Battery Energy Storage System Standards for Connection

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1 SCOPE

This document provides a common set of requirements for Battery Energy Storages System, known as BESS, which intend to operate in parallel with the LV & MV distribution networks of Saudi Electricity Company (SEC) in the Kingdom of Saudi Arabia (KSA). These requirements shall be fulfilled regardless the presence of loads in the Consumer's installation. Especially the document defines:

- Requirements for the equipment to be used for the interconnection of BESS with the distribution network.
- Requirements to support the frequency and voltage stability of the power system when it is subject to disturbances.
- Requirements for the start-up, the operation and the disconnection of the BESS.
- Requirements to prevent the BESS from causing disturbances and damages either to the distribution network and to the other Consumers connected to the same distribution network.
- Requirements to prevent the BESS from operating in parallel with a portion of the distribution network which has been disconnected on purpose from the main power system.

The present document is not incompatible with additional requirements set out by other national & international standards, network codes or specific technical requirements of SEC, and which may apply for the connection of a BESS. In particular The Saudi Arabian Distribution Code Updated Version: April 2021 (in this document referred to as "Distribution Code").

The Distribution Code is applicable to all users of the distribution system and still represents the main technical document to refer to for the connection of a new Consumer or for the modification of the connection of an existing Consumer. The present Technical Standards shall apply in case the new installation (or the modified one) includes a BESS as defined in WERA Regulations and shall be intended as an extension of the Distribution Code for what not directly ruled by the code itself. For all the aspects not covered by the present document, reference shall be made to the Distribution Code.

It is not within the scope of the present document to:

- define the process to be followed for the selection and evaluation of the Exit Point.
- define the process to be followed for the assessment of the impact of connecting BESS to SEC distribution network.
- define the process to be followed for the assessment of a connection application and its compliance with the present standards.

This information can be found in other companion documents, as listed in chapter 3. Finally, it is not under the purpose of these standards to define technical rules for the off-grid operation of networks in isolated (e.g. rural) areas, where no part of SEC distribution network is involved. Unless otherwise explicitly specified, the requirements set forth by the present standards apply to new BESS, i.e. to those BESS which do not have already been approved by SEC at the date of publication of the standards.

Finally, even if it is not directly within the scope of the present standards, it is important to stress and remind the fundamental importance and necessity for these systems to be built in a workmanlike manner, which means the use of products and their assembly in accordance with the national and international standards commonly used for the planning, design, installation, operation and maintenance of BESS technology. As regards the Service Conditions, the equipment/material used for the BESS shall be suitable for operating at their standard ratings under the usual service condition in the inland, desert or coastal areas environment in the Kingdom of Saudi Arabia. Typical service conditions for the KSA are indicated in ANNEX D.

1.1 Notice to users

This document is for use of employees of SEC, Consumers, Consultants, Contractors and Manufacturers. Users of this guideline should consult all applicable laws and regulations. Users are responsible for observing or referring to the applicable regulatory requirements. SEC does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Users should be aware that this document may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. These Technical Standards at any point in time consist of the current edition of the document together with any amendments, corrigenda, or errata then in effect. All users should ensure that they have the latest edition of this document, uploaded on SEC website.

Finally, the user shall refer to Saudi Building Code –Chapter 725, as well as to applicable SASO Standards or International Standards mentioned in these SEC documents, unless differently indicated in other SEC documents related to BESS Regulations.

1.2 SEC Limitation of Liability and Consumer's undertaking

SEC disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the Exit Point. Consumers are responsible for observing or referring to the applicable laws and regulatory requirements.

It is the responsibility of the Consumer to determine that the interconnection equipment's specifications and confirmed performance satisfy the technical needs of the SEC system and to be compatible with the present and any other applicable SEC standards. SEC standards are indispensable for the BESS application. All equipment in an installation connected to SEC system shall be designed, manufactured, tested and installed in accordance with all applicable statutory obligations and shall conform to the relevant SEC standards current at the time of the connection of the installation to SEC system.

The Consumer shall undertake to comply with the following:

- Arrange all necessary requirements and systems to connect BESS to SEC system including compliance with security and safety requirements and providing necessary equipment.
- Terms and conditions of offer to connection, connection agreement, connection conditions, and any other relevant requirement adopted by SEC.
- Not to exceed the authorized Maximum Connected Capacity for exporting to SEC system.
- Not to exceed the authorized Maximum Connected Capacity for importing from SEC system.
- Not to conduct any action impacting the safety and efficiency of SEC system.
- Cooperate with SEC staff in all matters related to electricity exported to the system.
- All costs associated with the connection of a BESS to SEC system shall be borne by the Consumer.
- If there is a risk for the safety or the security of the system and the public electricity network, SEC is entitled to either disconnect or to require immediate disconnection of the BESS from the system.

2 REFERENCE DOCUMENTS

[1] The Saudi Arabian Distribution Code Updated Version: April 2021 (in this document referred to as “Distribution Code”)
[2] The Saudi Arabian Grid Code, Electricity & Cogeneration Regulation Authority, Updated Version: April 2021 (in this document referred to as “Grid Code”)
[3] The Saudi Building Code Electrical Requirements (SBC401) – 2007
[4] IEC 61000-3-2:2014 Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
[5] IEC 61000-3-12:2011 Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase
[6] IEC 61000-13-15:2011 table -7. Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase
[7] IEC/TR 61000-3-15:2009, Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network
[8] DS3: Rate of Change of Frequency (ROCOF) Workstream, EirGrid 2011.
[9] IEC 62485-1: Safety requirements for secondary batteries and battery installations - Part 1: General safety information.
[10] IEC 62485-2: Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries.
[11] IEC 62933-1: Electrical energy storage (EES) systems - Part 1 Vocabulary.
[12] IEC 62933-2-1: Electrical energy storage (EES) systems - Part 2-1 Unit parameters and testing methods - General specification.
[13] IEC 62933-3-1: Electrical energy storage (EES) systems - Part 3-1 Planning and performance assessment of electrical energy storage systems - General specification.
[14] IEC 62933-4-1: Electrical energy storage (EES) systems - Part 4-1 Guidance on environmental issues - General specification.
[15] IEC 62933-5-1: Electrical energy storage (EES) systems - Part 5-1 Safety considerations for grid-integrated EES systems - General specification.
[16] IEC 62933-5-2: Electrical energy storage (EES) systems - Part 5-2 Safety requirements for grid-integrated EES systems - Electrochemical-based systems.
[17] IEEE 1375: Guide for the protection of stationary battery systems.
[18] IEEE 1491: IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.
[19] IEEE 1679: IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy. Storage Technologies in Stationary Applications.
[20] NECA 416: Recommended Practice for Installing Energy Storage Systems (ESS).
[21] NEMA ESS 1-2019: Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems.
[22] NFPA 855: Installation Standard for Energy Storage Systems.
[23] UL 9540: Standard for Energy Storage Systems and Equipment.
[24] UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.

3 COMPANION DOCUMENTS

The documents listed hereinafter have to be considered a compendium of the current document. Therefore, they should be carefully read in addition to this.

[1] CESI_SEC-DREG BESS Component Specifications_v3.0 Final.docx
[2] CESI_SEC-DREG Best Practice for Design for BESS_v3.0. Final.docx
[3] CESI_SEC-DREG Connection Guidelines for BESS_v3.0 Final.docx
[4] CESI_SEC-DREG Health and Safety Requirements for BESS_v3.0 Final.docx
[5] CESI_SEC-DREG Inspection and Testing Checklists for BESS_v3.0 Final.docx
[6] CESI_SEC-DREG Inspection and Testing Guidelines for BESS_v3.0 Final.docx
[7] CESI_SEC-DREG Manual for the maintenance for BESS_v3.0 Final.docx

4 TERMS AND DEFINITIONS

Active Power - Active Power is the real component of the apparent power, expressed in watts or multiples thereof (e.g. kilowatts (kW) or megawatts (MW)). In the text this will be generically referred as P or Pnom in case of nominal active power of equipment.
Apparent Power - Is the product of voltage (in Volt) and current (in Ampere). It is usually expressed in kiloVolt-Ampere (kVA) or MegaVolt-Ampere (MVA) and consists of a real component (Active Power) and an imaginary component (Reactive Power). In the text this will be generically referred as S or Sn in case of rated apparent power of equipment.
Auxiliary Supply Power – Electricity supply to auxiliary systems and services such as Interface Protection or circuit breaker and contactor opening coils.
Exit Point – The physical point at which Consumer's Plant or apparatus is joined to the SEC Distribution System.
Consumer/Eligible Consumer – Any Person supplied with electricity services for his own consumption. In this context, this term will also be used to refer to a User owning the BESS.
Delay time (of a protection relay) – Indicates the minimum duration of a fault detected by the protection relay before the output of the protection relay is triggered.
Distribution System / Network – The system which consists of electric lines, electric plant, transformers and switchgear and which is used for conveying electricity to final Customers / Consumers. It can be either a Medium or Low Voltage system, for the scope of the present document and in accordance with international standards:

- A Low Voltage (LV) Distribution System is a network with nominal voltage lower than 1kV AC or 1.5 kV DC. The LV Distribution System nominal voltages in KSA are 400/230V, 380/220V and 220/127V.
- A Medium Voltage (MV) Distribution System is a network with nominal voltage included in the range from 1kV AC up to 69 kV. The main MV Distribution System nominal voltages in KSA are 13.8, 33 and 69kV.

For avoidance of doubt, the term Distribution Network will be preferred in this document in place of Distribution System.
Connection/Exit Point – The physical point at which Consumer's Plant or apparatus is joined to the SEC Distribution System.
Islanding - Situation where a portion of the distribution network, containing generating plants, becomes physically disconnected from the rest of the distribution network and one or more generating plants maintain a supply of electrical energy to such isolated part of the distribution network.

Loss Of Mains (LOM) – Represents an operating condition in which a distribution network, or part of it, is on purpose or in case of fault separated from the main power system with the final scope of de-energization. This denotes also the protection which detects this condition, and it is also known as anti-islanding.

Main Meter - Is the bidirectional device installed at the Exit Point which measures the amount of electric energy actually exchanged (either in import or in export) by the Consumer with the distribution network.

Maximum Connected Capacity - The Eligible Consumer maximum BESS installed capacity which SEC allows to operate in parallel to the Distribution Network. The Maximum Connected Capacity shall not exceed for any reasons the limits set forth by WERA Regulations.

Rated active power – Represents the sum of the nominal active power of all the BESS units; it is generally referred as Pnom.

Reactive power capability – Defines the reserves of inductive/capacitive reactive power which can be provided by a generating system/unit. The reactive power capability usually varies with the active power and the voltage of the generating system/unit.

Reactive Power - Represents the imaginary component of the apparent power, usually expressed in kilovar (kVAr) or Megavar (MVAr).

BESS - Rechargeable electrochemical Battery Energy Storage System that store energy from different sources (i.e. electric grid, solar, etc…) and can provide the stored energy to the user's premises when needed. In some sections the BESS system is referred to as DG.

BESS Meter - Is the device installed at the common output point of the BESS and which measures the total energy produced from the BESS units. As per WERA Regulations this will be required only for Storages with Maximum Capacity > 100 kW

BESS Unit – A group of devices which connect together with all plant and apparatus and any step-up transformer to the Distribution Grid. For avoidance of doubt, in this document the generic term BESS unit will be considered equivalent to BESS System.

Interface Protection (IP) - The electrical protection required to ensure that either the BESS and/or any BESS unit is disconnected for any event that could impair the integrity or degrade the safety and reliability of the distribution network.

Switch – Mechanical device capable of making, carrying and breaking currents in normal circuit conditions and, when specified, in given operating overload conditions. In addition, it is able to carry, for a specified time, currents under specified abnormal circuit conditions, such as short-circuit conditions.

THD (Total Harmonic Distortion) – With reference to an alternating quantity, it represents the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component or the reference fundamental component.

5 GLOSSARY

The following acronyms and symbols are used throughout the document:

AC	Alternating Current
BESS	Battery Energy Storage System
B2G	Battery to Grid power mode (Discharging)
cos φ	Power factor
WERA	Water & Electricity Regulatory Authority
G2B	Grid to Battery power mode (Charging)
IP (or I.P.)	Interface Protection
LOM	Loss Of Mains
LV	Low Voltage (namely 220/127 Vac or 380/220 Vac or 400/230 Vac)
LVRT	Low Voltage Ride Through
MV	Medium Voltage (namely 13.8kV, 33 kV and 69kV)
P	Active power
Pnom	Nominal active power of equipment
p.u. (or pu)	per unit
Q	Reactive Power
ROCOF	Rate Of Change Of Frequency expressed in Hz/s.
S	Apparent Power
Sn	Nominal Apparent Power
SEC	Saudi Electricity Company
V	Voltage
Vnom	Nominal Voltage

6 TECHNICAL REQUIREMENTS

6.1 General requirements

A BESS shall be connected to SEC Distribution Network, either LV or MV, at an appropriate point, called Exit Point. It is the responsibility of SEC to design a suitable process which determines the appropriate Exit Point and assesses the capacity of the network to host the connecting BESS at that point whilst maintaining a stable, reliable and economical operation of the system for all operating conditions.

According to the Distribution Code, if the results of such process highlight that the connecting BESS is likely to cause the network to possibly operate outside of SEC statutory performance standards, SEC has the right to reject the connection application or to propose modifications (for example in terms of Exit Point and/or characteristics of the BESS) or alternative solutions (for example in terms of network reinforcements) to enable the connection. The Maximum Connected Capacity of the BESS to be proposed by the Consumer, will be determined in agreement with the specific clauses of WERA Regulations.

6.2 Connection schemes

A BESS shall be in compliance with the connection requirements of SEC, and especially shall meet the following requirements:

- the synchronization, operation and disconnection of the System under normal network operating conditions, i.e. in the absence of faults or malfunctions, shall bear no consequences to the statutory power quality of the network.
- the protection schemes and settings needed for the BESS shall be coordinated with those of the distribution network; they shall therefore be agreed between SEC and the Consumer with the following purpose:
    - faults and malfunctions within the BESS shall not impair the normal operation of SEC distribution network. In particular, any faults that including earth-faults with leakage current internal to the Consumer's installation will be detected and cleared below or at the Exit Point before any SEC protection operates.
    - the protection schemes and settings for electrical faults within the Consumer's installation must not affect the performances of the BESS. For example, bad settings might cause random trips of MCCBs when not required causing a discontinuous production from the BESS.
    - the protection schemes of the BESS shall be coordinated with those of the distribution network in order to operate properly in case of faults either within the BESS or within the distribution network.

In order to satisfy the above requirements, The Figures reported in Annex A present the typical equipment which shall be at least installed for a safe and reliable interconnection of a BESS to the LV and MV distribution network respectively:

- A Main Switch shall be installed as close as possible to the Exit Point and shall be operated by a protection system in case of internal faults, in accordance with the Distribution Code [1]. If agreed with SEC, it is possible to install more than one main switches in order, for example, to have two separate circuits, one dedicated to the Consumer's loads and one dedicated to the BESS. An example of this is given in Figure 10 and Figure 12 in ANNEX A.

[1] For the definition of the requirements of the protection system against faults within the Consumers' installations, please refer to DCC4.2 in the Distribution Code

- The Interface Switch, operated by an Interface Protection, shall be envisaged in the Consumer installation to separate the portion of it containing one or more BESS units from both the remaining part of the Consumer's installation containing only loads and SEC distribution network. If BESS units are numerous that can't be aggregated under one interface switch, then it would be recommended to install the interface switch and the Interface protection in the MV side. For BESS whose power exceeds 20kW, a backup is necessary in case of failure on this switch opening.
- The BESS unit Switch shall be installed as electrically close as possible to the terminals of each BESS unit, for the protection and the connection/disconnection of that unit. For the protection issues, the recommendations and requirements of the Manufacturer of the equipment shall apply.

ANNEX A presents typical connection schemes which can be adopted for the connection of a BESS to SEC Distribution Networks. Different arrangements may be used if previously agreed with SEC. For clarity purposes, a couple of general schemes are included in this section to provide a general overview on the main components to be used when connecting BESS in LV and MV network.

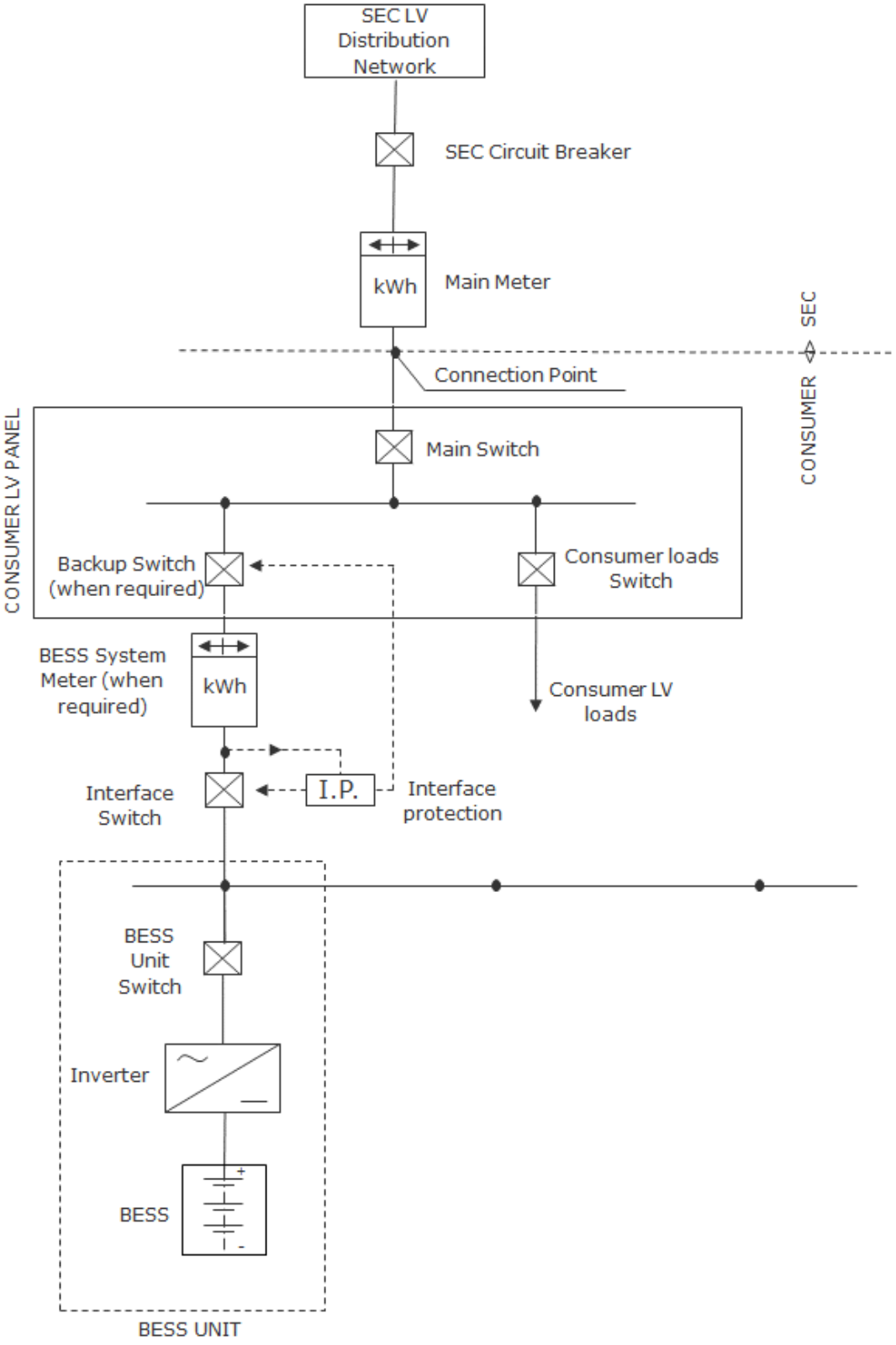


Figure 1 : Schematic representation for the interconnection of BESS with SEC LV Distribution Network

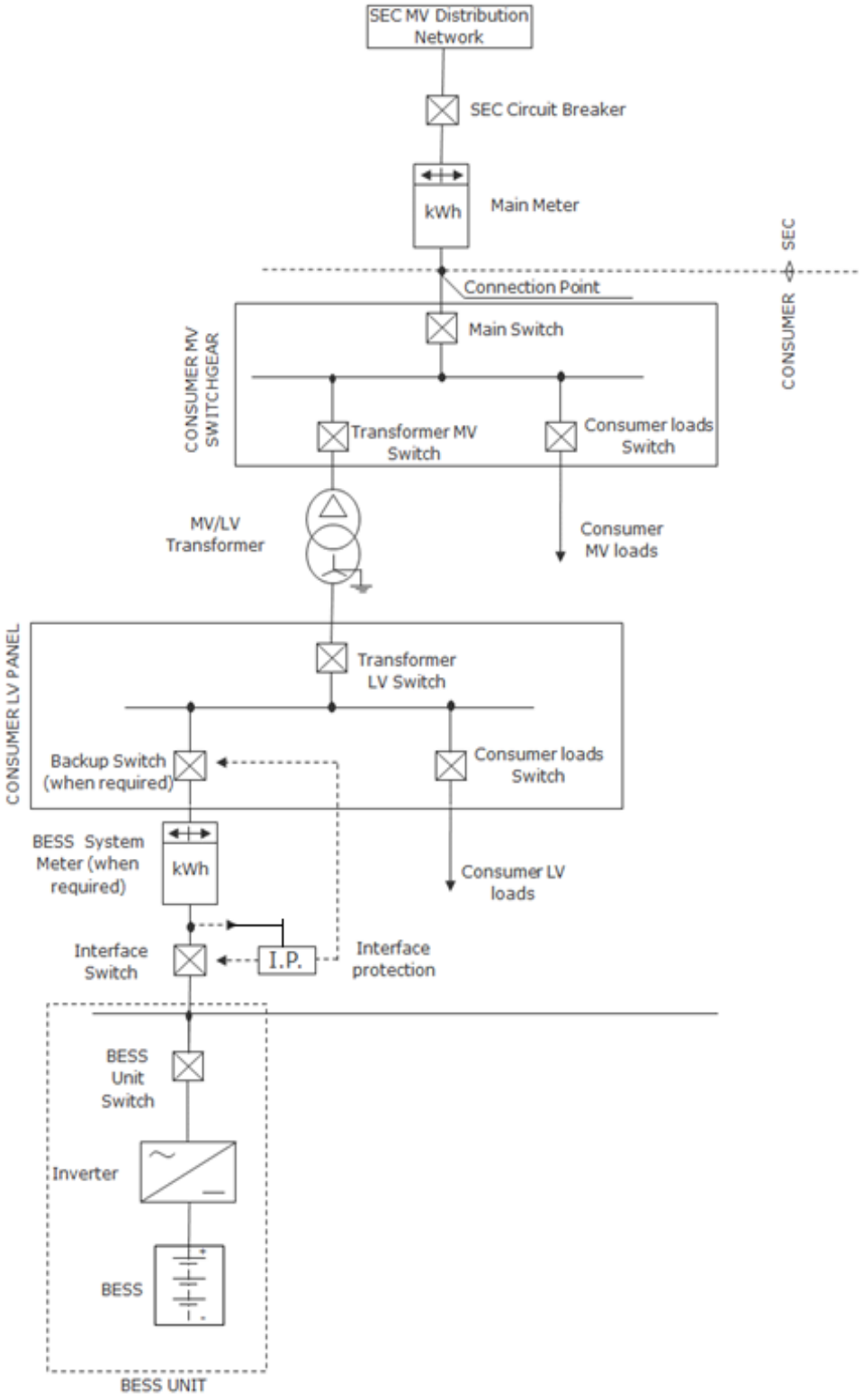


Figure 2: Schematic representation for the interconnection of BESS with SEC MV Distribution Network (either 13.8, 33kV or 69kV)

DISCLAIMER

In case the nominal voltage of the inverters does not match the nominal voltage of the distribution network, a transformer shall be necessary to connect either the BESS or each single BESS unit to the network. The cost of this transformer shall not for any reason be ascribed to SEC and shall be entirely borne by the Consumer solely.

6.3 Choice of Switches

For each of the above-mentioned switches, the choice of the type to be installed (circuit breaker, contactor, disconnecting switch with fuses, etc.…) shall be based on:

- the functions the switch shall carry out.
- the characteristics of the Consumer's installation.
- the characteristics of SEC Distribution Network at the Consumer's Exit Point.

Especially, the following criteria shall be adopted:

- the switches, panels and switchgear shall be compliant with the requirements of the Distribution Code,
- the switch(es) of the BESS unit(s) shall be compliant with the Manufacturer requirements,
- For BESS connected to the MV Distribution Network and with the Interface Switch on the MV side of the plant (see Figure 15 in ANNEX A), the Interface Switch shall consist of:
    - three-pole withdrawable automatic circuit breaker operated by an undervoltage release, or
    - three-pole automatic circuit breaker operated by an undervoltage release along with a line isolator (either upstream or downstream the circuit breaker)

In any case, the circuit breaker shall be motorized, to allow automatic reclosure once the network disturbances that have led to the trip of the Interface Protection have been cleared. The consensus to the reclosure of the Interface Switch shall be given by the Interface Protection itself, which has then to sense the voltages on the network side (as represented in the Connection Schemes, Figure 14 and Figure 15) and not on the BESS side of the Interface Switch

- For BESS connected to the MV Distribution Network and with the Interface Switch on the LV side of the plant (see Figure 14 in ANNEX A) or for BESS connected to the LV distribution network (see schemes from Figure 10 to Figure 15 in ANNEX A), the interface switch shall consist of either:
    - motorized automatic circuit breaker or switch disconnector operated by an undervoltage release, or
    - AC3 contactor which operates on all the poles (i.e. phases and neutral).

In order to allow automatic reclosure once the network disturbances that have led to the trip of the Interface Protection have been cleared. The consensus to the reclosure of the Interface Switch shall be given by the Interface Protection itself, which has then to sense the voltages on the network side (as represented in the Connection Schemes, from Figure 10 to Figure 15) and not on the BESS side of the Interface Switch;

- any switch shall have a breaking and making capacity coordinated with the rated values of the Consumer's installation, taking into consideration both the BESS charging system and the contribution to short circuit from the Distribution Network.
- the short time withstand current of the switching devices shall be coordinated with the maximum short circuit power at the Exit Point[2];
- in case of loss of auxiliary supply power to the switchgear, a secure disconnection of the Interface Switch is required immediately.

[2] Information about the maximum prospective short-circuit level of SEC distribution networks is reported in DCC4.5.1 of the Distribution Code.

The function of the Interface Switch can be combined with either the Main Switch or the BESS unit Switch in a single switching device[3]. In case of a combination of these, the single combined switching device shall be compliant with both the requirements of the interface switch and of either main switch or BESS unit switch, according to the combination chosen. As a consequence, at least two switches in series shall be always present between a BESS unit and the Exit Point. For further details, please refer to Connection Schemes in ANNEX A.

6.4 Operating ranges

BESS shall be capable of remaining connected to the Distribution Network and of operating stably, as specified in this document, in the frequency and voltage ranges for the time periods specified in the tables below, regardless of the type and settings of the protection systems:

Table 1: Frequency operating range

Below Nominal Frequency (Hz)	Above Nominal Frequency (Hz)	Operation Requirement
58.8 – 60.0	60.0 – 60.5	Continuous
57.5 – 58.7	60.6 – 61.5	for a period of 30 minutes
57.0 – 57.4	61.6 – 62.5	for a period of 30 seconds

Table 2: Voltage operating range

Voltage range at the Exit Point	Operation Requirement
90-110% Nominal Voltage	Continuous

6.5 Immunity to disturbances

6.5.1 Low Voltage Ride Through (LVRT) capability

A BESS shall contribute to the stability of the overall power system by providing immunity towards dynamic voltage changes, especially those due to faults on the higher voltage level networks. The requirements below apply to all kind of disturbances (1ph, 2ph and 3ph faults) and are independent of the Interface Protection settings (see 6.8.4) which overrule the technical capabilities of a BESS. Therefore, whether the BESS will stay connected or not will also depend on settings of the Interface Protection.

A BESS Unit with a Maximum Connected Capacity greater than 20kVA shall be capable to stay connected to the distribution network as long as the voltage at the Connection Point remains above the voltage-time diagram of Figure 3. The p.u. voltage shall be calculated with respect to the nominal voltage at the Exit Point. For three-phase generating systems, the smallest phase to phase voltage shall be evaluated. The compliance to such LVRT requirement shall apply to all equipment that might cause the disconnection of the BESS, i.e. Inverters and Interface Protection.

[3] For connection schemes using a single main switch, the combination of the interface switch with the main switch will lead to the disconnection of the overall Consumer's facility when the interface switch is opened, that is a lack of supply will also affect the Consumer load.

After the fault is cleared and the voltage returned within the voltage normal operating range (see 6.4), the pre-disturbance operating conditions (active & reactive power) shall be recovered as fast as possible and with a tolerance of ±10% of the BESS rated power.

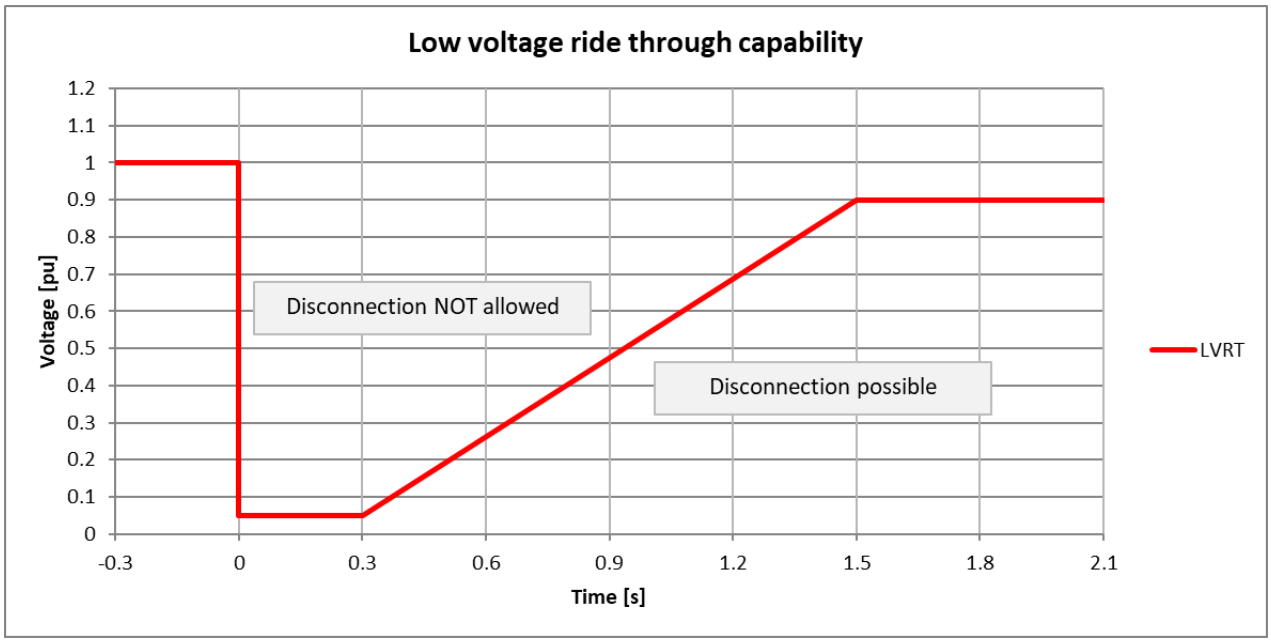


Figure 3: LVRT characteristic for BESS > 20 kVA

6.5.2 ROCOF withstand capability

BESS, when generating power, shall be able to go through frequency transients with frequency within the normal operating range (see 6.4) and with ROCOF value up to 2.5 Hz/s[4][11][12]. In the case the Loss Of Mains (LOM) protection, as described in 6.8.4, implements a ROCOF-based method, the threshold of the LOM function shall not cause the intervention of the protection within the immunity ranges as specified in this paragraph.

6.6 Requirements for the frequency stability of the power system

BESS can operate in both charging and discharging modes of Operation. In Discharging mode, BESS inject active power into the grid, B2G mode; in charging mode BESS absorbs Active Power from the Grid G2B. BESS are expected to provide ancillary service to the network whether when in charging or discharging mode, these requirements are illustrated in the upcoming paragraphs.

6.6.1 Active power response to frequency variations

All BESS shall be capable of regulating active power based on frequency variation in both charging and discharging modes according to the curve in Figure 4. When BESS is in charging mode so its absorbing active power from the distribution grid, it shall regulate the active power absorption according to the red curve illustrated in Figure 4.

[4] It is recommended to measure the ROCOF over a sliding 500ms time period.

BESS shall continue the absorption of active power in over frequency conditions and reduce the absorption of active power in under frequency conditions with the reduction slop settings. If frequency continue its drop, BESS shall be capable of inverting the flow if frequency droops below 59.4Hz. BESS has to inject towards the network all the stored power inside BESS until it reaches the maximum injection of power if frequency droops below 59.1 Hz.

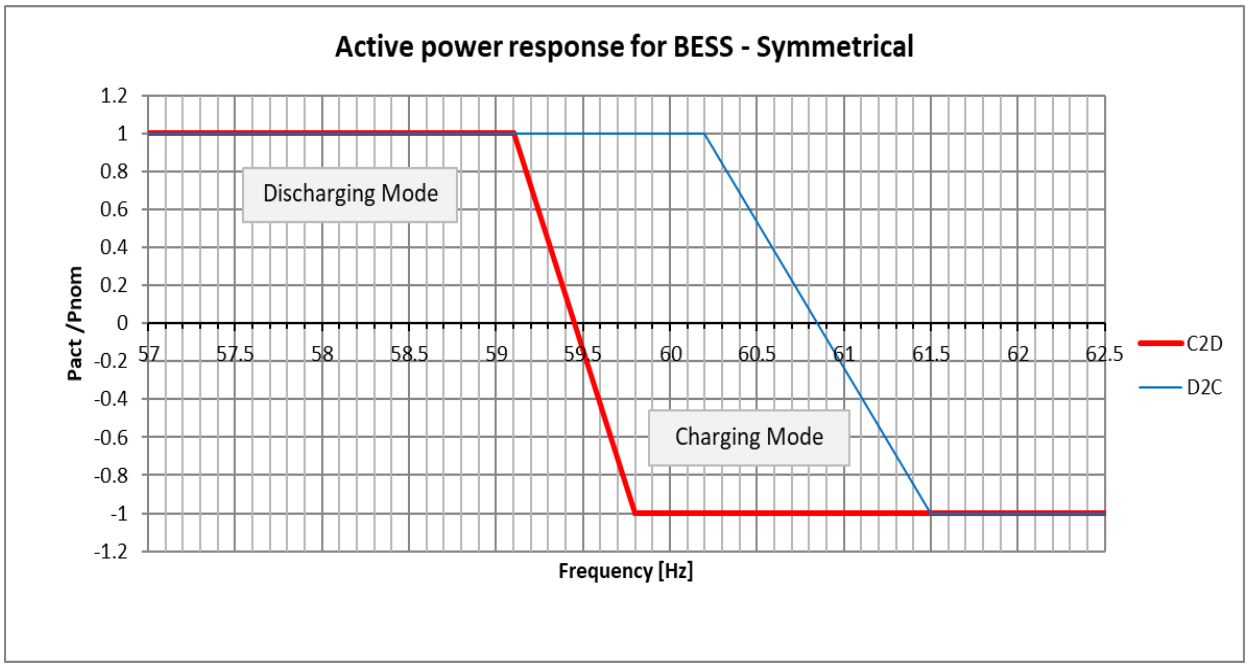


Figure 4: Active Power regulation for BESS – Symmetrical response

In case of Discharging mode of BESS, which means an injection of active power towards the grid, the active power response shall follow the blue line illustrated in Figure 4. In over frequency conditions:

- the frequency threshold shall be settable at least between 60 Hz and 62.5 Hz inclusive; if not differently specified by SEC, the threshold shall be set to 60.2Hz. So, when frequency exceeds the indicated threshold BESS shall reduce the injection of active power towards the grid.
- the generated active power Pgen shall be referred to the actual active power value Pact when the threshold is reached, and the reduction of active power response is activated.
- if frequency exceeds 60.8Hz, BESS shall be capable of inverting the power flow from injection to absorption. If frequency raise up to 61.5Hz, BESS shall absorb the maximum possible power from the network.
- the droop settings shall be between 2% and 8% in steps of a maximum of 1 %; if not explicitly specified by SEC, the droop shall be set to 3.83%.

In case of under frequency condition and BESS in discharging mode:

- the frequency threshold shall be settable at least between 60 Hz and 57 Hz inclusive, if not differently specified by SEC.
- BESS shall continue the production of power in under frequency condition in order to support the frequency, following the indicated blue line in Figure 4 if the BESS is not eligible for activating its power reserve.

The resolution of the frequency measurement shall be ±10mHz or less. The active power response shall be activated as fast as possible and shall be delivered with an accuracy of ±10% of the nominal power.

Not all BESS technology provides a symmetric behavior between the Charging power Pc and the Discharging power Pd. For these types of BESS it's possible to obtain a similar active power response as illustrated in Figure 4 but with asymmetric behavior as illustrated in Figure 5.

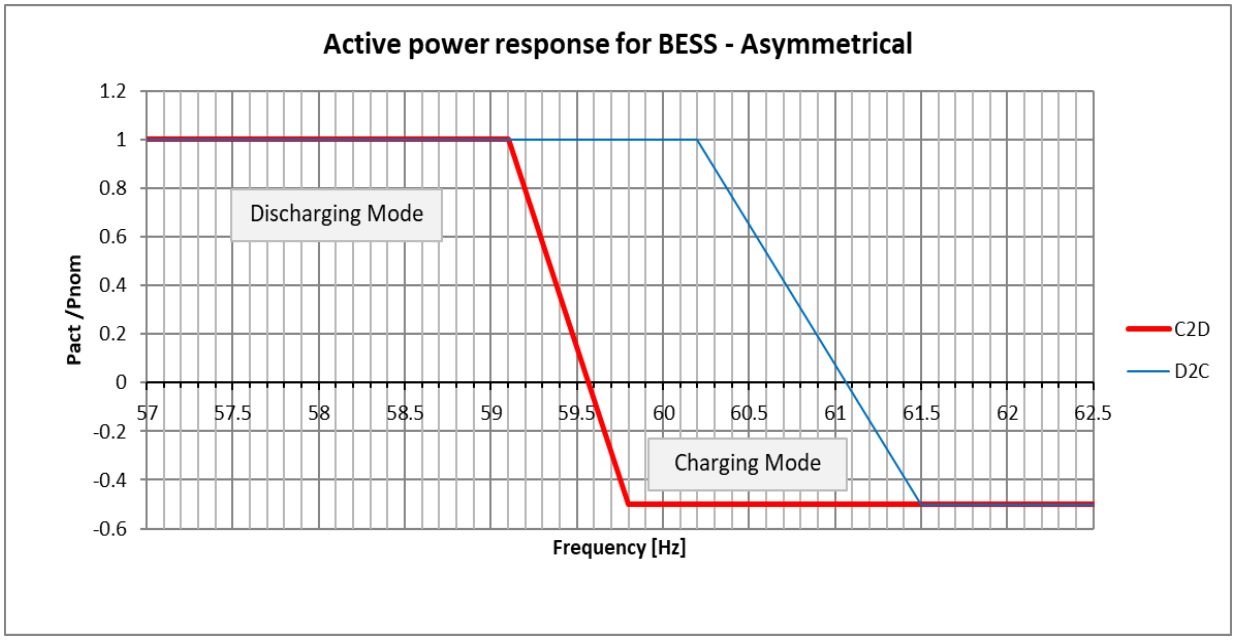


Figure 5: Active Power regulation for BESS – Asymmetrical response

In general, for both symmetrical and asymmetrical response, once there is an incident in the network that triggers the intervention of active power regulation, BESS shall respond according to the power response curve starting from the status of its operation in the instant previous to the incident.

6.6.2 Black start capability

BESS shall have the black start capability and the ability to feed the network in case of partial or total black out of the electrical system. This capability can be considered by the TSP and applied whenever is needed and can be included in the restoration plan. The Black start capability can be tested by the TSP upon their request from time to time, to ensure the effectiveness of this functionality in restoring the power system in a fast and effective way.

6.6.3 Maximum admissible Active power reduction.

When a BESS works in under-frequency operating conditions due to the Distribution Network while injecting the maximum power reserve available to sustain the frequency, it shall be capable of maintaining the output production active power as much constant as possible. If not possible for technical limitations, a small reduction of active power is allowed according to the curve of Figure 6.

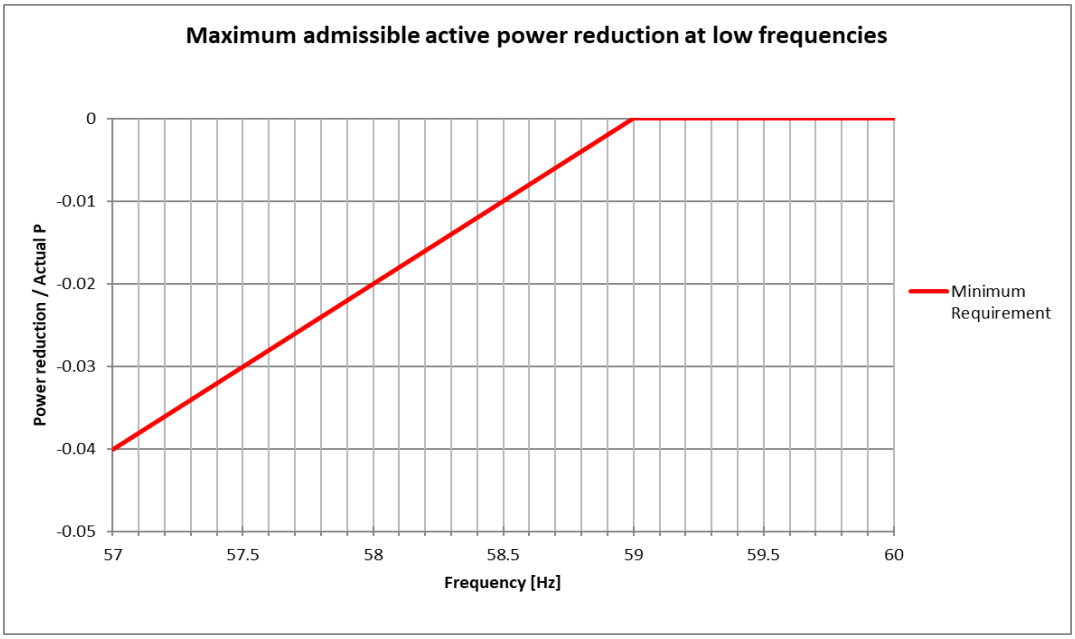


Figure 6: Maximum admissible output power reduction for BESS in case of under frequency

6.6.4 Remote limitation of Active power

A BESS with a Maximum Connected Capacity greater than 11 kVA shall be equipped with an interface (input port) which is able to receive, from a remote-control center, an instruction requiring the reduction of the active power output. The reduction of active power shall be carried out as fast as possible and with an accuracy greater than 5% of the nominal active power of the BESS.

In accordance with the provisions set forth in 6.8.6, SEC shall have the right to specify further requirements in terms of equipment, communication protocol, information to be exchanged and/or time of execution, which allow to integrate such feature into the control systems of its distribution network and which allow to remotely limit the active power output of the BESS units connected to its network.

6.7 BESS requirements for the voltage stability of the power system

6.7.1 Reactive power capability

When voltage and frequency at the Exit Point are within their normal operating ranges, a BESS shall be able to provide reactive power in any operating point within the boundaries of the reactive power capability curves defined in Figure 7[5]. According to this capability, the inverters shall be able to either generate or absorb reactive power, in order to participate to voltage support at the Exit Point.

The capability of BESS can differ from one technology to another depending on the type of used batteries and on how the capability of the inverter is interacting with the Batteries, etc. In these standards a general operating capability area for BESS is reported in Figure 7. However, because the capability may differ from one application to another, it's important that the installer or the consultant highlights those differences (if any) in their design documents.The Rectangular area required for inverters in BESS, as

[5] The active power 1 p.u. shall refer to the nominal active power value of the BESS: at 1 p.u. of active power, the reactive power capability of a BESS corresponds to a power factor varying between 0.95 leading (inductive reactive power absorbed) to 0.95 lagging (inductive reactive power generated).

they shall be capable of either generating or absorbing reactive power Q within the area. For a value of 1 p.u. of active power, that is when the generated power is equal to nominal power, this corresponds to a power factor cosφ of 0.95 (apex points of the rectangular area for P=1 p.u.).

Pc is indicating the charging power, while Pd is the discharging power capacity of the battery systems. In some applications Pc and Pd might not be symmetrical and this has to be clearly stated in the design documents of the applicant. Here are reported the general set points expected from BESS:

- Set Point A: The BESS can charge the batteries up to 100% of the capacity and it is controlled to support the voltage with 33% of the rating capacity in Mvar by absorbing the necessary reactive power and operating at power factor 0.95 Lag.
- Set Point O: The BESS is completely dedicated to the charging mode. Its power factor is unity.
- Set Point B: The BESS can charge the batteries up to 100% of the capacity and generate the necessary reactive power by 33% of the rating capacity in Mvar, operating at power factor 0.95 Lead.
- Set Point C: The BESS discharge the stored active power in the batteries by 100% of the charged capacity (in case fully charged) and it produce the necessary reactive power by generating 33% of the rating capacity in Mvar. It operates in this case at power factor 0.95 leading, the BESS works as a generator in this case.
- Set Point D: The BESS discharge the stored power in the batteries by 100% of the charged capacity (in case fully charged) and it absorb the necessary reactive power by absorbing 33% of the rating capacity in Mvar. It operates in this case at power factor 0.95 lagging, and the BESS works as a generator in this case.
- Pd is the maximum discharging power capability of battery system
- Pc is the maximum charging power capability of battery system

-

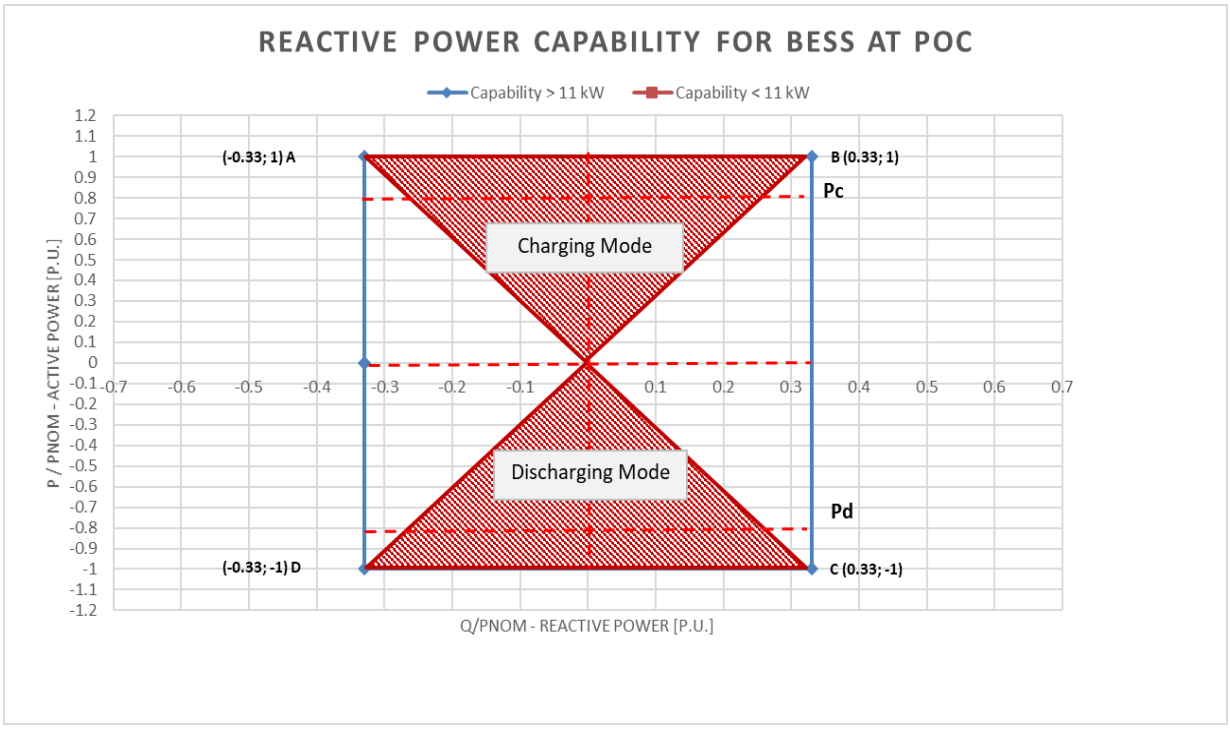


Figure 7 - Reactive power capability in Charging and Discharging Modes

The required reactive power Q shall be provided with an accuracy of above 2% of accuracy nevertheless the accuracy shall always be as good as technically feasible and shall not exceed 10% of Sn.

6.7.2 Reactive power control modes

A BESS shall be capable of operating in the control modes stated below, within the limits of its reactive power capability as expressed in 6.7.1:

- fixed Q: the reactive power is controlled in order to have a fixed value.
- fixed cos φ: the reactive power is controlled in order to have a fixed power factor.
- cos φ (P): the reactive power is controlled in order to have a power factor function of the actual active power delivery.
- Q=f(V): the reactive power is controlled as a function of the local voltage, according to a characteristic curve.

The above control modes are exclusive; only one mode may be active at a time. The activation, deactivation and configuration of the control modes shall be field adjustable. It is the responsibility of SEC to communicate to the BESS owner which of the abovementioned reactive power control mode shall be activated.

6.7.2.1 Fixed control modes

When operated with fixed Q or fixed cos φ control mode, the BESS unit shall control the reactive power or the cos φ of its output according to a set point set in the control system of the BESS. If not explicitly specified by SEC, the default set point values shall be 0 for fixed Q control mode and 1 for fixed cos φ control mode.

For a BESS with a Maximum Connected Capacity greater than 11 kVA, the BESS shall also be able to receive the set-point or a disconnection instruction from a remote control center in accordance with the provisions set forth in 6.8.6.

6.7.2.2 Power related control mode

The power related control mode cos φ (P) controls the cos φ of the output as a function of the active power output. A characteristic with a minimum and maximum value and three connected lines according to Figure 8 shall be configurable within the control systems of the BESS; a change in active power output results in a new cos φ set point according to the characteristic. All parameters listed in this paragraph both in charging and discharging mode shall be field adjustable and their settings are the responsibility of SEC. If not explicitly specified by SEC, these parameters shall be set as indicated below:

In Discharging mode:

- C P = 0 Pnom cos φ = 1
- D P = 0.5 Pnom cos φ = 1
- E P = Pnom cos φ = 0.95 Lag
- F P = Pnom cos φ = 0.95 Lead

In Charging mode:

- C P = 0 Pnom cos φ = 1
- B P = - 0.5 Pnom cos φ = 1
- A P = Pnom cos φ = 0.95 Lag
- G P = Pnom cos φ = 0.95 Lead

where Pnom is the active nominal power of the BESS unit.

The response to a new cos φ set point value shall be as fast as technically feasible after the new value of the active power is reached. The accuracy of the control to each set point shall be in accordance with the requirements of 6.7.1.

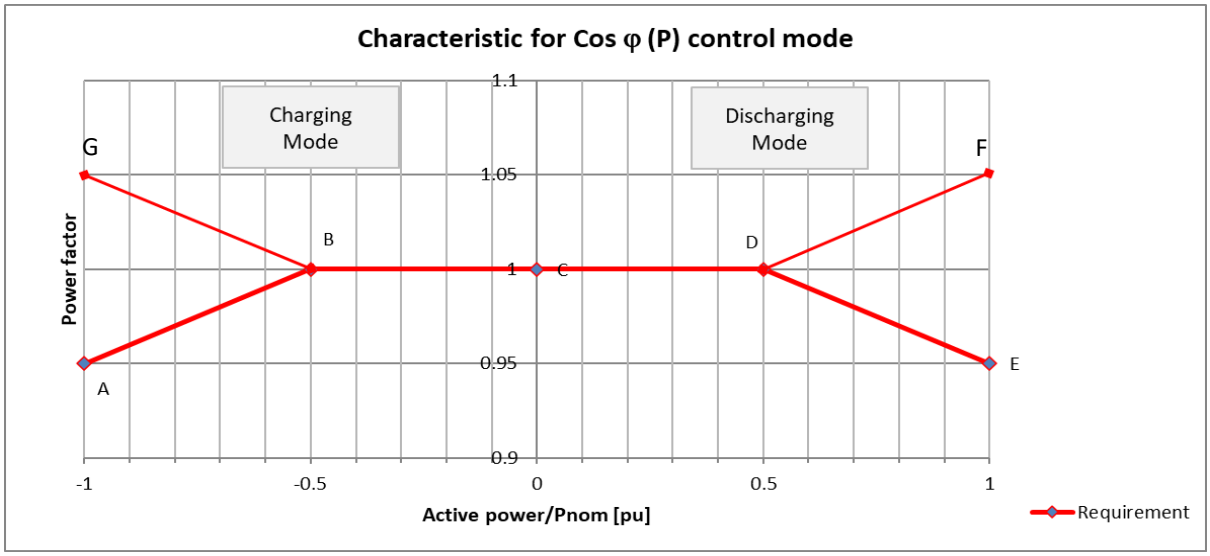


Figure 8 : Characteristic for Cos φ (P) control mode

The implementation of a lock-in and lock-out voltage level shall be configurable, each in the range 90% to 110% of the nominal voltage at the Exit Point: the contribution is activated when the voltage at the Exit Point exceeds the lock-in voltage and is deactivated when the voltage at the Exit Point drops below the lock-out voltage. When the contribution is not activated, the BESS shall be controlled with a unity power factor (cos φ = 1).

6.7.2.3 Reactive power support as a function of the voltage Q(V)

For BESS with a Maximum Connected Capacity greater than 11 kVA, for such control mode, a characteristic with a minimum and maximum reactive power value and three connecting lines according to

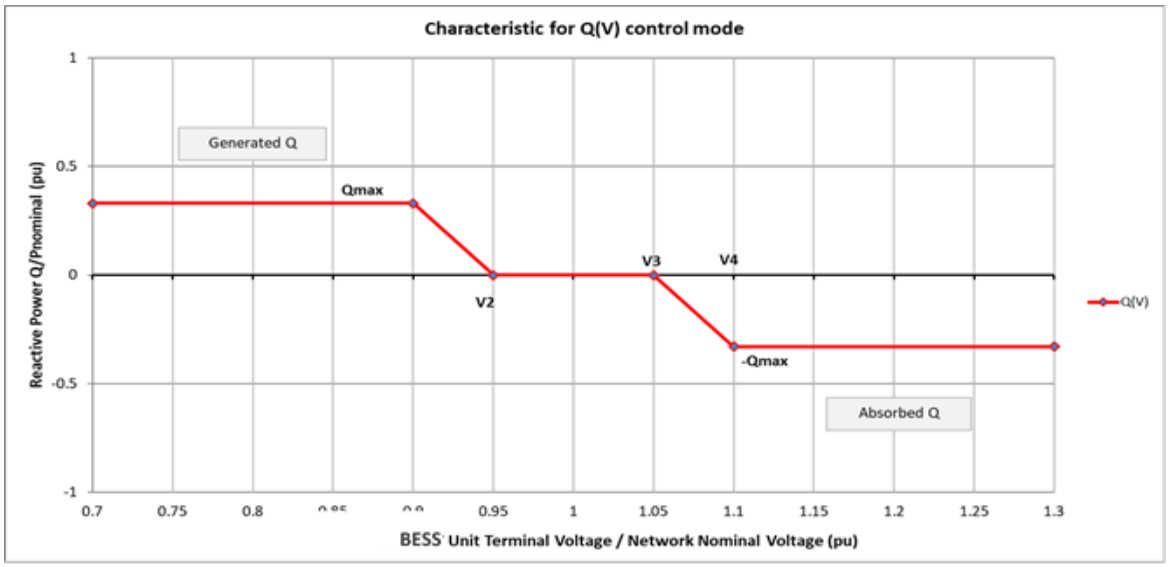


Figure 9 shall be configurable. It is SEC responsibility to communicate the parameters to be configured in case this support is required from BESS.

The values shall be assigned with the following criteria; therefore, the parameter ranges available in the inverter shall not limit this setting:

- Qmax and –Qmax correspond to the capability curve boundaries as per Figure 9 (e.g. 0.33 Pnom, where Pnom is the nominal power of the BESS unit)
- V1 > [27<] threshold of Interface Protection
- V4 < [59>] threshold of Interface Protection
- V2< Vnom <V3

Possible default values can be the following, unless differently agreed with SEC:

V1 = 0.9 Vnom
V4 = 1.1 Vnom
V2=0.95 Vnom, V3=1.05 Vnom

where Vnom is the nominal Voltage at the Exit Point.

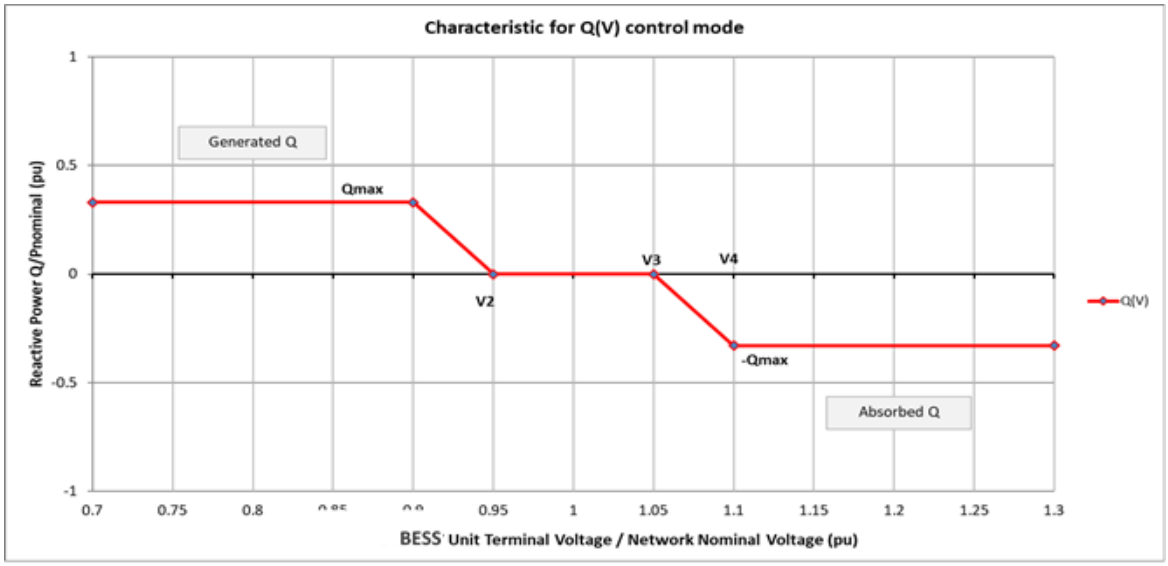


Figure 9: Characteristic for Q(V) control mode

6.7.3 Power reduction at increasing voltage

In order to avoid the disconnection due to overvoltage protection, a BESS is allowed to reduce its power input (active and/or reactive power) as a function of the rising voltage at the Exit Point. The implemented logic can be chosen by the Manufacturer/Consumer. Nevertheless, the implemented logic shall not cause steps or oscillations in the power output of the system.

6.7.4 Reactive current injection during a fault

The provision of reactive current during a fault is currently not required for BESS. Such feature might be introduced in the future and only for MV connected BESS, in a scenario of a growing penetration level of BESS and a decreasing short circuit power of the power system of the KSA.

6.8 Requirements for the management of the power system

6.8.1 Connection conditions

After the disconnection of BESS due to reasons not linked to the stability of the network, the BESS is allowed to reconnect to the network and to start to absorb electrical power due to normal operational start-up, when the voltage and frequency are within the following range for at least the observation time:

- Frequency range — 59.95 Hz ≤ Frequency ≤ 60.05 Hz (in charging mode).
- Frequency range — 59.5 Hz ≤ Frequency ≤ 60.05 Hz (in discharging mode).
- Voltage range — 95% Vnom ≤ Voltage ≤ 105% Vnom (Vnom= nominal voltage at the Exit Point).
- Minimum observation time — 30s.

After the connection, a BESS shall follow its target active power value with a variation rate not greater than 10% Pnom/min, where Pnom is the nominal active power of the BESS. The active power target shall be the maximum available active power input that the BESS can absorb or generate, except for the operating conditions when the power output shall follow changes due to the provision of some of the services specified in this document (see 6.6.1 and 6.7.3).

6.8.2 Remote disconnection

A BESS with a Maximum Connected Capacity greater than 11 kW shall be equipped with a logic interface (input port) in order to disconnect from the network following an instruction received at its interface.

In accordance with the provisions set forth in 6.8.6, SEC shall have the right to specify further requirements in terms of equipment, time of execution, communication protocol and/or data to be exchanged, to integrate such feature into the control systems of its distribution network and to allow the remote disconnection of the BESS connected to its network.

6.8.3 Automatic reconnection after tripping

After the trip of the interface protection, a BESS is allowed to reconnect to the network only if the voltage and frequency are within the following range for at least the observation time:

- Frequency range 59.95 Hz ≤ Frequency ≤ 60.05 Hz (in charging mode).
- Frequency range 59.5 Hz ≤ Frequency ≤ 60.05 Hz (in discharging mode).
- Voltage range 95% Vnom ≤ Voltage ≤ 105% Vnom (Vnom= nominal voltage at the Exit Point).
- Minimum observation time 300s.

After reconnection, the BESS shall return to its target active power value with a variation rate not greater than 10% Pnom/min, where Pnom is the nominal active power of the BESS.

6.8.4 Interface Protection

The purpose of the interface protection is to:

- disconnect the BESS from the Distribution Network in the following cases
    - the Distribution Network (or the feeder) the BESS is connected to is de-energised from the main source of supply. De-energisation can happen automatically due to protection system operation or manual/electrical disconnection. Electrical/manual disconnection in the Distribution Network can happen either remotely by SEC SCADA system or by local switching.
    - the voltage and/or frequency values at the Exit Point are out of the normal operating ranges as defined in 6.4.
- prevent the BESS, when absorbing power, to cause under-voltages in the distribution network it is connected to.
- prevent the BESS, when generating power, to cause over-voltages in the distribution network it is connected to.

It is not the purpose of the interface protection to:

- disconnect the BESS from the Distribution Network in case of faults within the Consumer's installation; for such issues, the requirements for the connection of passive customers shall apply (refer to Distribution Code).
- prevent damages to the Consumer's equipment (BESS charging units or loads) due to faults/incidents (e.g. short circuits) in the Distribution Network or on the Consumer's installation; for such issues, the recommendations and requirements of the manufacturers of the equipment shall apply.

The interface protection shall be a dedicated device which acts on the interface switch. For a BESS with a Maximum Connected Capacity smaller than or equal to 11 kVA, it is permitted to integrate both the interface protection and the interface switch into the Inverter (see for example Figure 10 in ANNEX A).

The interface protection shall command the interface switch; for a BESS with a Maximum Connected Capacity greater than 11 kVA, unless explicitly agreed by SEC, only one interface protection and one interface switch shall be used.

For a BESS with a Maximum Connected Capacity greater than 20 kVA, the interface protection shall additionally act on another switch (backup switch) with a proper delay in case the interface switch fails to operate (see for example Figure 14 in ANNEX A). The backup switch may consist of a dedicated switch or an already existing switch[6]. When the back-up switch is triggered because the interface switch has failed to open, only manual reclosure shall be possible[7].

For a BESS with a Maximum Connected Capacity greater than 11 kVA, the power supply of the interface protection shall include an uninterruptible power supply. The loss of the auxiliary voltage on either the interface protection or on the BESS control system shall trigger the interface switch without delay. The protection functions required in the Interface Protection are the following:

- Undervoltage [27]
    - One threshold [27<] in the range [20%; 100%] of the nominal voltage at the Exit Point adjustable by steps of 5%, and delay time in the range [0.1s;100s] adjustable in steps of 0.1s.
    - One threshold [27<<] in the range [0%; 100%] of the of the nominal voltage at the Exit Point adjustable by steps of 5%, and delay time in the range [0.1s;5s] adjustable in steps of 0.05s.
- Overvoltage [59]
    - One threshold [59>] in the range [100%; 120%] of the of the nominal voltage at the Exit Point adjustable by steps of 1%, and delay time in the range [0.1s;100s] adjustable in steps of 0.1s;
    - One threshold [59>>] in the range [100%; 130%] of the of the nominal voltage at the Exit Point adjustable by steps of 1%, and delay time in the range [0.1s;5s] adjustable in steps of 0.05s.
- Overfrequency [81>]
    - One threshold [81>] in the range [60Hz; 63Hz] adjustable by steps of 0.1Hz, and delay time in the range [0.1s;100s] adjustable in steps of 0.1s.
    - One threshold [81>>] in the range [60Hz; 63Hz] adjustable by steps of 0.1Hz, and delay time in the range [0.1s;5s] adjustable in steps of 0.05s.
- Underfequency [81<]
    - One threshold [81<] in the range [57Hz; 60Hz] adjustable by steps of 0.1Hz, and delay time in the range [0.1s;100s] adjustable in steps of 0.1s.
    - One threshold [81<<] in the range [57Hz; 60Hz] adjustable by steps of 0.1Hz, and delay time in the range [0.1s;5s] adjustable in steps of 0.05s.

The protection functions for under-voltage [27] and over-voltage [59] shall be fed by all the line voltages, whereas the protection functions for under-frequency [81<] and over-frequency [81>] shall be fed by at least one line voltage. Appropriate settings shall be applied to the interface protection and shall ensure the correct tripping of the BESS under specific conditions. The settings shall be chosen so that, in case a fault within the distribution network triggers the network protection systems (which in turn disconnect

[6] It is anyway recommended not to use the main switch as back-up switch since it could lead to the disconnection of the overall Consumer's facility in the case the interface switch fails to open, with the consequence of the power supply also being removed to Consumer's loads. Another alternative could be the use of BESS unit switch as a backup switch, but in this case the interface switch has to be an MCCB to protect the system against overcurrent and short circuit current.

[7] The reasons for this requirement is that the plant operator shall first acknowledges and checks the reasons why the interface switch failed to open, then remedies the technical issues and finally resumes operation.

the faulty feeder), all the BESS are disconnected before the attempt of reclosure in the MV distribution network takes place.

ANNEX B proposes default settings for 27, 59 and 81 protection functions. Such settings shall be actually applied to the Interface Protection of a BESS only in case no other settings have been explicitly specified and communicated by SEC.

Moreover, the Interface Protection shall have at least two configurable digital inputs which may be used in the future[8] by SEC for transfer trip, remote tripping or any other function that may be necessary to increase the capacity of the distribution networks to host distributed generation while keeping an acceptable level of reliability and security.

6.8.5 Protection and Control Ranking Priority

All BESS shall be designed and manufactured in a way that respects the priority ranking for the protections provided in this section. The purpose of the priority ranking is to avoid the confliction between 2 or more functions that has to be implemented at the same time. For instance, if there is an internal fault within the BESS and at the same time there is an over frequency problem in the network that indicates that the BESS that was absorbing power from the network shall maintain its operation and stay connected.

In this case which of the 2 function should prevail over the other? According to the below priority ranking the internal fault inside a BESS has the priority and the disconnection shall take place. the protection and control devices of a BESS shall be organized in accordance with the following priority ranking (from highest to lowest):

1. Protection of the BESS Units
2. Protection against faults within the Consumer's installation
3. Protection of the distribution network (Interface Protection)
4. Remote disconnection
5. Active power response to frequency variations
6. Remote limitation of active power
7. Remote reactive power control modes
8. Local reactive power control modes

6.8.6 Monitoring, remote control and information exchange

Adequate information concerning the Consumers connected to the Distribution Networks is a prerequisite for enabling SEC to maintain the stability, reliability and security of its networks. SEC needs to have a continuous overview of the state of the network, which may require, in some cases, updated information on the operating conditions of the BESS connected to its Distribution Networks, as well as the possibility to communicate with these plants in order to direct the operational instructions set forth by the provisions of the present document.

Such requirements are usually needed in case of growing penetration level of the BESS in the distribution networks of a certain size; they may also be introduced in the framework of other initiatives dedicated, for example, to the optimization of the control performances of the network. A BESS with Maximum Connected Capacity greater than 11 kVA shall therefore have provision for bi-directional communication exchange which can be used for the exchange of information with SEC.

[8] In a scenario of growing penetration level of distributed generation in the distribution networks of the KSA

Once actually needed for the operation of the network, in accordance with a cost/benefit approach, SEC shall have the right to specify additional requirements concerning especially:

- data, which shall be collected and sent to SEC in real-time or periodically, related to the operating conditions of the BESS.
- operational instructions sent by SEC which shall be executed by the BESS; such instructions shall be compliant with the requirements indicated in the present standards the requirements of 6.6.4 and 6.8.2.
- Communications channels and protocols to be used for the above requirements.

If technically possible, SEC may take advantage of already existing communication channels, such as smart metering infrastructure, in order to facilitate the integration of the monitoring activities into its ICT architecture and reduce the costs of implementation.

6.8.7 Power factor

Any installations containing a BESS shall comply with the power factor limits, as measured at the Exit Point, indicated in the Distribution Code[9] (amended to date).

6.8.8 Power quality

6.8.8.1 Voltage deviation

Under normal operating conditions, the connection and operation of a BESS shall not cause the voltage at its Exit Point and at the Exit Point of any other Consumers connected to the same Distribution Network, to vary from the system rated voltage by more than ±5%. The values of the voltages will then range in the following intervals as specified in the Distribution Code:

Table 3: Voltage range under normal operating conditions for the different voltage level

Nominal Voltage	Lowest Voltage	Highest Voltage
220/127 V	209/120 V	231/134 V
380/220 V	360/209 V	400/231 V
400/230 V	380/218.5 V	420/241.5 V
13.8 kV	13.1 kV	14.5 kV
33 kV	31.4 kV	34.7 kV

As regards the LV distribution network and voltage levels, ANNEX C describes the different configurations of SEC power system which can be found, with explanations of the different voltage levels.

6.8.8.2 Rapid voltage changes

Connection and disconnection of a BESS from the distribution networks shall not give rise to voltage variations exceeding 3% of the system rated voltage at the Exit Point.

6.8.8.3 Harmonic and interharmonic voltages

Harmonic and interharmonic voltages at the Exit Point of a BESS System connected to the MV Distribution Network shall not exceed the limits of the planning levels specified hereinafter:

[9] Specifically DPC2.4

Table 4: Maximum Continuous Harmonic Levels

Odd Harmonics not multiple of 3		Odd Harmonics multiple of 3		Even Harmonics	
Order h	**Harmonic voltage %**	**Order h**	**Harmonic voltage %**	**Order h**	**Harmonic voltage %**
5	5.0	**3**	4.0	**2**	**1.8**
7	4.0	**9**	1.2	**4**	**1.0**
11	3.0	**15**	0.3	**6**	**0.5**
13	2.5	**21**	0.2	**8**	**0.5**
17 ≤ h ≤ 49	**1.9×17/h-0.2**	**21 ≤ h ≤ 45**	**0.2**	**10 ≤ h ≤ 50**	**0.25×10/h +0.22**

NOTE: The corresponding planning level for the total harmonic distortion is THD = 6.5% for both 13.8 and 33kV voltage levels

For a BESS connected to the LV Distribution Network, as suggested by IEC/TR 61000-3-15:20011 and commonly accepted , the above mentioned requirements concerning the voltage harmonics are fulfilled if the harmonic current emissions of the BESS do not exceed the limits defined in the standard IEC 61000-3-12, Table 2 (where the values with R_{sce} = 33 shall apply).

6.8.8.4 DC injection

BESS shall not inject DC current into the network. The requirement is considered to be respected if the injected DC component is lower than 0.5% of the rated AC current value of the BESS.

In case of several units connected within the same BESS, the summation of DC injection component from all units shall be below the above-mentioned threshold. The single BESS shall be equipped with a DC fault detection system which disconnects the faulty unit when the above limit is exceeded. A valid alternative to such system is the use of an AC/AC transformer which prevents from any DC injection into the network.

6.9 Metering System

The metering system to be installed at Consumer Premises shall be in agreement with the requirements of WERA Regulations, that is:

- a first digital meter (Main Meter) supplied and installed by SEC at the Exit Point, to measure both the energy absorbed from the Distribution Network in presence of consumer loads or auxiliary load.
- a second digital meter (BESS Meter) supplied and installed by SEC at the Exit Point only in case the Maximum Connected Capacity of the BESS exceeds 100kVA.

The Main Meter measures the net energy at the Exit Point, whereas the BESS Meter measures the energy absorbed or produced by only the BESS. The BESS Meter will be installed outside, close to the Main System Meter, until remote reading capability from SEC of this meter will be available. From that time on, BESS Meters shall be installed within the Consumer Premises, as close as possible to BESS inverters.

7 COMPLIANCE

The Consumer shall ensure that its BESS complies with the requirements defined in the present standards throughout the overall lifetime of the facility.

The Consumer shall notify to SEC any incident, failure or planned modification of its BESS which may affect the compliance with the requirements defined in the present standards. The Consumer shall provide SEC with all the documents, studies and measurements useful to demonstrate the compliance of its BESS to the requirements defined in the present standards.

If deemed necessary, SEC shall have the right to request the Consumer to carry out additional tests or studies with the scope to demonstrate the compliance of the BESS with the provisions of the present document. Such activities may be requested not only during the connection process, but at any time throughout the lifetime of the BESS, and more specifically after any failures, modifications or replacements of any equipment that may have an impact on the compliance of the System with the present standards.

ANNEX A. CONNECTION SCHEMES

The schemes proposed in this Annex show as an example possible cases of connection of BESS to either LV or MV Distribution Network of SEC, to summarize in single line diagrams the clauses on the connection as presented in this document, in particular in 6.2 and 6.3. Different arrangements may be used if previously agreed with SEC. These schemes have to be combined with the general scheme of the installation, for the feeding of the Consumer's loads.

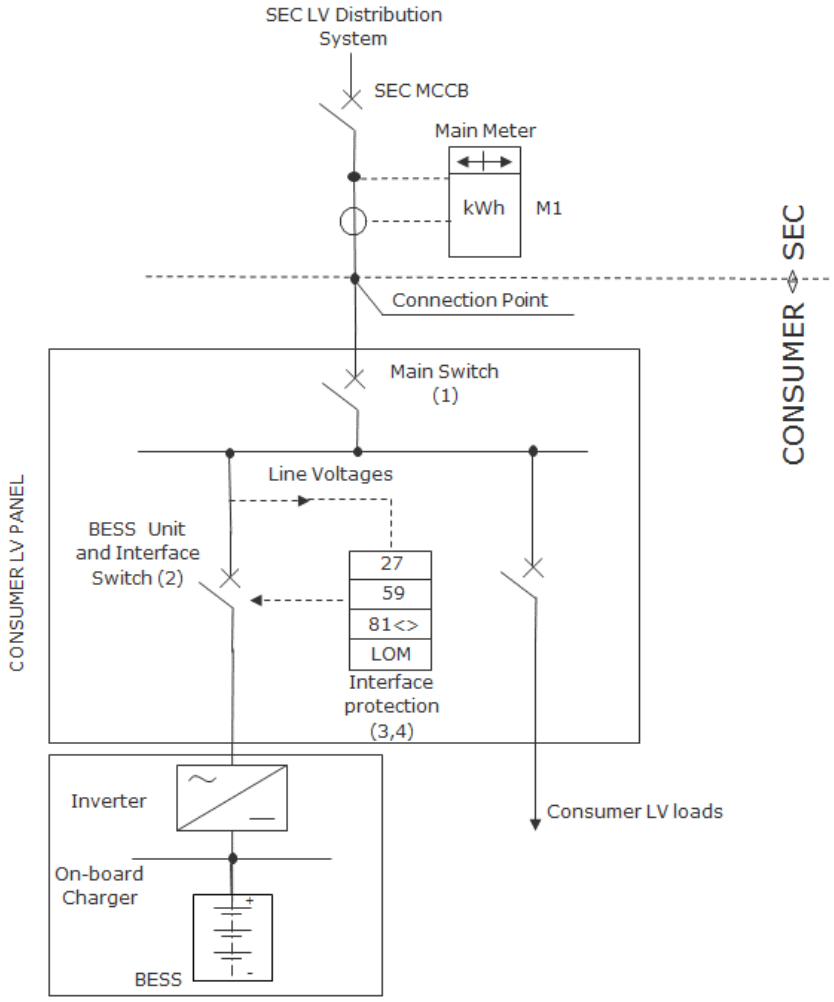
The cases presented in the following are here listed:

Figure	Distribution Network (LV/MV)	Maximum Connected Capacity of BESS	Notes
10	LV	< 20kVA	Three-phase AC with on-board inverter with External Interface Protection (not integrated in the inverter)
11	LV	> 20kVA and ≤ 50kVA	Three-phase system with External Interface Protection in the BESS units
12	LV	> 50kVA and ≤ 200kVA	Multiple BESS units with external and unique Interface Protection
13	LV	> 200kVA and ≤ 2 MVA	Multiple BESS units with unique Interface Protection internal to BESS unit. Backup Switch required. BESS Meter required if Maximum Aggregated Connected Capacity of the BESS > 100kVA
14	MV	≥ 2MVA and ≤ 25 MVA	Multiple BESS units with unique Interface Protection external to BESS. Interface Protection on the LV side. Backup Switch required. BESS Meter required if Maximum Aggregated Connected Capacity of the BESS > 100 kVA
15	MV	≥ 2MVA and ≤ 25 MVA	Multiple BESS units with external and unique Interface Protection. Interface Protection on the MV side. Backup Switch required. BESS Meter required if Maximum Aggregated Connected Capacity of the BESS > 100 kVA

The meaning of the symbols used in the single line diagrams is explained hereinafter:

LEGEND	
	SWITCH (CIRCUIT BREAKER OR CONTACTOR)
	CURRENT TRANSFORMER (CT)
	POTENTIAL TRANSFORMER (PT)
	LOAD
	INVERTER
	BESS
	POWER TRANSFORMER
	Meter / Smart Meter

ANSI SYMBOLS FOR PROTECTIONS	
27	UNDERVOLTAGE PROTECTION
59	OVERVOLTAGE PROTECTION
81	UNDERFREQUENCY (81<), OVERFREQUENCY (81>) PROTECTION
LOM	LOSS OF MAINS PROTECTION
50	INSTANTANEOUS OVERCURRENT PROTECTION
51	IDMT OVERCURRENT PROTECTION
50N/51N	EARTH FAULT CURRENT PROTECTION



NOTES:

(1) Automatic Circuit Breaker

(2) Motorized Automatic Circuit Breaker / Switch Disconnector or AC3 Contactor operated by Undervoltage release In case an AC3 Contactor is used, an additional Automatic Circuit Breaker / Switch Disconnector with:

Overload Protection

Short Circuit Protection

Protection against electric shock (RCD) (if required by the Bdg. Code) is needed for the protection of the circuit

(3) LOM Protection not required if integrated in the inverter

(4) Auxiliary power supply from a UPS

Figure 10: LV Connection Scheme – BESS with Maximum Connected Capacity ≤20kVA – External Interface Protection

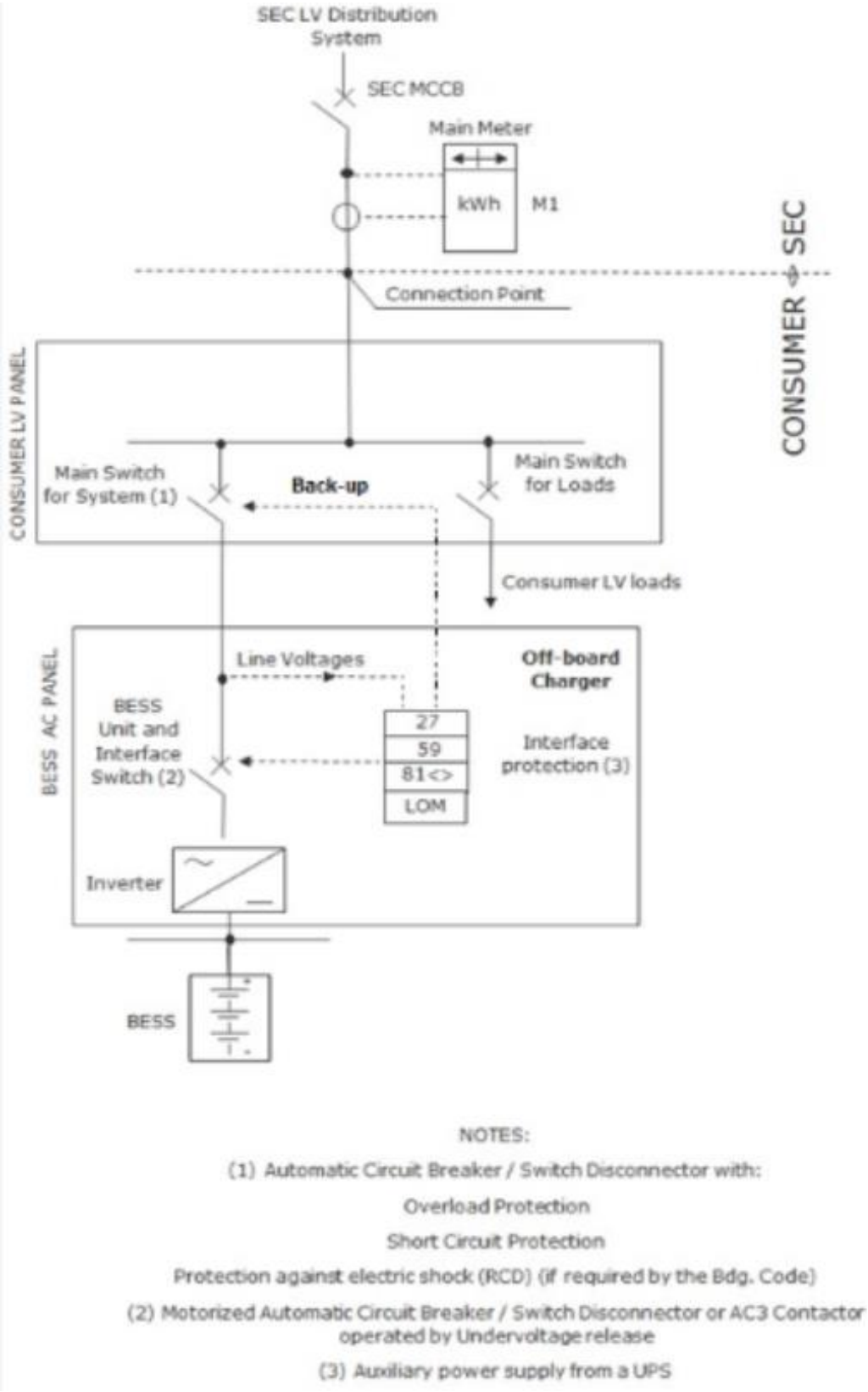
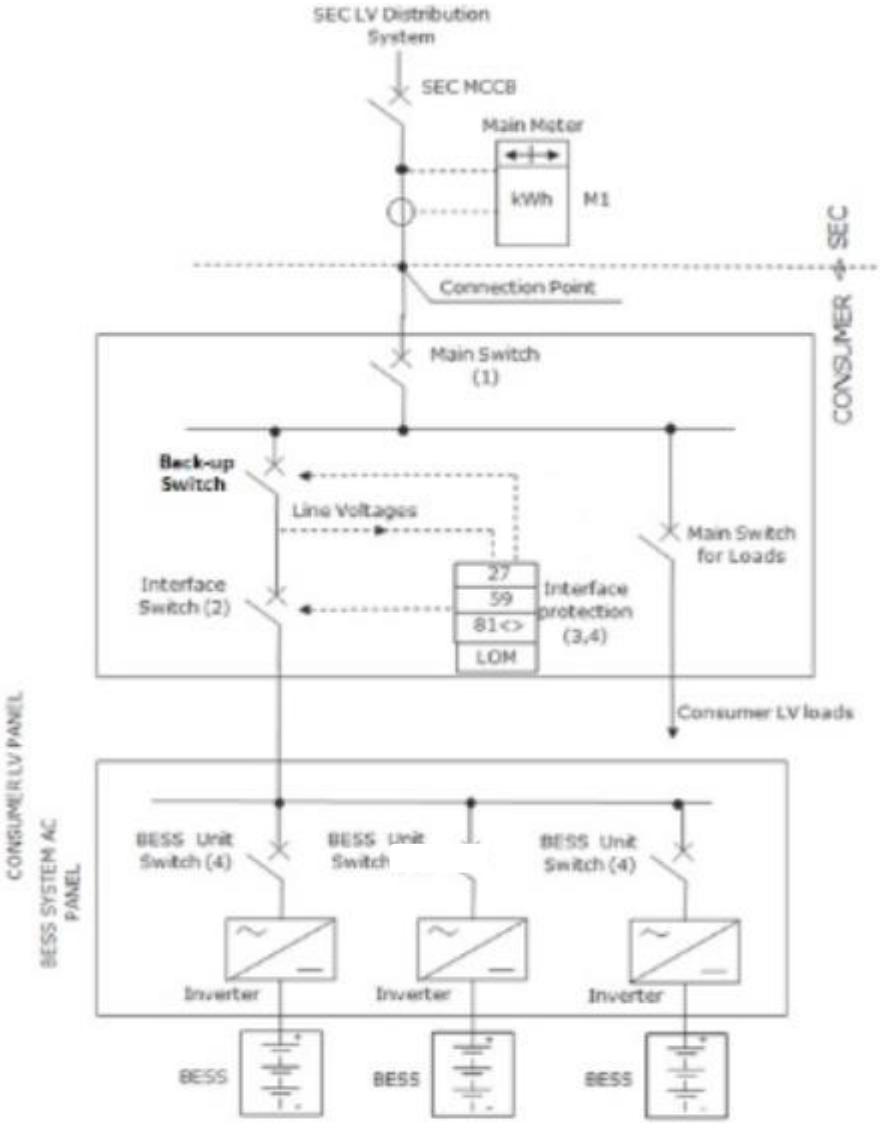


Figure 11: LV Connection Scheme – BESS with maximum capacity between 20 kVA and 50 kVA three-phase system with External Interface Protection



NOTES:

(1) Automatic Circuit Breaker

(2) Motorized Automatic Circuit Breaker / Switch Disconnector operated by Undervoltage release, with:

Overload Protection

Short Circuit Protection

Protection against electric shock (RCD) (if required by the Bdg. Code)

(3) Auxiliary power supply from a UPS

(4) Automatic Circuit Breaker or Switch Disconnector

Figure 12: LV Connection Scheme – BESS with maximum capacity between 50 kVA and 200 kVA BESS units with external and unique Interface Protection

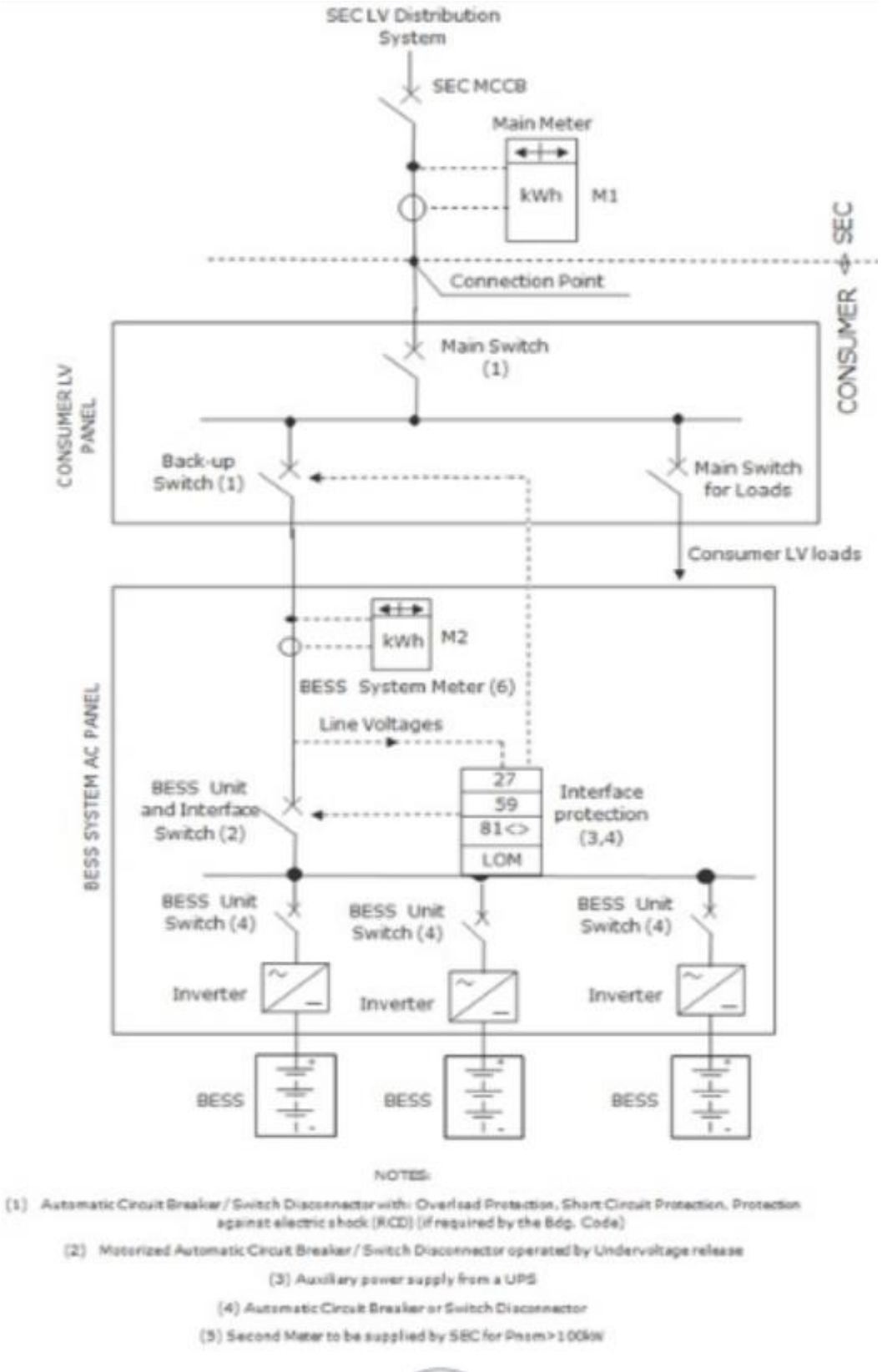


Figure 13: LV Connection Scheme – BESS with Maximum Connected Capacity between 200kVA and ≤2MVA – Multiple BESS units with unique Interface Protection external to BESS unit

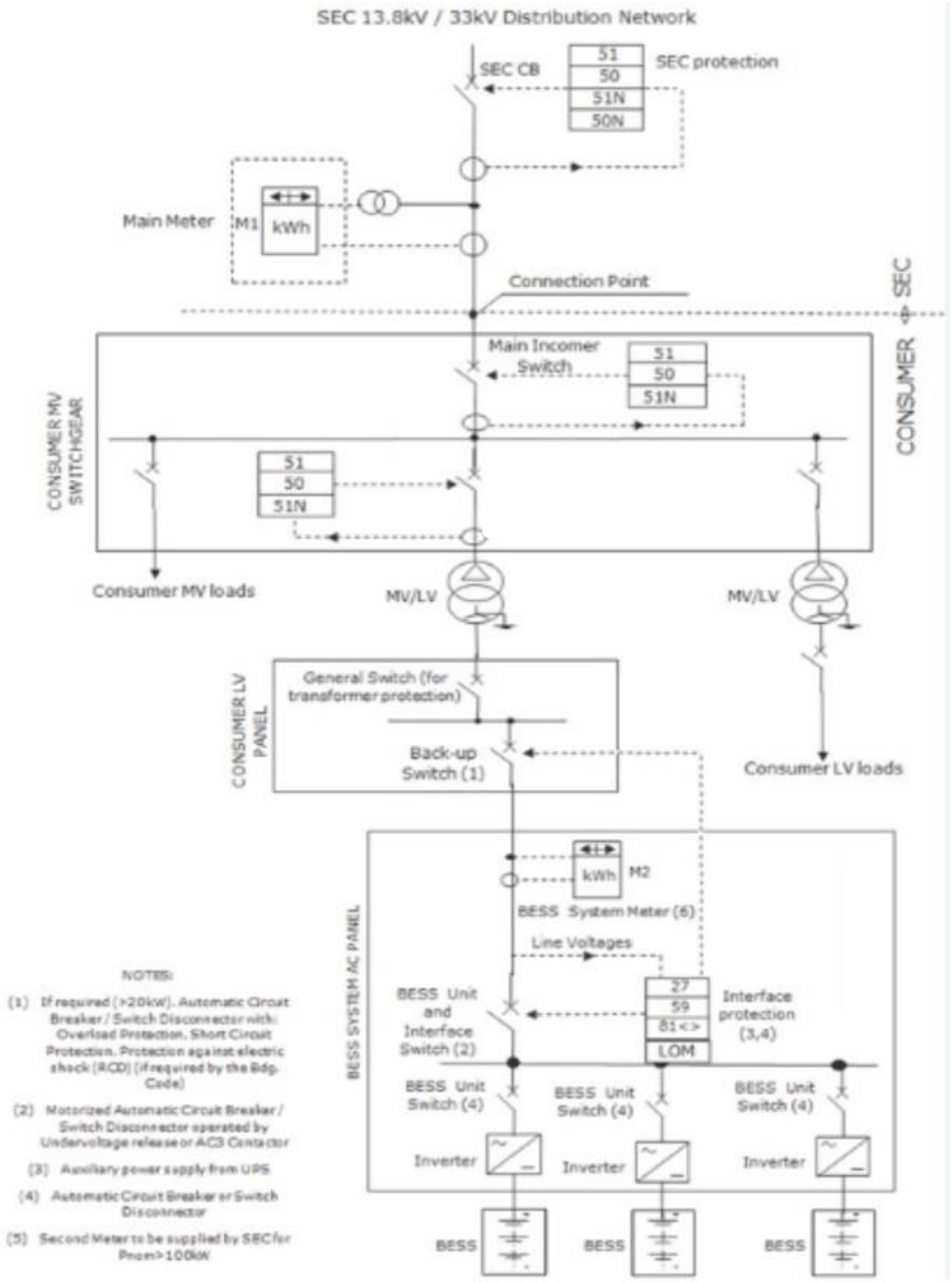
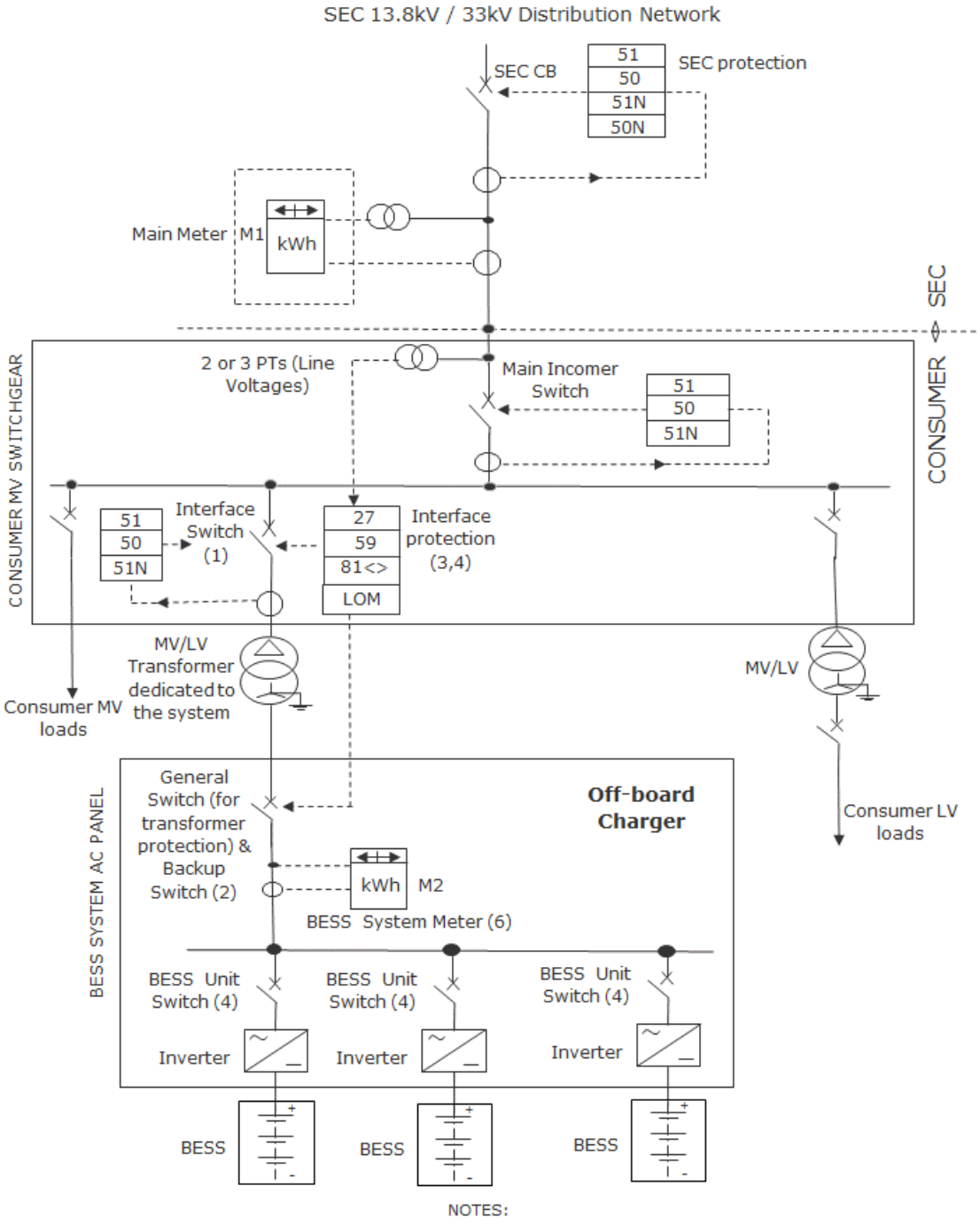


Figure 14: MV Connection Scheme – BESS with Maximum Connected Capacity between 2 MVA and 25 MVA–Multiple BESS units with external and unique Interface Protection external to the BESS; Backup Switch



NOTES:

(1) Motorized Automatic Circuit Breaker operated by Undervoltage release, with: Overload Protection (51), Phase Protection (50), Earth Protection (51N)

(2) Automatic Circuit Breaker / Switch Disconnector with: Overload Protection, Short Circuit Protection, Protection against electric shock (RCD) (if required by the Bdg. Code)

(3) Auxiliary power supply from a UPS

(4) Automatic Circuit Breaker or Switch Disconnector

(5) Second Meter to be supplied by SEC for Pnom>100kW

Figure 15: MV Connection Scheme - Interface Protection on the LV side of BESS with Maximum Connected Capacity > 2MVA and 25 MVA– Multiple BESS units with external and unique Interface Protection

ANNEX B. DEFAULT SETTINGS OF INTERFACE PROTECTION

The following table reports the default settings to be implemented in the Interface Protection of BESS when no other settings have been communicated by SEC.

Table 5: Default settings for the protection functions of the IP

Protection function	Setting	
	Threshold	Time delay
27<	90% Nominal Voltage	1.5 s
27<<	40% Nominal Voltage	0.8 s
59>	110% Nominal Voltage	3 s
59>>	120% Nominal Voltage	0.2 s
81>>	62.5 Hz	0.1 s
81<	57.5 Hz	4 s
81<<	57 Hz	0.1 s

Table 6 LOM settings

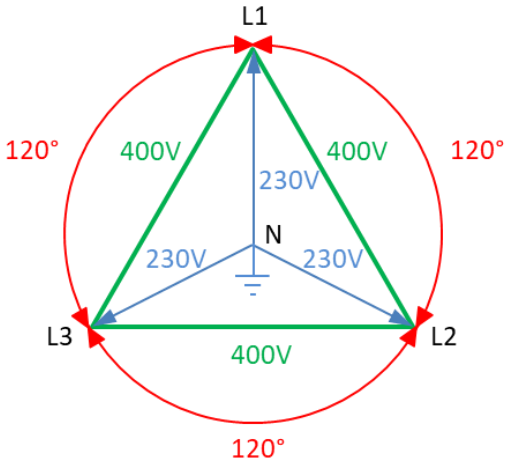
Vector Shift (VS)	**12 degrees**	**0.0s**
Rate of Change of Frequency (RoCoF)	**2.5 Hz per second**	**0.0s**

NOTE: in case the interface protection is external, the built-in IP can either be excluded (if LOM is made externally) or higher settings

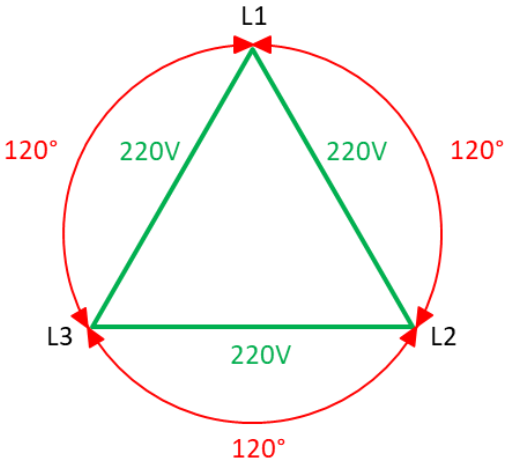
ANNEX C. CONFIGURATION OF LV DISTRIBUTION SYSTEMS OF SEC

The AC power can be distributed to Consumers in the following possible ways in the LV Distribution Network of SEC. This will have to be considered in the choice of the inverter and of the equipment of BESS connected to the LV network:

1) Three-phase four wires 400/230 Vac configuration



2) Three-phase three wires 220 Vac configuration



ANNEX D. TECHNICAL REQUIREMENTS FOR HYBRID SYSTEMS

In this Annex, its intended to illustrate the different possibilities of integrating a BESS with any Renewable Generation e.g., PV, Wind, Biomass, WtE, etc. highlighting the differences between renewable generation sources in terms of technology is not the purpose of this annex, however the focus will be on how to integrate the BESS with a renewable generation source regardless the technology, and how to transform a standalone BESS into a Hybrid System, considering that standalone BESS is not allowed according to the latest approved WERA regulations.

Starting with the basic case of an eligible user with a renewable generation source and connected to the distribution network, the typical scheme of such connection is shown in Figure 16.

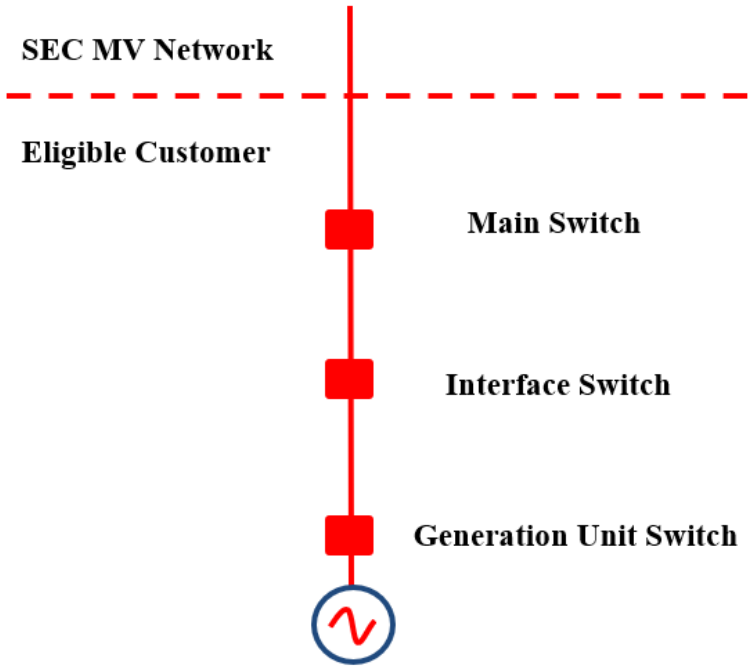


Figure 16: Connection Scheme of eligible customer renewable generation capable of operating in parallel to the distribution grid (general case without explanation of the transformation sections and measurement systems).

The diagram shown in Figure 16 exemplifies the case of a rotating generator coupled with a renewable source of energy, for which it is possible to operate in island mode on its own privileged loads. Figure 17 is illustrating the case of plants with BESS that together with a renewable source of energy they form a hybrid system.

This kind of illustration can't be used for design purposes, the scheme in Figure 17 and is highlighting the common approach in connecting a hybrid system to the grid. Usually this approach is used to allow the off-grid operation and it doesn't need an Automatic Switch Transfer ATS between the plant and the grid.

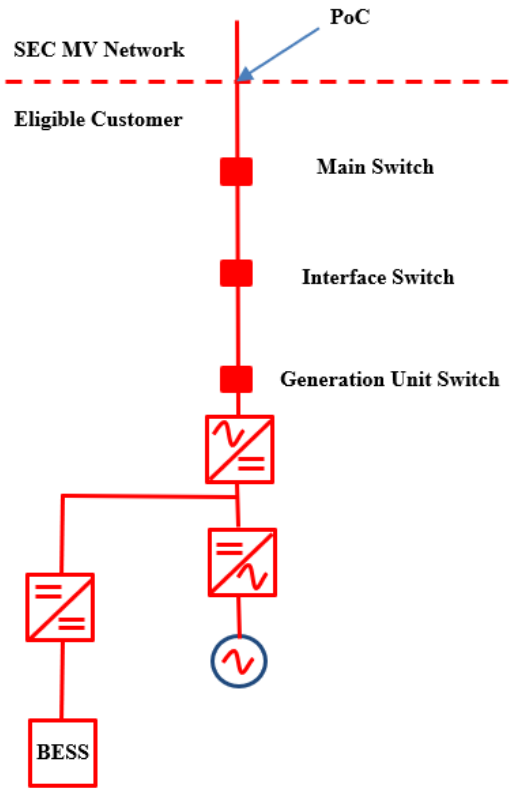


Figure 17: Connection Scheme of eligible customer renewable generation coupled with BESS in the DC side providing capability of operating in parallel with the grid and off-grid.

On the opposite, the configuration reported in xx is used typically for a continuous operation in parallel with the grid and it requires an Automatic Switch Transfer ATS to be able to synchronize with the network whenever there is a switch between the BESS and the renewable source of energy.

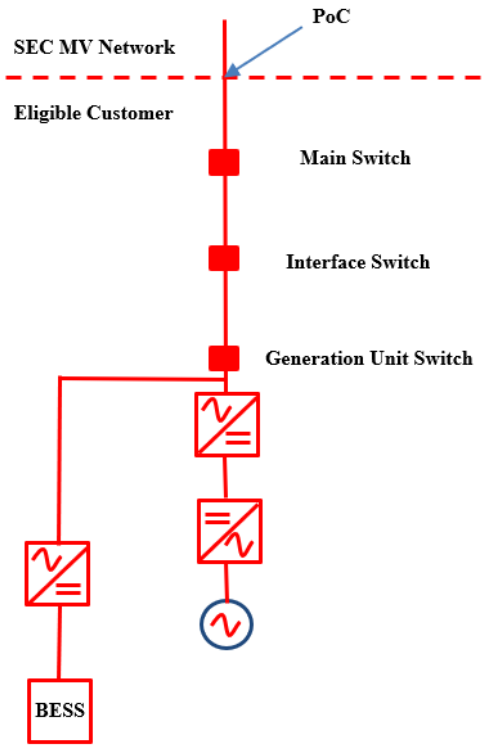


Figure 18: Connection Scheme of eligible customer renewable generation coupled with BESS in the DC side providing capability of operating in parallel with the grid and off-grid.

ANNEX E. SERVICE AND ENVIRONMENTAL CONDITIONS IN CASE OF OUTDOOR INSTALLATIONS

Following table lists service condition in the inland, desert or coastal areas environment in the Kingdom of Saudi Arabia:

Altitude above mean sea level (msl):	a. up to 1000m (normal) b. above 1000m (as required)
Ambient Temperature (Outdoor):	Minimum: -5 °C Maximum: 55 °C Monthly average of the hottest month: 40 °C Yearly average: 30 °C
Ambient Temperature (Indoor):	Air-conditioned buildings: 25 °C Buildings where no air-conditioning is provided: 40 °C
Ambient ground temperature:	40 °C
Maximum relative humidity:	100%
Temperature of exposed surfaces due to solar radiation:	75 °C
Soil thermal resistivity one (1) meter and below:	2.0 °C.m/W
Maximum earthquake frequency / severity:	Zone 2 (U.S. Build Code)
Soil condition– General:	Corrosive. Widespread salt deposits.
Ground water table level:	Varies from deep to very near the surface
Soil pH:	7.0 – 8.5
Salt concentrations (typical) Sulphates (SO3), by weight: 0 – 10 % Chlorides (as NaCl), by weight:	0 - 5%
Contamination level: Equivalent Salt Deposit Density (ESDD) in a period of any six:	0.3 to 0.5 mg/cm^2
Average hydrogen sulphide in the atmosphere:	40 Mg/m^3 (0.03 ppm)
Soil salinity:	0 to 140 g/m^3 (0 to 100000 ppm)
Average rainfall per year :	150 mm
Maximum wind velocity:	150 km/h
Approximate highest density solar radiation average over the summer months	1000 W/m^2
Isokeraunic level: (average / maximum / above 1000m):	10 /15 / 50 storm days/year

1) All equipment/material and accessories shall be designed for satisfactory operation/performance based on the above (Indoor or Outdoor) service conditions.
2) All outdoor equipment enclosures/material shall be weatherproof, and all metal parts shall be corrosion and/or abrasion resistant, and the degree or protection shall be at least IP54 as per IEC 60529 or equivalent NEMA Standard. The degree of protection for all indoor equipment shall be IP41 as per IEC 60529 or equivalent NEMA Standard.
3) It is the responsibility of the contractor and consultant to choose the most suitable location for the installation of the BESS, and if installed outdoor they shall guarantee the safety and integrity of the system in terms of performance and efficiency.
4) Manufacturer recommendations for BESS installations shall be taken into account by contractors and consultants.