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SOUTHERN AFRICA ENERGY PROGRAM (SAEP)

Energy Storage Partnership: Stakeholder Consultation

21 January 2020

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

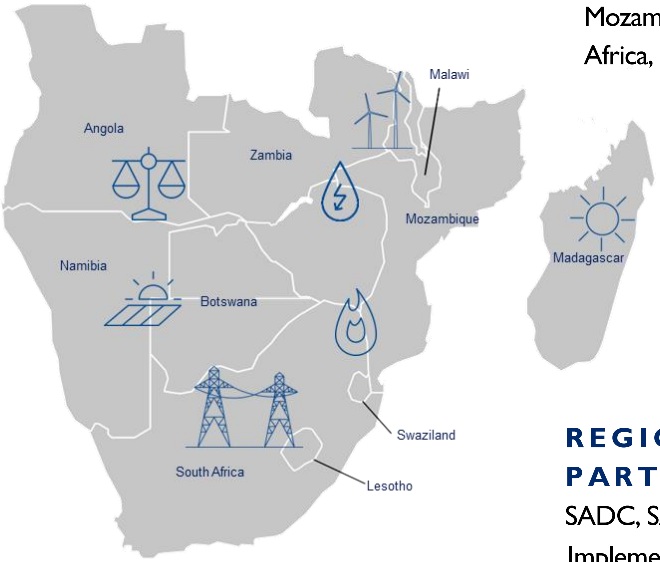
March 2017 – March 2022

10 TARGET COUNTRIES

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

IMPLEMENTED BY

Deloitte, *with* McKinsey, WorleyParsons, CrossBoundary, and Another Option



REGIONAL PARTNERSHIP FOCUS

SADC, SAPP, RERA, SACREEE

Implementing in collaboration with Power Africa Partners

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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

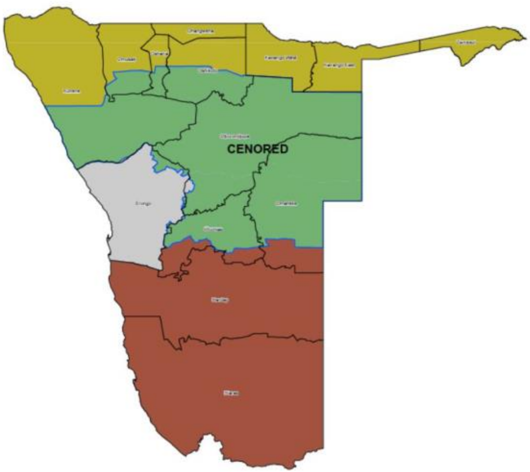
CENORED Overview

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

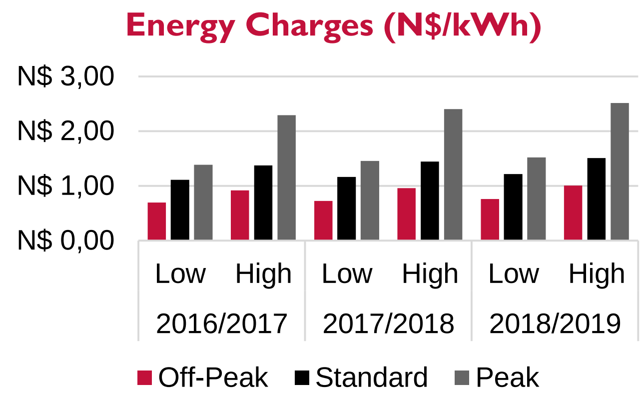


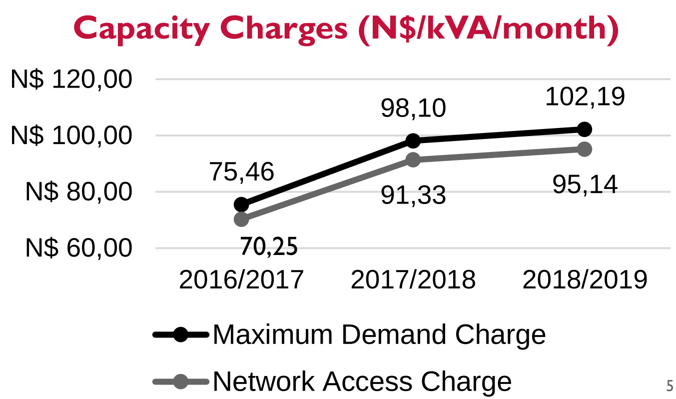
CENORED Case Study

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





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BESS Project LIFECYCLE

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

Planning

BESS project planning involves identifying and evaluating potential BESS applications and translating them into a set of project requirements.

Key Activities:

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

Procurement

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.

Key Activities:

- Procurement Development
- Bid Evaluation and Contract Issuance

Deployment

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

Operations and Maintenance

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)

Decommissioning

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

Source: ESIC Energy Storage Implementation Guide. EPRI, Palo Alto, CA: 2017. 3002010896.

The CENORED Case - Relevant Applications

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

Legend: ○ Very Low ◔ Low ◑ Unknown ◕ High ● Very High

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The CENORED Case - Relevant Technologies

				Competitiveness in SA		
Technology	**Maturity / Bankability**	**Advantages**	**Disadvantages**	**2016 – 2020**	**2021- 2025**	**2026- 2031**
Advanced Lead Acid	Mature / Strong	• Mature technology • Capital cost relatively low	• Low cycle life • Limited DoD			
Sodium Sulfur Battery	Mature / Strong	• Limited cycle life • Requires external heat system • High temperature system • Large daily self-discharge	• High power and energy density • Longer discharge times than Li-ion			
Lithium-Ion	Commercial / Strong	• High round trip efficiency • Continuing performance improvements and manufacturing cost reductions	• Limited but improving cycle life • Deep discharge cycles lower lifetime • Thermal management in harsh conditions			
Vanadium Flow	Demo / Moderate	• Mature for a flow technology • Vanadium is a SA resource • High cycle life, full DoD	• Lower round trip efficiency • Requires mechanical systems • High cost of Vanadium			
Zinc Bromine Flow	Demo / Moderate	• High cycle life, full DoD • Less expensive electrolyte than Vanadium • Small daily self-discharge	• Lower round trip efficiency • Requires mechanical systems • Power and energy not fully independent			
Iron-Chromium Flow	Demo / Weak	• Lower round trip efficiency • Low energy density • Requires mechanical systems	• Power and energy scale independently • Small daily self-discharge • High cycle life, full DoD			
Liquid Metal Batteries	R&D / Weak	• Long electrode life • Low cost potential • Rapid charge/discharge	• Liquid layers sensitive to motion • High temperature – requires active heating			

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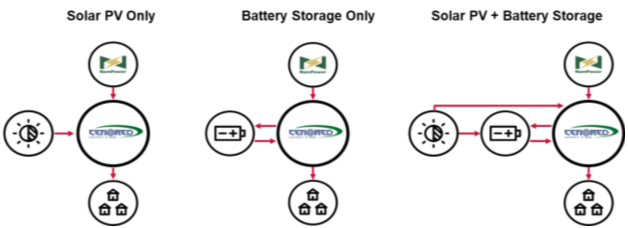
Assess the initial viability of battery storage

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.

Scenarios



Battery Storage Technology
Lithium-Ion NMC, Flow Vanadium

Battery Storage Costs
Low, Average, High

Tariff Price Path
Unlikely, Likely, Very Likely

Load Forecast
Unlikely, Likely, Very Likley

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

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Model Dashboard

Site:	
Battery Type:	Lithium-Ion NMC
Scenario:	Solar PV + BESS
Project Developer:	Solar PV + BESS
BESS Cost Level:	Average
Load Growth:	Very Likely
NamPower Tariff Path:	Very Likely

CENORED Financial Metrics	
Total Cost Savings (N$)	N$152,650,885
Average Cost Savings per Year (N$)	N$7,632,944

Project Developer Financial Metrics	
Net Present Value (N$)	N$1,231,286,253
Internal Rate of Return (%)	9.88%
Payback Period (Years)	11

System Characteristics	Value	Units
Peak Demand to Date (06/2017)	5.0	MVA
Main Transformer	10	MVA
Distribution	11	kV
Solar PV Power Capacity	3.5	MW
BESS Installed Power Capacity	0.875	MW
BESS Installed Energy Capacity	3.5	MWh
BESS Effective Energy Capacity	2.45	MWh
Battery DC Block Oversizing	20%	%
Capacity Degradation Factor	10%	%

BESS Performance Specs	Value	Units
Round Trip Efficiency	86.00%	%
Self-Discharge Losses per Hour	0.01%	%
Depth of Discharge	100%	%
Maximum Charge Rate	0.25	C
Cycle Life @ 100% DoD	4,000	Cycles
Calendar Life	10	Years

Load Growth & NMD	Value	Units
CENORED Load Growth: FY20+	1.60%	%
CENORED NMD Margin	10.00%	%

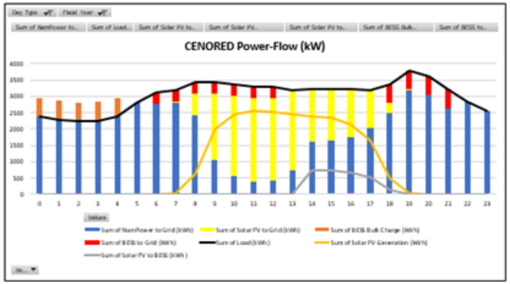
Price Path	Value	Units
NamPower Energy Charge: FY20	4.91%	%
NamPower Energy Charge: FY21+	6.70%	%
NamPower Demand Charge: FY20+	10.64%	%
NamPower Access Charge: FY20+	10.64%	%
Solar PV Energy Charge: FY20+	6.70%	%
Solar PV Energy Charge: FY20+ (GTT)	9.40%	%
BESS Energy Charge: FY21+	6.70%	%
BESS Capacity Charge: FY21+	0.00%	%

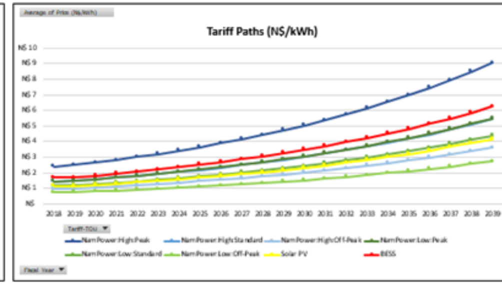
BESS Costs	Value	Units
Land	$7,000.00	N$
AC System	$955,605.00	N$
DC System	$17,452,365.00	N$
Other BESS Capital Costs	$2,766,225.00	N$
EPC	$2,761,195.50	N$
Augmentation	$9,203,985.00	N$/replacement
O&M	$317,612.93	N$/year
Extended Warranty*	$317,612.93	N$/year

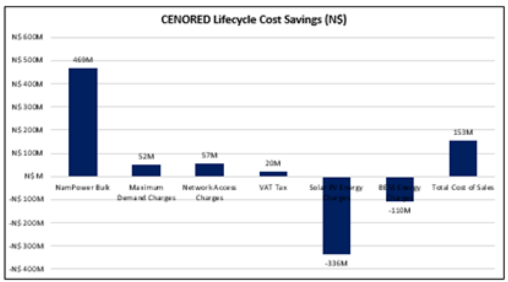
Assumes initial product warranty through Project Year 2

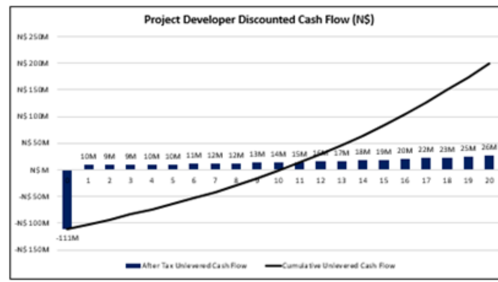
Solar PV Costs	Value	Units
Land	$35,000.00	N$
Solar PV System Capital	$87,500,000	N$

BESS OPEX Cost Calculations	Value	Units
EPC	15.00%	% of AC/DC System Costs
Augmentation	50.00%	% of AC/DC System Costs
O&M	1.50%	% of Installed Capital Costs
Extended Warranty	1.50%	% of Installed Capital Costs









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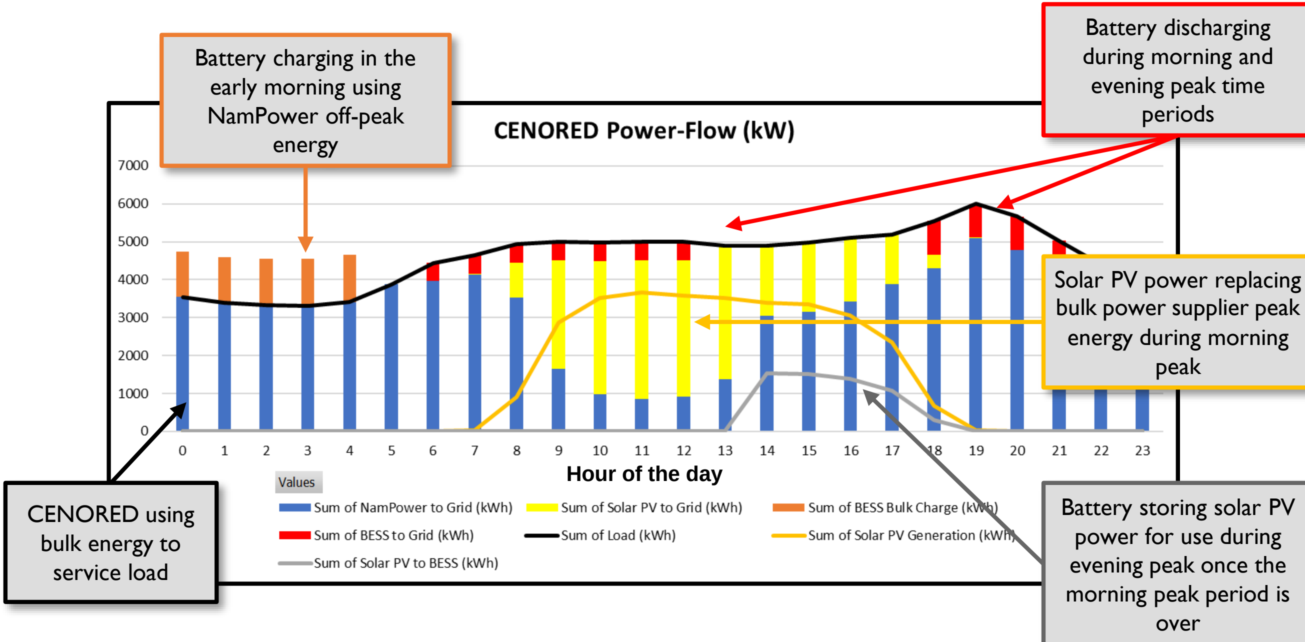
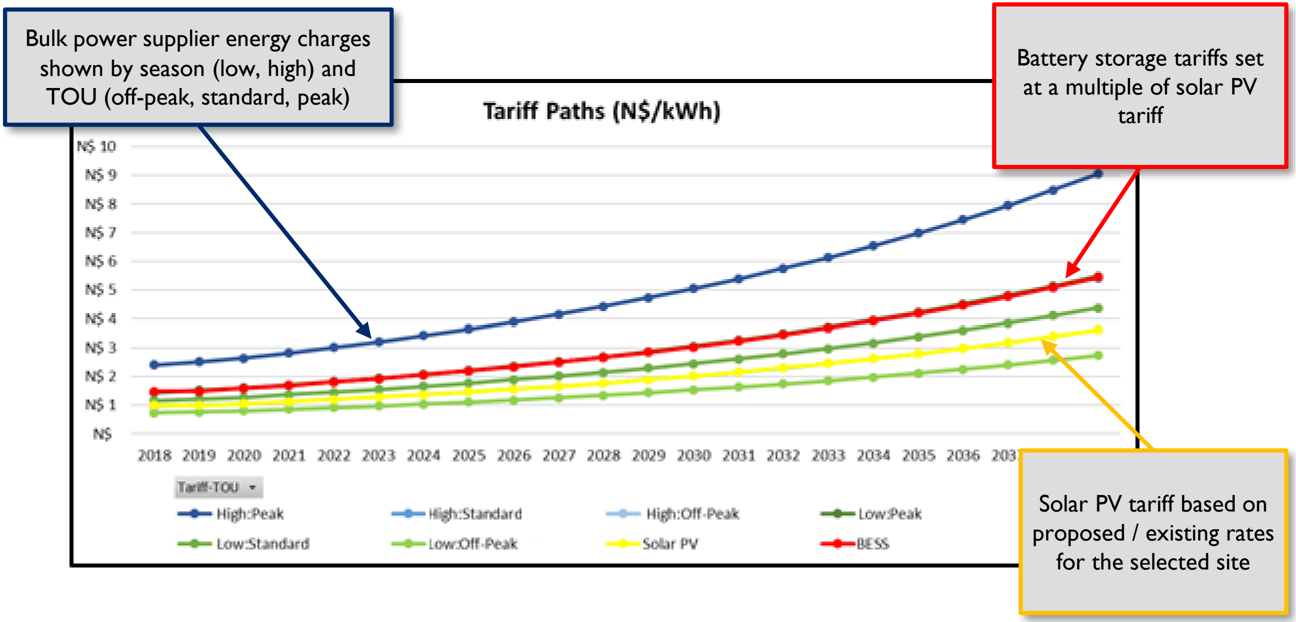
Model Outputs: Simulated Power Flow

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



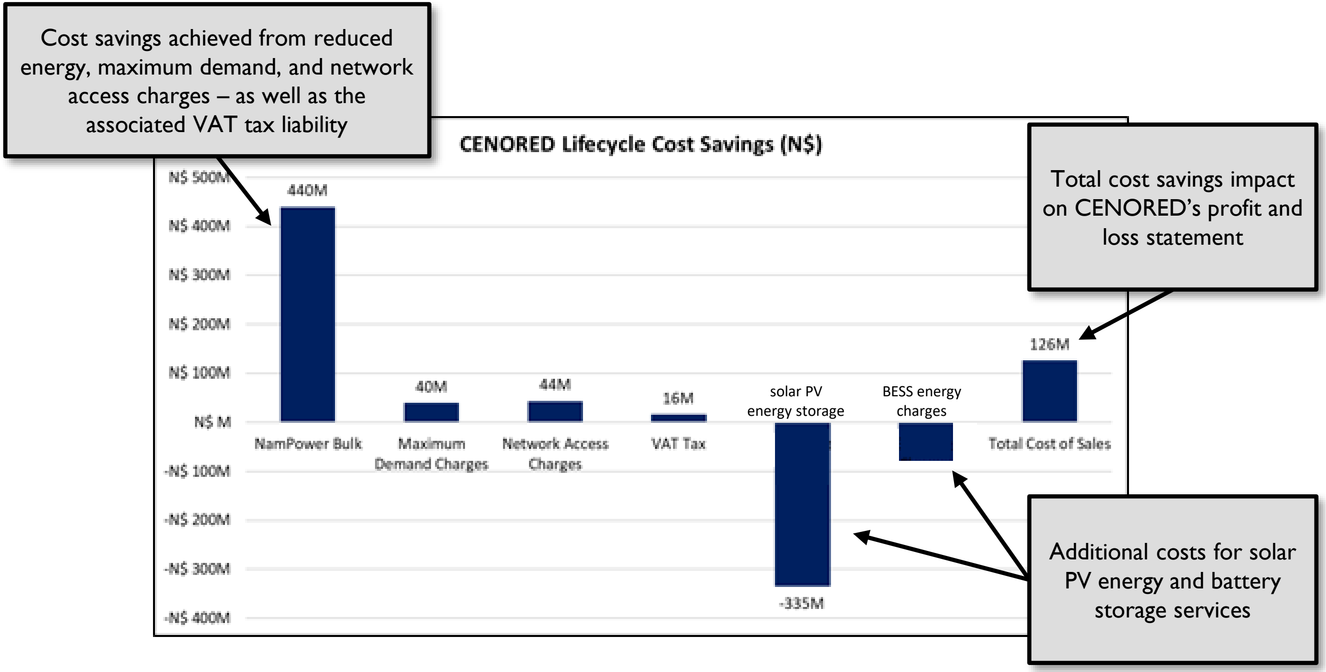
Model Outputs: Simulated Tariff Paths

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.



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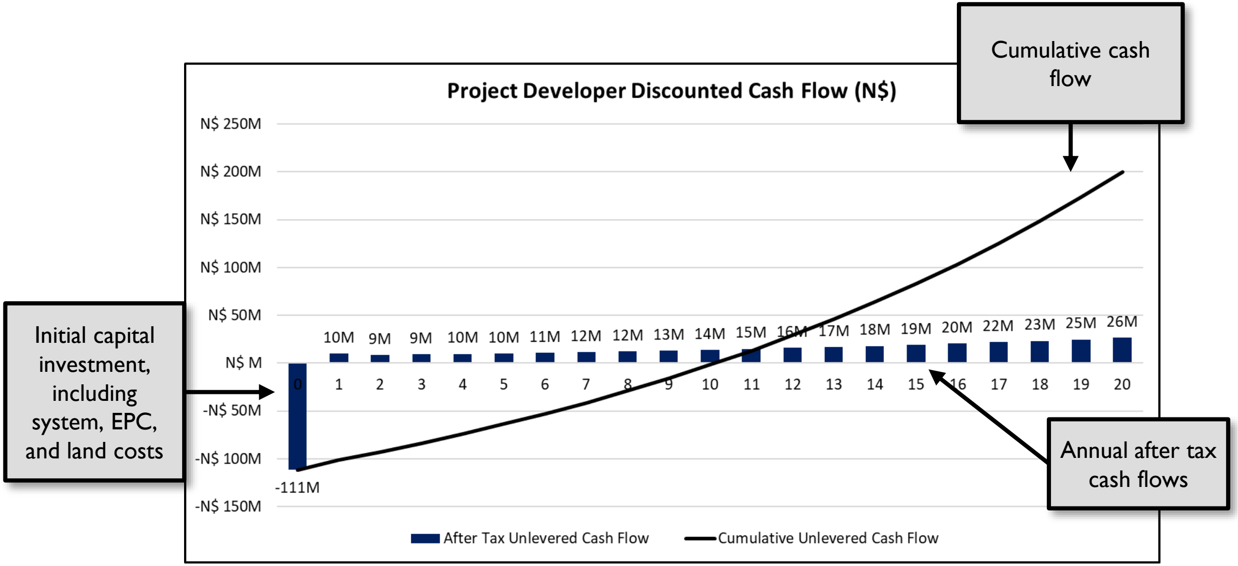
Model Outputs: Illustrative Project Cash Flows

The illustrative project cash flows demonstrate the potential return on investment for an independent project developer.



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Challenges and Issues experienced in the CENORED case

Challenge Type	Description
Finance / Procurement	• Necessary to value and stack as many use cases or services as possible • Grid-scale battery storage procurement test cases required in the region • Unknown level of interest and terms and conditions of funders/financiers
Technical	• Which chemistry/technology is appropriate for the region? • Degradation and requirements for augmentation for our region are not well known • Where are the technical skills?
Regulations	• Should a BESS be issued with a license as a generator or as a load? • How should battery storage services be incorporated into existing tariff regimes? • Utility-owned vs battery storage as a service

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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

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Contact Details

Tshegofatso Neeuwfan (Presenter) –
Deputy Lead RE & EE

tneeuwfan@southernafricaenergy.org

Craig VanDevelde – Chief of Party

cvandevelde@southernafricaenergy.org

Liz Pfeiffer – Deputy Chief of Party - Technical

lpfeiffer@southernafricaenergy.org

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