SOUTHERN AFRICA ENERGY PROGRAM (SAEP)
West Africa Regional Energy Summit. Senegal
December 2019
USAID Southern Africa Energy Program (SAEP) Overview

The USAID Southern Africa Energy Program’s assists in the development of generation, transmission and distribution whilst promoting investment in the energy sector for a brighter, more sustainable future.

5 Years
ACTIVITY DURATION
March 2017 – March 2022

IMPLEMENTED BY
Deloitte, with McKinsey, WorleyParsons, CrossBoundary, and Another Option

TARGET COUNTRIES
Angola, Botswana, Eswatini, Lesotho, Madagascar, Malawi, Mozambique, Namibia, South Africa, Zambia

REGIONAL PARTNERSHIP FOCUS
SADC, SAPP, RERA, SACREEE
Implementing in collaboration with Power Africa Partners
USAID Southern Africa Energy Program (SAEP) Overview (cont.)

OUR OBJECTIVE
Increase investment in electricity supply and access in Southern Africa by strengthening the regional enabling environment and facilitating transactions through technical assistance.

OUR GOALS
Assist in the development of:
1. Generation capacity – 3,000 MW
2. Transmission capacity – 1,000 MW
3. New connections – 3 million

PROGRAM OUTCOMES / TASK AREAS

**Outcome 1**: Improved Regulation, Planning and Procurement for Energy

**Outcome 2**: Improved Commercial Viability of Utilities

**Outcome 3**: Improved Regional Harmonization and Cross-Border Trade

**Outcome 4**: Scaled Renewable Energy (RE), Energy Efficiency (EE) and Access

**Outcome 5**: Increased Human and Institutional Capacity
Battery Storage as a Renewable Energy (RE) Technology

Why Batteries?

The role of grid-scale Battery Energy Storage Systems (BESS) has gained prominence because of the increasing need for power system flexibility coupled with the rapid decline in the cost of storage technologies such as lithium-ion batteries.

Battery storage facility at the Tsumkwe plant in Namibia.

More utilities and governments are seeking to determine whether battery storage is a cost-effective option for enabling power systems to integrate large shares of variable renewable energy.

Source: https://www.climatelinks.org/blog/grid-scale-battery-key-renewable-energy-integration
CENORED Overview

NamPower

- Namibia’s national utility responsible for Gx, Tx and energy trading (imports & procurement from large IPPs) and operates in 15 municipalities
- Distribution is operated by Regional Electricity Distributors (REDs) or Municipalities

CENORED - Central North Regional Electricity Distributor

- **CENORED, ERONGORED, and NORED** are the 3 REDs in Namibia
- CENORED distributes electricity to the various towns and settlement areas of Central and Northern Namibia and covers more than 120,000 square km
- Strategic objectives include improving cost efficiency and increasing embedded RE generating capacity to 20 MW or greater if energy storage proves viable
CENORED Case Study

CENORED wanted to evaluate the costs and benefits of using battery storage

Key Considerations:

- Increasing time-of-use (TOU) tariffs, including fast-growing maximum demand and network access charges
- Significant discrepancies between peak and off-peak energy charges
- Management of variable renewable energy from solar PV resources
- CENORED is interested in being an off-taker of battery services, rather than owning and operating the facilities

Energy Charges (N$/kWh)

<table>
<thead>
<tr>
<th>Year</th>
<th>Off-Peak</th>
<th>Standard</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016/2017</td>
<td>Low N$0.00</td>
<td>High N$1.00</td>
<td>Low N$2.00</td>
</tr>
<tr>
<td>2017/2018</td>
<td>Low N$1.00</td>
<td>High N$2.00</td>
<td>Low N$3.00</td>
</tr>
<tr>
<td>2018/2019</td>
<td>Low N$2.00</td>
<td>High N$3.00</td>
<td>Low N$4.00</td>
</tr>
</tbody>
</table>

Capacity Charges (N$/kVA/month)

<table>
<thead>
<tr>
<th>Year</th>
<th>Maximum Demand Charge</th>
<th>Network Access Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016/2017</td>
<td>N$70,25</td>
<td>N$75,46</td>
</tr>
<tr>
<td>2017/2018</td>
<td>N$91,33</td>
<td>N$98,10</td>
</tr>
<tr>
<td>2018/2019</td>
<td>N$95,14</td>
<td>N$102,19</td>
</tr>
</tbody>
</table>
BESS Project LIFECYCLE

A BESS project can be broken up into five phases: planning, procurement, deployment, operations and maintenance, and decommissioning.

<table>
<thead>
<tr>
<th>Planning</th>
<th>Procurement</th>
<th>Deployment</th>
<th>Operations and Maintenance</th>
<th>Decommissioning</th>
</tr>
</thead>
</table>
| BESS project planning involves identifying and evaluating potential BESS applications and translating them into a set of project requirements. | If the planning process determines that a BESS project is feasible, the prospective BESS owner or offtaker initiates a procurement based on the defined minimum requirements. | After the procurement has taken place, the BESS is installed, tested, and commissioned. **Key Activities:**  
- Site and System Engineering  
- Permitting  
- Product Installation, Connection, and Integration  
- Project Commissioning and Site Acceptance Testing | Once the system has been commissioned and approved for use, the BESS must be operated and maintained for the life of the project. **Key Activities:**  
- Handoff to Distribution/System Operations  
- Maintenance  
- Environmental and Safety Reporting  
- Operational Needs Revisions and Recommissioning (as required) | When the project is no longer viable due to a predetermined end date, safety or reliability issues, or degradation, the BESS is decommissioned. **Key Activities:**  
- Decommissioning  
- Second Use / Relocation  
- Recycling or Disposal |

Key Activities:
- Use Case Evaluation
- Ownership and Contract Structure Selection
- Documentation of Minimum Requirements

# The CENORED Case - Relevant Applications

<table>
<thead>
<tr>
<th>Type</th>
<th>Application</th>
<th>Relevance &amp; User(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bulk Storage</strong></td>
<td>Energy Time-Shift</td>
<td>Primary driver of analysis (CENORED)</td>
</tr>
<tr>
<td><strong>Renewables Integration</strong></td>
<td>Renewables Capacity Firming</td>
<td>Primary driver of analysis (CENORED)</td>
</tr>
<tr>
<td></td>
<td>Renewables Ramp Rate Control</td>
<td>Dependent on regulatory requirements and total vRE supply levels (CENORED)</td>
</tr>
<tr>
<td><strong>Ancillary Services</strong></td>
<td>Frequency Regulation</td>
<td>Dependent on existing services (CENORED and/or NamPower)</td>
</tr>
<tr>
<td></td>
<td>Voltage Support</td>
<td>Dependent on existing services (CENORED and/or NamPower)</td>
</tr>
<tr>
<td></td>
<td>Spinning/Non-Spinning Reserves</td>
<td>Dependent on existing reserves and regulatory requirements (NamPower)</td>
</tr>
<tr>
<td></td>
<td>Black Start</td>
<td>Multiple black start plants already in production (NamPower)</td>
</tr>
<tr>
<td><strong>Transmission and</strong></td>
<td>T&amp;D Upgrade Deferral</td>
<td>Dependent on load forecasts and infrastructure capacity (NamPower)</td>
</tr>
<tr>
<td><strong>Distribution (T&amp;D)</strong></td>
<td>Transmission Congestion Relief</td>
<td>Dependent on load forecasts and infrastructure capacity (NamPower)</td>
</tr>
</tbody>
</table>

**Legend:**
- Very Low
- Low
- Unknown
- High
- Very High
### The CENORED Case - Relevant Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Maturity / Bankability</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Competitiveness in SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Lead Acid</td>
<td>Mature / Strong</td>
<td>• Mature technology</td>
<td>• Low cycle life</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Capital cost relatively low</td>
<td>• Limited DoD</td>
<td></td>
</tr>
<tr>
<td>Sodium Sulfur Battery</td>
<td>Mature / Strong</td>
<td>• Limited cycle life</td>
<td>• High power and energy density</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Requires external heat system</td>
<td>• Longer discharge times than Li-ion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High temperature system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Large daily self-discharge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithium-Ion</td>
<td>Commercial / Strong</td>
<td>• High round trip efficiency</td>
<td>• Limited but improving cycle life</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Continuing performance improvements and</td>
<td>• Deep discharge cycles lower lifetime</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>manufacturing cost reductions</td>
<td>• Thermal management in harsh conditions</td>
<td></td>
</tr>
<tr>
<td>Vanadium Flow</td>
<td>Demo / Moderate</td>
<td>• Mature for a flow technology</td>
<td>• Lower round trip efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vanadium is a SA resource</td>
<td>• Requires mechanical systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High cycle life, full DoD</td>
<td>• High cost of Vanadium</td>
<td></td>
</tr>
<tr>
<td>Zinc Bromine Flow</td>
<td>Demo / Moderate</td>
<td>• High cycle life, full DoD</td>
<td>• Lower round trip efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less expensive electrolyte than Vanadium</td>
<td>• Requires mechanical systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Small daily self-discharge</td>
<td>• Power and energy scale independent</td>
<td></td>
</tr>
<tr>
<td>Iron-Chromium Flow</td>
<td>Demo / Weak</td>
<td>• Lower round trip efficiency</td>
<td>• Power and energy scale independently</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low energy density</td>
<td>• Small daily self-discharge</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Requires mechanical systems</td>
<td>• High cycle life, full DoD</td>
<td></td>
</tr>
<tr>
<td>Liquid Metal Batteries</td>
<td>R&amp;D / Weak</td>
<td>• Long electrode life</td>
<td>• Liquid layers sensitive to motion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low cost potential</td>
<td>• High temperature – requires active heating</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rapid charge/discharge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assess the initial viability of battery storage

CENORED model relied on tariff, solar PV generation, and CENORED load data to generate a simulated power-flow and tariff paths, as well as illustrative CENORED cost savings and project cash flows.

**Inputs**
- TOU tariff schedule
- Proposed solar PV tariffs
- Proposed solar PV nameplate capacity
- Projected solar PV capacity factor
- CENORED load for each site

**Outputs**
- Simulated power-flow
- Simulated tariff paths
- Illustrative lifecycle and annual cost savings for CENORED
- Illustrative project cash flows for an independent developer
Model Outputs: Simulated Power Flow

The simulated power-flow shows the exchange of energy between CENORED, bulk power supplier, the solar PV plant, the battery storage system, and the load on a week day, Saturday, or Sunday.

- Battery charging in the early morning using NamPower off-peak energy.
- Battery discharging during morning and evening peak time periods.
- Solar PV power replacing bulk power supplier peak energy during morning peak.
- Battery storing solar PV power for use during evening peak once the morning peak period is over.

CENORED using bulk energy to service load.
Model Outputs: Simulated Tariff Paths

The simulated tariff paths show the relative price per kWh of the bulk power supplier TOU tariffs, solar PV tariffs, and battery storage tariffs.
Model Outputs: Illustrative CENORED Cost Savings

The illustrative CENORED cost savings show the potential savings that could be achieved from the selected scenario relative to business as usual.

Cost savings achieved from reduced energy, maximum demand, and network access charges – as well as the associated VAT tax liability

Total cost savings impact on CENORED’s profit and loss statement

Additional costs for solar PV energy and battery storage services

CENORED Lifecycle Cost Savings (N$)

- NamPower Bulk
- Maximum Demand Charges
- Network Access Charges
- VAT Tax
- Total Cost of Sales
- solar PV energy storage
- BESS energy charges

-40M
-44M
-16M
-126M
-335M
-500M
-400M
-300M
-200M
-100M
-0M
-100M
-200M
-300M
-400M

N$
The illustrative project cash flows demonstrate the potential return on investment for an independent project developer.
Challenges and Issues experienced in the CENORED case

<table>
<thead>
<tr>
<th>Challenge Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance / Procurement</td>
<td>• Necessary to value and stack as many use cases or services as possible&lt;br&gt;• Grid-scale battery storage procurement test cases required in the region&lt;br&gt;• Unknown level of interest and terms and conditions of funders/financiers</td>
</tr>
<tr>
<td>Technical</td>
<td>• Which chemistry/technology is appropriate for the region?&lt;br&gt;• Degradation and requirements for augmentation for our region are not well known&lt;br&gt;• Where are the technical skills?</td>
</tr>
<tr>
<td>Regulations</td>
<td>• Should a BESS be issued with a license as a generator or as a load?&lt;br&gt;• How should battery storage services be incorporated into existing tariff regimes?&lt;br&gt;• Utility-owned vs battery storage as a service</td>
</tr>
</tbody>
</table>
Results of our approach with CENORED – may be applied to other counterparts

**Allows decisions about resource-investment early in the process**

SAEP’s approach was to quickly develop models that could enable decision-making through an iterative process with refinements of the model after each iteration and decision-point.

**Enables informed discussions with stakeholders**

Using outputs from each phase of analysis, the utility was able to have discussions with counterparts based on research and analysis. This enhanced the quality of discussion outputs.

**Narrows the scope of analysis after each iteration of the model**

CENORED was able to eliminate 3 sites after the initial iteration of analysis and proceeded to detailed analysis with a smaller set of sites. In the next iteration of investigation, CENORED will only focus on the most viable sites.

**Includes legal, regulatory and procurement considerations**

SAEP included a scan of the regulatory environment as well as procurement approaches to enable CENORED to identify barriers and enablers that they need to consider to make their battery storage project a success.
What does the future look like for customers?

**Future Price Paths**

- We know that the battery storage technology is *transformational, scalable* and *dispatchable*
- When coupled with other technologies (e.g. PV), may be one of the solutions leading to effective tariff and pricing options which may invariably lead to cheaper options for the customer

**Support for Our Regional Grids**

- With the global trends on the use of battery storage to support Electricity Grids, there is a significant and economic scalability in installing battery systems before the meters than with individual customers.
- Grid stabilization will support the access needs for the end customer
- According to an article from ee publishers South Africa, escalating electricity prices are pushing grid parity, where the cost of generating solar energy is nearing the same cost of purchasing power from the electricity grid, encouraging more self-consumption (and low-cost storage) Article - [Behind-the-meter functionality offers energy independence](#)
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