Battery Energy Storage System Safety Concerns

7000Acres Response to:

Outline Battery Storage Safety Management Plan - PINS reference: EN010133

Appendix 17.4 BESS Fire Technical Note

Deadline 1 Submission – October 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 Outline Battery Storage Safety Management Plan does not identify and mitigate all the hazards associated with a BESS thermal runaway. Instead it primarily refers to BESS fires, which is a different chemical process.

The Outline Battery Storage Safety Management Plan and Appendix 17.4 do not identify the toxic emissions that would be released in the event of a thermal runaway.

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 for a major incident. The volume of water quoted is only sufficient to douse a thermal runaway in two Tesla car sized batteries.

The National Fire Chiefs Council (NFCC) recommends a separation distance of 6m (National Fire Chiefs Council, 2022) between enclosures. ED Appendix 4.1 Engineering Drawings and Sections appear to show the battery containers closely packed. The spacing of the BESS enclosures is critical in preventing a chain reaction. The current design is unclear if it meets the NTCC recommendations.

Recommendations have been made on how the safety of the BESS should be improved.

Contents

1 Introduction

7000Acres represents a large number of local residents concerned about the impact of the Cottam industrial solar 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 thermal runaway 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 activated it would have made little impact on the resulting runaway 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 were 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 Thermal Runaway

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 thermal runaway, the water should be stored on site, as in the case of Cottam, 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."

5.1 Cottam Onsite Water

The Applicant's Outline Battery Storage Safety Management Plan, paragraph 5.3 shows that "no less than 228,000 litres of water will be stored onsite. This is considerably less than the 5.5 million litres considered necessary by the Yorkshire Fire Brigade for a 50MW BESS.

“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 Cottam BESS is probably just sufficient for 2 Tesla car thermal runaways!

The BESS proposed for Cottam 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 just 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. The Applicant’s Battery Safety Management Plan does briefly use the term thermal runaway in paragraph 2.3.2 but then concentrated on firefighting, which is a different chemical process.

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 Energy Bill 3rd Reading September 2023

The Energy Bill 3rd reading on 5 September 2023 confirmed that BESS will require an Industrial Installation Permit. The BESS design should reflect this requirement.

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

8.1 Enclosure Separation

The draft DCO Work No. 2 (b) and Work No. 3 (b) identify the battery enclosure as being "either one container or multiple containers joined to each other, mounted on a reinforced concrete foundation slab or concrete piling;".

The National Fire Chiefs Council (NFCC) recommends a separation distance of 6m (National Fire Chiefs Council, 2022) between enclosures. ED Appendix 4.1 Engineering Drawings and Sections appear to show the battery containers closely packed. The spacing of the BESS enclosures is critical in preventing a chain reaction. The current design is unclear if it meets the NTCC recommendations.

In the Applicant's Outline Battery Safety Management Plan they do not reference the National Fire Chiefs Council guidance, which is a serious omission.

8.2 Applicant's Terminology

The Applicant only uses the term "*thermal runaway*" once in the document text and once in references. They prefer to use the term "*fire*", which the evidence shows is

not the main cause of major BESS incidents, or the major hazard. Their terminology might be due to a lack of comprehension of the issues, or to downplay the foreseeable risk from a thermal runaway.

8.3 Emissions

In Appendix 17.4: BESS Fire Technical Note, the Applicant does not take due regard for the risks associated with a BESS of the size proposed. In particular, their dismissive statement in 4 (2) is not supported by numerous cases worldwide, including the 20MW example in Liverpool:

“A BESS fire would only produce a short-term impact in terms of surrounding environment;”

Evidence demonstrates that lethal concentrations of emissions are produced in BESS thermal runaways (Larsson F, 2017). Therefore, the Applicant’s assessment must take account of these real-world examples.

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.
- 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 Appendix 17.4 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 foreseeable scenarios, including thermal runaways in single and multiple containers.
- It is recommended the Applicant applies the Control of Major Accident Hazards (COMAH) Regulations to the design and operation of the BESS.
- The Energy Bill 3rd reading on 5 September 2023 confirmed that BESS will require an Industrial Installation Permit. The BESS design should reflect this requirement.

10 References

Leeds Planning Application, 2023. 23/00450/FU | Erection of Battery Energy Storage Facility and associated works. | Land At Westfield Road Carlton Leeds WF3 3TW. [Online]
Available at: https://publicaccess.leeds.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=ROZA71JBLAA00&fbclid=IwAR06qImlV_TnF9ZdJNG85LXXPhkOR_xGP130EsGRXGABE1d0b5NstZl2nYY
[Accessed 25 Jul 2023].

California Public Utilities Commission, 2023. *Energy Storage Procurement Study.* [Online]
Available at: file:///D:/Solar%20Farms/BESS/2023-05-31_lumen_energy-storage-procurement-study-report.pdf
[Accessed 26 July 2023].

DNV GL, 2020. *McMicken Battery Energy Storage System Event Technical Analysis and Recommendations. Arizona Public Services.* [Online]
Available at: https://www.aps.com/-/media/APS/APSCOM-PDFs/About/Our-Company/Newsroom/McMickenFinalTechnicalReport.ashx?la=en&hash=50335FB5098D9858BFD276C40FA54FCE
[Accessed 27 July 2023].

Fordham, E. A. W. M. D., 2021. Safety of Grid Scale Lithium-Ion Battery Energy Storage Systems, s.l.: University of Oxford.

Hansard, 2023. *Lithium-Ion Battery Storage (Fire Safety and Environmental Permits).* [Online]
Available at: https://bills.parliament.uk/bills/3336
[Accessed 27 July 2023].

Larsson F, A. P. B. P. M., 2017. Toxic fluoride gas emissions from lithium-ion battery fires., s.l.: Research Gate.

Merseyside Fire and Rescue Service, 2022. MFRA Fire Investigation Report 132-20 Incident Number 018965 Orsted Bess, Carnegie Road, s.l.: Merseyside Fire and Rescue Service.

National Fire Chiefs Council, 2022. *Grid Scale Battery Energy Storage System planning – Guidance for FRS.* [Online]
Available at: https://www.ukfrs.com/sites/default/files/2023-04/Grid%20Scale%20Battery%20Energy%20Storage%20System%20planning%20Guidance%20for%20FRS.pdf
[Accessed 28 Jul 2023].

Yorkshire Fire and Rescue, 2023. *Re: Planning application 23/00450/FU at Westfield Road Leeds.* [Online]
Available at: https://publicaccess.leeds.gov.uk/online-applications/files/CB2CD9E01F9A54FC4EA68467BD12688A/pdf/23_00450_FU-WEST_YORKSHIRE_FIRE_AND_RESCUE-4685662.pdf
[Accessed 25 Jul 2023].