BATTERY STORAGE SYSTEMS

Given the ongoing improvement in battery storage technology and the significant advantages of combining battery storage with renewable generation, it is proposed that each solar farm will have a battery energy storage system "BESS".

1. Battery Type

The BESS will be made up of Lithium-Ion batteries due to them being extremely safe with regard to any potential impact on the environment at the solar farm, easy to install and due to their technical characteristics, will work well as energy storage systems for improving solar farm generation, as well as supporting grid stability.

2. Physical Design of the BESS

The battery's smallest component is the "battery cell" which are similar to the batteries that we all use in our appliances. These cells have only a very small proportion of their mass made up electrolyte liquid adsorbed in solid components and are completely sealed in the factories where they are manufactured. No electrolytic liquids or other dangerous goods are thus handled on site. A number of cells are then combined together into "battery modules" in the factories. The modules are then combined into metal "battery racks" and the racks are installed in closed containers.

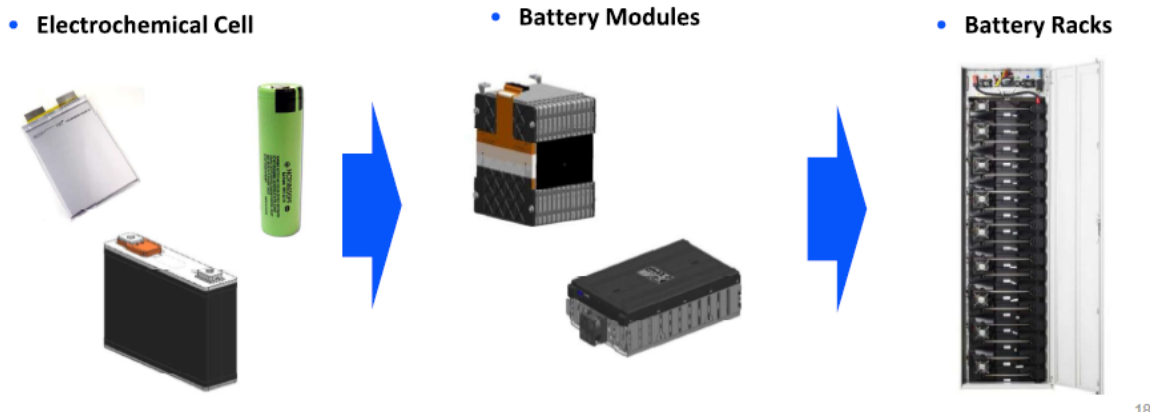

Figure 1: components of a battery rack

Each container will therefore contain many battery racks, a HVAC or air conditioning system, a fire detection and suppression system (that uses inert gas), battery management system and other electrical components required to manage the batteries. The containers are standard size containers of 12m long x2.5m wide x2.7m high. The addition of the HVAC systems may protrude outside the containers making them a bit longer or higher (but not higher than 4.5m and thus lower than the highest buildings in the substation). See image below that shows a typical layout of one of these containers. The HVAC system that each container has is composed of a number of air conditioning units and a ventilation system to provide both heating and cooling to maintain the internal conditions as per equipment requirements. The noise from the external equipment should not exceed about 50 dB which is well below the noise from a turbine.

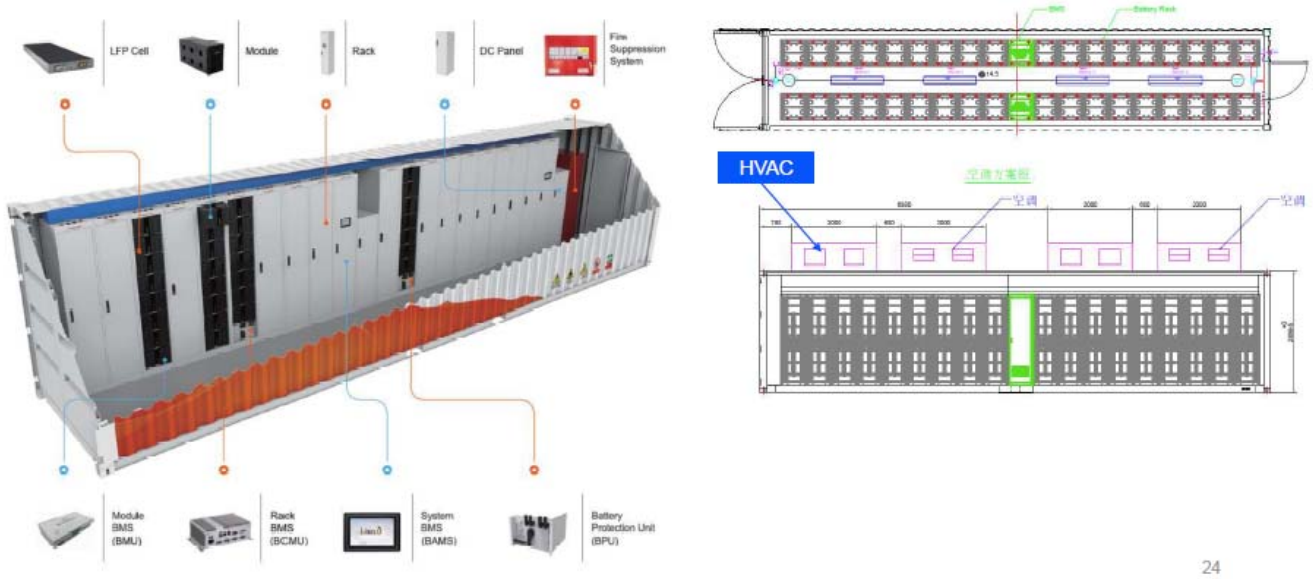

Figure 2: typical composition of a battery container

Alternative configurations proposed by suppliers foresee the use of smaller "blocks" providing the same functions of the containers or the installation of batteries inside buildings.

Figure 3: typical configuration of BESS installed inside containers and buildings

The BESS shall be able to store electrical energy and to charge and discharge electrical energy when connected to a Power Conversionnit (PCU), which performs the current conversion from LV DC to MV AC (and vice versa). The battery is commonly connected at AC MV level to the solar farm for HV conversion and grid interconnection.

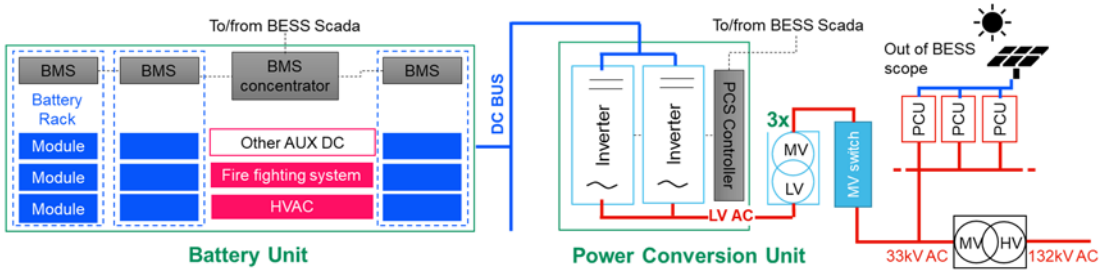

Figure 4: components of a BESS

3. Size, layout and position of the BESS

The BESS technology is modular and the layout is customized depending on the required application. The size of the BESS proposed at each solar farm will be no more than a 115 MWac system and be located in an area no bigger than 2 ha. This will be made up of multiple battery containers, with inverters and transformers spaced between them and 3-5 extra containers for electrical connections and controls. See image below giving an indicative layout of a BESS.

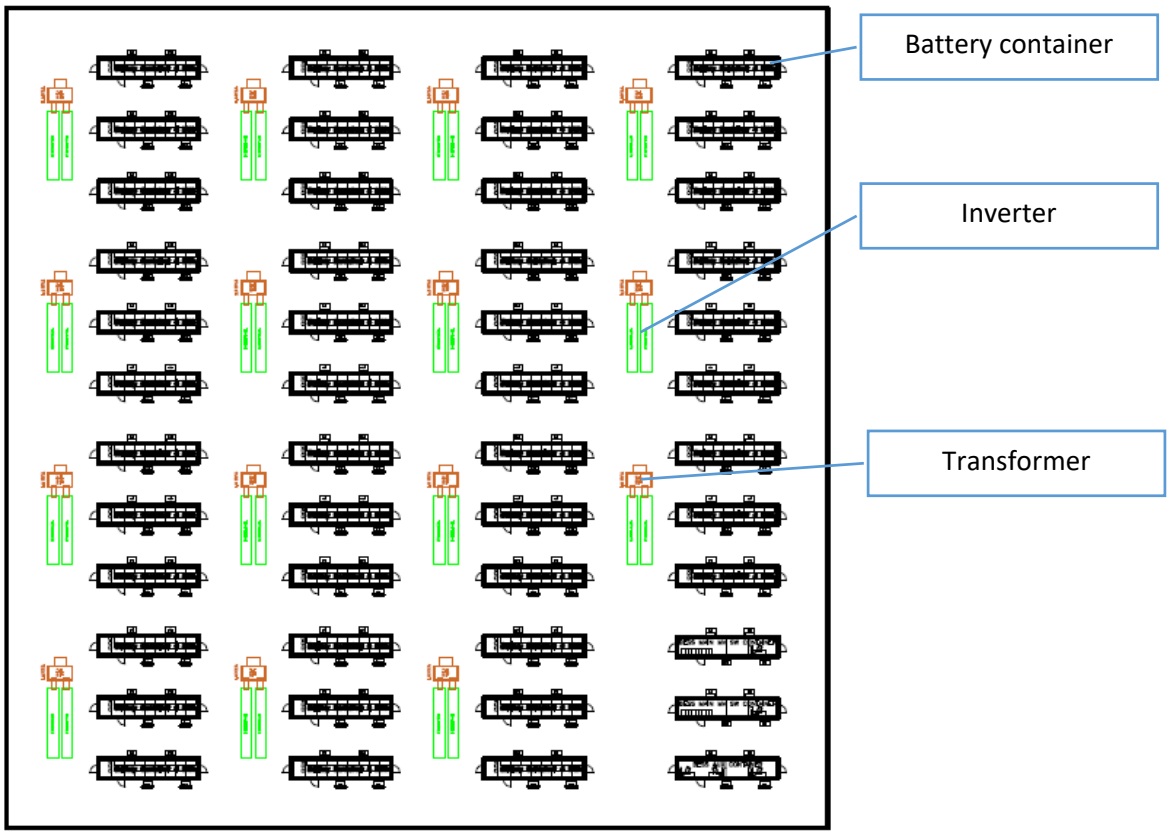

Figure 5: indicative layout of a BESS on a 1 Ha site

The BESS will be located in close proximity to the solar farm substation, will be linked to the substation via 33kV (or less) cables and will not have any additional office/ operation/ maintenance infrastructure as those of the substation and solar farm will be used for the battery facility as well. In effect, the battery facilities are extensions of the substation infrastructure and, as per the substation, will be contained within a security fence.

4. Compliance to local and international standards

The BESS will be compliant with all local laws and regulations and health and safety requirements governing battery facilities. Over and above that they will comply with international standards such as UN 38.3 (Transportation Testing for Lithium Batteries), UL 1642 (Standard for Safety – Lithium-ion Batteries) and IEC 62619 (Secondary cells and batteries containing alkaline or other non-acid electrolytes Safety requirements for secondary lithium cells and batteries, for use in industrial applications). Furthermore, the battery facility will

also comply with standards such as UL 1973 (Batteries for Use in Stationary Applications) and IEC 62619-2017 including thermal runaway non-propagation and safety zone region operation limits and a failure mode analysis. The design will be compliant with UL 9540 (Energy Storage Systems and Equipment): this standard defines the safety requirements for battery installation in industrial and grid connected applications.

5. Risks to the environment

The main risks to the environment on site is fire of the cells. The design of the BESS in compliance with all the local and international standards ensures that fire risk is minimal. Furthermore, each container has a built-in fire detection and suppression system. This system continually monitors the batteries and in an unlikely event of a fire it suppresses the fire using inert gas. Each container is also spaced about 3m apart ensuring the chance of a fire spreading between containers (which are made of metal and thus not easily flammable) is also minimal.

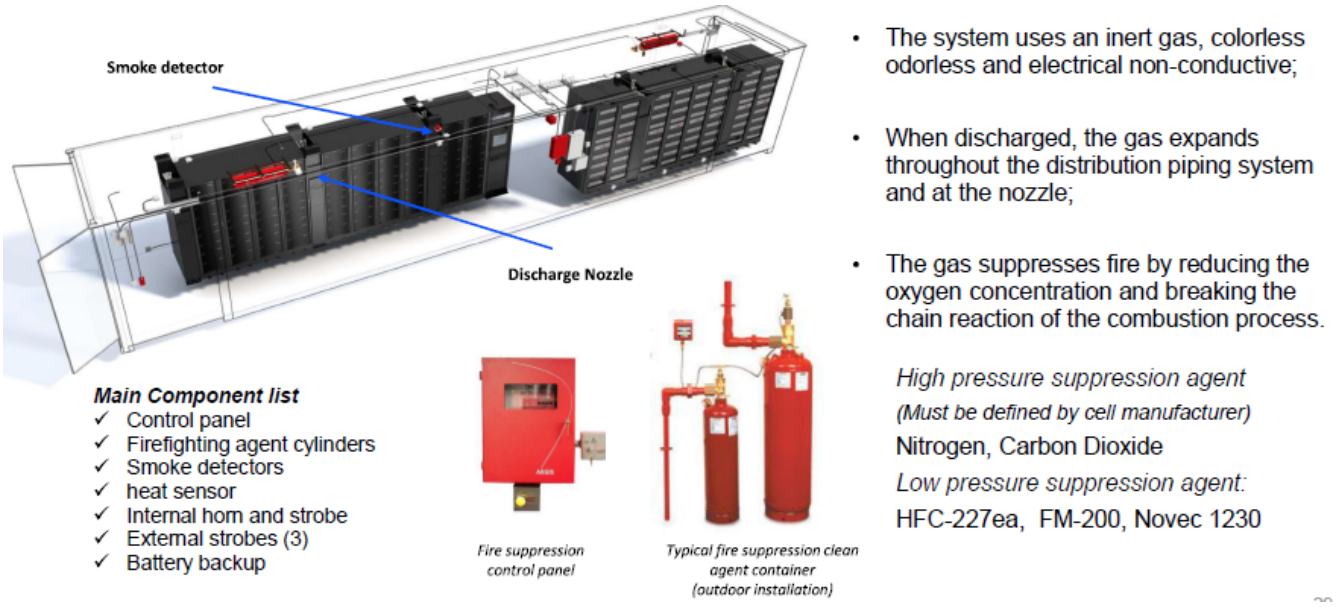

Figure 6: typical configuration of fire detection and suppression system