Appendix O.2

Battery Energy Storage System
Preliminary Failure Mode and Effects Analysis

Starlight Solar
Major Use Permit PDS2022-MUP-22-010
Battery Energy Storage System
Preliminary IEC 60812 Failure Mode and Effects Analysis

20250320-SLS-AW0764-BESS-FMEA-R1

Issued: 23 July 2025

AHJ Revision Note: This Preliminary IEC 60812 failure Mode and Effects Analysis is provided as a "Basis of Design" information only analysis to support the initial permitting of the Starlight Solar Energy Storage Project in San Diego County California. This BESS FMEA was created using the best available OEM information and addresses the majority of the liquid cooled GridSolv Quantum design failure modes that could result in fire, shock, explosion, or injury to personnel.

The information presented in this BESS FMEA is provided only as a technical basis for a fire risk assessment for the development of the required Major Use Permit Hazard Mitigation Analysis. This BESS FMEA shall be updated upon determination of the actual energy storage technology for the Starlight Solar Project. This BESS FMEA is intended to be considered as "information only" and shall not be used for final Building Permit Approval.

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Revision History

Revision	Date	Description
0	24 April 2025	Released for Customer Review
1	22 July 2025	Redefinition of the intent of the document as preliminary at the client. Title page and appropriate verbiage changed as directed by client.

Purpose and Objectives

The intent of performing this Failure Modes and Effects Analysis (FMEA) is to identify and quantify the potential failure mechanisms that, if left unmitigated, could result in fire, shock, or personal injury hazards associated with the Empire II LLC Starlight Solar battery energy storage Project utilizing a typical Lithium-Iron-Phosphate (LFP) based technology. The Empire II LLC Starlight Project is an eight-parcel project located in San Diego County, southeast of Manzanita CA in proximity of 32.66016162785173, -116.28052568720432.

A standards-based FMEA is typically and recursively developed throughout the design development process where key design decisions are implemented using a combination of Engineering and Administrative Controls and to establish the technical basis for fire risk management decisions. FMEAs are a key element for the formation of a Layers of Protection Analysis where risk informed decisions can be made leading to Independent Protection Layers (IPLs) that may consist of the combination of Engineering and Administrative Control mitigation measures.

Whenever a system failure could result in undesirable consequences such loss of availability, reliability, system degradation, fire, etc., best practices advise carrying out a quantitative or qualitative risk analysis, such as a Failure Mode and Effects Analysis (FMEA), as an integral part of the design and operational development process. American Fire Technologies standards-based FMEA process, when incorporated into the design development of Battery Energy Storage Systems industry expertise can be a powerful decision aid in identifying possible failures which could potentially improve the overall safety of consumer products.

This BESS level FMEA focused on the external threats to the Starlight Solar Battery Energy Storage System (BESS) Project with the objective of evaluating theoretical failure mechanisms, modes and evaluating the potential impact that could result in a fire, shock, or personal injury. This BESS level FMEA follows the guidelines outlined in IEC 60812, *Failure Modes And Effects Analysis (FMEA And FMECA)* [1] to establish the standards-based technical basis of the interdependent system performance upon which risk informed design decisions are made.

This FMEA also integrates the industry lessons learned, supporting databases and publications including:

- *Electric Part Reliability Data* (EPRD) -2014 [2]
- *Non-electric Part Reliability Data* (NPRD) – 2016 [3]
- *Failure Mode/Mechanism Distributions* (FMD) – 2016 [4]
- Center for Chemical Process Safety, *Guidelines for Process Equipment Reliability Data (PERD), with Data Tables* [5]
- OREDA, *Offshore Reliability Data Handbook* [6]
- *Reliability Data for Safety Instrumented Systems PDS Data Handbook* [7],
- *Reliability Prediction Method for Safety Instrumented Systems PDS Method Handbook* – 2013 Edition [8]
- MIL-HDBK-217F, *Military Handbook - Reliability Prediction of Electronic Equipment* [9]
- IEC/TR 62380 - *Reliability data handbook – Universal model for reliability prediction of electronics components, PCBs and equipment* [10]
- IEEE Standard 493-1997: *IEEE Recommendation Practice for the Design of Reliable Industrial and Commercial Power Systems* [11]

- CARDEROCKDIV NSWC-10: *Handbook of Reliability Prediction Procedures for Mechanical Equipment - Mechanical equipment - military applications* [12]
- *Safety Equipment Reliability Handbook, Volume 1 – Sensors* [13]
- *Safety Equipment Reliability Handbook, Volume 2 - Logic Solvers and Interface Modules* [14]
- *Safety Equipment Reliability Handbook, Volume 3 – Final Elements* [15]
- IEEE Std. 500-1984: *IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear Power Generating Stations* [16]
- *Failure mode and effect analysis: FMEA from theory to execution* [17]
- *The Basics of FMEA* [18]
- *Guidelines for failure mode and effects analysis for automotive, aerospace and general manufacturing industries* [19]
- *The Power of Deduction-Failure Modes and Effects Analysis for Design [20]*

Engineering Methodology

FMEA Overview

A FMEA is a design and engineering tool which analyzes potential failure modes within a system to determine the impact of those failures. It was first developed by the US Department of Defense for use in Systems Engineering Design practices. The FMEA technique has since been adopted by commercial industries in an attempt to minimize failures and reduce safety, and environmental and economic impacts that could result from these failures. FMEAs have more recently become a preferred risk analysis tool in the energy storage market sector and is recommended as a Safety Analysis tool of the Energy Storage Management System (ESMS) in UL 9540 and the Installation Standard for Stationary Energy Storage Systems, and NFPA 855 [21, 22]. It is required for certain systems by the internationally recognized safety standards, Societies, select regulatory bodies, and industry groups to improve the safety of a design or operation, to increase its reliability and to minimize undesired events. As an integral part of the Risk Management Program, FMEAs are also an essential element of the design process to identify the risk and the associated hazards where purposeful engineering and administrative controls are applied to minimize the likelihood of occurrence. The methodology presented in this FMEA follows the suggested use of IEC 60812:2018 [1] as referenced in NPFA 855 [22] and UL 9540 [23].

This BESS level FMEA was developed using Isograph Reliability Workbench v. 15.0.2.5 with data from the Electronic Parts Reliability Data, EPRD-2016, Nuclear Parts Reliability Data, NPRD-2016, and Failure Mode/Mechanisms Distribution, FMD-2016 as well as the other referenced recognized process safety industry databases to provide technically defendable reliability data. If component information was not contained in these databases, comparable reliability data was based on recent energy storage market sector data and engineering judgement.

FMEA Process Summary

The FMEA is generated through a desktop analytical process intended to identify system design and safety system configuration opportunities for improvement in all expected operational modes of the particular system. This BESS level FMEA utilized the numerous Starlight Solar Project engineering documents that delineate the as-constructed installation.

Once it has been determined that an FMEA will be performed and the scope of the study is agreed upon, an appropriate FMEA team of subject matter experts from American Fire Technologies and the Starlight Solar team to carry out the analysis using the Delphi Method [24] to identify the potential system level failures when the failure modes/mechanisms were not documented in the referenced Reliability Engineering databases. This process relied primarily on the experienced FMEA practitioner knowledgeable in the typical Battery Energy Storage System(s) normative requirements and was supplemented by specific design details not readily presented in the engineering design media.

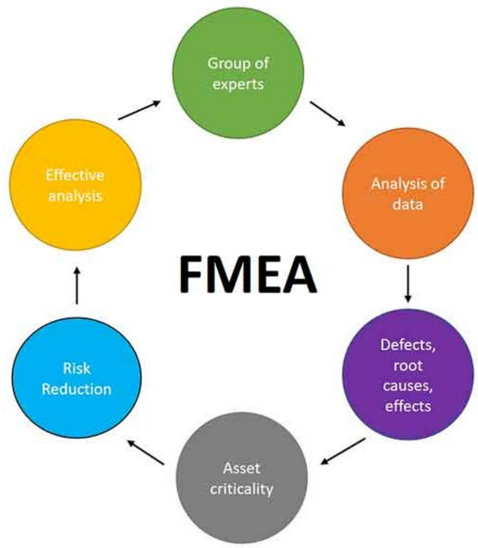

Figure 1: Classical FMEA Approach

The Starlight Solar System boundaries are defined as the BESS Container and the interdependent and supporting structures, systems and components (SSCs) from the BESS Yard to the connections to the existing 34.5kV Switchgear. The AFT/ Starlight Solar team interfaced with the applicable stakeholders to exchange data, including collection of system schematics, operational procedures and manuals and system configurations as needed. The team primarily relied upon:

- Published failure modes (FM),
- Failure rate distributions and probabilities (Occ)
- Cascading impacts effects throughout the interdependent system leading to fire, shock or injury to personnel (Severity – Sv),
- Failure Causes (FC)
- Anticipated detection methods, alarms, and annunciations (Dt)
- Recommended compensatory corrective actions (RA).

Recommendations were provided for design considerations throughout the FMEA development process, and these recommendations may be ranked according to the severity of the potential effect to mitigate the consequence or probability of fire related events.

The general process flow elements of the IEC 60812 FMEA process are presented in Figure 2.

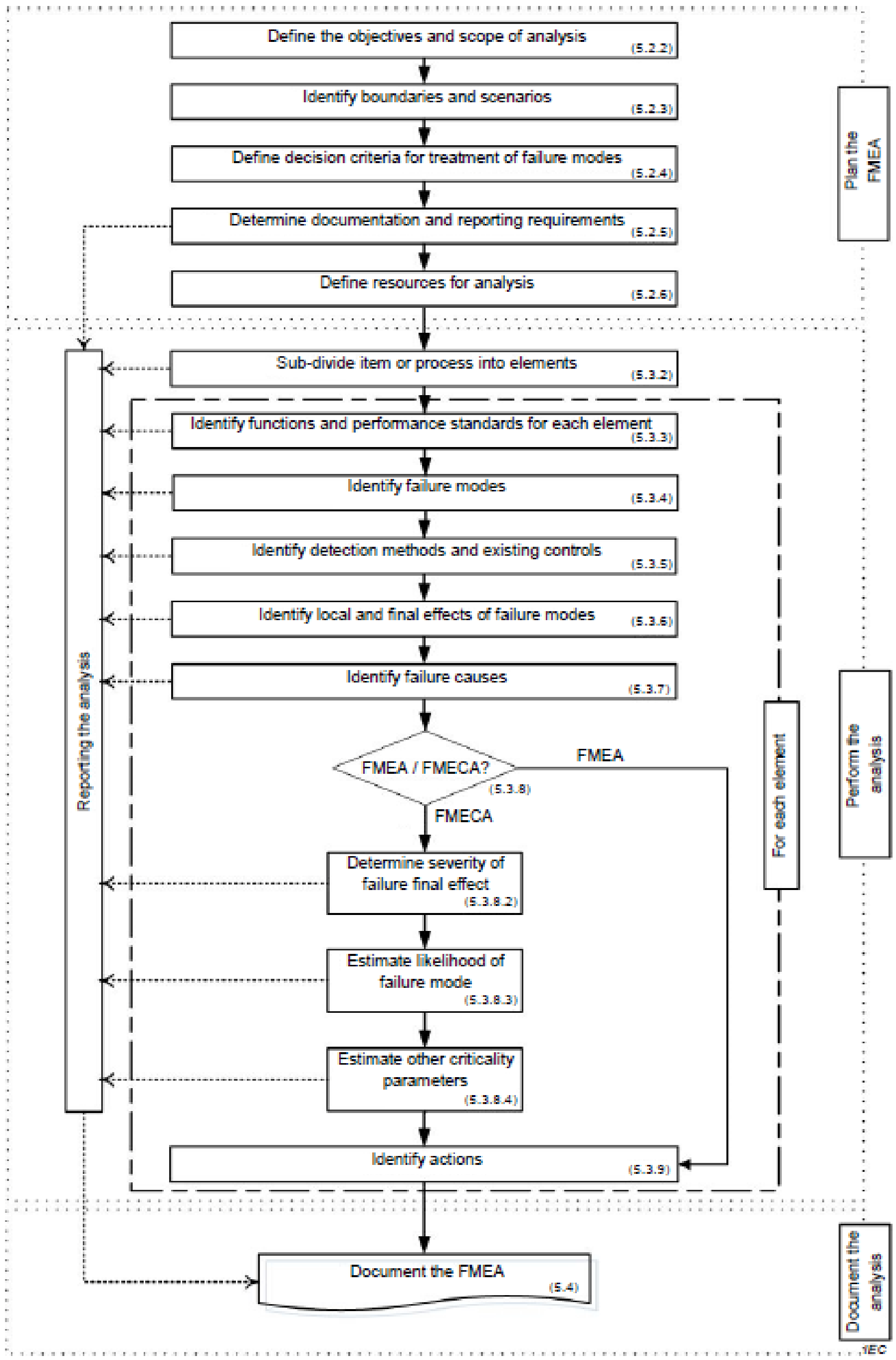

Figure 2: IEC 60812 FMEA Process Flow Chart

Definition of the Project Scope

The system model used for this FMEA is based on the Starlight Solar Battery ESS Project is based on the engineering documentation provided and was decomposed into the following subsystems presented in Figure 3.

Figure 3: LFP BESS Representation

The Starlight Solar BESS Project is built on the safe installation of individual *LFP BESS* structures Battery Energy Storage Systems as show in Figure 3. The Starlight Solar *LFP BESS* Project Site Plan is presented in Figure 4.

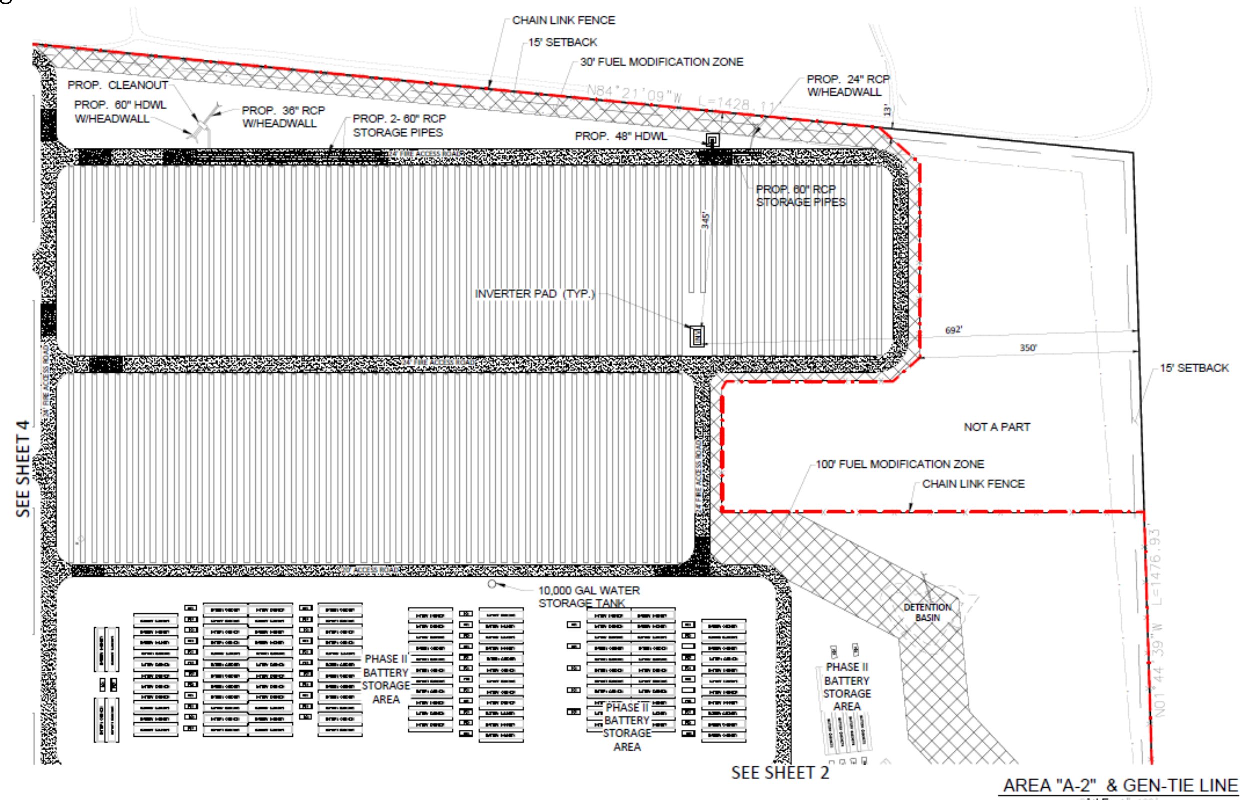

Figure 4: (typ.) Starlight Solar Site Layout

Analysis Enabling Assumptions

The following enabling assumptions were used to facilitate this Failure Mode and Effects Analysis (FMEA) to characterize the typical failure scenario:

Assumptions made in the development of this FMEA include:

- Full compliance with NFPA 70 is field verified and documented accordingly.
- In the absence of specific component failure data, it is assumed the reliability data contained within the *Electronic Parts Reliability Data*, EPRD-2016; *Nuclear Parts Reliability Data*, NPRD-2016; and *Failure Mode/Mechanisms Distribution*, FMD-2016 provide technically defendable reliability data. When specific component data is not listed within EPRD, NPRD, or FMD, approximates are used based on class of equipment.
- No distinction is made for each item's maturity of design or its associated failure rates; each item was modeled based on its intended function.
- The system analyzed included the identified interdependent subsystems of the *LFP BESS* ESS Project.

- In the absence of the interfacing inverter design details, the inverter is assumed to be UL1741 compliant, and no additional analysis of failure modes are assessed as part of this FMEA.
- The FMEA emphasized analysis at the functional level, based on the defined component functions.
- The failure modes were generally defined as the negative of the function resulting in contributors leading to fire, electrical shock, or injury to personnel or the environment.
- Limited procedures were provided that indicate typical responses to emergent conditions. Therefore, typical Administrative Controls were assumed and included in the proposed Layers of Protection. Validation of assumed Administrative Controls will be required as part of NFPA 855 documentation and is not part of this project deliverable.
- The *LFP BESS* BESS design is not inclusive of Safety-Related components or systems. Therefore, unmitigated failures of interdependent systems are assumed to cause cascading failure.
- This analysis assumes the combinations of known or published latent/hidden failure/additional failure combinations that lead to an undesired event.

Hazard Identification

This FMEA does not attempt to identify every possible fault of every component in the system but focuses on those events that will result in fire, electrical shock, or injury to personnel. This FMEA relies upon the best available structure, system, or component information and leverages failure consequences of related quantitative analysis and/or national consensus standards for hazard identification. The attached FMEA is structured to depict system level functional failure modes and effects and evaluates documented mean-time-to-failure (MTTF) of the integrated systems and published failure modes and mechanisms that can lead to identified hazards. Many of the evaluated hazards are based on those presented in the National Fire Protection Association (NFPA) Standard 855 *Standard for the Installation of Stationary Energy Storage Systems* [22].

The potential risks range from loss of availability of a given subsystem to the potential cascading impact of interdependent system performance. Interdependent system failures are evaluated to determine the impacts that can result in system or subsystem loss. For example, understanding there is no Safety Integrity Level (SIL) certified equipment within the Starlight Solar Project, given a theoretical failure within the HVAC system, its failure is evaluated to determine if the Energy Storage Management System (ESMS) could be adversely impacted or damaged. The unavailability of the ESMS is then evaluated to determine the impact of increased probability of a fire, resulting in a shock, or injury to personnel.

Criticality Ranking (FMECA)

Failure Modes, Effects, and Criticality Analysis (FMECA) is an extension of the AFT FMEA process which includes an additional criticality assessment for the Starlight Solar Project. The criticality ranking explicitly and transparently brings to prominence the most critical issues and is extremely helpful for deciding if additional corrective actions need to be implemented. In the development, follow-up and implementation process of corrective actions, the criticality ranking helps to evaluate that the effort, time and resources are commensurate with the criticality of the item.

Criticality rankings based on risk use a combination of the consequence (severity) of the failure and the anticipated likelihood of the consequence occurring. The analysis will highlight failure modes with high probability of occurrence and severity of consequences, allowing corrective actions to be implemented where they will produce the greatest impact. Ideally, frequency estimates will be based on historically quantifiable databases, but in many cases data of this type is unavailable or poorly documented. If the event of the information unavailability industry experience is relied upon.

It is worth noting that some standards draw a distinction between a qualitative and quantitative criticality assessment. The quantitative assessment as described by the MIL STD 1629 [25] is quite involved and will not be discussed here as it not a requirement of this analysis. When necessary, qualitative assessment principles and judgement of criticality used expert judgment to place the event in criticality or risk matrix or a criticality benchmark.

The most common method used in this FMEA for qualitative evaluating the criticality is the use of ranking systems which scale severity of consequence vs. likelihood. The matrix shown in Figure 5 example has four levels of consequence and four levels of likelihood. More levels can be defined as needed, but anything less than four levels may not provide enough granularity to make appropriate risk-based decisions. This FMEA is a quantitative analysis that leverages recognized industry process safety management reliability databases supplemented by qualitative assessment when necessary.

Given the overall lack of reliability data for many evaluated systems and components, performing an assessment on a semi-qualitative level based on experience and knowledge of the system under study is sometimes the only means by which to achieve a meaningful criticality assessment. However, this BESS level FMEA leveraged published reliability data for comparable systems and components and utilized engineering judgement when necessary. A high severity and high likelihood event is not acceptable, and where appropriate risk control measures to reduce either the likelihood of occurrence or severity may be applied to establish technically defensible bases for risk.

Failure Mode Identification

A common approach for the FMEA is to analyze failures related to a particular function of the equipment not being performed or performed incorrectly. For example, while not directly applicable to the Starlight Solar project, assuming a system needs to pump *x gpm* from *point A* to *point B*. Typical functional failures for such a system would include failure of pumping capability, pumping at a rate below requirements, pumping at a rate exceeding requirements and pumping backwards. The causes or failure mechanisms for these functional failures would include motor failure; loss of power; degraded pump or motor, under voltage to motor; over voltage to motor; leaky non-return valve on discharge of pump.

This FMEA utilizes the failure modes/mechanisms identified in FMD-2016, OREDA, exida, and other identified recognized industry publications to characterize credible failure modes [4, 6, 12-15].

The intent of the use of FMD-2016, IEEE Std. 493-1997 and the other databases is to present failure distributions on parts and assemblies to be used in support of reliability analyses for the Starlight Solar Project. Failure Data and Distributions presented in the attached FMEA can be used to apportioned cut-sets (a cut set is the unique combination of component failures that can cause system failure) of an item's failure rate into modal elements by multiplying the failure rate by the percentage attributable to specific failure modes. The intent of these distributions is to provide a baseline set of probabilities to be used in understanding the potential risks of a given hazard.

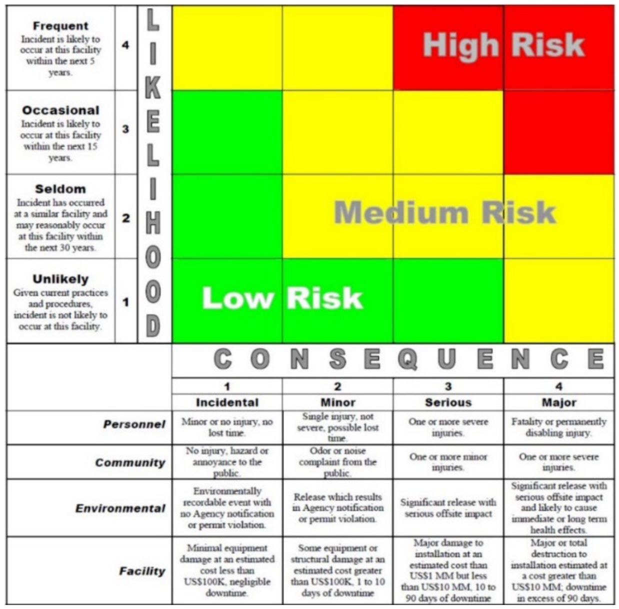

Figure 5: Example of a Qualitative Risk Matrix

The majority of information used in this document is derived from previously published industry and market sector reports on energy storage systems. Where and when necessary, engineering judgement is applied based on energy storage market sector experience. Historical published Maintenance data was the next most predominant performance source followed by failure analysis reports. It is noted that there are inherent gaps in the published failure databases where specific manufacture device information may not be available. To address this issue, applicable failure distributions were derived based on several data sources and will be integrated to yield a single failure normal distribution. Initial data analysis and summarization efforts included the use of various weighting schemes to rank the data in accordance with a combination of both the quality and quantity of data. While this methodology has merit, in some circumstances and where appropriate some individual data sources were weighted equally.

The Failure Mode/Mechanism fields presented in the databases and publications used are "categorized failure modes or mechanisms". For the purposes of this analysis, a failure mode is defined as the "observable consequence of failure where the failure mechanism is defined as the physical process which causes the failure" [4]. Failure modes and normal probability distributions are categorized by industry expertise and empirical data from which the detailed failure description is derived. Industry expertise and empirical data is relied upon for the efficacy of all reviewed failure modes and mechanisms for a given part type or a structured list that is representative of all data sources. Relevant and recent industry data will be used when applicable.

The Starlight Solar BESS level FMEA considered the following typical functional failures and impacts:

- Catastrophic Failure – leading to fire, electrical shock, and injury of personnel.
- Premature or spurious operation leading to degraded or catastrophic failure.
- Failure to operate when required as an unmitigated operating scenario as no SIL equipment is included in the design.
- Intermittent operation where interdependent system reliability/availability may be

overcome by environmental conditions due to fire or system degradation.

- Failure to stop/initiate operating when required.
- Loss of interdependent communication and control input/output or failure during operation.
- Degraded output or degraded operational capability or functionality.

Single Failure Criteria

While NFPA 855 does not require consecutive failures, this FMEA was performed assuming single failures and their effects (i.e., two simultaneous independent failures are not considered) are the initiating events that could lead to over applicable 500 failure scenarios. Assessments of this type are usually limited to SSC failures that would result in unwanted consequences. A "single act" is generally taken to mean the operation of a single button, switch, lever, etc. There are two distinct instances when more than one failure was considered in this FMEA:

- When one of the failures can be latent, undetected or hidden.
- When two or more systems or components can fail due to a single specific event or cause (common cause failures).

Hidden Detectable Failures

Figure 6: Hidden Detectable Failure

An exception to the single failure criteria is for the case of latent, or hidden, failures where their presence is not readily detectable. In such cases, single failures in combination with an initial hidden failure and their combined consequences were included in this analysis. Since the initial hidden failure is typically unknown until the second failure occurs, the two failures are considered together as a single event. Equipment that performs a back-up function and is in a non-operational or standby state may fall into this category if the functionality of the stand-by equipment cannot be verified until it is activated. Likewise, most safeguards and barriers are prone to hidden failures. They are not needed for operation but without proper monitoring to detect their failure, could result in a common cause/mode failure. It is generally understood that it is only discovered when there is a demand for the safeguard due to another failure of an interdependent system or subsystem.

It is important to note that not every hidden failure was specifically assessed in the evaluation of the Starlight Solar Project BESS level FMEA. The level to which hidden failures are assessed depends on the ramifications known and where detectability and probability of occurrence and are based on either industry experience or published data. Unknown failure mechanisms of known systems are not considered as part of this FMEA. Unknown failure mechanisms of the documented system could result in an unanalyzed state resulting in catastrophic loss of the ESS, electrical shock, or injury to personnel.

The *LFP BESS* BESS design is not inclusive of Safety-Related components or systems. Therefore, unmitigated failures of interdependent systems are assumed to cause cascading failure. No other SIL equipment was identified to be used in this analysis.

This analysis assumes the combinations of known or published latent/hidden failure/additional failure combinations that lead to an undesired event, but loss of either component on its own will not.

Common Cause Failures

A common cause failure occurs when multiple failures occur due to a shared cause or cause (e.g., multiple components failing due to high temperature): a design deficiency, a manufacturing defect, operation and maintenance errors, an environmental issue, an operator-induced event, or an unintended cascading effect from any other operation, failure within the system, or a change in environmental conditions. For the purposes of this FMEA development, it is critical to identify aspects of the system design where a single event could cause the loss of more than one component leading to the system failing to perform its intended function.

In conducting this FMEA, consideration was given to external factors such as temperature, humidity and vibration which can lead to common cause failures in interdependent systems. An example of common cause failure might be a common power supply breaker operation that supplies electricity for redundant or interdependent functions.

Common connections between systems create paths by which a fault in one system may affect another independent system.

No design basis accidents are considered in this analysis.

Unavailability of Redundancy (due to maintenance or other cause)

The Starlight Solar BESS level Project does not include redundant systems.

Failure of Active and Passive Components

Many of the evaluated components associated with the Starlight Solar BESS level FMEA utilize passive components protective components. This FMEA utilizes the active and passive failure mechanisms outlined in FMD-2016 and are applied when necessary.

Passive static components are, in general, considered to be of high reliability, whereas active components have lower reliability. However, unless otherwise indicated, the failure data classification applied to passive components may, based on EPRD, NPRD, OREDA, or exida data, have a significant probability of failure within certain systems and associated failures modes. In these cases, consideration for typical administrative controls is applied within this BESS level FMEA to supplement associated engineering control for an integrated, layered protection scheme. The applied Layers of Protection Analysis is based on IEC 61511, ANSI/ISA 84.01-1996, for risk mitigation [26, 27].

The concept of passive and active equipment can be explained as follows:

- Active or rotating components in mechanical systems refer to machinery that moves and rotates during operation (e.g., pumps, compressors, generators, thrusters, remote controlled valves, etc.). For electrical/electronic systems, active equipment refers to those that require being powered in some way to make them work (e.g., integrated circuits, PLCs, switchboards, etc.).

- Passive or static components in mechanical systems refer to those having parts that normally do not move (e.g., pipes, tanks, vessels, shell-and-tube heat exchanger, manual valves, etc.). For electrical/electronic systems, passive components are those that do not require energy to make them work (e.g., electrical cables, resistors, capacitors, etc.).

External Events as Failure Modes

This BESS level FMEA does not evaluate external events leading to equipment failure as no design-basis accident scenarios have been identified.

FMEAs of Controls, Instrumentation and Safety Systems

The Starlight Solar BESS level Project does not have any identified Instrumented Safety Systems, and associated performance and failure effects are assumed to result from their failure. Safety Controls and levels are not evaluated as part of this FMEA.

Therefore, those systems designed for mitigation of fire, electrical shock, or injury of personnel are identified and applied as commercial grade assemblies.

Severity Classifications (Sv.)

Severity is a measure of the seriousness of the effect of the failure mode. The Severity classifications applied for the Starlight Solar ESS Project are assumed safety confidence metric and are assigned to provide a qualitative measure of the worst possible consequences resulting from failure. Typically, scales are assigned to predetermined loss criteria.

Table 1 presents the severity classification that was used in the analysis of this BESS level Project.

Table 1: Starlight Solar Severity Classification

Rating	Severity	Customer Description
10	Catastrophic Weighting:100	Very hazardous effect. Effect occurs suddenly without warning to user and may pose a safety concern. Non-compliance with regulatory requirements and injury is likely.
9	HAZARDOUS EFFECT WITH WARNING Weighting:90	Potentially hazardous effect with safety concerns. Able to halt system operation without mishap, i.e., gradual failure. Compliance with significant regulatory requirements is in jeopardy.
8	SERIOUS EFFECT Weighting:80	System, subsystem, major component is inoperable but safe, or a system is inoperable but safe.

7	MAJOR EFFECT Weighting:70	System performance is severely degraded but has some operational capability and remains safe. A subsystem may be inoperable but in a degraded condition impacting BESS LEVEL mission objectives.
6	SIGNIFICANT EFFECT Weighting:60	Noticeable system degraded performance is observed but operable and safe, or a non-vital subsystem is inoperable. A subsystem may be in a degraded condition impacting BESS LEVEL mission objectives causing interdependent system instability.
5	MODERATE EFFECT Weighting:50	Moderate degradation of BESS LEVEL performance; Non-vital fault often requires repair.
4	MINOR EFFECT Weighting:40	Minor degradation of product performance that generally does not require repair.
3	SLIGHT EFFECT Weighting:30	Slight degradation of product performance. Non-vital fault noticed by median performance with inconsequential annunciation of system performance parameters not satisfied.
2	VERY SLIGHT EFFECT Weighting:10	Very slight degradation of BESS LEVEL interdependent system performance. Easily corrected during convenient scheduled maintenance activities.
1	No Effect Weighting:0	No discernible effect.

Occurrence Classifications (OC.)

Occurrence is often expressed as a qualitative or quantitative probability of failure mode occurrence. Typically, metrics are assigned to predetermined probability criteria. Occurrence classifications reflect the probability that a failure mode will occur during the planned life expectancy of the system. These qualitative probabilities can be described in terms of potential occurrences per unit time, events, population, items, or activity.

Table 2: Starlight Solar Occurrence Classification Ranking

Rating	Occurrence	History	Failure Rate
1.	Remote	Significant, proven prevention controls. Implemented design previously and has proven predictability. Failure rate of 1 in a million operational hours	>1E^{-6}
2.	Very Low	Significant, proven prevention controls. Failure rate of 1 in a one hundred thousand to million operational hours	1E^{-5} to 1E^{-6}

3.	Low	Good and effective prevention controls. Existing Technology with new application. Knowledge of many factors, effects and noises. Failure rate of 1 in ten thousand operational hours	0.0001
4.	Moderate: 1 in 2000	Strong prevention controls. Existing Technology with new application. Knowledge of many factors, effects and impacts. Failure rate of 1 in 2000 operational hours	0.005
5.	Moderate: 1 in 400	Significant, proven prevention controls. Implemented design previously and has proven predictability. Failure rate of 1 in 400 operational hours	0.0025
6.	Moderate: 1 in 80	Some proven prevention controls. Failure rate of 1 in 80 operational hours	0.0125
7.	High: 1 in 20	limited prevention controls. Failure rate of 1 in 20 operational hours	0.05
8.	High: 1 in 8	Ineffective prevention controls. Failure rate of 1 in 8 operational hours	0.125
9.	Very High: 1 in 3	Ineffective prevention controls. Failure rate of 1 in 3 operational hours	.025
10.	Very High: 1 in 2	No prevention controls. Failure rate of 1 in 2 operational hours	0.5

Detection Classifications (Dt.)

Detection is a qualitative measure of the probability of observing the failure mode or indications of imminent failure before advancing to the next operation, activity, or delivering a product to a customer. Typically, scales are assigned to predetermined detection probability criteria.

Detection classifications reflect an assessment of the ability of existing process controls to detect a potential failure mode or cause before the failure effect can be realized. Detection Classification criteria used for Starlight Solar Project are presented in Table 3.

Table 3: Starlight Solar Detection Classification Ranking Criteria

Rating	Detection	Criteria
1	Almost Certain	Highest effectiveness of method; detection nearly certain in all known cases (proven design standard, best practice with near-total elimination of failure, etc.) where highly instrumented systems will annunciate when performance thresholds are achieved. **Detection Probability: 1**
2	Very High	Effectiveness is very high but requires discretion i.e., test history of similar parts using proven test methods or validated simulation, computation, or modeling **Detection Probability: 0.5**
3	High	High level of effectiveness, such as previously verified calculation or simulation based on similar designs; degradation testing prior to design release **Detection Probability: 0.25**
4	Moderately High	Effective detection based on data-driven extrapolation and/or technical judgment from testing to failure or computation, simulation, or analysis with some correlation to expected operating conditions **Detection Probability: 0.125**
5	Moderate	Moderate detection from testing or computation, i.e., test results from moderately similar designs or order-of-magnitude computations; pass/fail testing prior to design release **Detection Probability: 0.05**
6	Low	Detection methods reveal failure modes less than half the time; degradation testing in controlled conditions **Detection Probability: 0.0125**
7	Very Low	Available methods reveal failure modes only under optimal conditions; testing to failure after design release **Detection Probability: 0.0025**
8	Remote	Available methods require extensive judgment or extrapolation and are known to have limited capability; pass/fail testing after design release **Detection Probability: 0.005**
9	Very Remote	Speculative, unproved, or unreliable methods of detection; virtual analysis is not correlated with expected operating conditions **Detection Probability: 0.0001**
10	Absolute Uncertainty	No known effective technique or method available, or no analysis planned **Detection Probability: 0**

Causes

Causes indicate a reason for why or how a failure mode can occur. However, all causes do not contribute equally to a potential failure mode. Only "root causes" are likely to contribute to the majority of the failure mode. These root causes were emphasized in cause determination. A failure cause is attributed to physical or electrical processes, design defects, quality defects, part misapplication, or other processes which are the basic reason for failure, or which initiate the physical process by which deterioration proceeds to failure.

Common cause failures (CCFs) are those failures when there is more than one component, item, or system due to the same cause or initiating event. CCF can involve the initiating event and one or more safeguards, or the interaction of several safeguards.

Risk Priority Number

Automotive FMEAs often use Risk Priority Number (RPN) values to assess criticality. Higher RPN values are an indication of more critical items. The product of the severity, occurrence, and detection values determines the RPN. The equation for RPN is: RPN = Severity × Occurrence × Detection.

Results and Discussion

The detailed BESS level results for Part I of the Starlight Solar Project are contained in Attachments A of this report.

The detailed FMEA demonstrates the credited potential failure mode, potential effect, cause, measures for prevention, and detection that is presented FMD-2016, IEEE Std. 493 or understood from industry databases for each system, subsystem or major system component. Using the values determined for severity, occurrence, and detection a risk priority number (RPN) was calculated for each failure mode.

Failure modes with a RPN greater than 100 should be evaluated and actions were taken in order to reduce the RPN to a value below 100. The RPN value of 100 is an industry accepted threshold that is used to promote further discussions to determine if additional cost-effective measures can be implemented to reduce the probability of the risk. Likewise, it is recommended mitigation strategies be considered by the design team to lessen the likelihood of an event occurring.

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Attachment A: Starlight Solar LFP BESS Level Failure Mode and Effects Analysis for the Starlight Solar Project

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1	1.1	Starlight Solar Project BESS Project Battery Energy Storage Subsystem	Reduced Capacity	Moderate Effect - Moderate degradation of product performance;	5	FC-78 System degradation results in reduced power delivery to the grid	10	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	200	RA-35: SOPs, EOPs, and O&M Manuals delineating system performance and designed response and actions to mitigate anticipated events and operating scenarios	Wartsila Project	Mitigative measures defined in Wartsila SOPs & EOPs and O&M Manuals	5	7	3	105
	1.2		Eventual BESS Unavailability	Moderate Effect - Moderate degradation of product performance;	5	FC-75 Degradation/Age related failure: Failures realized as part of programming lifecycle	7	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	175	RA-35: SOPs, EOPs, and O&M Manuals delineating system performance and designed response and actions to mitigate anticipated events and operating scenarios	Wartsila Project	Mitigative measures defined in Wartsila SOPs & EOPs and O&M Manuals	5	5	3	75
	1.3		No Immediate Measurable Impact	Moderate Effect - Moderate degradation of product performance;	5	FC-76 Random Failure: Failures that they do not appear to have any pattern or regularity.	1	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	1	5	No Actions Necessary	No anticipated response to this event	No Actions Necessary	5	1	1	5
	1.4		Industrial Safety (Fire, Personnel) Issue	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-04 Haz Internal Temp: High temperature in the room from normal operations	8	AC-01: EOP - System operator plan to handle all emergency events.	7	560	RA-35: SOPs, EOPs, and O&M Manuals delineating system performance and designed response and actions to mitigate anticipated events and operating scenarios	Wartsila Project	Mitigative measures defined in Wartsila SOPs & EOPs and O&M Manuals	10	6	3	180
	1.5		ESMS/BMS Control Failure	Hazardous Effects with Indication	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	6	AC-01: EOP - System operator plan to handle all emergency events.	6	324	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Project	Credit given based on Wartsila Controls/PLC Logic Table and Drawing review	9	4	3	108

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1	1.6	Starlight Solar Project BESS Project Battery Energy Storage Subsystem	Electrical fault resulting in unavailability	Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FM-01: Electrical Failure	5	EC-22 Site Elec Prot: Protection for electrical systems such that a failure of the PCS or associated circuit does not result in adverse effects on the site balance of system electrical gear	5	200	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	Wartsila Engineering/ Site Owner & Operator	RA-17: Knowledge of failure condition for active mitigation and response management. Mitigative measures defined in Wartsila SOPs & EOPs and O&M Manuals	8	5	3	120
	1.7		Failure to Operate	Moderate Effect - Moderate degradation of product performance;	5	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	5	EC-08 Duplicate HVAC: Design, sizing, and hardware physical duplication of the HVAC system EC-21 BMS CTRL: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary (Failure of Temperature Control)	5	125	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering & O&M Contractor	RA-01: Performance of Scheduled System Maintenance	5	4	3	60
	1.8		Partial/Total loss of capacity	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	EC-03 ESS HVAC: Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	2	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	7	56	RA-07: Environmental Temperature Monitoring and Alarms RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions for Loss of Temperature Control	4	3	4	4

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1	1.1.1	BESS - Whole System	System Level Short Circuit Current Contribution	Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-39 Human Factors - Design Errors and Omissions	4	EC-17 Elec Pass Prot: Current interrupt devices, fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	6	192	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented action	8	2	7	112
	1.1.2		Rapid Cell Discharge	Eventual BESS Unavailability Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-17 Cell Therm Runaway: A single cell has entered thermal runaway resulting in flames and combustion or production of flammable or explosive gases	4	EC-19 Adequate Sense/Cntrl: Aggregate of the ability of the BMS to detect cell imbalance and to properly return system to balance if possible.	6	192	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented action	8	2	7	112
	1.1.3		Cascading Fire and BESS Loss	Hazardous Effects with Indication Industrial Safety (Fire, Personnel) Issue Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-47 Elec Risks, FD/FSS Failure to detect and actuate suppressant	7	AC-02: EOP - Fire department response including active firefighting suppression	7	490	RA-17: Knowledge of failure condition for active mitigation and response management. RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT Team	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	10	3	4	120
	1.1.4		System Overtemperature Trip	Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	6	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	240	RA-01: Performance of Scheduled System Maintenance RA-06: Duplicate HVAC Units	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1	1.1.5	BESS - Whole System	Excessive Thermal Cycling	Moderate Effect - Moderate degradation of product performance; Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	6	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	240	RA-03: ESMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	5	120
	1.1.6		Thermal Abuse	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Hazardous Effects with Indication	9	FC-03 Module Failure: Hazardous Temperature Condition - Module. High temperature in the module during normal operation without failure/thermal runaway	6	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	270	RA-03: ESMS Testing and Commissioning RA-04: BMS Testing and Commissioning RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions, Commissioning and Design Verification	7	4	4	112
	1.1.7		Electrical Abuse		8	FC-39 Human Factors - Design Errors and Omissions	4	EC-17 Elec Pass Prot: Current interrupt devices, fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	6	192	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented action	8	2	7	112
	1.1.8		Liquid Cooling System Degraded/Inoperable	Partial/Total loss of capacity Eventual BESS Unavailability Loss of Coolant system Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FM-96 Liquid Cooling System Hardware Failure	4	EC-05 Module Therm Mgmnt: Thermal management at the model scale including effectiveness of system HVAC at this level, passive materials, fans and liquid cooling	5	1	RA-17: Knowledge of failure condition for active mitigation and response management. RA-05: Auto System S/D	Wartsila/Duke/Pike	AC-01: EOP - System operator plan to handle all emergency events. RA-05: Auto System S/D	5	5	4	1

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Project Manager: Mr.James Whalen

Design Responsibility: Empire II, LLC and BESS OEM

Design Basis: Assumed Typical LFP BESS Project Documents

Prepared by: Robert Steele, PhD.

FMEA Date (Orig.): 23 July 2025

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
													Mitigative measures defined in Nebo SOPs & EOPs and O&M Manuals				

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.1	1.1.1.1	UPS Output fails to zero/ Unhealthy non-zero	BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	5	FC-31 Elec Risks, Hazardous Voltage Condition: This could include high line voltages, high voltages from the PCS, floating ground issues, or other high voltage issues at the cell, module or rack level	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	4	60	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions, Commissioning and Design Verification	5	3	4	60
	1.1.1.2		BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	5	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radio frequency interference (EMI/RFI) induced fault	2	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	4	40	RA-03: ESMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews_ performance requirement decomposition and verification RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiat	Wartsila Engineering	Credit given for implemented actions, Commissioning and Design Verification	5	3	4	60
	1.1.1.3		BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radio frequency interference (EMI/RFI) induced fault	3	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	90	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and	Wartsila Engineering	Credit given for implemented actions, Commissioning and Design Verification	5	2	3	30

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.1	1.1.1.4	UPS Output fails to zero/ Unhealthy non-zero	BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radio frequency interference (EMI/RFI) induced fault	3	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	90	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and	Wartsila Engineering	Credit given for implemented actions, Commissioning and Design Verification	4	3	3	36

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.2	1.1.2.1	Prolonged Exposure to External Environment	Increased battery temperature, reduced life and capacity , HVAC overload	Eventual BESS Unavailability Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-37 Misc Human Factors: Human induced failures due to negligence	5	AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	5	150	RA-16: SOP to handle any and all emergency events for firefighting RA-05: Auto System S/D	Wartsila Project Management	RA-05: Auto System S/D upon opening of Battery Enclosure Doors (hard wired switches)	5	3	3	45
	1.1.2.2		Increased battery temperature, reduced life and capacity , HVAC overload	Eventual BESS Unavailability Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-37 Misc Human Factors: Human induced failures due to negligence	5	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	5	150	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	RA-05: Auto System S/D upon opening of Battery Enclosure Doors (hard wired switches)	5	2	3	30

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.3	1.1.3.1	Thermal Management System fails during operation	Delayed thermal management system Reaction	Cascading Fire and BESS Loss Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	7	EC-12 Thermal Management: BYD Thermal Management Water Injection Unit Direct Injection to mitigate TRA	4	90	RA-33: Construction Contractor Installation and Commissioning RA-12: Inclusion of additional engineering controls	Wartsila Engineering	RA-16: EOP to handle any and all emergency events for firefighting	8	6	3	36
	1.1.3.2		Insufficient Quantity of Coolant	Cascading Fire and BESS Loss Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-39 Human Factors - Design Errors and Omissions	6	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	560	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice RA-33: Construction Contractor Installation and Commissioningr	Nebo ProjectTeam	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	6	3	5	90
	1.1.3.3		EMCU I/O Loss	Excessive Thermal Cycling Liquid Cooling System Degraded/Inoperable	8	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	4	EC-05 Module Therm Mgmnt: Thermal management at the model scale including effectiveness of system HVAC at this level, passive materials, fans and liquid cooling	6	420	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	Nebo Project Team	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes AC-01: EOP - System operator plan to handle all emergency events.	5	4	4	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.4	1.1.4.1	Protection Against System Overcurrent/Shock	Protection Against External Fault	System Level Short Circuit Current Contribution Rapid Cell Discharge Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-31 Elec Risks, Hazardous Voltage Condition: This could include high line voltages, high voltages from the PCS, floating ground issues, or other high voltage issues at the cell, module or rack level	4	EC-22 Site Elec Prot: Protection for electrical systems such that a failure of the PCS or associated circuit does not result in adverse effects on the site balance of system electrical gear	6	192	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540)	Wartsila Engineering	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	6	2	6	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.5	1.1.5.1	Key System/Subsystem Status	BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Moderate Effect - Moderate degradation of product performance;	5	FC-31 Elec Risks, Hazardous Voltage Condition: This could include high line voltages, high voltages from the PCS, floating ground issues, or other high voltage issues at the cell, module or rack level	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolati on capabilities of the affected BMS/module or system if necessary.	4	1	RA-17: Knowledge of failure condition for active mitigation and response management. RA-05: Auto System S/D	Pike/Duke/Wartsila	AC-01: EOP - System operator plan to handle all emergency events. RA-05: Auto System S/D Mitigative measures defined in Nebo SOPs & EOPs and O&M Manuals	3	2	3	1
	1.1.5.2		BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Moderate Effect - Moderate degradation of product performance;	5	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radi o frequency interference	2	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	4	1	EC-31 EMCU/BMS CTRL: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	Nebo Project Team	RA-30: Nebo Design Engineering performing detailed design reviews resulting in design changes RA-16: SOP to handle any and all emergency events for firefighting	3	2	3	1
	1.1.5.3		BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Moderate Effect - Moderate degradation of product performance;	5	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radi o frequency interference	3	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	1	EC-31 EMCU/BMS CTRL: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors RA-05: Auto System S/D	Nebo Project Tea,m	RA-30: Neboo Design Engineering performing detailed design reviews resulting in design changes RA-16: SOP to handle any and all emergency events for firefighting	4	2	4	1

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.1.5	1.1.5.4	Key System/Subsystem Status	BESS trip if UPS output falls to zero or below threshold. Strings lost if output falls unhealthy (Non-zero)	Moderate Effect - Moderate degradation of product performance;	5	FC-64 Operating Outside of Specification: A failure resulting from the fact that the failed system was operating outside of specifications (e.g., high voltage surge caused by lightning, electromagnetic/radio frequency interference	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation on capabilities of the affected BMS/module or system if necessary.	5	1	EC-31 EMCU/BMS CTRL: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors RA-05: Auto System S/D	Nebo Project Team	RA-30: Nebo Design Engineering performing detailed design reviews resulting in design changes RA-05: Auto System S/D Mitigative measures defined in Nebo SOPs & EOPs and O&M Manuals	4	2	4	1

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1.1.6	1.1.6.1	GridSolv Energy Segment Flooding	Loss of Cooling	Liquid Cooling System Degraded/Inoperable Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	EC-03 Liquid Cooling : Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	4	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	4	1	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing	Wartsila	Presently an Unmitigated Risk	5	3	4	1
	1.1.6.2		Battery Module Overtemperature Shutdown	Thermal Abuse System Overtemperature Trip	9	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	5	1	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing	Wartsila	Presently an Unmitigated Risk	5	4	4	1
	1.1.6.3		Degraded System Operation	Excessive Thermal Cycling	6	EC-03 Liquid Cooling : Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	4	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	4	1	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing	Wartsila	Presently an Unmitigated Risk	5	3	4	1

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2	1.2.1	Typical LFP Cell EVE 280 Ah	Degraded Current Output	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	Internal Component Failure - Equipment Lifecycle Failure	5	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	150	RA-03: ESMS Testing and Commissioning RA-04: BMS Testing and Commissioning RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions	5	4	3	60
	1.2.2		Eventual Cell Failure	Moderate Effect - Moderate degradation of product performance; Reduced Capacity	5	FC-19 Int Defect/Failure/Fault: A cell has failed as a result of an internal defect or dendrite formation, creating a short circuit, open circuit, or other electrical condition or off-gas but not entering thermal runaway	5	EC-20 Act Cell Prot: Active cell protections which may mitigate thermal runaway such as module fans, liquid cooling systems, module scale suppression systems, or other mitigation measures	5	125	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions	4	4	3	48
	1.2.3		Manufacturer Defect, Manufacturing Tooling Error/Drift	Reduced Capacity Eventual BESS Unavailability	5	FC-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	2	AC-05: Human Factors: Overall quality of the cell such that internal defects are minimized and cells maintain rigidity and shape during operations.	8	80	RA-01: Performance of Scheduled System Maintenance RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540	Wartsila Procurement and Commissioning	Embedded potential failure that may not be field detectable	4	3	3	36
	1.2.4		Thermal Runaway, Internal Cell Failure	Industrial Safety (Fire, Personnel) Issue	10	FC-17 Cell Therm Runaway: A single cell has entered thermal runaway resulting in flames and combustion or production of flammable or explosive gases	4	EC-20 Act Cell Prot: Active cell protections which may mitigate thermal runaway such as module fans, liquid cooling systems, module scale suppression systems, or other mitigation measures	8	320	RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance RA-04: BMS Testing and Commissioning	Wartsila Engineering	Credit given for implemented actions	7	4	3	84

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2	1.2.5	Typical LFP Cell EVE 280 Ah	Electrical Abuse	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-03 Module Failure: Hazardous Temperature Condition - Module. High temperature in the module during normal operation without failure/thermal runaway	5	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	175	RA-08: Cell Thermal Abuse Tolerance RA-04: BMS Testing and Commissioning RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.1	1.2.1.1	Reduced Battery Life	Reduction in Battery Performance	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	7	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	6	126	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	5	3	2	30
	1.2.1.2		Reduction in Battery Performance	Reduced Capacity Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	4	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	5	160	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.2.1.3		Reduction in Battery Performance	Reduced Capacity Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	3	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	3	63	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.2.1.4		Reduction in Battery Performance	Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	3	EC-20 Act Cell Prot: Active cell protections which may mitigate thermal runaway such as module fans, liquid cooling systems, module scale suppression systems, or other mitigation measures	5	90	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.1	1.2.1.5	Reduced Battery Life	Reduction in Battery Performance	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	5	FC-39 Human Factors - Design Errors and Omissions, wrong set point from unit controller	3	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	3	45	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	4	3	3	36
	1.2.1.6		Reduction in Battery Performance	Reduced Capacity Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway, battery imbalance, variation and different rate of deterioration	4	EC-19 Adequate Sense/Cntrl: Aggregate of the ability of the BMS to detect cell imbalance and to properly return system to balance if possible.	5	140	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.2.1.7		Overall capacity reduction, end of life	Reduced Capacity Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	7	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	4	224	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	5	3	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.2	1.2.2.1	Cell degradation	Reduced Cell Level Performance, Number of charge/discharge cycles	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	6	Internal Component Failure - Electrical Abuse	5	EC-19 Adequate Sense/Cntrl: Aggregate of the ability of the BMS to detect cell imbalance and to properly return system to balance if possible.	5	150	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for actions taken	5	3	3	45
	1.2.2.2		Reduced Cell Level Performance, Overcharge/Discharge	Reduced Capacity Electrical Abuse Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	5	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	175	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.2.2.3		Reduced Cell Level Performance, Number of charge/discharge cycles	Degraded Current Output Eventual Cell Failure Electrical Abuse Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Moderate Effect - Moderate degradation of product performance;	7	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	5	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	5	175	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.2.2.4		Low Cell Charging, BMS Failure	Eventual Cell Failure Degraded Current Output Thermal Runaway, Internal Cell Failure Moderate Effect - Moderate degradation of product performance; Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	3	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	8	240	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.3	1.2.3.1	Battery Leakage	Impact, Dropping during assembly	Eventual Cell Failure Manufacturer Defect, Manufacturing Tooling Error/Drift Thermal Runaway, Internal Cell Failure Slight Effect - Slight degradation of product performance. Minor Effect - Minor degradation of product performance that generally does not require repair. Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-23 Ext/Envr Risk, Mechanical Shock/Drop - The system, rack or module is subject to mechanical shock or drop, mechanical jarring or damaging the system	3	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	8	240	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.4	1.2.4.1	Cell Damage	Manufacturing and Assembly	Eventual Cell Failure Degraded Current Output Thermal Runaway, Internal Cell Failure Moderate Effect - Moderate degradation of product performance;	10	FC-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	3	AC-05: Human Factors: Overall quality of the cell such that internal defects are minimized and cells maintain rigidity and shape during operations.	8	240	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-05: Auto System S/	Wartsila Engineering and Procurement	Credit given for implemented actions	7	3	4	84
	1.2.4.2		Manufacturer Defect, Breakdown in Electrolyte Separator	Eventual Cell Failure Thermal Runaway, Internal Cell Failure Minor Effect - Minor degradation of product performance that generally does not require repair. Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	3	AC-05: Human Factors: Overall quality of the cell such that internal defects are minimized and cells maintain rigidity and shape during operations.	8	240	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-05: Auto System S/	Wartsila Engineering	Credit given for implemented actions	7	3	6	126
	1.2.4.3		High Resistance Short	Eventual Cell Failure Degraded Current Output	8	FC-41 Cell Damage: Battery Cell Internal Defect/Contamination or External Short	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	8	192	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-05: Auto System S/	Wartsila Engineering	Credit given for implemented action	6	3	7	126
	1.2.4.4		Low Resistance Short - Electrical	Eventual Cell Failure Degraded Current Output	8	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	8	192	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-05: Auto System S/D RA-04: BMS Testing and Commissioning	Wartsila Engineering	Credit given for implemented action	6	3	6	108

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.2.4	1.2.4.5	Cell Damage	Low Resistance Short - Thermal	Degraded Current Output Eventual Cell Failure Thermal Runaway, Internal Cell Failure	10	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway	6	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	300	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-05: Auto System S/D RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	7	4	3	84
	1.2.4.6		Internal Pressure Increase/Expansion	Thermal Runaway, Internal Cell Failure Eventual Cell Failure Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-21 Cell Pressure Increase: A cell has begun to build internal pressure as a result of gas generation. The cell has not yet failed or vented this gas.	5	EC-02 Cell Thermal Management: Active and passive controls put in place to manage cell temperature. Includes passive materials like Phase change material, module fans, liquid cooling system or passive systems dependent on system HVAC	8	400	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-05: Auto System S/D RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	7	4	3	84

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3	1.3.1	Typical LFP Battery Module	Degraded Current Output	Serious Effects - Product is inoperable but safe, or a system is inoperable but safe. Reduced Capacity Eventual BESS Unavailability	8	FC-19 Int Defect/Failure/Fault: A cell has failed as a result of an internal defect or dendrite formation, creating a short circuit, open circuit, or other electrical condition or off-gas but not entering thermal runaway	5	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	3	120	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1973/9540/A)	Wartsila Engineering	Credit given for implemented actions	8	4	3	96
	1.3.2		Uneven Cooling within Module	Eventual BESS Unavailability Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-42 Module Internal Cooling Failure	4	EC-05 Module Therm Mgmnt: Thermal management at the model scale including effectiveness of system HVAC at this level, passive materials, fans and liquid cooling	4	128	RA-04: BMS Testing and Commissioning RA-08: Cell Thermal Abuse Tolerance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-26: Container thermal man	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.3.3		Thermal Runaway/Fire	Industrial Safety (Fire, Personnel) Issue Hazardous Effects with Indication	10	FC-18 Multi Cell Therm Runaway: Multiple cells have entered thermal runaway or begun burning	6	EC-12 Gas Phase Supr: Novec, FM-200, inert gas or aerosolized gas-based agent designed for fire suppression	7	420	RA-08: Cell Thermal Abuse Tolerance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	7	4	4	112
	1.3.4		Thermal Abuse, Loss of Coolant/TMS	Eventual BESS Unavailability Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-42 Module Internal Cooling Failure	5	EC-32 BMS S/D: Ability of the BMS to isolate affected modules or strings without shutting down the entire system if unneeded	3	120	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	6	4	3	72
	1.3.5		Compression Forces on Adjacent Cells	Reduced Capacity Eventual BESS Unavailability Industrial Safety (Fire, Personnel) Issue Hazardous Effects with Indication	10	FC-21 Cell Pressure Increase: A cell has begun to build internal pressure as a result of gas generation. The cell has not yet failed or vented this gas.	5	EC-35 Cell Passive Protection: High pressure release of gasses (venting)	7	350	RA-04: BMS Testing and Commissioning RA-08: Cell Thermal Abuse Tolerance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-26: Container thermal manage	Wartsila Engineering	Credit given for implemented actions	8	4	5	160

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
											RA-26: Container thermal manage						
1.3	1.3.6	Typical LFP Battery Module	Eventual Cascading Compression Forces	Industrial Safety (Fire, Personnel) Issue Reduced Capacity Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	10	FC-21 Cell Pressure Increase: A cell has begun to build internal pressure as a result of gas generation. The cell has not yet failed or vented this gas.	4	EC-32 BMS S/D: Ability of the BMS to isolate affected modules or strings without shutting down the entire system if unneeded	8	320	RA-04: BMS Testing and Commissioning RA-08: Cell Thermal Abuse Tolerance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-26: Container thermal man	Wartsila	Credit given for implemented actions	8	3	6	144
	1.3.7		Manufacturing and Assembly Induced Failures	Reduced Capacity Eventual BESS Unavailability Slight Effect - Slight degradation of product performance.	7	FC-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	5	AC-06: Human Factors: Quality control or other processes put in place to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling	3	105	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-29: Thermal protections inside the battery compartment which would limit module fire/thermal exposure	Wartsila Engineering	Credit given for implemented actions	5	3	2	30
	1.3.8		Field Assembly Induced Failures	Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	84	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3	1.3.9	Typical LFP Battery Module	Cell Short Circuit	Industrial Safety (Fire, Personnel) Issue Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	10	FC-41 Cell Damage: Battery Cell Internal Defect/Contamination or External Short	3	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	5	150	RA-01: Performance of Scheduled System Maintenance RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-03: ESMS Testing and Commissioning RA-04: BMS Testing and CxA	Wartsila	Credit given for implemented actions	8	2	3	48
	1.3.10		Introduction of Grounding Pathway	Reduced Capacity Industrial Safety (Fire, Personnel) Issue Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-36 Elec Risks, Electrical Design Failure: Overall bad design that allows ground loops, floating, voltages, etc which would force errors.	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	5	150	RA-01: Performance of Scheduled System Maintenance RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	Credit given for implemented actions	8	2	3	48
	1.3.11		Electrical Abuse	Reduced Capacity Eventual BESS Unavailability Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	Internal Component Failure - Electrical Abuse	5	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	5	200	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-03: ESMS Testing and Commissioning RA-04: BMS Testing and Commissioning	Wartsila Engineering	Credit given for implemented actions	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.1	1.3.1.1	Inadequate cooling	Reduced Battery Life , Increased Temp, Excessive current	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-19 Int Defect/Failure/Fault: A cell has failed as a result of an internal defect or dendrite formation, creating a short circuit, open circuit, or other electrical condition or off-gas but not entering thermal runaway	4	EC-05 Module Therm Mgmnt: Thermal management at the model scale including effectiveness of system HVAC at this level, passive materials, fans and liquid cooling	3	84	RA-01: Performance of Scheduled System Maintenance RA-04: BMS Testing and Commissioning RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.3.1.2		Reduced Battery Life , Increased Temp.loose electrical connection	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Moderate Effect - Moderate degradation of product performance;	6	FC-08 Elect Hotspot: Loose connections in the system may increase resistance and cause hotspots. Hotspots may form in other ways for unknown reasons.	4	AC-05: Human Factors: Overall quality of the cell such that internal defects are minimized and cells maintain rigidity and shape during operations.	3	72	RA-01: Performance of Scheduled System Maintenance RA-04: BMS Testing and Commissioning RA-08: Cell Thermal Abuse Tolerance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.3.1.3		Reduced Battery Life , Increased Temp. Coolant/TMS Controller failure	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	3	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	3	63	RA-29: Thermal protections inside the battery compartment which would limit module fire/thermal exposure RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	2	2	24
	1.3.1.4		Reduced Battery Life , Increased Temp. IO sensor failure	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	EC-19 Adequate Sense/Cntrl: Aggregate of the ability of the BMS to detect cell imbalance and to properly return system to balance if possible.	3	84	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	2	3	36

Prepared by: Robert Steele, PhD.

FMEA Date (Orig.): 23 July 2025

Empire II, LLC

12302 Exposition Blvd | Los Angeles, CA 90068

Project Manager: Mr.James Whalen

Design Responsibility: Empire II, LLC and BESS OEM

Design Basis: Assumed Typical LFP BESS Project Documents

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.1	1.3.1.5	Inadequate cooling	Reduced Battery Life , Increased Temp. Over voltage/ overcharging	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	3	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	3	63	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.3.1.6		Reduced Battery Life , Increased Temp/Coolant/TMS failure	Reduced Capacity Thermal Abuse, Loss of Coolant/TMS Moderate Effect - Moderate degradation of product performance;	7	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	3	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	2	42	RA-06: Redundant HVAC Units RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	6	2	2	24

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.2	1.3.2.1	Loose electrical connection in one battery	Reduced Battery Life , May lead to Temperature hotspot,Structural Vibrations	Reduced Capacity Minor Effect - Minor degradation of product performance that generally does not require repair.	6	FC-23 Ext/Envr Risk, Mechanical Shock/Drop - The system, rack or module is subject to mechanical shock or drop, mechanical jarring or damaging the system	4	EC-23 ESS Cont Struct: Resiliency of the system and container of the system to withstand impacts or strikes	5	120	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.3.2.2		Reduced Battery Life , May lead to Temperature hotspot, Corrosion at junction	Reduced Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	Internal Failure - Electrical (Corrosion)	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	90	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	6	3	3	54
	1.3.2.3		Reduced Battery Life , May lead to Temperature hotspot, Poor workmanship;	Reduced Capacity Moderate Effect - Moderate degradation of product performance;	6	FC-37 Misc Human Factors: Human induced failures due to negligence	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	90	RA-01: Performance of Scheduled System Maintenance,	Wartsila Engineering/O&M Provider	RA-01: Performance of Scheduled System Maintenance	5	3	2	30

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.2	1.3.2.4	Loose electrical connection in one battery	Reduced Battery Life , May lead to Temperature hotspot, Short Circuit Introduction	Degraded Current Output Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-08 Elect Hotspot: Loose connections in the system may increase resistance and cause hotspots. Hotspots may form in other ways for unknown reasons.	3	EC-20 Act Cell Prot: Active cell protections which may mitigate thermal runaway such as module fans, liquid cooling systems, module scale suppression systems, or other mitigation measures	5	120	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila/O&M Provider	RA-01: Performance of Scheduled System Maintenance	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.3	1.3.3.1	Uneven rate of cell degradation -- Different cells at different timing	BMS Failure to control Module, Loss of Communication	Degraded Current Output Uneven Cooling within Module Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	3	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	8	192	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.4	1.3.4.1	Battery catches fire	Electrical Abuse,Too many deep cycle charge/discharge	Thermal Runaway/Fire Hazardous Effects with Indication	10	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway	6	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	8	480	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-11: FSS Testing, Commissioning, and Analysis	Wartsila Engineering	RA-13: Implementation of the NFPA 68 Deflagratrion Protection Measures	5	3	3	45
	1.3.4.2		Thermal Abuse, LTA Environmental Control	Thermal Runaway/Fire Hazardous Effects with Indication	10	FC-04 Haz Internal Temp: High temperature in the room from normal operations	3	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	4	120	RA-07: Environmental Temperature Monitoring and Alarms RA-09: Module Thermal Management RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.5	1.3.5.1	Indvidual Cell Failure/Expansion	Compression forces on adjacent cells, Individual Cell Failure/Internal Pressure Development	Compression Forces on Adjacent Cells Eventual Cascading Compression Forces Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-21 Cell Pressure Increase: A cell has begun to build internal pressure as a result of gas generation. The cell has not yet failed or vented this gas.	3	EC-35 Cell Passive Protection: High pressure release of gasses (venting)	7	210	RA-08: Cell Thermal Abuse Tolerance RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	7	3	6	126

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.6	1.3.6.1	External Forces Damage	Manufacturing and Assembly, Unintentional Module Housing Damage	Degraded Current Output Moderate Effect - Moderate degradation of product performance;	8	FC-22 Ext/Envr Risk, Impact - Something has struck, sharply or as blunt force, the battery system, causing mechanical damage or deformation	2	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	4	64	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional	CATL/Wartsila Project Forces	Credit given for QA and Commissioning and training	7	3	3	63
	1.3.6.2		Introduction of Debris, Manufacturing QA Oversight	Degraded Current Output Manufacturing and Assembly Induced Failures Moderate Effect - Moderate degradation of product performance;	8	FC-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	5	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	3	120	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional	CATL/Wartsila Project Forces	Credit given for QA, CxA, and Training	8	3	2	48
	1.3.6.3		Introduction of Debris, Module Cooling System Entrainment	Uneven Cooling within Module Degraded Current Output Moderate Effect - Moderate degradation of product performance;	8	FC-29 Ext/Envr Risk, Dust/Dirt/Particulate Accumulation: LTA Maintenance	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	72	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional	Wartsila Project Forces	Credit given for CxA/Training	6	3	3	54
	1.3.6.4		Rack Field Assembly, Drop, Impact	Field Assembly Induced Failures Degraded Current Output Minor Effect - Minor degradation of product performance that generally does not require repair.	8	FC-22 Ext/Envr Risk, Impact - Something has struck, sharply or as blunt force, the battery system, causing mechanical damage or deformation	3	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other mechanical abuse	3	72	RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of t	Wartsila Project CxA	Credit given for QA, CxA, and Training	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.6	1.3.6.5	External Forces Damage	Manufacturing and Assembly, Internal Creepage and Clearance during transport and assembly	Field Assembly Induced Failures Compression Forces on Adjacent Cells Degraded Current Output Minor Effect - Minor degradation of product performance that generally does not require repair.	10	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	180	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila CxA	Credit given for QA, CxA, and Training	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.7	1.3.7.1	Debris Entrainment	Accumulation of Conductive Solids, Coolant Failure	Cell Short Circuit Introduction of Grounding Pathway Minor Effect - Minor degradation of product performance that generally does not require repair.	10	FC-29 Ext/Envr Risk, Dust/Dirt/Particulate Accumulation: LTA Maintenance	3	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	5	150	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Provider	RA-01: Performance of Scheduled System Maintenance	7	2	3	42

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.8	1.3.8.1	Electrical Abuse	BMS Failure to control Module, Excessive Discharge	Electrical Abuse Degraded Current Output Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	5	160	RA-08: Cell Thermal Abuse Tolerance RA-04: BMS Testing and Commissioning RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.3.8.2		BMS Failure to control Module, Excessive Overcharge	Electrical Abuse Degraded Current Output Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-44 Module Failure: Loss of BMS Control	4	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	5	160	RA-08: Cell Thermal Abuse Tolerance RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.3.9	1.3.9.1	Thermal Abuse	BMS Failure to control Module, LTA Module Environmental Control	Thermal Abuse, Loss of Coolant/TMS Degraded Current Output Uneven Cooling within Module Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-04 Haz Internal Temp: High temperature in the room from normal operations	6	EC-03 ESS HVAC: Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	5	240	RA-09: Module Thermal Management RA-06: Redundant HVAC Units RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.4	1.4.1	Typical Battery Assembly/Enclosure	Excessive/Fast Discharge	ESMS/BMS Control Failure Reduced Capacity	9	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	3	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	7	189	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate	Wartsila Engineering	Credit given for implemented action	6	3	3	54
	1.4.2		Step-Touch Potential	Industrial Safety (Fire, Personnel) Issue	10	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	3	EC-28 Insul Monitoring: Continual, or active, monitoring of insulation integrity, ground v float voltage, and other practices to prevent insulation or isolation degradation	5	150	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Provider	RA-01: Performance of Scheduled System Maintenance	6	3	3	54
	1.4.3		Stray Ground Currents	Eventual BESS Unavailability Reduced Capacity Industrial Safety (Fire, Personnel) Issue	10	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	3	EC-28 Insul Monitoring: Continual, or active, monitoring of insulation integrity, ground v float voltage, and other practices to prevent insulation or isolation degradation	5	150	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Provider	RA-01: Performance of Scheduled System Maintenance	6	3	3	54
	1.4.4		Exothermic Reaction - Fire	Industrial Safety (Fire, Personnel) Issue Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-18 Multi Cell Therm Runaway: Multiple cells have entered thermal runaway or begun burning	5	EC-10 Therm Isolation/Protection: Thermal protections inside the battery compartment which would limit module fire/thermal exposure	7	350	RA-21: Wartsila ESMS Software controls monitors to safely detect system degradation RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-17: Knowledge of failure condition for active mitigation and response management.	Wartsila Project Team	RA-17: Knowledge of failure condition for active mitigation and response management.	6	4	5	120

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.4.1	1.4.1.1	Late isolation of short circuit fault (sensing time to reaction time)	LTA Overcurrent Protection, Design Induced Failure	Excessive/Fast Discharge Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Moderate Effect - Moderate degradation of product performance;	9	FC-39 Human Factors - Design Errors and Omissions	3	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	189	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.4.2	1.4.2.1	Insufficient Rack Grounding	Insufficient Bonding/Grounding/Earthing, Field Assembly	Step-Touch Potential Stray Ground Currents Moderate Effect - Moderate degradation of product performance;	7	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	3	AC-10 Human Factors/NRTL: Throughout UL1973, UL9540, UL1741 and other US standards are a number of requirements for product analysis and review including FMEAs, SIL/LOPAs, and other failure modes and safety analysis.	5	105	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	Credit given for implemented actions	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.4.3	1.4.3.1	Fire from Electrical Abuse	Single Cell Failure - Combustion: A single cell has failed and is now producing flame or combusting	Thermal Runaway/Fire Electrical Abuse Compression Forces on Adjacent Cells Exothermic Reaction - Fire	10	FC-17 Cell Therm Runaway: A single cell has entered thermal runaway resulting in flames and combustion or production of flammable or explosive gases	4	EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection	8	320	RA-12: Inclusion of additional engineering controls for the GridSolv that include Hydrogen Detection and Control System Response to Ventilate the BESS RA-13: Implementation of the Jensen Hughes NFPA 69 Explosion Mitigation Measures	Wartsila/AFT	RA-13: Implementation of the NFPA 68 Deflagratrion Protection Measures	5	3	6	90
	1.4.3.2		Single Cell Failure - Off gas: A single cell has failed or entered thermal runaway and is now producing off-gas	Exothermic Reaction - Fire Thermal Runaway/Fire Compression Forces on Adjacent Cells Electrical Abuse	10	FC-19 Int Defect/Failure/Fault: A cell has failed as a result of an internal defect or dendrite formation, creating a short circuit, open circuit, or other electrical condition or off-gas but not entering thermal runaway	4	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	8	320	RA-12: Inclusion of additional engineering controls for the GridSolv that include Hydrogen Detection and Control System Response to Ventilate the BESS RA-13: Implementation of the Jensen Hughes NFPA 69 Explosion Mitigation Measures	Wartsila/AFT	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	6	3	5	90
	1.4.3.3		Single Cell Failure - Fire/Combustion	Exothermic Reaction - Fire Thermal Runaway/Fire Compression Forces on Adjacent Cells Eventual Cascading Compression Forces	10	FC-19 Int Defect/Failure/Fault: A cell has failed as a result of an internal defect or dendrite formation, creating a short circuit, open circuit, or other electrical condition or off-gas but not entering thermal runaway	4	AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	8	320	RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-17: Knowledge of failure condition for active mitigation and response management. RA-19: Implementation of inert gas or aerosolized gas-based agent designed for fire suppression	Wartsila/AFT	RA-16: SOP/EOPs to handle any and all emergency events for firefighting	6	3	5	90
	1.4.3.4		Multicell/Module Failure - Combustion: Multiple cells have failed or entered thermal runaway, resulting in a propagating fire or combustion up to a full module fire	Exothermic Reaction - Fire Industrial Safety (Fire, Personnel) Issue Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-17 Cell Therm Runaway: A single cell has entered thermal runaway resulting in flames and combustion or production of flammable or explosive gases	4	EC-12 Gas Phase Supr: Novec, FM-200, inert gas or aerosolized gas-based agent designed for fire suppression	9	360	RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-17: Knowledge of failure condition for active mitigation and response management. RA-19: Implementation of inert gas or aerosolized gas-based agent designed for fire suppression	Wartsila/AFT	RA-16: SOP/EOPs to handle any and all emergency events for firefighting	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.4.3	1.4.3.5	Fire from Electrical Abuse	Multicell/Module Failure - Off-gas: Multicell/Module Failure - Off-gas	Exothermic Reaction - Fire Industrial Safety (Fire, Personnel) Issue Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-18 Multi Cell Therm Runaway: Multiple cells have entered thermal runaway or begun burning	4	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	10	400	RA-13: Implementation of the Jensen Hughes NFPA 69 Explosion Mitigation Measures RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-20: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke	Wartsila/AFT	RA-25: Structured Wartsila Design Reviews performance requirement decompositi on and verification	6	3	5	90
	1.4.3.6		Multi Module/Rack Fire: Multiple modules have begun burning, resulting in a growing fire which may overcome internal suppression capabilities	Exothermic Reaction - Fire Industrial Safety (Fire, Personnel) Issue Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-18 Multi Cell Therm Runaway: Multiple cells have entered thermal runaway or begun burning	4	EC-12 Gas Phase Supr: Stat-X or inert gas or aerosolized gas-based agent designed for fire suppression	10	400	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-16: SOP/EOPs to handle any and all emergency even	Wartsila/AFT	RA-16: SOP/EOPs to handle any and all emergency events for firefighting	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5	1.5.1	Typical BESS Battery Management Unit Failure	Failure to Measure Battery Module/Cell Temperatures	Reduced Capacity Eventual BESS Unavailability	7	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	140	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.5.2		Failure to Measure Battery Ampacity Charging/Discharging	Reduced Capacity Eventual BESS Unavailability	6	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	4	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	5	120	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	Credit give for implemented actions	5	3	3	45
	1.5.3		Energy Abuse	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	5	EC-27 Inv/PCS Cntrl: Includes monitoring, shutdown/isolation capabilities. and transient protections	5	225	RA-03: ESMS Testing and Commissioning RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verific	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	3	5	90
	1.5.4		Failure to Measure Cell Voltage	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	135	RA-03: ESMS Testing and Commissioning RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decomposition an	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5	1.5.5	Typical BESS Battery Management Unit Failure	Failure to Control Cell/Module/Rack	Reduced Capacity ESMS/BMS Control Failure Eventual BESS Unavailability	9	FC-16 ESMS/BMS Bal Fail: Failure of the system at the cell, module, or rack level to maintain balance, resulting in unstable or unbalanced system. This will result in premature end of life condition or adverse safety condition	6	EC-32 BMS S/D: Ability of the BMS to isolate affected modules or strings without shutting down the entire system if unneeded	7	378	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	4	4	96
	1.5.6		Fieldbus/Modbus Failure	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	6	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	7	378	RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-27: Proper training procedures, availability of subject matter expe	Wartsila	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.1	1.5.1.1	Sensor Failures	I/O Thermocouple wiring fails open, Manufacturing Defects	Batteries overheat, potential for off-gas Failure to Measure Battery Module/Cell Temperatures	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	2	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	9	180	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managi	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.5.1.2		Overcharging CT Failure, End of Design Life, External Short Influenced Failure	Failure to Measure Battery Ampacity Charging/Discharging Battery Management System (BMS) Failure Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	84	RA-01: Performance of Scheduled System Maintenance RA-17: Knowledge of failure condition for active mitigation and response management. RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdi	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	5	3	3	45
	1.5.1.3		Imbalance charging of cells/modules, Subcomponent failure	Energy Abuse Battery Management System (BMS) Failure	9	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	6	162	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.1	1.5.1.4	Sensor Failures	Voltage Sensor, End of Design Life	Failure to Measure Cell Voltage Battery Management System (BMS) Failure Moderate Effect - Moderate degradation of product performance;	9	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	3	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	5	135	RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.5.1.5		Instrument drift out of tolerance, LTA Maintenance	Failure to Measure Battery Module/Cell Temperatures Failure to Measure Battery Ampacity Charging/Discharging Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-37 Misc Human Factors: Human induced failures due to negligence	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	140	RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.2	1.5.2.1	BMS Software Failures	Failure to Operate, Software Induced Error	Fieldbus/Modbus Failure Failure to Control Cell/Module/Rack	9	FC-45 Loss of BMS due to Software Induced Problem/Failure	6	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	432	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdicti	Wartsila Project	RA-22: Wartsila BMS Software controls interconnect ed modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	4	4	112

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.2.1	1.5.2.1.1	BMS software error allows continuous operation	Software coding does not command performance	Failure to Operate Battery Management System (BMS) Failure Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-45 Loss of BMS due to Software Induced Problem/Failure	4	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	256	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	6	3	5	90
	1.5.2.1.2		Software Fails to respond to voltage/current data, Human/Electrical induced failure	Imbalance charging of cells/modules, Subcomponent failure Battery Management System (BMS) Failure Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	9	FC-39 Human Factors - Design Errors and Omissions	5	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	225	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.2.2	1.5.2.2.1	BMS software error does not allow continuous operation	Coding - Failure to Operate	Failure to Operate, Software Induced Error Software Errors, Software Programming, PLC error Battery Management System (BMS) Failure Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	10	FC-39 Human Factors - Design Errors and Omissions	6	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	480	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-17: Knowledge of failure condition for active mitigation and response management.	Wartsila Project	Credit given for implemented actions	7	4	5	140

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.3.1	1.5.3.1.1	BMS Contactor /Disconnect fails to interrupt	Contactor energize or de-energize, Failed Relay Coil	Failure to Operate Batteries overheat, potential for off-gas	10	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	320	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	4	72
	1.5.3.1.2		Individual contacts welded, No positive guidance of contacts (for relays this failure is not assumed if they are built and tested according to EN 50205 or equivalent)	Failure to Operate Batteries overheat, potential for off-gas Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	224	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	4	72
	1.5.3.1.3		No positive opening (for position switches this failure is not assumed if they are built and tested according to IEC 60947-5-1, or equivalent), Failed sub-component	Failure to Operate Battery Management System (BMS) Failure Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	6	168	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.5.4	1.5.4.1	BMS power supply failure	Loss of external 24VDC Power, Component I/O failure	Energy Abuse Failure to Control Cell/Module/Rack Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	6	240	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.5.4.2		External Communication Failure - not transmitting data	Failure to Control Cell/Module/Rack Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Fieldbus/Modbus Failure	9	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	4	144	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6	1.6.4	Typical BESS Battery Management Unit Failure	Failure to Measure Battery Module/Cell Temperatures	Reduced Capacity Eventual BESS Unavailability	7	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	140	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	1.6.5		Failure to Measure Battery Ampacity Charging/Discharging	Reduced Capacity Eventual BESS Unavailability	6	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	4	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	5	120	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	Credit give for implemented actions	5	3	3	45
	1.6.6		Energy Abuse	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-32 Elec Risks, Hazardous Current Condition: This includes high current issues from the PCS or interconnection	5	EC-27 Inv/PCS Cntrl: Includes monitoring, shutdown/isolation capabilities. and transient protections	5	225	RA-03: ESMS Testing and Commissioning RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verific	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	3	5	90
	1.6.7		Failure to Measure Cell Voltage	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	5	135	RA-03: ESMS Testing and Commissioning RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decomposition an	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6	1.6.8	Typical BESS Battery Management Unit Failure	Failure to Control Cell/Module/Rack	Reduced Capacity ESMS/BMS Control Failure Eventual BESS Unavailability	9	FC-16 ESMS/BMS Bal Fail: Failure of the system at the cell, module, or rack level to maintain balance, resulting in unstable or unbalanced system. This will result in premature end of life condition or adverse safety condition	6	EC-32 BMS S/D: Ability of the BMS to isolate affected modules or strings without shutting down the entire system if unneeded	7	378	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-25: Structured Wartsila Design Reviews performance requirement decom	Wartsila Engineering	RA-03: ESMS Testing and Commissioning	6	4	4	96
	1.6.9		Fieldbus/Modbus Failure	ESMS/BMS Control Failure Eventual BESS Unavailability Reduced Capacity	9	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	6	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	7	378	RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-27: Proper training procedures, availability of subject matter expe	Wartsila	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	6	3	5	90

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1.6.5	1.6.5.1	Sensor Failures	I/O Thermocouple wiring fails open, Manufacturing Defects	Failure to Measure Battery Module/Cell Temperatures	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	2	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	9	180	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managi	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnect ed modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.6.5.2		Overcharging CT Failure, End of Design Life, External Short Influenced Failure	Failure to Measure Battery Ampacity Charging/Discharging	7	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	84	RA-01: Performance of Scheduled System Maintenance RA-17: Knowledge of failure condition for active mitigation and response management. RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdi	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnect ed modules within the GridSolv to safely detect system degradation and initiate S/D protocols	5	3	3	45
	1.6.5.3		Imbalance charging of cells/modules, Subcomponent failure	Energy Abuse	9	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	3	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolati on capabilities of the affected BMS/module or system if necessary.	6	162	RA-04: BMS Testing and Commissioning RA-01: Performance of Scheduled System Maintenance RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnect ed modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.5	1.6.5.4	Sensor Failures	Voltage Sensor, End of Design Life	Failure to Measure Cell Voltage	9	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	3	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	5	135	RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.6.5.5		Instrument drift out of tolerance, LTA Maintenance	Failure to Measure Battery Module/Cell Temperatures Failure to Measure Battery Ampacity Charging/Discharging	7	FC-37 Misc Human Factors: Human induced failures due to negligence	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	140	RA-05: Auto System S/D RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.6	1.6.6.1	BMS Software Failures	Failure to Operate, Software Induced Error	Fieldbus/Modbus Failure Failure to Control Cell/Module/Rack	9	FC-45 Loss of BMS due to Software Induced Problem/Failure	6	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	432	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdicti	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	4	4	112

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.6.1	1.6.6.1.1	BMS software error allows continuous operation	Software coding does not command performance		8	FC-45 Loss of BMS due to Software Induced Problem/Failure	4	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	256	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	6	3	5	90
	1.6.6.1.2		Software Fails to respond to voltage/current data, Human/Electrical induced failure	Imbalance charging of cells/modules, Subcomponent failure	9	FC-39 Human Factors - Design Errors and Omissions	5	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	225	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.6.2	1.6.6.2.1	BMS software error does not allow continuous operation	Coding - Failure to Operate	Failure to Operate, Software Induced Error	10	FC-39 Human Factors - Design Errors and Omissions	6	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	480	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-17: Knowledge of failure condition for active mitigation and response management.	Wartsila Project	Credit given for implemented actions	7	4	5	140

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.7.1	1.6.7.1.1	BMS Contactor /Disconnect fails to interrupt	Contactor energize or de-energize, Failed Relay Coil		10	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	320	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	4	72
	1.6.7.1.2		Individual contacts welded, No positive guidance of contacts (for relays this failure is not assumed if they are built and tested according to EN 50205 or equivalent)		8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	224	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	4	72
	1.6.7.1.3		No positive opening (for position switches this failure is not assumed if they are built and tested according to IEC 60947-5-1, or equivalent), Failed sub-component		7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	6	168	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.8	1.6.8.1	BMS power supply failure	Loss of external 24VDC Power, Component I/O failure	Energy Abuse Failure to Control Cell/Module/Rack	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	6	240	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	3	54
	1.6.8.2		External Communication Failure - not transmitting data	Failure to Control Cell/Module/Rack Fieldbus/Modbus Failure	9	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	4	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	4	144	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.7	1.6.1	Switchgear module	Failure to Operate	Partial/Total loss of capacity Failure to Operate Electrical fault resulting in unavailability	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	6	192	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	4	4	128
	1.6.2		Degraded Operation	Reduced Capacity Failure to Operate Partial/Total loss of capacity	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	4	128	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	1.6.3		Loss of Capability	Electrical fault resulting in unavailability Reduced Capacity	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	4	128	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.1	1.6.1.1	String Level Battery Management System	Failure to Operate, Software Induced Error		1	FC-45 Loss of BMS due to Software Induced Problem/Failure	6	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	6	36	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdicti	Wartsila Project	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	1	3	5	15

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.1.1	1.6.1.1.1	BMS software error allows continuous operation	Software coding does not command performance	Failure to Operate, Software Induced Error	7	FC-45 Loss of BMS due to Software Induced Problem/Failure	4	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	224	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	5	3	4	60
	1.6.1.1.2		Software Fails to respond to voltage/current data, Human/Electrical induced failure	Failure to Operate, Software Induced Error	8	FC-39 Human Factors - Design Errors and Omissions	5	AC-11 Human Factors/RAGAG: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	200	RA-05: Auto System S/D RA-17: Knowledge of failure condition for active mitigation and response management. RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Project	Credit given for implemented actions	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.1.2	1.6.1.2.1	BMS software error does not allow continuous operation	Coding - Failure to Operate	Failure to Operate, Software Induced Error	8	FC-39 Human Factors - Design Errors and Omissions	6	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	8	384	RA-04: BMS Testing and Commissioning RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-17: Knowledge of failure condition for active mitigation and response management.	Wartsila Project	Credit given for implemented actions	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.2	1.6.2.1	Manual Load Disconnect Switch	Failure to Operate	Failure to Operate Degraded Operation	8	FC-45 Loss of BMS due to Software Induced Problem/Failure	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	7	336	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	4	4	128
	1.6.2.2		Failure to Isolate Stranded Power	Degraded Operation Failure to Operate Loss of Capability	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	7	336	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	4	4	128

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.2.1	1.6.2.1.1	Broken wire	Module Load Break SW: Wiring error/failure, Fretting/Maintenance/Installation	Failure to Operate Failure to Isolate Stranded Power Partial/Total loss of capacity	7	FM-40 Human Factors, MFG Quality Control: MFG induced failures due to quality control	4	AC-10 Human Factors/NRTL: Throughout UL1973, UL9540, UL1741 and other US standards are a number of requirements for product analysis and review including FMEAs, SIL/LOPAs, and other failure modes and safety analysis.	7	196	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling	Wartsila Engineering	AC-10 Human Factors/NRTL: Throughout UL1973, UL9540, UL1741 and other US standards are a number of requirements for product analysis and review including FMEAs, SIL/LOPAs, and other failure modes and safety analysis.	5	3	4	60

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.2.2	1.6.2.2.1	Manual Load Disconnect SW Mechanism Failure	High Resistive Connection: Insufficient Voltage, Large Voltage Drop	Failure to Operate Failure to Isolate Stranded Power	7	FC-46 Subcomponent/Sub system Failure: Lifecycle failure of components impacting availability/capabilit y to execute intended design function	4	EC-24 Module Resiliency: Resiliency of the individual modules to withstand impacts, shocks or other Mechanical/Elect rical abuse	7	196	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	Credit given for implemented actions	5	3	4	60

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.3	1.6.3.1	String Level Fuse Protection	Premature Open, MFG Defect	Failure to Operate	8	FC-55 Manufacturer Defect, QA/QC	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	3	96	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	1.6.3.2		Failure to Interrupt Fault, Excessive SCA	Failure to Operate Degraded Operation Loss of Capability	8	FC-01: Electrical Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	6	192	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	4	72
	1.6.3.3		OCPD Failure to interrupt, Misapplication - Excessive SCA	Loss of Capability Failure to Operate	8	FC-39 Human Factors - Design Errors and Omissions	4	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	6	192	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	2	4	48

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.4	1.6.4.1	DC Contactor	Failure to Charge/Discharge Batteries, LTA Installation/ Maintenance	Failure to Operate	9	FC-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	324	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering/O&M Contractor	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	6	4	4	96
	1.6.4.2		Contactor Welding	Failure to Operate Electrical fault resulting in unavailability	8	FM-84 Internal Failure - Electrical (Corrosion) FM-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	4	EC-21 BMS CTRL: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	7	224	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	3	4	72
	1.6.4.3		Contactor energize or de-energize, Failed Relay Coil	Failure to Operate	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	256	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering/O&M Contractor	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-01: Performance of Scheduled System Maintenance	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.6.4	1.6.4.5	DC Contactor	No positive opening (for position switches this failure is not assumed if they are built and tested according to IEC 60947-5-1, or equivalent), Failed sub-component	Failure to Operate	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	6	192	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-01: Performance of Scheduled System Maintenance	6	3	5	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.8	1.7.1	Battey Management Control Unit (BMCU) Failure	Command/Control Failure	Failure to Operate Electrical fault resulting in unavailability	8	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	EC-36 Manual Shutdown: Ability of system to actively shut itself down or disconnect itself upon actuation	9	288	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-20: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmosp	Wartsila Engineering	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	6	3	5	90
	1.7.2		Delamination	Reduced Capacity Electrical fault resulting in unavailability Failure to Operate	8	FM-25 Ext/Envr Risk, Water Damage - Condensation: The system is subject to uncontrolled condensation of water via HVAC failure, inadequate design, internal condensation of moisture, or from natural reasons.	4	EC-36 Manual Shutdown: Ability of system to actively shut itself down or disconnect itself upon actuation	5	160	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	4	2	2	16
	1.7.3		Broken	Failure to Operate Electrical fault resulting in unavailability	8	FM-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	4	EC-36 Manual Shutdown: Ability of system to actively shut itself down or disconnect itself upon actuation	6	192	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	3	3	72
	1.7.5		Electrical Failure	Electrical fault resulting in unavailability Failure to Operate	8	FM-53 Elect Contact Fail: Internal Failure FM-60 High Resistive Contacts: Internal Failure - Electrical (High Resistive Contacts)	5	EC-36 Manual Shutdown: Ability of system to actively shut itself down or disconnect itself upon actuation	5	200	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-33: Construction Contractor Installation and Commissioning	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
1.8	1.7.4	Battey Management Control Unit (BMCU) Failure	Improper Output	Electrical fault resulting in unavailability ESMS/BMS Control Failure	9	FM-01: Electrical Failure FM-08 Elect Hotspot: Loose connections in the system may increase resistance and cause hotspots. Hotspots may form in other ways for unknown reasons.	4	EC-36 Manual Shutdown: Ability of system to actively shut itself down or disconnect itself upon actuation	3	108	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering/Commissioning Contractor	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	9	3	2	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2	2.1	Starlight Solar Project BESS Project Operating Thermal Management Maintains environment for battery operation and longevity; removes heat losses from batteries and container equipment	Failure to Operate	Hazardous Effects with Indication	9	FC-05 HVAC Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	6	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	5	270	RA-06: Redundant HVAC Units RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	Credit given for implemented actions	6	5	2	60
	2.2		Battery performance and output impacted	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-16 ESMS/BMS Balance Fail: Failure of the system at the cell, module, or rack level to maintain balance, resulting in unstable or unbalanced system. This will result in premature end of life condition or adverse safety condition	6	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	144	RA-03: ESMS Testing and Commissioning RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verificat	Wartsila Engineering	Credit given for implemented actions	6	4	1	24
	2.3		Loss of Coolant system	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	6	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	192	RA-05: Auto System S/D RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	Credit given for implemented actions	8	4	2	64
	2.4		Partial/Total loss of capacity	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	EC-03 ESS Thern Management: Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	6	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	144	RA-07: Environmental Temperature Monitoring and Alarms RA-05: Auto System S/D	Wartsila Engineering	Credit given for implemented actions	6	4	2	48

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1	2.1.1	Module Liquid Cooling Failures	Loss of Cooling	Loss of Coolant system Failure to Operate Battery performance and output impacted Partial/Total loss of capacity	9	EC-03 ESS Thermal Management: Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	6	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	5	270	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	2.1.2		Battery Module Overtemperature Shutdown	Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Partial/Total loss of capacity	7	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	210	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-09: Module Thermal Management	Wartsila Engineering	Credit given for implemented actions	7	4	3	84
	2.1.3		Degraded System Operation	Partial/Total loss of capacity Loss of Coolant system Failure to Operate	9	FC-05 Thermal Management Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	4	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	5	180	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.1	2.1.1.1	System Degradation: LTA Module Cooling	Cooling Medium, Less Than Adequate Design	Battery Module Overtemperature Shutdown Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Loss of Cooling	9	FC-39 Human Factors - Design Errors and Omissions	6	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	270	RA-04: BMS Testing and Commissioning RA-22: Wartsila GEMS BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-09: Module Thermal Management	Wartsila Engineering	Credit given for implemented actions	9	4	3	108
	2.1.1.2		Partial System Blockage, Fabrication and Installation	Moderate Effect - Moderate degradation of product performance; Loss of Cooling	9	FC-37 Misc Human Factors: Human induced failures due to negligence	2	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	126	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS GEMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-09: Module Thermal Management	Wartsila Engineering	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	6	4	4	96
	2.1.1.3		Compressor Failure	Moderate Effect - Moderate degradation of product performance; Loss of Cooling Battery Module Overtemperature Shutdown	9	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	270	RA-01: Performance of Scheduled System Maintenance RA-04: BMS Testing and Commissioning RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	8	4	4	128

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.1	2.1.1.4	System Degradation: LTA Module Cooling	Internal Blockage, LTA Maintenance, accumulation of debris	Battery Module Overtemperature Shutdown Moderate Effect - Moderate degradation of product performance;	7	FC-29 Ext/Envr Risk, Dust/Dirt/Particulate Accumulation: LTA Maintenance	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	5	105	RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	6	3	3	54
	2.1.1.5		Filtration Failure, LTA Maintenance	Moderate Effect - Moderate degradation of product performance; Loss of Cooling	9	FC-37 Misc Human Factors: Human induced failures due to negligence	6	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	3	162	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	6	4	3	72

Empire II, LLC

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Project Manager: Mr.James Whalen

Prepared by: Robert Steele, PhD.

FMEA Date (Orig.): 23 July 2025

Design Responsibility: Empire II, LLC and BESS OEM

Design Basis: Assumed Typical LFP BESS Project Documents

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.2	2.1.2.1	Loss of Coolant	System Leakage	Moderate Effect - Moderate degradation of product performance;	7	FC-26 Ext/Envr Risk, Corrosive Environment Exposure: Long term exposure of the system corrosive environment conditions that will result in long term corrosion with electrical activity	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	5	140	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	5	3	3	45
	2.1.2.2		Bad Soldering/Welds	Moderate Effect - Moderate degradation of product performance;	7	FC-37 Misc Human Factors: Human induced failures due to negligence	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	112	RA-28: QC or other processes to prevent mishandling of systems that may result in adverse or hazardous conditions or mishandling RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Project	Credit given for implemented actions	5	3	3	45
	2.1.2.3		Impact	Moderate Effect - Moderate degradation of product performance;	6	FC-37 Misc Human Factors: Human induced failures due to negligence	2	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	3	36	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.3	2.1.3.1	Compressor Failure	End of Design Life	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	5	EC-08 Thermal Management: Design, sizing, and hardware physical redundancy of the Coolant system such that failure of one or multiple units does not result in adverse conditions within the container or system	4	140	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	4	3	72
	2.1.3.2		Degraded System Operation	Battery Module Overtemperature Shutdown Moderate Effect - Moderate degradation of product performance;	7	FC-75 Degradation/Age related failure: Failures realized as part of programming lifecycle	3	EC-08 Thermal Management Design: Design, sizing, and hardwaresuch that failure of one or multiple unit does not result in adverse conditions within the container or system	5	105	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	6	3	4	72
	2.1.3.3		Loss of Refrigerant/Coolant	Battery Module Overtemperature Shutdown Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	140	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.3	2.1.3.4	Compressor Failure	Software/Firmware/Coding Failure to Start on Demand	Battery Module Overtemperature Shutdown Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-67 Hardware/Software Design Error: A failure that is traceable to an error in the design of the hardware and/or software	6	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	294	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	Credit given for implemented actions	6	4	4	96
	2.1.3.5		Cooling System Component Failure	Battery Module Overtemperature Shutdown Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	210	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Project	RA-26: Container/Rack thermal management and protections within container which would limit module fire/thermal exposure	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.4	2.1.4.1	Defective evaporator fan	End of Design Life	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Loss of Cooling	9	FC-75 Degradation/Age related failure: Failures realized as part of programming lifecycle	6	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	5	270	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	6	4	3	72
	2.1.4.2		Degraded System Operation, Cooling System Blockage	Moderate Effect - Moderate degradation of product performance; Degraded System Operation	9	FC-05 HVAC Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	3	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	5	135	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	7	3	4	84
	2.1.4.3		Software/Firmware/Coding Failure to Start on Demand, Power Spikes, Cyber	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Degraded System Operation Loss of Cooling	9	FC-67 Hardware/Software Design Error: A failure that is traceable to an error in the design of the hardware and/or software	6	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	378	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	7	4	3	84

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.4	2.1.4.4	Defective evaporator fan	Cooling System Component Failure, Power Surge, Random Failure	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Loss of Cooling Degraded System Operation	9	FC-76 Random Failure: Failures that they do not appear to have any pattern or regularity.	5	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	3	135	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	6	3	4	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.1.5	2.1.5.1	Control System Malfunction	Cooling System Control Malfunction, Sensor Failure	Battery Module Overtemperature Shutdown Moderate Effect - Moderate degradation of product performance;	7	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	5	AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	3	105	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	6	3	4	72
	2.1.5.2		Communications System Failure, Component Failure	Battery Module Overtemperature Shutdown Moderate Effect - Moderate degradation of product performance;	7	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	105	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	6	3	3	54
	2.1.5.3		Communications System Failure, External Threat	Battery Module Overtemperature Shutdown Moderate Effect - Moderate degradation of product performance;	7	FC 38 Human Factors Failures due to malfeasance	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	84	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	6	2	3	36

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.2	2.2.1	Anticondensation Heating Failures	Degraded System Performance	Partial/Total loss of capacity Failure to Operate Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	6	EC-18 Redundant Fail Detect: Ability of system to determine a sensor has failed, to operate safely without that sensor to shutdown, or operate safely indefinitely without sensor.	3	144	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	Credit given for implemented actions	6	4	4	96
	2.2.2		Failure to Operate - Heating	Failure to Operate Partial/Total loss of capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the Coolant system that will result in high temperatures throughout system	5	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	3	120	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	Credit given for implemented actions	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.2.1	2.2.1.1	Thermal Management Sensor/RTD self heating error	Component Failure, End of Design Life	Degraded System Performance Failure to Operate - Heating Moderate Effect - Moderate degradation of product performance;	8	FC-46 Subcomponent/Sub system Failure: Lifecycle failure of components impacting availability/capabilit y to execute intended design function	4	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	128	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	2.2.1.2		Instrument Drift, Component Aging	Failure to Operate - Heating Moderate Effect - Moderate degradation of product performance;	7	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	3	84	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.2.2	2.2.2.1	No Temperature Measurement	I/O Failure, Component Failure	Failure to Operate - Heating Degraded System Performance Moderate Effect - Moderate degradation of product performance;	8	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	3	96	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.3.1	2.3.1.1	Control System Malfunction	EV System Control Malfunction, Sensor Failure	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	5	300	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	4	96
	2.3.1.2		Communications System Failure, Component Failure	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. Failure to Operate	10	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	300	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	3	72
	2.3.1.3		Communications System Failure, External Threat	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. Failure to Operate	8	FC 38 Human Factors Failures due to malfeasance	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	6	240	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	3	72
	2.3.1.4		Incorrect Settings	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	7	FM-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection	6	210	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
								EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions					RA36 - NFPA 68 Deflagration Venting Implementation				

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.3.2	2.3.2.1	Manual Initiated Ventilation System Malfunction	EV System Control Malfunction, Sensor Failure		10	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	5	300	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	4	96
	2.3.2.2		Communications System Failure, Component Failure		10	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	300	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	3	72
	2.3.2.3		Communications System Failure, External Threat		8	FC 38 Human Factors Failures due to malfeasance	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	6	240	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-33: Construction Contractor Installation and Commissioning	6	4	3	72
	2.3.2.4		Incorrect Settings		7	FM-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection	6	210	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	6	4	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
								EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions					RA36 - NFPA 68 Deflagration Venting Implementation				

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
2.6	2.6.1	Door switches	Failure To Operate	Failure to Operate Loss of Coolant system Partial/Total loss of capacity	6	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	5	120	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	2.6.2		Intermittent Operation	Failure to Operate Loss of Coolant system Partial/Total loss of capacity	6	FC-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	4	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	96	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	5	3	3	45
	2.6.3		Insufficient Voltage, Large Voltage Drop	Loss of Coolant system Partial/Total loss of capacity	6	FC-46 Subcomponent/Sub system Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	96	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	Credit given for implemented actions	5	3	3	45

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3	3.1	Starlight Solar Project BESS Project Fire Suppression Subsystem (Dry-Pipe)	Failure to Operate	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-48: Fire detection/Suppression System: Partial or full system degradation due to internal component failures, impact.	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	360	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	Credit given for implemented actions	10	4	3	120
	3.2		Premature Operation	Moderate Effect - Moderate degradation of product performance;	5	FC-48: Fire detection/Suppression System: Partial or full system degradation due to internal component failures, impact.	3	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	5	75	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	Credit given for implemented actions	5	2	2	20
	3.3		Unable to suppress fire	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-48: Fire detection/Suppression System: Partial or full system degradation due to internal component failures, impact.	4	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	280	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	Credit given for implemented actions	10	3	2	60

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3	3.4	Starlight Solar Project BESS Project Fire Suppression Subsystem (Dry-Pipe)	FSS Degraded Capability/Performance	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-48: Fire detection/Suppression System: Partial or full system degradation due to internal component failures, impact.	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	420	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	Credit given for implemented actions	10	4	2	80
	3.5		ESS Corrosion	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FC-26 Ext/Envr Risk, Coorsive Environment Exposure: Long term exposure of the system to corrosive conditions that will result in long term corrosion with electrical activity	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	2	24	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire. RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	Credit given for implemented actions	4	2	2	16
	3.6		Unable to Exhaust Flammable Gases	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-05 EV Failure: Mechanical or electrical failure of the EV system that will result in high temperatures throughout system	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	5	250	RA-12: Inclusion of additional engineering controls for the GridSolv that include Hydrogen Detection and Control System Response to Ventilate the BESS	Wartsila/AFT	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	10	4	3	120
	3.7		Failure to Operate Manually	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	4	200	RA-03: ESMS Testing and Commissioning RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance	Wartsila Project	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	10	4	3	120

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3	3.8	Starlight Solar Project BESS Project Fire Suppression Subsystem (Dry-Pipe)	Failure to Detect Flammable Gases	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	9	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-18 Redundant Fail Detect: Ability of system to determine a sensor has failed, to operate safely without that sensor to shutdown, or operate safely indefinitely without sensor.	5	270	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	8	4	4	128

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.1	3.1.1	Flammable Gas Detection System	Failure to Operate, System Miswiring	Failure to Operate Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	192	RA-01: Performance of Scheduled System Maintenance RA-12: Inclusion of additional engineering controls for the GridSolv that include Hydrogen Detection and Control System Response to Ventilate the BESS	Wartsila/AFT	Credit given for implemented actions	6	4	3	72
	3.1.2		Premature Operation, Non-SIL rated equipment failure	Premature Operation ESS Corrosion	5	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	45	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	4	3	3	36
	3.1.3		Subsystem Component Failure, Broken, Shorted, Open	Failure to Operate Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.1.1	3.1.1.1	Emergency/Manual Ventilation Command Failure Emergency/Manual Ventilationt Shutdown on Command from FACP	HVAC & Thermal Management S/D Failure	Failure to Operate Unable to suppress fire Failure to Operate	10	FM-14 S/D Isolation Failure: Failure of the system to shutdown or isolate itself when an adverse condition is detected	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	9	450	RA-20: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	Wartsila/AFT	Credit given for implemented actions	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.1.2	3.1.2.1	Combustible Gas Detection (XCL) Subsystem	Failure to Operate, System Miswiring	Failure to Operate	9	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	2	EC-08 Redundant HVAC: Design, sizing, and hardware physical redundancy of the HVAC system such that failure of one or multiple units does not result in adverse conditions within the container or system	5	90	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	7	2	3	42
	3.1.2.2		Premature Operation, Non-SIL rated equipment failure	Failure to Operate Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-48: Fire detection/Suppression System: Partial or full system degradation due to internal component failures, impact.	2	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	128	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	6	3	3	54
	3.1.2.3		Subsystem Component Failure, Broken, Shorted, Open	Failure to Operate Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	180	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.1.2	3.1.2.4	Combustible Gas Detection (XCL) Subsystem	Environmental Constraints/Influences, Corrosion	Failure to Operate Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-24 Ext/Envr Risk, Water Damage - Flooding: The system is flooded with water as a result of suppression failure or natural forces	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	120	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	7	3	3	63

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12302 Exposition Blvd | Los Angeles, CA 90068
Project Manager: Mr.James Whalen
Design Responsibility: Empire II, LLC and BESS OEM
Design Basis: Assumed Typical LFP BESS Project Documents
Prepared by: Robert Steele, PhD.
FMEA Date (Orig.): 23 July 2025

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.1.3	3.1.3.1	FACP Control Interface	Monitoring Sensor Failure	Hazardous Effects with Indication	9	FM-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	180	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	7	3	2	42
	3.1.3.2		Reference Sensor Failure	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FM-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	5	EC-09 FSS: Fire suppression inside battery compartment which may address BoS fire without adverse effect on batteries.	8	160	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	4	2	3	24
	3.1.3.3		Failure of Combined Monitor/Reference Controller	Moderate Effect - Moderate degradation of product performance;	5	FM-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	4	EC-18 Redundant Fail Detect: Ability of system to determine a sensor has failed, to operate safely without that sensor to shutdown, or operate safely indefinitely without sensor.	9	180	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	5	3	3	45
	3.1.3.4		Incipient Software Failure	Interdependent System Induced Failure	1	FM-62 Programming Error: A failure resulting from an error in the system software or firmware.	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	10	40	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.2	3.2.1	Emergency Ventilation (EV) Exhaust System EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	Command/Control Failure	Unable to Exhaust Flammable Gases Failure to Operate Failure to Operate Manually Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	EC-03 ESS HVAC: Heating, ventilation and air conditioning for the overall container designed to maintain overall system temperature and humidity levels.	9	360	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-20: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmosp	Wartsila/AFT	RA-24: Wartsila commissioning and testing to demonstrate s interdependent system performance of the GridSolv	7	3	3	63
	3.2.2		Delamination	ESS Corrosion	4	FM-25 Ext/Envr Risk, Water Damage - Condensation: The system is subject to uncontrolled condensation of water via HVAC failure, inadequate design, internal condensation of moisture, or from natural reasons.	3	EC-23 ESS Cont. Struct: Resiliency of the system and container of the system to withstand impacts or strikes	2	24	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	4	2	2	16
	3.2.3		Broken	Unable to Exhaust Flammable Gases Failure to Operate Manually Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. Failure to Operate	10	FM-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	4	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	6	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	4	3	96
	3.2.4		Electrical Failure	Unable to Exhaust Flammable Gases Failure to Operate Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FM-53 Elect Contact Fail: Internal Failure FM-60 High Resistive Contacts: Internal Failure - Electrical (High Resistive Contacts)	5	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	5	250	RA-14: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-33: Construction Contractor Installation and Commissioning	8	4	3	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.2	3.2.5	Emergency Ventilation (EV) Exhaust System EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions	Improper Output	Failure to Operate Manually Failure to Operate Loss of Coolant system Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FM-01: Electrical Failure FM-08 Elect Hotspot: Loose connections in the system may increase resistance and cause hotspots. Hotspots may form in other ways for unknown reasons.	4	EC-13 Exh Vent: Effectiveness of exhaust ventilation to remove battery off-gas, heat, and smoke which may result in adverse atmospheric conditions EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection	3	120	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance RA36 - NFPA 68 Deflagration Venting Implementation	8	3	2	48

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.3	3.3.1	Explosion Prevention System	Deflagration Vent: Undersized		10	FM-39 Human Factors - Design Errors and Omissions, Design Basis Assumptions too low	4	EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	9	360	RA-17: Knowledge of failure condition for active mitigation and response management. RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-17: Knowledge of failure condition for active mitigation and response management . RA36 - NFPA 68 Deflagration Venting Implementation	8	3	4	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
3.4	3.4.1	Fire Alarm Control Panel	Monitoring Sensor Failure	Unable to suppress fire Hazardous Effects with Indication	10	FM-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	6	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	300	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	6	3	2	36
	3.4.2		Reference Sensor Failure	FSS Degraded Capability/Performance Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FM-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	5	EC-09 FSS: Fire suppression inside battery compartment which may address BoS fire without adverse effect on batteries.	8	400	RA-01: Performance of Scheduled System Maintenance	Wartsila/AFT	RA-01: Performance of Scheduled System Maintenance	6	3	3	54
	3.4.3		Subsystem Component Failure, Broken, Shorted, Open	FSS Degraded Capability/Performance Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-46 Subcomponent/Sub system Failure: Lifecycle failure of components impacting availability/capabilit y to execute intended design function	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	360	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	10	5	3	150
	3.4.4		Incipient Software Failure	Failure to Operate Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FM-62 Programming Error: A failure resulting from an error in the system software or firmware.	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	10	400	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	Credit given for implemented actions	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4	4.1	Starlight Solar Project BESS - Wartsila GridSolv GEMS Management System (ESMS) Primary System Contol	Premature Operation	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-72 Intermittent failure: Failures that appear and disappear seemingly at random	7	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	6	252	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	4	3	72
	4.2		Failure to Operate	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-74 Sudden Failure: Failures that they occur comparatively rapidly (as opposed to gradual degradation or age-related failure).	8	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	224	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	5	3	105
	4.3		Batteries overheat, potential for off-gas	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway	6	AC-01: EOP - System operator plan to handle all emergency events.	6	360	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	10	4	3	120

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4	4.4	Starlight Solar Project BESS - Wartsila GridSolv GEMS Management System (ESMS) Primary System Contol	Battery Management System (BMS) Failure	Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Interdependent System Induced Failure	7	FC-31 Elec Risks, Hazardous Voltage Condition: This could include high line voltages, high voltages from the PCS, floating ground issues, or other high voltage issues at the cell, module or rack level	7	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	4	196	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	5	2	70
	4.5		Loss of ESMS Control	Hazardous Effects with Indication	9	FC-12 ESMS Failure: Failure of the controller at the rack or system level which results in adverse condition to the system	8	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	288	RA-03: ESMS Testing and Commissioning RA-05: Auto System S/D RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	9	5	3	135
	4.6		Loss of BMS Control	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-44 Module Failure: Loss of BMS Control	8	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	4	224	RA-04: BMS Testing and Commissioning RA-05: Auto System S/D RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	5	3	105

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4	4.7	Starlight Solar Project BESS - Wartsila GridSolv GEMS Management System (ESMS) Primary System Contol	Loss of Control Thermal Management	Interdependent System Induced Failure	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	6	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	5	270	RA-03: ESMS Testing and Commissioning RA-05: Auto System S/D RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	7	4	3	84
	4.8		Loss of Control FD/FSS	Interdependent System Induced Failure	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	4	FC-46 Subcomponent/ Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	5	180	RA-10: Fire Detection and Suppression System is design and certified by a Licensed Fire Protection Engineer RA-11: FSS Testing, Commissioning, and Analysis demonstrates suppressant will mitigate fire.	Wartsila/AFT	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	6	3	4	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4.1	4.1.1	ESMS - General	Operator Error	Premature Operation Batteries overheat, potential for off-gas Failure to Operate	10	FC-37 Misc Human Factors: Human induced failures due to negligence	5	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	5	250	RA-17: Knowledge of failure condition for active mitigation and response management. RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	3	6	126
	4.1.2		Software Errors	Premature Operation Failure to Operate Batteries overheat, potential for off-gas	10	FC-62 Programming Error: A failure resulting from an error in the system software or firmware.	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	8	320	RA-03: ESMS Testing and Commissioning RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	10	3	4	120
	4.1.3		Cyber Security Challenges	Failure to Operate Batteries overheat, potential for off-gas Loss of BMS Control	10	FC 38 Human Factors Failures due to malfeasance	4	AC-01: EOP - System operator plan to handle all emergency events.	9	360	RA-32: ESS Cyber Security Implementation, Vulnerability Analysis, Pen Testing	Wartsila Cyber Security	RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	6	3	8	144
	4.1.4		Redundant Failure Detection/System Intelligence: Ability of system to determine a sensor has failed, to operate safely without that sensor to shut down, or operate safely indefinitely without sensor.	Loss of ESMS Control Loss of BMS Control	9	FC-12 ESMS Failure: Failure of the controller at the rack or system level which results in adverse condition to the system	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	8	360	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81

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4.1	4.1.5	ESMS - General	System Shutdown/Disconnect: Ability of system to actively shut itself down or disconnect itself. This is the aggregate of the BMS or inverter's shutdown ability as well as physical disconnects and the BoS controller's ability to shut down.	Failure to Operate Loss of BMS Control Premature Operation	7	FC-69 Execution-sequence-dependent: Failures that typically occur because an expected sequence of events does not occur in the order expected.	5	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	7	245	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierar	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	3	3	63
	4.1.6		Passive Circuit Protection and Design: Current interrupt devices, fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	Failure to Operate Loss of ESMS Control Loss of BMS Control	9	FC-12 ESMS Failure: Failure of the controller at the rack or system level which results in adverse condition to the system	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	8	360	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	3	2	54
	4.1.7		Cell Electrical Abuse Tolerance due to loss of ESMS: Ability of the cell to withstand electrical abuse such as overcharge, over discharge, high currents, or other adverse electrical abuse.	Battery Management System (BMS) Failure Loss of BMS Control Loss of ESMS Control Industrial Safety (Fire, Personnel) Issue Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	Internal Component Failure - Electrical Abuse	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	7	350	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-30: Wartsila Design Engineering performing detailed design reviews RA-33: Electrical Design Withstand Rating Validat	Wartsila Engineering	Credit given for implemented actions	10	2	3	60

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4.1	4.1.8	ESMS - General	Interdependent System Induced Failure: Failure of interdependent subsystem fails and introduces a failure mechanism to ESMS	Failure to Operate Loss of Control Thermal Management Loss of Control FD/FSS	7	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	4	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	5	140	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4.2	4.2.1	ESMS - BESS BMS Array Controller	Loss of Communication	Failure to Operate Battery Management System (BMS) Failure	7	FC-62 Programming Error: A failure resulting from an error in the system software or firmware.	3	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	105	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	7	3	3	63
	4.2.2		Processor Lockup	Failure to Operate Loss of ESMS Control Loss of BMS Control	9	FC-62 Programming Error: A failure resulting from an error in the system software or firmware.	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	3	108	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81
	4.2.3		Communications Timeout	Loss of ESMS Control Failure to Operate Battery Management System (BMS) Failure Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	9	FC-69 Execution-sequence-dependent: Failures that typically occur because an expected sequence of events does not occur in the order expected.	4	EC-31 ESMS/BMS CTRL: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	4	144	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4.2	4.2.4	ESMS - BESS BMS Array Controller	Loss of Control Power	Failure to Operate Loss of BMS Control	7	FC-12 ESMS Failure: Failure of the controller at the rack or system level which results in adverse condition to the system	5	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	3	105	RA-05: Auto System S/D RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	7	3	3	63
	4.2.5		Incorrect Firmware Programming	Premature Operation Loss of ESMS Control Failure to Operate Loss of BMS Control	9	FC-62 Programming Error: A failure resulting from an error in the system software or firmware.	6	AC-04 Human Factors: Knowledge of failure condition for active mitigation and response management.	6	324	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	9	2	2	36
	4.2.6		Unable to reset	Battery Management System (BMS) Failure Failure to Operate Loss of BMS Control Loss of ESMS Control	9	FC-77 Systematic Failure: Failures that they are related deterministically to a certain cause or causes	7	EC-32 BMS S/D: Ability of the BMS to isolate affected modules or strings without shutting down the entire system if unneeded	3	189	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	9	4	2	72
	4.2.7		Incorrect/False Output	Premature Operation Failure to Operate Loss of ESMS Control Battery Management System (BMS) Failure	9	FC-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	8	360	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4.2	4.2.8	ESMS - BESS BMS Array Controller	Subcomponent Failure/Damage	Failure to Operate Loss of ESMS Control Premature Operation	9	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-21 BMS CTRL: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	7	378	RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81
	4.2.9		Software programming error	Failure to Operate Loss of BMS Control Loss of ESMS Control	9	FC-62 Programming Error: A failure resulting from an error in the system software or firmware.	4	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	252	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-05: Auto System S/D	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	4	3	108

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
4.3	4.3.1	ESMS - BESS BMS Controller	Subsystem Component Failure: Broken, Short, Open	Failure to Operate Batteries overheat, potential for off-gas Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	10	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	160	RA-01: Performance of Scheduled System Maintenance RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	10	2	2	40
	4.3.2		Software Errors, Software Programming, PLC error	Failure to Operate Batteries overheat, potential for off-gas Moderate Effect - Moderate degradation of product performance;	10	FC-49 FSS/FD Software Error: Human induced software error resulting in system degradation/unavailability	3	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	4	120	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	8	3	3	72
	4.3.3		Operator Error, Training, Distraction	Batteries overheat, potential for off-gas Failure to Operate Moderate Effect - Moderate degradation of product performance;	10	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	3	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	5	150	RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	10	3	3	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5	5.1	Starlight Solar Project BESS Project Mechanical and Structural	TMS/Mech Degraded Operation	Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-05 HVAC Failure: Mechanical or electrical failure of the TMS system that will result in high temperatures throughout system	4	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	128	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-07: Environmental	Wartsila Engineering	Credit given for implemented actions	8	3	3	72
	5.2		Failure to Operate	Interdependent System Induced Failure Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	5	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	5	175	RA-07: Environmental Temperature Monitoring and Alarms RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	7	3	3	63
	5.3		Cell venting and fire	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway	6	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	3	180	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-26: Container thermal management and protections within container which would limit module fire/ther	Wartsila Engineering	Credit given for implemented actions	10	4	3	120

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.1	5.1.1	Structural failure	Degraded Performance, TMS Degradation	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-05 HVAC Failure: Mechanical or electrical failure of theTMS system that will result in high temperatures throughout system	6	EC-25 Container Monitoring: Monitoring within the container which may detect high humidity, water condensation, water leakage, salinity in humidity, and other adverse water conditions	4	168	RA-07: Environmental Temperature Monitoring and Alarms RA-12: Inclusion of additional engineering controls for the GridSolv that include Hydrogen Detection and Control System Response to Ventilate the BESS	Wartsila Engineering	Credit given for implemented actions	7	4	3	84
	5.1.2		Long-term Structural Degradation	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FC-26 Ext/Envr Risk, Salt Water Exposure: Long term exposure of the system to salt fog, water, or otherwise salty condition that will result in long term corrosion with electrical activity	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	36	RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verification RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	None required	4	2	2	16
	5.1.3		Degraded System Level Power Delivery	Moderate Effect - Moderate degradation of product performance;	5	FC-31 Elec Risks, Hazardous Voltage Condition: This could include high line voltages, high voltages from the PCS, floating ground issues, or other high voltage issues at the cell, module or rack level	4	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	3	60	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	5	2	3	30
	5.1.4		Degraded Protection from Step-Touch Potential	Moderate Effect - Moderate degradation of product performance;	5	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	3	45	RA-01: Performance of Scheduled System Maintenance RA-27: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	5	2	2	20

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5.1	5.1.5	Structural failure	Degraded Structural Integrity	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FC-22 Ext/Envr Risk, Impact - Something has struck, sharply or as blunt force, the battery system, causing mechanical damage or deformation	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	2	24	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	4	2	2	16
	5.1.6		Fire, Loss of BESS	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC 43 Module Failure: Battery Cell Internal Defect/Contaminati on or External Short	6	EC-15 Deflagration Protection: NFPA 68, NFPA 69, or other deflagration protection	3	180	RA-08: Cell Thermal Abuse Tolerance RA-13: Implementation of the Jensen Hughes NFPA 69 Explosion Mitigation Measures RA-26: Container thermal management and protections within container which would limit module fire/thermal exposure	Wartsila Engineering	RA36 - NFPA 68 Deflagration Venting Implementati on	5	4	3	60

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5.1.1	5.1.1.1	Structural failure due to Corrosion	Corrossion of the enclosure- Aesthetic Flaw, Insufficient paint, Improper surface Finish/ Coating	Long-term Structural Degradation Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FC-26 Ext/Envr Risk, Salt Water Exposure: Long term exposure of the system to salt fog, water, or otherwise salty condition that will result in long term corrosion with electrical activity	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	1	12	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	4	1	1	4
	5.1.1.2		Corrosion of external electrical connections/terminals, etc	Degraded System Level Power Delivery Moderate Effect - Moderate degradation of product performance;	5	Internal Failure - Electrical (Corrosion)	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	2	30	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	5	2	2	20
	5.1.1.3		Galvanic Corrosion of grounding connection, LTA Maintenance	Degraded Protection from Step-Touch Potential Minor Effect - Minor degradation of product performance that generally does not require repair.	5	FC-29 Ext/Envr Risk, Dust/Dirt/Particulate Accumulation: LTA Maintenance	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	45	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	5	2	1	10

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5.1.1	5.1.1.4	Structural failure due to Corrosion	Enclosure Leaking, Water ingress, Sand accumulation	Degraded Structural Integrity Moderate Effect - Moderate degradation of product performance;	5	FC-26 Ext/Envr Risk, Salt Water Exposure: Long term exposure of the system to salt fog, water, or otherwise salty condition that will result in long term corrosion with electrical activity	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	1	15	RA-01: Performance of Scheduled System Maintenance RA-07: Environmental Temperature Monitoring and Alarms	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	5	2	2	20

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.1.2	5.1.2.1	Loss of environmental protection/ sealing	IEC 60529 Environmental Protection Requirements/Degraded Performance, LTA Construction	Degraded Performance, TMS Degradation Moderate Effect - Moderate degradation of product performance;	7	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	2	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	2	28	RA-07: Environmental Temperature Monitoring and Alarms RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	7	2	1	14

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.1.3	5.1.3.1	Arc flash transient pressure bursts doors	Deflagration, Cell/Module Exothermic Reaction	Fire, Loss of BESS Hazardous Effects with Indication Degraded System Level Power Delivery	10	FC-02 Cell Failure: Hazardous Temperature Condition - Cell. High temperature at the cell level during normal operations w/o thermal runaway	4	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	3	120	RA-33: Electrical Design Withstand Rating Validated by Testing	Wartsila Engineering	Credit given for implemented actions	10	2	4	80

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5.2	5.2.1	Mechanical	Reduced Production Capacity	Minor Effect - Minor degradation of product performance that generally does not require repair.	4	FC-75 Degradation/Age related failure: Failures realized as part of programming lifecycle	5	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	60	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	4	4	3	48
	5.2.2		Battery Failure, Exothermic Reaction, Fire	Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. TMS/Mech Degraded Operation Failure to Operate Cell venting and fire	10	FC-17 Cell Therm Runaway: A single cell has entered thermal runaway resulting in flames and combustion or production of flammable or explosive gases	6	EC-21 BMS Cntrl: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	3	180	RA-08: Cell Thermal Abuse Tolerance RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-27: Proper training procedures, availability of subject matter expert	Wartsila Engineering	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	10	4	3	120
	5.2.3		Corrosion of Structure	Minor Effect - Minor degradation of product performance that generally does not require repair. TMS/Mech Degraded Operation	5	FC-26 Ext/Envr Risk, Salt Water Exposure: Long term exposure of the system to salt fog, water, or otherwise salty condition that will result in long term corrosion with electrical activity	3	EC-23 ESS Cont Struct: Resiliency of the system and container of the system to withstand impacts or strikes	4	60	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	4	2	2	16

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.1	5.2.1.1	Support structure damage due to 'drop'	Battery damage -Leakage, Structural design not adequate	Reduced Production Capacity Battery Failure, Exothermic Reaction, Fire Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	10	FC-39 Human Factors - Design Errors and Omissions	2	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	3	60	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540)	Wartsila Engineering	Credit given for implemented actions	10	2	2	40

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.2	5.2.2.1	Batteries damaged during transportation (by road and shipping)(Shock and vibration)	Battery damage -Leakage, Structural design not adequate	Reduced Production Capacity Battery Failure, Exothermic Reaction, Fire Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-39 Human Factors - Design Errors and Omissions	2	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	140	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540)	Wartsila Engineering	Credit given for implemented actions	10	2	3	60

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.3	5.2.3.1	Batteries damaged during shipping due to shelf buckling	Battery damage -Leakage, Structural design not adequate to take the weight	Battery Failure, Exothermic Reaction, Fire Reduced Production Capacity Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC-39 Human Factors - Design Errors and Omissions	2	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	120	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540)	Wartsila Engineering	Credit given for implemented actions	10	2	2	40

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.4	5.2.4.1	Batteries damaged due to rack weld failures	Battery damage -Leakage, Poor weld strength	Reduced Production Capacity Battery Failure, Exothermic Reaction, Fire Moderate Effect - Moderate degradation of product performance;	10	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	320	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540)	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.5	5.2.5.1	Batteries damaged from excitation of local rack modes	Battery damage -Leakage, HVAC vibrations	Reduced Production Capacity Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	7	FC-23 Ext/Envr Risk, Mechanical Shock/Drop - The system, rack or module is subject to mechanical shock or drop, mechanical jarring or damaging the system	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	112	RA-02: Verification of NRTL End-Product Safety Certification to mitigate fire, shock, or personal injury (UL:-1642, 1973, 9540A, 9540) RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.6	5.2.6.1	Oxidation	corrosion of structure, Improper coating material	Corrosion of Structure Very Slight Effect - Very slight degradation of product performance. Non-vital fault noticed by system operations.	6	FC-25 Ext/Envr Risk, Water Damage - Condensation: The system is subject to uncontrolled condensation of water via HVAC failure, inadequate design, internal condensation of moisture, or from natural reasons.	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	72	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	6	3	2	36

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
5.2.7	5.2.7.1	Loosening of electrical connections & busbar joints during transport and assembly	Loss of Control, loose connections during assembly	Reduced Production Capacity Moderate Effect - Moderate degradation of product performance;	5	FC-08 Elect Hotspot: Loose connections in the system may increase resistance and cause hotspots. Hotspots may form in other ways for unknown reasons.	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	45	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	5	2	2	20

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6	6.1	Starlight Solar Project BESS Project Electrical	Failure to Charge/Discharge	Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-09 INV/PCS Failure: Inverter or power electronics fail in a way that poses risk to the batteries. Could include a lock up in the "On" position which drives overcharge.	5	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	5	200	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	8	4	3	96
	6.2		Failure to Operate, Internal Component Failure - Mechanical	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	210	RA-01: Performance of Scheduled System Maintenance RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	5	3	105
	6.3		Degraded System Performance	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-75 Degradation/Age related failure: Failures realized as part of programming lifecycle	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	210	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	4	2	56
	6.4		Spurious Operation	Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	6	FC-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	5	150	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6	6.5	Starlight Solar Project BESS Project Electrical	Industrial Safety Issue	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	3	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	6	126	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	3	3	63
	6.6		Loss of Temperature Control	Interdependent System Induced Failure	8	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	5	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	4	160	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	4	3	84
	6.7		Externally induced thermal abuse	Hazardous Effects with Indication	9	FC-30 Ext/Envr Risk, External Fire Impingement: An external fire that is impinging on the system from outside the containment	6	AC-01: EOP - System operator plan to handle all emergency events.	7	378	RA-16: SOP/EOPs to handle any and all emergency events for firefighting	Wartsila Project	RA-16: SOP/EOPs to handle any and all emergency events for firefighting	7	4	3	84
	6.8		Reduce System Capacity	Battery Management System (BMS) Failure	7		1		1	1				1	1	1	1

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1	6.1.1	Power System	Batteries not being charged	Moderate Effect - Moderate degradation of product performance;	5	FC-09 INV/PCS Failure: Inverter or power electronics fail in a way that poses risk to the batteries. Could include a lock up in the "On" position which drives overcharge.	3	EC-21 BMS CTRL: Includes monitoring and shutdown/isolation capabilities of the affected BMS/module or system if necessary.	3	45	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	5	2	2	20
	6.1.2		Failure to Operate	Failure to Operate, Internal Component Failure - Mechanical Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	Internal Component Failure - Electrical Abuse	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	160	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit give for implemented actions	8	3	3	72
	6.1.3		Potential Loss of Control	Failure to Operate, Internal Component Failure - Mechanical Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	5	AC-10 Human Factors/NRTL: Throughout UL1973, UL9540, UL1741 and other US standards are a number of requirements for product analysis and review including FMEAs, SIL/LOPAs, and other failure modes and safety analysis.	8	320	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1	6.1.4	Power System	High Incident Energy	Degraded System Performance Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-01: Electrical Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	160	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	10	3	3	90
	6.1.5		Failure to Deliver Power	Degraded System Performance Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-59 Inadvertent Fuse Clearing: Protective Device actuation due to voltage transient/spike, instantaneous overcurrent	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	128	RA-04: BMS Testing and Commissioning RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	Credit given for implemented actions	8	3	3	72
	6.1.6		Step and Touch Potential - Shock Hazard	Industrial Safety Issue Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	3	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	6	126	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv	Wartsila Engineering	Credit given for implemented actions	7	2	3	42

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1	6.1.7	Power System	Long-Term Degraded Performance	Degraded System Performance Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable. Failure to Charge/Discharge	9	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	7	EC-31 ESMS/BMS Cntrl: Ability of the BMS and balancing system to adequately balance the circuit including sizing of the balancing resistors or transistors	3	189	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	8	4	3	96
	6.1.8		Unable to S/D ESS Upon Demand	Failure to Charge/Discharge Degraded System Performance	8	FC-11 BMS Failure: Cell/module level monitoring and control fails, resulting in inability to shutdown, report adverse conditions, properly monitor, balance or protect the system resulting in adverse condition	5	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	8	320	RA-16: SOP/EOPs to handle any and all emergency events for firefighting RA-17: Knowledge of failure condition for active mitigation and response management. RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of	Wartsila Engineering	Credit given for implemented actions	8	4	3	96

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.1	6.1.1.1	Loss of power supply connected Branch Circuit	Loss of Charging Power, Inverter Malfunction	Batteries not being charged Failure to Operate Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-09 INV/PCS Failure: Inverter or power electronics fail in a way that poses risk to the batteries. Could include a lock up in the "On" position which drives overcharge.	3	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	3	72	RA-22: Wartsila BMS Software controls interconnected modules within the GridSolv to safely detect system degradation and initiate S/D protocols RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D	8	2	2	32
	6.1.1.2		Spurious Fuse Clearing, Power Transients	Failure to Operate Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	8	FC-76 Random Failure: Failures that they do not appear to have any pattern or regularity.	3	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	3	72	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	6.1.1.3		SC Event Damages Branch Circuit Fuses, Arc Flash, SC Event	Failure to Operate Hazardous Effects with Indication	9	FC-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	5	EC-29 Sys Elec Abuse Tolerance: Refers to ability of the overall system collectively to withstand adverse electrical abuse such as overcharge or dead shorts without failure	4	180	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	9	4	3	108

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.2	6.1.2.1	Protective Device (Fuse) failure	Failure to Operate - Interrupt: Issues associated the design and selection of fuse	High Incident Energy Hazardous Effects with Indication	10	FC-39 Human Factors - Design Errors and Omissions	4	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	10	3	3	90
	6.1.2.2		Premature Fuse Clearing	Failure to Deliver Power Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-55 Manufacturer Defect, QA/QC	4	EC-22 Site Elec Prot: Protection for electrical systems such that a failure of the PCS or associated circuit does not result in adverse effects on the site balance of system electrical gear	8	256	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.3	6.1.3.1	Possible shock hazard	Insulation Breakdown,Undetected Ground Loop	Step and Touch Potential - Shock Hazard Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	240	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridS	Wartsila Engineering	Credit given for implemented actions	10	2	3	60
	6.1.3.2		Insulation Breakdown - Maintenance Induced, Undetected Ground Loop	Step and Touch Potential - Shock Hazard Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern.	10	FC-27 Ext/Envr Risk, Human Factors: An adverse condition caused by the result of human interaction, error, or imperfection	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	6	240	RA-01: Performance of Scheduled System Maintenance RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridS	Wartsila Engineering	Credit given for implemented actions	10	3	3	90
	6.1.3.3		No connection between inner/outer grounding boss, Undetected Ground Loop, design oversight	Step and Touch Potential - Shock Hazard Hazardous Effects with Indication	9	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	6	162	RA-01: Performance of Scheduled System Maintenance RA-24: Wartsila commissioning and testing to demonstrates interdependent system performance of the GridSolv RA-25: Structured Wartsila Design Reviews performance requirement decomposition and verificat	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.3	6.1.3.4	Possible shock hazard	Degraded or eroded Grounding Conductor, Grounding Rod, Damage, Time, LTA Maintenance	Step and Touch Potential - Shock Hazard Minor Effect - Minor degradation of product performance that generally does not require repair.	7	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	112	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.4	6.1.4.1	Prolong operation may lead to insulation failure	Insulation Breakdown - Power Transients, Electrical Abuse, Internal Component Failure - Electrical Abuse	Long-Term Degraded Performance Slight Effect - Slight degradation of product performance.	8	Internal Component Failure - Electrical Abuse	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	3	96	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	Credit given for visual inspections	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.5	6.1.5.1	Ground fault	Grounded Conductor, Insulation Breakdown	Failure to Deliver Power Failure to Operate Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	9	FC-33 Elec Risks, Ground Fault/Insulation Fault: This could include localized shorting of cells, shorting between modules, shorting of entire racks or systems and ground fault shorting.	4	EC-28 Insul Monitoring: Continual, or active, monitoring of insulation integrity, ground v float voltage, and other practices to prevent insulation or isolation degradation	3	108	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.6	6.1.6.1	Arc Flash Hazard	Arc Flash Hazard Maintenance Induced	Failure to Deliver Power High Incident Energy	10	FC-37 Misc Human Factors: Human induced failures due to negligence	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	10	3	3	90

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.1.7	6.1.7.1	Rapid system shutdown	E-Stop Failure: Broken Wire	Failure to Operate Potential Loss of Control Unable to S/D ESS Upon Demand	8	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	256	RA-01: Performance of Scheduled System Maintenance	Wartsila Project	RA-01: Performance of Scheduled System Maintenance	8	3	3	72
	6.1.7.2		E-Stop Failure: Shunt trip mechanism failure	Failure to Operate Unable to S/D ESS Upon Demand Potential Loss of Control	8	FC-28 Ext/Envr Risk, Shipping and Construction: An issue occurs with the system during shipping or construction that results in an adverse condition that may or may not be detected or protected via active controls. Results in Cell Failure	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	256	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	8	3	3	72
	6.1.7.3		E-Stop Failure: E Stop driver circuit fails	Failure to Operate Potential Loss of Control Unable to S/D ESS Upon Demand	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	256	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-01: Performance of Scheduled System Maintenance	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2	6.2.1	Low Voltage Panel	Failure to Operate	Failure to Operate, Internal Component Failure - Mechanical Degraded System Performance Loss of Temperature Control	7	FC-01: Electrical Failure	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	140	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	4	3	84
	6.3.2		Loss of Control	Degraded System Performance Failure to Charge/Discharge Loss of Temperature Control	8	FC-01: Electrical Failure	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	128	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	3	3	72
	6.2.3		Degraded Performance	Degraded System Performance	7	FM-46 Subcomponent/Sub system Failure: Lifecycle failure of components impacting availability/capabilit y to execute intended design function	5	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	4	140	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	7	4	3	84

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2	6.2.4	Low Voltage Panel	Reduced Capability	Degraded System Performance Reduce System Capacity	7	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	5	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	175	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.1	6.2.1.1_	Power Delivery	LVPBD: Intermittent Operation	Moderate Effect - Moderate degradation of product performance;	5	FC-72 Intermittent failure: Failures that appear and disappear seemingly at random	4	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	6	120	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.1.1	6.2.1.1	Broken/High Resistive Connections	Failure to Charge/Discharge Batteries, LTA Installation/ Maintenance	Failure to Charge/Discharge Failure to Operate, Internal Component Failure - Mechanical Degraded System Performance Significant Effect - Product performance is degraded but operable and safe, or a non-vital part is inoperable.	8	FC-35 Elec Risks, Electrical Arcing/Arc Fault/Contactor Failure: Switch failures, arcing issues	3	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	5	120	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.3.1.3	6.3.2.3.1	BESS UPS/Aux Power failure	Aux Transformer Failure, CPT Fusing,Internal Component Failure - Electrical Abuse	Failure to Operate, Internal Component Failure - Mechanical Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	EC-30 Vol/SoC Monitoring: This may apply at the cell, module, and rack level. While voltage monitoring may be useful more advanced methods such as coulomb counting may be used as well.	9	288	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	3	5	120

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.2	6.2.2.1	Overcurrent Protection	OCPD: Degraded/Cascading Failures	Failure to Operate Loss of Control	8	FC-59 Inadvertent Fuse Clearing: Protective Device actuation due to voltage transient/spike, instantaneous overcurrent	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	128	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	3	54
	6.2.2.2		OCPD Failure to Operate	Failure to Operate Degraded System Performance	7	FC-01: Electrical Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	112	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.2.1	6.2.2.1.1	Protective Device - Fuse or Control Power	OCPD fails to Operate, Inherent Design Flaw	OCPD Failure to Operate Failure to Operate, Internal Component Failure - Mechanical	7	FC-55 Manufacturer Defect, QA/QC	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	224	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63
	6.2.2.1.2		OCPD Failure to interrupt fault	OCPD Failure to Operate Failure to Operate, Internal Component Failure - Mechanical	7	FC-01: Electrical Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	8	224	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63
	6.2.2.1.3		Contact welding, less than adequate inspection/maintenanc e	Failure to Operate, Internal Component Failure - Mechanical OCPD Failure to interrupt fault Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-53 Elect Contact Fail: Internal Failure - Electrical (welded contacts)	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	224	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.2.1	6.2.2.1.4	Protective Device - Fuse or Control Power	Fail to Clear Fault, Sustained Arcing Current LTA Maintenance	OCPD Failure to Operate Degraded System Performance	7	FC-53 Elect Contact Fail: Internal DC Converter Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	112	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.2.2	6.2.2.2.1	Protective Device Fuse Overcurrent Protection, SCA Protection	Premature Open, MFG Defect	Degraded System Performance OCPD: Degraded/Cascading Failures	8	FC-55 Manufacturer Defect, QA/QC	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	3	96	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	3	3	72
	6.2.2.2.2		Failure to Interrupt Fault, Excessive SCA	Failure to Charge/Discharge OCPD: Degraded/Cascading Failures Degraded System Performance	8	FC-01: Electrical Failure	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	6	192	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	3	3	72
	6.2.2.2.3		OCPD Failure to interrupt, Misapplication - Excessive SCA	Failure to Operate Failure to Operate, Internal Component Failure - Mechanical	7	FC-39 Human Factors - Design Errors and Omissions	4	AC-11 Human Factors/RAGAG EP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	6	168	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	7	3	3	63

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.3	6.2.3.1	ACC/DCC cabinet	Subcomponent Intermittant Performance	Loss of Control Failure to Operate Reduced Capability	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	8	4	3	96
	6.2.4.2		Degraded Performance	Reduced Capability Degraded Performance	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.3		Loss of Capability	Reduced Capability Failure to Operate	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.4		Failure to Operate	Failure to Operate Loss of Control	8	FM-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	6	EC-26 ESS Volt Mon: Overall effectiveness of the voltage monitoring scheme of the system. Includes resilience to errors, error checking, and other measurement intelligence	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.4.1	6.2.4.1.1	PLCs	Critical Failure - Erratic output (OREDA)	Subcomponent Intermittant Performance Degraded Performance Loss of Capability Failure to Operate	7	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	6	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	168	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.2		Critical Failure - Fail to function on demand (OREDA)	Failure to Operate	8	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	6	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	192	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.3		Critical Failure - Low output (OREDA)	Failure to Operate Degraded Performance Loss of Capability	8	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	6	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.4		Critical Failure - Spurious operationt (OREDA)	Degraded Performance Failure to Operate	8	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	6	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	5	240	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.5		Degraded Failure - Erratic output (OREDA)	Degraded Performance	7	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	140	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.6		Degraded Failure - High output (OREDA)	Degraded Performance	7	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	140	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.7		Degraded Failure - Low output (OREDA)	Degraded Performance	7	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	140	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.4.1	6.2.4.1.8	PLCs	Degraded Failure - Other (OREDA)	Degraded Performance	7	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	4	140	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	6	4	3	72
	6.2.4.1.9		Incipient Failure - Erratic output (OREDA)	Failure to Operate Loss of Capability	6	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	4	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	3	72	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	5	3	3	45
	6.2.4.1.10		Incipient Failure - High output (OREDA)	Failure to Operate Loss of Capability	6	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	4	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	3	72	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	5	3	3	45
	6.2.4.1.11		Incipient Failure - Minor Inservice Problems (OREDA)	Loss of Capability Failure to Operate	6	FM-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	4	EC-35 ESMS Aux System Monitoring to safely S/D upon detection of loss of permissives	3	72	RA-01: Performance of Scheduled System Maintenance	Wartsila/O&M Contractor	RA-01: Performance of Scheduled System Maintenance	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.4.2	6.2.4.2.1	Network switches and patch panels	Subcomponent Failure, End of Design Life	Failure to Operate Loss of Capability	8	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	5	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	3	120	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	6.2.4.2.2		Electrical Failure: Internal Fault, Lifecycle Failure	Failure to Operate Loss of Capability	8	FC-59 Inadvertent AC PNL B Breaker Trip: Molded Case Circuit Breaker trip due to bimetallic memory, voltage spike, instantaneous overcurrent	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	3	120	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	6.2.4.2.3		Improper Output, Programming, Overtemp/voltage, EMI	Failure to Operate Loss of Capability	8	FC-39 Human Factors - Design Errors and Omissions	5	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	5	200	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.4.2	6.2.4.2.4	Network switches and patch panels	Input Failure Response	Failure to Operate Loss of Capability	7	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	140	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.4.3	6.2.4.3.1	Uninterruptible power supply	Failure to Operate	Failure to Operate Loss of Capability	8	FC-01: Electrical Failure	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	4	3	72
	6.2.4.3.2		Loss of Control	Failure to Operate Loss of Capability	8	FC-01: Electrical Failure	5	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.5	6.2.5.1	Auxiliary control cabinet	Failure to Operate	Failure to Operate Loss of Control	8	FC-01: Electrical Failure	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	8	4	3	96
	6.2.5.2		Loss of Control	Failure to Operate Loss of Control	8	FC-01: Electrical Failure	4	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	4	128	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
6.2.6	6.2.6.1	DC combiner cabinet	Failure to Operate	Failure to Operate Loss of Control	8	FC-01: Electrical Failure	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	160	RA-30: Wartsila Design Engineering performing detailed design reviews resulting in design changes	Wartsila Engineering	Credit given for implemented actions	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7	7.1	Starlight Solar Project BESS Project Communications	Intermittent Operation	Moderate Effect - Moderate degradation of product performance;	5	FC-72 Intermittent failure: Failures that appear and disappear seemingly at random	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	6	150	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	5	4	3	60
	7.2		Degraded Operation	Degraded System Performance Failure to Operate, Internal Component Failure - Mechanical Spurious Operation	8	FC-20 Lifecycle Failure: A cell or cells have reached end of life, resulting in an adverse electrical condition which could exacerbate imbalance or other adverse electrical conditions	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	5	200	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	4	3	84
	7.3		Failure to Operate	Hazardous Effects with Indication Interdependent System Induced Failure	9	FC-01: Electrical Failure	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	180	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	7.4		Cascading HVAC Failure Impacting ESMS	Moderate Effect - Moderate degradation of product performance;	7	FC-05 HVAC Failure: Mechanical or electrical failure of the HVAC system that will result in high temperatures throughout system	4	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	112	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7	7.5	Starlight Solar Project BESS Project Communications	Cyber Security Attack	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	10	FC 38 Human Factors Failures due to malfeasance	6	AC-09 Human Factors/SME: Proper training procedures, availability of subject matter expertise and system competence, and clear jurisdictional hierarchy for managing situations	9	540	RA-32: ESS Cyber Security Implementation, Vulnerability Analysis, Pen Testing	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	4	6	168
	7.6		Failure to Provide System Status	Major Effect - Product performance is severely degraded but has some operational capability and remains safe.	7	FC-45 Loss of BMS due to Software Induced Problem/Failure	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	140	RA-32: ESS Cyber Security Implementation, Vulnerability Analysis, Pen Testing	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.1	7.1.1	FSS system may not act	Software Induced Failure, Programing	Major Effect - Product performance is severely degraded but has some operational capability and remains safe. Failure to Operate, Internal Component Failure - Mechanical Unable to suppress fire	10	FC-49 FSS/FD Software Error: Human induced software error resulting in system degradation/unavailability	5	AC-08 Human Factors Maint: Proper preventive maintenance to minimize the impact of adverse, long term or slow acting environmental effects resulting in degradation	3	150	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	10	4	3	120
	7.1.2		Comms/HVAC Interface Failure	Intermittent Operation Failure to Operate Degraded Operation Cascading HVAC Failure Impacting ESMS	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	5	EC-04 Temp Monitoring/Alarms: Thermal monitoring within the container including BMS, fire alarm thermal monitoring and any BoS temperature monitoring	4	180	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.2	7.2.1	Modbus Adapter Failure	Subcomponent Failure, End of Design Life	Failure to Operate, Internal Component Failure - Mechanical Intermittent Operation Moderate Effect - Moderate degradation of product performance;	7	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	5	EC-01 Auto Shutdown: Ability of system to actively shut itself down or disconnect itself	3	105	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	7	4	3	84
	7.2.2		Electrical Failure: Internal Fault, Lifecycle Failure	Degraded Operation Intermittent Operation	6	FC-59 Inadvertent AC PNL B Breaker Trip: Molded Case Circuit Breaker trip due to bimetallic memory, voltage spike, instantaneous overcurrent	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	3	72	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	5	4	3	60
	7.2.3		Improper Output, Programming, Overtemp/voltage, EMI	Intermittent Operation Failure to Operate Moderate Effect - Moderate degradation of product performance;	9	FC-39 Human Factors - Design Errors and Omissions	4	AC-11 Human Factors/RAGAGEP: In addition to analysis required by product standards, good engineering practice should require design review such that design mistakes and weaknesses are identified and corrected in a timely and efficient manner	7	252	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.2	7.2.4	Modbus Adapter Failure	Input Failure Response	Intermittent Operation Failure to Operate Degraded Operation	9	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	180	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	8	3	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.3	7.3.1	GridSolv Master Switch	Loss of Power, Failure of interdependent/interconnected sys cascades and induces sys/component failure	Failure to Operate Serious Effects - Product is inoperable but safe, or a system is inoperable but safe.	9	FC-59 Inadvertent AC PNL B Breaker Trip: Molded Case Circuit Breaker trip due to bimetallic memory, voltage spike, instantaneous overcurrent	4	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	144	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	3	3	54
	7.3.2		Loss of AC Power (120VAC)	Failure to Operate Failure to Provide System Status Degraded Operation	9	FM-59 Inadvertent Protective Device Operation: Protective Device actuation due to voltage transient/spike, instantaneous overcurrent	5	EC-17 Elec Pass Prot: Current interrupt devices,fuses or other passive surge arresting elements which may open the circuit in the case of failure and general resilience of design to withstand adverse electrical conditions.	4	180	RA-34: Communications System Commissioning and Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	6	3	3	54

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.4	7.4.1	GridSolv EMS Controller Communication Peripheral	Improper Output	Intermittent Operation Degraded Operation	5	FC-57 Spurious Output: System or component produces spurious signals due to subsystem failure or transient.	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	9	225	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	5	3	3	45

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.5	7.5.1	GridSolv I/O Fast Switch FD/FSS Interface Control	RS485 TO DC METER (X4): Failure of interdependent/interconnected sys cascades and induces sys/component failure	Degraded Operation Failure to Operate	9	FC-46 Subcomponent/Subsystem Failure: Lifecycle failure of components impacting availability/capability to execute intended design function	4	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	7	252	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	9	3	3	81
	7.5.2		E-Stop Emergency Button Failure, Fail to respond to input	Failure to Operate Catastrophic - Very hazardous effect. Effect occurs suddenly without warning to user and may pose an industrial safety concern. Failure to Operate, Internal Component Failure - Mechanical Degraded System Performance	10	FC-15 Comms Failure: Failure of the system to properly report an adverse condition to local or remote monitoring. Failure of the system to report failures within itself and to act on those failures, resulting in adverse condition	5	AC-03 O&M: Proper maintenance and monitoring of the system in conjunction with adequate commission and site acceptance testing to reduce likelihood of loose connections or other transportation or construction defects	8	400	RA-01: Performance of Scheduled System Maintenance	Wartsila Engineering	RA-23: Wartsila ESMS Software controls interdependent system to safely detect system degradation and initiate S/D protocols	5	3	3	45
	7.5.3		Temperature Probes: Failure of interdependent/interconnected sys cascades and induces sys/component failure	Degraded Operation Cascading HVAC Failure Impacting ESMS Failure to Operate	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	4	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	7	252	RA-01: Performance of Scheduled System Maintenance RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72

Parent	ID	Item function	Potential failure mode	Effects descriptions	Sv	Potential cause(s) / failure mechanisms	Oc	Current Design Controls	Dt	RPN	Recommended Action(s)	Responsibility and Date	Actions Taken	Sv	Oc	Dt	RPN
7.5	7.5.4	GridSolv I/O Fast Switch FD/FSS Interface Control	Humidity/Temp Sensor Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	Degraded Operation Loss of Temperature Control	7	FC-10 Sensor Failure: A sensor inside the system fails, resulting in incorrect reporting of system properties	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	6	210	RA-07: Environmental Temperature Monitoring and Alarms RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	7.5.5		Door Contact Switch Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	Degraded Operation Failure to Operate	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	2	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	5	90	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	7.5.6		HVAC System Induced Failure, Failure of interdependent/interconnected sys cascades and induces sys/component failure	Degraded Operation Failure to Operate	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	5	225	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72
	7.5.7		FD/FSS System Induced Failure, Failure of interdependent/interconnected sys cascades and induces sys/component failure	Failure to Operate Cascading HVAC Failure Impacting ESMS	9	FC-56 Interdependent System Induced Failure: Failure of interdependent/interconnected sys cascades and induces sys/component failure	5	EC-36 ESMS Monitoring: ESMS programming evaluates system operation and initiates system shutdown upon detection of abnormal system performance	4	180	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	Wartsila Engineering	RA-21: Wartsila ESMS Software controls monitors interdependent system to safely detect system degradation and initiate S/D protocols	6	4	3	72