BESS DESIGN REPORT

BESS Webinar Amperecloud
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Prepared for: Amperecloud

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1. INTRODUCTION

The objective of this report, produced by RatedPower, is to define the specification of the proposed Battery Energy Storage System ('BESS') at Webinar Amperecloud, and to clarify the technical features of all equipment within the specification. The current description of the project could be subject to changes in the next stages of the project development.

The proposed design solution has 6 battery container units of 2000.0 kWh with total rating of 5500.0 kWac/12.0 MWhdc. The main characteristics of the project are shown in Table 1.

Table 1. Project Characteristics

Webinar Amperecloud Project	
Main characteristics	
Location	Spain, Andalucía
Rated power (AC)	5500.0 kWac
Installed energy (DC)	12.0 MWhdc
Power supply duration	2.18 h
Civil characteristics	
Suitable plot area	0.82 ha
Electrical characteristics	
Medium voltage	20 kV
Power conversion systems - PCS (up to 5500.0 kW)	1
Number of transformers (up to 5500.0 kVA)	1
Number of storage inverters (up to 2750.0 kVA)	2
Number of BESS containers (up to 2000.0 kWh)	6

The general layout of the BESS is shown in Figure 1.

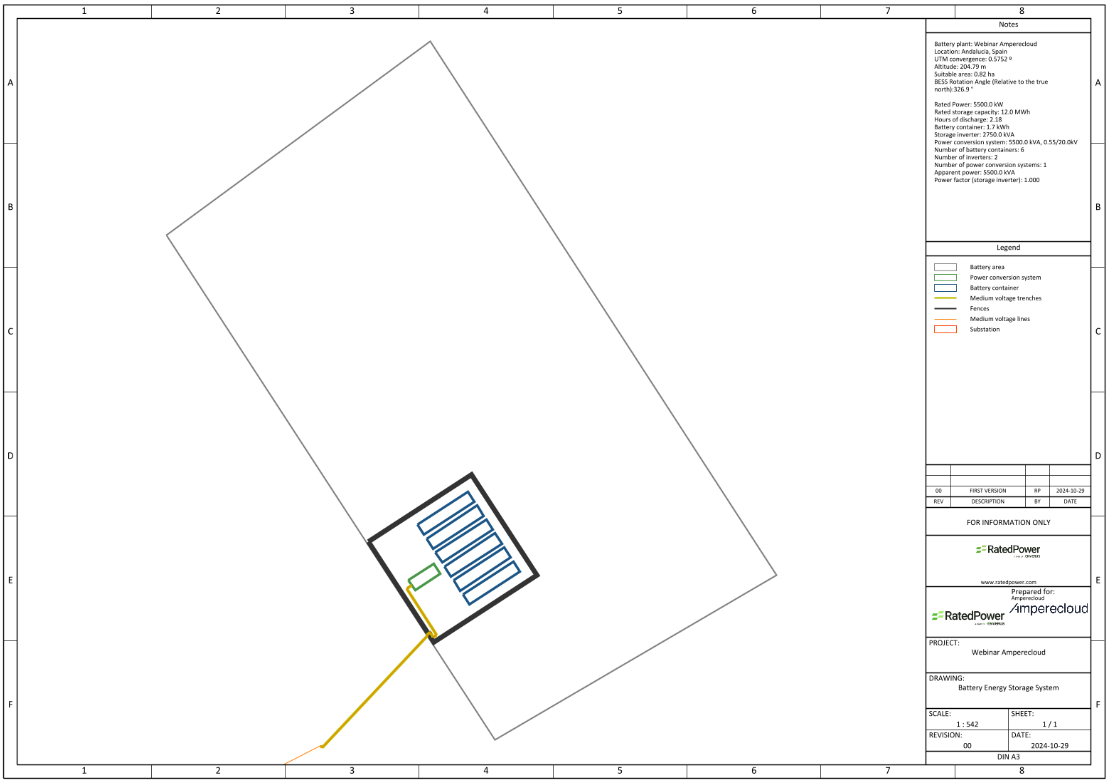

Figure 1. General layout

The Battery Energy Storage System is parallel to an axis rotated 56.9 degrees with respect to true north in the clockwise direction.

2. SITE

2.1. Location

The PV Plant location has the characteristics shown in Table 2.

Table 2. Location characteristics

PV Plant location characteristics	
City / Town	Carboneras
Region	Andalucía
Country	Spain
Latitude	+36.99 °
Longitude	-2.04 °
Altitude	204.79 m a.m.s.l.
Timezone	UTC +1

The area where the BESS is to be built consists of one area with a total surface area of 0.82 ha.

2.2. Topography

A preliminary terrain topography analysis was performed to study the suitability of the terrain for the construction of the BESS.

The elevation data was uploaded by the user in CSV (XYZ) format.

Using the previously mentioned elevation data, earthworks were performed to level the terrain. The ground within the boundaries defined by the area in the KML file was leveled for the installation of the BESS. The earthworks analysis resulted in a total fill volume of 9838.41 m3 and cut volume of 9881.95 m3.

3. MAIN EQUIPMENT

The main equipment used to build the battery energy storage system is:

- Battery containers, which hold the necessary equipment to store the DC energy.
- Storage inverters, which convert from DC to AC or from AC to DC.
- Power Transformers, which raise the voltage level from low to medium.
- Power Conversion Systems, which hold the necessary equipment to convert the DC power to AC.

3.1. Battery Container

A battery container is filled with battery racks connected in parallel. It is composed of the following elements:

- One Energy Management System (EMS), which will monitor the status of the batteries and define the battery system operation. It will be responsible for estimating the batteries SOC, controlling the charge/discharge and managing the status of the system, which includes the temperature management, safety protection and communication with other elements of the BESS.

- One HVAC system, which will ensure that the batteries work under the desired temperature conditions.

- One fire suppression system able to extinguish any potential fire spread within the battery container.

The features of the battery container are shown in Table 3 and Table 4.

Table 3. Battery containers

Battery containers	Quantity	Nominal Energy
Default container 1	6	2000.0 kWh

Table 4. Battery container dimensions

Battery container dimensions	
Mechanical characteristics	
Length	12.19 m
Width	2.44 m
Height	2.59 m

An example picture of a battery container is shown in Figure 2.

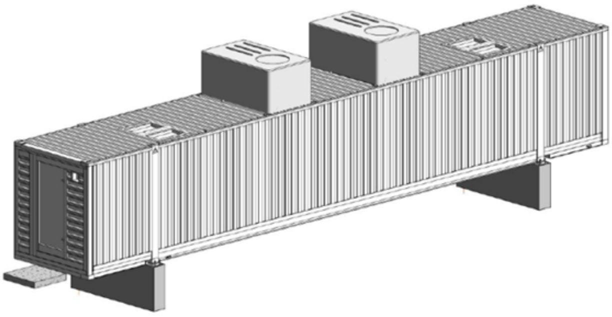

Figure 2. Example of battery container

Storage inverter

The storage inverter converts the direct current from the batteries to alternating current and vice versa. It is composed of the following elements:

- One or several DC-to-AC bidirectional power conversion stages with a voltage level controller.
- Protection components against high working temperatures, over or under voltage, over or under-frequencies, minimum operating current, mains failure of transformer, anti-islanding protection, protection against voltage gaps, etc. In addition to the protections for the safety of the staff personnel.
- A monitoring system, which has the function of relaying data regarding the inverter operation to the owner (current, voltage, power, etc.).

In Figure 3 a commonly used storage inverter for BESS is shown.

Figure 3. Example of storage inverter

The main characteristics of the selected inverter are shown in Table 5.

Table 5. Storage inverter characteristics

Storage inverter characteristics
Main characteristics

Inverter model	Generic Bidirectional
Manufacturer	Generic
Maximum DC to AC conversion efficiency	98.78 %
Input side (DC)	
Voltage range	800 - 1300 V
Maximum input voltage	1500 V
Output side (AC)	
Apparent power	2750.0 kVA
Maximum Power (datasheet)	2750.0 kVA
Nominal Power (datasheet)	2500.0 kVA
Rated power	2750.0 kW
Power factor	1.000
Output voltage	550 V
Output frequency	50 Hz

Table 6. Storage Inverters

Inverters	Quantity	Rated power AC	Apparent power	Power factor at inverter output
Generic Bidirectional	2	2750.0 kW	2750.0 kVA	1.000

3.2. Power transformer

The power transformer raises the voltage of the inverter AC output to achieve a higher efficiency transmission in the power lines of the BESS. An example of a power transformer is shown in Figure 4.

Figure 4. Example of power transformer

The main features of the power transformer are shown in Table 7.

Table 7. Power transformer characteristics

Power transformer characteristics	
Rated power	5500.0 kVA
Voltage ratio	0.55/20.0kV
Cooling system	ONAN
Tap changer	2.5%, 5%, 7.5%, 10%
Short circuit (Xcc)	0.08

3.3. Power Conversion System

The power conversion systems or PCS are buildings or containers whose objective is to increase the voltage of the energy collected from the batteries to a higher level, to facilitate the evacuation of the stored energy.

The storage inverters and power transformers will be housed in the power conversion system.

An example of a power conversion system is shown in Figure 5.

Figure 5. Example of a power conversion system (example from Ingeteam)

The power system shall be supplied with medium voltage switchgears that include one transformer protection unit, one direct incoming feeder unit, one direct outcoming feeder unit and electrical boards. Particularly, for the first power conversion system of each MV line, a direct incoming unit will not be installed.

The main features of the default power system are shown in Table 8.

Table 8. Power conversion system characteristics

Power conversion system characteristics	
Number of transformers	1
Voltage ratio	0.55/20.0kV

Table 9. Power conversion systems

Power conversion systems	Quantity	Num Inverters	Power AC	Energy DC	Power supply duration
1	1	2	5.5 MVA	12.0 MWh	2.18 h

4. BESS SIZING

4.1. Electrical configuration

The methodology used to define the BESS power requirement consists of sizing the battery containers to find a configuration that satisfies the power supply duration goal.

The main features of the electrical configuration are shown in Table 10.

Table 10. BESS configuration characteristics

Electrical configuration characteristics	
Power factor at storage inverter output	1.000
BESS rated power	5.5 MW
BESS installed energy	12.0 MWh
Power supply duration	2.18 h

The medium voltage network connecting the power conversion systems to the substation operates at 20 kV. It is composed of 1 medium voltage branches.

4.2. Electrical Cabling Design

The goal when calculating the characteristics of the electrical wiring is to minimize the cable lengths and sections. The sections are selected according to IEC 60502-2 standard.

When selecting a cable cross section, the current carrying capacity, the voltage drop, and the short circuit current were considered. The maximum allowed voltage drop was 0.50% for the AC cables of the MV network.

A summary of the selected cable sections and their installation method is shown in Table 11.

Table 11. Summary of the selected cable sections

Section	Conducting material	Insulating material	Installation type
150 mm2	Al	XLPE	Buried in trench

4.3. Civil works

Some of the parameters considered for the civil works required to build the BESS are shown in Table 12.

Table 12. Civil works

Civil works	
Distance face to face between BESS	4.0 m
Distance side to side between BESS	3.0 m
MV trench maximum section	1.2 m2

A total perimeter of 98.03 m of chain link fence surrounds the different areas of the BESS. The fence has at least 2.0 m of height and 3.0 m between posts

The minimum depth at which medium voltage cables are placed is 700.0 mm. These cables are separated horizontally by 200.0 mm. The vertical separation between them is 200.0 mm.

A simplified trench cross section of the MV trenches is shown in Figure 6.

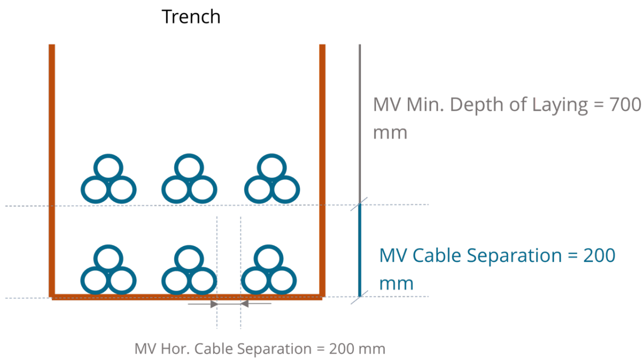

Figure 6. Simplified MV trench cross section

The offset horizontal space between the cable rows and the trench boundaries is 50.0 mm.

The section of the trenches used in the design are shown in Table 13, along with the total trench length and volume for each type.

Table 13. Trench cross sections

Trench type	Cross section	Length	Volume
Medium voltage trench	800.0 x 1000.0 mm	125.37 m	100.29 m3
Medium voltage trench	800.0 x 1500.0 mm	0.22 m	0.26 m3