Scoping and Environmental Impact Assessment for the Proposed Development of the 240 MW Kaladokhwe Wind Energy Facility 3 near Nxuba (Cradock) in the Eastern Cape

DRAFT SCOPING REPORT

APPENDIX G: Additional Information

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G.1: TECHNICAL DEVELOPMENT REPORT ON BATTERY STORAGE SYSTEMS RELEVANT TO THE PROPOSED KALADOKHWE WEFS

ANNEXURE 1

Bulskop PV Cluster: Battery Storage

DESCRIPTION AND LAYOUT REQUIREMENTS

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ACCRONYMS AND ABBREVIATIONS

AC	Alternating Current
CAPEX	Capital Expenditure
DC	Direct Current
DEA	Department of Environmental Affairs
DoE	Department of Energy
EIA	Environmental Impact Assessment
EOL	End of Life
EPC	Engineering, Procurement and Construction
HVAC	Heating, Ventilating, and Air Conditioning
IPP	Independent Power Producer
IRP	Integrated Resource Plan
Li	Lithium
Li-ion	Lithium Ion
KW	Kilowatt
kWh	Kilowatt Hour
MW	Megawatt
MWh	Megawatt Hour
NaS	Sodium Sulphur
NERSA	National Energy Regulator of South Africa
O&M	Operations & Maintenance
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
PV	Photovoltaic(s)
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme

1 INTRODUCTION

South Africa has recognised the need to expand electricity generation capacity within the country. This is based on national policy and informed by ongoing planning undertaken by the Department of Energy (DoE) and the National Energy Regulator of South Africa (NERSA).

In recent years, recurring large-scale power cuts (i.e. load shedding) have highlighted the need to improve reliability and resilience of electricity supply.

The Integrated Resource Plan (IRP 2019) sets the direction for the energy sector, with a shift away from coal, increased adoption of renewables and gas, and an end to the expansion of nuclear power. The IRP calls for some 6 000MW of new solar PV capacity and 14 400MW of new wind power capacity to be commissioned by 2030, as current coal generation capacity will be reduced (by over 80%) by 2050.

One of the main challenges faced by Eskom is managing and balancing electricity demand and supply. While renewable sources can now achieve lower costs than fossil fuels, photovoltaic (PV) arrays and wind turbines both have variable electricity production, since they rely on energy inputs that cannot be controlled (i.e. sunshine and wind). For this reason, fossil fuels currently still have a key role in the energy sector as they can provide electricity on demand and when consumption reaches its peak.

However, cost reductions of energy storage technologies and the wider deployment of battery (particularly lithium-ion) installations globally, have now stimulated interest in combining renewable energy generation with energy storage to provide dispatchable energy (i.e. energy on demand) and reliable capacity.

For example, the production peak of PV facilities occurs around noon, whereas electricity demand normally peaks for about two hours in the morning and two hours in the evening (i.e. when the population is at home and using electrical appliances). By incorporating energy storage technologies into renewable energy facilities, the supply of electricity can be controlled by absorbing/storing during generation peaks and supplying power during demand peaks.

2 UNDERSTANDING THE SOUTH AFRICAN LEGISLATION

In March 2020, the Department of Environmental Affairs (DEA) clarified the applicability of listed activities, under the EIA regulations (as amended), which relate to the development and operation of facilities or infrastructure, for the storage, or storage and handling of a dangerous good, where such storage occurs in containers in volumes that may meet or exceed the thresholds specified under the Listing Notices 1, 2 & 3.

As per the DEA's response, installations, facilities or infrastructure related to the development and operation (or expansion and operation) of battery energy storage will not trigger any of these listed activities. Batteries are not regarded as facilities or infrastructure for the storage or storage and handling of a dangerous good, considering that its inherent purpose or objective is not to store, or store and handle a dangerous good. Furthermore, a battery is not deemed to be a "container".

Although a battery will not trigger these listed activities, the following should be noted:

- There may be instances where the battery is not fully assembled and the electrolyte (or substance making up the electrolyte) intended for the battery, may be stored in a container on site prior to filling. In these instances, these activities would be applicable as the purpose would be the storage of that substance (if indeed a dangerous good), and not the storage of energy.

- Battery storage facilities have the potential to trigger other listed or specified activities. It is therefore important to consider all other listed and/ or specified activities in the context of the development and relevant scenario. All listed or specified activities that will be triggered by the development must be identified, described and assessed in the EIA.

In the case of this application, while other listed activities are triggered, no electrolyte nor dangerous good will be stored in a container on site in volumes that may meet or exceed the thresholds specified in EIA regulations. Therefore, activities relating to the storage and handling of a dangerous good, where such storage occurs in containers, will not be triggered.

3 OVERVIEW OF THE ENERGY STORAGE FACILITY

3.1 TECHNOLOGY

Unlike conventional energy storage facilities, such as pumped hydro, battery storage has the advantage of being flexible in terms of site location and sizing. Therefore, they can be incorporated into, and placed in close proximity, to a wind or solar facility. They also have the advantage of being easily scaled and designed to meet specific demands.

As technological advances within battery energy storage systems (BESS) are frequent, two BESS technology alternatives are considered: Solid state battery electrolytes and Redox-flow technology.

Solid state battery electrolytes, such as lithium-ion (Li-ion), zinc hybrid cathode, sodium ion, flow (e.g. zinc iron or zinc bromine), sodium sulphur (NaS), zinc air and lead acid batteries, can be used for grid applications. Compared to other battery options, Li-ion batteries are highly efficient, have a high energy density and are lightweight. As a result of the declining costs, Li-ion technology now accounts for more than 90% of battery storage additions globally (IRENA, 2019).

Flow batteries use solid electrodes and liquid electrolytes. The most used flow battery is the Vanadium Redox Flow Battery (VRFB), which is a type of rechargeable flow battery that employs vanadium ions in different oxidative states to store chemical potential energy.

Considering the nature of the project, only a solid-state technology type would be envisaged for implementation. The technology includes batteries housed within containers which are fully enclosed and self-contained. Therefore, the assessment proposes all solid-state technologies for authorisation to allow the precise technology to be selected when the project is implemented, on the understanding that further investigation into the specific technologies available at the time of being awarded preferred bidder status will allow for one of two to be selected and ultimately developed.

Figure 1: Tesla's Megapack Li-ion Battery (Modular System).

3.2 SIZE OF THE BATTERY

Our design aims to provide two hours of stored energy during the morning and evening demand peaks (i.e. four hours of stored energy per day). The size of the battery will depend on the net output (MWAC) of the facility. For example, assuming a 100 MWAC PV plant grid limitation, we could export 400 MWh (100MWAC x 4 hours) per day. Hence a 400 MWh battery would be required.

The table below provides the battery sizes required, based on net output of the facility, to supply four hours of stored energy per day.

Table 1: Battery Sizes.

Facility net output	Battery Size
75 MW_{AC}	300 MWh
100 MW_{AC}	400 MWh
140 MW_{AC}	560 MWh
200 MW_{AC}	800 MWh

3.3 LOCATION AND SIZE OF THE BATTERY STORAGE AREA

The battery storage facility will be constructed preferably adjacent to the on-site substation.

The size of the battery storage area required will depend on the specific manufacturer. Based on our research, the area required typically ranges from $12kWh/m^2$ to approximately $120kWh/m^2$. These calculations include all additional support equipment and any necessary clearances between Battery Modules/Containers.

It is customary to develop the final detailed design of the facility only once an Independent Power Producer (IPP) is awarded a successful bid under the Renewable Energy Independent Power

Producer Procurement Programe (REIPPPP), after which major contracts are negotiated and final equipment suppliers identified. Therefore, at this stage the exact supplier/manufacturer has not yet been identified. However, for the purpose of the EIA in accordance with the minimum requirements prescribed by the Department of Environmental Affairs (DEA), we would adopt the conservative approach and apply for and assess an allowance of 12kWh/m^2.

The table below provides the battery storage areas required, based on the most conservative requirement of 12kWh/m^2.

Table 2: Battery Storage Area.

Battery Size	Battery Storage Area (Maximum)
300 MWh	2.5 ha
400 MWh	3.33 ha
560 MWh	4.66 ha
800 MWh	6.66 ha

The figure below illustrates the 100 MW/129 MWh Li-ion battery storage facility at Hornsdale wind farm in Australia. The total battery storage area is less the 1 hectare.

Figure 2: The 100 MW/129 MWh Li-ion battery coupled with the Hornsdale wind farm in Australia.

3.4 GENERAL COMPONENTS

The exact design will depend on the manufacturer and technology chosen, however traditional utility-scale Li-ion battery storage facilities include the following main components:

1. Battery cells → modules → packs → racking system (DC).
2. Storage container (HVAC system, thermal management, monitors and controls, fire

suppression, switchgear, and energy management system).

3. Power conversion system (bidirectional inverter to convert AC to DC for battery charging and DC to AC for discharging).

4. Transformer (to step up 480-V inverter output to 12–66 kV).

Figure 3 illustrates the components that generally make up the primary battery system, Figure 4 is a typical flow diagram of a PV plant with battery storage and Figure 5 is a conceptual example of a typical battery storage facility.

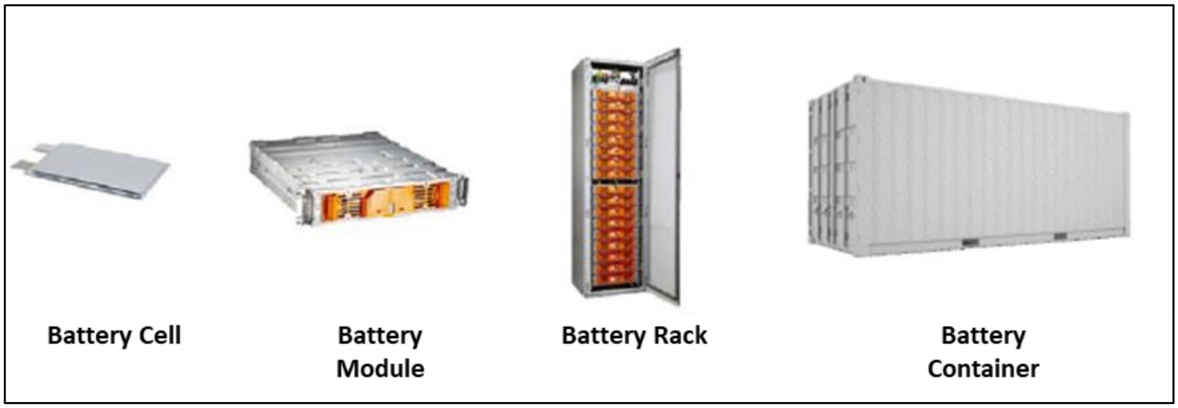

Figure 3: Typical Battery System Components.

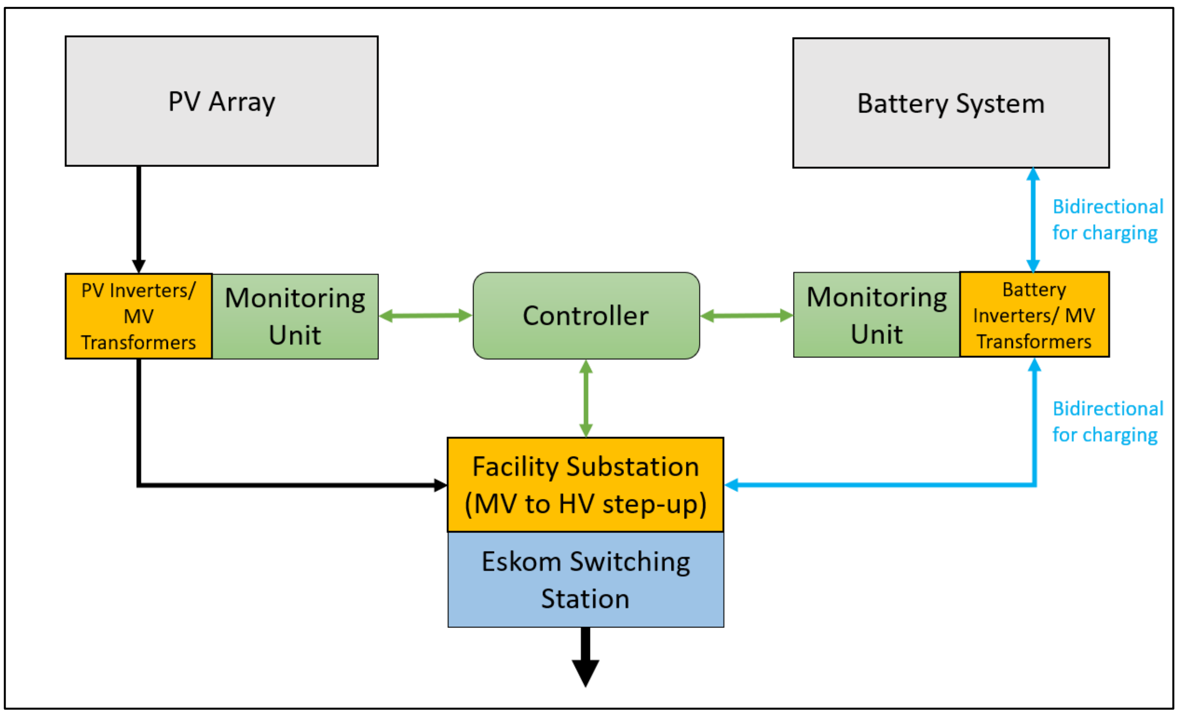

Figure 4: Typical flow diagram of PV plant with battery storage

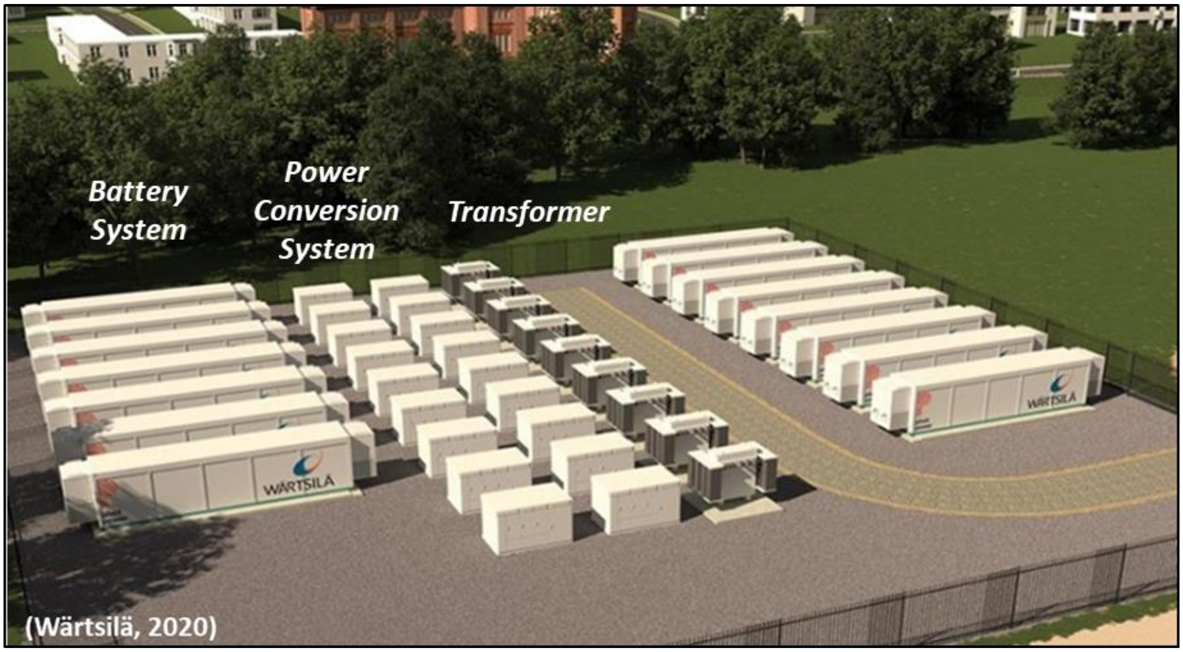

Figure 5: Pivot Power's proposed 50MW lithium-ion battery in Kemsley, Kent.

In the case of Tesla's new Megapack Modular System (Figure 6), each Megapack arrives from the factory fully-assembled and pre-tested in one containerised/modular enclosure—including battery modules, bi-directional inverters, a thermal management system, an AC main breaker and controls.

No assembly is required on site which significantly reduces complexity and ensures an easy installation and connection process. These compact modules also increase the energy density of the battery, reducing the amount of space required (Tesla, 2020). Figure 6 C) is a conceptual design of a 160 Tesla Megapack battery storage facility. By way of comparison, a 400 MWh storage facility (see Table 2 above) would require in the order of 192 Megapacks.

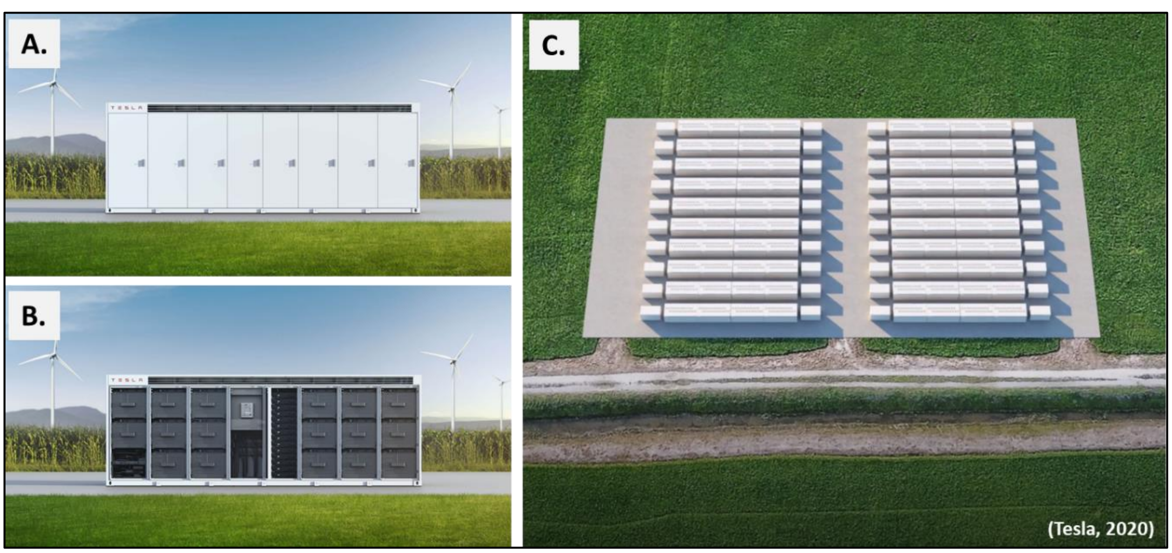

Figure 6: A & B) Single Megapack. C) Conceptual design of Megapack battery storage facility containing 160 Megapacks.

3.1.1 Battery module/container dimensions

Based on our research each manufacturer has slightly different individual battery container/module dimensions, however they all typically fall within the following ranges:

- Length: 6m – 12m
- Width: 1.5m – 2.5m
- Height: maximum of 3m

3.1.2 Foundation

It is likely that the batteries will require a solid foundation/ plinths, such as a concrete pad, grade beams or a structural steel deck. These will need to be strong enough to support the equipment and large enough to account for any necessary equipment clearances.

The final foundation design will be undertaken by a relevant qualified civil or structural engineer. The design will be in accordance with local building standards.

3.1.3 Perimeter Fence

A perimeter fence of approximately 2.1m high will be installed around the battery facility. Only authorised persons will be allowed to enter the battery storage facility.

4 INSTALLATION

4.1 SEQUENCE

The installation process typically includes the following activities:

1. Site clearing;
2. Site preparation (laying foundations etc.);
3. Delivery (transported to site on a flatbed trailer);
4. Unloading (with the use of cranes and the necessary rigging equipment);
5. Anchoring Containers/ Modules;
6. Wire and cable connections;
7. Commissioning and miscellaneous fine tuning; and
8. Electrical inspection and testing.

It is important to note that this is an iterative process, as can be seen in Figure 7.

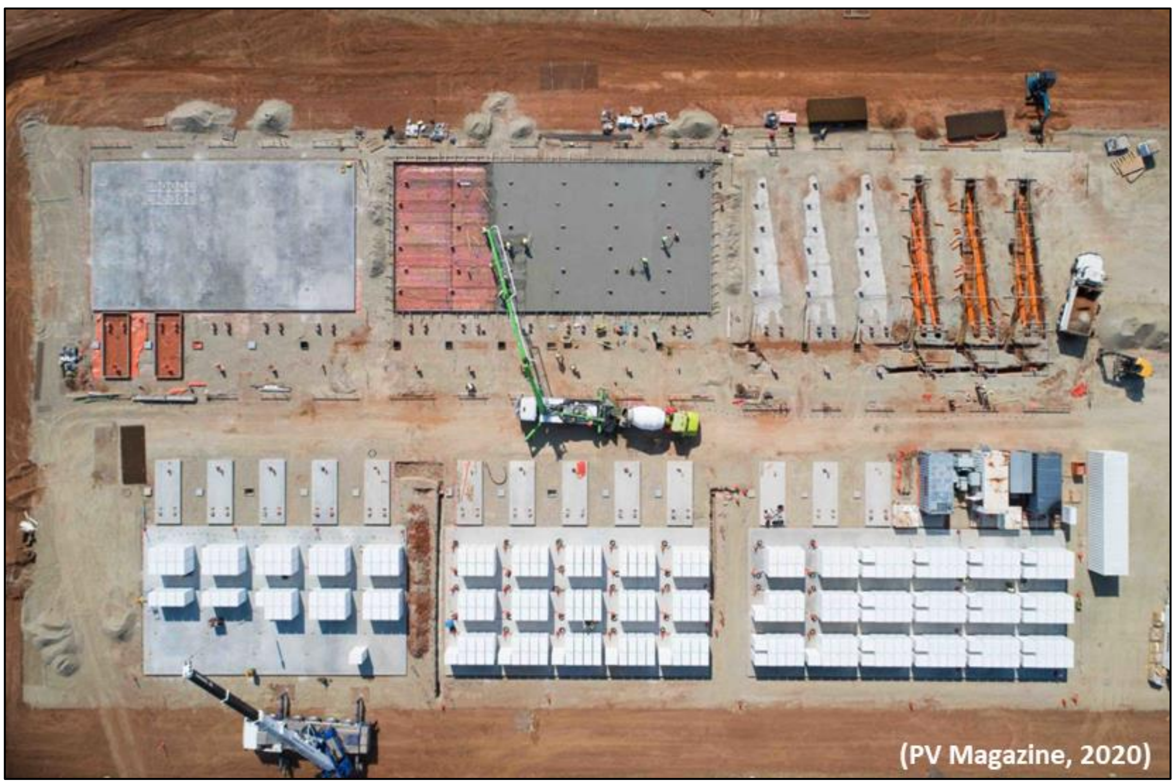

Figure 7: Installation of the 100 MW/129 MWh Li-ion battery at the Hornsdale wind farm.

4.2 INDICATIVE COSTS

The indicative cost of a battery storage system is expected to range between ZAR 5,680 and ZAR 9,480 per kWh, inclusive of the battery modules/ containers, inverters, controllers, battery management system, cabling, delivery, warranties and commissioning supervision. For a 300 to 400 MWh storage facility, this equates to a range of between ZAR 1.7 billion and ZAR 3.8 billion capital expenditure (CAPEX), over and above the cost of the conventional solar PV facility.

The indicative installation cost of a battery storage system is expected to range between ZAR 840 and ZAR 2,520 per kWh. For a 300 to 400 MWh storage facility, this equates to a range of between ZAR 252 million and ZAR 1 billion for the installation, over and above the cost of the conventional solar PV facility and cost of the battery storage system.

The indicative operating expenditure (OPEX) of the battery storage system is expected to range between 2 and 3% of CAPEX per annum, therefore between ZAR 34 million and ZAR 114 million per annum for a 300 to 400 MWh system.

4.3 INDICATIVE EMPLOYMENT FIGURES

It is estimated that the construction of the battery storage system will require a maximum of 50 personnel including the proprietary equipment supplier's installation and supervisory team. This is over and above the total Engineering, Procurement and Construction (EPC) workforce required to construct the solar PV facility. Furthermore, it is expected that a maximum of 5 personnel will be required to operate and maintain the battery storage system, over and above the Operations & Maintenance (O&M) workforce required for the solar PV facility.

5 MAINTENANCE

Any maintenance, service or repairs required to be carried out on the proprietary battery storage equipment will be conducted by the supplier's personal or their authorised agent. This includes any preventative maintenance that is identified to be carried out on the plant.

Any necessary maintenance equipment and spares will be kept in the renewable energy facility general maintenance building and/or storage area. No hazardous or dangerous goods will be stored in a container on site in volumes that may meet or exceed the thresholds specified in EIA regulations.

It should be noted that it is highly unlikely that battery modules will be stored on site for strategic spares purposes. Most Lithium Battery Technologies have a recommended depth of discharge of 80%, meaning that the life of the battery will significantly increase if the depth of each discharge is limited to 80% of the rated capacity. It is therefore detrimental for battery cells to be stored for long periods on site, as they may discharge below their recommended limit (potentially down to 100% depth of discharge) and potentially become unusable. It is therefore very likely that battery modules will be shipped to site on a needs-be basis during operation of the plant.

6 DECOMMISSIONING AND DISPOSAL PROCEDURES

Solid state battery products contain several recyclable materials (e.g. nickel, cobalt, copper, aluminium, steel, and lithium), and the majority of proprietary suppliers advocate recycling of their products. When a battery module reaches its end of life (EOL) or needs to be replaced for a specific technical reason, it will be returned to the supplier's facility for disassembly and further processing.

Decommissioning and disposal of batteries will always be in accordance with South African Regulations. In some cases, batteries will be disposed of without returning to the supplier. In this instance, local recycling processors may be used adhering to appropriate methods for disposal and recycling, and where required, under surveillance from the original equipment manufacturer (OEM).

It must be noted that the specific solid state battery products under consideration will not contain heavy metals such as lead, cadmium, or mercury, which therefore facilitates the safe use and disposal of these technologies.

Our research shows that the majority of OEMs operate a formal battery recycling plan as they strive to retrieve all batteries out in the field that have reached EOL for purposes of recycling. These plans are constantly evolving as OEMs work to further improve their methods of recycling their products.

7 SAFETY AND ENVIRONMENT

7.1 GENERAL CARE DURING CONSTRUCTION AND OPERATION

Batteries are energy storage devices, whether single cell batteries or a collection of battery packs which assembled with other systems, make up a high-capacity containerised battery solution. As with most battery products, care should be taken not to short circuit, puncture, crush, immerse, force discharge or expose to temperatures outside of the recommended safe operating temperature range of the specific technology type. Standard measures will need to be implemented to ensure the safe installation and operation of battery modules, as well as to prevent unauthorised entry into the battery storage area during construction and operation.

7.2 HIGH VOLTAGE HAZARD RISKS

A battery storage system poses standard high voltage hazard risks that need to be managed during construction and operation. A significant high voltage and electrocution risk will exist if the various equipment enclosures and/or safety circuits are compromised or damaged. A battery pack contains a substantial electrical charge and can lead to injury or death if mishandled. If a component in the battery module has been significantly visibly damaged or its enclosure compromised, then it is recommended to follow appropriate high-voltage preventative measures until the danger has been assessed by a suitably qualified person.

7.3 OPERATING TEMPERATURE RANGES

The various solid state battery technologies are designed to operate within recommended safe operating temperature ranges. The final supplier selection will therefore need to consider site climatic conditions to ensure the health of the unit. Prolonged exposure to temperatures outside of the safe operating range can drive battery cells into thermal runaway and result in a fire.

7.4 THERMAL MANAGEMENT SYSTEMS

Solid state battery technologies include sealed thermal management systems which contain coolants and/or refrigerants. Mechanical damage of the sealed thermal management system may result in leakage of the coolant. Considering that the battery modules are containerised solutions, it is highly probable that any spillage will occur only within the confines of the enclosure, and therefore pose a negligible risk of contamination to the environment.

7.5 RISK OF ELECTROLYTE LEAKAGE

There is a very low risk associated with leaked electrolyte from battery cells. This may vary depending on the specific solid state battery technologies. In the case of a Li-ion cell, the electrolyte is largely absorbed in the electrodes within individual sealed cells. There is therefore little free liquid electrolyte, and hence a negligible risk of spillage. Should this occur, it would be within the confines of the enclosure. It is assumed that this would be the case for most Lithium Battery Technologies.

8 CONCLUSION

Renewable energy can currently achieve lower costs than fossil fuels. By incorporating energy storage technologies into renewable energy facilities, electricity can be stored during generation peaks and supplied during demand peaks.

Lower costs coupled with improved efficiencies, high energy density, lightweight design and low environmental risks, make solid state batteries the preferred alternative.

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