Battery Energy Storage System Connection Guidelines

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1 SCOPE

These Guidelines provide information meant for KSA Consumers, Consultants and Contractors on the essential aspects which have to be taken into consideration in order to connect a Battery Energy Storage System to the Distribution Network of SEC. These Guidelines apply to the planning, execution, modification, operation and maintenance of the Battery Energy Storage Systems. The Guidelines are in compliance with the international best practices and experience of the technology experts.

This document contains basic principles of Battery Energy Storage System along with the illustration of the connection process as per SEC specific conditions. Thus, this guide shall serve as a basis for SEC and for the Consumer or its appointed Consultant/Contractor in the planning and decision-making process at all applicable stages.

The technical aspects are not treated here, but separately in the Technical Standards for the Connection of Battery Energy Storage Systems to Distribution Networks of SEC (in this document referred to as "Technical Standards"), which represents the main reference document for the definition of the requirements that these generating facilities have to comply with in order to be connected to the Distribution Network. The Annexes provide the Consumers and Consultants/Contractors with a template of the Initial Application Form, and instructions about the information and the documentation of the Battery Energy Storage System that shall be submitted at each stage of the connection process.

1.1 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 Health and Safety Requirements for BESS_v3.0 Final.docx
[4] CESI_SEC-DREG Inspection and Testing Checklists for BESS_v3.0 Final.docx
[5] CESI_SEC-DREG Inspection and Testing Guidelines for BESS_v3.0 Final.docx
[6] CESI_SEC-DREG Manual for the maintenance for BESS_v3.0 Final.docx
[7] CESI_SEC-DREG Standards for Connection of BESS_v3.0 Final.docx

2 TERMS AND DEFINITIONS

BESS – Rechargeable electrochemical Battery Energy Storage System that store energy from different sources (i.e. electric grid, solar …) and can provide the stored energy to the user's premises when needed. In some sections the BESS system is referred to as DG.
Connection/Exit Point – The physical point at which Consumer's Plant or apparatus is joined to the SEC Distribution System.
Consultant/Contractor – An entity that is capable to carry out design and Electrical Installations work specific to the Battery Energy Storage System systems as a consultant or contractor.
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 Battery Energy Storage System.
Inspection – examination of an electrical installation using all the senses in order to ascertain correct selection and proper erection of electrical equipment.
Interface Protection (IP) - The electrical protection required to ensure that either the BESS System 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.
SOC - state of charge is the ratio between the available energy from a BESS and the actual energy capacity; typically expressed as a percentage.
SOC/SOE – State of charge or State of Energy refers to the charge level of a BESS.
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.
Testing – implementation of measures in an electrical installation by means of which its effectiveness is proved (Note: It includes ascertaining values by means of appropriate measuring instruments, said values not being detectable by inspection).
Verification – all measures by means of which compliance of the electrical installation to the relevant standards is checked.
Rated value - value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system.

3 GLOSSARY

The following acronyms and symbols are used throughout the document:

AC	Alternating Current
BCSS	BESS Control Subsystem
BESS	Battery Energy Storage System
BMS	Battery Management System
BOP	Balance of Plant
DC	Direct Current
WERA	Water & Electricity Regulatory Authority
EMS	Energy Management System
IEC	International Electrotechnical Commission
IP (or I.P.)	Interface Protection
IR	Infrared

ISO	International Organization for Standardization
NEC	National Electrical Code
NFPA	National Fire Protection Association
P	Active power
PCS	Power Converter Subsystem/Power Conversion Subsystem
Pnom	Nominal active power of equipment
PPE	Personal protective equipment
PR	Performance Ratio
Q	Reactive Power
RCD	Residual Current Device
RTE	Round Trip Efficiency
S/Sn	Apparent Power
SASO	Saudi Standards, Metrology and Quality Organization
SEC	Saudi Electricity Company
SELV	Safety extra low voltage
SOC	State of Charge
SOE	State of Energy
UL	Underwriters Laboratories
V	Voltage

4 BATTERY ENERGY STORAGE SYSTEM – BENEFITS, TECHNOLOGY, ENVIRONMENT

4.1 Architecture of a BESS

A typical BESS' architecture is shown in Figure 1.

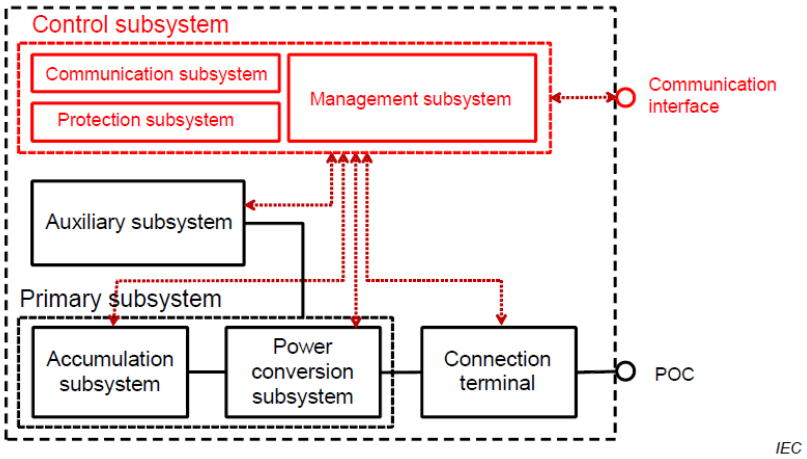

Figure 1: General architecture of a Battery Energy Storage System

The more important features of the subsystems/components included in the BESS are described in the following paragraphs.

4.1.1 Accumulation/Battery Subsystem

The Battery subsystem represents the reservoir where the primary energy is stored. This storage of energy shall be built upon secondary cells batteries. The secondary cells batteries shall be assembled in battery modules which, in turn, shall be connected in series in battery strings accommodated in rack mounting structures in order to have a DC bus within the range 600-1500Vdc. The racks of batteries shall then be connected in parallel to meet the desired energy and power capacities. The use of DC bus not comprised in the aforementioned voltage range shall be clearly stated and justified.

The battery subsystem shall be suitably designed and dimensioned to have the required rated power and energy capacities fully usable for the expected lifetime of the BESS. Depending on the specific characteristics of the chemistry, it means that the installed energy and power capacities shall be oversized with respect to the desired rated values, to account for capacity degradation over time. The battery subsystem shall be comprehensive of all internal wiring required for the connection to the other subsystems, especially the PCS, the BOP and auxiliary subsystem and the BCSS.

The battery subsystem shall be complete of all the auxiliary equipment such as: fire, heat, and/or smoke detection system, fire extinguisher or suppression system, HVAC systems, and so on; necessary to ensure the normal operation and the protective shutdown of the subsystem in case of internal or external faults which can potentially create damages to the subsystem.

In particular, the battery subsystem shall be equipped with a BMS to ensure the safety and reliability of the batteries during operation. The BMS may have a hierarchical organization which reflects the assemblies of batteries in modules and racks and shall especially provide the following services:

- Monitor the charge/discharge rate of the batteries and avoid a use beyond the limits.

- Monitor the state of charge of the modules and avoid over-charge or discharge.
- Monitor the temperature, voltage and current of cells and modules and prevent thermal runaways.

The BESS subsystem shall be enclosed in containers suitable for an outdoor installation on a concrete box pad. A short introduction to the principle of operation of the currently most used batteries in BESS. **Lithium-ion (Li-ion) batteries:** Lithium-ion (Li-ion) batteries make up most of the batteries currently deployed to date. Lithium-ion cells are comprised of a positive and a negative electrode, the anode and the cathode. Between them, there is an ion-conducting electrolyte. This allows the transport of the lithium ions between the electrodes during the charging and discharging processes. The separator stops direct contact between the anode and cathode.

During the discharging process lithium ions and electrons are released on the anode side. The electrons flow through the external circuit and perform the electrical work. At the same time, the lithium ions cross through the electrolyte fluid and the separator over to the cathode. Figure 1 displays a figure showing lithium-ion BESS system works.

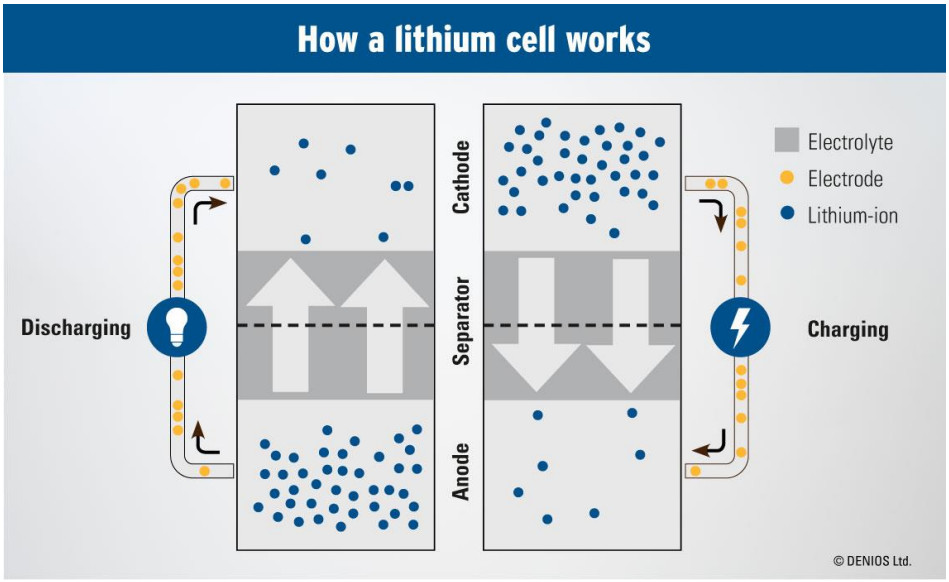

Figure 2 - How a lithium cell works I

Li-ion batteries utilize the exchange of Lithium-ions between electrodes to charge and discharge the battery. Li-ion is a highly attractive material for batteries because it has high reduction potential, i.e., a tendency to acquire electrons, and it is lightweight. Li-ion batteries are typically characterized as power devices capable of short durations (approximately 15 minutes to 1 hour) or stacked to form longer durations (but increasing costs). Rechargeable Li-ion batteries are commonly found in consumer electronic products and are the standard battery found in electric vehicles. In recent years this technology has developed and expanded its portfolio of applications considerably into utility-scale applications. Today, Li-ion batteries have been implemented for longer duration applications from load shifting and Peaker plant replacement, to ancillary services in grid connected storage. Additionally,

[1] How a lithium-ion battery works: https://www.denios-us.com/expertise-advice/help-advice/safe-storage-of-lithium-ion-batteries/

because of its characteristics, Li-ion technology is well suited for fast-response applications like frequency regulation, frequency response, and short-term (30-minutes or less) spinning reserve applications. As such, lithium-ion batteries are rapidly developing – and with this development towards mass production, costs are falling.

Li-ion batteries do carry some safety and environmental risk. Toxic or reactive gases may be released both during creation of the battery cells, as well as in case of thermal runaway within an operating system. However, this risk is being managed across the industry. Li-ion BESS systems come with various methods of cooling, not only to help prevent thermal runaway but also to provide the most beneficial operating temperatures for the battery cells. This risk is being managed from a broader perspective, too; firefighters and local authorities are preparing to appropriately address any fire concerns, and standards are being developed both nationally and internationally e.g., firefighters and international standards such as: NFPA 855, UL 9540, UL9540A, etc.

4.1.2 Power Conversion Subsystem

The PCS/inverter shall consist in one or more power conversion modules consisting of a bi-directional four quadrant GCPC and a LV/MV step-up transformer. The number and organization of the power conversion modules shall be chosen according to cost-efficiency and reliability criteria. The PCS/inverter shall be comprehensive of all the switchgears, cables and circuit breakers required for the connection to the other subsystems, especially the battery subsystem, the BOP and auxiliary subsystem and the BESS control subsystem, as well as all the equipment such as: fire extinguisher, HVAC system, etc., necessary to ensure a secure and reliable operation of the subsystem.

The PCS/inverter shall be equipped with all the controllers, equipment and protections which can ensure the correct operation of the single power conversion modules and their protective shutdown in case of internal or external faults. The PCS/inverter shall also be comprehensive of the casings suitable for outdoor installation on a concrete box pad.

4.1.3 BESS Control Subsystem

The BESS shall be equipped with a control, protection and communications subsystem (BCSS) which coordinates all the BESS subsystems and equipment and implements all the functions and control algorithms necessary to assure a safe, effective and efficient operation of the BESS as well as the information exchange with external systems. Especially, it means that the BESS shall be equipped with all the HW & SW equipment and communications interfaces for the implementation of a local HMI and a local SCADA for on-site monitoring, control and protection purposes as well as for the exchange of information with remote systems.

The BCSS shall provide for the continuous acquisition, processing, transmission, archiving and display of all the relevant information from all the different subsystems of the BESS and from any additional measurements deemed necessary. The BCSS shall provide graphical interfaces to the BESS operators, which offer a comprehensive understanding of the current operational state of the BESS (HMI, warnings, alarms, etc.) and of its subsystems. The graphical interfaces shall also allow the BESS operators to insert commands (request of operating modes, operating procedures, etc.) and/or reference values/setpoints which shall thus be processed by the subsystem to coordinate the controllers of the other subsystems and to have the BESS responding accordingly, especially delivering the proper power to the grid and respecting the operational constraints of all the BESS subsystems.

The BCSS shall also collect the information coming from the protection subsystem and protections devices to detect either abnormal operating conditions or emergency situations. In these cases, the system shall coordinate all the BESS subsystems to swiftly switch the BESS in the safest state either for the personnel and for the property. The communication interfaces for the information exchange with external remote systems shall be designed to support the full remote monitoring and control of the BESS and all the communications either within the BESS or with external systems shall be designed against potential cyber-attacks.

The BCSS shall be complete of all its auxiliary equipment such as: fire extinguisher, HVAC system, and so on, necessary to ensure a secure and correct operation of the subsystem. *Figure 3* provides a more detailed schematic of a general Li-ion BESS. This includes monitoring, control, and management systems, power converter/inverter, and the batteries themselves.

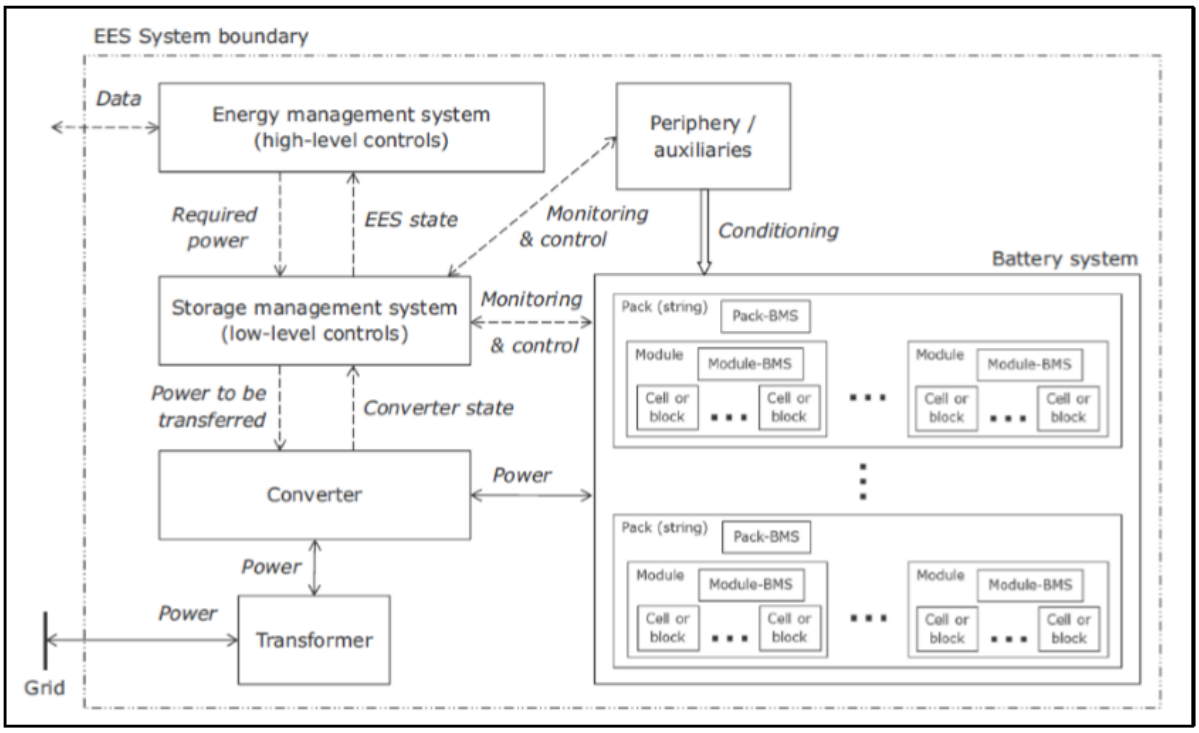

Figure 3 - General Schematic and Components of a Cell-Based Battery Energy Storage System[2]

Energy storage is an adaptable technology that offers control over energy costs in households and in all sectors that need power such as commercial activities, factories, office buildings and many others. BESS can provide reserve power, target specific demand-based charges and reduce charges and act as backup power source all without disruptions in operations.

Lithium-ion batteries are versatile, high in energy density and come in various designs optimized for its intended use. Li-ion Battery Energy Storage Systems, while differing across battery chemistries are generally appropriate for serving energy applications, moderate power applications, and applications requiring a short response time. Further, if charged at the time of the outage, Li-ion systems can support

[2] DNV GL, Safety, operation and performance of grid-connected energy storage systems, September 2017.

a black start. Across the board, with an increase in adoption, Li-ion technologies have reduced in price and improved in operation. However, of the technologies reported on in this project, Li-ion batteries are some of the most sensitive to temperature. As such, Li-ion systems are generally installed with cooling and heating systems, which may consume a portion of the useable system capacity.

During charge and discharge cycles, Li-ion batteries undergo electrochemical reactions involving exchange of **lithium-ions** between the electrodes. Historically, **Li-ion** batteries have been used in consumer electronics and are currently the primary technology used for stationary battery energy storage system installations.

4.2 Battery Energy Storage System

The battery modules are connected in series to form a battery string. More strings are connected in parallel to form a battery array. The array provides all the power coming from the conversion, but we cannot use it directly because is not compatible with the characteristics of the electric appliances and the electric grid.

The DC power coming from the array is thus converted in AC power fully compatible with the public distribution networks. This function is operated by means of specific electronic equipment called Power Converter Subsystem (PCS)/inverter. The PCS performs several functions: mainly it optimizes the electrical operation of the array and transforms the DC power into AC power that may be used by the electric appliances or injected into the distribution network when necessary.

In *Figure 4*, it is shown the general configuration of a BESS. Beside the PCS there are other equipment aimed to safeguard the distribution network (Interface protection), to measure the energy produced and exchanged with the distribution network (Meters) and to sort the power (AC switchgear). Such BESS are called *Grid-connected BESS* or *Grid-tied BESS*.

Figure 4 - Example of a BESS Enclosure[3]

[3] AltaGas opens North America's largest battery storage facility: http://theamericanenergynews.com/innovation/altagas-opens-north-americas-largest-battery-storage-facility

4.3 BESS fit for everyone

The possibilities offered by BESS are countless, a few examples are shown in *Figure 5*. From the figure, systems readily on the market range from 80 kWh-1 MWh. BESS can be comprised of several racks of batteries that can be enclosed in large containerized systems or can be contained within a small enclosure.

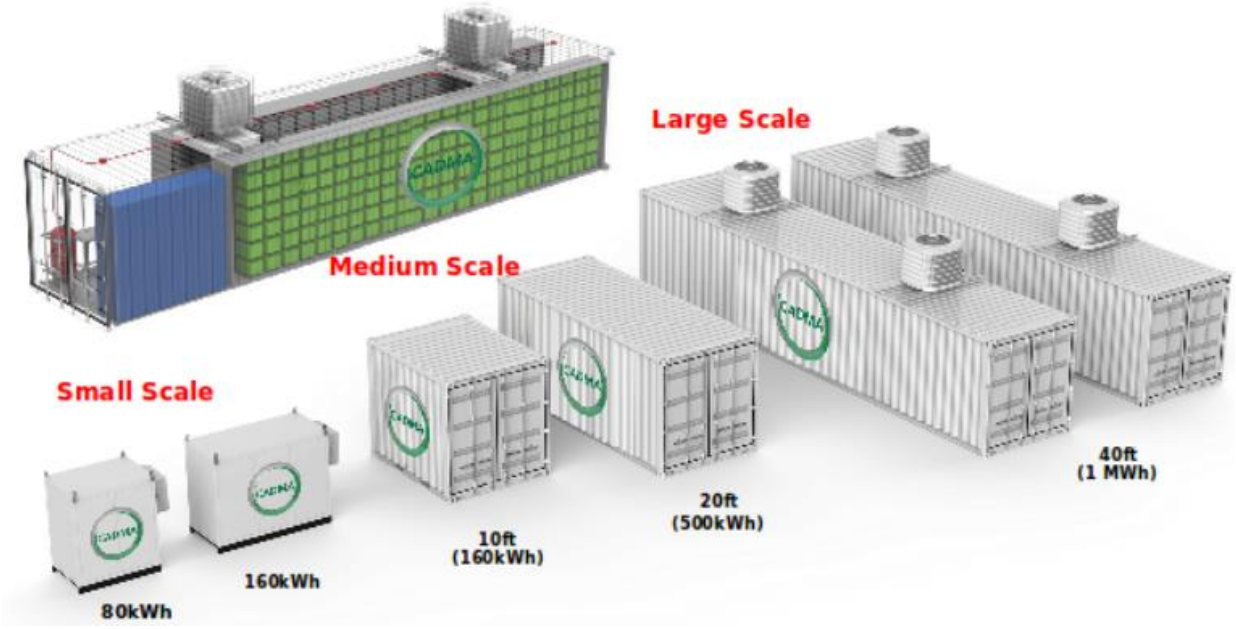

Figure 5 – Examples of BESS installations[4]

[4] CALB battery storage solutions for homes and businesses: https://www.solarchoice.net.au/blog/calb-battery-storage-solutions

5 DEFINITION OF THE RESPONSIBILITIES

5.1 Foreword

The purpose of this section is to define a list of obligations and entitlements that each one of the parties involved in the connection process. The limits of responsibility of the below are outlined:

- SEC
- The Consumer (as owner of the REG System); and
- The Contractor/Consultant (appointed by the Consumer)

5.2 SEC

5.2.1 Responsibility

SEC shall be responsible for:

- Operating and maintaining a secure, reliable and efficient electric distribution network, in order to be able to receive the power produced by the REG system.
- Connection the Eligible Consumer to the network.
- Conducting the site and REG system inspections as per the internal checklists.
- Undertaking any possible provisions to clear a fault in the distribution network in the shortest time. SEC shall not be liable for the loss of production that the REG System will undergo in case of disconnection following the intervention of the Interface Protection.
- If there is a risk for either the safety or the security of the system and the public electricity network, SEC is entitled to disconnect the REG System from the distribution network.

SEC claims no 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 connection point. The Eligible Consumer is responsible for observing or referring to the applicable laws and regulatory requirements.

The Consumer is in particular responsible for observing or referring to the applicable laws and regulatory requirements that regard the mechanical and civil design related to the construction of the plant. Although some details regarding the mechanical design of connection equipment are required at the Connection Application and Approval Stage, these details are only informative. It is not the responsibility of SEC to check nor to approve the design of the REG Systems as well as any issues that regard the compatibility of the REG systems with the aesthetic rules or regulations in force.

5.2.2 Ownership Boundaries

The boundary between Eligible Consumer and SEC are regulated as follows:

- The boundary between SEC and the Eligible Consumer is the Connection Point as indicated in the connection schemes in the document.
- The respective ownership of Plant or equipment shall be recorded in the Connection Agreement between SEC and the Eligible Consumer in the form of a diagram.
- Technical Standards for the Connection of REG systems to the LV and MV Distribution Networks of SEC.

5.3 Eligible Consumer

5.3.1 Connection Agreement

- The Eligible Consumer shall enter into a Connection Agreement with SEC. The Connection Agreement encompasses both the technical and commercial aspects of the connection, addresses the Standards and Minimum Technical requirements and specifies the terms and conditions including the connection fee, net billing criteria, use of system and quality of supply in accordance with SEC Standards.
- The Eligible Consumer shall indemnify SEC and accept liability for safety and supply quality issues that occur when the REG System is operating.
- The term of Agreement between the Eligible Consumer and SEC shall be valid for 20 years with effect from the date of the connection agreement signature of the REG System.

5.3.2 Responsibility

The Eligible Consumer shall be responsible for:

- Selecting the Contractor/Consultant and inserting all respective data, considering that the eligible consumer can act as or appoint himself/herself as the assigned Contractor/Consultant.
- Coordinate with the Contractor/Consultant with all information needed as relevant
- Payment of the fees as applicable
- Signing all the relevant agreements as applicable
- All costs associated with the connection of a REG System to SEC system shall be borne by the Eligible Consumer

5.3.3 Undertaking and compliance

The Eligible Consumer shall undertake to comply with the following:

- Cooperate with SEC staff in all matters related to electricity exported to the system.
- Any electricity generated in excess by the plant above the electricity consumed in the premise shall be exported to SEC system in accordance with the provisions of the connection agreement.
- If there is a risk for either the safety or the security of the system and the public electricity network, SEC is entitled to disconnect the REG System from the distribution network.

5.3.4 Disconnection

SEC may limit the operation and/or disconnect or require the disconnection of a plant from distribution network at any time, with or without notice, in the event of fault. SEC may also limit the operation and/or disconnect or require the disconnection of the plant from the distribution network upon the provision of notice for the following conditions:

- To allow for routine maintenance, repairs or modifications to the distribution networks.
- Upon SEC's determination that the plant is not in compliance with its Regulations.
- Upon termination of the Connection Agreement.

5.4 Contractor/Consultant

Consultant's responsibility and liability are defined by the laws in force. In particular, the Consultant shall be responsible for:

- Carrying out the application process on behalf of the Eligible Consumer as described above.
- Carrying out the design according to the technical requirements and specifications of SEC and Saudi distribution code.

- The installation, operation and maintenance (if agreed with the Eligible Consumer) of all the equipment of the REG system.
- Applying a safe system of work during the construction of a REG System, in compliance with all applicable standards, regulations and statutory requirements.
- Ensuring that there is a safe system of work for all representatives that are involved in the REG System construction, in compliance with all applicable standards and statutory requirements.
- The reliable protection of the REG system (e.g. short-circuit, earth-fault and overload protection).
- Proposing to the Eligible Consumer adequate and certified REG equipment by the responsible authorities.
- Installation in accordance with best practice and in compliance with all applicable technical standards.
- Appointing a Test Engineer to perform all the needed tests in the plant.
- Providing O&M services (if agreed with the Consumer).
- Arrange all necessary requirements and systems to connect a DG System to SEC distribution networks, including compliance with security and safety requirements, and providing the necessary equipment.
- Not to exceed the authorized maximum installation capacity for exporting to SEC network.
- Not to conduct any action impacting the safety and efficiency of SEC network
- Cooperate with SEC staff in all matters related to electricity exported to the system.

As stated above, the limits of liability as specified for the Consultants apply also for the Contractors when their services extend to include consultancy services and the design of the plant. 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 be conform to the relevant SEC standards in force at the time of the connection of the installation to SEC system.

5.4.1 Protection requirements

The REG system's protection and control diagrams for the interconnection shall be in accordance with the provisions of the Distribution Code and approved by SEC prior to the commissioning of the proposed interconnection facilities. The Consultant/Contractor has to make sure to install a manual disconnecting device to isolate the DG system from the distribution network as also required in the Saudi Building Code.

5.5 Manufacturers

Manufacturers' responsibility and liability are defined by the laws in force. The manufacturers shall in particular be liable in case of delivery of false certificates of compliance for the REG System products.

DISCLAIMER
All checklists and application forms for the connection of the BESS are reported in the Inspection and testing checklists and their descriptions is also listed in the connection process document, readers can refer to these 2 documents for further information.

ANNEX A – CONSUMER REQUEST AND INSERT OF DATA

The following form is used by the Eligible Consumer.

Data name	Data type	Author	Notes
Eligible Consumer Personal Details			
Account Number of Eligible Consumer*	Number	Consumer	Drop list of already existing account numbers.
*Category**	Selection	IFS	☐ *Residential* ☐ *Commercial* ☐ N/A Automatically filled
Consumer Status*	Selection	Consumer	☐ *Rental* ☐ *Owner* ☐ Other
Consultant Selection	Drop List	Consumer	☐ *Internal belonging to the consumer* ☐ *External Consultant*
Consumer ID Number	Numeric	IFS	Automatically filled
Consumer Nationality	Alphabetic	IFS	Automatically filled
Consumer Email	Alphabetic	IFS	Automatically filled
Consumer Name	Alphabetic	IFS	Automatically filled
Consumer Contact Details			
Mobile Number	Numeric	IFS	Automatically filled
Home phone number	Numeric	IFS	Automatically filled
Office phone number	Numeric	IFS	Automatically filled
P.O. Box	Numeric	IFS	Automatically filled
Fax Number	Numeric	IFS	Automatically filled
Consumer Address Details			
*Tax Number**	Numeric	Consumer	
Address	Alphabetic	IFS	Automatically filled
Information on BESS Consultant (whether internal or external)			
*City**	Selection	Consumer	
*Name as per the commercial register CR**	Alphabetic	Consumer	
☐ *The eligible consumer authorizes the selected consultant to upload all required information on REG system application and design on his behave.* ☐ *The selected consultant takes full responsibility on all uploaded documents and REG system design and SEC will never be accounted responsible for any design lacunes or mistakes that might jeopardize the safety or the performance of the REG system.*			

The following form is used by the Assigned Consultant.

Data name	Data type	Author	Notes
Information on Consultant			
*Commercial Register CR **	Upload	Consultant	
*Name of the responsible person * Including employment verification.*	Upload	Consultant	

P.O.BOX	Numeric	Consultant	
E-mail	Alphabetic	Consultant	
Information on the location			
*Type of site**	Selection	Consultant	☐ Open field ☐ apartment ☐ building ☐ Villa ☐ Commercial building ☐ Factory ☐ Office building ☐ Other
Voltage	Selection	IFS	☐ 127/220 V ☐ 220/380 V ☐ 230/400 V ☐ 13.8 kV ☐ 33 kV ☐ 69 kV Automatically filed (to be verified on site by SEC)
Latitude, Longitude according to meter location	Numeric	IFS	xx.xxx °N yy.yyy °E Automatically filed (to be verified on site by SEC)
Account number	Numeric	IFS	Automatically filed (to be verified on site by SEC)
Meter number	Numeric	IFS	Automatically filed (to be verified on site by SEC)
Pole number	Numeric	IFS	Automatically filed (to be verified on site by SEC)
Breaker size	Numeric	IFS	Automatically filed (to be verified on site by SEC)
Information on the REG System			
Type of REG System*	Selection	Consultant	☐ PV (>2 MW) ☐ Wind ☐ CSP ☐ WtE/Biomass ☐ Geothermal ☐ Battery Storage ☐ Green Hydrogen
Type of BESS*	Selection	Consultant	☐ Hybrid System
In case of Hybrid System, what is the associated technology *	Selection	Consultant	☐ PV (>2 MW) ☐ Wind ☐ CSP ☐ WtE/Biomass ☐ Geothermal ☐ Green Hydrogen
Large Scale BESS Plant Size KVA*	Numeric	Consultant	
Technology details*	Drop List	Consultant	
Data name	**Data type**	**Author**	**Notes**
BESS System			
*BESS Total Capacity(kW)**	Numeric	Consultant	
BESS installation	Selection	Consultant	☐ *On building* ☐ *Ground* ☐ *indoor* ☐ outdoor
Approximated area available for	Numeric	Consultant	

BESS installation (m^2)			
*Total Number of batteries in the BESS **	Numeric	Consultant	
Capacity of the single battery (kW)	Numeric	Consultant	
Total number of inverters	Numeric	Consultant	
Nominal Energy [kWh]	Numeric	Consultant	
BESS technology	Numeric	Consultant	☐ *NMC* ☐ *LFP* ☐ *Other (specify)*
*Power Factor**	Selection	Consultant	☐ Fixed ☐ Variable

*are mandatory fields and required for conducting CYME simulation.

ANNEX B – BESS DESIGN DOCUMENTATION REQUIREMENTS

5.6 Preface

In this section the minimum documentation that should be provided in the frame of the process for the installation of a grid connected BESS is listed. This information will ensure key system data is readily available also to a Consumer, inspector or maintenance engineer. The documentation includes basic system data and the information expected to be provided in the operation and maintenance manual.

5.7 BESS

5.7.1 Basic system information

As a minimum, the following basic system information shall be provided. This “nameplate” information shall be presented on the cover page of the system documentation pack:

a) Project identification reference (where applicable).
b) Rated (nameplate) system power (kW DC and kVA AC).
c) Rated (nameplate) system energy capacity (kWh).
d) BESS PCS/inverters – manufacturer, model and quantity.
e) Installation date.
f) Commissioning date.
g) Customer name.
h) Site address.

5.7.2 System designer information

As a minimum, the following information shall be provided for all bodies responsible for the design of the system. Where more than one company has responsibility for the design of the system, the following information should be provided for all companies together with a description of their role in the project.

a) System designer, company.
b) System designer contact person.
c) System designer, postal address, telephone number and e-mail address.

5.7.3 System installer information

As a minimum, the following information shall be provided for all bodies responsible for the installation of the system. Where more than one company has responsibility for the installation of the system, the following information should be provided for all companies together with a description of their role in the project.

a) System installer, company.
b) System installer contact person.
c) System installer, postal address, telephone number and e-mail address.

5.8 BESS up to 2 MW

5.8.1 Wiring diagram

As a minimum, a single line wiring diagram in a suitable and readable format shall be provided.
In general, it is expected that this information will be presented as annotations to the single line wiring diagram. In some circumstances, typically for larger systems where space on the diagram may be limited, this information may be presented in table form.

5.8.1.1 BESS information

The wiring diagram or system specification shall include the following BESS information.

a) BESS – number of racks, type of modules, etc.)
b) Overcurrent protective device specifications (where fitted) – type and voltage/current ratings.

5.8.1.2 BESS electrical details

The wiring diagram or system specification shall include the following electrical information (where fitted).

a) Junction boxes/combiner boxes: Locations, manufacturer, model and internal electric diagram.
b) DC switch disconnector: Location and rating (voltage/current), manufacturer and model.
c) Overcurrent protective devices: Type, location, rating (voltage/current), manufacturer and model.
d) Other enclosure electronic protective circuitry (such as arc fault detection), if applicable: Type, location, rating, manufacturers and models.

5.8.1.3 AC system

The wiring diagram or system specification shall include the following AC system information.

a) AC isolator location: Type, rating, manufacturer and model.
b) AC overcurrent protective device: Location, type, rating, manufacturer and model.
c) Residual current (where fitted): Device location, type and rating.
d) Interface protection: Type, manufacturing and model.
e) Interface switch (and backup switch if applicable): Location, type, rating, manufacturer and model.

5.8.1.4 Earthing and overvoltage protection

The wiring diagram or system specification shall include the following earthing and overvoltage protection information.

a) Details of all earth/bonding conductors – size and type.
b) Details of any connections to an existing Lightning Protection System (LPS).
c) Details of any surge protection device installed (both on AC and DC lines) to include location, type and rating.

5.8.2 Datasheets

As a minimum, datasheets shall be provided for the following system components:

a) BESS datasheet for all types of cells used in system.
b) PCS/inverter datasheet for all types of inverters used in system.
c) Interface protection datasheet.

The provision of datasheets for other significant system components should also be considered.

5.8.3 Emergency systems

Documentation of any emergency systems associated with the BESS (fire alarms, smoke alarms, etc.). This information shall include both operation and design details.

5.8.4 Esteem of the yearly energy production

An esteem of the yearly energy production, based on data from literature, shall be calculated.

5.9 BESS above 2 MW

5.9.1 Technical report

Here below the structure of the Technical report is described along with a list of the minimum information to be included. Further information might be required, depending on the type and size of the BESS, and the document might be organized differently.

Although the organization of the Technical report as described below is recommended, it might be possible to adopt a different structure, provided the general criteria be fulfilled (e.g. separation of the input data from the information elaborated during the design) and no information are missing.

5.9.1.1 Preliminary information

As a minimum, the following basic system information shall be provided. This "nameplate" information preferably shall be presented on the cover page of the system documentation pack:

a) Project identification reference or name.
b) Rated (nameplate) system power (kW/kWh).
c) BESS – manufacturer, model and quantity.
d) Installation date.
e) Commissioning date.
f) Customer name.
g) Site address.

5.9.1.2 Chapter 1 – Foreword (or Introductory section, or Preface, etc.…)

As a minimum, the following information shall be provided:

- A short description of the purpose of the project, also referring to the benefits for the client, for the environment, for the electric system, for the Nation, etc.…
- System designer information for all bodies responsible for the design of the system. Where more than one company has responsibility for the design of the system, the following information should be provided for all companies together with a description of their role in the project.
    a. System designer, company.
    b. System designer contact person.
    c. System designer, postal address, telephone number and e-mail address.
- System installer information for all bodies responsible for the installation of the system. Where more than one company has responsibility for the installation of the system, the following information should be provided for all companies together with a description of their role in the project.
    a. System installer, company.
    b. System installer contact person.
    c. System installer, postal address, telephone number and e-mail address.

5.9.1.3 Chapter 2 – Input data

It is important to dedicate a chapter for the input data used for the design (environment, local laws/grid code and rules, constraints, relevant grid characteristics, etc.) listed here below, whereas the information elaborated at design stage will be detailed in the upcoming paragraphs.
As a minimum, the following input data and information shall be provided:

- Definitions (recommended).
- Laws/grid code and standards applicable (the most relevant ones).

- Geological and environmental constraints (if any) as type of soil, inclination, need of stabilization or other treatment, shading, presence of vegetation, animals, etc.).
- Characteristics of the distribution network at POC: voltage, frequency, No. of phases, type of earthing system (TT, TN, IT, etc.…), short circuit current, any further available information on power supply.

5.9.1.4 Chapter 3 – Characteristics of the main devices and equipment

As a minimum, the following information shall be provided:

- BESS (Manufacturer, model, technology, type of battery chemistry, dimensions and weight, certifications, etc.).
- PCS/inverters (manufacturer, model, Pn, Max input current, Max input voltage, output voltage and frequency range, Max temperature, IP enclosure, dimensions, weight, certifications, etc.).
- DC combiner boxes – if present – (Manufacturer, model, No. of inputs, protection on inputs, switch/disconnector, BESS string monitoring if any, IP enclosure, dimensions, weight, certifications, etc.).
- Interface protection – if external to the inverters – (Manufacturer, model, functions, standards compliance, certifications, etc.).
- Monitoring system – if present – (manufacturer, model, DC inputs, AC inputs, data line exchange, storage, data display, certifications if any, etc.).

5.9.1.5 Chapter 6 – AC section

As a minimum, the following information shall be provided:

- Measures to prevent electric shocks from direct contacts (class II insulations, tubes and channels, etc.).
- Measures to prevent electric shocks from indirect contacts (earthing, RCDs, etc.).
- Characteristics of the main AC devices (Manufacturer, model, type of device, No. of poles, aux contacts, nominal current, short-circuit current, characteristics of the protection, etc.).
- AC calculations (verification of compliance for AC devices and cables).

5.9.1.6 Chapter 7 – Civil and mechanical installation

As a minimum, the following information shall be provided:

- Structural calculations (if necessary).

5.9.1.7 Chapter 8 – Performance calculation

As a minimum, the following information shall be checked and validated:

- The power rating, that unit rated power conforms to provider specifications.
- The energy rating, that unit rated energy conforms to provider specifications.
- The stored energy capacity, the amount of electric energy capable of being stored by a BESS expressed as the product of rated power of the BESS and the discharge time at rated power.
- The dispatch response, that unit dispatches accurately with proper speed of response.
- The roundtrip efficiency of the unit efficiency as function of cycle type.
- The standby unit losses corresponding to auxiliary power and battery parasitic loss, and so on.

5.9.2 Wiring diagram

As a minimum, a multiple line wiring diagram in a suitable and readable format shall be provided. If necessary, the diagram may be distributed in more than one sheet.
In addition, a single line diagram, which contains the most relevant information and gives an overview of the BESS, is recommended, especially in case of large systems.
The information listed below is also required. In general, it is expected that this information will be presented as annotations to the single line wiring diagram. In some circumstances, typically for larger systems where space on the diagram may be limited, this information may be presented in table form.

5.9.2.1 Enclosure – General specifications

The wiring diagram or system specification shall include the following enclosure design information.

a) BESS module types.
b) Total number of BESS modules.
c) Number of racks.
d) Number of BESS modules per rack.

The wiring diagram or system specification shall include the following electrical information (where fitted).

a) DC switch disconnector: Location and rating (voltage/current), manufacturer and model.
b) Enclosure overcurrent protective devices: Type, location, rating (voltage/current), manufacturer and model.
c) Other enclosure electronic protective circuitry (such as arc fault detection), if applicable: Type, location, rating, manufacturers and models.

5.9.2.2 AC system

The wiring diagram or system specification shall include the following AC system information.

a) AC isolator location: Type, rating, manufacturer and model.
b) AC overcurrent protective device: Location, type, rating, manufacturer and model.
c) Residual current (where fitted): Device location, type and rating.
d) Interface protection: Type, manufacturing and model
e) Interface switch (and backup switch if applicable): Location, type, rating, manufacturer and model.

5.9.2.3 Earthing and overvoltage protection

The wiring diagram or system specification shall include the following earthing and overvoltage protection information.

a) Details of any connections to an existing Lightning Protection System (LPS).
b) Details of any surge protection device installed (both on AC and DC lines) to include location, type and rating.

5.9.3 Datasheets

As a minimum, datasheets shall be provided for the following system components:

a) BESS datasheet for all types used in system.
b) Inverter datasheet for all types of inverters used in system.
c) Interface protection datasheet.

The provision of datasheets for other significant system components should also be considered.

5.9.4 Emergency systems

Documentation of any emergency systems associated with the BESS (fire alarms, smoke alarms, etc.). This information shall include both operation and design details.

5.10 Operation and Maintenance Manual

The Operation and Maintenance manual shall contain at least the basic information that can be used in order to operate and maintain the BESS in a safe and efficient manner. Here below the minimum content of the Operation and Maintenance Manual is reported.

5.10.1 Shutdown/isolation procedure

Shutdown and isolation procedures are designed to ensure safe working practices and must be strictly followed whenever systems are de-energized prior to servicing.
Shutdown and isolation is required when energized equipment is serviced or maintained, safety guards are removed or bypassed, a worker has to place any part of his or her body in the equipment's point of operation, or hazardous energy sources are present. The procedures shall include:

- A list and description, where necessary, of the steps to be done for system shutdown and isolation achievement
- Safe operation of electrical disconnects
- Labelling of the equipment switched off (where necessary)

Particular care to be taken to observe and follow warning labels reading "DO NOT DISCONNECT UNDER LOAD" or having the similar meaning located on module connections, combiner boxes, disconnects, and some inverter switches not designed as a load-break switch. Failure to heed these warning labels can lead to instrument malfunction, arcing, fires, and personnel injuries.

5.10.2 PPE and other safety equipment

Service personnel must know what kind of PPE is required for a specific task and wear it while completing the task. PPE includes fall protection, arc flash protection, fire-rated clothing, hot gloves, boots, and protective eyewear, among other items. PPE is designed to help minimize exposure to inherent system hazards. Identification of potential hazards is crucial to the process of selecting the appropriate PPE for the task at hand.

5.10.3 Spare parts management

Spare Parts Management is an inherent and substantial part of O&M, especially for BESS with a power capacity larger than 2MW. It should ensure that spare parts are available in a timely manner for corrective maintenance in order to minimize the downtime of (a part of) a BESS plant. As regards to spare part management, the following considerations have to be made:

- Ownership and responsibility of insurance
- Stocking level
- Location of storage (Proximity to the plant, Security, Environmental conditions)

5.10.4 Preventative maintenance activities

A provisional list of the preventative maintenance activities shall be produced. When required, it shall be integrated and refined later according to the specific needs of the BESS to be maintained.
The list shall contain a short description of the activities and their interval (months, years, etc.).
The list shall include at least the following subsystems:

- BESS Modules.

- BESS DC Components.
- PCS/inverters.
- AC section and wirings.

5.10.5 Warranty documentation

The warranty documentation shall concern at least BESS modules and inverters. It shall include starting date of warranty and period of warranty.

ANNEX C – DOCUMENTS REQUIRED WHEN APPLYING FOR INSPECTION

This Annex provides templates and information regarding some of the documents that Contractors usually submit when applying for the onsite inspection. However, SEC will review only certain documents that are the most relevant documents for SEC and this revision will take place according SEC internal checklist.

5.11 Declaration of Conformity

DECLARATION OF CONFORMITY

The Consultant/Contractor . . . . . .
Postal address . . . . . .
Telephone and e-mail . . . . . .
Reference person . . . . . .

Under his responsibility

DECLARES

That the BESS described hereinafter

Name of PROJECT			
Name of CONSUMER			
Type of installation	☐ Indoor ☐ Outdoor		
Address of the site			
Region/City/(nearest) District			
GIS - Latitude, Longitude	_____° N; _____° E		
BESS kW	kW		
BESS kWh	kWh		

– has been made in a workmanlike manner. – has been made according to the design approved by SEC and minor changes (if any) do not worsen the grid compatibility, the performances and the safety. Any minor changes are duly reported in an as-built design attached to the Declaration of Conformity. – All the materials, components and equipment used in the BESS have been chosen according to the design and to the laws and rules in force in KSA.
Date . . . . . Signature . . . . .

5.12 Specification of Major Equipment

BESS SPECIFICATION OF MAJOR EQUIPMENT			
Name of PROJECT			
Name of CONSUMER			
Name of CONSULTANT/CONTRACTOR			
Type of installation	☐ Indoor ☐ Outdoor		
Address of the site			
Region/City/(nearest) District			
GIS - Latitude, Longitude	_____° N; _____° E		
BESS kW	kW		
BESS kWh	kWh		
Equipment 1			
TYPE 1 (Number . . . . .)			
Manufacturer	Model		
Pn [W]	Filename*		
TYPE 2 (Number . . . . .)			

BESS SPECIFICATION OF MAJOR EQUIPMENT	
Manufacturer	Model . . . . .
Pn [W]	Filename* . . . . .
TYPE 3 (Number . . . . .)	
Manufacturer	Model . . . . .
Pn [W]	Filename* . . . . .
PCS/inverters	
TYPE 1 (Number . . . . .)	
Manufacturer	Model . . . . .
Maximum capacity @ AC [W]	Filename* . . . . .
TYPE 2 (Number . . . . .)	
Manufacturer	Model . . . . .
Maximum capacity @ AC [W]	Filename* . . . . .
TYPE 3 (Number . . . . .)	
Manufacturer	Model . . . . .
Maximum capacity @ AC [W]	Filename* . . . . .
TYPE 4 (Number . . . . .)	
Manufacturer	Model . . . . .
Maximum capacity @ AC [W]	Filename* . . . . .
TYPE 5 (Number . . . . .)	

BESS SPECIFICATION OF MAJOR EQUIPMENT	
Manufacturer	Model . . . . .
Maximum capacity @ AC [W]	Filename* . . . . .
Interface protection (when present)	
Manufacturer	Model . . . . .
* Filename where the serial numbers of equipment are recorded. The number of values shall be equal to the number specified for the given type of equipment. The format of the file is Text (TXT)	

5.13 Details of the Protection Arrangements and Settings

BESS DETAILS OF THE PROTECTION ARRANGEMENTS AND SETTINGS			
Name of PROJECT			
Name of CONSUMER			
Name of CONSULTANT/CONTRACTOR			
Type of installation	☐ Indoor ☐ Outdoor		
Address of the site			
Region/City/(nearest) District			
GIS - Latitude, Longitude	_____° N ; _____° E		
BESS kW	kW		
BESS kWh	kWh		
Main Switch			

BESS DETAILS OF THE PROTECTION ARRANGEMENTS AND SETTINGS	
Manufacturer	Model . . . . .
Operating voltage	Device* . . . . .
Rated current [A]	Icw . . . . .
Interface Switch	
Manufacturer	Model . . . . .
Operating voltage	Device* . . . . .
Rated current [A]	Icw . . . . .
BESS Unit Switch	
TYPE 1 (Number . . . . .)	
Manufacturer	Model . . . . .
Operating voltage	Device* . . . . .
Rated current [A]	Icw . . . . .
TYPE 2 (Number . . . . .)	
Manufacturer	Model . . . . .
Operating voltage	Device* . . . . .
Rated current [A]	Icw . . . . .
TYPE 3 (Number . . . . .)	
Manufacturer	Model . . . . .

BESS DETAILS OF THE PROTECTION ARRANGEMENTS AND SETTINGS	
Operating voltage	Device* . . . . .
Rated current [A]	Icw . . . . .
* Depending on the voltage we may have different devices. In MV e.g. Vacuum switch + TA. In LV e.g. Circuit-Breaker with magneto-thermic curve or Circuit-Breaker + Fuses. Contactors are allowed only for Interface Switch.	

5.14 Maintenance Program for the BESS

The Consultant/Contractor shall upload the proposed Maintenance Program for the BESS. This document is additional to the Operation and Maintenance information provided with the Final Design submitted for Design Evaluation and Approval.

5.15 Clearance and Readiness for Energisation

BESS CLEARANCE AND READINESS FOR ENERGISATION **The Contractor/Consultant . . . . . .** **Postal address . . . . . .** **Telephone and e-mail . . . . . .** **Reference person . . . . . .** **Under his responsibility** **DECLARES** **That the BESS described hereinafter**	
Name of PROJECT	

Name of CONSUMER			
Name of CONSULTANT/CONTRACTOR			
Type of installation	☐ Indoor ☐ Outdoor		
Address of the site			
Region/City/(nearest) District			
GIS - Latitude, Longitude	_____° N ; _____° E		
BESS Maximum Capacity @ AC	kW	kWh	

- The protection details are those indicated in the document DETAILS OF THE PROTECTION ARRANGEMENTS AND SETTINGS
- All the equipment and all associated apparatus related to the service connection are compliant with the applicable standards and in particular with document [7].
- The electric circuit is compliant with the applicable standards and in particular with document [7].

Date . . . . . Signature . . . . . .