ALCAP EDUCATIONAL DOCUMENT | ENERGY STORAGE

Battery Energy Storage Systems

Power, energy, use cases, controls, degradation, safety, and the questions behind a sound business case

A battery energy storage system can shift energy, reduce peaks, support resilience, and complement solar PV. Its value depends on the use case, control strategy, tariff, duty cycle, electrical design, and safe lifecycle management.

WHAT YOU WILL LEARN

- The difference between battery power (kW) and energy (kWh)
- How backup, peak shaving, and load shifting impose different duties
- Why efficiency, degradation, state of charge, and cycle limits matter
- What must be addressed in safety, siting, controls, and maintenance

PRACTICAL. INDEPENDENT. DECISION-FOCUSED.
Written for South African commercial and industrial energy users. Prepared July 2026 | Version 1.0

01 | THE ESSENTIALS

Build the right mental model

Power tells you how fast a battery can charge or discharge. Energy tells you how much it can store. A 500 kW / 1,000 kWh system can theoretically discharge at rated power for about two hours before considering operating limits and losses.

Use case first

Backup requires reliable islanding and critical-load definition. Peak shaving requires accurate forecasting and fast controls. Energy shifting depends on price spread, losses, and available capacity.

Usable capacity

Nameplate kWh is not automatically available. State-of-charge limits, depth of discharge, temperature, ageing, reserve, and power limits reduce the usable operating window.

System, not only cells

A complete BESS includes cells/modules, racks, battery management, power conversion, controls, protection, thermal management, communications, enclosure, metering, and fire/life-safety provisions.

> DURATION
> **Nominal duration (hours) = Energy rating (kWh) / Power rating (kW).**
> Real delivered duration depends on usable state-of-charge window, auxiliary loads, temperature, degradation, conversion efficiency, and the discharge rate.

A QUICK REFERENCE

Use case	Primary sizing driver	Critical control
Backup	Critical kW and outage duration	Islanding and reserve
Peak shaving	Peak shape and demand rule	Forecast and dispatch
TOU shifting	Energy window and price spread	Charge/discharge schedule
PV firming	Solar/load variability	Coordinated power flow

02 | PUT IT TO WORK

Turn understanding into action

Model the intended duty at interval level over representative years. Then test technical sizing, safety, degradation, replacement, and revenue or savings under conservative scenarios.

1. **Define the service**
State the load, response, duration, reserve, availability, and whether services can overlap.

2. **Build the dispatch model**
Use interval load, PV, tariff, outages, losses, power limits, and state-of-charge rules.

3. **Size power and energy**
Test constraints, future degradation, auxiliary load, temperature, and redundancy.

4. **Engineer the installation**
Coordinate network studies, protection, earthing, ventilation/thermal control, access, separation, emergency response, and communications.

5. **Contract lifecycle performance**
Define warranties, throughput/cycles, availability, response, data, maintenance, augmentation, recycling, and end-of-life responsibility.

ILLUSTRATIVE EXAMPLE: PEAK SHAVING VS BACKUP

A battery uses most of its charge to shave a late-afternoon peak. A grid outage then occurs with little reserve remaining. The controls must explicitly prioritise economic dispatch versus backup state of charge; the same capacity cannot be assumed fully available for both at once.

A GOOD DECISION LOOKS LIKE

- The model includes efficiency, degradation, auxiliary loads, reserve, and replacement.
- Safety and emergency arrangements are designed with qualified specialists and relevant authorities.
- The contract states who controls the asset, owns the data, and carries performance and end-of-life obligations.

03 | CHECKLIST AND NEXT STEPS

Use this before you proceed

[ ]	Define critical loads, peak targets, tariffs, and service priorities.
[ ]	Model interval dispatch and state of charge across representative conditions.
[ ]	Include degradation, warranties, temperature, auxiliaries, and augmentation.
[ ]	Complete network, protection, fault, earthing, and control studies.
[ ]	Address siting, access, thermal management, detection, response, and signage.
[ ]	Plan maintenance, spares, incident response, recycling, and end of life.

RED FLAGS

- Quoting only kWh without a kW rating and duty
- Counting full battery capacity for several simultaneous services
- A business case without degradation or replacement
- Treating fire and emergency planning as an equipment-vendor issue only

PLAIN-LANGUAGE GLOSSARY

BESS	Battery energy storage system.
SOC	State of charge - estimated remaining stored energy.
DoD	Depth of discharge used from the available capacity.
BMS	Battery management system supervising cells and limits.
Round-trip efficiency	Energy discharged divided by energy charged over a cycle.

SOURCES AND FURTHER READING

- U.S. DOE - Battery Energy Storage System Evaluation Method
- U.S. DOE - Solar energy and storage basics
- NREL - PV and storage O&M; best practices

IMPORTANT NOTE

This document is for general education only. It is not a substitute for a site assessment, electrical design, tariff review, safety study, or professional advice. Use the latest applicable standards, utility rules, municipal requirements, and manufacturer instructions. Work on electrical systems must be performed by suitably qualified and authorised persons.

Learn more at **alcap.co.za** or contact **admin@alcap.co.za**.