noise at their boundaries.

In 2014, the Institute of Environmental Management and Assessment provided guidelines for undertaking environmental noise impact assessments[28], in which it recognises that most new developments, regardless of their scale, will generate noise which has the potential to affect people's health, quality of life, property; and that some new developments might also impact on locations valued for their tranquility or soundscape, historic buildings and wildlife. It set a series of good practice standards for the scope, content and methodology of noise impact assessments. These standards should be used for undertaking assessments of the design of new backup generation and battery storage, to demonstrate that the noise produced by the facility has been minimized by good design to the absolute minimum.

British Standard 4142-2104 also provides methods for rating and assessing industrial and commercial sound. It describes methods for measuring and determining existing ambient, background and residual sound levels, which can be used as the baseline against which the sound produced by any new development can be compared at the boundary. It is designed to give consistent results across a range of situations (including developments such as backup generation or battery storage facilities) and supports current UK planning guidance and Environment Agency guidance.

The PPG sections on Noise[29], are also used by local planning authorities when assessing and rating noise.

[27] NPPF paragraph 123
[28] IEMA Guidelines for Environmental Noise Impact Assessment 2014
[29] PPG Noise - Reference ID 30-006-20141224

21 How can the adverse effects of noise be mitigated?

If noise exposure causes a material change in behaviour (such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present, the planning process should be used to avoid this effect occurring, by requiring appropriate mitigation Mitigation measures can include avoiding noisy locations; designing the development to reduce the impact of noise from the local environment; including noise barriers; and, optimising the sound insulation provided by the building envelope (see the PPG guidance on design for more information)[30].

[30] PPG Noise Paragraph: 008 Reference ID: 30-008-20140306

22 Can noise outweigh other planning concerns?

It can, but neither the Noise policy statement for England nor the National Planning Policy Framework (which reflects the Noise policy statement) expects noise to be considered in isolation, separately from the economic, social and other environmental dimensions of proposed development[31].

[31] PPG Noise - Paragraph: 002 Reference ID: 30-002-20140306

23 Can air quality/pollution be relevant to a planning decision for backup generation or battery storage?

Whether or not air quality is relevant to a planning decision on backup generation or battery storage will depend on the nature of the proposed development and its location. Concerns could arise if the development is likely to generate air quality impact in an area where air quality is known to be poor. They could also arise where the development is likely to impact adversely upon the implementation of air quality strategies and action plans and/or, in particular, lead to a breach of EU legislation (including that applicable to wildlife).

Assessments should be proportionate to the nature and scale of development proposed and the level of concern about air quality, and because of this are likely to be location-specific. The scope and content of supporting information are therefore best discussed and agreed between the local planning authority and applicant before it is commissioned. Air quality is a consideration in Environmental Impact Assessment, if one is required, and in a Habitats Regulation Appropriate Assessment.

The following could figure in assessments[32] and be usefully agreed at the outset:

- A description of baseline conditions and how these could change;
- Relevant air quality concerns;
- The assessment methods to be adopted and any requirements around verification of modelling air quality;
- Sensitive locations;
- The basis for assessing impact and determining the significance of an impact;
- Construction phase impact; and/or
- Acceptable mitigation measures.

[32] PPG Air Quality - Paragraph: 007 Reference ID: 32-007-20140306

24 How should heritage be taken into account in assessing backup generation and battery storage applications?

As the significance of a heritage asset derives not only from its physical presence, but also from its setting, careful consideration should be given to the impact of developments on such assets[33] . Depending on its scale, design and prominence, a backup generation or battery storage facility within the setting of a heritage asset might cause substantial harm to the significance of the asset.

[33] PPG Renewable and Low Carbon Energy Paragraph: 019 Reference ID: 5-019-20140306

25 How should the decommissioning of backup generation and battery storage facilities be considered?

Local planning authorities should consider using planning conditions to ensure that redundant facilities are removed when no longer in use, and land is restored to an appropriate use[34].

[34] PPG Renewable and Low Carbon Energy Paragraph: 024 Reference ID: 5-021-20140306

26 Who decides what weight to give to a material consideration?

The law makes a clear distinction between whether something is a material consideration and the weight which it is to be given. Whether a particular consideration is material will depend on the circumstances of the case and is ultimately a decision for the courts. Provided regard is given to all material considerations, it is for the decision maker to decide what weight is to be given to each of the material considerations in each case.

In addition to the interests of land-owners and the operators of the National Grid, there is a range of legitimate public interests reflected in the range of factors outlined in section 6 of this Guidance *What general planning considerations relate to backup generation and battery storage developments?* Local authorities should call for and give clear and detailed justification for the proportions of weight allocated to those interests.