Capture Energy Safety Specification

Summary

This document describes the safety strategy and safety features of the Capture Energy Battery Energy Storage Systems, Powerbox BESS. Capture Energy employs a multilayered strategy in terms of safety, to minimize risk while also being ready for any hazardous event.

The BESS is equipped with several safety features, such as a two level battery management system, a non-invasive fire suppression system, and fire walls able to withstand a fire for up to 120 minutes.

The document supplies a layout of the BESS showing all of its safety features, as well as a flow diagram showing how the BESS acts in the event of a fire.

Revision

Date	Revision	Release note
2023-12-01	1	First release

Abbreviations

BESS	Battery Energy Storage System
EMS	Energy Management System
ENTSO-E	European Network of Transmission System Operators
FSS	Fire Suppression System
GPC	Grid Point Controller
LER	Limited Energy Reserve
OMS	Operation and Maintenance System
PCS	Power Conditioning System (Inverter)
SOC	State of Charge
SOH	State of Health
THD	Total Harmonic Distortion
TSO	Transmission System Operator
VPN	Virtual Private Network

Introduction

This document contains information about the safety features and certifications of the Capture Energy Powerbox BESS, Battery Energy Storage System (BESS). The information is valid for all variants, but the exact location of some of the safety systems may differ, due to the BESS having different layouts.

Safety Strategy

The core of the safety strategy is to use multiple levels of strategy, to minimize overall risk. This is visualized in Figure 1. Additionally, all subcomponents carry relevant safety certifications.

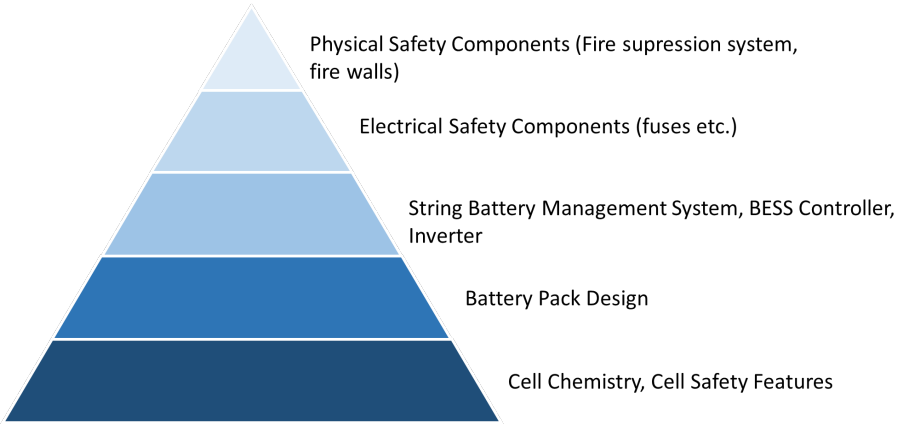


Figure 1: Safety strategy of the Capture Energy Powerbox BESS.

The foundation of the safety strategy is to use cells with a high level of safety using the chemistry Lithium Iron Phosphate (LFP), as well as built in safety features such as PTC and over-pressure vent.

The second layer of safety is the design of the battery pack, with several safety features designed in to prevent a thermal runaway from propagating to adjacent cells, as well as fusing capabilities in the event of a short circuit.

Above that is the string battery management system (BMS), the BESS controller and the inverter. They provide functional safety to the battery strings by collecting sensor data from all the battery packs and disconnects the string from the BESS if any parameters deviate from the safety specification of the cell. This is done both by the String BMS (with its own breakers) and the BESS controller/inverter. The system is designed so that the BESS controller will intervene before the String BMS, to reserve extra safety margins close to the cells. If the BESS controller detects any anomalies, it will disconnect the load through the inverter.

The fourth level consist of electrical safety components, able to break current in the event of an external short circuit. Fuses are designed into all necessary subcomponents, thus being able to prevent harmful scenarios independent of where the short circuit occurs. In case that the connection to the grid is lost, the BESS will disconnect itself (i.e., it cannot operate in island mode).

The final layer of safety is based on physical safety features. The BESS is equipped with firewalls, preventing fires from spreading from the outside to the BESS (and from the inside to the outside), as well as between the battery compartment and the inverter compartment. Additionally, the BESS is equipped with a fire suppression system (FSS) able to extinguish fires in the battery compartment in the event of a thermal runaway, as well as fans to vent out flammable gasses in the battery compartment.

The details of these safety features will be given in the following sections.

Battery Management System

The Battery Management System (BMS) is an active safety device that continuously monitors the state of the BESS to ensure that it is operating within its safety limits, as defined by the cells. The Capture Energy BESS has a multilayered BMS with a string BMS responsible for the local safety of each battery string individually, and a BESS controller (master BMS) that takes in data from all battery strings and set operating limits to prevent the battery strings from entering hazardous conditions to ensure that the BESS is able to operate efficiently.

Each layer of the BMS has limits for cell voltage, cell temperature, pole temperature, and current where a safe operating window is defined. The limits are set so that the BESS controller will disconnect before the string BMS, to build in safety margin closer to the cells.

The limits in the BMS are set to guarantee both safety and cycle life.

String BMS

Each battery string (8/BESS for the 1 MW/1.1 MWh BESS, and 6/BESS for the 1.2 MW/2 MWh BESS) is equipped with a string BMS. The string BMS collects sensor data (cell voltage, temperature) from all the battery packs to ensure that it is operating within its safe limits. Additionally, the HVU (the physical component that houses the string BMS) also collects data on currents to be able to act on that.

The string BMS safety limits are given in Table 1.

Table 1: Safety limits in string BMS.

	Minimum	Maximum
Cell voltage [V]	2.6	3.65
Cell temperature, Charge [°C]	-5	55
Cell temperature, Discharge [°C]	-5	55
Pole temperature [°C]	-	60
Current, Charge [A]	-	180
Current, Discharge [A]	-	180

BESS controller/Master BMS

The BESS controller is the central controller of the BESS, gathering data from all subsystems to optimize operation. It is equipped with a master BMS functionality with its own safety limits, slightly more restrictive to ensure that it reacts before the string BMS's. Additionally, the BESS controller is responsible for activating the FSS, and for climatization of the BESS. The limits set in the BESS controller is given in Table 2.

Table 2: Safety limits in the BESS controller/Master BMS.

	Minimum	Maximum
Cell voltage [V]	2.8	3.55
Cell temperature, Charge [°C]	5	45
Cell temperature, Discharge [°C]	5	45
Pole temperature [°C]	-	50
Current, Charge [A]	-	180
Current, Discharge [A]	-	180

Physical Safety Features

The BESS is equipped with several physical safety features, providing a physical safety layer to the BESS. This includes a FSS, external fire walls, and fire sectioning.

Prevention

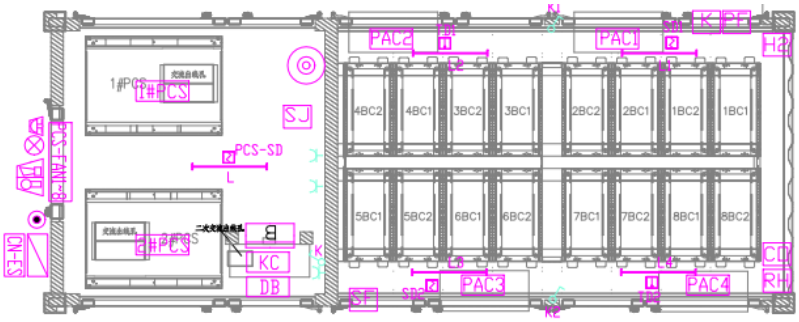
The physical properties of the BESS, such as encasement and compartmentization, prevents external fire from spreading into the BESS, and internal fire to spread out, it is equipped with firewalls in all external walls, floors and ceilings. They have a fire resistance level of 120 minutes, meaning that it can withstand a fire for 120 minutes.

Additionally, there is a firewall between the battery compartment and the inverter/power conversion system (PCS) compartment of the BESS. It is designed to prevent an internal fire in either compartment from spreading to the other.

Detection

The BESS is equipped with several detection devices/sensors able to detect hazardous conditions such as thermal runaway. Sensors include temperature sensors, smoke detectors, and gas detectors (H_2 and CO). The gas detectors are not used to trigger the FSS, but rather to initiate forced ventilation to prevent build-up of flammable gasses inside the BESS.

A layout of the container and all detection devices is displayed in Figure 2. Additionally, temperature sensors are located inside each battery pack of the battery strings, shown here has “xBCy”.



Layout of container equipment

26							13	H2	Hydrogen detector	Gan760-H2-200Q	1	pcs
25	SJ	Water intrusion	SF11201-31-K1H1-M8PP04	1	pcs		12	CO	Carbon monoxide detector	Gan760-CO-200Q	1	pcs
24	SF	Fire inlet fan	FV0300-I	1	pcs		11		Fire fighting bottle	SPS020-MS-032-EN	1	pcs
23	PF	Fire exhaust fan	FV0300-230	1	pcs		10		Socket	Socket	3	pcs
22	B	Power distribution Box	K11031M2	1	pcs		9		lighting	STL-020AXX	5	pcs
21	Bell	Fire alarm bell	JL-188	1	pcs		8		lighting switch	G07K111C	3	pcs
20	AVA	Audible and visual alarm	958CHL1000	1	pcs		7	PAC	Industrial air conditioner	MC90HDNC1A	4	pcs
19	FX-L	Fire exhaust indicator	QM-ZSD-01E	1	pcs		6	CN-ES	Container emergency stop button	ZB4-BS844	1	pcs
18		Manual automatic and emergency starting device	K911110M8	1	pcs		5	DB	Distribution box	500H*450W*220D(mm)	1	pcs
17	XF-ES	Fire emergency stop button	K91000M10	1	pcs		4	PCS-FAN	PCS room fan	BL-A250C-EC-E0S	8	pcs
16		heat detector	55000-121	2	pcs		3	RH	Temperature and humidity transmitter	JWST-10AC	1	pcs
15	S	smoke detector	55000-316	3	pcs		2	KC	Control box	650H*600W*220D(mm)	1	pcs
14	K	Ventilation control module	F-VENT-M	1	pcs		1	PCS	Power converter system	PWS1-500KTL-EX-8M4	2	pcs
No.	Legend	Device Name	Model and Specification	Quanity	Unit	Remark	No.	Legend	Device Name	Model and Specification	Quanity	Unit

Figure 2: Layout of a Capture Energy Powerbox BESS with all components and detection devices shown.

Suppression

The BESS is equipped with a FSS using the extinguishing agent FK-5-1-12 (previously called 3M Novec 1230) [1]. The suppression agent provides a combination of safety, low environmental impact and high extinguishing performance. It is stored as a liquid but distributed as a gas.

FK-5-1-12 functions by removing the heat from the fire. When released, the fluid creates a gaseous mixture with air, which has a significantly higher heat capacity compared to pure air. This means that the gas mixture requires more energy for temperature to increase. At the levels distributed by the supression system it absorbs sufficient heat to disrupt the combustion and cool it to the point that the fire is extinguished.

Fire suppression system deployment flow chart

A flow chart describing how the BESS acts in the event of a fire is shown in Figure 3. As seen in the diagram, there is a 30 second delay before initiation of the FSS. During this time, if it is discovered that the FSS has been triggered falsely, there is an emergency stop switch on the outside FSS panel.

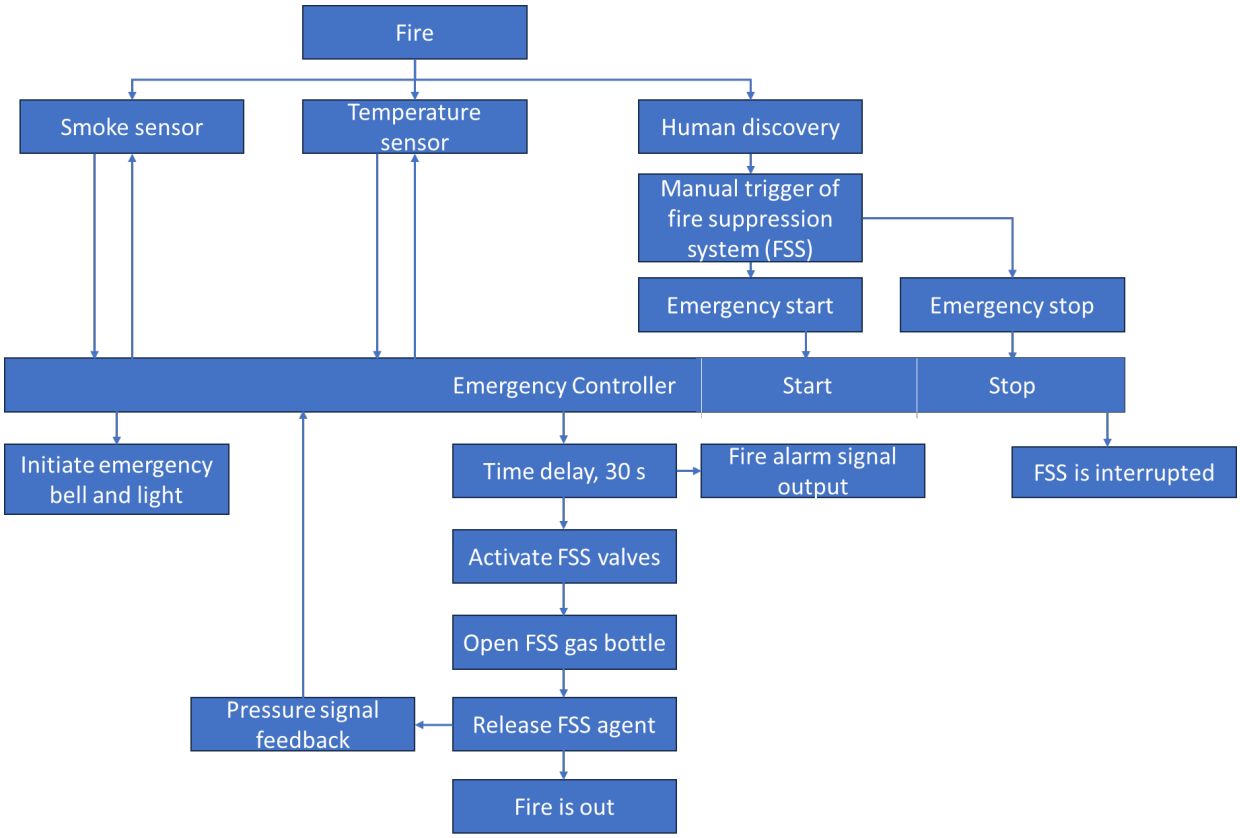


Figure 3: Flow chart describing how the BESS acts in the event of a fire.

Safety certification

The BESS variants, and their subcomponents carry all necessary safety certifications. A list of relevant safety certifications for the European market is provided in this section.

BESS:
IEC 62933-5-1 (pending)
IEC 62933-5-2 (pending)
UL 9540A
UN 3536

Battery string:
IEC 62619
IEC 63056 (pending)
UL 9540A
UN 38.3

Battery pack:
UN 38.3
UL 9540A

Cell:
IEC 62619
UL 9540A
UN 38.3

Inverter:
EN 50549-1
EN 50549-2

Referenced documents

Number	Title	Revision	Link
[1]	3M Novec 1230 Technical Data Sheet	6	https://multimedia.3m.com/mws/media/124688O/3m-novec-1230-fire-protection-fluid.pdf?&fn=3M-Novec-1230-Fire-Protection-Fluid-Technical-Data-Sheet_R6.pdf