CanadianSolar

SolBank
User Manual
(DC1324.8V)

V1.8

CSI Energy Storage Co., Ltd.

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Contents

1 Preface

1.1 Document Purpose and Scope

The purpose of this document is to provide an overview of the processes and procedures required to operate the SolBank Energy Storage System (ESS) (1500V models only). The scope of this manual is limited to only those tasks applicable to operation of this product. Topics covered include, major component overview, operational safety hazards and precautions, modes of operation, pre-operation checklists, and startup and shutdown procedures.

This manual should be made available to all field personnel participating in the design, installation, operation, and maintenance of the DC SolBank energy storage system. A copy of this Manual should be available on-site at all times.

This manual is to be considered supplemental to project specific design and safety documentation. Please read and understand all aspects of this document prior to initiating SolBank operation.

Should any questions arise, please contact CSI support:

- By telephone at (xxx)xxx-xxxxxx
- By email at supportAmerica@csisolar.com

1.2 Applicable Models

This manual covers the following models only:

- **CSI-SolBank-S-2967-2h-US**
- **CSI-SolBank-S-2967-4h-US**
- **CSI-SolBank-S-2225-1.5h-US**
- **CSI-SolBank-S-2967-2h-EU**
- **CSI-SolBank-S-2967-4h-EU**
- **CSI-SolBank-S-2225-1.5h-EU**

1.3 Reference Documents

The SolBank User Manual exists as part of library of product specific documents. Please consult the following documents to ensure a comprehensive understanding of SolBank attributes.

- ***SolBank Installation Manual***
- ***SolBank User Manual***
- ***SolBank safety Manual***
- ***SolBank Maintenance Manual***
- ***SolBank Commissioning Manual***

1.4 Version Control

This is the initial release of the DC SolBank User Manual. As part of CSI's continuous improvement process, CSI reserves the right to make technology and document changes. Please contact CSI support to verify this manual reflects the most recent release or to report omissions or inaccuracies.

Version	Description	Date of Issuance
SolBank User Manual_v0.0	Initial publication date	
SolBank User Manual _v1.0	Format optimization	2022.5.13
SolBank User Manual _v1.2	Add product sequence	2022.10.22
SolBank User Manual _v1.3	Update Product models	2022.11.18
SolBank User Manual _v1.4 UK	Change to European product range	2023.01.06
SolBank User Manual _v1.5 EU	Example Modify the product model name	2023.03.03
SolBank User Manual _v1.5	Modify product model	2023.03.03
SolBank User Manual _v1.6	Delete the description of ground fault detection in the DMC	2023.08.01
SolBank User Manual_v1.7	Increase: 1) Temperature and humidity requirements during maintenance; 2) Derated operation with ambient temperature > 45 ° C	2023.11.08
SolBank User Manual_v1.8	1) Format optimization 2) merge UK/EU version	223.12.13

1.5 Document Safety Notices

Throughout this manual the below indicated labels are used to convey hazards associated with specific tasks and procedures. These safety notices do not represent all hazards present when performing a given task. Installers and operators of the SolBank should adhere to industry safety best practices; site specific Environmental, Health and Safety plans; and local safety requirements and regulations. ***Only properly trained and qualified personnel should be permitted to complete the installation procedures identified in this manual.***

Labels	Explanation
UK CA	UKCA mark of conformity.
CE	CE mark of conformity.
	Indicates a hazardous situation which, if not avoided, could result in death or serious injury. Indicators are not used for property damage hazards unless personal injury risk appropriate to this level is also involved.
	Label the product as inflammable and explosive, and do not involve open flame.
	Electrical hazard sign, non-professional personnel do not approach. Professional personnel are required to perform maintenance and operation.
	Do not discard randomly
	Recycling equipment

1.6 Product Certification and Compliance

The SolBank is compliant with the standards, regulations, and requirements identified in Table 1.

Standards	
System	**NEC – National Electrical Code®** **IEC 60529 – Degrees of protection provided by enclosure UL 508 – Standard for Industrial Control Equipment** **UL 991 – Standard for Tests for Safety-Related Controls Employing Solid- State Devices.** **UL 1998 – Standard for Software in Programmable Components** **IEEE C84.1 – Standard Preferred Voltage Ratings for Alternating-Current Electrical Systems** **IEEE 693 – Recommended Practice for Seismic Design of Substations IEEE 1584-2018 – Guide for Performing Arc-Flash Hazard Calculations** **Modular Energy Storage Architecture – Energy Storage System (MESA-ESS) Standard**
Fire Protection and Safety	**NFPA 855 – Installation of Energy Storage Systems** **NFPA 70E® – Standard for Electrical Safety in the Workplace®** **NFPA 72 – National Fire Alarm and Signaling Code** **NFPA 69® – Standard on Explosion Prevention Systems** **NFPA 68® – Standard on Explosion Protection by Deflagration Venting** **UL9540A – Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems**

Table 1: SolBank Standards Compliance

2 Acronyms and Abbreviations

AC – Alternating Current

AHJ – Authority Having Jurisdiction

BMS – Battery Management System

BOL – Beginning of Life

DC – Direct Current

SolBank Controller – Local Energy Management System (Battery system)

EOR – Engineer of Record

ESS – Energy Storage System

COG – Center of Gravity

HVAC – Heating Ventilation Air Conditioning

IFC - Issued for Construction

LFP – Lithium Iron Phosphate

LOTO – Lock-Out-Tag-Out

NFPA – National Fire Protection Association

PCS – Power Conversion System

PPE – Personnel Protective Equipment

SPD – Surge Protection Device

UPS – Uninterruptible Power Supply

EPC – Engineering, Procurement, and Construction contractor

CapEx - Capital Expenditures

3 Introduction

3.1 Acknowledgement

Thank you for purchasing the containerized SolBank system supplied by CSI Energy Storage Co., Ltd. The SolBank is an advanced modular battery energy storage system incorporating industry leading capabilities enabled by cutting-edge technologies and innovative design. High energy density, liquid cooled battery and power electronics, extended service life, and advanced safety features are just a few of the attributes that set the SolBank apart from other ESS products.

The SolBank is fully factory integrated and tested at CSI's facility, arriving on site with battery racks populated and sub systems installed. This high level of pre-integration results in rapid installation, reduced EPC CapEx, and improved system performance and reliability.

3.2 System Overview

The SolBank System integrates all power electronics, controls, and safety features required to support the DC side of a battery energy storage system. An overview of the SolBank layout and key features is shown in Figure 3-1 and further described in Table 2.

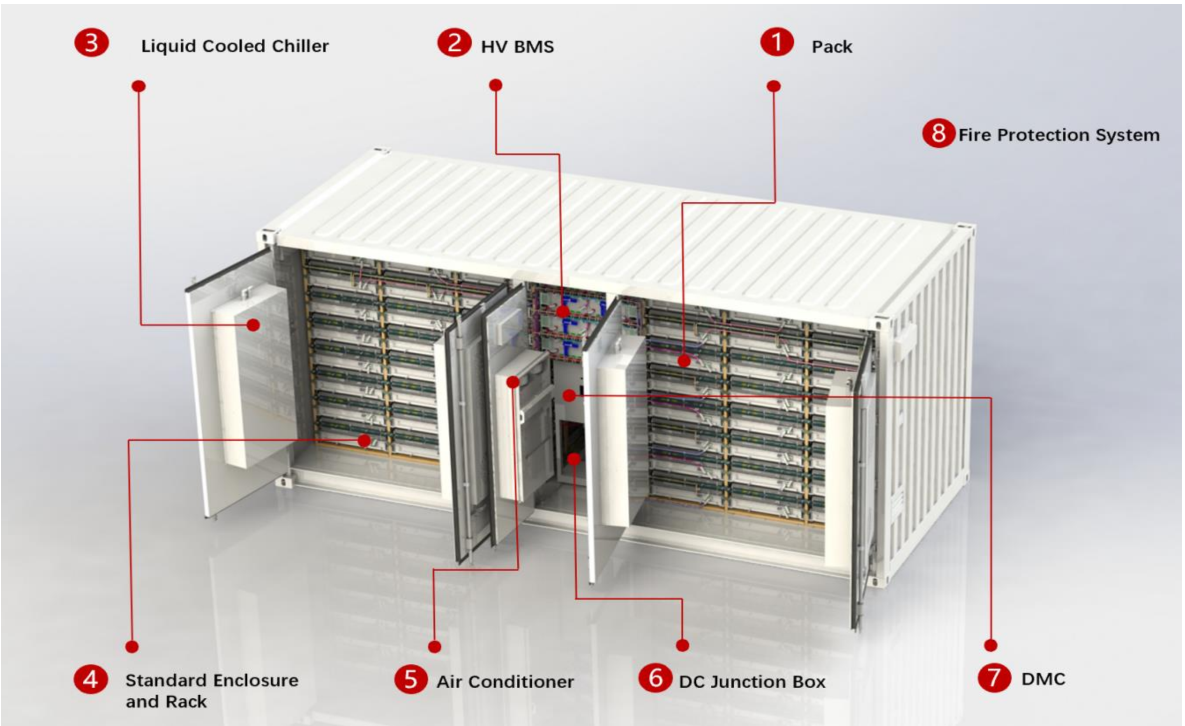


Figure 3-1: Layout and features of the SolBank

Table 2: Key System Features

NO.	Name	Remarks
1	Pack	The SolBank contains 48(36 in CSI-SolBank-S-2225-1.5h) Lithium Iron Phosphate (LFP) battery packs, each consisting of 69 series wired battery cells.
2	HV BMS	The SolBank contains 8(6 in CSI-SolBank-S-2225-1.5h) HV BMS.These are easily accessed for installation and maintenance within the central bay of the container.The BMS ensure optimal battery functionality and safety.
3	Liquid Cooled Chiller	The SolBank's liquid cooling/heating system facilitates improved battery temperature management efficiency relative to traditional forced air systems. Each battery pack is liquid cooled, allowing for greater heat dissipation and uniform cell temperature management. During charge and discharge, cell temperature is maintained between 20°C - 35°C.
4	Standard Enclosure and Rack	All models of the SolBank utilize a standard IP-55 rated 20'ft HC container and battery rack design allowing for enhanced system modularity without increased production and equipment costs.
5	Air Conditioner	The SolBank's Air HVAC is used to control the temperature of the DMC and Junction Box within the 25℃(±3) range, as well as the temperature and humidity inside the SolBank enclosure.
6	Junction Box	The SolBank's DC Junction box contains all primary DC busbar, fusing, Surge Protection Devices (SPD), disconnects, and power monitoring.
7	DMC	The Distribution Management Cabinet (DMC) houses all aux power distribution equipment including 2-hour backup UPS; system communication, control, and monitoring hardware including network switch, and SolBankController, and all required customer communication, signal, and aux power interfaces.
8	Fire Safety System	SolBank is equipped with heat and smoke detection for fire alarm system and equipped with explosive gas detection and ventilation for explosion prevention.

3.3 System Specifications

The SolBank system has two models, as shown in Table 3 below. Each model has varying C-rate, power, and energy characteristics. Battery string size, nominal voltages, form factor, and physical dimensions remain consistent across all models. This manual applies only to model

Table 3: SolBank (DC 1324.8V) Specifications.

SYSTEM MODEL NUMBER	CSI-SolBank-S-2967-4h	CSI-SolBank-S-2967-2h	CSI-SolBank-S-2225-1.5h
Discharge Duration	4-hour	2-hour	1.5-hour
Charge/Discharge C-rate	0.25P	0.5	0.67C
BOL Cell Energy (kWh)	2.967	2.967	2.225
Usable Energy (kWh)	2800	2750	1.95
Voltage Range (VDC)	1159.2~1490.4		
Recommended Discharge Power (kW)	700	1375	1300
# of LFP Battery Rack	1P414S	1P414S	1P414S
# of BMS	8		6

Table 4: Additional Specifications

SYSTEM MODEL NUMBER	CSI-SolBank-S-2967-4h	CSI-SolBank-S-2967-2h	CSI-SolBank-S-2225-1.5h
Cell Chemistry	LFP		
Rated Capacity (Cell)	280Ah		
Rated Voltage (Cell)	3.2V		
Ingress Protection/Environmental Rating(Pack)	IP65		
Rack type	1P414S		
Enclosure Power Rating (Nominal)	0.7MW	1.375MW	1.3MW
Rated Capacity (Nominal)	8*280Ah	8*280Ah	6*280Ah
Rated Voltage (Nominal)	1324.8V		
Enclosure Energy Capacity Rating (Nominal)	2.967MWh	2.967MWh	2.225MWh
Enclosure Usable Energy Capacity	2.8MWh	2.75MWh	1.95MWh
Charging/Discharging Mode	0.25P	0.5P	0.67P
Cooling concept	Liquid cooling + air-cooled		
Dimensions (LxWxH)	6058*2438*2896mm		
Weight	29,500 kg (65,700 lbs)		24000 kg (53,800 lbs)
Auxiliary power interface	AC380V/ 50Hz, 3 phase 5 wire		
Communication interfaces	Ethernet		
Communication protocols	Modbus TCP/IP		
Cycle Life (25 ℃, 0.25C)	8000 @ 60%SOH. 100%DOD		
Noise	＜75dB(A)		
Environmental temperature	-30°C to 55°C （derating between ＞45℃）		
Environmental humidity	≤90%RH		
Ingress Protection/Environmental Rating	IP55		
Seismic Parameters	Zone4		
Altitude	<2000m (derating between 2000 m ~ 4000 m)		
Design Standards/Codes	UL1973, UL9540, UL9540A, IEC62619, NFPA855		

4 Operational Safety

4.1 SolBank Hazards

The primary hazards associated operation of the SolBank are indicated below and in Table 5 and discussed in detail within the SolBank Safety Manual. Hazard warning signs and other signage are identified in Annex 1. The below hazard summary does not represent a complete list of hazards at an ESS site. User should reference project and site-specific safety documentation such as an Environmental Health and Safety (EH&S) plan or Emergency Response Plan (EMP) for further details.

4.1.1 Electrocution Hazard

Personnel will be exposed to voltages up 1500 VDC from the SolBank's battery packs. Battery packs cannot be de-energized. Low and medium voltage AC is also present – exposure levels will depend on site specific conditions. Risk of arc flash and electrocution is omnipresent at an ESS site. CSI encourages full compliance with the practices and procedures indicated in NFPA 70E including use of Personal Protective Equipment (PPE) sufficient to mitigate any hazards identified in a site-specific arc flash study. Emergency Response Personnel should rely on Standard Operating Procedures (SOP) for responding to incidents at electrical generating facilities.

4.1.2 Fire and Explosion Hazard

The SolBank contains combustible fuels, ignition sources, and sufficient oxygen to result in propagation of fire. Fire and other sources of extreme heat, if not properly mitigated, can lead to battery cascading thermal runaway and the release of combustible gases. **These combustible gases, if present in sufficient density, pose a risk of explosion.** If a fire, or other indications of thermal runaway are present within the SolBank or at the ESS site, first responders are advised to maintain a safe perimeter until it can be verified that entry into the ESS site is safe per the site specific Emergency Response Plan (ERP) and SOP.

4.1.3 Chemical Exposure Hazard

The SolBank contains the following hazardous chemicals: LFP battery electrolyte, lead acid battery electrolyte, R410a refrigerant, and Ethelyne Glycol coolant. **These chemicals can be hazardous to both human health and environment.** Please refer to the Safety Data Sheets (SDS) contained within the SolBank Safety Manual for hazards and precautions specific to each chemical.

Table 5: SolBank primary hazards

CLASSIFICATION	HAZARD	DESCRIPTION	QUANTITY	RISK
Electrical hazards	DC voltage	Primary voltage of storage system	1500VDC	Electrocution
	AC voltage	Primary voltage of auxiliary power supply	400VAC/480V AC	Electrocution
Chemical hazards	Ethelyne Glycol	Coolant used in battery liquid cooling system	284L (75gal)	See Emergency Response Manual
	R410a Refrigerant	Refrigerant used in roof mounted AC system	2.5kg (5.5lbs)	See Emergency Response Manual
	Li-ion Electrolyte	Battery electrolyte used in LFP battery cells	336L (89gal)	See Emergency Response Manual
	Lead Acid Electrolyte	Battery electrolyte used in UPS	0.16L(0.04gal)	See Emergency Response Manual
Fire & Explosion Hazards	Electrical Fire	Fire caused by cable fault or component failure	--	Fire
	Thermal Runaway	Thermal runaway from battery fault or excessive heat	--	Fire, off-gassing
	Battery off-gassing	Off-gassing resulting from thermal runaway	--	Explosion

4.2 Emergency Shutdown

See Section 9.1 for emergency shutdown procedures.

4.3 Operational Precautions

DANGER

Batteries cannot be deenergized. The shutdown sequences described below can only isolate batteries and associated dangerous voltage. Personnel must always exercise extreme caution and wear proper PPE.

DANGER

Complete ESS Shutdown sequences will vary by site specific design. Always consult site specific schematics and manuals to ensure proper isolation of electrical equipment.

DANGER

Lock-out-tag-out (LOTO) procedures should be implemented to prevent accidental energization of equipment.

All personnel operating the SolBank shall be properly trained and qualified. Personnel shall read and understand all manuals and project documentation and adhere to the requirements and direction within.

Shutting down thermal management and communication systems for extended periods may result in damage to equipment and inability to detect and communicate fault conditions.

Closing the BMS contactors under load may result in damage to SolBank BMS. Only use the E-stop buttons in event of emergency.

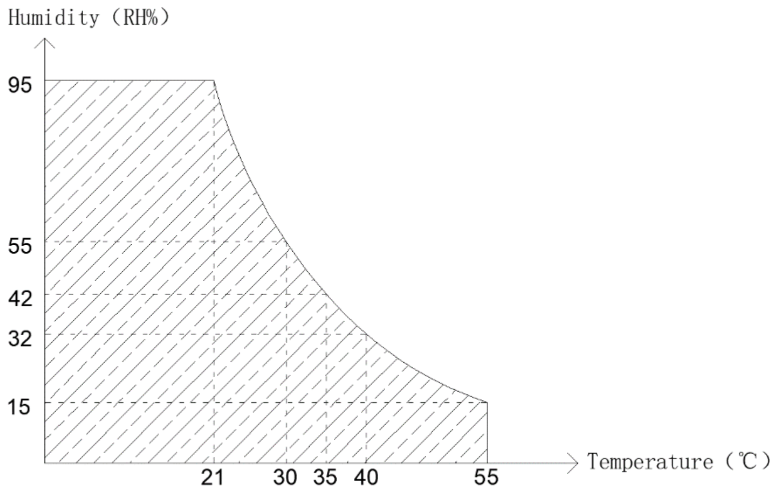
Do not initiate SolBank operation until system is fully commissioned and inspected by CSI field technicians, or until all required periodic maintenance is performed.

Opening of doors during "appropriate weather" :

1) no rain;

2) wind speeds ≤18 mph；

3) The ambient temperature and humidity conditions meet the requirements of the shadow part of the figure below



Do not modify or alter the SolBank without written permission from CSI

4.4 System Protection Features

The SolBank incorporates numerous features designed to protect personnel and equipment from harm. See Table 6 for a summary of these features.

Table 6: SolBank System Protection Features

FEATURE	DESCRIPTION
Smoke detection	Smoke detector located centrally on the interior of the ceiling and calibrated to an alarm sensitivity of （1.02-4）%/ft
Heat detection	Heat detector located centrally on the interior of the ceiling and calibrated to an alarm threshold of 57
Firefighting aerosol (EU version use only)	There are four equipments located in the ceiling
Audible and visual alarms	One Externally mounted alarm bell and one externally mounted siren and strobe combination alarm.
Water sprinkler system	Integrated water-based fire suppression system and external dry-pipe or hose connection for water supply.
Lightning strike mitigation	2 units(6 pieces) Surge Protection Devices (SPD) located on the main DC bus,auxiliary power bus.
Water and flood detection	Water detection sensors located on the floor of the SolBank.
Thermal runaway prevention	Sophisticated battery cell and pack design, advanced BMS functionality, and stable cell electrolyte chemistry combine to greatly reduce the probability of battery thermal runaway.
Overcurrent Protection	All SolBank electrical circuits are protected by properly sized Overcurrent Protection Devices (OCPD)
Emergency stop buttons	Two emergency stop (E-stop) buttons are located on the external ends of each SolBank. Activating an E-stop button will immediately open all BMS DC contactors.
Access door limit switch alarms	The User Interface Cabinet access door contains a limit switch that prevents operation of the SolBank when the door is open.

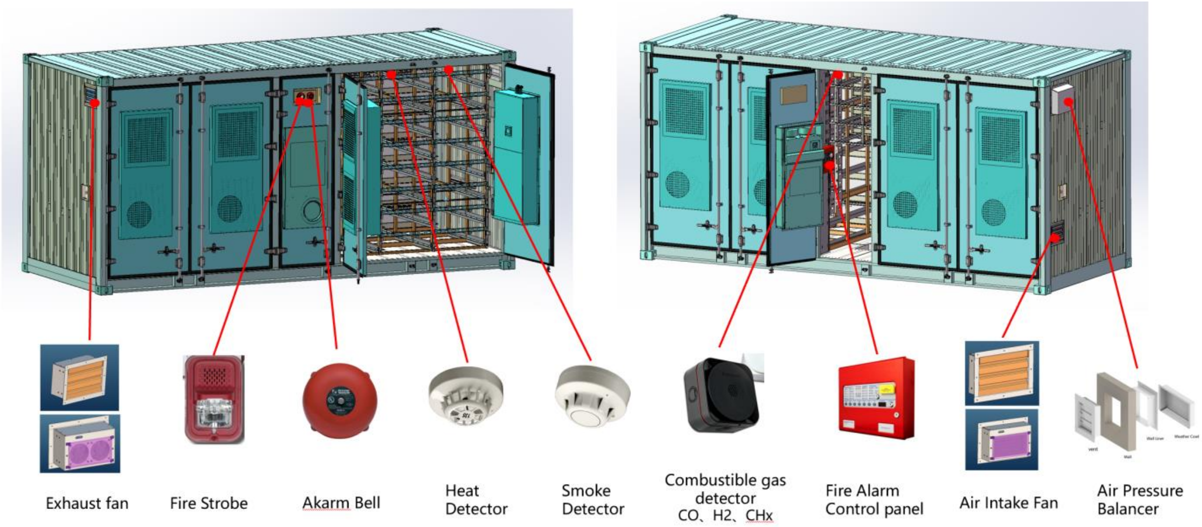


Figure 2: Layout and features of the SolBank

5 Key Component Overview

5.1 SolBank Enclosure

All models of the SolBank utilize a standard IP-55 rated container and battery rack design allowing for enhanced system modularity without increased production and equipment costs. The enclosure and all components within are factory installed and commissioned, requiring only limited field integration upon arrival on-site. See the *SolBank Installation Manual* for further details.

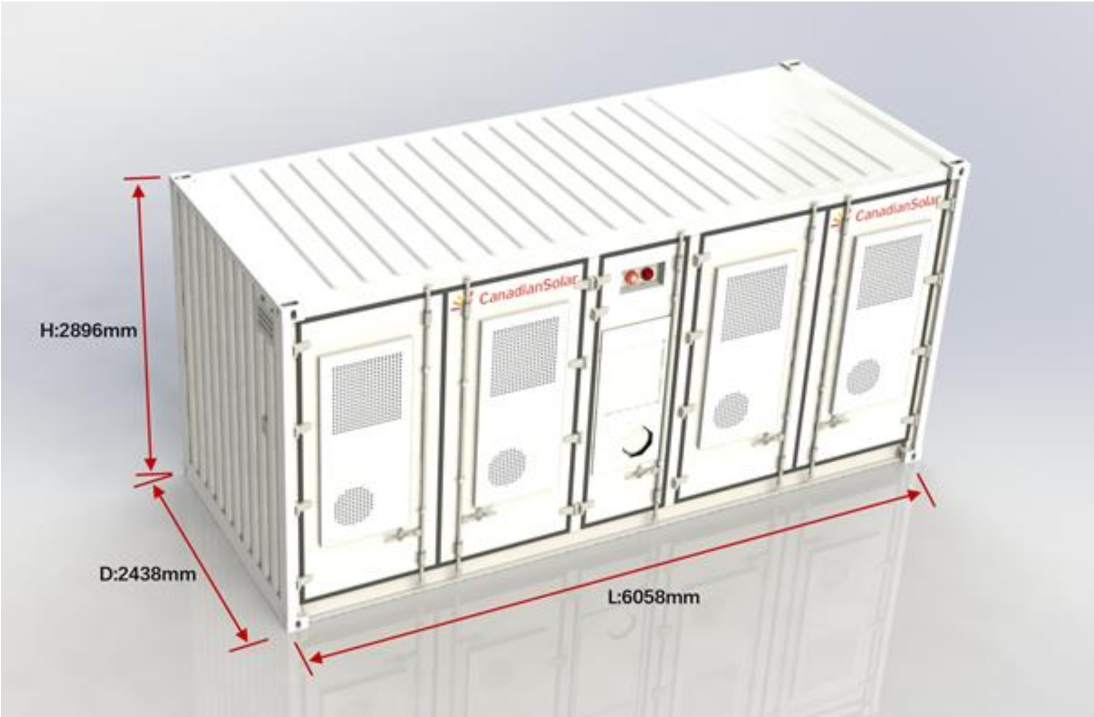


Figure 3: SolBank Dimensionss

5.2 SolBank Battery System

The SolBank contains 48(36 in CSI-SolBank-S-2225-1.5h) Lithium Iron Phosphate (LFP) battery packs, each consisting of 69 series wired battery cells. Each battery pack has a nominal voltage of 220.8VDC and is wired in series with five other battery packs to achieve a nominal string voltage of 1,324.8VDC. Each battery pack contains roughly 14L (3.7gal) of electrolyte. Each SolBank contains roughly 336L (52gal) of electrolyte. The battery pack housing is constructed from a material with a flame-resistant rating of 5VA.

The SolBank contains 1P69S battery packs and 8(6 in CSI-SolBank-S-2225-1.5h) BMS. A typical battery string consists of 6*1P69S battery packs wired in series and connected to a single BMS as shown in Figure 4 such strings exist within each SolBank. To ensure safe transport of the SolBank, the battery packs have been electrically isolated by disconnecting several interconnection cables.

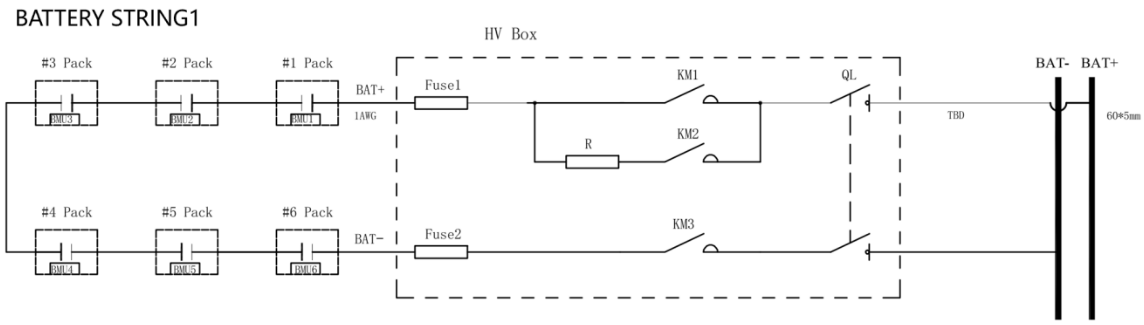


Figure 4: SolBank battery string. 1 of 8 shown.

Other notable attributes of the battery pack include the liquid cooling connectors, positive and negative terminals connector. See Figure 5 for further details. The SolBank will arrive on site with the battery packs installed and integrated to the extender permissible by shipping and transit regulations. Site installers will be required to land pre-terminated and secured inter-string cabling, and install maintenance switches. See the *SolBank Installation Manual* for further guidance.

Figure 5: SolBank battery pack

Table 7: SolBank battery pack specifications

DIMENSIONS	
Height	260±3m
Width	730±3mm
Length	1849±1.5mm
Weight	461±5kg

ELECTRICAL PARAMETERS	
Nominal Voltage	220.8V
Nominal Capacity	280Ah
	61,824kWh
Charge Mode	CP
Charge Current	140A (Standard Continuous Charge Current@25℃)
	180A (Max. Continuous Charge Current@25℃,≤30min)
	200A (@ 25°C， ≤10s, Tmax≤40℃)
Charge Cut-off Voltage	3.60V/Battery Cell
Discharge Mode	CP
Discharge Cut-off Voltage	2.80V/Battery Cell
Discharge Current	140A (Standard Continuous Discharge Current@25℃)
	180A (Max. Continuous Discharge Current @ 25℃, ≤60min)
OPERATING CONDITIONS	
Operating Temperature	Charge: 0~+50℃
	Discharge: -20~+55℃
Storage Temperature	Storage (≤3 Months): -20~+45℃ (SOC:30%~60%)
	Storage (≤12 Months): 0~+35℃ (SOC 30%~60%)
Storage Humidity	⩽90%
Shipment Status	Voltage: 3.25~3.31V (Battery Cell)
	SOC: 30%

5.3 SolBank Battery Management System (BMS)

The SolBank houses 8 rack-mounted (6 rack-mounted in CSI-SolBank-S-2225-1.5h), Battery Management Systems (BMS) (one for each string). These are easily accessed for installation and maintenance within the central User Interface Cabinet of the SolBank. The BMS works in concert with CSI-SolBank battery pack Battery Management Units (BMU) to ensure optimal battery functionality, lifespan, and safety by continuously monitoring battery parameters such as voltage, temperature, insulation, while also performing maintenance functions such as cell balancing. In the event the BMS detects a fault condition, or if an operational parameter exceeds an acceptable range, the BMS will isolate the impacted battery string by opening integrated DC contactors. See Figure 6 for additional details.

Figure 6: BMS plug receptacles and termination locations.Battery string positive (bottom) and negative (upon) indicated by red circle

5.4 SolBank Liquid Cooling and Heating System

The SolBank leverages a liquid cooling and heating system which distributes a temperature regulated ethylene glycol solution throughout the SolBank enclosure, efficiently dissipating heat from battery cells when charging and discharging, while also providing necessary cell heating during periods of cold weather. See Figure 7 for an overview of the coolant distribution system.

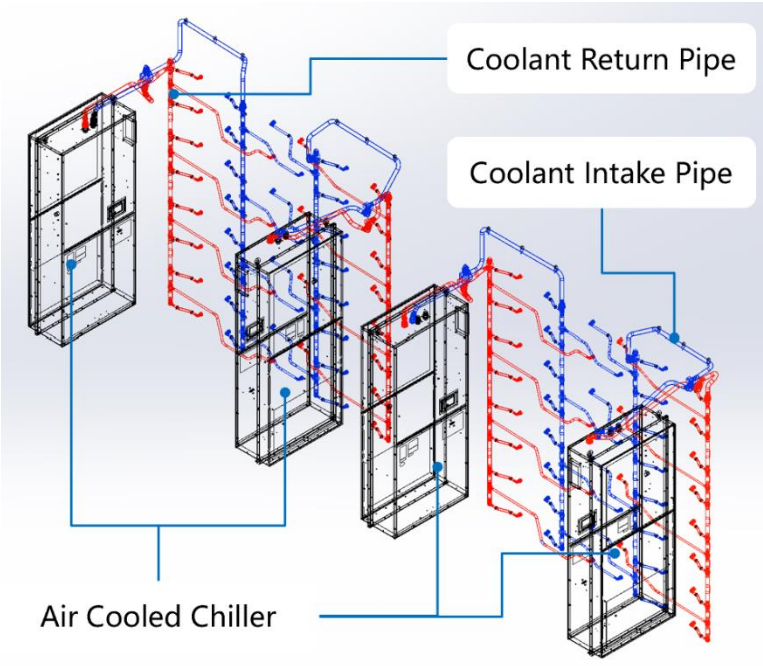


Figure 7: SolBank liquid cooling system schematic

Temperature regulated coolant flows outbound from the coolant reservoir located within the HVAC cabinet to the 48 battery packs (36 battery packs in CSI-SolBank-S-2225-1.5h) via the green distribution lines shown in Figure 7. After passing through each required device, and absorbing heat (or releasing heat – heating mode), the coolant then flows back into the HVAC cabinet via the red piping, where it is cooled, if necessary, by a glycol/refrigerant heat exchanger. The cold side of this heat exchanger is part of a refrigerant loop supported by the SolBank's door mounted AC system shown in Figure 8. The SolBank coolant system is factory charged. However, in the event damage or shipping limitations require field charging, please consult the SolBank Coolant Filling Manual.

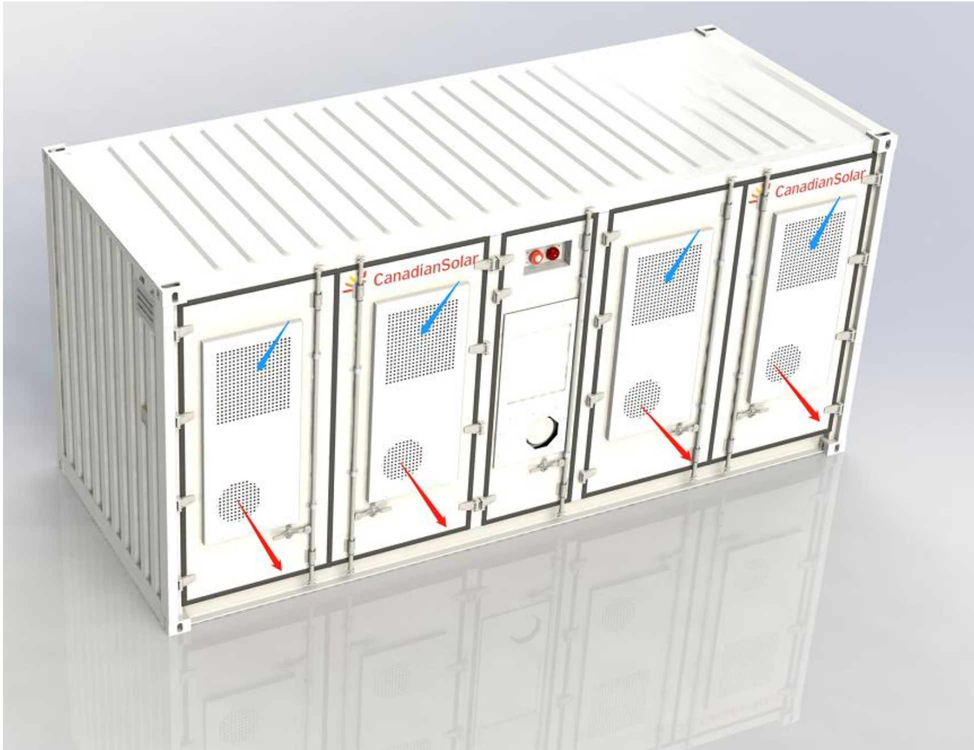


Figure 8: Door mounted heat exchangers for air conditioner refrigerant loop

The SolBank's HVAC system can be turned on by closing breaker QF3~QF6 (0.25P: QF3~QF4) within the Distribution and Control Cabinet. See Section 9 for system startup procedures. The SolBank's HVAC system can be controlled and adjusted, if need be, via the HVAC Human Machine Interface (HMI) located within the HVAC cabinet. Always consult CSI technical support before adjusting HVAC parameters or setpoints.

Table 8: Coolant System Specifications

ITEM	PARAMETER	REMARK
Cooling system medium	50/50 Ethylene Glycol and deionized water	
MSDS Ethelene Glycol	See *SolBank Safety Manual*	
Equipment cooled/heated	48/36 SolBank LFP battery packs	0.67P : 36 SolBank LFP battery packs
# of Primary system valves	4(supply and return). Located in HVAC bay	0.25P : 2(supply and return). Located in HVAC bay
# of Branch circuit valves	8 (4distribution and 4supply). Located throughout	0.25P :4 (2distribution and 2supply). Located throughout

Table 9: Air Conditioning System Specifications

ITEM	PARAMETER	REMARK
Cooling Capacity	40 kW (0.72 tons)	0.25P: 20kW
Heating Capacity	8 kW	
Operating Temperature Range	-30°Cto 55°C (-22°F to 131°F)	
MSDS refrigerant	See *SolBank Safety Manual*	
Sound(＜1M)	＜75dBA	＜1M

5.5 SolBank DC Junction Box

The SolBank's DC Junction box contains all primary DC busbar, fusing, Surge Protection Devices (SPD), disconnects, and power monitoring required to safely exchange power between the SolBank and ESS Power Conversion System (PCS).

All field wiring, to include system ground, primary DC cables, and communication cables enter the base of the DC Junction Box. See the *SolBank Installation Manual* for further details.

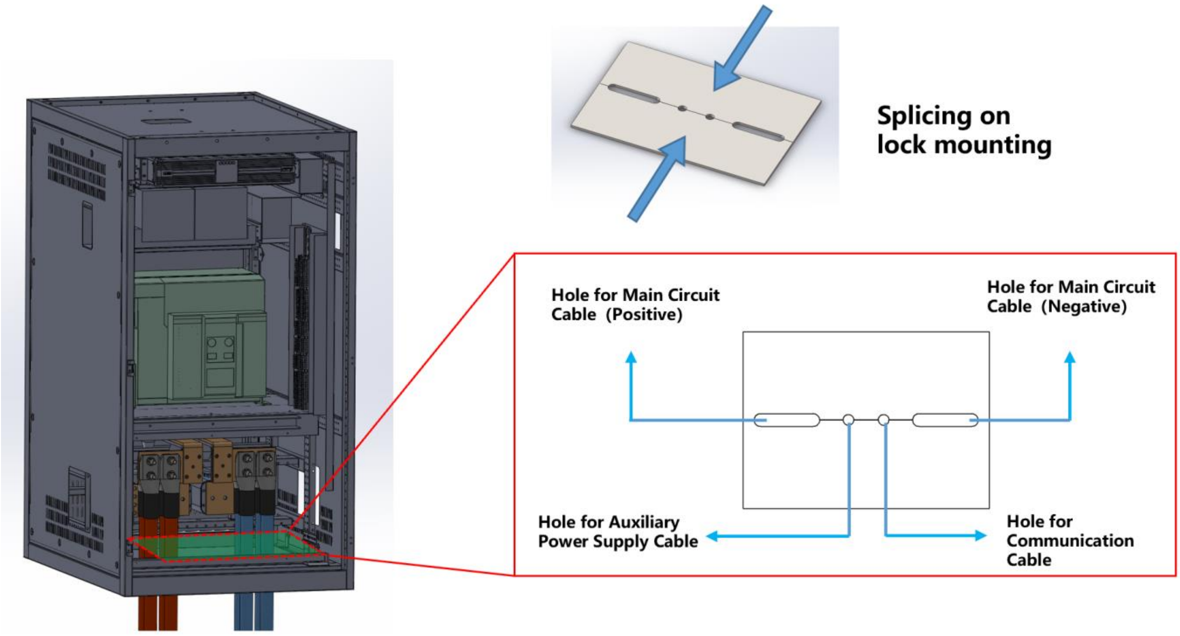
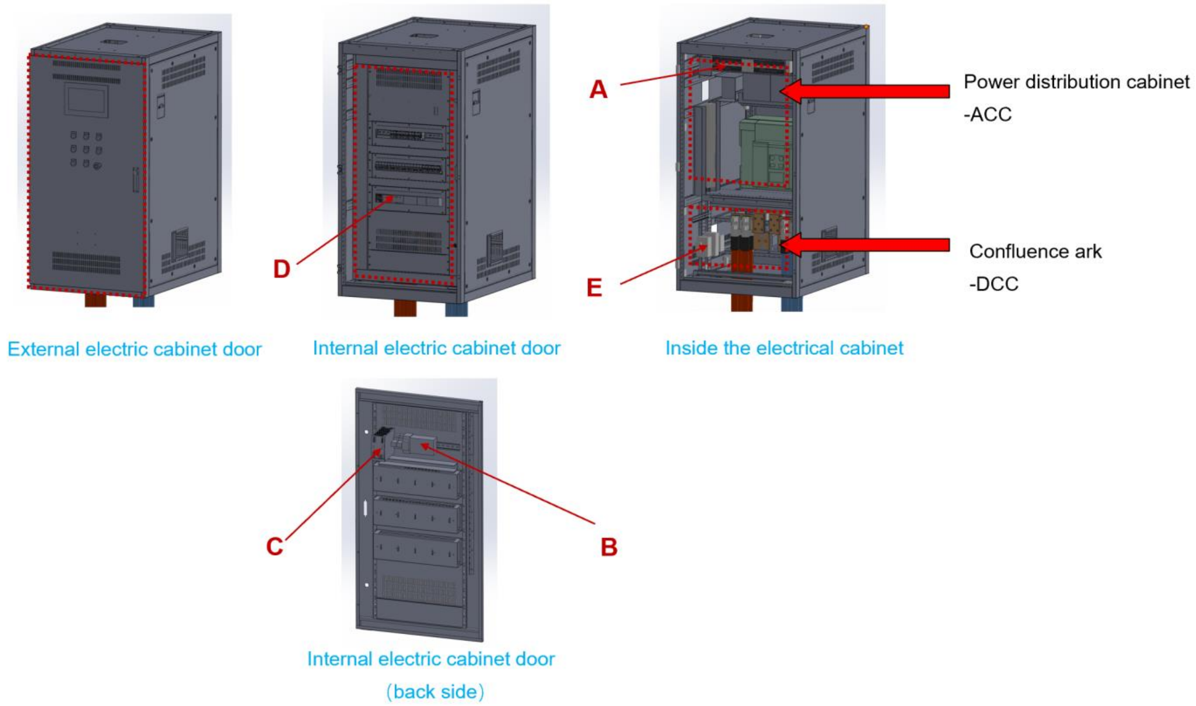


Figure 9: Location of power cable foundation exit

The Junction Box contains the primary 1800A DC disconnector used to disconnect the SolBank's battery system and main DC bus from the DC terminals of the plant PCS. Do not operate the DC disconnector under load.

5.6 SolBank Distribution and Control Cabinet

The Distribution and Control Cabinet houses all aux power distribution equipment including 2-hour backup UPS; system communication, control, and monitoring hardware including network switch, and Energy Management Control Unit (SolBank Controller); and all required customer communication, signal, and aux power interfaces.



No.	Interface	Remarks
A	**UPS**	**Used for auxiliary power supply in equipment**
B	**Fibre Channel switch**	**Ring network communication line**
C	**24 V power supply**	**Used for sensor equipment**
D	**Watt-hour meter**	
E	**Auxiliary power terminal**	

Figure 10: Distribution and Control Cabinet

The Distribution and Control Cabinet is the primary user interface required for SolBank startup and shutdown procedures. See Section 9, Section 10, and Table 10 for additionally details.

Table 10.1: Auxiliary Power Overcurrent Protection Device (OCPD) index(0.5P&0.67P)

PROTECTIVE DEVICE	CIRCUIT DESCRIPTION	VOLTAGE	AMPS	Remarks
QF1	Supplies aux power system POWER	480Vac(US) 400Vac(EU)	0.67P:50A(US) 0.5P:50A(US) 0.5P:63A(EU)	
QF2	Supplies Surge Protection Device switch	480Vac(US) 400Vac(EU)	32A	
SPD1	Supplies Surge Protection Device (SPD)	480Vac(US) 400Vac(EU)	20/40kA	

QF3	Supplies 1# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF4	Supplies 2# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF5	Supplies 3# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF6	Supplies 4# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF7	Supplies AIR HVAC system	230Vac	32A	US(480VAC , 16A)
QF8	Container power supply	230Vac	10A	
QF9	Supplies fire controller	230Vac	6A	
QF10	Supplies UPS input	230Vac	10A(US) 6A(EU)	
QF11	Supplies Battery Rack	230Vac	6A	
QF12	Supplies AC/DC (24VDC)	230Vac	6A	
QF13	Supplies signal lamp& divide-shut brake	230Vac	6A	
QF14	Supplies Container Fan	230Vac	6A	

Table 10.2: Auxiliary Power Overcurrent Protection Device (OCPD) index(0.25P)

PROTECTIVE DEVICE	CIRCUIT DESCRIPTION	VOLTAGE	AMPS	Remarks
QF1	Supplies aux power system POWER	480Vac(US) 400Vac(EU)	0.25P:32A(US) 0.25P:40A(EU)	
QF2	Supplies Surge Protection Device switch	480Vac(US) 400Vac(EU)	32A	
SPD1	Supplies Surge Protection Device (SPD)	480Vac(US) 400Vac(EU)	20/40kA	
QF3	Supplies 1# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF4	Supplies 2# Liquid HVAC system	480Vac(US) 400Vac(EU)	16A	
QF5	Supplies AIR HVAC system	230Vac	32A	US(480VAC , 16A)
QF6	Container power supply	230Vac	10A	
QF7	Supplies fire control power supply	230Vac	6A	
QF8	Supplies UPS input	230Vac	10A(US) 6A(EU)	
QF9	Supplies Battery Rack	230Vac	6A	
QF10	Supplies AC/DC (24VDC)	230Vac	6A	
QF11	Supplies signal lamp& divide-shut brake	230Vac	6A	
QF12	Supplies Container Fan	230Vac	6A	

5.7 SolBank Power Meter

Integrated into the Distribution and Control Cabinet panel is the SolBank's DC power and energy meter, shown below in Figure 11. The SolBank's power meter continuously displays and logs data from the DC transducer located on the main DC bus. Data displayed includes voltage, power, current, and Energy. The internal data logger will store 1-minute data for a period of 4 months. The SolBank pulls data from power meter over Modbus RTU, and surfaces that data to the site EMS.

5.8 SolBank Fire Detection and Suppression System

The SolBank incorporates heat and smoke detection. The below alarm sequence will be programmed into the SolBank.

- Stage 1 Alarm: If a single sensor (heat or smoke) is triggered, the exterior mounted alarm bell will ring notifying on-site personnel of a potential fire within the SolBank. Simultaneously, the SolBank will communicate the alarm condition to the site EMS.
- Stage 2 Alarm: If a second sensor (heat or smoke) is triggered, the exterior mounted alarm siren and visible strobe will activate, notifying on-site personnel that both elevated heat and smoke exist within the SolBank. Simultaneously, the SolBank will communicate the alarm condition to the site EMS.

Table 11: The control logic of fire alarms

Phenomenon	Temperature Sensor	Smoke Sensor	Flammable Gas Sensor	Alarm Behavior/Level	Recovery Conditions
Small amount of flammable gases (>25% LEL default), no smoke, no high temperature			×	Level 1 gas alarm+exhaust system operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Large amounts of flammable gases (>50% LEL default), no smoke, no high temperature			×	Level 2 gas alarm+exhaust system operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Smoke only		×		Level 1 fire alarm +alarm bell operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
High temperature only	×			Level 1 fire alarm +alarm bell operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Smoke+high temperature	×	×		Level 1 fire alarm +Level 2 fire alarm+alarm bell operation+horn/strobe operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Small amount of flammable gas with smoke		×	×	Level 1 gas alarm+exhaust system operation+ Level 1 fire alarm +alarm bell operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Small amount of	×		×	Level 1 gas alarm+exhaust	Fault signal clears;

flammable gas with high temperature				system operation+ Level 1 fire alarm +alarm bell operation	after check onsite, manually confirm final clear of the fault
Large amount of flammable gas with smoke		×	×	Level 1 gas alarm +Level 2 gas alarm+exhaust system operation+ Level 1 fire alarm +alarm bell operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Large amount of flammable gas with high temperature	×		×	Level 1 gas alarm +Level 2 gas alarm+exhaust system operation+ Level 1 fire alarm +alarm bell operation	Fault signal clears; after check onsite, manually confirm final clear of the fault
Small amount of flammable gas with smoke/high temperature	×	×	×	Level 1 gas alarm + exhaust system operation +Level 1 fire alarm+ Level 2 fire alarm +bell operation+horn/strobe operation	Fault signal clears; after check onsite,manually confirm final clear of the fault
Large amounts of combustible gases, with smoke/high temperature	×	×	×	Level 1 gas alarm + exhaust system operation + Level 2 gas alarm +Level 1 fire alarm+ Level 2 fire alarm +bell operation+horn/strobe operation	Fault signal clears; after check onsite,manually confirm final clear of the fault

If an alarm is triggered, do not open any of the SolBank access doors – explosive gases may be present. If safe to do so, stop the system via E-stop, evacuate the site, and notify emergency response authorities. See Section 10.1 below and the *SolBank Safety Manual* for additional details.

6 Controls and Communication

6.1 ESS Network Design

The typical ESS network design is built upon a hierarchical control and communication structure. System dispatch commands are often sent to a site EMS controller from remotely located ESS fleet controllers, cloud-based EMS interfaces, or Automatic Generation Control (AGC) dispatchers. These commands get passed down to the PCS and BMS via the SolBank. Conversely, system status and alarms are communicated back to the EMS and remote operations personnel from the SolBank and other devices. See Figure 12 for an example network block diagram.

The SolBank communicates with other equipment within the ESS via multiple communication protocols. Chief among them are Modbus TCP, Modbus RTU, and CANbus. Please reference the *Auxiliary Distribution and Communication Schematic* contained in Annex 2 for further details.

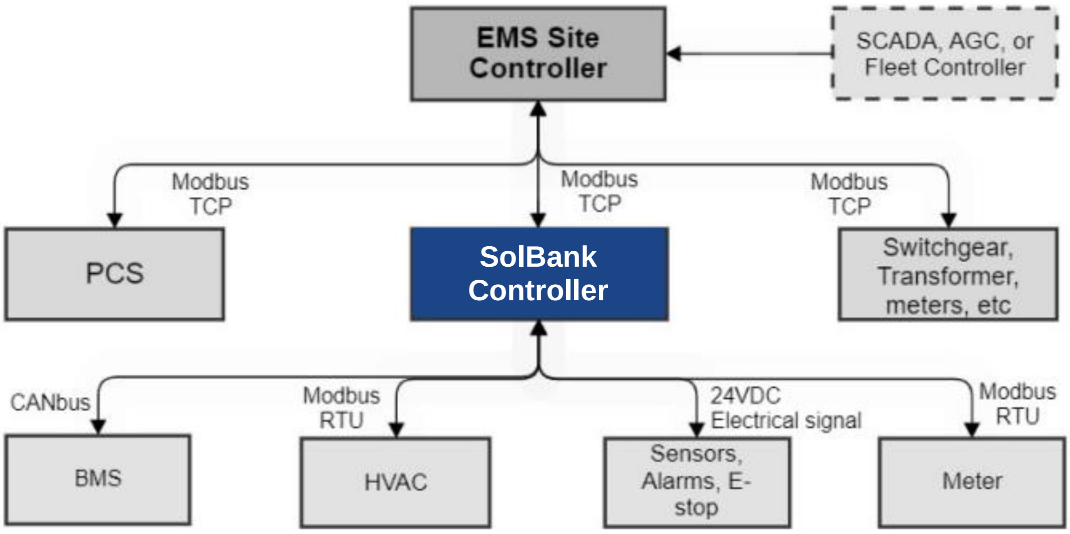


Figure 11: Example ESS communication network with a single SolBank. Site specific network design may vary.

6.2 Communication Data

Please reference the *SolBank Communication Protocol* contained in Annex 3 for a mapping of control points.

6.3 Modes of Operation

The SolBank can be placed into the operational modes indicated in Table 12. Further indicated below is the status of key system components and switching devices when in a given mode, in addition to a brief summary of each mode of operation.

For system startup and shutdown procedures, please see Section 9 and Section 10 respectively.

Table 12: SolBank modes of operation.

MODE	MAIN DC DISCONNECT STATUS	BMS CONTACTOR STATUS	LOCAL/ REMOTE KEYED SWITCH	ON/OFF KEYED SWITCH	ENABLED LOCALLY OR REMOTELY
Operation Mode	Closed	Closed	Remote	On	Remotely
Idle Mode	Closed	Open	Remote	On	Remotely
Eco Mode	Closed	Open	Remote/Local	On/Off	Remotely
Failure Mode	Closed	Open	Remote	On	Automatic
Debug Mode	Open/Closed	Open/Closed	Local	Off	Locally

6.3.1 Operation Mode

When in Operation Mode, the SolBank can charge and discharge energy from its battery bank in response to commands from the site EMS. To transition into Operating Mode, a “Run” command must be received from the site EMS to do so. Each BMS will in-turn close their internal DC contactors and energize the SolBank’s main DC bus. To enter Operation Mode, 1 or more BMS must successfully respond the “Run” command. When Operation Mode is exited, all BMS contactors will open and the main DC bus will de-energize.

6.3.2 Idle Mode

When in Idle Mode, the system shutdown and in a state ready to receive a “run” command from the EMS. All manually operated disconnects are closed, and the BMS DC contactors are open. The main DC bus will not be energized. The SolBank will enter Idle Mode when a “stop” command is issued by the BMS or after resolution of a system fault (i.e. Failure Mode is exited).

6.3.3 Eco Mode

When the SolBank is placed in Eco Mode, a load shedding scheme is automatically implemented by the SolBank’s EMCU, shutting down specific auxiliary loads to conserve energy. Specifically, the EMCU will open relay’s K2 and K3, disconnecting auxiliary power supply from the BMS and system fans. Communication and control systems, sensors and alarms, and HVAC systems will remain operational. Eco Mode can be enabled remotely by the EMS only when the SolBank is in Idle Mode. Additionally, if the grid supplied auxiliary power feed is lost, the SolBank will also enter Eco Mode. However, in this event, HVAC systems will power off, and all critical loads will be supported by the UPS.

Note, when in Eco mode, relay K2 will momentarily close once per 24-hour period to obtain BMS system status data (cell temperature, voltage, etc). Upon completion of data upload, K2 will re-open.

6.3.4 Failure Mode

The SolBank will automatically enter Failure Mode when all 8 of the system BMS fail to respond to a “Run” command from the site EMS. In this state, the BMS DC contactors will remain open. If 1 or more BMS returns to operational readiness, the system will automatically transition to Idle Mode.

6.3.5 Debug Mode

Debug Mode is enabled locally when a need arises to modify BMS software parameters of investigate system faults. Debug Mode should only be enabled by qualified CSI technicians. When the Debug Mode is enabled, remote operation of the SolBank is prevented.

7 Pre-Operation Checklist

Prior to initiating SolBank operation, please ensure the following items are addressed. Note, the below pre-operation checklist may not represent a complete list of all items requiring inspection or completion prior to operating the SolBank or the ESS within which it is installed. The following is provided for general advisement only.

7.1 Safety checklist

- ☐ All on-site personnel have proper PPE as dictated by the project specific EH&S plan, and safety codes and regulations
- ☐ Task specific safety training and orientation has been completed as required
- ☐ All personnel are properly trained and qualified to operate the SolBank
- ☐ The site is clean, orderly and all hazards have been mitigated to the extent possible and required by law
- ☐ All enclosures containing electrical or chemical hazards are secured to prevent access during operation
- ☐ The site is secured to prevent access by unqualified personnel
- ☐ All safety placards and arc flash labels are installed and clearly visible

7.2 Operational Readiness Checklist

- ☐ The SolBank has been fully commissioned and deemed ready for service by CSI personnel
- ☐ All required routine SolBank maintenance and inspections have been performed per the SolBank Maintenance Manual
- ☐ All other ESS BOP equipment required for safe and reliable operation of the SolBank has been fully commissioned and deemed ready for service by appropriately qualified commissioning personnel and AHJ.
- ☐ All required ESS BOP routine maintenance and inspections have been performed per OEM recommendations and requirements.
- ☐ Remote operations personnel have been notified of pending operation as required

7.3 Functional Checklist

- ☐ Site auxiliary power is energized, and all ESS BOP equipment aux power systems are on and ready for service
- ☐ Site communications are active and site ESS EMS HMI (local and remote) are free of system alarms. Note: this may be an iterative check, performed as system components are powered up.
- ☐ All manually operated up-stream switching devices, external to the SolBank are closed as required. Utility side of PCS AC disconnect should be energized. Remotely operated AC switching devices which are part of startup sequence may remain open in necessary.

8 Initial System Startup

The following steps describe the initial startup sequence of the SolBank. Typically, this process should be used after either i) initial system commissioning ii) maintenance activities requiring full system shutdown and component isolation, or iii) periods of extended system storage.

- Step 1: Ensure completion of the Pre-Operation Checklists contained in Section 7.
- Step 2: Close and secure all external SolBank access doors with exception to the User Interface Cabinet door which provides access to the Distribution Control Cabinet, DC Junction Box, and BMS. See Figure 13 for door location.
- Step 3: Close breaker labeled QF1、QF2, suppling power to system SPDs. Note, circuit will not be energized until Step 3 is complete.
- Step 4: Close breaker labeled QF3~QF7 (0.25P: QF3~QF5), supplying power to the SolBank Liquid Cooling and Heating system. Thermal management systems will turn on automatically.
- Step 5: Close breaker labeled QF8 (0.25P: QF6), Supplies power to auxiliary devices in containers
- Step 6: Close breakers QF9 (0.25P: QF7), Supplies fire controller.
- Step 7: Close breakers QF10 (0.25P: QF8), Supplies UPS power supply and Start the UPS.
- Step 8: Close breakers QF11 (0.25P: QF9),supplying SolBank Rack Controller.
- Step 9: Close breakers QF12 (0.25P: QF10) and the 8 DC disconnects located on the front of each BMS. Note, the main DC bus will not be energized until a start command is sent to the BMS, and the internal DC contactors close.
- Step 10: Close breakers QF13 (0.25P: QF11) and QF14 (0.25P: QF12), Supplies signal lamp & divide-shut brake and Container Fan.
- Step 11: Ensure all SolBank subsystems are powered on and operating normally. Ensure communication between the site EMS and SolBank is enabled and operating normally.
- Step 12: Press the closed DC Disconnect button "NO" to electrically connect the SolBank DC bus to the DC terminals of the PCS.

For detailed power-on operation procedures, please refer to the "DC *SolBank* Commissioning Manual"

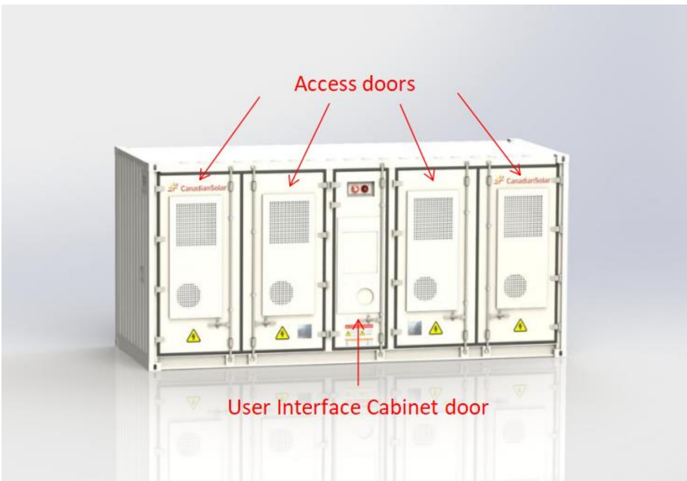


Figure 12: for door location

9 System Shutdown

9.1 Emergency System Shutdown

In the event of an emergency on site, the SolBank can be shut down locally or remotely. A system shutdown will result in electrical isolation of the battery strings and cessation of battery charging or discharging. A system shutdown will not de-energize the battery bank, nor will it guarantee that a fault or thermal runaway event has been stopped. Do not open the SolBank until deemed safe to do so by an individual qualified to direct such decision.
Procedures for shutdown of the site and isolation from the grid should be dictated within the ERP.

9.1.1 Local Emergency Shutdown

If safe to approach the SolBank, as defined by the project Emergency Response Plan, SOPs, Emergency Incident Commander, or other qualified on-site personnel, the E-stop button located on the either end of the SolBank can be pushed. When the E-stop is pushed, the SolBank BMSs will disconnect all battery strings from the main system bus, thereby stopping all charging and discharging. Simultaneously, the plant PCS will shut down if properly configured to do so. When multiple SolBanks exist on a single site, their Estop circuits can be interconnected, resulting in total system shutdown when a single E-stop button is triggered.

Pressing the E-stop while charging and discharging places considerable stress on the system. Only use the E-stop to stop the system during an emergency. Before restarting the system, the E-stop must be pulled out to its original position.

If indications of a fire within the SolBank exists, such as smoke emanating from the SolBank, or activation of the fire alarm strobe, it is recommended to immediately evacuate the area and maintain a safe perimeter. System shut down should be attempted remotely as described in Section 9.1.2. Do not open the SolBank access doors. See the *SolBank Safety Manual* for further details.

9.1.2 Remote Emergency Shutdown

During normal operation, the SolBank will be under the control of a site Energy Management System (EMS) or Local Plant Controller (LPC). The EMS or LPC in turn will communicate with, and be controlled by, an offsite fleet controller, SCADA operations center, or other third-party dispatch and monitoring entity. SolBank alarms will be forwarded to such remote operations, and in turn, remote operations personnel can attempt to shut down the SolBank if determined to be necessary.

On-site personnel witnessing an emergency should not however assume automated alarms have reached the LPC or EMS or that they have been passed onto remote operations. Such personnel are advised to first call 911, and then contact remote operations directly in addition to other key stakeholders identified in the ERP.

9.2 Partial System Shutdown

The following sequence describes the steps required to transition the SolBank from normal operation to a state of safe isolation from the primary interconnection circuit. At the conclusion of this process, the auxiliary power system will remain energized in support of SolBank thermal management, safety, and communication systems. This process should typically be used when there exists a need to perform maintenance or inspections on the PCS or upstream devices.

- Step 1: Suspend operation of the SolBank through site EMS and confirm PCS has opened automatic AC and DC disconnects through remote or local HMI.
- Step 2: Prevent subsequent startup of the SolBank by turning the keyed switch on the external side of the SolBank to “Off.”
- Step 3: Open the access door to the User Interface Cabinet.
- Step 4: Verify absence of voltage on the main DC bus as indicated by the SolBank Power Meter.
- Step 5: Prevent remote control of the SolBank by turning the keyed switch on the Distribution and Control Cabinet to “local.”
- Step 6: Open the SolBank’s main DC disconnect, thereby isolating the SolBank’s DC bus from the PCS and upstream devices.
- Step 7: Perform LOTO as necessary.
- Step 8: Close and secure access door to User Interface Cabinet.

9.3 Full System Shutdown

The following sequence describes the steps required to transition the SolBank from normal operation to a state of complete system shutdown. At the conclusion of this process, all primary SolBank components will be deenergized to the extent possible through normal user interfaces. This process should typically be used when there exists a need to perform comprehensive maintenance on the SolBank.

- Step 1: Suspend operation of the SolBank through site EMS and confirm (through local or remote HMI) PCS has opened automatic AC and DC disconnects.
- Step 2: Prevent subsequent startup of the SolBank by turning the keyed switch on the external side of the SolBank to “System Stop.”
- Step 3: Open the access door to the User Interface Cabinet.
- Step 4: Prevent remote control of the SolBank by turning the keyed switch on the Distribution and Control Cabinet to “local.”
- Step 5: Open the SolBank’s main DC disconnect, thereby isolating the SolBank’s DC bus from the PCS and upstream devices.
- Step 6: Disconnect each battery string from the main SolBank DC bus by manually opening the 8 DC disconnects located on the front of each BMS. Note, DC contactors will be open at this stage.
- Step 7: Turn off all 8 BMS via the power switch located in the upper left of each device.

- Step 8: Open breaker QF1, disconnecting all grid supplied auxiliary power from the SolBank.
- Step 9: Turn off the SolBank's Uninterruptable Power Supply (UPS). Caution, communication and fire safety equipment will power down. UPS should not be turned off unless necessary to do so for maintenance purposes.
- Step 10: Perform LOTO as required.
- Step 11: Close and secure User Interface Cabinet access door.

Note that the battery pack cannot be powered off. However, the battery pack voltage can be reduced by isolating the battery cells by unplugging the battery pack power connector. See the SolBank Maintenance Manual for details.

10 Storage Condition

a) "**Storage Condition**" means when there is no Auxiliary Power available for a SolBank for more than two (2) days during Warranty Period. For clarity, scheduled maintenance hours per SolBank Maintenance Manual are not considered as Storage Condition. In the case that a SolBank needs to be put into Storage Condition after COD, the SolBank's state of charge (SOC) shall be adjusted to between 30% and 40%.

b) During the Storage Condition, SolBank shall remain within an ambient temperature range of -20°C and 45°C, with further restrictions on a cumulative period of 736 hours during which the temperature exceeds 35°C. The maximum duration for consecutive storage is 12 months.

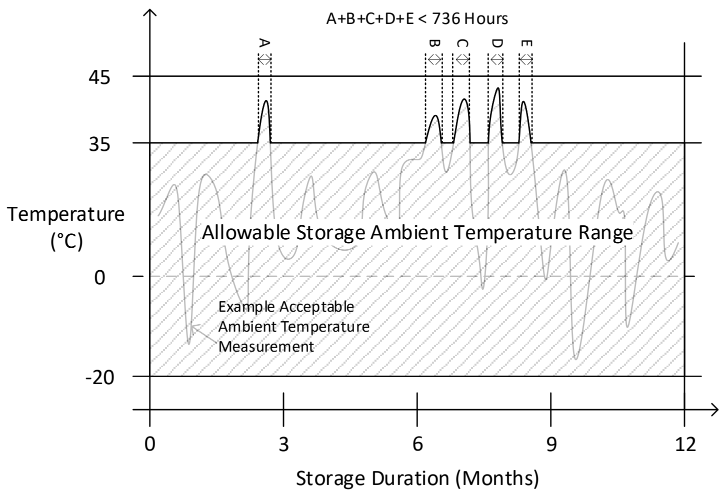


Figure 13- Storage Condition Temperature Limitations

c) For ambient temperature records during Storage Condition:

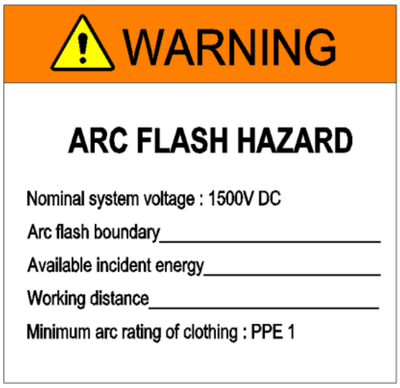
If SolBank is stored onsite, temperature readings will be taken from, in order of preference:

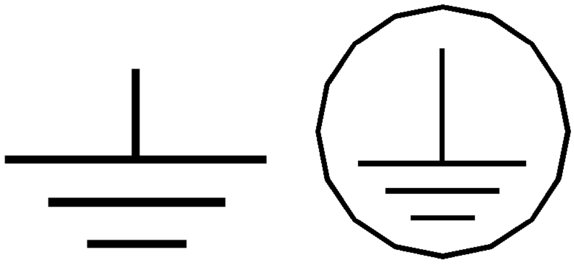
- A thermometer in the shade external to the unit, or
- the onsite weather station, or
- the nearest publicly available weather station.

If SolBank is stored inside, Owner shall provide ambient temperature data at the storage location.

11 Annex

11.1 Annex 1: SolBank Signage

<table>
<tr><th>Safety Signs</th><th>Location</th><th>Quantity</th></tr>
<tr><td>
</td><td>Located on the front of each access door</td><td>1</td></tr>
<tr><td>
</td><td>Located on the front of each access door</td><td>1</td></tr>
<tr><td>
</td><td>Located on the front of each access door</td><td>1</td></tr>
</table>

SYSTEM EMERGENCY STOP	Located adjacent to each E-stop button	2
CONTROL MODE SWITCH	Located adjacent to the keyed control switch on the exterior side of the SolBank	1
	Located on the SolBank primary field-ground point	4

11.2 Annex 2: SolBank Design Package

Please reference the project specific SolBank structural and electrical design package provided by CSI.

11.3 Annex 3: SolBank Communication Protocol

Please reference the SolBank communication protocol and project specific points mapping provided by CSI.