SOUTHERN AFRICA ENERGY PROGRAM

CENORED BATTERY STORAGE ASSESSMENT PHASE II FINAL REPORT (DRAFT)

November 15, 2019

1 ABBREVIATIONS

Acronym	Definition
AC	Alternating Current
BESS	Battery Energy Storage System
CENORED	Central North Regional Electricity Distributor
DC	Direct Current
ECB	Electricity Control Board of Namibia
ESI	Electricity Supply Industry
ESS	Energy Storage System
GRN	Government of the Republic of Namibia
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producer
kW	Kilowatt
kWh	Kilowatt-hour
kV	Kilovolt
LV	Low Voltage
MME	Ministry of Mines and Energy
MV	Medium Voltage
NAD (N$)	Namibian Dollar
NamPower	Namibia Power Corporation (Pty) Ltd.
PPA	Power Purchase Agreement
PV	Photovoltaic
PVS	Solar PV plus Battery Energy Storage System
RE	Renewable Energy
SAEP	Southern Africa Energy Program
SAPP	Southern Africa Power Pool
USD (US$)	United States Dollar
V	Volt
vRE	Variable Renewable Energy
W	Watt

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3 EXECUTIVE SUMMARY

This document details the approach and findings of Phase 2 of the CENORED Battery Storage Assessment, which analyzes the legal and regulatory factors in Namibia that could impact battery storage deployment, explores leading battery storage procurement practices, and further evaluates the technical and economic feasibility of battery energy storage systems (BESS) at CENORED's three largest sites: Tsumeb, Okahandja, and Otjiwarongo. While Tsumeb and Okahandja considered solar PV and BESS projects at their sites, Otjiwarongo considered a BESS project with a separate developer, as the HopSol solar PV plant is currently operational there.

The analysis first evaluates the existing market and regulatory structures in Namibia to determine potential impacts and limitations to battery storage deployment. Through the review of Namibia's electricity supply industry and regulatory environment, six potential barriers to battery storage deployment were identified, which revolved around an evolving electricity market structure and a lack of explicit regulations that account for battery storage technologies. While these barriers may not necessarily prevent a battery storage deployment, obtaining clarity on how the electricity market and regulator will treat battery storage technologies will be important for both CENORED and developers when moving forward with a project.

In order to understand the leading practices associated with a battery storage project, it was important to first break down the project lifecycle and its components. Currently, CENORED is going through the planning phase of a battery storage project, which involves evaluating appropriate use cases, selecting ownership and contract structures, and documenting minimum requirements for a project. Phase 1 of the Battery Storage Assessment evaluated different use cases for a battery storage project for CENORED through a cost-benefit analysis that focused on the battery storage applications of energy and demand charge management as well as renewable capacity firming. This report provides context on the important ownership and contract structure decisions that need to be made prior to a project, as well as the approach and next steps associated with defining the minimum requirements for a project.

The following outlines the decision points and the options that may be the most suitable for the proposed projects:

- **Ownership Model:** 3rd party developer owned
- **Procurement Approach:** Combined solar PV and BESS procurement
- **Contract Structure & Payment Mechanism:** Time-variant PPA (with potential capacity charge)
- **Procurement Method:** RFI and RFP

Refinements to the cost-benefit analysis from Phase 1 were made to include an updated dashboard that provides input fields for system specifications, contract structures, and tariffs, updated cost assumptions for the solar PV and BESS, as well as updated NamPower tariff schedules. In order to evaluate the project economics at each of the sites, acceptable BESS tariffs for developers to earn the necessary returns were calculated. Using these tariffs, SAEP calculated the annual and lifecycle cost savings of projects at each site.

According to the refined analysis, the report concludes that a standalone solar PV project can provide the greatest level of cost savings for CENORED, while providing acceptable returns to a developer at both Tsumeb and Okahandja. However, a solar PV and BESS project can also provide CENORED with substantial cost savings at both sites, while providing acceptable returns to a developer. Between the two sites, a solar PV and BESS project at Okahandja offers greater lifecycle cost savings than a project at Tsumeb, in part due to the larger solar PV size at Okahandja. The findings also suggest that a BESS at Otjiwarongo paired with the existing HopSol plant may not be able to mitigate the losses CENORED incurs at the site.

Based on these findings, SAEP proposes that CENORED conclude the preliminary planning phase of a solar PV and BESS project, gain clarity on the regulatory environment around BESS, gather information from battery storage market participants, and explore financing options:

1. **Feasibility Study:** Further explore a solar PV and BESS project at Okahandja through a feasibility study given the potential for such a project to yield cost savings and because this site does not involve grid charging and thus creates less regulatory uncertainty. The purpose of the feasibility study will be to further evaluate the techno-economic potential, the grid impacts, and the developmental impacts of deploying a solar PV and BESS project; CENORED should consider applying for grant funding to conduct the feasibility study. The SAEP analysis used 2018 battery cost and performance data to develop a preliminary conclusion that a solar PV plus BESS project would yield cost savings to CENORED but that a standalone PV project would yield greater cost savings. It is important to note that battery storage costs are declining and the range of battery technology and chemistry types is increasing. A detailed feasibility study that uses current data to optimize a battery's technology, size, and duty cycle may demonstrate that a solar PV and BESS project will be more economical than a standalone solar PV project by the time CENORED is ready to issue a procurement, especially given the continued decline in BESS costs and improvements in battery storage technology
2. **Coordination with Regulatory Stakeholders:** Engage with the Electricity Control Board (ECB), the Namibian Standards Institution, the Ministry of Environment and Tourism to gain clarity on the timeline for the transition to the modified single buyer plan and future regulations for BESS asset classification, grid interconnection, and environmental and safety standards, and provide up-to-date information about CENORED's potential solar PV and BESS project to ensure it meets upcoming regulatory standards; additionally CENORED should work with the Ministry of Mines and Energy and NamPower to ensure their cooperation and support to drive a successful BESS deployment
3. **Financing Sources:** Work with financial institutions, to understand if there are avenues for CENORED to obtain discounted debt for a solar PV and BESS project. Additionally, CENORED should explore funds dedicated to increasing the deployment of BESS regionally or globally. While DFIs have expressed interest in BESS projects in Namibia, it seems unlikely that a solar PV and BESS project would obtain concessional financing, given that our assessment shows that currently a standalone solar PV project can provide greater savings
4. **Pilot Project:** Consider the possibility of deploying a solar PV and BESS project as a pilot project with Investec and additional interested partners; seek technical and financial partners interested in the construction of a pilot project for a solar PV and BESS project at one of the three sites evaluated to deploy a project that can help mitigate some risk elements of future BESS deployments in Namibia

4 INTRODUCTION

The USAID Southern Africa Energy Program (SAEP), a Power Africa initiative, is a five-year program (2017-2022) designed to increase power generation and transmission and to increase access to electricity throughout the Southern Africa region. SAEP leverages its resources to unlock private investment in the energy sector, helping countries, such as Namibia, achieve their energy-related development goals.

The CENORED Battery Storage Assessment activity falls under SAEP Outcome 4: Scaled Renewable Energy (RE) and Energy Efficiency (EE). The assessment aims to help Namibia's Central North Regional Electricity Distributor (CENORED) explore the deployment of utility-scale battery energy storage systems (BESS) on CENORED's distribution network. SAEP and CENORED's collaboration on this activity is enabled by a letter of collaboration (LOC) that was signed by both parties in July 2018.

During Phase 1 of this activity, which was completed in December 2018, SAEP investigated the technical and economic feasibility of deploying battery storage at six locations within CENORED's distribution network: Grootfontein, Khorixas, Otavi, Otjiwarongo, Outjo and Tsumeb. The analysis evaluated the costs and benefits of standalone battery storage, standalone solar PV, and solar PV with battery storage (PVS) relative to "business as usual" (i.e., current operations) at each of the sites. CENORED indicated that it was not interested in owning and operating these assets, therefore the analysis examined these scenarios under a third-party or independent power producer (IPP) ownership model, in which CENORED was the sole off-taker of the solar PV and battery storage services.

The battery storage use case considered in the analysis focused on reducing CENORED's bulk electricity costs by purchasing off-peak power from the grid and solar PV power to use during peak hours. This use case was designed to mitigate CENORED's financial exposure to increasing NamPower Time-of-Use (TOU) tariffs and enable increased solar PV penetration on CENORED's distribution network. Two battery storage technologies, lithium-ion and flow vanadium, were selected by SAEP with CENORED's input for the analysis based on their alignment with these operational needs and near to medium-term competitiveness, due to their maturity, bankability, cost, and performance specifications.

The study concluded that of the scenarios examined, solar PV with lithium-ion battery storage has the potential for the highest cost savings, followed by standalone solar PV. Under the conditions applied in the analysis, standalone battery storage increased CENORED's operating costs relative to business as usual. Therefore, a standalone battery storage was not deemed to be a feasible investment. The cost savings to CENORED from an integrated solar PV with lithium-ion battery storage varied by site because of location-specific tariff levels and load characteristics. Of the sites analyzed, the two largest load centers, Tsumeb and Grootfontein, presented the best opportunities for savings.

To build on these findings, CENORED requested SAEP to conduct three additional tasks in the second phase (i.e., Phase II) of the CENORED Battery Storage Assessment. These tasks and their intended results are described below:

- **Market and regulatory assessment:** Evaluate the market and regulatory environment for distribution-level battery storage deployment in Namibia, including legal and regulatory measures governing energy, land use, environmental, and commercial activities. Provide CENORED with a clear understanding of potential market and regulatory barriers for battery storage deployment and inform stakeholder engagement activities with the Ministry of Mines and Energy (MME), Electricity Control Board (ECB), NamPower, and other relevant stakeholders.
- **Procurement leading practices review:** Review leading practices for battery storage procurement and identify potential funding and financing sources for utility-scale battery storage projects the Southern Africa region to help inform the procurement of battery storage services by CENORED.
- **Refined cost-benefit analysis:** Analyse further the costs and benefits of deploying battery storage at CENORED's networks at Tsumeb, Okahandja, and Otjiwarongo to provide CENORED with a greater understanding of the financial and economic feasibility of projects at these sites.

5 MARKET AND REGULATORY ASSESSMENT

Prior to moving forward with the procurement of battery storage services, CENORED needs to understand how the market and regulatory environment would influence project feasibility. SAEP reviewed Namibia's electricity supply industry and regulatory environment to determine whether any potential barriers to battery storage deployment exist and to recommend actions that CENORED can take to mitigate the impact of these barriers.[1] Table 1 lists the key documents reviewed.

[1] The term barrier, as used in this report, is broadly defined as an issue that could hinder the deployment of battery storage technologies. In some instances, a barrier may prevent deployment; and in others, it may limit deployment, limit revenue or limit consideration for deployment.

Table 1: Market and Regulatory Assessment Key Documentation

Document	Source	Version	Publication Date
The Modified Single Buyer Market: Market Rules (Draft)	ECB	1.0	September 2019
Namibia MSB Market Workshop: Market Rules	ECB	N/A	September 2019
NamPower Tariff Application for the Financial Year 2019/20: A Presentation to the ESI Stakeholders	NamPower	N/A	March 2019
Study on Grid Integration of Intermittent Renewable Energy in Namibia	ECB	Final Report	August 2018
Namibian Electricity Sector Detailed Market Framework Design	ECB	Draft 2.0	June 2018
Energy Storage in Namibia	ECB	Draft 1.0	April 2018
National Policy for Independent	MME	Revised Final Report	October 2017
Final Electricity Bill	GRN	Final Report	December 2017
National Energy Policy	MME	Final Report	July 2017
National Renewable Energy Policy	MME	Final Report	July 2017
NEP Implementation Plan	MME	Final Report	December 2016
National Grid Code	ECB	Final Report	May 2005
National Electricity Tariff Study	ECB	Final Report	November 2001

The review identified the following potential market and regulatory barriers to battery storage deployment, each of which is expanded upon in the report:

- **Evolving electricity market design and tariff schedule:** The implementation of the modified single-buyer (MSB) market design by the ECB and the recent changes to NamPower's TOU tariff schedule pose risks for a distribution-level battery storage system designed to provide energy and demand management. Adjustments to NamPower's TOU tariff schedule has the potential to impact the business case for BESS as it changes the business as usual (BAU) scenario against which the cost savings from a BESS are compared.
- **Limited revenue compensation mechanisms:** Although a BESS can be compensated for a number of services provided, Namibia's existing single-buyer market design does not include compensation methods for capacity or ancillary services. This limits the value proposition and available revenue streams for battery storage deployments. Compensation mechanisms for these services are expected to be implemented as part of Phase I of the MSB framework. However, the scope and timing of the service requirements are not yet clear. Therefore, in the near term, it is pre-mature to incorporate capacity and ancillary services into a battery storage use case.
- **Regulatory uncertainty impacting pricing:** The ECB has recognized there are issues related to having a standardized methodology for pricing and procuring energy storage services in Namibia. A recent energy storage study conducted by RINA Consulting on behalf of the ECB proposes the adoption of a willingness-to-pay approach for valuing energy storage services, which represents a departure from the existing cost-based approach to valuing energy services in Namibia. This would ideally result in an arrangement for the minimum price for the services provided by the BESS. However, the study does not set price ceilings for services nor does it provide guidance on the underlying regulatory measures required to support this approach.
- **Unclear asset classification:** Namibia's legal and regulatory framework does not contain clear rules around whether and how energy storage systems are classified as an asset. While there are provisions that

require a license for the storage of electricity, the rules governing energy storage and the required license have not yet been defined. The classification of storage systems may have implications on project planning and feasibility, in particular for a grid-connected system that provides ancillary services to a network. Asset classification of BESS is important to clarify to provide guidance on who can own and operate storage assets, how storage can participate in the market, and what charges are incurred by a BESS owner. However, given that a near-term BESS project cannot be compensated for ancillary services due to the current market rules, the economic impacts associated with asset classification are limited.

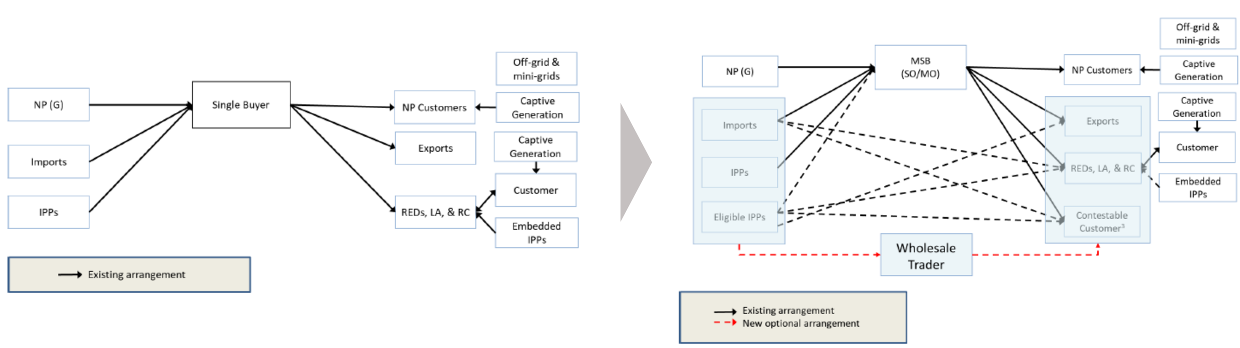
- **Lack of interconnection guidelines:** The Transmission Grid Code and Distribution Grid Code do not contain requirements for the integration of energy storage systems into the power grid. The RINA Consulting energy storage study recommends a review and amendments to the Grid Codes' provisions to include energy storage systems, however these activities have not yet been completed, and a timeline for their completion has not been shared. In particular, including guidance around protection related requirements for system integration and SCADA requirements that account for the bidirectional capabilities of BESS are important elements that need to be accounted for. Additionally, since BESS can be integrated with renewable energy sources, it is important to define the appropriate parameters, such as ramp rate requirements, to enable integrated renewable energy and storage systems.
- **Lack of environmental and safety standards:** Namibia's environmental and safety regulations governing energy generation projects, distribution projects, and hazardous materials do not include provisions for energy storage systems. Therefore, the scope of requirements and procedures for battery storage have not yet been defined. Without a clear regulatory framework and guidelines, concerns of environmental and safety impacts may result in prohibitive delays in battery storage deployment.

The following sections outline each of these potential barriers, their expected impact on CENORED's plans to deploy distribution-level battery storage, and actions that CENORED can take to mitigate this impact.

5.1 EVOLVING MARKET DESIGN AND TARIFF SCHEDULE

A variety of factors can create uncertainty when deploying energy generation projects, including variability in fuel prices, continued technological development, and economic volatility. In Namibia, the ongoing shift to the MSB market framework has the potential to magnify these factors and the resulting project risks for battery storage deployment in the near term because the impacts and timing of these market changes are still under evaluation. As an early entrant in the battery storage space, CENORED has the opportunity to influence the development of the rules that could impact battery storage deployment. Figure 1 shows the scope of the proposed changes to Namibia's electricity market, from the existing single-buyer model to the final phase (Phase 4) of the MSB framework.

Figure 1: Market Evolution from Single-Buyer Model to MSB Phase 4[2]



[2] "Namibian Electricity Sector Detailed Market Framework Design." ECB, June 2018

The downstream effects of these changes and broader market shifts resulting from increased renewable energy penetration have already begun to surface in the form of expected revisions to the NamPower transmission tariff schedule for 2019/20. According to a presentation given by NamPower to ESI stakeholders in March 2019, NamPower plans to change the seasonality and TOU periods of the tariff schedule beginning in July 2020 – removing the existing high/low season distinctions, shortening the morning week day peak period, and moving both the morning and evening peak period up by one hour. While the proposed changes to NamPower TOU tariffs included an adjustment of the seasonality of tariffs and new TOU periods, the actual changes announced in June 2019 provided the option to transition to a single season tariff schedule with no change to the actual TOU periods. The optional TOU single season schedule is illustrated in Figure 2.

Figure 2: Changes to TOU Seasonality in 2019/20 NamPower Tariff Application[3]

Seasonality	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current	Low	Low	Low	Low	Low	High	High	High	Low	Low	Low	Low
New	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same

These shifting market dynamics increase the likelihood of changes to market rules, products, and prices during the lifetime of a battery storage deployment. The ability of a battery storage asset to provide a variety of services can help mitigate the risk associated with these types of changes; however, under a third-party ownership model, this advantage is contingent on the flexibility of the contract structure and terms. Some third-party contract structures, such as capacity agreements that incorporate a fixed fee for the capacity of the system made available to the off-taker, allow for more flexible use of the asset than others. Another approach to increasing the flexibility of third-party contracts is to include a re-negotiation clause that is triggered by significant market changes, however these types of clauses can result in less competition in the procurement and/or higher bid prices.

These NamPower TOU tariff changes will likely impact the costs and benefits of CENORED's defined battery storage use case, since the projected cost savings associated with the system's energy and demand charge management applications are based on peak consumption levels and account for the high/low seasons applied to the existing bulk tariff. Due to the potential impact of the tariff changes, SAEP updated the NamPower TOU tariff to reflect the single season tariff as part of the refined cost-benefit analysis.

Recommended Actions for CENORED

- Explore contract structures and terms with a developer that allow for price and service flexibility in the case that market changes have a significant impact on project economics. While CENORED may not be able to pre-define all details of the contract, it should include provisions that define specific regulatory and commercial risks, and provide instances that could trigger negotiations with a developer.

5.2 LIMITED REVENUE COMPENSATION MECHANISMS

Under current SAPP operating guidelines, NamPower falls within Eskom's control area. As a result, NamPower currently does not provide any ancillary services for Namibia's transmission system, except for requiring that generators have Automatic Generation Control (AGC) capabilities to respond to frequency deviations. There is also no mechanism that NamPower can use to compensate domestic sellers for these services.[4] This restricts the available revenue streams for battery storage services to energy arbitrage functions and, in doing so, reduces the bankability of storage projects that could otherwise also sell capacity and ancillary services. While implementation of Phase 1 of the MSB started on September 1, 2019, this phase does not include provisions for creating ancillary services and capacity markets. According to the Namibia MSB Market Rules draft document, a market for specific ancillary services may be established in future phases of the MSB. According to an ECB workshop from September

[3] "Electricity Tariff Decrease 2019/2020: Transmission Customers." NamPower, June 2019

[4] "Energy Storage in Namibia." ECB, April 2018

2019, future markets and services would include the following outlined in Table 2 as part of Phase II, which is not set to begin until July 2026.

Table 2: Future Markets and Services from Phase II of the MSB

Future Markets
Day-ahead market
Intra-day market
Balancing market
Demand side participation
Specific ancillary services
Future Services
Facility to match short-term trading
Day-ahead ancillary services and balancing market trading platform
Access to regional trading
Financial trading platform

This suggests that revenue compensation mechanisms will be established for capacity and ancillary services in July 2026. However, it does not specify the associated pricing methodologies and service requirements for these markets. Given that these markets would not open until several years after the anticipated BESS would go into operation, and that pricing methodologies and service requirements have not yet been defined for capacity and ancillary services, prospective battery storage owners cannot adequately assess the potential value of providing the services.

Recommended Actions for CENORED

- Focus the refined cost-benefit analysis on the original battery storage use cases (energy and demand charge management and renewable capacity firming), as studied in Phase I of the Battery Storage Assessment activity, since specific guidelines for capacity and ancillary services are not yet available
- Engage the ECB to gain a better understanding of the timing, pricing methodology, and service requirements for capacity and ancillary services in the MSB and use this information to inform continued battery storage planning and procurement efforts

5.3 REGULATORY UNCERTAINTY IMPACTING PRICING

There are multiple methodologies that can be used to calculate the value of a product or service in electricity markets. Namibia currently uses a cost-based approach, per the guidance from the National Electricity Tariff Study, due to the lack of significant competition in the electricity market.[5] However, the recent energy storage study conducted by RINA Consulting proposes that the ECB shift to a willingness-to-pay approach for energy storage services, in which the ECB identifies issues facing the electricity market and potential solutions to these issues from a technology agnostic perspective. For example, meeting load demand during the evening peak period is currently reliant on imported power from neighboring countries. Therefore, under a willingness-to-pay approach, the cost of this service would inform the maximum price level for using energy storage systems (or other solutions) to displace spare generation capacity during these periods.[6] The RINA Consulting report recommends that the ECB conduct an initial valuation to set a ceiling price for these types of services and mentions additional considerations that ECB should address to guide energy storage procurement, including tender rules, financial incentives, and contract structures. However, it does not include specific guidance on the valuation of these price ceilings or associated regulatory measures. As CENORED is considering procuring BESS services from a third-party developer, the ECB

[5] "National Electricity Tariff Study." ECB, Nov. 2001
[6] "Energy Storage in Namibia." ECB, April 2018

would need to review and approve any PPA between CENORED and the BESS. If the ECB shifts to a willingness-to-pay approach and adopts a ceiling for valuing energy services, it should develop and distribute guidance similar to that which it provides for the cost-based valuation approach, especially for BESS. Doing so will help CENORED and a developer work together to ensure the PPA meets the requirements set forth by the ECB to avoid regulatory delays to project deployment.

Due to the early stage of Namibia's regulatory framework for pricing and procuring energy storage services, the ECB may be hesitant to approve a CENORED battery storage project prior to finalizing the regulatory measures. However, this may also present an opportunity for CENORED to help shape these measures and potentially frame a battery storage project as a test case for the operation of battery storage services and suitable contract structures.

Recommended Actions for CENORED

- Consider the willingness-to-pay valuation guidelines and tariff options outlined in the RINA Consulting report when determining the optimal contract structure for a battery storage project. The tariff options included in this Phase 2 report are (1) a time-variant PPA that incorporates off-peak and peak energy prices as an alternative to using a blended price, and (2) a fixed fee for energy storage capacity that can be supplied as and when the system operator requires it
- Encourage ECB to take proposed contract arrangements into account when promulgating regulations that govern energy storage procurement and, if appropriate, include a "grandfather" provision that exempts pre-established pricing arrangements from subsequent regulations or restrictions to provide certainty to investors that a project's revenue streams will not be jeopardized by future ECB guidance. However, given that the PPA between CENORED and a developer would result in reduced costs and improved service quality for CENORED and its end-users, there is limited concern around updated regulations impacting the PPA.

5.4 UNCLEAR ASSET CLASSIFICATION

Although the Electricity Bill in Namibia (2017) outlines that a license is required for the storage of electricity, clear rules surrounding the applicable requirements of electricity storage and how to obtain such a license have not yet been established. As a result, it is not clear how the legal framework in Namibia would account for the load and generation capabilities of an energy storage system.[7] From a grid interconnection perspective, energy storage systems are often treated as generation resources, however this definition does not account for the assets' unique bidirectional capabilities as both load and generator. For this reason, the lack of a clear classification for energy storage systems and the resulting uncertainty of their long-term treatment and code compliance can be a cause for concern among investors. The RINA energy storage report recommends that the ECB define energy storage as a distinct classification to allow a framework to be implemented for the technical, commercial, and regulatory requirements of energy storage assets, however this classification has not yet been established.[8]

Another issue that can arise in the absence of an asset classification and associated framework for energy storage assets is a lack of clarity regarding the charges incurred by grid-connected systems. The existing charging rules in Namibia are based on a distinction between generation and load. Therefore, under this set of rules, an energy storage system that both absorbs energy from the grid (i.e., load) and discharges back into the grid (i.e., generation) could be exposed to use-of-system charges, network load charges, and final consumption levies, adding to the project's operating costs, and therefore, changing the economics of the project. The RINA Consulting report advises the ECB to consider implementing regulations that exempt energy storage systems from some of these demand and generation charges when the system is providing benefits to the network (e.g., ancillary services), but these regulations have not yet been enacted. While exemption from these charges is a method recommended by the RINA

[7] "Electricity Bill." Republic of Namibia Parliament, 2017.

[8] "Energy Storage in Namibia." ECB, April 2018

Consulting report, the key takeaway is to ensure that the BESS owner is compensated for providing grid support services in a way that would allow for recovery of use-of-system charges.

However, such regulations would not have benefits for a near-term BESS project that was not able to provide grid support services that would warrant exemptions from certain demand and generation charges, as suggested in the RINA Consulting report. As a result, this consideration did not impact the refined cost-benefit analysis of Phase 2 of the CENORED Battery Storage Assessment. If a BESS project has the ability to provide and be compensated for grid support services in the future, CENORED should consider the impacts of demand and generation charges when providing ancillary services to the business case of procuring or owning the asset

In the case of a distribution-level energy storage system that is not selling to customers outside of the distribution network, transmission use-of-system charges do not apply. Distribution licensees in Namibia currently follow a postage stamp approach for distribution use-of-system charges and the detailed market design study recommends that the industry retain this approach in the MSB framework.[9] Therefore, the only charges in question for battery storage systems that provide services to customers within the same distribution network are the network load charges and final consumption levies. In the cost-benefit analysis conducted during Phase I of the Battery Storage Assessment, CENORED incurred the additional NamPower network load charges and final consumption levies associated with the system's grid-charging. If CENORED ultimately chooses to pass on these charges to the battery storage owner, or if the ECB requires this approach, the cost of the battery storage services will presumably increase to reflect this shift in cost allocation.

Recommended Actions for CENORED

- Encourage the ECB to expedite the classification of energy storage as a distinct asset and creation of underlying rules to govern its technical, commercial, and regulatory requirements

5.5 LACK OF INTERCONNECTION GUIDELINES

The Transmission Grid Code and the Distribution Grid Code of Namibia do not currently include guidance for integrating energy storage systems into the national electricity grid. While NamPower has developed a set of technical guidelines for the integration of renewable energy facilities and other embedded generation, these guidelines have not yet been expanded to include energy storage systems. The RINA Consulting report recommends the consideration and amendment of two areas in this review:[10]

1. Protection-related requirements for system integration and maintaining system operations in accordance with governing standards and industry practices.
2. SCADA and communication requirements to the system operator in which the additional communication and information required from the system operator for inclusion of ESS should be defined.

Until this review is completed, the lack of interconnection guidelines for energy storage systems has the potential to delay the interconnection process for a CENORED battery storage project. In Great Britain, the following elements were recommended to be reviewed and updated to account of energy storage systems:[11]

- Frequency variations, frequency response, and governor behavior
- Voltage variations, reactive power capability, voltage control capability, voltage waveform quality and response to voltage fluctuations
- Fault ride through and behavior under fault conditions

[9] "Namibian Electricity Sector Detailed Market Framework Design." ECB, June 2018
[10] "Energy Storage in Namibia." ECB, April 2018
[11] "Grid Code Issue Pape: Provisions for Energy Storage in the Grid Code." National Grid, May 2016.

While these specific elements have been called out, it is important to note that an exhaustive review of the Transmission and Distribution Grid Codes should be conducted to identify all areas that would be impacted by the inclusion of energy storage systems. In Great Britain, multiple workgroups were formed to define a comprehensive set of updates to the Grid Code to account for the incorporation of energy storage systems.[12]

Recommended Actions for CENORED

- Require adherence to Institute of Electrical and Electronics Engineers (IEEE) standards and leading practices for battery storage interconnection in a battery storage procurement, including:
    a. IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems
    b. IEEE P2030.2.1: Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems
    c. IEEE P2030.3: Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
- Monitor updates from the Namibian Standards Institution on interconnection standards and NamPower's review of the technical guidelines for renewable energy integration; if possible, CENORED should provide input to the Namibian Standards Institution to align Namibian standards with international standards.

5.6 LACK OF ENVIRONMENTAL AND SAFETY STANDARDS

Namibia's Environmental Management Act establishes environmental planning requirements for energy generation and distribution activities, including the completion of an Environmental Impact Assessment (EIA) and issuance of an Environmental Clearance Certificate by the Ministry of Environment and Tourism. According to the legislation, the Minister of Environment and Tourism via the Environmental Commission determines categories of activities in which an EIA is required based on the size, production capacity, and other relevant project considerations. Based on the established categories, energy storage projects under the size and capacity threshold may be exempt from environmental and ecological studies. Further energy storage coupled with solar PV may not be explicitly covered by the existing rules.[13]

The Environmental Management Act requires an EIA for projects that involve the storage of hazardous substances. Given the chemical composition of many battery technologies, including lithium-ion and flow vanadium, these products may be classified as hazardous materials and will need to be handled according to relevant regulations. In Namibia, the Hazardous Substances Ordinance and Pollution Control and Waste Management Bill regulate the use, transportation, and disposal of hazardous substances and thereby influence the costs and responsibilities for projects that involve them. However, the existing regulations do not contain specific measures for the application of these rules to battery energy storage procurement.

Without a clear regulatory framework and guidelines for managing these aspects of a battery storage project, delays in development could arise due to concerns of environmental impacts.

Recommended Actions for CENORED

- Require adherence by developers to relevant Namibia regulations in a battery storage procurement, including:
    a. Environmental Management Act
    b. Environmental Impact Assessment Regulations
    c. Hazardous Substances Ordinance
    d. Pollution Control and Waste Management Bill
- Require adherence by developers to IEC standards and leading practices for solar and battery storage environmental issues in a battery storage procurement, including:
    a. IEC 62933: Electrical Energy Storage (EES) Systems, Part 4-1: Guidance on Environmental Issues

[12] "GC0096 Modification Title: Energy Storage, Draft Final Modification Report." National Grid ESO. 2019.
[13] "Energy Storage in Namibia." ECB, April 2018

b. IEC 62619: 2017 - Secondary Cells and Batteries Containing Alkaline or Other Nonacid Electrolytes
c. IEC 62485: Safety Requirements for Secondary Batteries and Battery Installations
d. IEC 62281:2016 - Safety of Primary and Secondary Lithium Cells and Batteries During Transport
e. United Nations (UN) 38.3: UN Manual of Tests and Criteria for the Transportation of Dangerous Goods, Lithium Metal and Lithium Ion Batteries

6 PROCUREMENT LEADING PRACTICES REVIEW

To procure battery storage services, CENORED should complete additional planning tasks, generate requirements, and determine an appropriate procurement method. This section outlines key inputs to these activities based on findings from Phase I of the Battery Storage Assessment, the Market and Regulatory Assessment contained in this report, global leading practices, and interviews with national and regional power sector stakeholders. These inputs can be organized into the five sequential stages of a BESS project illustrated in Figure 3: planning, procurement, deployment, operations and maintenance (O&M), and decommissioning.

Figure 3: BESS Project Lifecycle[14]

Planning	Procurement	Deployment	Operations and Maintenance	Decommissioning
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	If the planning process determines that a BESS project is feasible, the prospective BESS owner or off-taker initiates a procurement based on the defined minimum requirements. **Key Activities:** • Procurement Development • Bid Evaluation and Contract Issuance	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 Ops • Maintenance • Environmental and Safety Reporting • Operational Needs Revisions and Re-commissioning (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:** • De-commissioning • Second Use / Relocation • Recycling or Disposal

CENORED is currently in the planning stage of the BESS project lifecycle, having already identified relevant battery storage applications, conducted a cost-benefit analysis of battery storage, and evaluated market and regulatory measures impacting BESS deployment as part of the Use Case Evaluation task. To advance the project to the

[14] ESIC Energy Storage Implementation Guide. EPRI, Palo Alto, CA: 2017. 3002010896

procurement stage, CENORED must complete a two additional planning tasks: Ownership and Contract Structure Selection, and Documentation of Minimum Requirements. Figure 4 below outlines the detailed tasks within the planning and procurement phases of a BESS project lifecycle. This section of the report addresses the remaining planning tasks and provides guidance to help inform the first procurement task, Procurement Development.

Figure 4: BESS Planning and Procurement Activities

Planning			Procurement	
Use Case Evaluation	Ownership and Contract Structure Selection	Documentation of Minimum Requirements	Procurement Development	Bid Evaluation and Contract Issuance
✓ Identify relevant BESS applications and services ✓ Conduct cost-benefit analysis of BESS compared to alternative solutions • Evaluate market and regulatory measures impacting BESS deployment	• Select BESS ownership model • Establish procurement approach (BESS or PV and BESS) • Determine BESS contract structure, payment mechanisms, and contract tenor	• Define technical requirements (e.g., system and operational, interconnection, land, safety) • Determine performance guarantees and warranties • Identify finance and funding requirements	• Select BESS procurement method • Develop scope of work and supplemental documents • Develop bid evaluation criteria • Initiate BESS procurement	• Review BESS bids • Conduct contract negotiations (if applicable to procurement method) • Select winning bid and finalize contract • Receive approval on bid selection and final contract from relevant stakeholders

6.1 OWNERSHIP AND CONTRACT STRUCTURE SELECTION

6.1.1 OWNERSHIP MODEL

One of the primary considerations for a battery storage project is determining who should own and operate the assets. This decision has broad implications the project's design, costs and revenue streams, contract structure, and feasibility. Front-of-the-meter battery storage ownership models can be separated into three broad categories: utility ownership, third-party ownership, and hybrid ownership.

- **Utility Ownership:** The utility owns and operates the energy storage system but may contract out the construction of the system. The utility has a choice of procuring a storage system piecemeal, through separate acquisitions of the component parts, or procuring the entire system on a turnkey basis. To date, turnkey contracts for modular storage systems have been more commonly used by utilities to procure energy storage systems. Turnkey acquisitions relieve the utility from specifying each subsystem and managing the procurement and installation processes separately.

- **Third-Party Ownership:** A third-party owns and operates the energy storage system and provides specific services according to contractual agreements. Under a third-party ownership model, a third-party owns, operates, and maintains the energy storage system and provides services to one or more off-takers according to contractual agreements. This structure is similar to that used for power purchasing agreements

(PPAs) with independent power producers (IPPs), typically defined by a contract duration, fixed and variable payments, plant availability assurance, and performance obligations. Storage performance obligations should include operating parameters specific to the procured technologies. One of the main advantages of third-party ownership is that it shelters utilities and end-users from financial and technology risks. It is most commonly used to procure energy storage services alongside renewable energy projects owned by IPPs.[15]

- **Hybrid Ownership:** Both a utility and a third-party developer have an ownership stake in the BESS and establish roles and responsibilities for the lifecycle of the project. A hybrid ownership model may involve the formation of a special purpose vehicle (SPV) by the utility and developer and various contract structures may be created to divide the responsibilities of the project. A hybrid ownership model would share the financial and technology risk of a BESS project between two entities, which may provide an advantage to both the utility and the developer.

CENORED expressed a preference for third-party ownership in Phase 1 of the project to shift the majority of the project's financial and technology risk to an IPP and avoid making a large capital investment in a battery storage facility. Assuming CENORED receives technical assistance managing the BESS procurement process and is able to identify an experienced project developer, a third-party ownership model will likely result in a timelier and more cost-effective project. While a third-party model does not allow for the same flexibility as direct ownership, CENORED's current battery storage use case involves a predictable power flow for energy and demand charge management and, therefore, can be treated similarly to a traditional generation power purchase agreement. In many cases, this arrangement is also more attractive for lenders, as it assures consistent cash flows over the life of the project. Table 3 outlines the primary advantages of utility, third-party, and hybrid ownership models.

Table 3: Advantages of Utility, Third-Party, and Hybrid Ownership Models

Utility Ownership	Third-party Ownership	Hybrid Ownership
• Offers additional flexibility to modify the types of services provided by the BESS to adapt to changes in operational needs or market forces • Allows for more direct control over BESS availability and usage • Enables BESS to provide ancillary services in regions where competitive ancillary markets or other payment mechanisms do not exist • May be the only option for utilities that are not creditworthy off-takers or do not have the capacity or experience required to effectively manage a competitive procurement • May be simpler for DFIs to provide financing to a government-affiliated utility	• Transfers the majority of the project's financial and technology risk to a third-party • Does not require a large capital investment in the BESS plant, property, and equipment • Contracting BESS services from third-party developers with experience operating and maintaining BESS may result in lower prices and higher performance • Payment mechanisms used in third-party contracts, such as capacity payments and take-or-pay PPAs used in third-party contracts, may be more attractive to lenders	• Shares the project's financial and technology risk between the utility and third-party • Utility can leverage the expertise of a developer or an engineering, procurement, and construction (EPC) for project responsibilities that are unfamiliar to the utility (e.g., BESS operations) • Creates an opening for DFI financing when those DFIs are required to lend to a government-affiliated entity

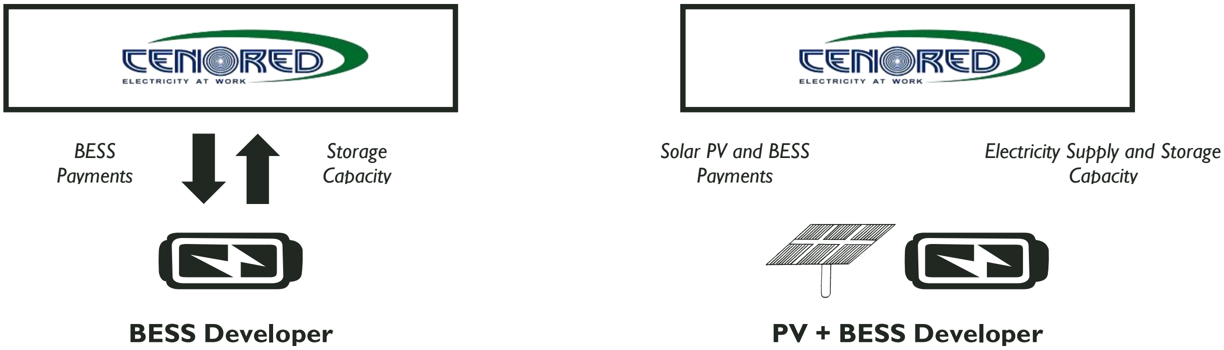
6.1.2 PROCUREMENT APPROACH

Phase 1 of the Battery Storage Assessment found that the feasibility of the CENORED battery storage use case is dependent on access to low-cost solar PV energy. Therefore, to facilitate this use case, CENORED must determine

[15] "Electricity Storage Handbook in Collaboration with NRECA, Rev 1." US Department of Energy and Electric Power Research Institute, 2015.

whether to procure battery storage services together with solar PV power or procure each separately. Figure 5 outlines these two procurements approach options.

Figure 5: Procurement Approach Options



Selecting the appropriate approach involves considering impacts to contract structure, procurement and deployment timelines, and technology performance. Table 4 describes advantages and disadvantages associated with a separate BESS procurement and a combined solar PV and BESS procurement.

Table 4: Procurement Approach Comparison[16]

	Separate BESS Procurement	Combined Solar PV and BESS Procurement
Advantages	• Reduces technology performance and lifespan dependencies • Increases transparency of payment mechanisms	• Creates opportunities for project design synergies and cost savings • Allows for a single procurement and bid evaluation process • Offers a single developer as a point of contact during construction and operation of the solar PV and BESS
Disadvantages	• Eliminates opportunities for project design synergies and cost savings • Requires multiple procurement and bid evaluation processes • May increase charging costs for BESS	• Creates additional technology performance and timeline dependencies • May limit procurement competition • Often requires a more complex contract structure

Due to design synergies and the presence of a single third-party owner, a combined procurement will likely result in lower capital and operating costs for the BESS – such as BESS charging costs – and may result in lower prices for CENORED. Additionally, the combined solar PV and BESS procurement also allows CENORED to avoid holding multiple procurements and evaluations that can delay the deployment of the assets. While there are potential disadvantages to holding a combined procurement, these can be mitigated using the contract structure. Payment mechanisms and performance guarantees included in the contract for the solar PV and BESS procurement can be designed in a manner that reduces dependencies between the solar PV and BESS and fairly values distinct BESS services. Although a combined solar PV plus BESS procurement can reduce competition among bidders, it will likely attract a narrow pool of qualified bidders capable of developing this type of project. This can make the process of evaluating bids simpler for CENORED, saving time and resources.

[16] Fitchner Engineering and Consulting PV-storage workshop materials; interviews with JCM and Tesla

6.1.3 CONTRACT STRUCTURE

Although battery storage contracts are not yet standardized around the globe, the recent growth in BESS deployments has yielded some common contract structures that account for the unique value propositions and characteristics of BESS. These contract structures differ based on the project's ownership model. Although CENORED is interested in pursuing a third-party ownership model for battery storage services, it is important to note that utility-owned and hybrid-owned BESS contract structures also have their own advantages, such as system integration and operation responsibilities. Table **5** outlines common contract configurations for utility-owned BESS projects.

Table 5: Utility-Owned BESS Contract Structures[17]

Contract	Description
Turnkey	The utility purchases a turnkey BESS asset from a developer, integrator, or EPC at a particular price on a specific date. Turnkey contracts generally come with performance guarantees and may come with operations and maintenance (O&M) agreements with the developer or EPC contractor.
Sale-leaseback	The utility or reliability provider purchases a BESS to provide reliability services. The utility then leases the BESS back to a developer for a specified time to use in the market.

Hybrid-owned BESS contract structures can provide their own advantages to a utility by allowing the utility to mitigate some financial and technology risk by leveraging a third-party developer's BESS experience across the project lifecycle. Table 6 outlines common hybrid-owned BESS contract structures; however, these are not exhaustive and additional contract structures involving both a utility and developer can be created to fit the needs of specific projects.

Table 6: Hybrid-Owned BESS Contract Structures[18]

Contract	Description
Owners Engineer/ Hybrid	The utility is more involved in the project development phase than in a turnkey contract and works with a third-party developer that provides technical and subject matter expertise to develop a BESS project. This arrangement may involve forming an SPV for legal purposes and to clarify responsibilities between the utility and developer.
Utility as System Integrator	The utility purchases a turnkey BESS asset, but it functions as the integrator of the system by a managing the construction, installation, and the vendors involved. This arrangement may involve forming an SPV for legal purposes and to clarify responsibilities between the utility and developer.

Third-party BESS contract structures, on the other hand, can be organized into two sub-categories based on the BESS procurement approach: separate or combined with solar PV. While the separate BESS procurement contracts provide mechanisms for a developer to receive compensation for BESS services, they do not account for how the solar PV asset would fit into the system; as a result, it would require its own separate contract. Table 7 outlines the commonly used contract structures that have been used for third party-owned BESS projects and solar PV plus BESS projects. While these contract structures provide a good overview of the contract structures that have been employed, they are not exhaustive as variations of these structures and new innovative structures emerge as new projects are deployed around the world.

[17] "A Framework for Utility Procurement of Energy Storage." Global Energy Storage Alliance, 2017.

[18] "A Framework for Utility Procurement of Energy Storage." Global Energy Storage Alliance, 2017.

Table 7: BESS Third Party-Owned Contract Structures[19]

Contract	Description
Combined Solar PV and BESS Procurement	
Blended PPA	The PVS owner is paid a single PVS PPA unit price that accounts for the additional value provided by the BESS; the contract sets charge and discharge parameters for the BESS.
Solar PPA + BESS Capacity Payment	The PVS owner is paid a PPA unit price for the PV power output and a capacity payment for the BESS; the contract sets charge and discharge parameters for the BESS.
Variant PPA + Optional BESS Capacity Payment	Multiple unit prices exist for energy delivered at certain hours and/or energy delivered that has been cycled through the BESS; capacity payments may also be applied for the BESS.
Renewable Dispatch Generation	The PVS owner is paid based on the availability and performance of the system, similar to a tolling agreement; this includes a lump sum payment based on the net energy potential of the PVS (multiplied by a unit price), minus any discounts (liquidated damages) due to non-delivery of that potential.
Separate BESS Procurement	
Capacity Agreement	The BESS owner is paid a fixed capacity payment based on the value of the energy supply capacity the system provides to the network.
Tolling Agreement	The BESS owner is paid fixed capacity and variable O&M payments, subject to discounts for reduced availability and performance of the system; the utility dictates the BESS dispatch schedule and is responsible for costs associated with the purchase and sale of energy.

To select the most appropriate contract structure for CENORED, it is important to consider the advantages of the third party-owned contract structures and how they are used for combined solar PV plus BESS procurements. Determining the appropriate contract structure involves understanding the valuation of the BESS services provided in particular use cases. Based on the BESS services needed by CENORED, the structuring of NamPower TOU tariffs, and ECB guidance, the variant PPA and optional BESS capacity payment may be the most appropriate contract structure. The variant PPA and optional BESS capacity payment contract structure is effective when multiple unit prices are required to adequately value the solar PV and BESS services and incentivize usage of the asset during peak periods, which would align with CENORED's objectives of using the BESS to time-shift energy to minimize exposure to NamPower's TOU tariffs. The solar PPA and BESS capacity payment also has the potential to serve as a viable contract structure given CENORED's needs. RINA Consulting proposed that ECB value energy storage services using a willingness-to-pay approach that compares the price of a new product to the price of an existing product to set a price ceiling. In the case of CENORED, the existing "product" would be the current NamPower TOU tariffs and the new product would be the tariff for the solar PV + BESS. The solar PPA and BESS capacity payment would help CENORED realize cost savings while using the solar PV plus BESS asset for its intended objectives. However, the solar PPA and BESS capacity payment would not be able to provide the nuanced prices that the variant PPA could offer, resulting in potentially lower cost savings for CENORED.

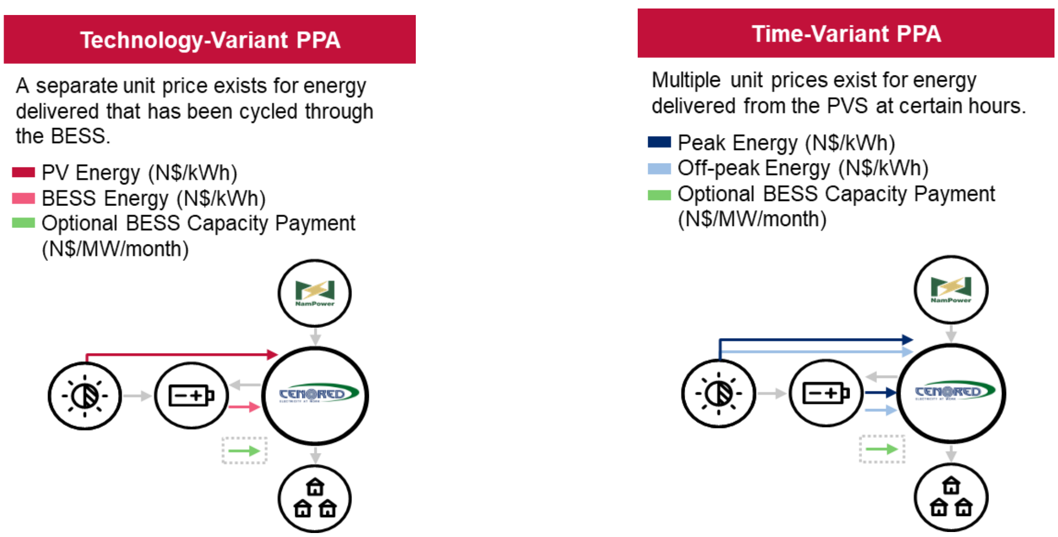
[19] "A Framework for Utility Procurement of Energy Storage." Global Energy Storage Alliance, 2017; "Energy Storage Update 2018." Orrick, 2018; "New PV-Plus-Storage Benchmark in Hawaii." Bloomberg New Energy Finance, 2019.

CENORED aims to derive value from the BESS through time-shifting generation from both the solar PV and the grid. The blended PPA structure would not benefit CENORED as much as the other options as it is used primarily when the BESS exclusively stores PV generation, not from the grid. Meanwhile, the renewable dispatch generation contract structure has been used in networks where there is a significant risk of curtailment due to high variable renewable energy penetration. CENORED does not currently observe this level of renewable energy penetration, therefore this contract structure option was not further evaluated.

6.1.4 PAYMENT MECHANISMS

A critical component of contract structures is how exactly the payment mechanism works between the developer and the off-taker. If CENORED chooses to employ a variant PPA and optional BESS capacity contract structure, it is important to determine (1) how the multiple PPA prices would vary, and (2) if a BESS capacity payment should be included. While there are a number of ways the variant PPA could be structured, SAEP proposed two different approaches: technology-variant and time-variant, shown below in Figure 6.

Figure 6: Variant PPA Payment Mechanisms



Technology-Variant PPA

Advantages:

- Decouples PV and BESS payments
- Allows for clear allocation of technology costs and benefits
- Aligns closely with BESS charge and discharge parameters

Disadvantages:

- More difficult to compare directly to NamPower energy charges

Time-Variant PPA

Advantages:

- Peak/off-peak prices could be tied to NamPower TOU tariff
- Allows for more direct comparison to NamPower energy charges
- Considered in RINA report

Disadvantages:

- Needs to be translated to/from BESS charge and discharge parameters

Under a **technology-variant PPA**, the off-taker pays a separate PPA price ($/kWh) for energy coming from the PV system and energy coming from the BESS with an option for a capacity payment ($/MW) to the BESS.

Under a **time-variant PPA**, the off-taker pays a standard, peak, and off-peak price corresponding to NamPower's TOU schedule, irrespective of whether the energy is delivered from the BESS or the PV system with an option for a capacity payment to the BESS.

When considering the advantages and disadvantages of a technology-variant and time-variant PPA, it is important to note that either mechanism would be effective in a solar PV and BESS project, but they would allocate costs differently to achieve the same cost savings for CENORED. Neither payment mechanism offers an advantage or disadvantage to the potential cost savings to CENORED, as this is determined by the tariff price. As SAEP conducted the analysis, tariff prices were set in a way that would result in equal cost savings using both a technology-variant and time-variant PPA. For example, to achieve cost savings equal to that of a solar PV plant in Tsumeb using a technology-variant PPA, CENORED would need a BESS tariff of N$ 2.65/kWh. However, if a time-variant PPA was used, CENORED would need a solar PV and BESS standard tariff of N$ 1.27/kWh in order to achieve the same cost savings as the solar PV plant. The solar PV and BESS peak and off-peak tariff prices would be set in a way similar to NamPower's peak and off-peak prices. Figures below highlight the different tariff prices for a technology-variant and a time-variant PPA at Tsumeb that would result in the same cost savings.

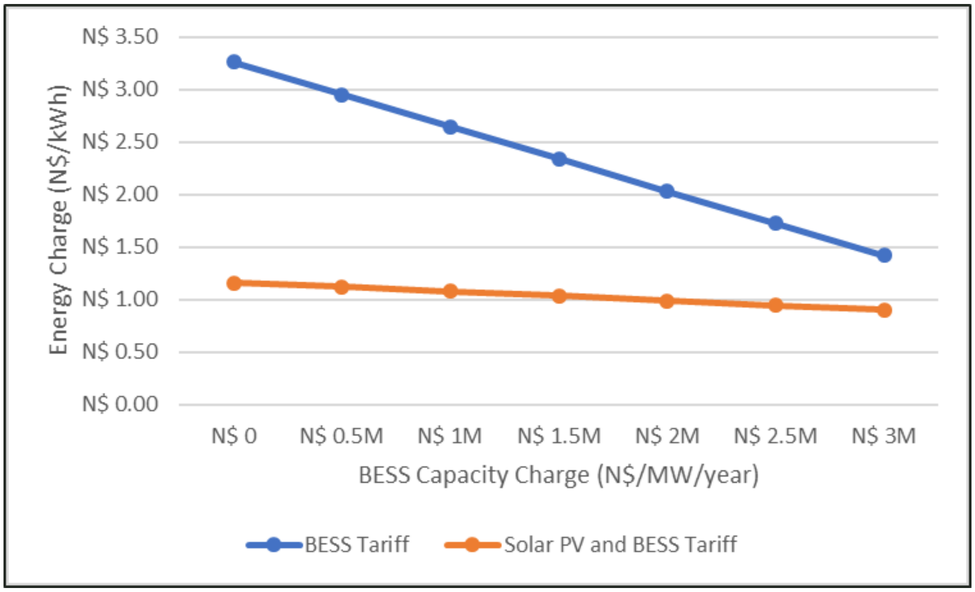
One of the major advantages associated with the time-variant PPA is the ability to tie and compare peak and off-peak prices to NamPower's TOU tariff. This becomes a more attractive option especially when considering NamPower's optional single season TOU tariff schedule. By employing a time-variant payment mechanism, CENORED could directly use NamPower's TOU tariff to determine an acceptable price it is willing to pay in order to achieve greater savings.

The other important question to answer is whether a BESS capacity payment should be included. BESS capacity payments are used to compensate the BESS as an "on-call" asset that holds a certain capacity available for production. Paying for BESS capacity can be an effective arrangement between a developer and an off-taker when the BESS is providing ancillary services or others that may not be consistently called upon. However, given the current market and regulatory environment in Namibia, a BESS project would not be able to provide these types of services. CENORED would be using the BESS for time-shifting and renewable energy capacity firming purposes, and CENORED has indicated it would be the sole off-taker of the services and energy from the BESS. Therefore a capacity payment is not justified.

However, Namibia's transition from a single-buyer model to an MSB model may provide an opportunity for a BESS to provide additional services that may be better suited for the optional capacity payment. Phase 1 of the transition to an MSB model would allow for the MSB to purchase ancillary services from licensed sellers.[20] With a significant update to the market and regulatory structures of the electricity market, a BESS developer may be able to provide these services and make use of these updates. Under those conditions, a BESS capacity payment could be warranted as a mechanism for compensating the asset holding capacity in reserve to provide ancillary services when called upon to do so. Figure 7 illustrates the potential impact of a capacity charge to the energy charge in both a technology-variant and time-variant payment mechanism in Tsumeb.

Figure 7: Tsumeb, Potential Energy and Capacity Charge Combinations

[20] "Detailed Market Design," New Energy, 2018.



6.1.5 CONTRACT TENOR

It is important to consider the contract tenor, which refers to the duration of the contract. Especially in the case of a combined solar PV and BESS, determining an appropriate tenor that accounts for the difference in lifespans between the two assets is essential to effective operation of the facility and execution of the PPA. From the initial deployment of the project, there are timeline inconsistencies that need to be accounted for. Due to differences in construction timelines, a BESS can begin commercial operation before the solar PV asset can come online, which can create some uncertainty around if and how the BESS will operate in the time before the solar PV asset begins its commercial operations. This can and should be addressed in the contract to ensure that either both assets come online simultaneously or that there is a specific clause in the contract to account for the operation and payment of the BESS prior to the solar PV's commercial operation. Additionally solar PV assets generally have a longer lifespan than BESS and many solar PV plus BESS contracts have terms that go beyond expected battery lives, which can cause concerns if this fact is not properly addressed in the contract tenor.[21] CENORED can mitigate this risk by including provisions in the contract for the augmentation of the BESS to ensure that the system provides the agreed upon services for the duration of the contract.

6.2 DOCUMENTATION OF MINIMUM REQUIREMENTS

6.2.1 TECHNICAL REQUIREMENTS

After identifying key characteristics of the ownership and contract structure for a BESS project, the next step of the planning stage involves defining minimum technical requirements for the system. These requirements are critical components of the procurement as they establish the criteria which responding developers must meet in their proposal submissions. Although CENORED is planning to procure services from the BESS and not own the asset, it is still important to include specific requirements that can ensure the safe and reliable delivery of agreed upon services to CENORED. The five key requirement categories that should be incorporated into the procurement are 1) system and operational specifications, 2) interconnection requirements, 3) communications and control requirements, 4) land/site requirements, and 5) safety requirements. Table 8 outlines considerations associated with each category along with guidance on how these specifications can effectively be developed. In order to appropriately define these requirements, CENORED should undertake a comprehensive feasibility study that examines each

[21] "Energy storage: drivers and pitfalls," Norton Rose Fulbright, 2017.

component in detail. CENORED should investigate the potential for obtaining grant funding from donor finance institutions (e.g., US Trade and Development Agency) to defray some or all of the cost of a feasibility study.

Table 8: Technical Requirement Considerations and Guidelines

Requirement	Consideration	Development Guidance
System and Operational Specifications[22]	Procuring entities should include information on the system's minimum requirements and its expected operation. Performance guarantees are generally set up in a way to ensure that these specifications are consistently met over the project's lifetime. System specifications may include: • Minimum level of power (kW) and energy (kWh) • Round trip efficiency • Type of BESS technology (optional) • Cycle life • BESS/project life Operational specifications may include: • Predetermined or required ramp rates • BESS duty cycles (charge and discharge) • BESS applications (e.g., demand charge management, ancillary services, etc.)	For CENORED, system and operational specifications may be informed by the cost-benefit analysis conducted in Phase 1 of the assessment. With the exception of ramp rates, the system and operational specifications have been defined in Phase 1; however, further optimization of the sizing and other attributes may occur, as necessary.
Interconnection[23]	Procuring entities should include the following requirements related to BESS interconnection: • Location of the interconnection point • Protection schemes and devices • Capacity and power quality related constraints • Interconnection site requirements (e.g., access roads, security)	Prior to defining interconnection technical requirements, CENORED should coordinate with ECB to understand what storage interconnection requirements will be in the updated National Grid Code. As part of the procurement development process, CENORED should identify specific points of interconnection along with accompanying requirements (e.g., grid impact study) to ensure safe interconnection and operation with the grid. • IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems • IEEE P2030.2.1: Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and

[22] Energy Storage Procurement Guidance for Municipalities. Sandia National Laboratories, Albuquerque, NM: 2016.
[23] ESIC Energy Storage RFP Guide. EPRI, Palo Alto, CA: 2017. 3002011738.

Requirement	Consideration	Development Guidance
		Mobile, and Applications Integrated with Electric Power Systems • IEEE P2030.3: Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
Communications and Control[24]	Procuring entities should include details on communications and control requirements that impact safe and reliable operation of the BESS and delivery of services, including: • Dispatch authority/remote operation • Specific SCADA points • Monitoring requirements • Required control functions and key control parameters • Cybersecurity requirements	As CENORED is not owning the BESS, specific details regarding all aspects of the communications and control systems may not be necessary. Relevant elements for CENORED to include in a procurement include outlining who will maintain dispatch authority over the BESS, required control functions and key control parameters, and cybersecurity requirements. Relevant standards to consider may overlap with IEEE interconnection standards, including: • IEEE P2030.2.1: Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems • IEEE P2030.3: Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
Land / Site	Procuring entities should include details on the land and site where the BESS will be located, to include: • Party responsible for providing the land for the BESS, along with accompanying responsibilities (e.g., permitting, environmental studies). • Physical site requirements (e.g., site access, security)	Prior to issuing a procurement, CENORED should determine the entity responsible for providing the land used for the BESS, including environmental studies in accordance with Namibian laws and regulations, such as: • Environmental Management Act (2007) • Environmental Impact Assessment Regulations (2012)
Safety[25]	Procuring entities should outline domestic and international safety standards that must be	CENORED should identify the relevant national and international safety

[24] ESIC Energy Storage Implementation Guide. EPRI, Palo Alto, CA: 2017. 3002010896

[25] ESIC Energy Storage Implementation Guide. EPRI, Palo Alto, CA: 2017. 3002010896; Energy Storage in Namibia. ECB/RINA, Namibia: 2018.

Requirement	Consideration	Development Guidance
	adhered to across the construction, installation, deployment, operation, and decommissioning phases of a BESS project.	standards associated with BESS to incorporate as requirements for a procurement, including: Namibia: • SAN10400 Building code applies for all requirements for handling fire suppression in buildings and smoke extraction (adopted from South African standards) • Hazardous Substances Ordinance 14 of 1974 • Pollution Control and Waste Management Bill International: • IEC 62933 - Electrical Energy Storage (EES) systems • IEC 62619: 2017 - Secondary cells and batteries containing alkaline or other nonacid electrolytes • IEC 62485: Safety requirements for secondary batteries and battery installations • IEC 62281:2016 - Safety of primary and secondary lithium cells and batteries during transport • UN 38.3 (United Nations): UN Manual of Tests and Criteria for the Transportation of Dangerous Goods, Lithium metal and lithium ion batteries

6.2.2 PERFORMANCE GUARANTEES

Given the nascent stage of BESS technology and limited operational experience, performance guarantees are often a critical component of BESS contracts. Performance guarantees commit the developer or EPC contractor to a minimal operating performance of a BESS given its operational and environmental conditions.[26] These guarantees serve as a risk mitigation tool for an off-taker receiving specific services from a BESS asset to ensure timely and adequate delivery of services. In the event that the BESS cannot provide the agreed upon services, corrective action must be taken, often in the form of reduced payments by the off-taker and/or repair/replacement of the BESS. Guarantees also improve the bankability of the project by incentivizing the developer to provide the agreed upon services and thereby receive appropriate and regular compensation for the asset's services.

[26] "Energy Storage Financing: A Roadmap for Accelerating Market Growth," Sandia National Laboratory, 2016.

Comprehensive performance guarantees in BESS contracts consist of four main elements: (1) metrics/functions to be tested, (2) guidance on how testing will occur, (3) timing and frequency of testing, and (4) recourse for non-compliance of meeting guarantees. CENORED should include provisions for the types of performance guarantees it expects developers to provide. Table 9 below outlines common elements of performance guarantees that should be included in a contract for a BESS project.

Table 9: Performance Guarantee Considerations

Guarantee Element	Considerations
Metrics/Functions	At a minimum, CENORED should provide guidance on the following parameters a bidder must guarantee the following for a BESS project: • *Availability:* the amount of time a BESS system can perform at an expected level over a specified period • *Capacity:* the amount of average power and energy that can be discharged by a BESS; capacity should be measured as instantaneous capacity (MW) and in durational/sustained capacity (MWh) • *Round-trip Efficiency:* the amount of energy that can be discharged from the battery relative to how much was charged into the battery While the guarantees mentioned above are the main ones considered for BESS, they are not exhaustive, and additional guarantees may be included depending on legal, regulatory, and project requirements. Examples of additional guarantees include: ramp rate, charge and discharge rate, and subsystem performance.
Guidance on Testing	Currently, there are not clear market or industry standards for the tests to confirm BESS performance guarantees. However, the Energy Storage Integration Council (ESIC) has published an Energy Storage Test Manual to measure BESS performance and functionality. While this test manual provides guidance, it is important to remember that leading practices for BESS operations are evolving. Including provisions to adapt testing procedures to industry leading practices may be beneficial for a long-term project.
Timing/Frequency of Testing	Testing to ensure compliance with performance guarantees should occur at the following times to ensure agreed upon requirements of the battery throughout its lifetime: • *Commercial Operation Date:* Conducting the appropriate tests that correspond to ensuring the performance guarantees are met should be a requirement after the installation and before the deployment of the BESS • *Specified Intervals:* Regular testing and confirmation of the performance guarantees over the lifetime of the contract should be included to address any concerns to ensure the BESS is able to provide agreed upon services
Recourse for Non-compliance	The inclusion of performance guarantees in a contract is important because of the protection it offers the off-taker from a failure to receive agreed upon services from the BESS. This protection comes in the form of recourse taken when performance guarantees are not met. The following outline common, but not mutually exclusive, approaches included as penalties for non-compliance: • *Liquidated Damages:* Adjustments (reductions) in payment according to pre-determined criteria and formulas will be triggered when performance guarantees are not satisfied • *Obligation to Repair/Replace:* A developer will repair, augment, or replace the BESS in order to achieve the performance guarantees set forth in the contract

Performance guarantees are critical to de-risking a BESS project, and SAEP recommends including explicit guarantees in a contract structure. However, as shown above, determining the parameters around performance guarantees is not a simple task and requires its own well thought out structure after optimizing and finalizing the specifications and duty cycles of a BESS and potentially determining the payment mechanisms for the contract if using liquidated damages. While it is noteworthy that guaranteed performance may result in higher prices, due to the additional risk a developer.

- **Metrics/Functions:** SAEP recommends that CENORED define parameters around the metrics and functions after the minimum technical requirements for each solar PV plus BESS project is defined. Maintaining consistency between the minimum technical requirements for the system and the performance guarantees provides a simple, yet effective approach to setting up the requirements of a performance guarantee. As CENORED is focused on a solar plus BESS project and not a standalone BESS, it will be important to consider any implications and necessary adjustments to performance guarantee metrics that can arise due to the co-location of the solar PV and BESS. If CENORED chooses to proceed with a combined procurement but include decoupled payments for the solar PV and the BESS, SAEP recommends including separate performance guarantees for both assets to maintain transparency regarding the costs and performance associated with each.
- **Guidance on Testing:** While the ESIC Test Manual can serve as a guide on how to test BESS for particular functions, CENORED should accompany its review of the Test Manual with interviews with BESS developers and SMEs to ensure the appropriate tests are being used to confirm adherence to the performance guarantees.
- **Timing/Frequency of Testing:** SAEP recommends that CENORED adhere to industry leading practices and confirm adherence to performance guarantees through tests as a condition at the contract's commercial operation date (COD) as well as specified intervals through the lifetime of the contract.
- **Recourse for Non-compliance:** SAEP recommends CENORED include liquidated damages and an obligation to repair/replace a BESS as penalties for non-compliance. Including provisions for both as penalties can help CENORED achieve its cost savings goals while also ensuring the longevity of the BESS.

6.2.3 WARRANTIES

Warranties for BESS are often discussed along with performance guarantees, but their significance to a project justifies a separate discussion. Suppliers will often provide warranties for BESS components, such as the battery, power conversion system, transformers, switchgears, and controls.[27] Often time, these warranties by equipment manufacturers and suppliers serve as a backstop to performance guarantees by developers and EPC contractors. While it is clear that warranties are critical to understand for a BESS project, the implications of warranties differ depending on the ownership model of the BESS. Utility-owned BESS projects require additional considerations as to how exactly warranties are structured and how they can be called upon because the utility may need to make use of the warranty if any issues arise. In addition to the scope and lengths of warranties, another important consideration for utility-owned BESS projects is understanding if there is a fully wrapped warranty or separate warranties with different suppliers. A fully wrapped warranty provides a single mechanism that bundles all of the warranties that comprise the BESS under one entity.[28] This provides a simpler method for utilities to manage the warranties associated with their system. However, for third-party owned BESS projects, the procuring entity does not need to be as involved with the warranty. Instead, the advantage of a third-party ownership model involves transferring the technology risk to a developer. This technology risk component includes managing the various warranties associated with the different BESS components.

[27] "Energy Storage Integration Council RFP Guide," Electric Power Research Institute (EPRI), 2017.
[28] "Energy Storage – Network Services," RES, 2016.

As CENORED is not planning to own the BESS and will instead procure services from a third-party developer, the significance of the warranty relates to how a developer can back up its performance guarantee in the event of equipment failure. CENORED should mainly be focused on structuring a comprehensive performance guarantee for the BESS. The developer, in turn, should be responsible for securing the appropriate warranties to be able to maintain the performance guarantee. However, this does not imply that CENORED should not be mindful and aware of the warranties that suppliers for the BESS project offer. SAEP recommends that CENORED include a component in a procurement for bidders to provide information on the warranties for BESS components. While CENORED will not directly need to make use of these warranties, they are important in understanding how resilient proposed BESS projects can be.

6.2.4 FINANCE AND FUNDING REQUIREMENTS

There is limited private debt financing activity for grid-scale BESS applications in Southern Africa generally. Discussions with donors, project developers, and energy storage manufacturers indicate that lenders are hesitant to engage in this sector given the nascent regulatory framework governing energy storage and the limited range of applications and revenue streams for BESS. In conversations with SAEP, the World Bank and KfW have indicated they are open to providing concessional financing for a BESS project after a level of financial and technical analysis had been conducted. However, because the current assessment shows that a standalone solar PV project would yield greater savings than the solar PV and BESS project, it is unlikely that this project would receive discounted debt, unless the money came from a source that was focused on increasing the adoption of BESS.

Additionally, an investment bank in South Africa, Investec, mentioned its interest in providing discounted debt for a small, pilot-scale BESS project in Namibia. As Investec provides financing as well as project development support, CENORED's BESS project poses an opportunity for Investec to develop experience with BESS while furthering the proposition of future BESS projects in Namibia. While this holds potential, CENORED should further engage with Investec and other financial institutions to understand the requirements of a pilot-scale project and the terms and conditions of their involvement in such a project.

6.3 PROCUREMENT DEVELOPMENT

6.3.1 PROCUREMENT METHOD

After the planning phase of a BESS project, the next phase is to develop the procurement. One of the first questions that must be answered early on in this process is what kind of procurement method should be used. While there are many variations of different procurement methods, there are five overarching categories of procurement methods that are used in various situations. While no one method is superior to the other, each method carries its own advantages and disadvantages. Selecting the most appropriate procurement method requires considering the motivations and goals of the project. Table 10 outlines the five overarching types of procurement methods.

Table 10: Procurement Methods[29]

Method	Description
Request for Tender	A procuring entity will announce a project with clearly defined criteria that is open to all qualified bidders. Bids are evaluated based on their ability to provide services needed at the lowest cost.
Restrictive Tender	A procuring entity will select and invite companies to bid on a project with clearly defined criteria.

[29] 6 Procurement Methods: Obtaining Quality Goods and Services. Udemy: 2014.

Request for Proposals (RFP)/Request for Offer (RFO)	A procuring entity will seek solutions-based proposals to meet a specific need but may not have a clear idea of what the solution should be. Bidders will submit a separate technical and financial proposal. Next, the procuring entity and the selected bidder have the ability to negotiate the technical and financial proposal to reach an agreement.
Request for Quotations	The procuring entity obtains price quotes for a project with clearly defined criteria. Bids are evaluated based on price only.
Single Source	The procuring entity issues a request for a project from a sole provider. This method is not competitive and should only be used in specific circumstances.
Request for Information (RFI)[30]	An RFI is not an independent procurement method but can be an effective tool that precedes one of the above methods. RFI are employed to gain more information about the potential options that exist for services or products in a marketplace and do not always result in a future procurement.

Given the fact that BESS is still considered a nascent and evolving technology, a procurement method that offers insights into available BESS technology and service options and provides the ability to negotiate technical parameters with experienced developers can provide CENORED with the flexibility to adapt to developments in the BESS market through incorporating lessons learned by developers on previously deployed projects. As a result, CENORED may benefit from using an RFI and RFP/RFO procurement method. The RFI would provide CENORED with a better understanding of the different technologies and solutions from interested bidders. After evaluating the information from the RFI, CENORED can choose to develop a solar PV and BESS RFP/RFO. As this would be the first utility-scale BESS project in the country, working with experienced developers would equip CENORED with knowledge and best practices to successfully deploy a BESS project in the future. Additionally, this early collaboration between CENORED and the developer can help identify and mitigate project risks early on in the process, increasing the likelihood of the project's deployment. While the negotiations aspect of the RFP/RFO approach has many benefits, it is important to highlight the associated potential risks. Negotiations between CENORED and the developer may result in a lengthier procurement process that delays project deployment, and additional negotiations carries the potential risk that modified technical specifications may result in increased prices. While these risks exist, they can be mitigated and the overall benefits that are offered through this method make it an appealing option for CENORED to employ.

Given the size of the project, it will also be important for CENORED to potentially coordinate the procurement activities with the Central Procurement Board (CPB) for sensitization and general technical awareness. Based on documents that define the CPB's role to provide procurement guidance for public entities, and documents that define REDs in Namibia, it appears that the procurement rules from the CPB may not apply to CENORED as it is not a legally defined public entity incorporated through an Act of Parliament. According to the Public Procurement Act, public entities include a local authority, a regional council, public enterprises, and a body or trust that is owned or controlled by the Government. Additionally, the Minister of Finance can declare any entity to be a public entity if the Government provides funds above the threshold via equity, grant, or loan, or if the Government grants the entity an exclusive license or monopoly on the provision of services. Each of the REDs, including CENORED, are established through the Companies Act as private companies with initial shareholding by Government-owned agencies or other public entities. Given these facts, it seems that the procurement rules from the Public Procurement

[30] 6 Procurement Methods: Obtaining Quality Goods and Services. Udemy: 2014.

Act would not apply to CENORED unless the Minister of Finance explicitly declares CENORED to be a public entity since it is granted an exclusive license to distribute electricity. However, conversations with some officials at ECB have revealed that it is possible that CENORED may be defined as a public entity that would be subject to the guidance of the CPB. Further investigation is needed to determine if CPB rules would apply to a CENORED procurement of a BESS project due to the potential project cost size and the possibility that other factors could result in Ministerial declarations. Additionally, while it appears that the CPB rules apply to procurements, it will also be important to understand if the CPB would play a role in RFIs that precede procurements.

According to the CPB's guidance, the CPB must conduct the bidding process on behalf of public entities for a contract that exceeds a threshold, which is set based on the public entity.[31] If these rules do apply to CENORED, the PPA for a solar PV and BESS project in Tsumeb or Okahandja, or a BESS project in Otjiwarongo, would exceed the highest threshold for goods that exists (N$ 45M), which would then require CPB involvement in the procurement. While it is uncertain if CENORED would need to interact with the CPB, it is important to note what an interaction with the CPB would entail. The list below, while not exhaustive, covers the key metrics needed to comply with the legislation and regulations of the CPB. As a result, CENORED may be required to provide the following information to CPB in the event interaction is required for a procurement:

- Source of funds or / Project ID as an IPP interaction with an annual procurement commitment plan
- Technical specifications
- Design specifications
- Performance specifications
- Connection Agreement
- PPA conditions
- Instructions to bidders
- Proposal data sheet
- Evaluation criteria

According to the guidance set out in the Public Procurement Regulations (2017), the procurement process conducted by the Board would include a procurement committee, a procurement management unit, and a bid evaluation committee. The procurement committee's role is to oversee the procurement process. The procurement management unit conduct and manages procurement activities from the initiation of the procurement but is not responsible for the evaluation of bids. The bid evaluation committee is established as an independent body to evaluate the bids responding to the procurement released by the procurement management unit. As a result of the potential required CPB involvement in the procurement due to the value of the solar PV + BESS project, CENORED should consider engaging the CPB to understand the appropriate timeline and requirements to conduct such a procurement as previously reasoned above.

6.3.2 PROCUREMENT COMPONENTS

After identifying the procurement method, the next stage involves putting together the components of a BESS RFP. As shown in Table 11, RFPs consist of multiple components that provide background and context on the project, its purpose, the services requested, and how the procurement process itself will be conducted. Details on the services requested will often be directly informed by the outputs of the planning phase. The procurement components are designed in a way to provide context of why a project is being procured, the procurement process, the services being requested, along with the materials required by bidders for proposal submission.

[31] Public Procurement Regulations: Public Procurement Act, 2015. Government Gazette of the Republic of Namibia. 2017.

Table 11: RFP Components[32]

Component	Description
Introduction/Background	This section outlines the purpose and background of the project, a description of the project, along with a potential list of a definitions and acronyms, as necessary.
Procurement Process Overview	This overview section will include guidance on the how the procurement process will occur from release to bidder selection. Important elements of this section may include: • Confidentiality agreements • Bidder qualifications/requirements • Schedule/timeline • Proposal preparation and submission • Evaluation criteria • Disclosure of proponents
Scope of Work	The scope of work is a core component of the RFP and outlines the details of the services and/or products that are being procured. The technical requirements mentioned above will inform the content that comprises the scope of work. It is important to remember that CENORED is procuring the solar PV and BESS to use its services, not own the actual asset. As a result, the scope of work developed for CENORED will differ from that of a utility-owned BESS project. Important elements within the scope of work include: • Scope of supply • Division of responsibility matrix (optional) • Deliverable requirements • Technical Specifications – Buyer requirements
Required Proposal Submittals: PPA/PPA Template[33]	As CENORED is planning to procure the services from the solar PV and BESS, a detailed PPA should be included as part of the RFP. Although the contract structure was determined as part of the planning phase, including more detailed PPA terms or a PPA template in the RFP offers a standardized method where bidders can respond. CENORED should determine which sections of the PPA can be open to modification by the bidders, and which terms should be designated as non-negotiable.
Required Proposal Submittals: Project-specific Elements	This section of the RFP should include a list of items which the bidder should respond to with detailed information on the project requirements. These items should relate directly to meeting the services requested in the scope of work. Specific elements may include: • Pricing details – information on costs related to the solar PV and BESS and resulting charges prices associated with the output and services of the system • Technical specification – Bidder offering – bidder's response with the appropriate technical specifications of a solar PV and BESS • Project schedule – timeline with key milestones and deliverables for the project deployment • Lists of project clarification, assumptions, exclusions, and exceptions – outlining any discrepancies in the bidder's response from the RFP

[32] ESIC Energy Storage RFP Guide. EPRI, Palo Alto, CA: 2017. 3002011738.
[33] Draft Request for Proposals for Variable Renewable Dispatch Generation and Energy Storage. Hawaiian Electric, Oahu, HI: 2019.

	• Subcontracting plan (if necessary) – information on any subcontractors that may be involved with the project from construction up until decommissioning • Supplier information – Information on what suppliers the bidder will use to meet the needs of the scope of work. This may include highlighting how specific local requirements may be met, if necessary.

7 REFINED COST-BENEFIT ANALYSIS

7.1 COST-BENEFIT ANALYSIS OVERVIEW

As part of Phase I, SAEP developed a techno-financial model to help quantify the costs and benefits of deploying lithium-ion and flow vanadium battery storage technologies at six proposed sites by examining three distinct scenarios: (1) solar PV only, (2) BESS only, and (3) solar PV and BESS.

Each scenario was analyzed from the perspectives of both CENORED and the project developer to provide a holistic view of costs and benefits for both parties. Consistent with the structure of CENORED's existing solar IPP contract, the analysis assumes a take-or-pay agreement between CENORED and the project developer, in which CENORED is obligated to pay for all of the energy produced by the solar PV plant and discharged by the battery storage system. It also assumes that the IPP has guaranteed a certain level of performance from the assets over the project lifetime, and that the system performs according to the service level agreement. The model compares all of these scenarios to "business as usual," which is defined by CENORED's financial performance without the solar PV and/or battery storage assets, to determine its incremental value proposition. "Business as usual" simulates current operations at all of the sites except for Otjiwarongo, which already has a solar PV plant online. Therefore, for Otjiwarongo site, the solar PV only scenario represents current operations, while the "business as usual" scenario simulates operations in the absence of the plant.

Through this analysis, the solar PV and lithium-ion BESS scenario emerged as the most viable option to provide the greatest cost savings to CENORED compared to the business as usual scenario across the six sites. Based on the findings from Phase 1, SAEP conducted a deep dive analysis into three of the sites: Tsumeb, Okahandja, and Otjiwarongo.

For Tsumeb and Okahandja, the follow-on analysis focused on identifying the impacts of deploying a solar PV and BESS under a single procurement and owner. The BESS in both scenarios would use a four-hour lithium-ion battery with a power capacity that is 25% of the PV. In the case of Otjiwarongo, the follow-on analysis identifies the impact of deploying a BESS with the same characteristics as the BESS in Tsumeb and Okahandja by a separate developer to the existing solar PV plant at the site to determine potential cost savings.

7.2 COST-BENEFIT ANALYSIS FOR SELECTED SITES

At the request of CENORED and as part of the deep dive analysis, SAEP refined this analysis for Tsumeb, Okahandja, and Otjiwarongo. This refinement includes the following enhancements:

- **Contract structure input field:** An input field for the type of contract structure has been included for the user to select "technology-variant" or "time-variant". This will correspond to input fields under the "Tariff Inputs" section
- **Tariff and escalation rate input fields:** A tariff inputs section was created to allow for the user to modify the tariff, capacity charge, and escalation rates of the system, given the selected scenario and understand the impacts of different prices to the overall project. This section allows for the user to adjust the following tariffs and escalation rates: technology-variant PV, technology-variant BESS, time-variant PV and BESS, and BESS capacity charge

- **Fiscal year tariff comparison chart:** A chart was included to highlight the difference between NamPower tariffs and the solar PV and BESS tariffs at standard, off-peak, and peak rates. The comparison will vary based on the fiscal year selected as well as the contract structure selected. If the technology-variant contract structure is chosen, NamPower tariffs will be compared against a solar PV tariff and a BESS tariff. If the time-variant contract structure is chosen, NamPower tariffs will be compared against a combined solar PV and BESS tariff
- **BESS operational parameter assumptions:** The round-trip efficiency of the lithium-ion BESS was updated to reflect current average efficiency levels
- **BESS cost assumptions:** Given technology advances and market trends that have driven lithium-ion costs down, the underlying costs for the BESS were updated. Additionally, the BESS cost levels input was removed to now reflect the average for the BESS cost assumptions.
- **Solar PV cost assumptions:** Capital costs and O&M cost assumptions for the solar PV plant were updated to reflected current numbers
- **Solar PV yield:** The PV yields for the Tsumeb and Okahanjda sites were updated to be reflective of the yield in their location. This PV yield data was gathered using Bloomberg New Energy Finance's Solar PV Capacity Factor tool[34]
- **Revised tariff schedules:** As CENORED has opted into NamPower's new optional single season time of use (TOU) schedule, the model has been adjusted to remove the differences between high and low seasons
- **Premium on prime rate:** To accurately reflect the additional risk premium, the model has been updated to reflect a 2% premium on prime rate for standalone solar PV projects and a 3% premium on prime rate for a project involving a BESS
- **Taxes:** The developer's cash flow statement was updated to include the payment of taxes (32%). However, the model does not yet include a depreciation schedule for the asset; updating the depreciation schedule would improve the business case for projects by reducing the tax liability owed by the developer
- **Additional financing costs:** Interest during construction costs, debt commitment fees, and other project development costs were added to the developer's cash flow statement
- **Debt sculpting:** The debt repayment schedule in the developer cash flow statement was updated to have a consistent debt service schedule over the lifetime of the loan to reduce costs associated with debt repayment in the various scenarios. In all three sites, the resulting minimum DSCR was determined in a scenario where the developer's NPV was N$0. Although the DSCR may be considered slightly low, but as a feasibility study is completed for a project, there will be additional clarity on the expectations of a DSCR by lenders in the region, and the tariff can be updated accordingly.

7.3 COST-BENEFIT ANALYSIS APPROACH

After the refinements to the model were completed, SAEP used the model to analyze various scenarios at each site to understand the potential cost savings to CENORED and impacts to developers. The following steps were taken at each site.

1. **Determine Site-specific Characteristics:** Given that each site had its own set of characteristics (e.g., PV plant power capacity, ability to grid charge, BESS ownership etc.), site-specific specifications were updated, as shown in Table 12

Table 12: Site-specific Characteristics

Site	Tsumeb	Okahandja	Otjiwarongo
Solar PV Plant Power Capacity	5 MW	8 MW	5 MW
BESS Power Capacity	1.25 MW	2 MW	1.25 MW

34 "Solar Capacity Factor Tool (SCFT 1.0.5)". Bloomberg New Energy Finance (BNEF): 2018.

BESS Energy Capacity	5 MWh	8 MWh	5 MWh
Grid Charging?	Yes	No	Yes
Project Developer	Solar PV + BESS	Solar PV + BESS	BESS only
BESS Project Duration	20 years	20 years	15 years
Solar PV Project Premium on Prime Rate	2%	2%	2%
Solar PV and BESS Project Premium on Prime Rate	3%	3%	3%

2. **Determine Solar PV Only Savings:** Under a solar PV only scenario, a cost-reflective tariff for the developer was determined using a 14.03% WACC. Using this PV tariff, a lifecycle cost savings figure (N$) was determined. This solar PV tariff remained constant when considering the potential impacts of BESS using a technology-variant or time-variant contract structure
3. **Determine Technology-Variant Tariff Minimum Acceptable to Developer:** After identifying tariff ranges acceptable to CENORED, SAEP determined the tariff range that a developer would be willing to accept to achieve an NPV of N$0
4. **Determine Lifecycle Cost Savings for Technology-Variant Contract:** After determining the tariff minimum acceptable for a developer, SAEP calculated the lifecycle cost savings associated with a solar PV and BESS project that would allow a developer to achieve an NPV of N$0 using a technology-variant contract structure
5. **Determine Time-Variant Tariff Minimum Acceptable to Developer:** After identifying tariff ranges acceptable to CENORED, SAEP determined the tariff range that a developer would be willing to accept to achieve an NPV of N$0 using a time-variant contract structure
6. **Determine Lifecycle Cost Savings for Time-Variant Contract:** After determining the tariff minimum acceptable for a developer, SAEP calculated the lifecycle cost savings associated with a solar PV and BESS project that would allow a developer to achieve an NPV of N$0
7. **Determine Impacts of Capacity Charge:** While the ranges that were determined in previous steps assumed no capacity charge, this step involved highlighting the impact of a BESS capacity charge to the energy charges in a technology-variant and time-variant contract structures

Additional detailed inputs and assumptions applied in the analysis can be found in Appendix A.

7.4 COST-BENEFIT ANALYSIS FINDINGS

7.4.1 TSUMEB

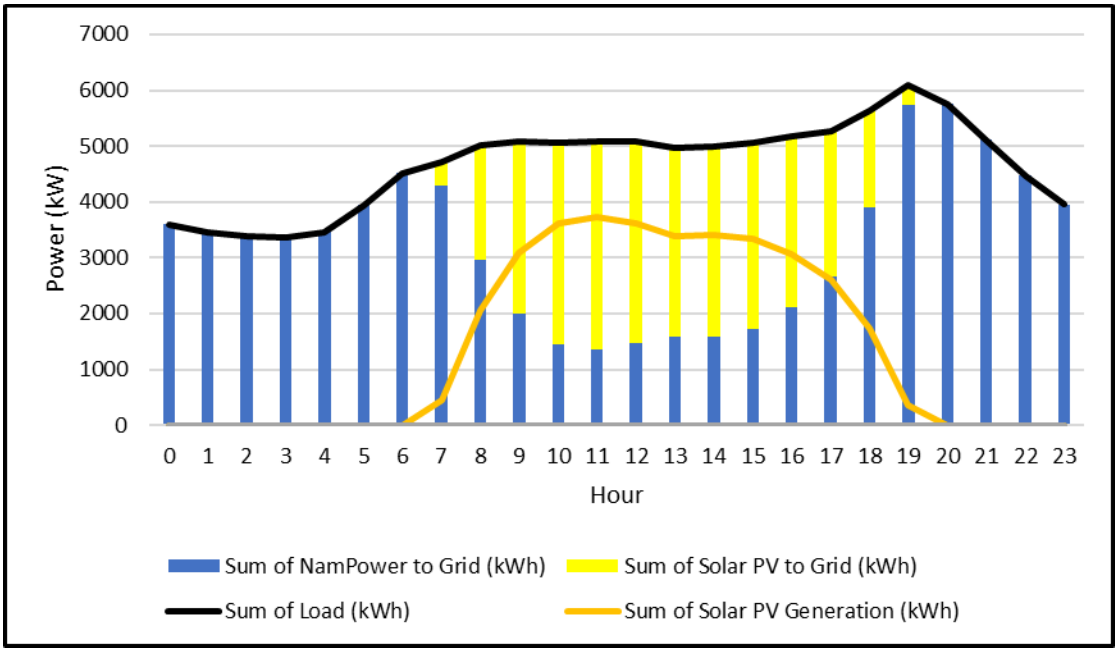
Solar PV only savings: Table 13 highlights the solar PV project savings at Tsumeb. With a solar PV only option, CENORED would be able to achieve N$ 258,420,962 in savings over the 20-year project lifetime using a N$ 0.91kWh tariff for the solar PV output. This translates to a lifecycle saving of 6.10%, calculated by comparing the lifecycle savings to the total costs in the business as usual (BAU) scenario.

Table 13: Solar PV Project Savings at Tsumeb

CENORED Financial Metrics	
Lifecycle Cost Savings (N$)	N$ 258,420,962
Lifecycle Cost Savings Margin (%)	6.10%
PV Tariff (N$/kWh)	N$ 0.93

Figure 8 shows the power-flow diagram of a 5 MW solar PV project at Tsumeb without BESS.

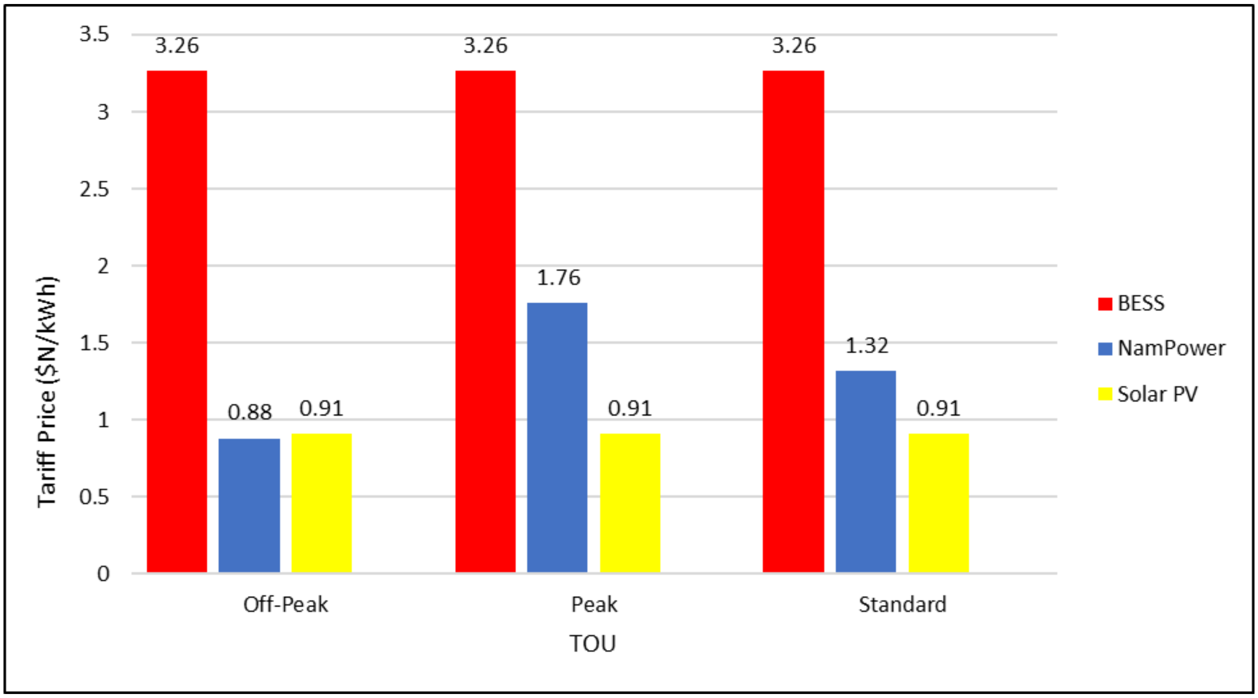
Figure 8: Tsumeb Solar PV Project Power-Flow



Technology-Variant Tariff Minimum: If using a technology-variant contract structure, a solar PV and BESS project is commercially viable with a solar PV tariff of $0.91/kWh and a BESS tariff of N$ 3.26/kWh, providing CENORED with N$ 192M in savings and a 14.69% IRR to a developer.

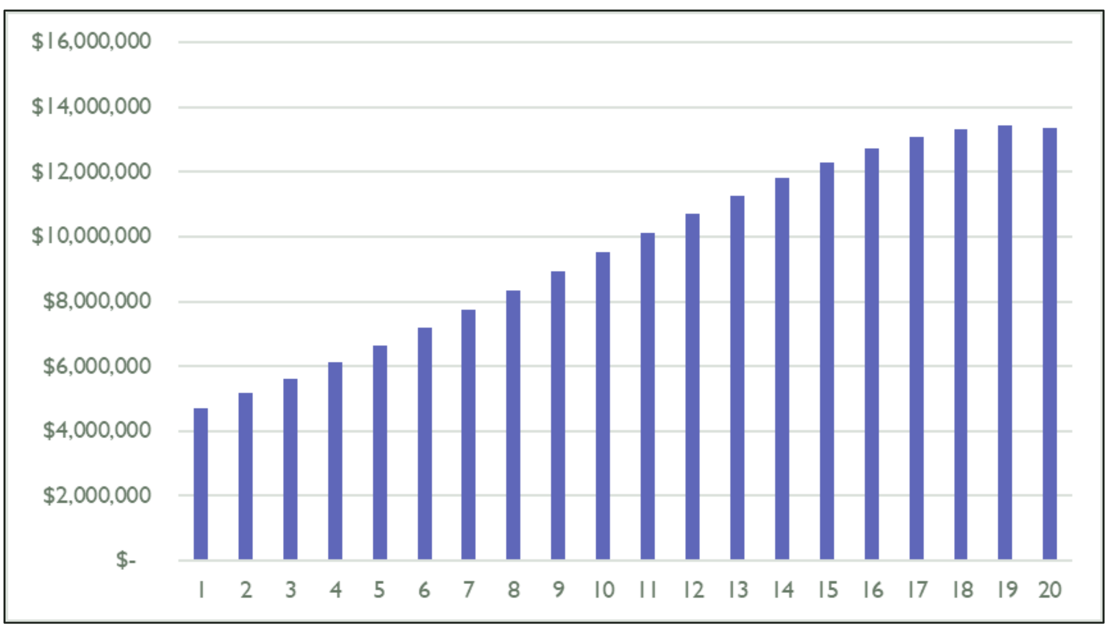
Figure 9 compares the NamPower tariff with the solar PV and BESS tariffs under a technology-variant contract structure and payment mechanism.

Figure 9: Tsumeb Technology-Variant TOU Tariff Comparison (FY 2021)



Although the BESS would require a tariff higher than that of NamPower's during off-peak, standard, and peak times, the project would result in overall savings for CENORED because the savings from the maximum demand and network access charges are not captured in a direct comparison of energy charges and CENORED would purchase energy from the solar PV, which has a lower tariff than NamPower's tariff at peak and standard times. However, the savings from the reduced demand and network access charges are included in the annual and lifecycle cost savings of the project, shown in Figure 10. The reduction in maximum demand and network access charges provides significant cost savings for CENORED throughout the project's lifecycle.

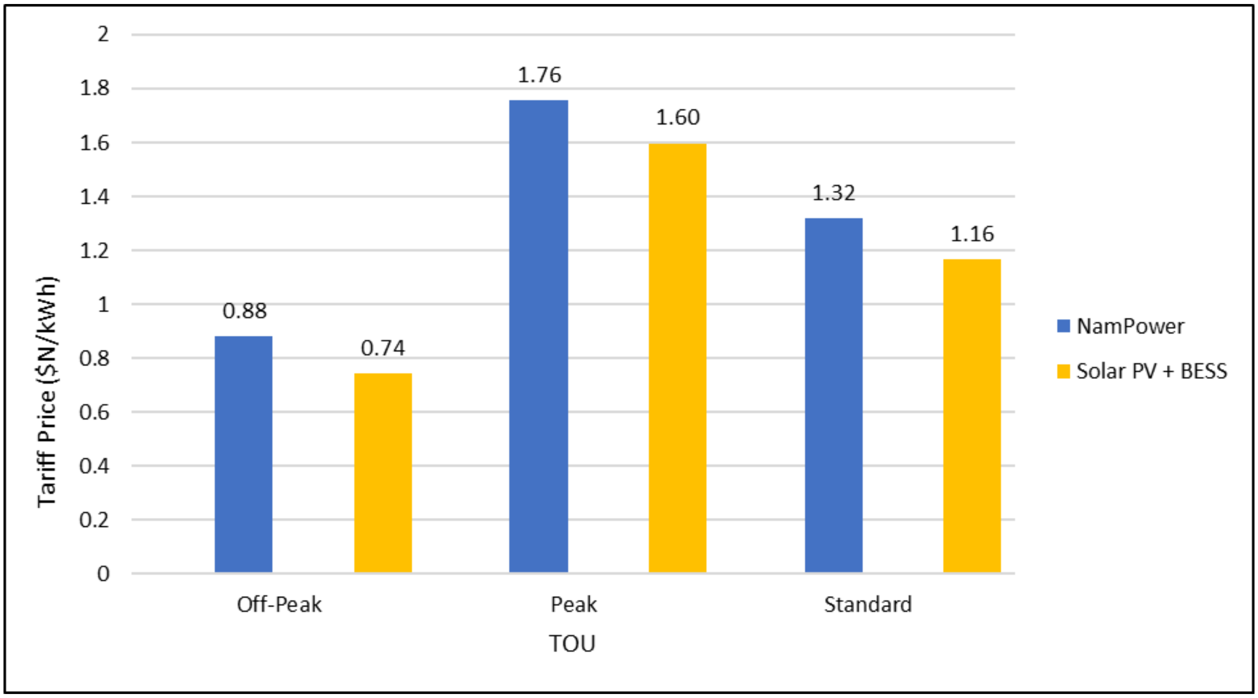
Figure 10: Annual Cost Savings at Tsumeb, Solar PV + BESS



Time-Variant Tariff Minimum: If using a time-variant contract structure, a solar PV and BESS project is commercially viable with a combined solar PV and BESS tariff of $1.16/kWh, providing CENORED with N$ 192M in savings and a 14.69% IRR to a developer.

Figure 11 shows that the combined solar PV and BESS tariff would provide lower rates than that of NamPower's during off-peak, standard, and peak times to provide savings for CENORED at Tsumeb.

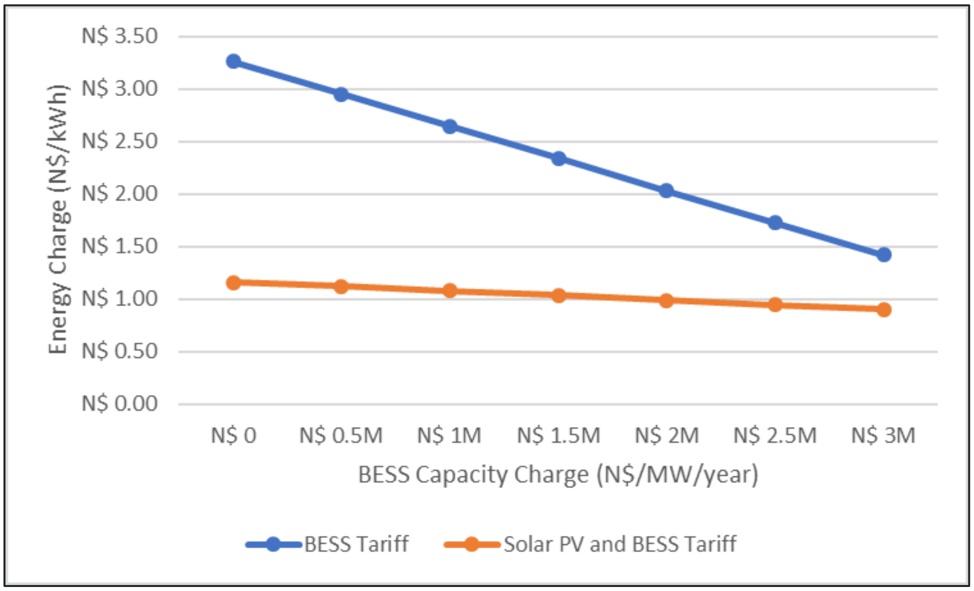
Figure 11: Tsumeb Time-Variant TOU Tariff Comparison (FY 2021)



While CENORED would realize savings from reduced energy charges from the combined solar PV and BESS tariff, it is important to note that the annual and lifecycle savings of the project would be equal to that of a project using a technology-variant contract structure (N$ 192M) due to the decreased demand charges.

Capacity Charge Implications: In addition to considering the energy tariff, CENORED should also consider the impacts and potential use of capacity charges for the BESS. In both the technology-variant and time-variant contract structures, a capacity charge could reduce BESS energy charges by shifting some of the costs to a fixed payment and could potentially allow flexibility to use the BESS for additional services, such as providing additional emergency capacity. However, cost data for these additional services was not included in this analysis, as there was not a standard methodology to price these services and they were not part of the use cases. As a result, the impacts of a capacity charge are shown as the impacts to the energy tariff. Figure 12 highlights the impact of a BESS capacity charge to a BESS tariff or a solar PV and BESS tariff.

Figure 12: Tsumeb, Potential Energy and Capacity Charge Combinations



7.4.2 OKAHANDJA

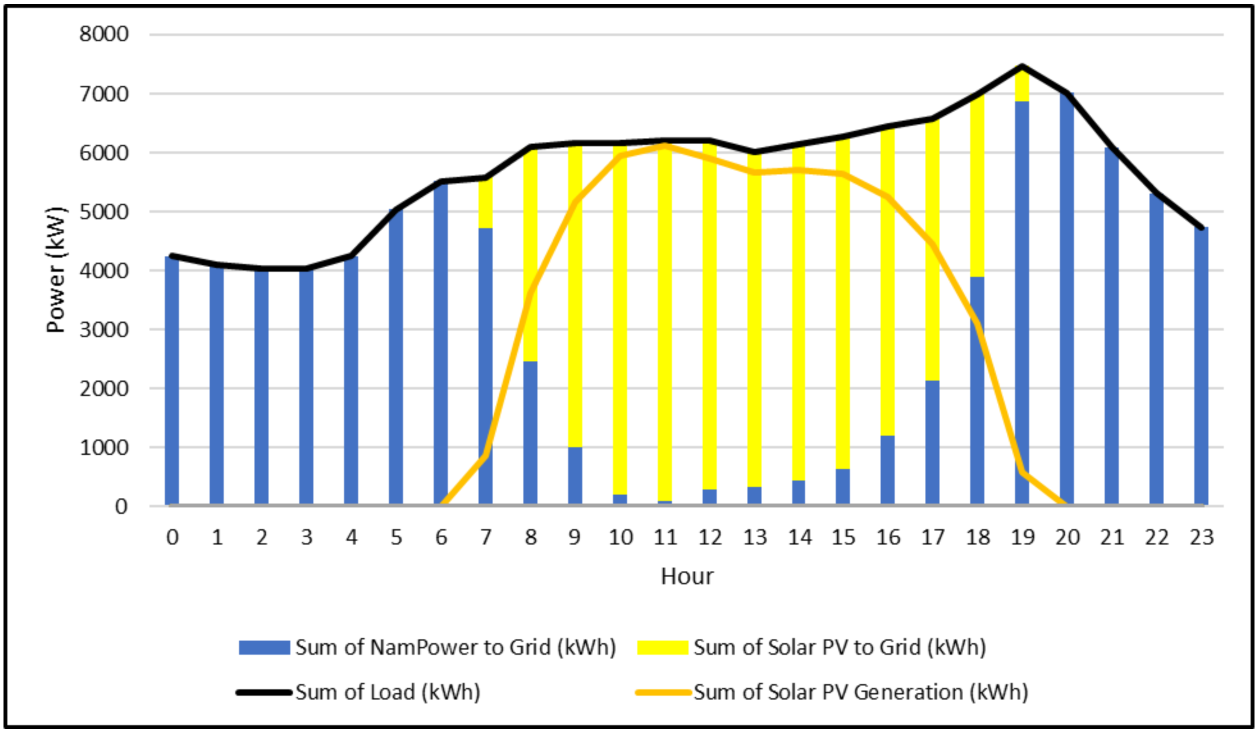
Solar PV only savings: Table 14 highlights the solar PV project savings at Okahandja. With a solar PV only option, CENORED would be able to achieve N$ 530,910,546 in savings over the 20-year project lifetime using a N$ 0.86/kWh tariff for the solar PV output. Okahandja's lifecycle cost savings are substantially greater than those of Tsumeb due to difference in power capacity of each plant (8 MW at Okahandja and 5 MW at Tsumeb). This translates to a lifecycle saving of 10.39%, calculated by comparing the lifecycle savings to the total costs in the business as usual (BAU) scenario.

Table 14: Solar PV Project Savings at Okahandja

CENORED Financial Metrics	
Lifecycle Cost Savings (N$)	N$ 530,910,546
Lifecycle Cost Savings Margin (%)	10.39%
PV Tariff (N$/kWh)	N$ 0.86

Figure 13 shows the power-flow diagram of an 8 MW solar PV project at Okahandja without BESS.

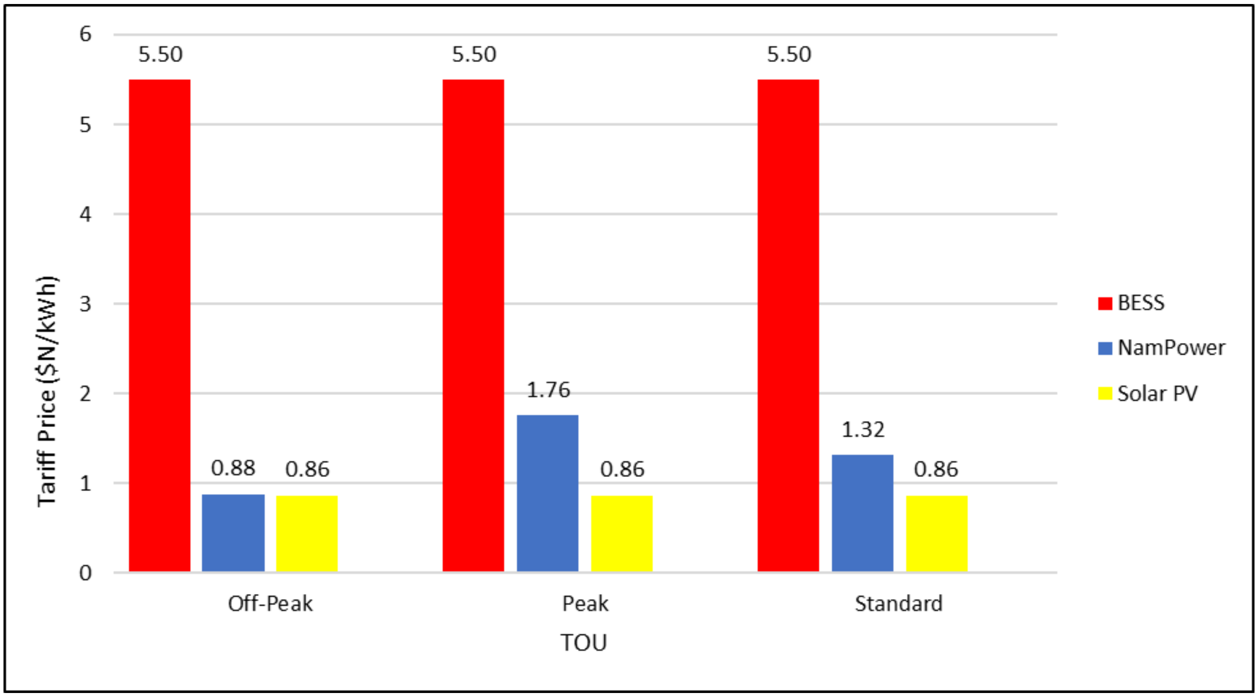
Figure 13: Okahandja Solar PV Power Flow



Technology-Variant Tariff Minimum: If using a technology-variant contract structure, a solar PV and BESS project is commercially viable with a solar PV tariff of $0.91/kWh and a BESS tariff of N$ 5.50/kWh, providing CENORED with N$ 410M in savings and a 14.69% IRR to a developer.

Figure 14 compares the NamPower tariff with the solar PV and BESS tariffs under a technology-variant contract structure and payment mechanism.

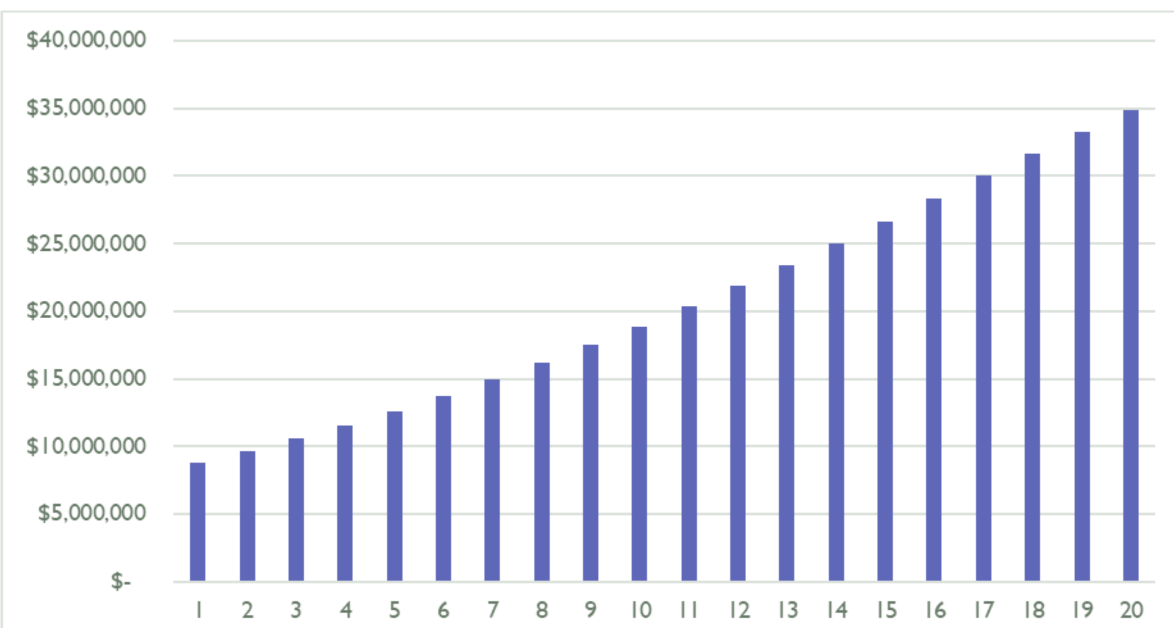
Figure 14: Okahandja Technology-Variant TOU Tariff Comparison (FY 2021)



Similar to the scenario in Tsumeb, the BESS would require a substantially tariff rate higher than that of NamPower's during off-peak, standard, and peak times. However, the project would still result in annual and lifecycle savings for CENORED because the savings resulting from lowered maximum demand and network access charges. The annual savings from a solar PV and BESS project are shown in

Figure **15**. The reduction in maximum demand and network access charges provides significant cost savings for CENORED throughout the project's lifecycle.

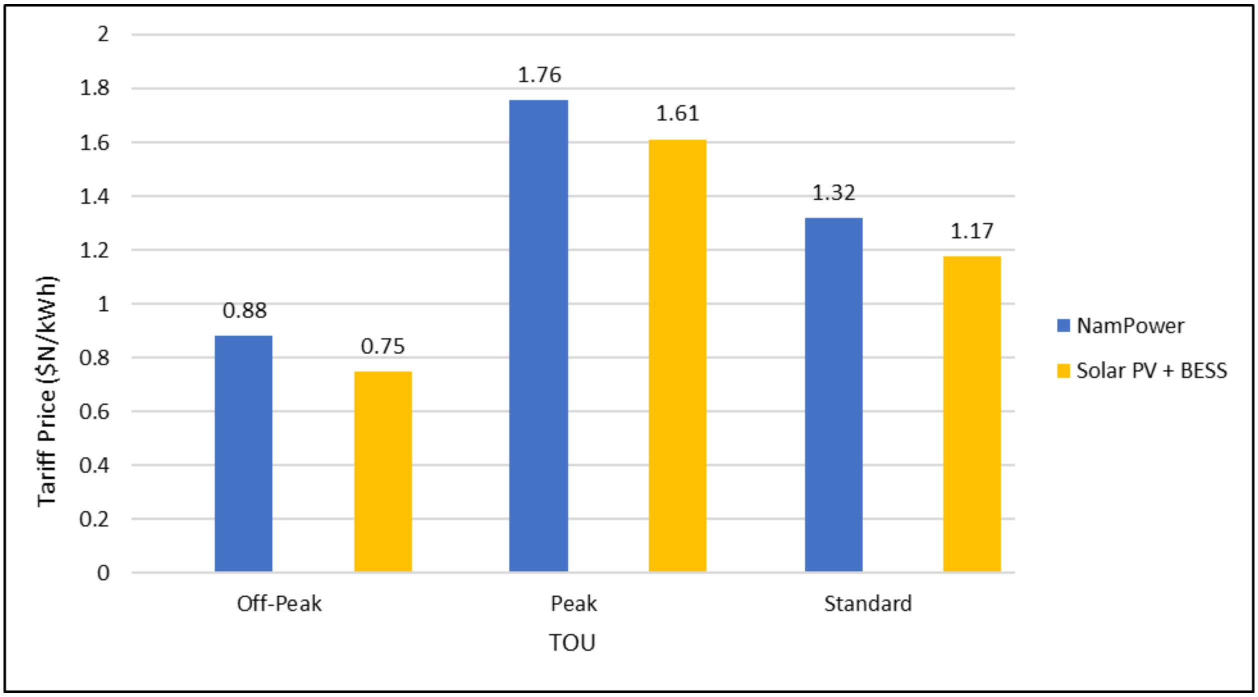
Figure 15: Annual Cost Savings at Okahandja, Solar PV + BESS



Time-Variant Tariff Minimum: If using a time-variant contract structure, a solar PV and BESS project is commercially viable with a combined solar PV and BESS tariff of $1.17/kWh, providing CENORED with N$ 410M in savings and a 14.69% IRR to a developer.

Figure 16 shows that the combined solar PV and BESS tariff would provide lower rates than that of NamPower's during off-peak, standard, and peak times to provide savings for CENORED at Okahandja under a time-variant contract structure. CENORED would also realize additional savings from reduced maximum demand and network access charges.

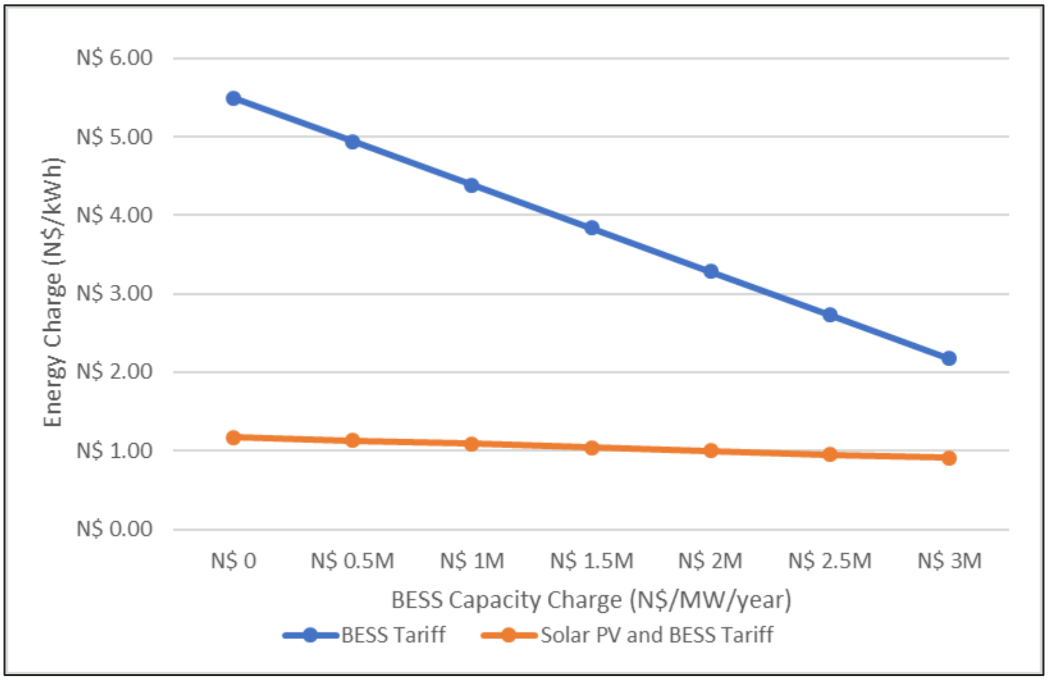
Figure 16: Okahandja Time-Variant TOU Tariff Comparison (FY 2021)



While CENORED would realize savings from reduced energy charges from the combined solar PV and BESS tariff, it is important to note that the annual and lifecycle savings of the project would be equal to that of a project using a technology-variant contract structure (N$ 410M) due to the decreased demand charges.

Capacity Charge Implications: In addition to considering the tariff rates for energy charges, CENORED should also consider the impacts and potential use of capacity charges for the BESS. In both the technology-variant and time-variant contract structures, a capacity charge would reduce the BESS energy charge by shifting some of the costs to a fixed payment and could potentially allow flexibility to use the BESS for additional services. However, cost data for these additional services was not included in this analysis, as there was not a standard methodology to price these services and they were not part of the use cases. As a result, the impacts of a capacity charge are shown as the impacts to the energy tariff. Figure 17 highlights the impact of a BESS capacity charge to a BESS tariff or a solar PV and BESS tariff.

Figure 17: Okahandja, Potential Energy and Capacity Charge Combinations



7.4.3 OTJIWARONGO

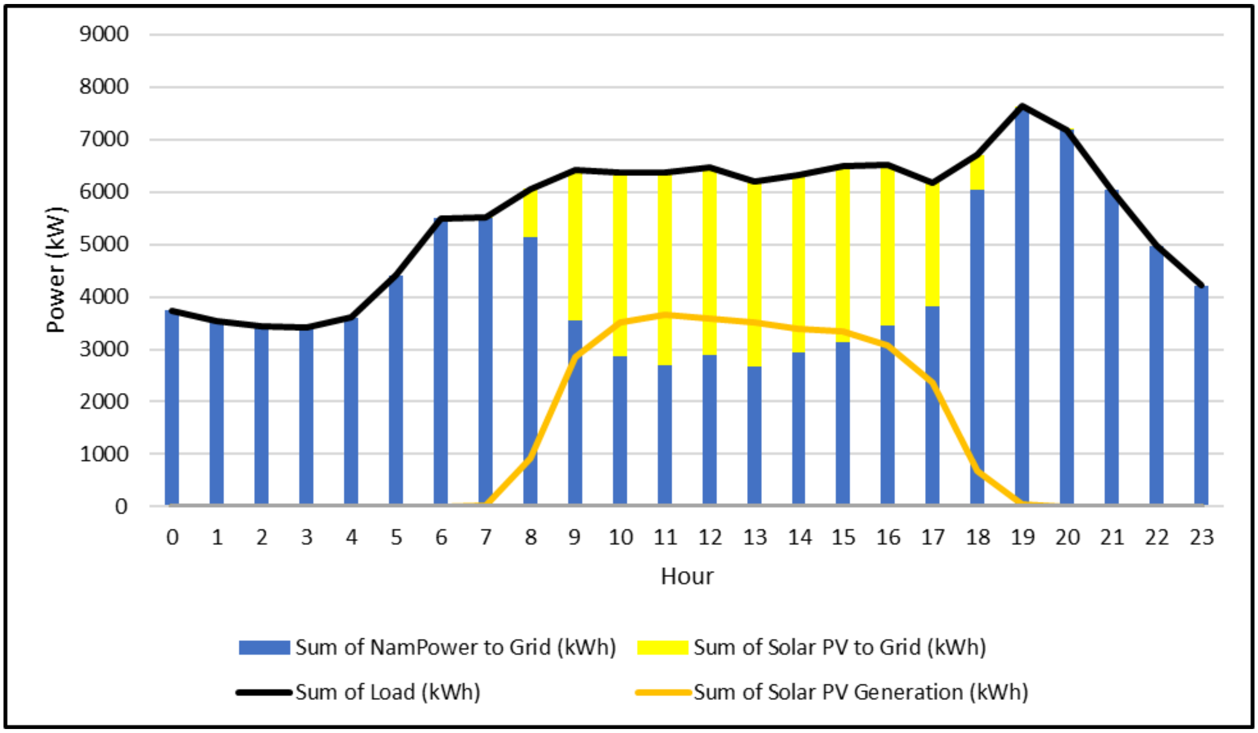
Solar PV only savings: Table 15 highlights the solar PV project savings at Otjiwargon. At Otjiwarongo, the solar PV only scenario was evaluated for a 15-year period, as the PV plant began operations in 2016. Over the course of the 15 years remaining in the project, CENORED is projected to lose approximately $163M due to the site's high solar PV tariff of N$ 1.79/kWh.

Table 15: Solar PV Project Savings at Otjiwarongo

CENORED Financial Metrics	
Lifecycle Cost Savings (N$)	-N$ 162,985,688
Lifecycle Cost Savings Margin (%)	-5.46%
PV Tariff (N$/kWh)	N$ 1.79

Figure 18 shows the power-flow diagram of the 5 MW solar PV project at Otjiwarongo without a BESS.

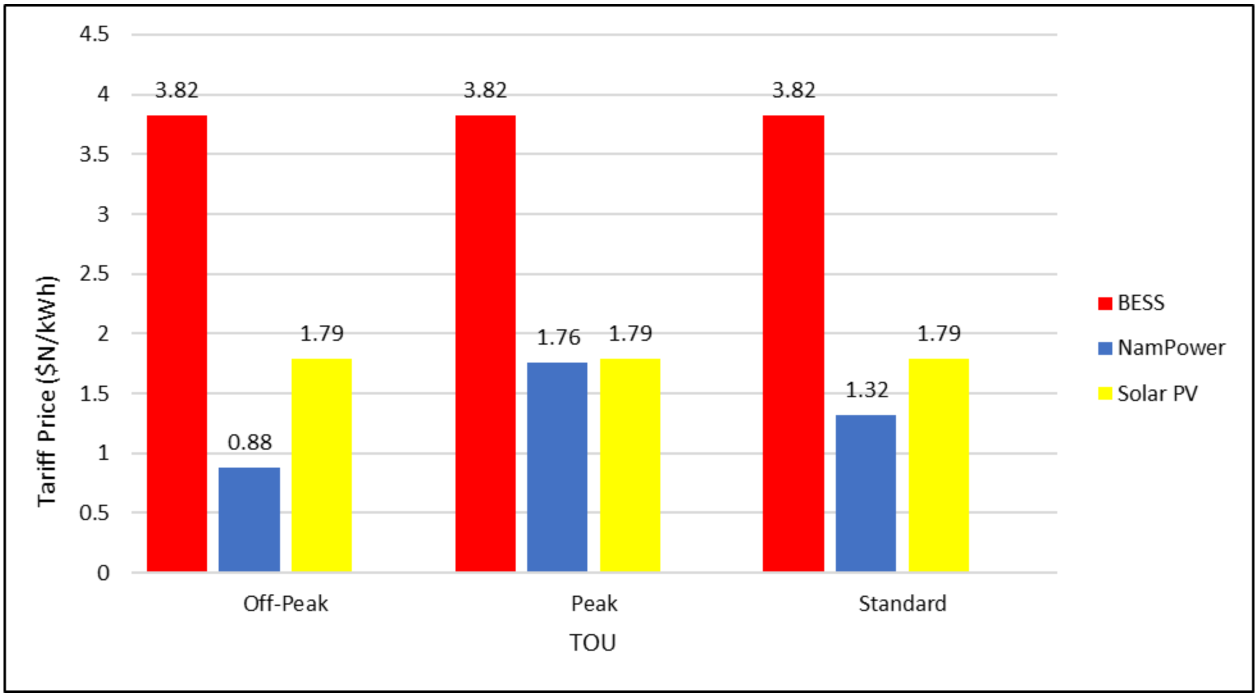
Figure 18: Otjiwarongo Solar PV Power Flow



Technology-Variant Tariff Minimum: In the case of Otjiwarongo, a technology-variant contract structure would be the only variant PPA option to be used as the solar PV developer (HopSol) and the BESS developer would be separate. Having a separate BESS developer would result in charging costs incurred by the BESS developer when shifting power output from the PV plant, which would drive up the BESS tariff rate for the site. The minimum tariff acceptable to a BESS developer would be N$ 3.82/kWh for the developer to achieve an NPV of N$ 0. However, with this BESS tariff coupled with the high solar PV tariff, CENORED would lose about N$ 193M from a BESS only project at Otjiwarongo, making it an unattractive investment for CENORED.

As demonstrated in the chart below, the current solar PV tariff rate is higher than NamPower's tariff rates at standard, peak, and off-peak hours, making it difficult for CENORED to achieve savings at this site. Figure 19*Figure 14* compares the NamPower tariff with the solar PV and BESS tariffs under a technology-variant contract structure and payment mechanism.

Figure 19: Otjiwarongo Technology-Variant TOU Tariff Comparison



Capacity Charge Implications: While the potential implications of a capacity charge at Tsumeb and Okahandja were explored, further evaluation at Otjiwarongo may not be as beneficial for CENORED. The use of a capacity charge would be adopted in order to provide CENORED with access to additional BESS services while achieving similar levels of cost savings with lower energy charges. However, as achieving those cost savings without a capacity charge would require significant concessional financing that may not be feasible, evaluating the impacts of a capacity factor may not provide additional insights into a BESS project at this site.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

8.1.1 MARKET AND REGULATORY

1. **CENORED must work closely with appropriate entities to overcome regulatory uncertainty that may otherwise pose barriers to BESS deployment**

   The regulatory environment in Namibia may pose commercial risks to BESS deployment, as regulations and standards have not yet been updated to address BESS asset classification, grid interconnection, or environmental and safety issues. Although a license for electricity storage is explicitly mentioned in the Electricity Bill of Namibia (2017), explicit rules governing how to obtain and maintain this license have not been defined. These concerns may delay or even prevent a BESS project from successfully being deployed due to the risk of regulatory uncertainty. CENORED should engage the ECB to address uncertainty around BESS asset classification and grid interconnection rules. The ECB has acknowledged the importance of BESS through commissioning a study on energy storage in Namibia, which was completed in April 2018, and has mentioned plans to update regulations to include provisions to address relevant issues under its purview. CENORED should also work with the Namibia Standards Institution to encourage adherence to international standards surrounding equipment interconnection and safety. Currently, the Transmission Grid Code references complying with IEC standards for equipment design, power system stabilizers, transformers, SCADA systems, series capacitors, and excitation systems; additionally, the Transmission Grid Code mentions adhering to relevant electricity industry standards broadly, but does not specify each of the standards explicitly. The Distribution Grid Code, on the other hand, references adherence to national standards for equipment requirements, but does not specify which standards in particular. However, this Grid Code references an IEEE standard for earthing requirements and an IEC standard for excitation systems. Although these standards do not directly relate to energy storage systems, they demonstrate how international standards and national standards can be incorporated directly into the Transmission and Distribution Grid Codes. Relevant international standards that should be considered include:

- IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems
- IEEE P2030.2.1: Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems
- IEEE P2030.3: Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
- IEEE P2030.2.1: Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems
- IEEE P2030.3: Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
- IEC 62933 - Electrical Energy Storage (EES) systems
- IEC 62619: 2017 - Secondary cells and batteries containing alkaline or other nonacid electrolytes
- IEC 62485: Safety requirements for secondary batteries and battery installations
- IEC 62281:2016 - Safety of primary and secondary lithium cells and batteries during transport
- UN 38.3 (United Nations): UN Manual of Tests and Criteria for the Transportation of Dangerous Goods, Lithium metal and lithium ion batteries

Additionally, CENORED should work with the Ministry of Environment and Tourism to overcome regulatory uncertainty about environmental concerns related to BESS. Currently, environmental regulations make general measures for energy as a listed activity; however, there are not specific regulations as it concerns the lifecycle of battery storage, including production, transport, installation, and disposal.

In Malawi, project developers cited regular engagement with the regulator as an important factor that contributed to the success of deploying a battery storage project amidst uncertain regulations. Early and regular engagement with the appropriate regulatory entities in Namibia may also decrease the likelihood of a CENORED BESS project from getting delayed due to regulatory factors as well as mitigate the regulatory risk for potential developers.

2. **Until Phase I of MSB is implemented, the single-buyer entity (i.e. NamPower) cannot purchase capacity and ancillary services from a BESS project. Therefore, the CENORED BESS use case cannot be expanded to include these potential revenue streams if the project is expected to be deployed in the near term.**

   Under the current single buyer model in Namibia, a mechanism does not exist for a BESS to receive compensation for capacity and ancillary services, depriving BESS from potential revenue streams from these services. Currently, ancillary services in Namibia are managed by Eskom in South Africa. While Phase II of the MSB model includes provisions for compensating specific ancillary services, implementation of this phase will not be effective until July 2026. Additionally, it is unclear if a BESS embedded in a distribution network would be able to provide ancillary services to the MSB unless it is located near a transmission substation. Until mechanisms are defined to establish capacity and ancillary service markets and value these services, it is not possible to accurately account for how a BESS can be compensated for these services in the near future and as such, discussions and engagement with the MSB is required.

8.1.2 PROCUREMENT

3. **A combined PV and BESS tender for an IPP-owned BESS that uses a time-variant PPA contract structure may be the most suitable ownership model and contract structure for the proposed projects.**

As part of the planning phase of a BESS project, there are important decisions around the procurement and contract structures of a project that need to be made prior to developing a BESS procurement. Determining the ownership structure, procurement approach, contract structure, and payment mechanism should be decided as they can impact the project economics and value proposition of a BESS.

The above-mentioned structural elements of a BESS procurement are consistent with BESS leading practices and CENORED's use case for a solar PV and BESS. Third party developer ownership would mitigate the technology and financial risk of a BESS project for CENORED. The combined solar PV and BESS procurement approach provides CENORED with developers that can use design synergies between a solar PV and BESS to reduce capital and operational costs. A variant PPA contract structure using a time-variant PPA payment mechanism would benefit CENORED because it would align with the objective of using BESS to time-shift energy to limit exposure to NamPower TOU tariffs.

The inclusion of a capacity charge to the time-variant PPA payment mechanism would reduce energy charges as capacity charges increase, and enable a developer to derive additional revenue streams from the BESS. CENORED may choose to provide bidders the option of including a capacity charge or limiting payments to an energy charge only. However, if a bidder does opt to use a capacity charge, the energy charge must also be adjusted to provide the same cost savings to CENORED as if there was no capacity charge.

To carry out the procurement, a two phased procurement approach consisting of an RFI followed by and RFP/RFO would benefit CENORED to successfully deploy a BESS project. Using an RFI initially allows CENORED to determine the potential options of services and interested developers, while the RFP/RFO provides CENORED with the ability to collaboratively work with developers with experience in BESS projects.

4. **There is interest from international donor organizations and a private bank in providing discounted debt financing for BESS projects**

As part of this phase of the Battery Storage Assessment, SAEP conducted outreach to potential DFI partners to explore their interest in a BESS project in Namibia. KfW and the World Bank have expressed interest in providing concessional debt financing, in the form of viability gap funding, for a BESS project in Namibia. KfW mentioned the possibility of providing viability gap funding for a BESS project, which could serve as concessional debt financing for a developer. The DFI and CENORED would come to an arrangement for an acceptable tariff for a solar PV and BESS project, and DFI support would be packaged as part of the RFP. Once a developer is selected for the project, the DFI would provide the viability gap funding to achieve a tariff that was determined prior to issuing the procurement. However, it seems unlikely that CENORED will be able to secure concessional financing for a solar PV and BESS project unless it works with a fund dedicated to increasing BESS deployment regionally or globally. Both a standalone solar PV project and a combined solar PV and BESS project are commercially viable based on the current analysis; however, a solar PV project would provide an opportunity for greater savings to CENORED.

Additionally, Investec, a private bank in South Africa, has expressed interest in providing discounted debt for a pilot solar PV and BESS project. Investec has mentioned it would be interested in also serving as the project developer for such a project. Additional conversations between CENORED and Investec (and other financial institutions) must occur to understand the requirements for securing discounted debt for a project, as well as detailed information on other terms and conditions.

8.1.3 REFINED COST-BENEFIT ANALYSIS

5. **Both a standalone solar PV project and a combined solar PV and BESS project are commercially viable and can provide CENORED with cost savings at both Tsumeb and Okahandja. However, a standalone solar PV project can provide CENORED with greater savings**

At Tsumeb, a standalone solar PV project can provide CENORED with N$258M in savings, while a solar PV and BESS project can provide $192M in savings over a 20-year project relative to business as usual (BAU). At Okahandja, a standalone solar PV project can provide CENORED with N$530M in savings, while a solar PV and BESS project can provide CENORED with N$410M in savings of a 20-year project relative to BAU. Table 16 outlines the potential cost savings at each site for both a standalone solar PV project and a combined solar PV and BESS project.

Table 16: Project Options

Project Option	Tsumeb Cost Savings	Okahandja Cost Savings
Solar PV	N$ 258M	N$ 530M
Solar PV and BESS	N$ 192M	N$ 410M
Marginal Cost Savings from Solar PV Only Project	N$ 66M	N$ 120M

Although CENORED has expressed its primary objective to achieve high cost savings, it is important to note that 1) the costs associated with BESS have been continually declining, even over the course of this assessment and 2) this cost-benefit analysis is limited by the fact that the BESS duty cycle and BESS size are not fully optimized. Given these two factors, CENORED should still consider further evaluation of a solar PV and BESS project through a feasibility study. This will allow CENORED to get a more detailed perspective on the cost savings that can be achieved through an optimized BESS on its network and how this compares to savings from a standalone solar PV project.

The benefits of proceeding with a solar PV and BESS project would provide CENORED with cost savings, while developing partnerships with international organizations that may provide support for future projects. Additionally, the immediate next step with moving forward with a solar PV and BESS project would involve conducting or contracting out a feasibility study to further explore additional project considerations, such as grid impacts and environmental impacts. Given that a feasibility study for a solar PV and BESS project could receive grant funding from agencies such as USTDA, CENORED could potentially have limited financial risk in proceeding with this route.

6. **A solar PV and BESS project at Okahandja would provide greater lifecycle cost savings than a solar PV and BESS project at Tsumeb**

A solar PV and BESS project at Okahandja would provide around N$ 410M in savings, while a solar PV and BESS project at Tsumeb would provide around N$ 192M in cost savings for CENORED. Additionally, a solar PV and BESS project at Okahandja may be de-risked from some regulatory uncertainty as it was not analyzed as a grid connected asset due to the 8 MW size of the solar PV plant at the site. Due to the uncertainty around BESS asset classification, the lack of a grid charging component would make the BESS a generation source but not a load for CENORED. However, as stated in the market and regulatory section of the report, the asset classification dilemma for BESS would not have any economic impacts unless the BESS charges from the grid. If the BESS does charge from the grid, the developer may be subject to capacity and grid access charges if CENORED imposes them or is forced to impose them by the ECB. Table 17 outlines the lifecycle cost savings and regulatory uncertainty at Tsumeb and Okahandja.

Table 17: Solar PV and BESS Project Comparison by Site

Site	Cost Savings	Regulatory Uncertainty
Tsumeb	N$ 192M	High – BESS is generation and load
Okahandja	N$ 410M	Lower – BESS is only generation

7. **At Otjiwarongo, the addition of a BESS project to the existing HopSol plant would not create opprotunities for cost savings for CENORED.**

   Over the remaining lifespan of the HopSol PV plant in Otjiwarongo, CENORED is projected to lose approximately $163M. This scenario was treated as the BAU case in Otjiwarongo. This loss is attributable to the relatively high solar PV tariff (N$ 1.79/kWh) and the accompanying escalation rate (5.8%). As the BESS at Otjiwarongo would be attached to the existing HopSol solar PV plant, the BESS developer would need to purchase energy from the HopSol plant at the high tariff mentioned. Under the new single season TOU tariff structure, the solar PV tariff in Otjiwarongo is higher than NamPower's peak tariff (N$ 1.76/kWh). Including a BESS project in Otjiwarongo would require a separate BESS developer and using a technology-variant PPA contract structure as the solar PV plant already exists at the site.

8.2 RECOMMENDATIONS

Based on the conclusions listed above, SAEP recommends that CENORED further explore a solar PV and BESS project at Tsumeb or Okahandja through a feasibility study to understand detailed project technical and economic implications of deploying a project at a particular site with an optimized BESS size and duty cycle. CENORED should also engage with the Electricity Control Board, the Namibian Standards Institution, and the Ministry of Environment and Tourism throughout the procurement and project lifecycle of a solar PV and BESS project due to the evolving market structures and regulatory uncertainty around BESS. ECB has acknowledged the potential value of BESS through commissioning a study on BESS in Namibia, and CENORED engagement on this topic with them and other entities may help drive a BESS deployment forward without any delays due to regulatory factors. CENORED should work with interested financial institutions and DFIs with BESS-specific funds to secure discounted debt in order to improve the potential cost savings from a combined solar PV and BESS project. CENORED should also consider the possibility of deploying a BESS as a pilot project in Namibia if it chooses to partner with Investec.

1. **Feasibility Study for a Solar PV and BESS Project**

   CENORED should further explore a solar PV and BESS project at Okahandja through a feasibility study due to the potential savings it can provide. CENORED should conduct or contract out a comprehensive feasibility study that evaluates the techno-economic potential of deploying a solar PV and BESS project, the system's impact on the grid, and the system's potential developmental impacts. Additionally, the feasibility study should optimize the sizing of the BESS as well as its duty cycle. To mitigate the financial risk of such a study, CENORED should consider applying for grant funding from interested organizations, such as the USTDA. The outputs of the feasibility study will provide more detailed insights around additional project economic considerations for deploying solar PV and BESS project at a particular site that incorporates grid interconnection viability and costs, as well as additional BESS cost reductions due to rapid technology advancement.

2. **Coordination with Regulatory Stakeholders**

   CENORED should regularly communicate with the ECB, Namibian Standards Institution, and the Ministry of Environment and Tourism prior to and while developing a solar PV + BESS procurement to demonstrate the business case and value add that BESS can provide. Specifically, CENORED should engage ECB to obtain clarity on the asset classification of BESS, methodologies to value BESS services, and interconnection guidelines for BESS. CENORED should work with the Namibian Standards Institution to update relevant equipment interconnection standards and safety standards that BESS must adhere to. Additionally, regular communication with the additional stakeholders, such as the Ministry of Mines and Energy (MME) and NamPower will be important for a successful BESS deployment.

   This coordination may involve holding workshops that highlight the potential of BESS at the sites that have been evaluated and the potential regulatory challenges that may impact BESS deployment. Interviews with developers revealed the importance of early and regular engagement with the regulator in the project lifecycle of a BESS project. This engagement is critical to making sure a BESS project is following the current and upcoming guidance and regulations around BESS in a country.

3. **Financing Sources**

   CENORED should engage financial institutions, such as Investec, to understand the conditions and opportunities to obtain discounted debt for a solar PV and BESS project. Additionally, CENORED should consider working with funds dedicated to increasing the deployment of BESS in the region or globally in order to obtain discounted debt and further increase the potential cost savings from a solar PV and BESS project. Although it may be difficult to secure confessional financing from DFIs, CENORED should work with Power Africa and SAEP to identify BESS-specific funds that may be interested in financing such a project with the long-term objective of opening up the Namibian market for utility-scale BESS.

4. **Pilot Project Partners**

   CENORED should consider the possibility of deploying a solar PV and BESS asset as a pilot project, given the interest expressed by Investec. CENORED should work with Investec to understand the types of discounted debt available for a BESS project and any accompanying requirements that would be tied to that debt, especially since Investec has mentioned interest in serving as a project developer. This would include conducting a feasibility study at the chosen site, determining the requirements, advantages, and disadvantages of putting together a pilot project and seeking additional interested technical and financial partners. Identifying partners who are willing to participate in a pilot project with Investec at a site in Namibia may provide CENORED with an option to deploy a project that aligns with the evaluated use case while also mitigating risks for developers for future solar PV and BESS projects at additional sites. In addition to Investec, CENORED should also determine if there are other entities that have an appetite to develop a battery storage installation, even independent of Investec.

9. APPENDIX

9.1 SOLAR PV AND BESS CONTRACT EXAMPLES

Project Name and Location	BESS Specs.	Energy Supply Source(s)	BESS Applications	Contract Structure	Pricing	Explanation
Molokai Hawaii PV Plant, Hawaii (In Operation)	Lithium-ion, 3 MW / 15 MWh	Solar PV, 4.88 MW	• Energy time-shift • Frequency regulation • Spinning / non-spinning reserves • Voltage support • Black start	Time Variant PPA + BESS Capacity Payment	• Solar PPA: $29.96/MWh for 25 years • BESS Capacity: $6,200/MW-month for 15 years (2% annual escalation)	This 22-year PPA consists of a two-tier rate for PV-generated energy delivered directly to the grid, a rate for time-shifted PV energy from the BESS, and a monthly BESS services payment. This contract structure is a modified version of the time variant PPA and partial storage capacity payment.
NextEra Fish Springs PV Ranch, Nevada (PPA Approved)	Lithium-ion, 25 MW / 100 MWh	Solar PV, 100 MW	Information not available	Solar PPA + Storage Capacity Payment	• Solar PPA: $52.11/MWh (initial) & $22.46/MWh • BESS PPA: $52.11/MWh • BESS Capacity: $1.2M/year	This structure consists of a flat rate for PV-generated energy and a BESS capacity payment that is charged per MW-month. The off-taker also has the option to purchase the BESS at periodic intervals of the project's operation.
E.ON Tucson Iron Horse, Arizona (In Operation)	Lithium-ion, 2.5 MW / 10 MWh	Solar PV, 2.6 MW	• Frequency regulation • Ancillary services • Renewables capacity firming	Solar PPA + Partial Storage Capacity Payment	Information not available	This contract structure compensates the developer for PV generation and grid support services from the BESS, which the utility previously received from more expensive gas combustion turbines.

9.2 COST-BENEFIT ANALYSIS ASSUMPTIONS

Financial Assumptions

Assumption	Units	Value
Consumer Price Index	%	5.8%
VAT Tax	%	15.0%
Capital Allowance for Buildings – Y1	% of capital costs	20.0%
Capital Allowance for Buildings – Y2 – Y20	% of capital costs	4.0%
Exchange Rate	N$ per US$	N$ 14.97
Loan Term	Years	10
Cost of Debt (no concessional financing)	%	12.5%
Cost of Equity	%	17.0%
Cost of Debt (with concessional financing)	%	6.0%
Debt	% of total capital	66.0%
Equity	% of total capital	34.0%
Pre-tax WACC	%	14.03%

NamPower TOU Single Season Tariffs

	Customer Service Charge	Point of Supply Charge		Maximum Demand Charge	Network Access Charge
	N$/Customer/Month	N$/PoS/Month		N$/KVA	N$/KVA
		No Diversity/ =< 10 MW	With Diversity/ > 10 MW	Peak and Standard	All Periods
Tariff > 33 kV	10,250.00	4,950.00	6,720.00	98.27	91.48
Tariff =< 33 kV	10,250.00	4,950.00	6,720.00	102.19	95.14

Energy Charge			
	Peak	Standard	Off-peak
	c/kWh	c/kWh	c/kWh
Tariff > 33 kV	161.43	121.08	80.72
Tariff =< 33 kV	164.72	123.55	82.37

NamPower TOU Tariff Escalation by Charge

Charge Escalation	Units	Value
NamPower Energy Charge Escalation	%	6.7%
NamPower Demand Charge Escalation	%	10.64%
NamPower Network Access Charge Escalation	%	10.64%

Solar PV Tariffs by Site

Site	FY 2021 Tariff (N$/kWh)	Escalation Rate
Tsumeb	1.16	5.8%
Okahandja	1.10	5.8%
Otjiwarong	1.79	5.8%