Battery Energy Storage System Safety Concerns

7000Acres Response to:

Outline Design Principles Document reference: EN010131/APP/2.3
Work No. 2
Battery Safety Management Plan EN010131/APP/7.1

Appendix 9-C: Outline Drainage Strategy

Unplanned Atmospheric Emissions from Battery Energy Storage Systems (BESS) - EN010131/APP/3.3

Deadline 2 Submission – 8 August 2023

Executive Summary

There have been over 30 recorded serious thermal runaways in Battery Energy Storage Systems (BESS) worldwide. In 2020 a 20 MWh BESS in Liverpool took over 11 hours to contain and resulted in an explosion and release of toxic gasses.

The Applicant has failed to take account of the large volume of water required to contain a BESS thermal runaway. The on-site storage identified by the Applicant is insufficient. Additionally, the Applicant's Appendix 9-C: Outline Drainage Strategy appears to take no account of retaining the large volume and highly contaminated water post a thermal runaway incident.

The Applicant does not explain how the evidence of emissions from a 100 kWh battery (Tesla car sized battery) can be applied to the Gate Burton BESS.

The Applicant has failed to follow the module spacing guidance of 6m between modules, shown in the National Fire Chiefs Council guidance but has chosen to apply only 3m.

The Applicant's Unplanned Atmospheric Emissions from the Battery Energy Storage Systems document refers mainly to a BESS fire and not the more hazardous thermal runaway. As the Applicant has chosen to apply a Rochdale Envelope to this project, the document should use worst-case assumptions in their modelling.

Six recommendations have been made on how the safety of the Application should be improved.

Contents

1 Introduction

7000Acres represents a large number of local residents concerned about the impact of the Gate Burton NSIP and three other solar NSIPs in the locality. This document identifies concerns over the design and safety of the Battery Energy Storage System (BESS) proposed by the Applicant.

2 National Policy Statements

There are no National Policy Statements that address BESS. The Infrastructure Planning (Electricity Storage Facilities) Order 2020 is determined through the Town and Country Planning Act by LPAs.

3 The Hazard

Li-ion batteries can fail by "thermal runaway" where overheating in a single faulty cell can propagate to neighbours with energy releases popularly known as "battery fires". These are not "fires" at all, requiring no oxygen to propagate. They are uncontrollable except by extravagant water cooling. They evolve toxic gases such as Hydrogen Fluoride (HF) and highly inflammable gases including Hydrogen (H2), Methane (CH4), Ethylene (C2H4) and Carbon Monoxide (CO). These in turn may cause further explosions or fires upon ignition. The chemical energy then released can be up to 20 times the stored electrochemical energy (Fordham, 2021). In the case of the Liverpool BESS thermal runaway parts of the container were blown 23m. Li-ion batteries are tightly regulated in aviation, under the category of Dangerous Goods, as even thermal runaways in handheld devices have led to accidents and serious incidents. Two cargo ships have been destroyed in 2023 when thermal runaways in electric cars being transported have led to an uncontained fire.

4 BESS Incidents Worldwide

There have been over 30 recorded BESS fires and thermal runaways since 2017. For example, a 20 MWh Liverpool BESS fire in September 2020 resulted in fire, explosion and release of toxic gases (Merseyside Fire and Rescue Service, 2022). It was theoretically protected by a fire suppression system that failed to activate, but even if it had would have made little impact on the resulting fire and explosion. BESS are susceptible to "thermal runaway", the condition when an electro- chemical

cell increases its temperature through self-heating in an uncontrollable fashion and progresses when the cell's heat generation is at a higher rate than it can dissipate, potentially leading to off-gassing, fire, or explosion. Once water was applied to the Liverpool BESS, the resulting run-off contained Hydrofluoric Acid (HF), a highly toxic substance which can dissolve concrete and whose fumes can be fatal to life. The incident released a plume of toxic gas. Efforts to douse the thermal runaway was hampered by the lack of available water from the hydrants (Merseyside Fire and Rescue Service, 2022). In total it took 11 hours to fully extinguish the runaway.

5 Fighting a BESS Fire

As identified by Fordham, "extravagant" water cooling is required for extended periods of time to douse a BESS thermal runaway. To ensure sufficient water is available to fight a fire, the water should be stored on site as the small rural water mains cannot be relied on to provide the large volume of cooling water required.

To reduce the risk of an explosion, inflammable gas is best managed by venting, but that releases a toxic cloud.

A planning application for a 50MW BESS (Leeds Planning Application, 2023) was withdrawn by the Applicant when Yorkshire Fire and Rescue raised objections (Yorkshire Fire and Rescue, 2023). Yorkshire Fire Brigade made a number of important points in their letter to the Planning Authority:

- *"The risks of vapour cloud, thermal runaway and explosion are unfortunately very real and are becoming more common as we see an increase in the number of BESS installations rise.*
- *There is currently no definitive or 'preferred' way of putting out a lithium ion/lithium iron fire. There are in effect two main options, one being to let it burn, the other being to use significant amounts of water for a protracted period.*
- *In this case, should the let it burn approach be taken, it may create a chain reaction from one unit to the next. Therefore, even in this case, there is a high possibility that attending crews will require large amounts of water to protect the exposure risks and disperse the vapour cloud (to ensure it remains below the explosive thresholds). This is likely to continue for the period of multiple hours whilst the unit(s) burns itself out.*
- *Due to the large amount of water required, the Environment Agency will need to be consulted, as the water run-off will be contaminated.*

- *Guidance suggests that lithium ion/lithium iron batteries should be doused with significant amounts of water, and ideally subject to full submersion of the batteries for a period of 24 hours. Taking a two ground monitor attack for 24 hours, would apply 5,472,000 litres of water (to confirm that is approx. 5.5 million litres). The run off of these tactics would likely have a significant impact on the surrounding area, we recommend the Environment Agency consider this impact."*

Case studies of thermal runaways in BESS worldwide are reported (California Public Utilities Commission, 2023) in a US study. Attachment F to the report considers the Victoria Big Battery Project thermal runaway in July 2021. The project is a 300MW/450MWh transmission-sited project installed at the end of 2021. The site design includes 212 Tesla Megapacks, each about 1.5 MW. The thermal runaway was allowed to self-extinguish, which took 3 ½ days. Of note is:

"*How thermal runaway spread to an adjacent Megapack was of particular concern as the systems were evaluated under UL 9540A testing methods and their spacings were designed to mitigate inter-pack propagation. ESV required this issue to be addressed in Tesla's investigation. ESV also noted that, "Designers are also working to ensure that Megapacks are engineered to fully mitigate the risk of fire propagation from one unit to another under Victorian climatic conditions," suggesting that propagation to the second Megapack may have been aided by weather factors such as wind, ambient temperature, and/or humidity. An investigation conducted by Fisher Engineering, Inc. confirmed that untested wind speeds were a key contributing factor, reaching up to 36 miles per hour during the event compared to a maximum of 12 miles per hour under the UL 9540A testing environment. In an interview, ESV characterized this situation as a "near miss" when considering an event like this in the context of other times of the year with higher temperatures and stronger winds."*

Other post incident safety investigations (DNV GL, 2020) confirm that technical and safety testing of utility scale BESS is insufficient and lagging the technology.

Another serious incident reported was the Elkhorn Battery Energy Storage Facility (Moss Landing, California) in September 2022. The Elkhorn Battery Energy Storage Facility is a 182.5 MW/730 MWh transmission-sited project installed in August 2021. The facility is designed as an outdoor array of 256 Tesla Megapacks (Monterey County 2022c), similar to the Victorian Big Battery Project. In this case:

"On September 20, 2022 a fire was detected at about 1:30 a.m. and fire crews arrived shortly thereafter. Fire crews followed a pre-planned strategy, based on their training, to not attempt to extinguish the thermal runaway and to instead focus on protecting surrounding structures with water spray. The fire was extinguished in 5 hours by about 6:30 a.m., then the thermal runaway process continued and released gas (including hydrogen fluoride) into the surrounding community."

The Applicant's Outline Design Principles Document reference: EN010131/APP/2.3 Work No. 2 identifies that sufficient water will be stored for a minimum supply of 1,900 litres per minute for 2 hours, i.e. 228,000 litres. Evidence shows that 1,900 litres a minute for 2 hours is insufficient to contain a BESS thermal runaway. (Fordham, 2021).

"For example, in the recent Tesla car fire the BEV battery kept re-igniting, took 4 hours to bring under control and used 30,000 (US) gallons of water [113,562 litres]. *This was for a 100 kWh BEV [*battery electric vehicle*] battery, designed with inter-cell thermal isolation barriers."*

So, the volume of water proposed for the Gate Burton BESS is probably just sufficient for 2 Tesla car thermal runaways!

The BESS proposed for Gate Burton is approximately 10 times (although uncapped) the size of the Leeds application, where in the expert opinion of the Yorkshire Senior Protection Manager 5.5 million litres of water would be required (Yorkshire Fire and Rescue, 2023). During a thermal runaway, the surrounding area must be cooled to prevent the incident expanding. Therefore, the volume of water held on site must be proportional to the energy storage capacity of the BESS, not the physical volume of the BESS. This is another reason why the storage capacity of the BESS must be capped, in order to ensure that the water held onsite is sufficient for cooling a thermal runaway. Sufficient on-site water for containing a BESS thermal runaway should be secured in the DCO. In order for that to occur, the storage capacity of the BESS must be identified and capped. The Applicant's Battery Safety Management Plan (Document Reference: EN010131/APP/7.1) does discuss water supplies but lacks any detail on the volume required to contain a thermal runaway over a prolonged period of time.

The Applicant's Work No.2 appears to have no bund to retain contaminated fire water or collection tanks for contaminated water. Work No.2 (ii) states " transformers and associated bunding", which

appears to relate to bunding around the transformers and not the BESS as a whole. Even the release of 228,000 litres of contaminated water would have a long-term adverse impact on the environment if not retained by bunding and collection and treatment tanks. The Outline Battery Safety Management Plan references the Applicant's Appendix 9-C: Outline Drainage Strategy. However, that document does not discuss contaminated fire water containing Hydrofluoric Acid. Means to retain and treat fire water should be secured in the DCO.

6 Health and Safety Regulations

At present the Health and Safety Executive (HSE) has chosen to exempt itself from regulating BESS, choosing to define battery systems as "*articles*". A strong case has been made (Fordham, 2021) that the Control of Major Accident Hazards (COMAH) Regulations should be applied to BESS, as the quantities and types of dangerous substances released during a BESS thermal runaway fall under the aegis of COMAH. A House of Commons Private Member's Bill (Hansard, 2023) received its Second Reading, categorising battery storage facilities as hazardous, so that the Environment Agency, the Health and Safety Executive and the fire and rescue services would be statutory consultees when planning applications are considered.

As the design of the BESS has not been finalised, and the Applicant has applied a Rochdale Envelope to the scheme, a reasonable worst case assumption is that in the future the BESS will be subject to COMAH. Therefore, the HSE, Environment Agency and the Fire Service should be consulted. The BESS design principles should take account of COMAH and all associated HSE Regulations.

7 Comment on Applicant's Unplanned Atmospheric Emissions from Battery Energy Storage Systems (BESS) - EN010131/APP/3.3

7.1 Enclosure Separation

The Applicant's Report paragraph 1.2.2 assumes that BESS enclosures will be separated by 3m. The National Fire Chiefs Council recommends a separation distance of 6m (National Fire Chiefs Council, 2022). The spacing of the BESS enclosures is critical in preventing a chain reaction and 3m does not meet current guidance, resulting in an increased probability of a chain reaction between BESS

enclosures. In the Applicant's Outline Battery Safety Management Plan (Document Reference: EN010131/APP/7.1) they do not reference the National Fire Chiefs Council guidance.

7.2 Applicant's Terminology

The Applicant only uses the term "*thermal runaway*" once in the document text and once in definitions. They prefer to use the term "*fire*", which the evidence shows is not the main cause of major BESS incidents. Their terminology might be due to a lack of comprehension of the issues, or to downplay the foreseeable risk from a thermal runaway.

7.3 Emissions

In paragraph 2.1.3 the Applicant uses evidence from the emissions of a 100 kWh battery fire (Tesla car sized battery) and states that the emissions from that case can be applied to the Gate Burton BESS, due to its modular nature. However, evidence from a 100kWh battery does not relate to the Applicant's Appendix 2-A: BESS and Substation Description, where 1.2.4 states that:

"Proposed arrangement uses LFP 280Ah cell type in a 416S10P configuration to reach a total battery capacity of 3,727 kWh per unit."

It is not clear how a test using a 100kWh battery in the outdoors can be directly applied to a 3,727 kWh BESS enclosure.

The Outline Battery Safety Management Plan 3.2.14 recognises gas venting as a control measure to prevent explosions. This is a reasonable approach to take. However, the Unplanned Atmospheric Emissions from Battery Energy Storage Systems document downplays the amounts and types of emissions. Paragraph 3.2.1 states:

"As the exact emissions from the BESS cannot be meaningfully estimated at present, the modelling is based on emissions that have been modelled as a volume source, at a nominal emission rate of 1 µg/m3 /s."

As the Applicant has chosen to adopt a Rochdale Envelope, their modelling should be based on a worst-case assumption.

Evidence demonstrates that lethal concentrations of emissions are produced in BESS thermal runaways (Larsson F, 2017).

8 BESS Layout

Apart from the battery enclosures being spaced 3m apart, rather than the recommended 6m, it is noted that there is only one access road to the BESS control room (ENO10131/APP/3.3 Annex A). The road is shown to be passing adjacent to a line of battery enclosures. If a thermal runaway occurred in one of those enclosures, access to the control room (or escape from the site) would be inhibited.

9 Recommendations

The following is recommended.

- The Applicant applies evidence from BESS thermal runaways to identify the large volume of cooling water required. The infrastructure, both storage and external sources, to supply the large volume of water required should be secured in the DCO.
- Means to retain and treat the large volume of water required to contain a thermal runaway should be secured in the DCO. This could include the use of bunding and collection tanks.
- The spacing between BESS enclosures should comply with the 6m spacing (or larger if industry guidance is updated) recommended by the National Fire Chiefs Council. The distance of 6m, or larger if industry guidance is updated, should be secured in the DCO.
- The Applicant's Unplanned Atmospheric Emissions from Battery Energy Storage Systems (BESS) - EN010131/APP/3.3 document should be updated to include consideration of a BESS thermal runaway as the primary hazard and not a fire. The Applicant's emission modelling should take account of the actual energy storage capacity of their system and not a small 100 kWh battery.
- It is recommended the Applicant applies the Control of Major Accident Hazards (COMAH) Regulations to the design and operation of the BESS.
- The requirement for two access routes to the BESS control room should be investigated.

10 References

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