TECHNICAL DESCRIPTION OF AMDA MIKE (PTY) LTD & AMDA NOVEMBER (PTY) LTD BATTERY ENERGY STORAGE SYSTEM

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1.1 Battery Energy Storage System

The applicant is requesting the inclusion of a Battery Energy Storage System (BESS) as part of the 2Ha substation block within the Roan 1and Roan 2 PV Development.

1.1.1 Overview of the BESS

The BESS would be designed and used to store electricity generated by the Roan 1 and Roan 2PV project during high electricity generation periods. When there are constraints on electricity generation by the PV project, the stored electricity is used as security to provide energy on demand at a reliable capacity to the national grid. The BESS can also be used to supply electricity to the national grid when there is a greater demand for rapid electricity distribution. Load shedding in South Africa could eventually be something of the past with the BESS's. The BESS can supply the electricity required to power parts of South Africa. In using the BESS, people would not need to source other means of generating heat or light during load shedding. The use of diesel, gas, and / or coal etc. is commonly used during load shedding which causes harm to the environment.

The BESS is designed to be housed in containers on land previously assessed and is proposed to be built within the authorised substation area. As the BESS will be located within close proximity to the substation, lengthy transmission cables are not required. The length of the route of the proposed cable connecting the BESS to the PV on-site substation will be approximately 200 m. The BESS will be connected via underground cabling to the substation, if not technically feasible to only use underground cabling, overhead cabling will be used as an alternative.

1.1.2 Technical Details of the BESS

The specifications for the BESS are listed in Table 2.6 below.

Table 2.6: Proposed Technical Details of the BESS

Type of Battery	BESS comprising Lithium-Ion Battery (with Redox Flow and Lead Acid listed as alternative battery technology)
Life span of BESS	Same duration as the Roan 1 PV and Roan 2 PV facility ~ 20 years
Client	AMDA Mike (Pty) Ltd AMDA November (Pty) Ltd
Footprint	Approximately 1 hectare
Connection to Development	Underground cabling is the preferred alternative for connecting the WEF on-site substation to the BESS. If not feasible to connect underground, overhead will be used as an alternative. The length of the route is proposed to be approximately 200 m.
Height of BESS	For the fence: 2.4 m For the containers: 2.9 m – 3.0 m
Other infrastructure	40' Tank Container (TC40) for O&M-control room and TC20 or TC40 for the delivery cabin to be connected to the Substation.

Plate 2.1 provides a visual representation of a typical set up of an on-site substation and BESS. The Roan 1 and 2 PV (if approved) will have similar project components with specifications as provided in this report.

Plate 2.1: SolarCity's Tesla Battery Storage Facility, Hawaii. [Source: https://www.pv-tech.org/news/solarcity-picks-tesla-for-52mwh-of-dispatchable-solar-plus-storage-in-hawai]

1.1.3 Benefits of the BESS for the Roan 1 & 2 PV

Unlike conventional energy storage facilities, such as pumped hydro, a BESS has the advantage of being flexible in terms of site location and sizing. As the BESS for the Roan 1 and Roan 2 PV development is proposed to be built next to the authorised substation, it will avoid any visual effects. It offers a wide range of advantages to South Africa including renewable energy time shift, renewable capacity firming, electricity supply reliability and quality improvement, voltage regulation, electricity reserve capacity improvement, transmission congestion relief, load following and time of use. The BESS will have the ability to reduce the impact caused by the variability and limited predictability of wind generation and national grid instability. In essence, this technology allows renewable energy to enter the base load and peak power generation market and therefore can compete directly with fossil fuel sources of power generation and offer a truly sustainable electricity supply option.

Renewable energy stored by the development in the BESS will allow for an increased amount of energy to be supplied to the national grid. At times of shortage supplies from the WEF, rapid release of electricity can be supplied to the national grid without any emissions to the air, and may in future reduce the need for new distribution substations to be constructed.

1.1.4 BESS Components

All permanent elements of the BESS will be located within a secure perimeter fence with an area of 100 m by 100 m (1 ha) within the authorised substation area. The BESS will consist of a battery array which will be housed in containers comprising of Lithium-ion. Compared to other battery options, Lithium-ion batteries are highly efficient, have a high energy density and are lightweight. As a result of declining costs, Lithium-ion technology now accounts for more than 90% of battery storage additions globally[1]. Redox Flow and Lead Acid are the proposed alternatives.

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[1] https://www.irena.org/publications/2019/Jul/Renewable-energy-statistics-2019

1.1.4.1 Layout and Positioning

The layout of the BESS considered the specific onsite constraints and area of vegetation to be cleared. The land which the BESS will be located on is confined to non-irrigated agricultural land, which is used less intensively. The BESS is proposed to be built next to the authorised substation, within the authorised footprint. The BESS will not have any additional effect on the agricultural land over-and-above what was previously assessed by all specialists. The BESS will be housed in containers which will be secure and designed to protect the contents of the elements. They are purpose built and designed.

1.1.5 BESS in South Africa

The BESS is relatively new and will become an integral support to the development of renewable energy technologies in South Africa. The development of a BESS associated with a PV system will promote added socio-economic benefits. The construction and installation of the BESS will create employment opportunities and it will be encouraged that the developer sources local manufacturers and employees, with the support of a skilled worker. For the operational phase of the BESS, software is expected to play an essential role as decentralised and digitised systems will be used.

As construction of a BESS being listed with a renewable energy development in South Africa is still not a common practice, the effect of this is that there is a major skills gap in our country regarding the BESS. It is important to ensure that the AMDA Mike, AMDA November undertakes skills development to ensure that the processes, from installation, to use and disposal, will be effective and cause minimal environmental impact.

1.1.6 Risk Assessment of the BESS

The risks associated with the BESS are well researched and documented in other parts of the world. With the correct management plans and protocols in place, the BESS will not pose major risks to the environment in South Africa.

Construction Phase

It is proposed that the BESS will be delivered to the development site in containers ready for connection to the WEFs electrical connection.

Operation Phase

There are two main concerns related to a BESS once operational, these are fire hazards and the potential for a condition known as '*thermal runaway*'[2].

Replacement / Decommissioning Phase

If batteries are replaced and / or once decommissioned, the disposal of the BESS may pose a risk to the environment.

The risk assessment mitigation measures provided below can be incorporated into a Battery Safety Management Plan and has also been included in the EMPr (Appendix B). This risk assessment has been prepared to ensure that safety risks related to the BESS are understood, accounted for and mitigated as far as practicable.

The following international guidance has been considered during the preparation of this Risk Assessment:

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[2] Thermal runaway is a situation where the current flowing through the battery causes the temperature to rise, which increases the current with a further rise in temperature.

- Allianz Risk Consulting (ARC), Tech Talk Volume 26 (2019). Battery Energy Storage Systems (BESS) using Li-ion batteries[3];
- National Fire Protection Association (NFPA) 855, Standard for the Installation of Stationary Energy Storage Systems, (2020 edition currently under development and not yet available)[4;]
- UL 9540, Standard for Energy Storage Systems and Equipment[5];
- Consolidated Edison and New York State Energy Research and Development Authority - Considerations for ESS Fire Safety (February 2017)[6.]
- The Energy Operators Forum "Good Practice Guide" (December 2014)[7];
- Institute of Engineering and Technology - Code of Practice for Electrical Energy Storage Systems (August 2017)[8]; and
- The Energy Institute: Battery Storage Guidance Note 1 - Battery Storage Planning (August 2019)[9].

The above standards and legislations are not specifically applicable to the proposed BESS for on this project, but notwithstanding, has provided valuable guidance for the preparation of this risk assessment.

The High-Level BESS Risk Assessment Matrix below (Table 2.7) assesses several potential situations which could result in a possible detrimental environmental hazard, which are:

1. The actual **risks** associated with the delivery, connection, operation, maintenance, disconnection and disposal of the batteries.
2. The **likelihood** of these actual risks occurring.
3. The **significance** of the impacts should these risks take place.
4. Appropriate and practical **mitigation** measures and/or management actions to reduce likelihood of the risk occurring and/or the impact.

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[3] https://www.agcs.allianz.com/news-and-insights/risk-advisory/tech-talk-volume-26-bess-english.html

[4] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855

[5] https://standardscatalog.ul.com/standards/en/standard_9540_1

[6] https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Energy-Storage/20170118-ConEd-NYSERDA-Battery-Testing-Report.pdf

[7] https://www.eatechnology.com/engineering-projects/electrical-energy-storage/

[8] https://shop.theiet.org/code-of-practice-for-electrical-energy-storage-systems

[9] https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fpublishing.energyinst.org%2Ftopics%2Fpower-generation%2Fbattery-storage%2Fbattery-storage-guidance-note-1-battery-storage-planning&data=01%7C01%7C%7Cfbce9f4783304951211308d72af01893%7C6b5953be6b1d4980b26b56ed8b0bf3dc%7C0&sdata=%2FgEjqDC2nzzxcKTWFaKkUEiiTiiOzTamrAsxsMz9Y4M%3D&reserved=0

Table 2.7: High-Level BESS Risk Assessment

Possible Risk	Resultant Impact Significance	Likelihood of occurrence	Management / Mitigation
Spillages **Thermal Runaway** **Poor Maintenance**	- Electrocution - Potential spillage of electrolytes or refrigerant - Vented gasses - Staff and personal injury - Contaminated Runoff - Soil and microbe contamination - Groundwater seepage - Downstream effects on the current terrestrial ecosystem.	**Low**	Over and above the Management actions already included in the EMPr: - Training of all staff and employees on how to handle spillages, fires and electrocutions; - Keeping records for well managed operations and maintenance; - Bunding of containers; - Installation of leak detection monitoring systems, where possible; - Implementation of spill handling and management in line with the EMPr; - Provision of spill kits on site for clean-up of spills and leaks; - Immediate clean-up of spills and disposal of contaminated absorbents and materials or soil at a licensed hazardous waste disposal facility; - Demarcate all no-go and sensitive areas; - Avoid the placement of batteries near watercourses and sensitive features; - All storm water runoff must be controlled to ensure that on-site activities do not culminate in possible off-site pollution; - Material Safety Data Sheet (MSDS) Records to be kept, as well as incidents reporting register; - Recording and reporting of all significant fuel, oil, hydraulic fluid or electrolyte spills or leaks so that appropriate clean-up measures can be implemented. A copy of these records must be made available to authorities (including Western Cape Directorate: Pollution and Chemicals Management) on request throughout the project lifecycle - Source batteries from reputable suppliers; - Battery inspection prior to installation; - Maintenance of the BESS; - Appropriate battery design and venting control; - Source from reputable manufacturers; - Lithium-ion batteries must have battery management systems (containment, automatic alarms and shut-off systems) to monitor and protect cells from overcharging or

Possible Risk	Resultant Impact Significance	Likelihood of occurrence	Management / Mitigation
			damaging conditions, such as temperature extremes; - Safe and appropriate storage in line with the above and the EMPr; - Frequent and appropriate disposal of both general and hazardous waste to prevent pollution of soil and groundwater; - On-site battery maintenance should only be undertaken on impermeable surfaces with secondary containment measures. Any resulting hazardous substances must be disposed of appropriately; - Safe handling which must include battery inspection prior to installation; - Development and implementation of an Emergency Response Plan in the event of a spill or leakage; - Provision of suitable emergency and safety signage on site, and demarcation of any areas which may pose a safety risk (including hazardous substances). Emergency numbers for the local police, fire department, Eskom and Matzikama Municipality must be placed in a prominent clearly visible area on the site; - Development and implementation of Thermal Management Plan prior to installation/construction; and - The Department of Forestry, Fisheries and the Environment and the Western Cape Directorate: Pollution and Chemicals Management are to be duly notified immediately of any incident in terms of section 30 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) ("NEMA").
Fire Risk	- On-Site Fire - Fire Spread - Staff and personal injury	**Medium**	- Procuring components and using construction techniques which comply with all relevant legislation; - Including automatic fire detection systems in the development design; - Including automatic fire suppression systems in the development design; - Including redundancy in the design of the BESS to provide multiple layers of protection; - Designing the BESS and substation yard to contain and restrict the spread of fire through the use of fire-resistant materials, and adequate

Possible Risk	Resultant Impact Significance	Likelihood of occurrence	Management / Mitigation
			separation between elements of the BESS; - Ensuring that Staff appointed to work within the BESS and substation area, as well as First Responders receive adequate emergency response training to a fire; and - Work with first responders and relevant personally to develop a Tactical Fire Response Plan in case of an incident.
Inappropriate Storage	- On site fires. - Electrical failure - Electrocution - Potential spillage of electrolytes or refrigerant - Vented gasses - Staff and personal injury - Contaminated Runoff - Soil and microbe contamination - Groundwater seepage - Downstream effects on the current terrestrial ecosystem.	**Low**	Over and above the Management actions already included in the EMPr: - Training of all staff and employees on how to handle spillages, fires and electrocutions; - Keeping records for well managed operations and maintenance; - Bunding of containers; - Implementation of spill handling and management in line with the EMPr; - Demarcate all no-go and sensitive areas; - Avoid the placement of batteries near watercourses and sensitive features; - Material Safety Data Sheet (MSDS) Records to be kept, as well as incidents reporting register; - Source batteries from reputable suppliers; and - Battery inspection prior to installation.
Limited Employee Training and Experience	- Time lag for first respondent - Inability to contain spillage - Fire - Electrocution - Damage to exiting/surrounding infrastructure	**Low**	- During the construction phase of the Development, first responders from the nearest major town (such as fire fighters and paramedics) must be given appropriate training on dealing with any emergency situation that may occur as a result of the BESS. Such training must be provided by the technology suppliers or an appointed service provider.
Inappropriate disposal at the end of life	- Potential scenario of fluids from the batteries leaking into environment. The release of such chemicals through leaching, spills or air emissions can harm communities, ecosystems and food production. - The potentially toxic materials contained in batteries means that they are classified as hazardous materials in terms of	**Medium**	- The recycling of batteries and their potential use as e-waste. - Disposal at a licensed hazardous waste site. - Prior to construction of the Development, the Applicant is to develop a dedicated Battery Recycling Programme to be adopted on-site. - Records of disposal at a licensed facility must be kept.

Possible Risk	Resultant Impact Significance	Likelihood of occurrence	Management / Mitigation
	NEM:WA. There are only a few licensed hazardous waste sites in South Africa and recycling of batteries and e-waste has been identified as a sure way of improving the lifespans of such sites.		

1.1.6.1 Fire Risk Management

To minimise the fire risk within the BESS and substation site, Table 2.8 provides proposed design and implementation recommendations which should be considered prior to installation and / or construction of the BESS. These recommendations should form part of a Tactical Fire Response Plan where applicable and has also been included in the EMPr (Appendix B).

Table 2.8: Proposed Design and Implementation Recommendations for the BESS

Initial Design Recommendations
1. Contact with the Fire department • Invite the fire department to the project site to discuss the BESS hazards. An adequate emergency response is the key to avoiding an uncontrolled fire. Ensuring the fire department is aware of and understands the type of battery which will be used and its hazards. • Key questions to discuss with the fire department include: ▪ What is the main difference between extinguishing and cooling? ▪ How to handle a damaged battery? ▪ How to manage the flammable and toxic gases? • Plan training exercises with the fire department when the system is commissioned. • Standard Operating Procedures (SOP) & Standard Operating Guidelines (SOG) are of major importance and should be updated and tested on a regular basis.
2. Construction and Location of the BESS • Install the BESS outdoors, a minimum of 20 m from important buildings or equipment. Maintain a minimum of 3 m separation from property lines, public ways and other exposures. • Within the module, maintain a minimum of 1 m separation distance between enclosures for all units up to 50 kWh when not listed, or up to 250 kWh when listed. • Install a thermal barrier where the minimum space separation cannot be provided. • If the BESS must be located indoors, install in a 2-hour fire rated cut-off room, which is accessible directly outdoors for manual firefighting. • Restrict the access to competent employees or sub-contractors. • Ensure enclosures are non-combustible.
3. Material, Equipment and Design of the BESS • AMDA should consider a 'Testing Method' for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems. A possible international standard to consider would be UL 9540A[10]. This standard evaluates thermal runaway, gas composition, flaming, fire spread, re-ignition and the effectiveness of fire protection systems. Data generated can be used to determine the fire and explosion protection requirements for a BESS. • Place a capacitor, transformer, and switch gear in separate rooms according to best engineering practices.
4. Ventilation and Temperature Control

[10] https://www.ul.com/news/ul-9540a-battery-energy-storage-system-ess-test-method

Initial Design Recommendations
• Install adequate ventilation or an air conditioning system to control the temperature. Maintaining temperature control is vital to the battery's longevity and proper operation as they degrade exponentially at elevated temperatures. • Ensure ventilation is provided in accordance with the manufacturer's recommendations. • Install and maintain the ventilation during all stages of a fire. Ventilation is important since batteries will continue to generate flammable gas as long as they are hot. Also, carbon monoxide will be generated until the batteries are completely cooled through to their core.
5. Gas Detection and Smoke Detection • Install a very early warning fire detection system, such as aspirating smoke detection. • Install carbon monoxide (CO) detection within the container or BESS room.
6. Fire Protection and Water Supply • Investigate the possibility of installing a sprinkler protection system within the BESS containers. The sprinkler system should be designed to provide (at a minimum) 12.2 l/min/m² over 232 m². It is important to note that other extinguishing agents, such as aerosols or gaseous extinguishing systems, will extinguish the fire, but they do not provide cooling like water. Insufficient cooling allows a hot and deep-seated core to remain. The heat will rapidly spread back through the battery and reignite remaining active sections. • Implement a procedure for battery submersion in the Tactical Fire Reponses Plan, as well as the WEF Emergency Response Plan to be performed by the fire department. Submerging batteries in water (preferably outdoors) after they burn has proven to be effective at cooling the batteries and neutralizing the thermal threat. They will continue to release gases, mostly carbon monoxide, but also flammable gas such as hydrogen. Therefore, it is not recommended to submerge several batteries in a confined space without adequate ventilation. • Ensure that sufficient water is available for manual firefighting. The ability of the fire department to control a fire involving a BESS depends on the presence of an adequate water supply and their knowledge of the hazards. The following should be considered: ▪ An external fire hydrant should be located within 100 m of the BESS room or containers. ▪ The water supply should be able to provide a minimum of 1,900 l/min (500 gpm) for at least 2 hours.
7. Maintenance • Follow original equipment manufacturer recommendations for the inspection, testing and maintenance of the BESS. In addition, ensure that the following (at a minimum) is completed: ▪ Measure the internal resistance of the battery cells. Replace the cells when a dramatic drop is detected. This will provide a good gauge of predictable battery life. ▪ Perform infrared scanning at least once per year. ▪ Check for fluid leakage. ▪ Implement electric terminal torqueing procedures to maintain connection integrity.