RWE

Tween Bridge Solar Farm

7.4 Outline Battery Safety Management Plan

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

APFP Regulation 5(2)(q)

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1 Introduction

1.1.1. The Outline Battery Safety Management Plan (Outline BSMP) has been prepared on behalf of RWE Renewables UK Solar and Storage Limited (the Applicant) in relation to a proposed solar PV electricity generation facility and associated storage and infrastructure (the Scheme), located approximately 10km to the northeast of Doncaster and 14km to the west of Scunthorpe.

1.1.2. This Outline BSMP has been developed to outline the potential risks presented by the Battery Energy Storage System (BESS) and its operation / maintenance. This Outline BSMP provides a robust safety strategy, supported by evidence to support full commissioning. The final design and equipment detail is yet to be fully defined and is based on the intended site layout plan and associated details currently available and provided by the Applicant at this juncture. This plan will be updated, as applicable, when additional information becomes available.

2 Background

2.1.1. ARC have conducted a generic Hazard Identification of the Scheme based on the information provided and cognisant of similar sites of this size and complexity. This analysis has provided the necessary foundation for the identification of hazards and the development of a preliminary Hazard Log (HL) **[Ref. 5 and Appendix B]**, which contains:

1. Consolidated list of hazards and hazard descriptions.
2. Associated causes associated with the hazards with linkage to the relevant hazard(s).
3. Design controls implemented to ameliorate / mitigate the causes.
4. Identification of the potential outcomes or consequences from the hazards.
5. Identification of any mitigation that will further ameliorate the probability of hazard or consequence frequencies.
6. Identification and linkage to mitigating factors that could ameliorate the severity or frequency of occurrence of the outcomes (consequences) and be contained in the Emergency Response Plan (ERP).

3 Aim

3.1.1. The overall safety aim is that the levels of risk of accident, death or injury to personnel or other parties, and risks to the environment due to the construction, operation and decommissioning are to be broadly acceptable or tolerable and As Low As Reasonably Practicable (ALARP) in accordance with the Health and Safety Executive (HSE) Reducing Risk, Protecting People (R2P2) **[Ref. 1].** For the Outline BSMP specifically, the document presents an initial appraisal of the safety risks including:

- An overview of the main characteristics and the associated design guidelines and legislative and compliance requirements.
- The identification of safety risks (including consideration to environmental impact and risk).

3.1.2. The identification of inherent safety features and additional safety recommendations (e.g. emergency response planning) to be secured through the Outline BSMP and secured by Requirement in the Development Consent Order (DCO).

- Determination of the identified safety risks and their significance.

4 Scope

4.1.1. The scope of the Outline BSMP for the Scheme covers the physical and functional aspects of the BESS equipment. The safety management covers design, validation, and operation. It also includes any remote monitoring and control, maintenance, storage / transportation, and calibration.

4.1.2. **Appendix A** of this Outline BSMP contains frequently asked questions and is provided for assurance and a greater awareness of BESS and Lithium-Ion technologies in general.

5 Safety Requirements

5.1. High Level Safety Objective

5.1.1. The primary safety objective is to comply with applicable legal requirements and relevant good practice for large / grid scale BESS. Compliance with these requirements will be used as part of the safety evidence, to demonstrate that '***the risk posed to individuals, the environment and property has been reduced to a level that is ALARP'***. The Hazard Log (HL) produced for the Scheme is to be used to ensure that all direct and indirect safety requirements are met, and the system remains safety compliant through the life of the installation.

5.2. Legislation and Compliance Requirements

5.2.1. Legislative compliance, specifically safety, will be demonstrated by compliance with the United Kingdom (UK) Health and Safety at Work Act (HSAWA) 1974 and the appropriate underlying legislation that is enacted through the HSAWA. The following legislation and industry guidance has been determined as applicable to this installation:

1. Legislation (England and Wales):

    a. Health and Safety at Work etc. Act 1974 – UKSI1974/0037.
    b. Control of Noise at Work Regulations 2005 – UKSI 2005/1643.
    c. Control of Substances Hazardous to Health Regulations 2002 – UKSI 2002/2677.
    d. Control of Vibration at Work Regulations 2005 – UKSI2005/1093.
    e. Electrical Equipment (Safety) Regulations SI 1994/3260.
    f. Electromagnetic Compatibility Regulations SI 2006/3418.
    g. Fire Safety (Employees' Capabilities) (England) Regulations SI 2010/471.
    h. Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
    i. Management of Health and Safety at Work Regulations 1999 – UKSI1999/3242.

j. Manual Handling Operations Regulations 1992 – UKSI1992/2793.
k. Personal Protective Equipment Regulations 2002 – UKSI2002/1144.
l. Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
m. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
n. Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.
o. Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.
p. Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations – 1907/2006.
q. Restriction of Hazardous Substances Directive – 2011/65/EU.
r. Persistent Organic Pollutants Regulations SI 2007/310
s. Dangerous Substances and Explosive Substances Regulations 2002.
t. Fire Safety Order 2023.
u. Fire Safety Act 2021.

2. Industry Guidance and Best Practice Documents:
   a. NFCC Grid Scale BESS planning – Guidance for FRS **[Ref. 2].**
   b. Department for Energy Security and Net Zero – Health and Safety Guidance for Electrical Energy Storage Systems **[Ref. 3].**
   c. National Fire Protection Association (NFPA) 885 – Standard for the Installation of Stationary Energy Storage Systems **[Ref. 4].**
   d. Underwriters Laboratory (UL)1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications **[Ref. 6].**
   e. UL9540A – BESS Test Methods **[Ref. 7].**
   f. UN38.3 – Standard Requirements for Lithium-Ion Battery Production **[Ref. 8].**
   g. FM Global Property Loss Datasheet 5-33 – Lithium-Ion BESS **[Ref. 9].**

5.3. National Fire Chiefs Council (NFCC) Recommendations

5.3.1. The NFCC Report Grid Scale Battery Energy Storage System Planning – Guidance for FRS **[Ref 2]** details the FRS recommendations for BESS installations. These have been distilled at **Table 5-1** cognisant of the indicative Scheme layout. At the time of submission of the DCO application there was no specific UK regulation regarding fire safety of BESS facilities, however the Department for Energy Security and Net Zero has produced the Health and Safety Guidance for Electrical Energy Storage Systems **[Ref 3]** report. For the BESS units, the NFPA 855 **[Ref 4]** code is the internationally recognised most relevant document and this will be considered in the procurement of the BESS units and ancillary equipment.

5.4. Fire and Rescue Service (FRS) Consultation

5.4.1. The Applicant acknowledges the important role of the FRS in finalising the BSMP for the Scheme and engage with the FRS throughout and beyond the examination process.

Table 1-1 NFCC Recommendations Cross-Referenced to the Scheme

No.	NFCC Recommendation	Site Status	Options / Comments
1	Access – Minimum of 2 separate access points to the site	**Compliant**	There are two points of access into each of the BESS compounds. Access to the BESS compounds will be afforded from differing points of the compass to avoid obstruction or obscuration by smoke emanating from a fire.
2	Roads/hard standing capable of accommodating fire service vehicles in all weather conditions. As such, there should be no extremes of grade.	**Compliant**	The site service road (that will allow access around the site and BESS compounds) will be a hard compacted surface a minimum of 4m wide. There is no extreme of gradient at the site.

			The site access road is suitable for HGV traffic. All internal services roads have been designed with a 10m radii and are compatible for a DB32 Fire Appliance.
3	A perimeter road or roads with passing places suitable for fire service vehicles	**Compliant**	There is a perimeter road in the BESS compounds allowing FRS vehicles to manoeuvre and relocate as necessary. Section 13.4 of Approved Document B5 **[Ref 10]** states that FRS vehicles should not have to reverse more that 20m from the end of an access road – given the provision of a circular perimeter service road the requirement for FRS vehicles to reverse is minimised to situations in which use of the perimeter service road is not possible, and in these circumstances, reversing more than 20m is not a requirement. Section 13.4 references Table 13.1 of the Approved Document B5 contains typical FRS vehicle access route specifications – the site meets these specifications.
4	Road networks on sites must enable unobstructed access to all areas of the facility	**Compliant**	Access to all BESS units is afforded from the network of services roads leading to the BESS compounds. The site is designed such that all routes have the capacity to allow for a Fire Tender (based on DB32 Fire Appliance).
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	**Compliant**	There is a perimeter road in each of the BESS compounds that are intersected with service roads allowing FRS vehicles to manoeuvre and relocate as necessary.

6	Distance from BESS units to occupied buildings and site boundaries. Initial min distance of 25m	**Compliant**	There are no buildings or occupied residences within 25m of the BESS units at any of the BESS compounds.
7	Access between BESS unit – minimum of 6 metres suggested. If reducing distances, a clear, evidence-based, case for the reduction should be shown.	**Complaint with caveat**	The suggested 6.0m separation is based on a 2017 Issue of the FM Global Loss and Prevention Datasheet 5-33 (footnote 9 in the NFCC Guidance refers). This Datasheet was revised in July 2023 and again in January 2024, it now details the following: 1. For containerized LIB-ESS comprised of Lithium iron phosphate (LFP) cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors, or deflagration vents. 2. For containerized LIB-ESS comprised of Lithium nickel manganese cobalt (NMC) cells where wall construction is unknown or has an ASTM E119 rating less than 1 hour, provide aisle separation of at least 13 ft (4.0 m) on sides that contain access panels, doors, or deflagration vents. For containerized NMC LIB-ESS where wall construction is documented as having at least a 1-hour rating in accordance with ASTM E119, aisle separation of at least 8 ft (2.4 m) is acceptable. Additionally, the Department for Energy Security and Net Zero published in March 2024 their Health and Safety Guidance for BESS in which it is stated that the separation distance, for sides with access panel, doors or deflagration panels should be a minimum of 1.5m for LFP.

			Following this revision to the Datasheet, the BESS containers on-site will be compliant with the minimum distances and conformance to ASTM E119 1-hour fire rating will be confirmed on the down select of the BESS units to be procured. Current NFCC guidance recommends 6m, unless deemed acceptable to be closer based on manufacturers UL testing / fire rating qualification. The BESS units on the site will be a minimum of 4m apart. A minimum of 4m apart is deemed acceptable based on batteries used as part of the Scheme containing LFP cells.
8	Site Conditions – areas within 10m of BESS Units should be cleared of combustible vegetation	**Compliant**	The BESS units will sit on concrete slabs or supporting feet. Internal access tracks will comprise crushed stone and the access road for the abnormal load will be asphalt. Within fence line and between BESS containers units the surface is laid over to gravel. All areas within 10m of the BESS are clear of vegetation.
9	Water Supplies	**Compliant**	Water storage tanks form an element of the site layout and design, with a minimum volume as recommended in NFCC Guidance. An emergency water supply of 228m^3 will be included as part of the Scheme.
10	Signage	**Compliant**	Signage to be positioned at the entrance to the site to be secured by planning requirement.

11	Emergency Plans	**Compliant at this juncture**	The Detailed BSMP will roll up the ERP outlining who and how the FRS will be alerted, facility description, number of operatives, detailed site plan etc.
12	Environmental Impacts	**Compliant at this juncture**	The Applicant will consult with the Environment Agency and develop a drainage strategy such that retention of firefighting water runoff is afforded and cannot be released to the wider environment prior to being tested for any contamination. The detailed drainage strategy will be development post consent.
13	System design, construction, testing and decommissioning	**Compliant at this juncture**	Several of the elements under this aspect of the NFCC Guidance are contained in this Outline BSMP, however details of the construction, testing and decommissioning will only be available in later stages of the programme and be contained in the Detailed BSMP, developed post consent.
14	Deflagration Prevention and venting	**Compliant at this juncture**	Elements of this requirement are contained in this Outline BSMP, but the actual technique to be adopted will not be apparent up to the point where the decision is made as to what BESS is being used. It is acknowledged that deflagration venting is possibly most effective when fitted to the roof of the BESS units, as such deflecting blast upwards and away from FRS personnel, this will form an element of the procurement strategy for the BESS units. This will be included as part of the Detailed BSMP.

6 Implemented Safety Strategy

6.1. Introduction

6.1.1. A safety strategy is required to support the design, development, and installation providing the necessary assurance that the safety of the Scheme is at an acceptable level for its role in its intended operating environment. The safety strategy employed provides a logically stated and convincingly demonstrated reason that all safety requirements can be met. The overarching safety claim has the following elements:

1. A Technical Risk Element:
    a. An element that provides the argument that articulates the technical aspects of the design which serve to control the identified hazards, through the application of design control measures.
    b. It will identify system hazards and the causes that can contribute to these hazards.
    c. It will specify the risk analysis conducted, and risk reduction requirements implemented.
    d. It will provide the evidence to support any risk reduction claimed.
2. A Confidence (Assurance) Element:
    a. This part seeks to demonstrate that the processes used to design, implement, and verify the product is appropriate to its contribution to overall system risk – this being specific to the development of software and provide the requisite audit trail to validate any claimed safety integrity.
    b. The development of the HL and identification of imbedded physical attributes that support risk reduction.
    c. The cross-referencing of these physical attributes (and any supporting qualification data / certification) to the relevant cause(s), providing the evidence of validity of the control measure claimed.

6.2. Safety Criteria

6.2.1. The consequence for each potential occurrence involving the BESS shall be categorised according to classification which accounts for both frequency of occurrence and severity of outcome (risk) as defined in the following:

1. The consequence definitions are defined in **Table 6-1.**
2. The frequency definitions and bands used are detailed in **Table 6-2**.
3. The Risk Class Matrix is shown in **Table 6-3**.
4. The Risk Class definitions are given in **Table 6-4**.

6.2.2. The safety criteria used in this document have been amended and adapted from those defined within the US Department of Defence Mil-Spec 882E **[Ref. 11]** and the Ministry of Defence UK Defence Standard 00-56 **[Ref. 12],** using safety target and limit benchmarks from the HSE R2P2 **[Ref. 02].** This assessment criteria will be used to ascertain the residual risk posed by prospective suppliers BESS.

Table 6-1 – Consequence Definitions

Risk Category	BESS Description			
	Asset	Capability	Environmental	Human
Catastrophic	Complete loss of BESS and surrounding third party assets	Capability lost	Irreversible and significant environmental impact	Fatality or permanent life changing disability
Critical	Complete loss of BESS	Capability seriously affected	Reversible but significant environmental impact (long-term)	Permanent partial disability, injuries, or occupational illness
Marginal	Partial loss of BESS Not repairable – components retrievable	Capability less seriously affected	Reversible moderate (decontamination possible) environmental impact	Less serious personal injury, illness – A&E / GP assistance required

Negligible	Minor BESS damage – repairable	Capability impaired but possible	Minimal (self-recoverable) environmental impact	Negligible injury or illness. Treatable without recourse to A&E / GP

Table 6-2 – Frequency Definitions

Accident Frequency	Occurrence Rate		Qualitative Definition
	Percentage Probability Range Per Annum	Frequency Per Annum (8760 hrs.) (fph)	
Frequent	10% < P	1.0E-03 or greater	Likely to occur often (repeatedly) in the 40-year operating period.
Probable	1% < P ≤ 10%	1.0E-04 to 1.0E-05	Will occur several times in the lifetime of the Scheme
Occasional	0.1% < P ≤ 1%	1.0E-05 to 1.0E-06	Likely to occur sometime in the lifetime of the Scheme
Remote	0.01% < P ≤ 0.1%	1.0E-06 to 1.0E-07	Unlikely, but possible to occur in the lifetime of the Scheme
Improbable	P ≤ 0.01%	1.0E-07 or less	So unlikely, it can be assumed occurrence may not be experienced in the lifetime of the Scheme
Eliminated	Incredible (physically impossible) of occurrence within the life of an item. This category is to be used when potential hazards are identified and later eliminated. (Nominally the occurrence rate has been assessed as <1.0E-08)		

Table 6-3 – Risk Class Matrix

	Severity			
	Catastrophic	Critical	Marginal	Negligible
Frequency	1	2	3	4
Frequent	A	A	A	B
Probable	A	A	B	C
Occasional	A	B	C	D
Remote	B	C	D	D
Improbable	C	D	D	D
Eliminated	E	E	E	E

Table 6-4 – Risk Class Definitions

Risk Class	Risk Class Definition
(A) *Intolerable*	Intolerable: Risks must be reduced.
(B) *Undesirable*	Undesirable: Risks should be reduced. ALARP must be demonstrated.
(C) *Limited Tolerable*	Limited Tolerable: Risks can be reduced. ALARP must be demonstrated.

(D) *Tolerable*	Tolerable: No action required. ALARP must be demonstrated.
(E) *No Risk*	No action required.

6.3. Safety Integrity Level Requirements

6.3.1. The BESS supplier will demonstrate with evidence that a layered protection approach from cell to container to remote monitoring is provided. The envisaged safety control measures and design features within the BESS are detailed in the HL, albeit at this stage generically, tabulated against the appropriate cause that they control. The HL will be revised and supplemented with actual evidence once the BESS units to be employed have been selected.

6.4. Modular Safety Assurance

6.4.1. The construct of the safety assurance in the design of a BESS unit is vested in a ground up approach from cell to battery to rack to fully built BESS, comprising:

1. UN38.3 Testing **[Ref 8]** - UN38.3 is the United Nations standard that lithium batteries must meet if they are certified as safe to transport. Whilst lithium batteries have safeguards built-in to withstand the environmental and physical hazards they may encounter during transportation, UN38.3 acts as a 'rubber stamp' and shows that batteries are safe to move from one location to another.
2. UL1973 (the Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications) **[Ref 6].** This is the safety standard for energy storage systems. It specifies detailed requirements that manufacturers of BESS must meet to qualify for safety certification. UL1973 certification ensures that the BESS system is safe and reliable for use in real-world conditions. Compliance with UL1973 is necessary to ensure the safety, reliability, and proper functioning of the battery components of a BESS system.

3. UL9540A (BESS Test Method) **[Ref 7]** is the Standard for Safety Test Method for Evaluating Thermal Runaway (TR) Fire Propagation in Battery Energy Storage Systems. There are four stages in the UL9540A test method:
    a. Cell Level Test: Assessing whether a cell can exhibit TR. It also checks its characteristics and flammability.
    b. Module (Battery) Level Test: The objective is to determine if TR propagates with the module. In addition, it establishes the heat release and gas composition.
    c. Rack Level Test: Assessment of the whole unit to establish initially how quickly fire spreads and secondly for the heat and gas release rates and relationship with other emerging hazards.
    d. Installation Level Test: For completeness installation testing is conducted. This is an optional test, but the objective is to determine how effective the product fire protection is.

6.5. Certification

6.5.1. The BESS units to be procured will be designed to meet relevant industry standards and legal requirements which contain specific safety requirements, Section 5.2 refers.

7 Safety Management

7.1. Site Access

7.1.1. There are four individual BESS compounds within the Order Limits, two in the Land Parcel A, one in the Land Parcel B and one in Land Parcel E. The locations of the BESS compounds can be seen in **ES Figure 2.2a and Figure 2.2b Indicative Operational Layout Plan [Document Reference 6.4.2.2].** The access routes to the BESS compounds will be provided in the ERP and they will be signposted. The ERP will be developed in consultation with the FRS and circulated to the FRS prior to site energisation /commissioning.

7.1.2. The primary access track to the BESS compounds will be a minimum of 4m in width, which loops around the site providing access to all BESS compounds. The primary access track is constructed using a crushed / compacted stone and capable of withstanding 20 tonne payloads. A laminated site layout will form part of the ERP, contained in the 'GERDA' style emergency services box at the entrance to the individual sites.

7.2. Hazardous Material

7.2.1. Any hazardous materials held and stored at the BESS facility will be fully justified and will be detailed in the ERP for the Scheme, detailing the location, description, precautions to be adopted and quantity.

7.3. Emergency Response Plan

7.3.1. As part of the detailed BSMP, an ERP will be developed, in conjunction with the FRS, that outlines how the operator will respond to incident and accident scenarios at the site. This includes the interfaces with external first responder organisations. The ERP is iterative in approach and been developed in parallel with technical safety requirements. This ensures that the Scheme and ERP are properly integrated, and that appropriate information can be provided to first responders to include in their planning activities.

7.4. BESS Hazard Log

7.4.1. The BESS HL **[Ref. 5 and Appendix B]** is managed in the form of an excel spreadsheet and is currently generic, detailing the risks most commonly present in a BESS utilising LFP technology. The benefit of using a HL tool is that it provides an auditable record of all decisions made for the assessment of risk for the BESS Project which will be managed through life on a central repository.

7.5. Safety Management Structure

7.5.1. The BESS safety management structure has yet to be fully defined and will be subject to the safety management strategies and procedures that are in place with the successful supplier and installer of the BESS. At this juncture the minimum requirement is for a formal top-down management structure that has the authority and responsibility to ensure safety management is at the forefront of products, procedures, and services.

7.6. Overarching Policy

7.6.1. All BESS development activities shall consider safety and environment as an integrated part of the BESS life cycle and shall be assessed from a safety viewpoint. This safety- focused approach shall span all programme phases. This encourages and develops a safety and environmental culture that spans all levels of the organisation and encompasses all aspects of its working practices. It views safety as a holistic quantity that is owned by the organisation rather than something to be passed by function. This safety culture is supported by training to develop and maintain expertise and awareness for good practice, knowledge of emerging standards and in the understanding of legislation.

7.7. Management Plan

7.7.1. This Outline BSMP incorporates the management activities relevant to safety. This includes the planning for quality, engineering development and configuration management. These are important disciplines that underpin arguments for safety and environment. Further details will be captured within the Detailed BSMP secured by DCO Requirement.

7.8. Staff Competence

7.8.1. The BESS safety and environmental management programme shall ensure that all personnel who have any responsibility for a safety or environmental activity are competent to discharge those responsibilities or are adequately supervised/approved by someone with appropriate competencies.

8 Conclusions and Recommendations

8.1. Results

8.1.1. The HL **[Ref. 5 and Appendix B]** is the tool used to monitor and manage hazards, causes and controls associated with this site. The HL is used to tabulate the level of residual risk posed by the installation. A Site Safety Audit will determine that the control measures identified are present.

8.2. Conclusions

8.2.1. It is concluded that, as far as reasonably practicable and for the Scheme, that currently foreseeable hazards associated with the equipment have been identified, and these are contained in the HL **[Ref. 5 and Appendix B].**

8.2.2. This Outline BSMP has been developed using existing knowledge of renewable and BESS capability. Installation of the BESS in accordance with Original Equipment Manufacturer (OEM) instructions followed by a period of qualification and testing will provide the supporting evidence. This will also allow for the consolidation of control evidence and enhanced development of mitigation to further reduce the level of risk posed.

8.3. Recommendations

8.3.1. It is recommended that the safety management as defined in this Outline BSMP, is adhered to throughout the Scheme's operational period to ensure that safety management is developed as the programme progresses and remains valid.

8.3.2. Given the current understanding of the Scheme, systems to be employed, and control measures to be implemented it has been determined that residual risk to the public is Class D, **Appendix B** refers. The Class C hazards all relate to maintainer hazards and represent the worst-case scenario. Periodic review of the HL will identify further opportunities to improve these hazards.

8.3.3. Adherence to the recommendations and safety principles through detailed design, installation and operation will be demonstrated through the Operational Safety Audit Report to be shared for information prior to commercial operation of the site.

8.3.4. Given the above discourse and pending the output of the Site Safety Audit, it will be possible to declare ALARP, cognisant of continued implementation of the proposed framework for safety management presented in this Outline BSMP and to be detailed further in the Detailed BSMP post-consent.

9 References

1. Reducing Risk, Protecting People (HSE Publications)

2. NFCC Grid Scale BESS Planning – Guidance for FRS dated Nov 2022.

3. Department for Energy Security and Net Zero – Health and Safety Guidance for Electrical Energy Storage Systems.

4. NFPA 855 Standard for the Installation of Stationary Energy Storage Systems dated Aug 2023.

5. Tween Bridge Solar Farm BESS Hazard Log - ARC-1302-011-R2, Draft A, dated June 2025.

6. UL1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications.

7. UL9540A – BESS Test Methods.

8. UN38.3 Standard Requirements for Lithium Battery Production - 4th Revision.

9. Factory Mutual Property Loss Prevention Datasheet 5-33 dated Jan 2024 (Interim Revision).

10. The Buildings Regulations 2010, Approved Document B (Fire Safety) – Volume 2

11. MIL-STD-882E, Department of Defence Standard Practice: Safety Systems Dated May 2012.

12. Defence Standard 00-56, Ministry of Defence: Safety Management Requirements for Defence Systems July 2012.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
1	How does a BESS work?	A BESS employs technology to temporarily store electrical energy, very much in the same manner as a mobile phone or laptop battery, but on a much bigger scale. The energy can be stored and released when demand on the National Grid is high and assists in balancing out variations in demand. BESS can be connected to a Photo-voltaic Solar Farm and store energy throughout the day for release in the evening and in this mode of operation is a green renewable technology. An alternative use for BESS is to store electrical energy generated by energy suppliers during period of low demand and releasing in periods of high demand, thus balancing out changes in supply and demand on the National Grid.
2	How safe is a BESS?	The Department for Energy Security and Net Zero promulgates on a regular basis the Renewable Energy Planning Database (REPD). From the quarterly extract (dated Apr 2025) the data has been filtered for BESS installations in the UK and the following salient points are deduced1:

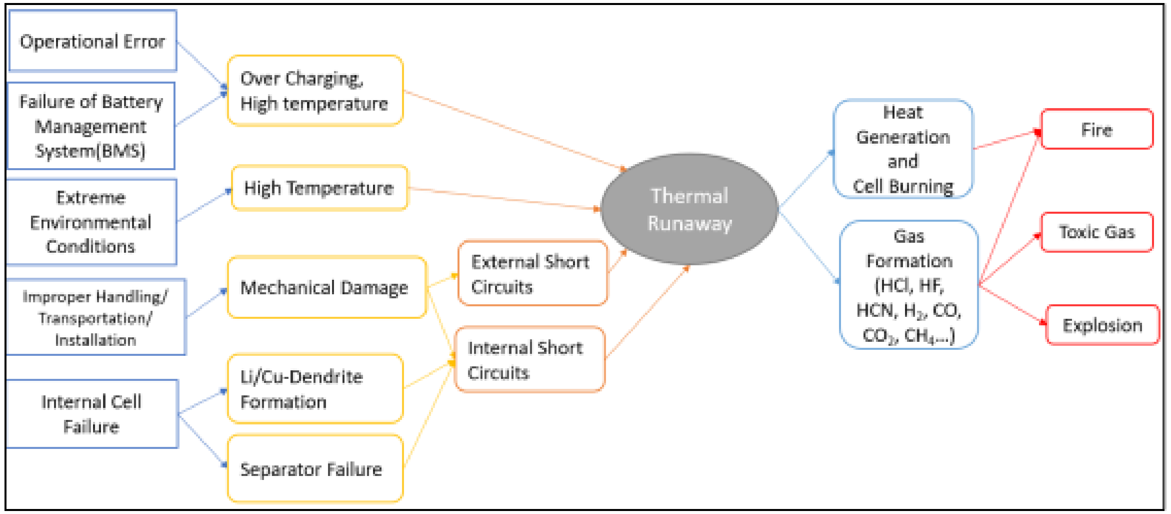
[1] The REPD tracks the progress of energy projects, including BESSs, through the planning system. Until 2021, the REPD only recorded projects with a capacity over 1 MW). Since 2021, it also includes projects with a capacity over 150 kilowatts (kW). Therefore, BESSs that were going through the planning system before 2021 may not have been captured in the REPD – Source: Commons Library Research Briefing, 19 April 2024 – BESS.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
		As of Apr 2025, there are approx. 132 operational BESS sites listed in the REPD[2], 8 having been decommissioned, 96 are under construction and a further 834 have planning consent and are awaiting construction. The current operational BESS provides the UK with an estimated 2.6GWelec storage and those awaiting construction will provide an additional 5.4GWelec of storage. Since 2006 UK BESS installations have accumulated an estimated 700 years of operation, this equates to 240,000 days of operation. There have currently been only two reported BESS fires in the UK that have required FRS attendance, these occurred at Carnegie Road, Liverpool in Sept 2020 and East Tilbury in Feb 2025, the cause of the latter is yet to be declared. Given the estimated 6 million hours of operation, extrapolates out to approx. 3.3E-07 (0.00000014) failures per hour (fph) for BESS in the UK. To date nobody in the UK has been killed in a BESS incident and there has been no damage to 3rd parties or the environment due to a BESS fire.

[2] This is a conservative figure as the REPD did not account for project under 1MW until 2021.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
3	Lithium-Ion is sensitive to temperature variations – how is this controlled?	The batteries are housed in an ISO container which is fitted with an Environmental Control Unit (ECU). The ECU maintains the temperature and humidity within the container, allowing the Lithium-Ion batteries to operate within the optimum temperature range. The temperature of individual cells in each battery is monitored by the battery management system (BMS) and is reported back to the container level BMS which adjusts the internal temperature in response. Should the ECU develop a fault the container will isolate charge and discharge to the batteries until the fault has been rectified. All faults in the BESS are remotely fed to a centralised Control Room.
4	What is Thermal Runaway?	Thermal Runaway (TR) is the term used to describe an internal short-circuit in one of the battery cells that can lead to cell over-pressure and the venting of combustible gases. Should this gas ignite then the cell will increase in over-pressure and the resulting fire will be self-sustaining until all the material in the cell is expended. Short-circuits in cells are generally a result of: Cell penetration by a foreign object (not usually an issue for a BESS as the batteries are housed in sturdy containers). Impurities in the electrolyte (deposited during the manufacturing process), which over time can lead to the formation of dendrites (electrolytic crystals) which puncture the membrane isolating the anode and cathode – this can, but not always, result in a short-circuit and TR. Over-temperature in the cell because of:

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
		Over-charging (which is controlled by 2 separate BMS – battery and rack). High ambient temperature – controlled by the ECU.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
		The illustration below provides an outline of the possible causes of TR. 

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
5	How can TR be controlled?	TR is not always inevitable, and the nature of the cell design is such that early warning signs of a stressed cell can be detected by the BMS. Initial signs of cell degradation are an increase in the time it takes the cells to reach full charge (maximum voltage) and a decrease in the time it takes to discharge. These indicators are picked up by the BMS and if persistent the BMS will isolate (prevent charge and discharge) to the battery and inform the centralised Control Room. In turn an engineer will be dispatched to remove the battery and replace it with a serviceable item. Since the early inception of BESS safeguards in the design have developed and are now details in UL1973 and BESS are assessed against UL9540A. If these indicators are not present, and the cell enters early stages of short-circuit the over-pressure in the cell will result in the venting of off-gas which is detected by the off-gas detectors built into the container Heating, Ventilation and Air Conditioning unit (the ECU). This will result in the container disabling the charge and discharge (the act of charging and discharging the batteries generates heat, which is what we want to avoid) and setting the ECU to maximum volume setting. This has a twofold effect, it clears the container of combustible gas and cools the internals, taking the energy out of the cells (the cells used in BESS, like other batteries do not perform well in low temperature conditions). It should be noted that most BESS only operate at between 80-90% of capacity provide an engineering margin that mitigates the probability of over-charging the cells.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
6	How is a BESS fire controlled and suppressed?	If the TR is not controlled and spreads, known as Thermal Runaway Propagation, the fire detection and suppression system (FDSS) will activate. There are currently two types of FDSS that are used in BESS; gaseous systems and aerosol systems. Each system has advantages and disadvantages: 1. Aerosol systems are better in terms of extinguishing the fire and benefit against gaseous systems, which generally supress the fire by reducing the level of oxygen in the container. 2. Gaseous systems are instantaneous in operation, the gas being kept under pressure in bottles. Aerosol, by the nature of the deployment as a fine mist, take a little longer to reach all areas of the container. 3. Aerosol systems generally require a more complex and intricate delivery system to reach all areas of the container. 4. Gaseous systems require a sealed environment in which to operate. As such if the container is opened and oxygen reintroduced it can lead to the fire reigniting, as such they require the ECU to close prior to activation (to prevent the ECU from pushing out the extinguishing medium). 5. Various FDSS aerosols (also known as aqueous) and gaseous systems are available, and they use a variety of aerosol solutions. Under consideration for this site is the use of an aerosol aqueous solution containing potassium carbonate (K_2CO_3) – this inhibits the fire by isolating at a molecular level with the chemical chain

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
		reactions forming the flame front. This aerosol is non-harmful to the environment and presents no health and safety concerns to first responders.
7	Can water be used to extinguish a Lithium-Ion fire?	The use of water to extinguish a BESS fire has some drawbacks and disadvantages over bespoke FDSS aerosol mediums, these being: 1. Due to the design of the BESS batteries and racks (in which they are contained), the inability of water to cool the cell interiors may result in re-ignition of a fire once the water application is halted. 2. The high conductivity of water may cause short circuiting of cells presenting collateral damage risk and increase the spread of the fire internal in the BESS. 3. A high volume of water is required to cool the cells below the critical temperature to prevent TR propagation, this results in a high volume of fire water run-off and a potential environmental impact. 4. The application of water on a BESS fire increases the generation of gases such as carbon monoxide (CO), hydrogen (H_2) and hydrogen fluoride (HF). Applying water causes incomplete combustion of organic substances inside the battery resulting in production of CO rather than CO_2; when water is applied, H_2 is released that, without combustion, can react with phosphorus pentafluoride, if present in free form, to produce gaseous HF.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
8	What are the environmental consequences of a BESS fire?	In the event of a BESS fire several chemicals in gaseous form can be released and the composition and concentration of the plume (also referred to as the vapour cloud). In the event of a BESS fire amongst the general gases released are CO, HF, oxygen and hydrogen. The only UK BESS fire (Carnegie Road, Liverpool – Sept 2020) was monitored and the resultant composition of the plume was determined as being negligible in toxic gas concentration. Should the resulting fire be treated with water in the presence of HF the result can be the formation of a HF acid which can be detrimental to the environment, especially the aquatic habitat. To prevent this, it is possible to contain the fire run-off water but often best to let the fire run its course and burn out. It is worth noting that the fire run-off water at Carnegie is considered to have been neutralised by the lime-based gravel covering used at the base of the BESS and on testing was found to be a low alkaline level, as opposed to acidic[3].

[3]The analysis of the fire water run-off, as tested by Bureau Veritas, (Significant Incident Report 018965 – 15092020 Summary and Key Learning (Page 4) Bullet 12 refers), states '*Once water was applied, the resulting run-off contained Hydrofluoric Acid (HF) (confirmed by Bureau Veritas) as a product of reaction between the cells and water contact. "Firefighting run-off was low due to the container involved being sited on a gravel base. Run-off was periodically checked for contamination, which was low. Appropriate environmental protection measures were put in place at the earliest opportunity". The run-off was mainly contained to the site*'.

Appendix A – BESS Frequently Asked Questions		
Ser	**Question**	**Answer**
9	How is the BESS site secured?	The BESS site is secured through fences / walls and monitored remotely via security cameras. Warning signs along the fence indicates the presence of electrical storage facilities within the site.
10	How is the serviceability of the BESS assured?	The Health and Usage data for each BESS is remoted to a centralised Control Room and the serviceability of each battery determined on an hour-to-hour basis. Given that the batteries have a finite number of cycles over a given period it is envisaged that the batteries will be renewed once during the 40-year life of the site.

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
Haz_BESS_001	Uncontrolled release of chemical energy - TR	Cse_BESS_001	Internal failure of cell	Ctrl_BESS_001	The cell has been selected and configured such that the loading of the cell does not cause excessive stress. The design of the BESS will be compliant to UL1973, and the BESS has been qualified to UL9540A	Improbable	Improbable	Marginal	D
				Ctrl_BESS_002	The cell will have been tested at the expected stress levels to show no signs of premature venting/failure or excessive voltage drop or temperature rise in accordance with the requirements of UL9540A				

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_003	The battery design spaces cells as far apart as possible to reduce direct heating effect from one cell to another, in accordance with UL1973				
				Ctrl_BESS_004	The cells are certified by an approved 3rd party to meet UN38.3 transport test requirements and IEC62619 Safety Requirements				
				Ctrl_BESS_005	The BMS senses the individual battery temperature will isolate the	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
					Charge (CHG) and discharge (DSG) of the totality of BESS.				
		Cse_BESS_003	Over Temperature	Ctrl_BESS_006	The BESS is remotely monitored and managed. Allowing the BESS to be electrically isolated from the supply (removing the charge will remove any external stimulus to the batteries).				
		Cse_BESS_004	OC - Excessive Charge Current	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
					whole) would be permanently disabled to block all further risks.				
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
		Cse_BESS_005	OC - Excessive Discharge (Surge)	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
		Cse_BESS_006	Over-Voltage (OV) - Continuous Charge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.				
		Cse_BESS_007	Low Temperature Charging	Ctrtl_BESS_021	The BESS is a temperature-controlled environment and as such unlikely to be subject to temperatures below the operating capability of the Li-Ion Cells. In the event of ECU failure (or failure to	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
					maintain the temperature parameters, the BESS will inhibit charging)				
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
		Cse_BESS_008	Under-Voltage (UV) - Continuous Discharge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to prevent further discharge.				
Haz_BESS_002A	Contact with exposed electrical	Cse_BESS_009	Exposure to electrical source	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	**D**

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
	components - HV-3P		(e.g., contacts, wiring etc.)	Ctrl_BESS_009	Access to the invertors is controlled and the access secured when in operation.	Improbable			
		Cse_BESS_010	Effect of high current pulses (Electro Magnetic (EM)) introduce a conductive path	Ctrl_BESS_010	3P cables are routed in separate cable tray and kept distant from other cables to reduce propensity for current induction	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	**Hazard Description**	**Cause ID**	**Causes Summary**	**Control ID**	**Control Measures**	**Cause Prob**	**Hazard Prob**	**Worst-Case Severity**	**Classification**
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	Inverters will be fully earthed to ground	Improbable			
Haz_BESS_002B	Contact with exposed electrical components - HV-DC	Cse_BESS_009	Exposure to electrical source (e.g., contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
		Cse_BESS_010	Effect of high current pulses (EM) introduce a conductive path	Ctrl_BESS_010	BESS sourced will be Electromagnetic Compatibility (EMC) certified to IEC 61000-6-2 and IEC 61000-6-4	Improbable			
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	All infrastructure is fully earthed to ground and monitored. All infrastructure is subject to periodic inspection	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
Haz_BESS_002C	Contact with exposed electrical components - LV-DC	Cse_BESS_009	Exposure to electrical source (e.g. contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	BESS units are fully earthed to ground and monitored by the BESS BMS	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	**Hazard Description**	**Cause ID**	**Causes Summary**	**Control ID**	**Control Measures**	**Cause Prob**	**Hazard Prob**	**Worst-Case Severity**	**Classification**
Haz_BESS_003	Failure of EMC/EMI protection impacts on system functionality	Cse_BESS_012	BESS not EM compatible with environment in which it is located	Ctrl_BESS_012	BESS is located remotely and EMC compatible with all associated site infrastructure	Improbable	Improbable	Marginal	**D**
Haz_BESS_004	Operator / maintainer exposure to	Cse_BESS_013	Operator/ Maintainer accesses internal component	Ctrl_BESS_013	All hazardous substance listed in the OEM documentation. All maintainers provided with the appropriate PPE. A list of hazardous substance held on site is detailed in the ERP	Occasional	Occasional	Marginal	**C**

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
	Hazardous substances		s of the BESS						
Haz_BESS_005	Ingress of water	Cse_BESS_014	Water Ingress into the BESS internals excessive to the degree that it effects the	Ctrl_BESS_014	BESS is housed in a container and a minimum of IP44 compliant and elevated on concrete plinths	Remote	Remote	Marginal	D

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
			functionality of BESS						
				Ctrl_BESS_015	The BESS design is such that the batteries are off the floor and held in shelving				
Haz_BESS_006	Maintainers required to access in the internals of BESS	Cse_BESS_013	Operator/ Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A Safe System of Work (SSOW) is to be developed, and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Critical	D

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
Haz_BESS_007	Maintainer required to lift, move, or carry heavy BESS components (in confined spaces)	Cse_BESS_015	Maintainer required to access and remove/refit heavy BESS components	Ctrl_BESS_017	A SSOW is to be developed, and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	C
				Ctrl_BESS_018	MHE to be provided for the movement of components more than 25kg				

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	**Hazard Description**	**Cause ID**	**Causes Summary**	**Control ID**	**Control Measures**	**Cause Prob**	**Hazard Prob**	**Worst-Case Severity**	**Classification**
Haz_BESS_008	Gases vented during BESS operation (off-nominal) accumulate within enclosure	Cse_BESS_013	Cells stressed through failure of BMS to monitor status correctly	Ctril_BESS_016	BESS are fitted with off-gas sensors that activate ECU on detection of off-gas from cells and concurrently notify the 24/7 Remote Monitoring Facility for additional action	Improbable	Improbable	Critical	D
			Operator/ Maintainer accesses internal component	Ctrl_BESS_017	A SSOW is to be developed, and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable			

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	**Hazard Description**	**Cause ID**	**Causes Summary**	**Control ID**	**Control Measures**	**Cause Prob**	**Hazard Prob**	**Worst-Case Severity**	**Classification**
			s of the BESS						
Haz_BESS_009	Operation / maintenance of the BESS exposes the user to sharp edges and hard surfaces	Cse_BESS_013	Operator/ Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A SSOW is to be developed, and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	C
				Ctrl_BESS_019	All sharp edges to be radiused or covered to ameliorate				

Appendix B – Tween Bridge Solar Farm Hazard Log									
Hazard ID	**Hazard Description**	**Cause ID**	**Causes Summary**	**Control ID**	**Control Measures**	**Cause Prob**	**Hazard Prob**	**Worst-Case Severity**	**Classification**
Haz_BESS_010	Operator / Maintainer exposure to biological growth in the BESS	Cse_BESS_013	Operator/ Maintainer accesses internal components of the BESS (after a prolonged period of use)	Ctrl_BESS_017	A SSOW is to be developed, and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Negligible	D