BOQ METHODOLOGY

RatedPower

pvDesign
by RatedPower

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1 Glossary

AC: Alternating Current.

DC: Direct Current.

BOQ: Bill of Quantities.

DC: Direct Current.

GCR: Ground Cover Ratio.

LV: Low Voltage.

MV: Medium Voltage.

HV: High Voltage.

PV: Photovoltaic.

TMY: Typical Meteorological Year.

PS: Power Station.

L2: Second Level

MPPT: Maximum Power Point Tracking.

KML: Keyhole Markup Language

KMZ: Keyhole Markup Language Zipped

BESS: Battery Energy Storage System

PCS: Power Conversion System

2 Introduction

This document provides a brief explanation of how RatedPower calculates the different parameters found in the Bill of Quantities (BOQ). The same file will present the plant and substation's bill of quantities in separate sheets. The parameters are divided into the same sections of the BOQ sheet.

For simplicity, low voltage will be written as LV, medium voltage as MV and high voltage as HV.

3 PV Plant Description

3.1 Main Equipment

This section includes all the main equipment of the PV plant.

3.1.1 DC Side

- **PV Modules:** the total number of PV modules installed in the PV plant.
- **Trackers or fixed structures:** the total kWdc of structures.
- **DC Electrical Box:** the total number of level 1 string boxes.
- **DC Electrical Box Level 2:** the total number of level 2 boxes

3.1.2 AC Side

- **Power Station:** the total number of power stations.
- **Inverter:** the total number of inverters installed.
- **Secondary inverter:** the total number of secondary inverters.

3.2 Civil Works

This section includes all the civil works, foundations, trenches and manholes of the PV plant.

3.2.1 Site Conditions

- **Clearing and grubbing:** consists of land preparation and cutting any undesirable elements for proper construction. It is the area inside the perimeter of the fence.
- **Topsoil and vegetation removal:** consists of the removal of a layer of 20 cm depth in the area inside the perimeter of the fence.
- **Internal roads:** the proposed road will be designed with a default value of 4.0 meters width, however, users can modify this value in RatedPower.

- **Road ditches:** are used to channel water if needed (drainage). They have the same length as the roads and are placed on one side of the road only.

3.2.2 Foundations

- **Power Station foundation:** equals the number of power stations in the PV plant.

  The design of the **foundation of the power stations** tends to be foundation slab or compacted terrain based on the terrain characteristics and the station supplier for power stations.

- **Foundation of structure/ tracker poles:** The **foundation of structures/trackers** has been defined without taking into account geotechnical information. Five options are available here:

  - Driving and screwing into the ground
  - Pre-drilling and concrete foundations
  - Screwing into the ground
  - Rock pre-drilling and ground screwing
  - Concrete foundation

The number of units of the five aforementioned points is the same. It is calculated by dividing the total power carried by the trackers by the product of the power of one module and the number of modules per tracker. The result is then multiplied by the number of poles per tracker. The same procedure should be done in the case of fixed structures. The only difference, however, would be multiplying the final result by 2 if bi-pole structures were selected.

3.2.3 Trenches and manholes

- **Trenches:** the design criteria of trenches and cable laying is as follows:

  1. LV cabling from strings to string boxes/DC Bus collectors/string inverters have been designed laid in trays/raceways/messenger cables.
  2. LV cabling from string combiner boxes/DC Bus collectors to inverters/L2 String boxes have been laid directly buried in LV trenches:
     a. The installation of LV cabling has been designed with a minimum depth of 700 mm.
     b. The installation of LV cables has been designed having the cables in contact (no distance between cables).
  3. MV cabling from Power Stations to Substation / MV delivery point have been laid directly buried in MV trenches:

   a. The installation of MV cabling has been designed with a minimum of 900 mm depth.
   b. The installation of the MV cables has been designed with a distance of 200 mm between circuits (three one-core cables per circuit).
4. The sizing of the trenches are designed according to the number of LV and MV circuits laid:
5. LV trenches dimensions will be 1000mm depth and from 400mm to 800mm width.
6. MV trenches dimensions will be from 1000mm to 2500mm depth and from 800 mm to 1200mm width.
7. LV/MV trenches will be designed with the largest dimension of depth and width according to the existing circuits in order to keep the distance between LV and MV circuits.

- **Earthing trench:** is the trench that holds the earthing cable of the power station. This trench extends around the perimeter of the foundation of the power station. The number of cubic meters of earthing trench can be calculated by multiplying the perimeter of a power station by the total number of power stations in the PV plant. The result is then multiplied by the cross-section of the earthing trench which equals 0.75 x 0.3 m^2.
- **Ancillary services trench:** is the trench that holds the auxiliary system cables. It has the same length as the perimeter of the fence. The number of cubic meters of ancillary services trench can be calculated by multiplying the perimeter of the fence by the cross-section of the ancillary services trench which equals 0.5 x 0.3 m^2.
- **Manholes:** are placed every 50 meters in each trench. This number differs from LV to MV. To calculate the number of LV manholes, the total number of cubic meters of LV trenches is divided by the cross-section area of the trench. If more than one trench type is used, this value is calculated for each. The resulting values are summed up together and then divided by 50. We then add the number of power stations multiplied by 2 to the previous result. The same method should be done in the case of MV manholes with the only exception of not multiplying by 2 in the final phase of the calculation.

3.2.4 Security and control

- **Chain link fence:** is the total perimeter of the fence. It is installed around the whole PV plant. It has been proposed with at least 2 meters of height and 3 meters between posts and at the corners.
- **Access gate:** is the number of access gates of the PV plant. This number depends on the number of "AC" placemarks of the site. It is a galvanized mesh metal gate with double swing gates made from heat galvanized tubes. The frame dimensions proposed are 5-meter length x 2.5 meters in height.
- **Light pole foundation:** a light pole foundation is placed for every 50 meters of the fence.

- **Video camera foundation:** a video camera foundation is placed for every 100 meters of the fence.

3.3 Electrical System

This section includes all the cables of the PV plant: electrical, earthing, communication, etc...

3.3.1 Cables

- **Cables:** in this section, the total length of each of the LV and MV cables of the PV plant is represented. We apply a unification of the cable sizes which defines a maximum of two cable sizes for each part of the electrical system.

3.3.2 Earthing System

- **Earthing cable 35 mm^2 (LV & MV trenches):** is the total length of the 35 mm^2 earthing cable which is the total length of the LV and MV trenches.
- **Earthing cable 50 mm^2 (Power Station):** is the earthing cable that goes around the perimeter of the foundation of each power station and connects to the 8 earthing rods of each. It is placed inside the earthing trench. This BOQ entry is thus, the total length of the earthing cables of all the power stations.
- **Earthing rods (Power Station):** each power station has 8 earthing rods situated on the perimeter of its foundation. This BOQ entry is thus, 8 times the number of power stations in the PV plant.

3.3.3 AC Ancillary System

- **Auxiliary AC Cable for the perimeter:** the length of the auxiliary cable which equals the perimeter of the fence.

3.3.4 Communication / Monitoring System

- **Multimode Fiber Optic Cable (Control System):** is the communication cable for the control system of each power station and equals the length of MV cables.
- **Single-Mode Fiber Optic Cable (Security System):** is the communication cable for the security system in the perimeter of the plant and equals the total length of the perimeter fence.
- **RS 485 Com cable (Monitoring System):** is the communication cable for the monitoring system of string boxes and equals 20% of the length of the low voltage cables.

3.3.5 Connectors

- **DC male and female connectors:** these connectors are MC4 or similar models and equal two times the number of strings.

- **MV connectors:** is the total number of MV connectors in the PV plant and equals three times the number of MV incomings and outgoings of each Power Station.
- **DC Bus Connectors (Niled type or similar):** is the total number of DC Bus connectors in the PV plant and equals two times the number of strings.

3.4 Miscellaneous

This section includes the monitoring and security and control systems of the PV plant.

3.4.1 Monitoring System

- **Weather Station:** one is placed for each 20 MW of plant rated power.
- **Monitoring system (SCADA):** there is only one SCADA system for the whole PV plant. It is connected by multimode fiber optics cables to all the power stations. SCADA is the control and monitoring system of the PV plant.
- **Remote Terminal Units:** used for remote monitoring and the control of various devices and systems within the PV plant. This equals the number of power stations.

3.4.2 Security and Control

- **Control Unit:** there is always only 1 control unit and it is connected to all the power stations by multimode fiber optics cables.
- **Lighting:** the number of lighting posts equals that of lighting foundations which are placed for every 50 meters of fence. These posts have a height of 4 meters.
- **Video cameras:** equals the number of video camera foundations which is for every 100 meters of fence. These posts have a height of 6 meters.
- **Domo cameras:** equals the number of access gates.
- **Microwave barriers:** one is placed for every 50 meters of fence.
- **Microphone cable (perimeter fence):** the length of this cable equals the perimeter of the fence.

3.4.3 Buildings

- **Control Room Building & Warehouse Building:** both are always equal to 1 in the PV plant.

4. Interconnection facility Description

4.1 Substation

The substation section represents the same categories and sub-categories found in the BOQ file. The elements found in the bill of quantity correspond to the resulting type of substation.

4.1.1 Power transformer system

This section includes the power transformer bay equipment.

- **Power transformer**: The power transformers' total number installed in the substation. The power transformer can be a two-winding or three-winding transformer.
- **HV winding earthing**: The total number of the power transformers' primary winding earthing
- **MV winding**: The total number of the power transformers' secondary winding earthing equipment.
- **MV surge arrester**: The total number of the MV surge arresters in the substation.

- **MV cable length: For the substation** the length of the cables is computed according to the safety distances ofthe bay width and the road width.

4.1.2 HV system equipment

This section includes all the equipment in the high voltage side of the power transformer.

Output Circuit Bay: The total number of HV output bays of the substation, each bay includes:

- Surge arrester: The total number of surge arresters in the output bays of the substation
- Earthing disconnector: The total number of earthing disconnectors in the output bays of the substation
- Current transformer: The total number of current transformers in the output bays of the substation
- Voltage transformer: The total number of voltage transformers in the output bays of the substation
- Circuit breaker: The total number of circuit breakers in the output bays of the substation
- Disconnector: The total number of disconnectors in the output bays of the substation. In the case of a double bus bar substation, the number of this element for each bay is 2.

Transformer bay: the total number of the circuit bays before connecting to the bus bar(s). Each bay includes:

- Surge arrester: The total number of surge arresters in the transformer bays of the substation
- Current transformer: The total number of current transformers in the transformer bays of the substation
- Circuit breaker: The total number of circuit breakers in the transformer bays of the substation
- Disconnector: The total number of disconnectors in the transformer bays of the substation. In the case of a double bus bar substation, the number of this element for each bay is 2.

Bus bar: This sub-section represents the quantities of the bus conductor and the electrical equipment of the bus bar, a circuit breaker, and a voltage transformer. In the case of a double bus bar substation the total number of voltage transformers in the bus bar is 2.

- Conductor: The total length of the bus bar conductor. For a double bus bar, the total length is the span length multiplied by the sum of the number of both input and output bays and the span length of the bus coupler multiplied by each busbar then multiplied by the 3 phases. For a single bus bar, the total length is the maximum number of bays between the input and output bays multiplied by the span length and the 3 phases. The same element is given per unit, each unit represents a span of a bus bar.
- Post-insulator: the total number of the post insulators in the bus bar. Each bus bar has 6 post insulators, so the total number depends on the number of the busbars.
- Voltage transformer: the number of the voltage transformers connected to the bus bar of the substation. In the case of a double bus bar, the quantity is 2 (one for each busbar).

Bus coupler: When the arrangement is a double busbar, this element represents the total number of circuit breakers (always 1) and disconnectors (always 2) in the bus coupler.

4.1.3 MV system equipment

Input feeder MV cubicle: Total number of the MV input cubicles in the substation. This element includes:

- Circuit breaker: Total number of circuit breakers in the input feeder cubicles.
- Earthing disconnector: Total number of earthing disconnectors in the input feeder cubicles.
- Current transformer: Total number of current transformers in the input feeder cubicles.

Output feeder MV cubicle: Total number of output feeder cubicles each connected to secondary winding. It includes:

- Circuit breaker: Total number of circuit breakers in the output feeder cubicles.
- Earthing disconnector: Total number of earthing disconnectors in the output feeder cubicles.

- Current transformer: Total number of current transformers in the output feeder cubicles.

Metering MV cubicle: The total number of metering cubicles in the substation. Each MV switchgear has 1 metering cubicle. It includes:

- Earthing disconnector: Total number of earthing disconnectors in the metering cubicles
- Voltage transformer: Total number of voltage transformers in the metering cubicles

Auxiliary MV cubicle: The number of auxiliary cubicles in the substation, which is always 1. The cubicle includes:

- An earthing disconnector
- A fuse
- An auxiliary power transformer

4.1.4 Civil works

Site conditions:This section presents the civil work done to the substation site. The perimeter considered in the following calculations is not the one of the substation polygon from the KML/KMZ file; however, it is calculated internally.

- **Clearing and grubbing:** consists of land preparation and cutting any undesirable elements for proper construction. It is the area inside the perimeter of the fence.
- **Topsoil and vegetation removal:** consists of the removal of a layer of 20 cm depth in the area inside the perimeter of the fence.
- **Internal roads:** the proposed road will be always designed with a default value of 4.0 meters width.
- **Road ditches:** are used to channel water if needed (drainage). They have the same length as the roads and are placed on one side of the road only.

Buildings: The area of the control building of the substation. This area depends on the substation capacity. If the capacity is less than 50MW, the area is 150m², if more the building will have an area of 300m². When the arrangement is a line-to-transformer, the area is always 150m².

Security and control:

- Chain link fence: the total perimeter calculated of the fence. It is installed around the whole substation. It has been proposed with at least 2 meters of height and 3 meters between posts and at the corners.
- Access gate: Total access gates in the substation, always 2.
- Video camera foundations: The total number of security camera's foundations, which is for every 100 meters of fence. These posts have a height of 6 meters.
- Light pole foundation: The total number of light pole foundations, which are placed for every 50 meters of fence. These posts have a height of 4 meters.

4.1.5 Miscellaneous

This section includes the monitoring and security systems of the substation.

Monitoring system: there is only one SCADA system for the whole substation. It is connected by multimode fiber optics cables to all the power transformers. SCADA is the control and monitoring system of the substation.

Security and control system:

- Control room building: There is one control building per facility.
- Fire system: There is one fire system in the substation.
- Surveillance system: The total number of video cameras that is the same as the number of its foundations calculated in the civil section.
- Lighting system: The total number of lighting systems that is the same as the number of its foundations calculated in the civil section.

4.2 Switching and breaking station:

This section presents the elements of the switching and braking station in the bill of materials, the following elements follow the order of the file.

4.2.1 Switching and breaking station

Input feeder MV cubicle: Total number of input feeder cubicles in the station.

Output feeder MV cubicle: The total number of output feeder cubicles in the station. The total number is always 1.

Protection MV cubicle: The total number of the protection cubicles in the station. The total number is always 1.

Metering MV cubicle: The total number of metering cubicles in the station. The total number is always 1.

Auxiliary MV cubicle: The total number of auxiliary cubicles. The total number is always 1.

4.2.2 Civil works

The civil section of the switching and breaking station consists of the total number of stations. The total number is always 1 station for each PV plant.

5. Overhead line description

The overhead line section represents the same categories and sub-categories found in the BOQ file. The elements found in the bill of quantity correspond to the resulting overhead line.

5.1 Main equipment

The main equipment sub-section refers to the designed equipment defining the overhead line.

5.1.1 Towers

Dead-end towers: The total number of the dead end towers of the line, this number is always 2. The entry includes the maximum and minimum heights of the dead-end towers and the name of the tower.

Suspension towers: The total number of the suspension towers of the line. The entry includes the maximum and minimum heights of the line's suspension towers and the name of the tower.

Angle towers :The total number of the angle towers of the line. The entry includes the maximum and minimum heights of the line's angle towers and the name of the tower.

5.1.2 Conductors

Phase conductor: the total length of the phase conductor in meters considering the number of phases and the number of conductors per bundle. The entry also includes the designation of the conductor and its cross-section.

Earth wire: the total length of the earth wire in meters considering the number of earth wires in the line. The entry also includes the designation of the earth wire and its cross-section.

5.1.3 Insulators

Suspension insulator: the total number of suspension insulators in the line considering the number of insulator sets per phase. The entry also includes the designation of the insulator and its lightning impulse.

Tension insulator: the total number of tension insulators in the line considering the number of insulator sets per phase. The entry also includes the designation of the insulator and its lightning impulse.

5.2 Miscellaneous

Danger plates: the total number of electrical danger plates. Each tower is considered having two danger plates.

Tower plates: the total number of the line's informative plates that is calculated as one plate per tower.

6. BESS description

6.1 Main battery equipment

The main equipment sub-section refers to the designed equipment defining the battery energy storage system.

6.1.1 Batteries

Battery rack: the total number of generic battery racks. The entry includes the capacity and voltage range.
Battery container: the total number of generic battery containers. The entry includes the capacity, voltage range, and container dimensions.

6.1.2 Power conversion system

Storage inverter: the total number of storage inverter. The entry includes the inverter model name and its nameplate capacity. This only applies with an AC-coupled configuration.
DC/DC converter: the total number of generic DC/DC converters. The entry includes the maximum conversion power. This only applies with a DC-coupled configuration.
Power Conversion System: the total number of PCSs. The entry includes the maximum capacity, and hours of discharge of the battery system. This only applies with an AC-coupled configuration.

6.2 BESS civil works

This section includes all the civil works, foundations and trenches of the BESS.

6.2.1 Site conditions

Clearing and grubbing: consists of land preparation and cutting any undesirable elements for proper construction. It is the area inside the perimeter of the fence.

Topsoil and vegetation removal: consists of the removal of a layer of 20 cm depth in the area inside the perimeter of the fence.

6.2.2 Earth works

The battery area is always completely flattened by doing earth works.
Total earth works fill volume: total volume of filled land.
Total earth works cut volume: total volume of removed land.

6.2.3 Foundations

Power Conversion System foundation: equals the number of PCSs in the battery system. The design of the foundation of the PCSs tends to be foundation slab or compacted terrain based on the terrain characteristics and the station supplier for the PCS.
Battery Container foundation: equals the number of battery containers in the battery system. The design of the foundation for the battery container tends to be foundation slab or screw piles based on the terrain characteristics and the container supplier.

6.2.4 Trenches

Trenches: the design criteria of trenches and cable laying is as follows:

- MV cabling from PCSs to Substation / MV delivery point have been laid directly buried in MV trenches:
    - The installation of MV cabling has been designed with a minimum of 900 mm depth.
    - The installation of the MV cables has been designed with a distance of 200 mm between circuits (three one-core cables per circuit).
- The sizing of the trenches is done according to the number of MV circuits laid: MV trenches dimensions will be from 1000mm to 2500mm depth and from 800 mm to 1200mm width.
- MV trenches will be designed with the largest dimension of depth and width according to the existing circuits in order to keep the distance between MV circuits.

Each type of trench has two entries, one indicating the volume of the trench, and the other indicating its total length.

6.2.5 Security and control

Chain link fence: is the total perimeter of the fence. It is installed around the whole BESS. It has been proposed with at least 2 meters of height and 3 meters between posts and at the corners.
Access gate: is the number of access gates of the battery area. There's an access gate per battery area. It is a galvanized mesh metal gate with double swing gates made from heat galvanized tubes. The frame dimensions proposed are 5-meter length x 2.5 meters in height.
Light pole foundation: a light pole foundation is placed for every 50 meters of the fence.

Video camera foundation: a video camera foundation is placed for every 100 meters of the fence.

6.3 Battery electrical system

6.3.1 Cables

MV cables: is the total length of the MV cable of the BESS.

6.4 Miscellaneous

6.4.1 Monitoring system

Monitoring system (SCADA): there is only one SCADA system for the whole BESS. It is connected by multimode fiber optics cables to all the PCSs. SCADA is the control and monitoring system of the BESS.
Remote terminal units: used for remote monitoring and the control of various devices and systems within the BESS. This equals the number of PCSs.

6.4.2 Security and control system

Control unit: there is always only 1 control unit, and it is connected to all the PCSs by multimode fiber optics cables.
Lighting: the number of lighting posts equals that of lighting foundations which are placed for every 50 meters of fence. These posts have a height of 4 meters.
Video cameras: equals the number of video camera foundations which is for every 100 meters of fence. These posts have a height of 6 meters.