Watts in Store

Part 2: Creating an enabling environment for the deployment of grid batteries in South Africa

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Written by Richard Halsey, Richard Bridle, Neil Overy, and Bathandwa Vazi

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About This Series

This paper is the second in a two-part series about energy storage in South Africa. Part 1 covered how energy storage can contribute to solving the electricity crisis in South Africa.[1] It explored why grid-located batteries are a strategic focus area and the status quo of current plans and projects. Part 2 takes a deeper look at grid-located batteries: how to maximize benefits, minimize human rights and environmental and safety risks, and solve challenges to deployment.

Like Part 1, Part 2 is written as an explainer piece in accessible language. The intended audience includes decision-makers in national and local governments, researchers, and the wider public interested in energy issues.

The reader is expected to be familiar with the basic concepts and arguments presented in Part 1, such as what services and benefits energy storage can provide.

This is not an exhaustive report; rather, it covers main points on a wide range of topics with the intention to spur debate. While the authors have summarized relevant points from existing literature, the content relies heavily on inputs from over 70 interviews in 2023 and 2024. The individuals who participated are not named or quoted but included representatives from the following South African entities or with the following expertise:

> Eskom (transmission, distribution, planning), government departments (Department of Mineral Resources and Energy and Department of Science and Innovation), municipal departments (energy planning), battery project developers, renewable energy independent power producers, battery system engineers, think tanks, finance institutions, law firms, local battery manufacturers, power system researchers, power system modelling teams, parliamentary portfolio committees, the Energy Council of South Africa, the South African Energy Storage Association, independent energy analysts, economists, GreenCape, and the South African Independent Power Producers Association.

In addition, there were internationally based interviewees from energy agencies, project development teams, research institutions, and the World Bank.

[1] https://www.iisd.org/system/files/2023-07/south-africa-watts-in-store-part-1.pdf

Executive Summary

This report is about improving the deployment of grid batteries in South Africa. Grid batteries are located on the transmission or distribution grid, and their primary function is to enhance grid infrastructure utilization, provide services to the system operator, or contribute to the public electricity supply. This report aims to investigate how to create an enabling environment for grid battery deployment while maximizing key benefits and minimizing human rights violations and environmental, health, and safety risks.

The focus is on the national level and the municipal level where appropriate. This research was informed by over 70 interviews with a wide range of stakeholders to give a summary of the main current challenges and potential solutions. Internationally, there is rapid growth in the installed capacity of utility-scale batteries. While South Africa can learn from leading regions like South Australia and California, the best approach depends on local circumstances.

Maximizing Local Benefits

South Africa should optimize grid battery rollout, choose appropriate technologies, and develop domestic value chains. An optimal national rollout strategy should identify the capacity, duration, location, sequence, and timing of grid battery deployment. Currently, the capacity procured nationally is based on modelling that does not adequately assess the benefits and services that these batteries can provide to the grid. As such, procurement needs to change to match the higher amounts that the system operator, Eskom, has determined are required.

Lithium-ion batteries are the market leader for grid applications. However, as South Africa has extensive reserves of vanadium and steps have already been taken to produce vanadium redox flow batteries locally, both technologies have the potential for local value chain development. The immediate opportunities are increased battery assembly (with imported cells) and increased beneficiation of minerals to battery grade. Other battery technologies, such as manganese-based chemistries, may become future options for South Africa to leverage local resources.

Minimizing Social and Environmental Risks

The extraction and processing of materials for batteries can have negative impacts on human rights, the environment, health, and safety. These risks can be reduced if the South African mining sector follows international best practices and if South African battery manufacturers make use of initiatives and tracking systems for tracking raw material sources. Battery procurement measures can enforce these activities by making them mandatory. While battery cell reuse and recycling are currently at low levels, there are processes for high rates of metal recovery, and over the medium to long term, these activities must grow within the South African battery industry through government policy support.

While there are fire risks associated with lithium-ion batteries, these can be mitigated through a range of measures.

Challenges for Grid Battery Deployment

One of the most prevalent concerns among interviewees was an insufficient understanding of grid batteries. This concern was presented at all stakeholder levels and across multiple topics—particularly around realistic battery capabilities, technical integration within the power system, and viable business or finance models. While there is still a range of technical challenges, most of these can already be solved with additional spending or prudent regulation.

Economic Challenges

Economic challenges dominated interviewee responses, with three important findings, despite the general expectation that battery-related costs will continue to decrease. First, not everyone is talking about the same costs, so care must be taken to identify exactly what costs are being discussed. Second, there is a need to recognize the value that batteries provide, as many services cannot yet be monetized in South Africa. Third, cost concerns are often actually about access to affordable capital as batteries are so capital intensive.

The viability of battery projects is also heavily linked to a range of tariffs. These include tariffs for charging and discharging the battery, wheeling, and ancillary services. In short, interviewees felt that extensive work is required on all existing tariffs, which are currently a source of uncertainty from a battery project development perspective. Battery operators' single biggest revenue-related concern was difficulty in accessing multiple revenue streams or an inability to do so. For example, there is not yet a national system for compensating battery operators for ancillary services. As a new entrant to the market, finance institutions have identified a range of factors that, if improved, could help bring down the cost of capital.

Electricity Sector Framework Challenges

Electricity sector framework challenges represent an opportunity to create a more enabling environment for battery deployment. On national-level planning, there was reasonable consensus that insufficient coordination and disjointed processes have resulted in plans that do not align. For example, the battery capacity allocation in the *Integrated Resource Plans* (2019 and draft 2023) is significantly less than in Eskom's *Transmission Development Plan* from 2022. In several instances, a lack of access to information was also cited, including the full details of transmission grid expansion.

Interviewees identified several laws and regulations that either do not adequately address energy storage (e.g., the Electricity Regulation Amendment Bill), do not contain enough detail (e.g., storage services in the grid codes), are too onerous on municipalities (Electricity Regulations on New Generation Capacity), are missing or incomplete (e.g., National Wheeling Framework), or provide too much control to the Minister at the Department of Mineral Resources and Energy (DMRE).

Incentives to encourage battery deployment were often covered within other economic factors, such as access to multiple revenue streams. However, some specific tariffs could be introduced (e.g., residential time-of-use), and tax allowances could be extended to energy storage to improve the business case for grid batteries.

On procurement, there was a strong sense not to repeat the lack of systems thinking evident in the Risk Mitigation Independent Power Producer Procurement Programme (REI4P). In addition to improving the specifications, one issue with the Battery Energy Storage Independent Power Producer Procurement Programme (BESI4P) has been that it was not realistic for vanadium redox flow batteries to compete, and local demand is required to develop a local value chain for this battery type.

Potential Solutions

This report provides many suggestions for how to address the challenges identified. A selection of these suggestions is provided in the table below. Priority actions that relate to three overall objectives are noted with icons as follows:

1. Improve the basis for planning and decision making.
2. Facilitate access to multiple revenue streams.
3. Support immediate local value chain opportunities.

Table ES1. Selected suggestions to address challenges of grid battery deployment

Challenges	Potential solutions
Insufficient understanding of grid batteries	Recognize the urgent need for knowledge sharing.
	Increase free access to relevant planning information, especially DMRE modelling, Eskom transmission planning, and battery tender documents.
Costs and value	Identify components of capital cost that can be reduced (while maintaining the required standard and function) in the short term, with a longer-term aim to increase local content.
	Support the development of better evaluation metrics, e.g., the levelized value of storage.
Tariffs and revenue	Government should decide on the best wheeling model, then set wheeling tariffs.
	Eskom and the battery industry should set prices for ancillary services.
	Establish a market for ancillary services.
	Develop remuneration models for revenue stacking.

Challenges	Potential solutions
Finance and funding	Multistakeholder engagement with finance institutions to address grid battery procurement concerns to reduce the cost of capital.
	The government should ensure that the Just Energy Transition Partnership is a success, as it could provide funding for grid batteries.
Planning and policy	Establish a multistakeholder collaborative platform to develop electricity infrastructure plans, reducing parallel planning efforts and conflicting outcomes.
	Align the battery capacity allocations in the *Integrated Resource Plan* to match the system operator needs in the *Transmission Development Plan*.
	Government should shift to open-source modelling.
	Prioritize the finalization and implementation of the South African Renewable Energy Masterplan.
	Expedite consultation on and the development of Critical and/or Battery Minerals Masterplans.
	Identify ways to assist municipalities with the information, skills, and budget needed to include batteries in their infrastructure development plans.
Laws and regulations	The Electricity Regulation Act (ERA) should clearly define energy storage, classify it, and provide clarity on how it is treated by other laws.
	ERA schedule 2 should extend the National Energy Regulator of South Africa (NERSA) licensing exemption to all battery storage.
	Grid codes need more details on ancillary services that match what batteries can provide. Each service should be individually defined so it can be procured separately.
	NERSA and battery developers should discuss ways to mitigate any commercial impacts from complying with the battery grid code.
	Remove the requirement for municipalities to apply to the minister at DMRE to procure energy services (including storage) from independent power producers, and simple power purchase agreements should be allowed.
	Identify any elements of the regulatory framework that may need to change to allow revenue stacking.
Incentives	Several sections of the Income Tax Act could be applied or extended to include energy storage, specifically sections 11A, 11D, 12B, 12I, and 12L.

Challenges	Potential solutions
Public procurement	Competitive tenders based on evaluation price should include a form of indexation to accommodate unavoidable increases in selected input costs.
	Have separate tenders for short- and long-duration batteries with an optimized contract period and cycling regimes.
	To encourage local value chains, procurement pipelines must be regular and predictable, having steady capacity additions each year that also align with system operator needs.
	Collaborative, interdepartmental work to determine a pragmatic way to phase in realistic local content requirements over time.
	See if battery tender specifications can be relaxed to deliver sufficient functionality and quality of installation but at a lower cost.
	Tenders should have supplier requirements for the best human rights and environmental practices for raw material extraction, processing, recycling, and waste disposal.

Table of Contents

List of Figures

List of Tables

List of Boxes

Abbreviations and Acronyms

ARENA	Australian Renewable Energy Agency
BESI4P	Battery Energy Storage Independent Power Producer Procurement Programme
BESS	battery energy storage system
DMRE	Department of Mineral Resources and Energy
DRC	Democratic Republic of the Congo
EITI	Extractives Industries Transparency Initiative
ERA	Electricity Regulation Act
ERAB	Electricity Regulation Amendment Bill
GW	gigawatt
IEA	International Energy Agency
IPP	independent power producer
IRP	Integrated Resource Plan
JET	just energy transition
JETP	Just Energy Transition Partnership
kW	kilowatt
LCA	life-cycle assessment
LCOS	levelized cost of storage
LFP	lithium ferrophosphate
LIB	lithium-ion battery
MW	megawatt
MWh	megawatt hours
NERSA	National Energy Regulator of South Africa
NMC	nickel manganese cobalt oxide
NREL	National Renewable Energy Laboratory
PV	photovoltaic
REI4P	Renewable Energy Independent Power Producer Procurement Programme
RMI4P	Risk Mitigation Independent Power Producer Procurement Programme
SAREM	South African Renewable Energy Masterplan
TDP	Transmission Development Plan
USAID	United States Agency for International Development
VRFB	vanadium redox flow battery

1.0 Introduction

This report focuses on batteries that are located on the transmission or distribution grid, the primary purpose of which is to improve grid functioning or the public electricity supply. These grid batteries are also termed front-of-the-meter batteries (see Appendix A) and can be stand-alone or co-located with renewable energy generators as a hybrid project.

Part 1 in this series explained how grid batteries can help the electricity crisis in South Africa, despite that there is not yet momentum in their deployment (Halsey et al., 2023). This report summarizes a range of issues related to grid battery development in South Africa.

The aim is to investigate how to create an enabling environment for grid battery deployment while maximizing key benefits and minimizing human rights violations and environmental, health, and safety risks.

This report does not provide detailed, technical information but rather identifies main issues, themes, and concerns, along with potential solutions. This analysis was achieved primarily through interviews with over 70 experts and stakeholders from a wide range of fields (see details in the section, About This Series). All interviews were conducted under the condition of anonymity. The focus was at the national level, with the municipal level included where appropriate. This report is not exhaustive—there were many issues raised in interviews that were beyond the scope for inclusion in this document but may feed into future work. There are several South Africa-specific studies that cover relevant battery topics in much more depth (Appendix B).

1.1 International Experience

Grid batteries have only recently gained traction internationally, with most of the capacity installed in the last 6 years. Annual capacity additions are increasing significantly each year, with 75% more in 2022 than in 2021, and lithium-ion is the dominant technology (International Energy Agency [IEA], n.d.). This ramping up mirrors the trajectory renewable energy followed in the early 2000s.

A brief overview of international experience shows that many levers can be used to promote the deployment of grid batteries. The specific needs of each country influence which approach will work best, and these circumstances evolve over time as energy systems transition.

In 2022, an RES4Africa study made a detailed comparison of the battery energy storage systems (BESSs) in the United Kingdom, California, and Chile. These three countries have significant amounts of utility-scale BESSs but **different drivers and enabling factors, which led to growth in BESSs.** This analysis indicated that a predominant driver (or use case) for BESSs is that it influences the design of procurement and remuneration models and that BESSs can still be enabled within a variety of market structures (Mackay et al., 2022).

Table 1. A comparison of grid battery deployment features in different regions

California	Chile	United Kingdom
Installed grid BESS capacity (MW)		
5,234 (July 2023)	263 (January 2024)	4,000 (January 2024)
Initial primary driver		
Timing imbalance between peak demand and renewable energy supply	The geography results in long transmission lines subject to bottlenecks	Inadequate system function due to an increased proportion of electricity from renewable sources.
Primary BESS function		
Energy shifting	Grid investment deferral	Ensure capacity availability Flexibility services
Market features		
Partially liberalized (hybrid of independent power producers and local utilities)	Fully liberalized Price for time supply blocks	Fully liberalized
Enabling factors		
• Bill requiring investor-owned utilities to procure a set amount of BESSs • Tax incentive provided investors with a credit to reduce upfront costs	• BESSs participate in the Transmission Development Plan • A 2020 Flexibility Strategy encourages investment in BESSs and promotes clear regulations for storage	• Capacity auctions (paid to have capacity available) • Ancillary services market (particularly ultra-fast balancing) • Remuneration structure included fixed long-term payment (for capacity, megawatts [MW]) and a variable payment (for bulk electricity or services, megawatt hours [MWh])

Source: Installed capacity: Asociación Chilena de Energías Renovables y Almacenamiento AG, 2024; California Energy Commission, n.d.; Energy Storage News, 2024; table contents are summarized from Mackay et al., 2022.

Note: All three countries had additional drivers of climate change-related commitments to increase renewable energy and decrease fossil fuel reliance.

The state of South Australia (in Australia) is widely recognized as a world leader in grid battery deployment. As of February 2024, the state had 512 MW of existing battery capacity, which is 7.6% of the total power supply capacity. This high percentage is on par with California, another battery front-runner.[2] These developments in South Australia are all recent, with the first "big battery" coming online in 2017, and proposed battery projects account for a massive 40% of all future state energy projects on a capacity basis (Australian Energy Market Operator, n.d.; California Independent System Operator, 2023).

Box 1. Support for rapid grid battery deployment in South Australia

South Australian Government

- **Clear government commitment** – strong renewable energy and storage policies give political backing and reduce bureaucratic hurdles.
- **Technological innovation support** – funding for hybrid solar and vanadium redox flow batteries to bring vanadium battery chemistries into the storage mix (Australian Renewable Energy Agency [ARENA], 2020).
- **Fast-tracking** – battery projects are given an exemption from certain planning requirements (Carroll, 2023).
- **Dedicated finance mechanism** – AUD 50 million Grid Scale Storage Fund established in 2018 matched applicants' existing funding dollar-for-dollar to help projects get developed sooner (Kenning, 2018).

Federal government

- **Funding** from ARENA, including to cover the additional cost of building grid-forming inverters with battery facilities, as these can provide additional services traditionally provided by synchronous generation, such as coal and gas (ARENA, 2022).
- **Battery tender guarantees baseline income** – A 600 MW/2,400 MWh tender in South Australia and Victoria has a floor revenue value underwritten by the federal government (Peacock, 2023).

Multiple revenue streams

- Australia's National Electricity Market allows battery operators to gain revenue from a variety of services, with lucrative new classes of frequency control introduced in 2023 (Colthorpe, 2024).

Key messages for South Africa:

- Solutions are location specific. Lessons can be taken from an increasing number of international success stories for deploying grid batteries, but they must be appropriate for the South African context.
- Identifying the primary use case can help to determine the best enabling factors, but these use cases will likely vary between locations within South Africa.

[2] The comparative figure for the United States in January 2024 was only 1.2% (U. S. Energy Information Administration, 2024).

- Multiple revenue streams, clear government policy support, catalytic funding, and specific financing mechanisms for initial battery projects can help accelerate adoption.

1.2 South African Context

The reforms required to enable an acceleration in the deployment of grid batteries depend on the current context of the sector. This section provides a summary of some of the aspects that have been identified through the interviews and a supporting literature review.

Outdated Electricity Sector Framework

The entire electricity sector framework (including planning, policy, laws, regulations, incentives, and procurement) in South Africa evolved to serve an energy system dominated by centralized, state-owned fossil fuel generators. The electricity system is changing into one with more distributed renewable energy and energy storage facilities that are owned and operated by a wider range of actors than in the past. The challenge is that **many of these electricity sector framework components have not yet been updated to accommodate the components of this emerging energy system.**

Energy storage poses a new set of considerations as it acts as both a load and a generator, can provide multiple services, and is often part of a hybrid installation with renewables. Many of the hurdles grid batteries face arise because the existing frameworks (at all governance levels) are not yet flexible enough to deal with these energy storage-specific features.

Political Will and Vested Interests

As described in Part 1 of this series, grid batteries can enable renewable energy and reduce the use of gas-fired peaking plants (Halsey et al., 2023). Such functions reduce fossil fuel dependence, and while this is part of a just energy transition backed by the national government, there is still high-level support from many government energy officials for keeping coal in the electricity sector going as long as possible and adding gas to be used at high-utilization rates.

Interviewees thought that under these circumstances, grid storage is not a priority nationally. An example is that the first round of grid battery capacity procurement in South Africa has been delayed by 3 to 4 years.[3]

Eskom Unbundling and an Evolving Market Structure

Eskom, the state-owned electricity utility, is in the process of unbundling, which involves splitting the utility into three separate legal entities for generation, transmission, and distribution. This unbundling presents an opportunity to improve enabling factors for energy storage as fundamental shifts in national electricity supply are being made anyway. The emergence of an independent transmission system operator and distribution entity could see

[3] Capacity that was meant to come online in 2022 will only come online in 2025 or 2026.

grid batteries receiving more attention, given the grid benefits these facilities can provide. However, interviewees also noted that the delays in the unbundling process are also pushing back opportunities for grid battery storage.

As international experience indicates, grid batteries have been deployed in a variety of market conditions. While grid batteries have been installed in countries with less liberalized electricity markets, there may be better platforms for BESS services to compete within more liberalized markets (Mackay et al., 2022). With a shift underway in South Africa toward a more open electricity market with competitive trading, there may be increased prospects for grid batteries.

Financial Constraints

Eskom and the majority of municipalities have severe financial constraints. This is a challenge for grid batteries, as they are capital intensive and have not yet established a track record in South Africa, which reduces companies' ability to secure sufficiently low-cost finance.

2.0 Maximizing the Local Benefits of Grid Batteries

An optimal national rollout strategy should identify the capacity, duration, location, sequence, and timing of battery deployment. The choice of battery chemistry to meet these power system requirements must also consider which technology can contribute the most to the South African economy and job creation through the development of local value chains.

2.1 An Optimal National Rollout Strategy for Grid Batteries

Power System Modelling

Power system models are one of the tools used in electricity system planning. They typically aim to identify the least-cost way to balance electricity supply and demand over time,[4] giving a recommended timeline for building the required new infrastructure. However, basic capacity expansion models may not consider the physical limitations of the transmission network (such as line congestion and transmission losses) or the spatial considerations for where to build the infrastructure.

Procurement of batteries at the national level is based on the *Integrated Resource Plan* (IRP) *2019* developed by the Department of Mineral Resources and Energy (DMRE). However, in Table C1 in Appendix C, the results published by five different power system modelling teams since 2020 (including the IRP) show that **national grid battery capacity allocations to 2030 vary from 0 to 18 GW.**

This is a huge range relative to the size of the South African power system, where Eskom's total fleet of power stations is 46.8 GW (Eskom, 2023a). Even results from individual research groups have changed significantly between their studies, which illustrates how sensitive this type of modelling is to changes in input assumptions, modelling software, scenario parameters, and available resolution.[5]

This variability and lack of consensus is evidence that the optimal strategy for national grid battery deployment should not rely on results from one modelling team. However, individual models are useful to test how changes in one variable affect the outputs. Across various scenarios in Table C1, some grid battery trends emerge (research interviews):

- As the power sector carbon budget decreases, the models favour more batteries, so as decarbonization becomes more of a priority, batteries will feature more prominently.

[4] These models can then add aspirational goals (like limits on greenhouse gas emissions) or add real life restrictions (like a rate at which infrastructure can feasibly be built).

[5] Resolution refers to the granularity of time intervals or spatial areas over which data is collected or simulations are performed; it affects the detail and accuracy of the model's predictions.

- Lower-resolution modelling undervalues the contribution of batteries, so as model resolution improves, batteries are expected to feature more prominently.
- The duration of recommended BESSs generally increases in later years. Although 1- to 2-hour durations may be sufficient until the mid-2020s, several optimizations choose 4-hour duration for initial builds and up to 8 hours could provide additional benefits.

Moreover, power system models that do not include spatial considerations do not consider the full picture of grid batteries. They primarily solve the problem of balancing overall electricity supply and demand in the system but do not address where to build batteries or how to use them to improve grid function, which is one of the main benefits of grid batteries.

On the other hand, grid development plans[6] may analyze the quantity and location of grid batteries required to optimize existing asset utilization and grid expansion in a way that also meets supply and demand. Given the many grid functions that batteries can provide, grid development plans are a key input into a national rollout strategy for these batteries.

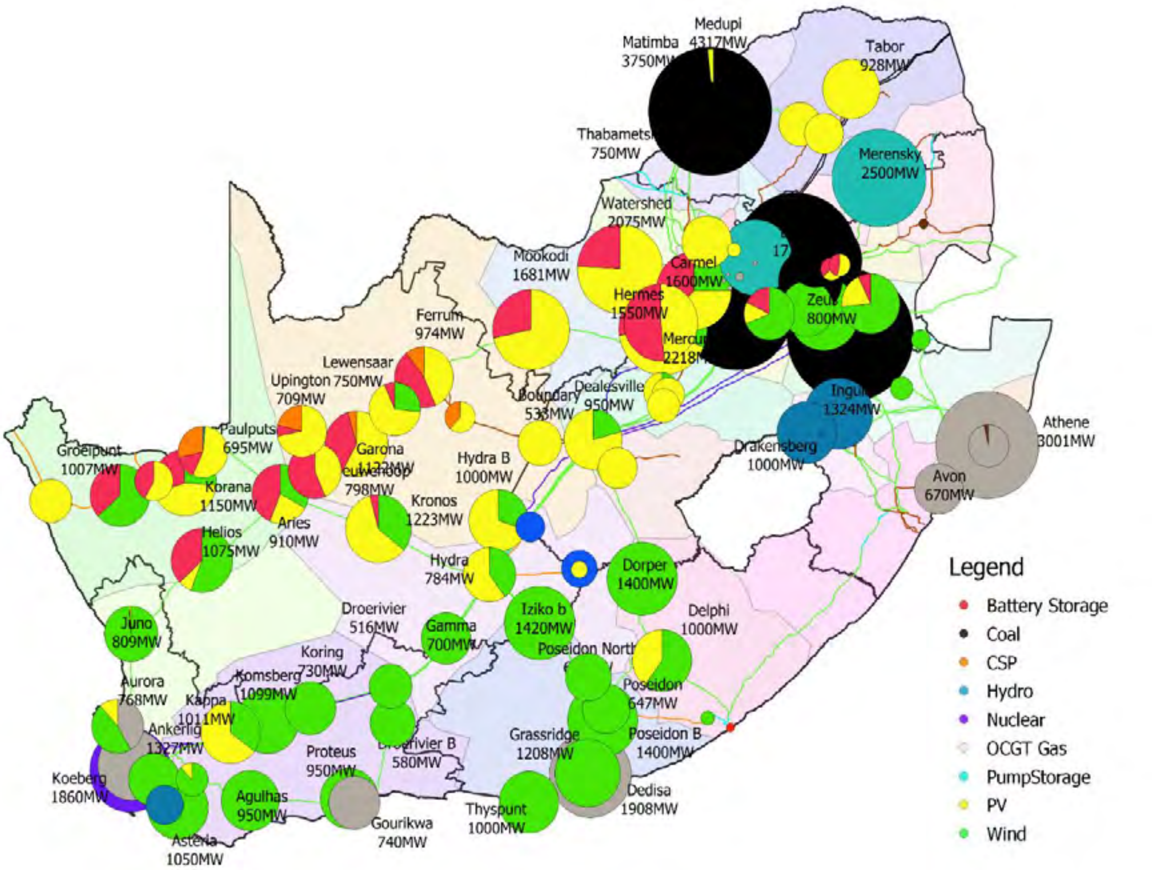
Transmission Development Plan

Eskom operates the national transmission grid and publishes an annual Transmission Development Plan (TDP). In 2023, Eskom was granted an exemption from publishing a TDP, so as of May 2024, the latest TDP is from 2022 and covers the period from 2023 to 2032.

The purpose of the TDP is to outline both the expansion of new grid components and the refurbishment of the existing network infrastructure. In addition to calculating new generation and storage capacity required over time, the **TDP estimates the best spatial distribution of these facilities and how they relate to load centres** (i.e., where the power is consumed). The published TDP 2022 provides the quantity *and* location of BESSs in 2032 (Figure 1), but in prior years, it only gives quantity. So, the full planned build sequence is not yet publicly available.

[6] They can be broadly divided into those for the transmission grid (developed by Eskom) and those for distribution grids (developed by Eskom or municipalities).

Figure 1. Spatial allocation of generation and storage in 2032 as per TDP 2022



Source: Eskom, 2022a (reprinted with permission). Note: The battery storage in red in 2032 is a total of 6,550 MW, with 308 MW in Mpumalanga, 3,267 MW in Northern Cape, and 2,975 MW in North West.

In TDP 2022, **Eskom has recognized the important role of grid batteries and increased capacity to 2030 by a factor of 2.75** compared to TDP 2021.[7] Importantly, the 5,750 MW by 2030 is significantly more than the 2,088 MW stated in the IRP 2019.

Renewables Plus BESSs

Many interviewees indicated that an optimal rollout strategy for grid batteries should **promote hybrid renewable and BESS projects rather than just stand-alone BESSs.** There are three possible reasons for this:

- In a constrained power system, there is an urgent need for more generation; otherwise, there may be insufficient power to charge the BESS.
- BESSs can improve the renewables output and value proposition.
- Hybrid renewables and BESSs can be more cost effective for dispatchable generation than gas or diesel peaker plants.

[7] To 2030, TDP 2021 = 2,088 MW batteries (same as IRP 2019); TDP 2022 = 5750 MW.

Suggestions

- Modelling teams need to work out how to factor in increased demand from charging storage (of all types: grid storage, consumer storage, electric vehicles), which will change the demand profile from what is currently used.
- There needs to be a much stronger feedback loop between national capacity expansion planning (such as the IRP) and national grid expansion planning (such as the TDP) so that the quantity and location of batteries best match the needs of the system operator. Grid battery allocation (capacity and duration) in the IRP and TDP should align.
- In the future, independent modelling teams should directly collaborate with Eskom and DMRE teams from the outset to give the best backing for the power system modelling that guides the TDP and IRP development.
- Eskom should make the full TDP sequence, location, and timing data public for all planned new-build capacity, including storage.
- Modelling and planning should incorporate renewables plus BESSs.
- One avenue to expedite renewables plus BESSs is to add the batteries to existing renewables sites. Several renewable energy developers have already fulfilled some requirements to build BESSs (such as environmental impact assessments) as part of their initial tender preparation (research interviews). As such, these sites could offer a faster route for BESS deployment but will likely provide less overall grid benefit compared with BESSs at optimal locations identified by the system operator.
- Further planning suggestions, including for the municipal level, are given in Section 4.4.

2.2 Technology Choice and Value Chain Development

The two leading technology choices for grid batteries in South Africa are lithium-ion batteries (LIBs), specifically the lithium ferrophosphate (LFP) type, as they are market leaders, and vanadium redox flow batteries (VRFBs) due to local factors, as explained in Appendix D. This section provides a brief overview of immediate value chain potential for both technologies. This is just a high-level summary; reports by Trade & Industrial Policy Strategies and LSF (Appendix B) and the South African Renewable Energy Masterplan (SAREM) investigate this topic in detail.

LIB Value Chain Potential

As LIBs can be used in electric vehicles and for consumer storage, the development of a LIB value chain is strongly linked to these sectors. South Africa has several companies that manufacture specific components for stationary, utility-scale LIBs and others that assemble imported cells into the cabinets or containers along with the battery management system.[8]

[8] An electronic system to monitor, control, and protect rechargeable batteries during operation.

South Africa has some comparative advantages for the further development of an LIB value chain. While it lacks a significant source of lithium,[9] it does have large reserves of other materials used in LIBs (such as cobalt, nickel, iron ore, manganese, and titanium) and extensive experience in mining and mineral processing.

However, there are also several disadvantages. First, although domestic or regional demand for LIBs is growing rapidly, it is still small by global standards. Wider international markets are distant, highly competitive, and dominated by Chinese production, where extensive economies of scale advantages are realized. Second, South Africa currently lacks the necessary research and development skills to be competitive in the field (Montmasson-Clair et al., 2021). Third, there is little immediate scope for LIB recycling in South Africa as too few batteries are available for recycling due to poor post-use collection infrastructure (Gericke et al., 2021). At present, the vast majority of LIBs end up in landfills or are shipped abroad for processing (Montmasson-Clair et al., 2021).

This status quo suggests that the immediate opportunities for local LIB value chain development are increased beneficiation of minerals to battery grade to serve the international battery market and increased battery manufacture (still with imported cells).

To this end, master plans that include mineral beneficiation are being developed (see Section 4.4).

VRFB Value Chain Potential

At present, VRFBs have higher capital costs than equivalent-capacity LIBs, but VRFBs will likely become more cost competitive as the technology matures and better economies of scale are realized (Huang et al., 2022). VRFBs can provide longer-duration storage (up to 12 hours under typical conditions), an attribute[10] that is likely to become more valuable as the low-carbon energy transition progresses (Moshikaro & Pheto, 2023).

Bushveld Minerals has built a vanadium electrolyte plant in East London and a VRFB hybrid mini-grid at the Vametco Mine in the North West province with 3.5 MW solar photovoltaic (PV) and a 1 MW/4 MWh VFRB. The battery was completed in July, and the solar plant was installed in September of 2023, but the mini-grid has not been fully turned on as of May 2024 due to a very complicated and lengthy grid compliance process from Eskom (research interviews). At the time of writing in May 2024, it had been reported in the press that the company is facing financial difficulties (Ryan, 2024). This highlights the importance of building a supportive policy environment for local battery minerals mining and battery manufacturing if South African companies are to succeed.

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[9] There are limited reserves of lithium in the Northern Cape (M. Creamer, 2023). While there are significant deposits in Zimbabwe, a recent export ban on unprocessed lithium creates uncertainty as to whether South Africa will gain access to Zimbabwean lithium (Makgatho, 2023).

[10] See Appendix D for additional advantages of VRFBs.

In time, and if the market grows for VFRBs as they anticipate, Bushveld Energy (a subsidiary of Bushveld Minerals) hopes to be able to build VFRBs in South Africa, with 80%–90% local content (Bulbulia, 2022).

Much like the situation with LIBs, any development of a local value chain for VFRBs would have to compete with China, where the development of the technology is far more advanced than it is in South Africa. China has the world's largest VRFB system and is also home to the world's largest vanadium reserves (Long & Lun, 2022).

It seems the **immediate opportunity is for the growth of the VRFB value chain segments initiated by Bushveld Minerals.** Since VRFBs are not used for electric vehicles and are a niche market for consumer storage, there would need to be local demand for them as grid batteries.

Table 2. Summary of opportunities for South African value chain development

	LIB	VRFB
Past or existing experience	• Mineral beneficiation battery assembly, including management systems	• Vanadium mining and processing • Electrolyte production • Battery assembly
Immediate opportunities	• Increase in battery manufacturing • Increase in mineral beneficiation to battery grade.	• Growth in vanadium mining, processing, electrolyte production, and VRFB assembly
Maximum	• Cell manufacturing	• Stack manufacturing*

* The stack is the assembly of individual cells where the electrochemical reactions occur.
Source: Adapted from DMRE et al., 2023.

Technological Lock-In

The current grid battery landscape features rapid innovation, but the market is dominated by LIB. This creates a danger of technological lock-in[11] if LIBs are invested in to an extent that prevents other technologies entering the market (Hering, 2018).

So, while South Africa is already investing in grid-located LIBs, this should be done in a way that leaves room for other technologies like VRFB in the short to medium term. Similarly, **given South Africa's significant manganese deposits (30% of global reserves), in the longer term, it may make sense to include investments in manganese-linked battery technologies,** which show significant potential for future grid-scale applications (Wang et al., 2020) and electric vehicles (Mulgund, 2023).

[11] Technology lock-in is where existing structures favour and perpetuate the use of certain technologies.

Local Content

The worsening electricity crisis in South Africa since 2019 has accelerated the uptake of batteries, but most are sourced from the global market. Imports, mainly from China, of lithium-ion cells and batteries into South Africa reached USD 1.75 billion in 2023, more than twice that in 2022 at USD 0.73 billion (research interviews).

Importing complete batteries impedes local assembly or manufacture and negates the kinds of skills transfer necessary to develop local battery value chains. While the recent increase in imports is predominantly for private or consumer storage projects, there is a risk this trend could extend to batteries for grid applications.

One way to foster local battery value chains is to implement local content[12] requirements for procurement similar to those imposed within the Renewable Energy Independent Power Producer Procurement Programme (REI4P) (DMRE, 2023c). However, these requirements must be realistic, and lessons should be drawn from the inability of project developers to meet the high local solar PV content requirements within REI4P in 2022 (Omarjee, 2022).

For the Eskom BESS program (the first contracts were awarded in 2022), the government lifted many of the stringent local content requirements that have featured in the REI4P (Burger, 2023; Eskom, 2022b). In March 2023, the DMRE released a request for proposals for 513 MW of battery capacity in line with the IRP 2019. Economic development commitments are not a qualification criterion, but at the evaluation stage, only 10 points out of 100 are for economic development commitments (one of which is local content); the other 90 points are for price (DMRE, n.d.).

Future procurement will need to find a balance in making mandatory local content requirements high enough to help grow a local battery industry but not so high that procurement fails and insufficient battery capacity is deployed.

Local manufacturing is only likely to succeed if there is compelling evidence that there is sustained regional demand for utility-scale batteries. Evidence from renewable energy deployment in South Africa demonstrates that uncertain policy (or its implementation), leading to uncertain demand, ultimately leads to local manufacturing failures. For example, in 2019, a South African company, DCD Wind Towers, closed due to a lack of government commitment to wind energy sources (Mhlathi, 2019).

Job Creation

There is limited data on the job creation potential of battery value chains in South Africa. Estimates from the main study on this topic (Table 3) are a starting point, but this is an area that needs more research.

[12] "Local content" is the portion of the total project value that comes from local products or services.

Table 3. Estimated job creation in South Africa to 2030 for battery value chain scenarios

Value chain scenario		Direct jobs	Indirect jobs	Total jobs
Increasing level of activity ↓	• Local battery minerals are beneficiated • Local companies are involved in extensive battery assembly for domestic and export markets	2,455	23,080	25,535
	• South Africa becomes a regional battery mineral beneficiation hub • Expansion of the battery pack manufacturing industry	3,195	36,948	40,143
	• Local LIB cell manufacturing and electric vehicle production within a fully integrated value chain	4,085	54,140	58,225

Source: Data from Customized Energy Solutions, 2023.

Suggestions

Overall, efforts should be directed at realizing the immediate avenues where there is consensus for LIB and VRFB value chain development, as these are prerequisites for medium- to long-term opportunities. Planning, procurement, and incentive suggestions are covered in Section 4.

- Increase skills development in partnership with the Energy Storage Consortium (initiated by the Department of Science and Innovation). Technology partnerships with countries with advanced battery experience can help develop skills further.
- DMRE should work with the mining industry to identify reserves and mining operations that can be expanded to increase battery mineral beneficiation.
- Grant funding and investment could help reduce local VRFB costs.
- Flexible energy planning with regular updates should assess new battery innovations against pre-existing advantages South Africa may have and opportunities for localization.
- Designing a pragmatic and incremental approach to increasing local content targets over time will require stakeholder collaboration between battery industry players, energy planners, and decision-makers to identify short-term localization limitations and how these can be improved in the medium term.
- Certainty on policy support for grid batteries, deployment timelines, and procurement processes will further encourage the localization of utility-scale battery production.
- Job data needs more research in conjunction with SAREM and minerals master plans.

3.0 Minimizing Human Rights Violations and Environmental and Safety Risks Associated With Grid Batteries

Batteries are part of a low-carbon energy transition, but like all technologies, they come with negative impacts and sustainability concerns. Since LIBs (particularly LFPs) and VRFBs are receiving the most attention in South Africa for grid applications, this section presents a non-exhaustive selection of identified risks. Building a greater understanding of risks is necessary to create policy.

3.1 Harmful Raw Material Extraction and Processing

LIBs

The mining and processing of raw materials for utility-scale batteries has both environmental and social costs. The nickel and cobalt in some LIB types are of particular concern because the mining of these materials has, in some cases, been closely associated with serious human rights and environmental abuses, especially in the Democratic Republic of the Congo (DRC) (Amnesty International, 2016; Müller & Reckordt, 2017).

Although life-cycle assessment (LCA) research demonstrates that LFP has the least overall environmental and social costs of all LIB battery types (Yudhistira et al., 2022), it still depends on a regular lithium supply.

While global lithium supplies remain relatively abundant, more data is required to understand the potential negative impacts on local peoples, water supplies, and local flora and fauna in the so-called Lithium Triangle located in Argentina, Bolivia, and Chile, where 70% of the world's proven lithium supplies exist (Agusdinata et al., 2018). Concern has also been expressed that as easier lithium deposits become exhausted, lithium in silicate rock deposits will be extracted, and the DRC has extremely large reserves of rock-based lithium (Alessia et al., 2021).

VRFBs

Vanadium is a toxic substance and an environmental and occupational hazard that has been shown to cause several illnesses in laboratory animals (Utembe et al., 2015). Worryingly, there is currently little understanding of how vanadium interacts with the wider environment, leading a group of scientists to recently argue that "vanadium hazard and risk assessments must be improved" (Watt et al., 2018). These scientists contend that an ongoing global increase in exposure to vanadium, likely to accelerate with the adoption of VRFBs, presents "a growing problem requiring wide-scale intervention" (Watt et al., 2018).

Recent LCAs of three flow battery chemistries (vanadium redox, zinc bromide, and all iron) showed that VRFBs exhibited the highest negative environmental and human health hazards (Tarroja et al., 2021). Despite these findings, research (largely based on predictions rather than real-world experience) indicates that the LCA impacts of VLRBs are still lower in all assessed categories (environmental, human toxicity, etc.) than the impacts of LIBs, despite the use of coal combustion in vanadium production in South Africa, which has significant greenhouse gas emissions (Weber et al., 2018).

Deep-Sea Mining

The potential for deep-sea mining (over 200 m) to supply core components of various battery types is a further environmental concern due to oceanic habitat destruction. Polymetallic nodules from the ocean floor have been shown to contain manganese, cobalt, nickel, iron, lead, zinc, copper, and lithium, among other metals. It is not yet known how much of a threat mining these nodules is to the world's oceans, but the likelihood of deep-sea mining going ahead increases as commodity prices rise (Sharma, 2019).

The International Seabed Authority, established by the United Nations to manage ocean mineral exploration, has already granted 31 rights for the "exploration of polymetallic nodules, polymetallic sulphides, and cobalt-rich ferromanganese crusts" in the deep seabed (International Seabed Authority, n.d.).

Suggestions

Mining and Processing Standards

The South African mining sector can follow the *Mining Policy Framework* from the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (2023), which represents the best practices required for good environmental, social, and economic governance, and also the equitable sharing of benefits.

South African battery manufacturers can source materials from

- countries that have signed up to the Extractives Industries Transparency Initiative (EITI) standards, which support the responsible and transparent production of minerals (EITI, n.d.);
- companies that follow the United Nations Free, Prior, and Informed Consent principles, which hold that nothing that impacts the lands or rights of people can take place without their full consent (United Nations Department of Economic and Social Affairs, 2016); and
- companies that have undergone stock market-imposed environmental, social, and governance screening processes (Investopedia, 2023).

Other important initiatives include

- the Transition Resource Tracker, which tracks the human rights record of companies involved in the mining of transition minerals (Business & Human Rights Resource Centre, n.d.) and
- the Battery Passport, a tool that documents battery features, including certification on minerals sourcing (Global Battery Alliance, n.d.).

Recycling and Waste Management

The sustainability and environmental footprint of battery value chains can be improved through recycling. The Chinese company Brunp Recycling demonstrates what can already be achieved for LIBs. They have a metal recovery rate of 99.3% for nickel, cobalt, and manganese at a facility with a recycling capacity of 100,000 tonnes of LIB scrap per year (Osmanbasic, 2021).

Internationally, it is unclear what percentage of LIBs are recycled, despite regular reports of very low volumes (Melin, 2019). In South Africa, it is reported that less than 1% of LIB waste is collected, with the rest going to landfills (Gericke et al., 2021)

These low LIB recycling rates exist partly because the large variety in chemical composition of LIBs creates difficulties in recycling. Furthermore, both current recycling techniques—pyrometallurgical and hydrometallurgical[13]—are relatively expensive and produce additional environmental challenges. These challenges include high energy use and emissions for pyrometallurgical processing and toxic chemicals and possible water supply contamination for hydrometallurgical processing (Costa et al., 2021; Windisch-Kern et al., 2021). Although there are obstacles, there is potential to greatly increase the recycling rates of LIBs in the future as LIBs become more widely deployed or if raw material prices rise.

Regarding VRFBs, there is potential to reuse the vanadium electrolyte in new VLRBs (Blume et al., 2022). While there is considerably less research available on the recyclability of VLRBs, what is available demonstrates that recycling VLRBs is far less complex than recycling LIBs, will subsequently be cheaper to undertake, and will have fewer environmental side effects (Weber et al., 2018).

One way to encourage recycling is to fully consider recycling during the battery design phase (Mohr et al., 2020). Another way is via mandatory recycling legislation that facilitates a circular economy for batteries. In the European Union, for example, legislation has been provisionally agreed to that imposes minimum recycling and reuse requirements on battery technologies (European Parliament, 2022).

Such legislation ensures that battery types, even those where there is currently limited economic incentive to recycle, such as LFPs, do get recycled (Mohr et al., 2020). However, there needs to be a market for recycled material. An additional benefit of recycling is that it also reduces the likelihood of price inflation caused by increases in the demand for raw materials.

Box 2. Steps toward battery reuse and recycling in South Africa

The South African company REVOV reuses LIBs from electric vehicles, converting them into small-scale stationary battery storage solutions (REVOV, n.d.).

In December 2022, it was announced that an American company, ACE Green Recycling, had partnered with a South African investment group, Tabono, to build "two environmentally sustainable battery recycling facilities" in South Africa for both lead-acid batteries and LIBs (Gumede, 2022).

[13] Pyrometallurgical processing involves smelting, while hydrometallurgical processing entails chemical leaching.

Ocean Reserves

One way to mitigate deep-sea mining impacts could be to increase the amount of ocean that is protected as a reserve. An international agreement was reached in early March 2023 to place 30% of the world's oceans under protection by 2030, but it is not yet clear how deep-sea mining in such areas will be limited (Stallard, 2023).

3.2 Overheating and Fire

Thermal runaway occurs when battery cells enter an uncontrollable, self-heating state that can destroy the battery, release gases, and cause fires or explosions. VRFBs are not considered susceptible to thermal runaway[14] (Whitehead et al., 2017), while LFP has a lower risk than other LIB chemistries (Sun et al., 2023). Factors that increase the chance of thermal runaway in LIBs include the use of low-quality components, manufacturing defects, poor overall design, exposure to temperatures outside of their operating range, damage, and improper charging and usage. Increasing competition could drive some LIB manufacturers to cut corners to reduce costs, which may result in products with a higher risk of thermal runaway (Pathak, 2022).

Suggestions

- The introduction of stringent South African Bureau of Standards regulations on battery design and component quality is necessary.
- Government should ensure that there are accredited laboratories to test that batteries comply with standards.
- LIB operators should select battery models and manufacturers carefully and run the batteries strictly within specifications.
- Effective battery management systems must be in place to regulate temperature and reduce the chance of malfunction.
- Local facility staff and firefighters must be trained specifically in how to handle battery fires in case they do occur.

[14] VRFBs use non-flammable liquid electrolytes and materials, so overall fire risk is negligible.

4.0 Solving the Challenges of Grid Battery Deployment

This section covers a range of technical, economic, and electricity sector framework challenges facing grid battery deployment in South Africa with some suggestions.

4.1 Insufficient Understanding of Grid Batteries

A key theme from interviewees is an insufficient understanding within government, parliamentary committees, regulators, business, finance, and even research institutions about aspects of grid battery storage at a range of levels. This knowledge gap includes how BESSs will technically integrate with existing electricity systems and how they will financially integrate into investment models.

A few reasons cited for this gap include that it is a new market entrant, it is rapidly evolving and disruptive technology, it behaves differently from existing utility-scale energy options, its tools and software have functional limitations, and human resource availability is limited (particularly at the municipal level).

In some cases, this knowledge gap is perceived to lead to either an underestimation or overestimation of the role grid batteries can play in the electricity system. So, although the electricity framework needs updating, there is a lack of knowledge about how to optimize the role for grid batteries.

Suggestions

- Recognize the need for more learning and knowledge sharing related to grid batteries.
- National and local governments should establish platforms to increase understanding of grid batteries, with the participation of public and private stakeholders.
- As the first grid-located LIB came online in South Africa in November 2023 (T. Creamer, 2023b), Eskom can now use performance data to better understand how these batteries function in reality. The same principle applies to the VRFB at the Vametco mine once it is connected to the grid.
- At the municipal level, pilot projects can provide real-world data for how grid batteries function within distribution systems.

4.2 Technical Challenges

Some of the technical challenges in Table 4 are specific to the constrained power system and nascent stage of the battery industry in South Africa. Others relate to understanding how to integrate BESSs with the existing system, and the remainder are global issues based on the limits of current technology, which may improve with more research and development. The solutions in blue will require regulation, and those in brown can partly be solved by spending more money on mitigation measures.

Table 4. Technical challenges and possible solutions for grid battery deployment in South Africa

(gavel icon) require regulation (money icon) can be partly solved by spending more money on mitigation measures

Challenge	Description and the South African context	Possible solutions
Insufficient energy available to charge the battery	In a situation of chronic power shortages, there may not be the surplus energy to charge batteries that there would be under normal power system operation.	• Build BESSs as part of a hybrid renewables system so that all or a majority of charging is not from grid supply. • Overall recovery of the power system in South Africa. • Municipal level – site selection is critical, as some areas are more prone to a supply shortfall.
Performance degradation and lifetime (money icon)	Repeated cycles cause chemical changes and physical wear within the cells that reduce capacity and round-trip efficiency over time. VRFBs have a lower performance degradation rate compared to LIBs.	• Battery technology can still improve with advancements in design. • LIB cells can be refreshed, but this is an additional project cost. • Where possible, manage the dispatch regime to maximize life as much as possible. Hybrid LIB and VRFB facilities can help achieve this.
Low-quality installation (gavel icon)	As a result of high capital costs, there can be a temptation to choose cheaper equipment suppliers, which could result in inferior quality.	• The National Energy Regulator of South Africa (NERSA), the South African Bureau of Standards, and industry stakeholders can establish and enforce minimum quality standards
Local skills limitation	As a new entrant to the market, there has not been time or the certainty of longevity to develop a local skills base.	• Include skills transfer from international workers during initial projects, such as the first national battery procurement rounds.
Inadequate safety measures, especially for fire (gavel icon)	While advanced fire protection mechanisms are now available for LIBs, these add to the cost.	• NERSA and industry stakeholders can establish and enforce minimum fire protection standards.
End-of-life management (money icon)	Globally, there is insufficient recycling infrastructure to deal with the amount of installed capacity.	• South Africa could learn from leaders in battery recycling and look for areas of collaboration, especially within the Southern African Development Community region. • Batteries can be designed to make recycling easier and minimize waste, but it may increase the cost.

Challenge	Description and the South African context	Possible solutions
Theft and vandalism	Theft of copper wire, steel supports, and solar panels is already a problem in South Africa, and battery cells could be similarly targeted.	• Battery enclosure or container design could include restriction of access. • Battery location sites could have dedicated security systems or personnel, but it will be an additional cost increase.
Grid connection	Upgrades may be required to connect BESSs to the existing distribution grid.	• Factor the timing into project development.
Land availability	Permitting and authorization for land access can cause delays for new projects.	• For installations at substations, Eskom or the municipality may already own sufficient land to accommodate the BESSs. • Adding BESSs to existing renewables projects may entail using land where access has already been granted.

Source: United States Agency for International Development (USAID), 2022c; research interviews.

4.3 Economic Challenges

The economic challenges fall into three categories: 1) costs, value, and capital; 2) tariffs and revenue; and 3) finance and funding.

Costs, Value, and Capital

Types of Costs

One of the main concerns that interviewees articulated about grid batteries was "costs are the biggest challenge" or "batteries are still too expensive." But these sentiments require unpacking, as interviews for this report revealed that the term "cost" can have multiple meanings for different people.

In terms of infrastructure, the "cost of grid batteries" could mean

1. the production or import cost of the battery cells and packs;
2. the production, assembly, or import cost of a functional grid battery unit, including management software and housing;
3. building an entire BESS facility, including land and network connection costs; and
4. the total lifetime cost of running a BESS facility, including construction, operations, maintenance, and decommissioning.

While these infrastructure costs are usually thought of in absolute terms, it may be useful to evaluate the net cost of infrastructure. For example, if the total build cost of a BESS facility in a municipality is ZAR 5 million, but ZAR 2 million can be saved in immediate network upgrades by investing in this BESS facility, then the net cost of required infrastructure spend would be ZAR 3 million.

In terms of energy, the "cost of electricity from grid batteries" could refer to or include

1. the cost to supply a distributor with a unit of electricity or services from a BESS facility at a point in time (which may be affected by how the BESS was charged);
2. the end cost that the consumer pays for the electricity or services at a point in time if the customer has a direct power purchase agreement with a BESS operator; and
3. the levelized cost of storage (LCOS).

LCOS is an extension of the concept of levelized cost of energy, and it is defined as the total lifetime cost of the investment in storage technology divided by the lifetime cumulative energy delivered. The calculation uses a standard discounted cashflow method so that the cost per energy unit (e.g., USD/MWh) is in present value terms. **The problem is that LCOS has several limitations in decision making.**

First, the result is heavily dependent on how the facility is used (i.e., how much energy is delivered). As such, LCOS is not an input variable in cost modelling—it is an output based on how a BESS functions within the entire power system. So, two identical BESS facilities (having the same total lifetime costs) could have very different LCOS values if one is cycled daily, providing lots of electricity to the system, and the other is a backup facility that is hardly ever used.

Second, some LCOS calculations include the cost of charging the BESS, and others do not. This complicates comparisons across research studies and could cause confusion.

Third, LCOS does not consider the financial value of the many other services BESSs can provide. Estimating the full value of a BESS is technically complicated[15] and situation dependent, but some local academics and industry professionals are working on a levelized value of storage concept to help guide this process (research interviews).

A fundamental challenge for BESS cost discussions is identifying and understanding exactly what costs are the most appropriate to consider under the circumstances and how best to measure these.

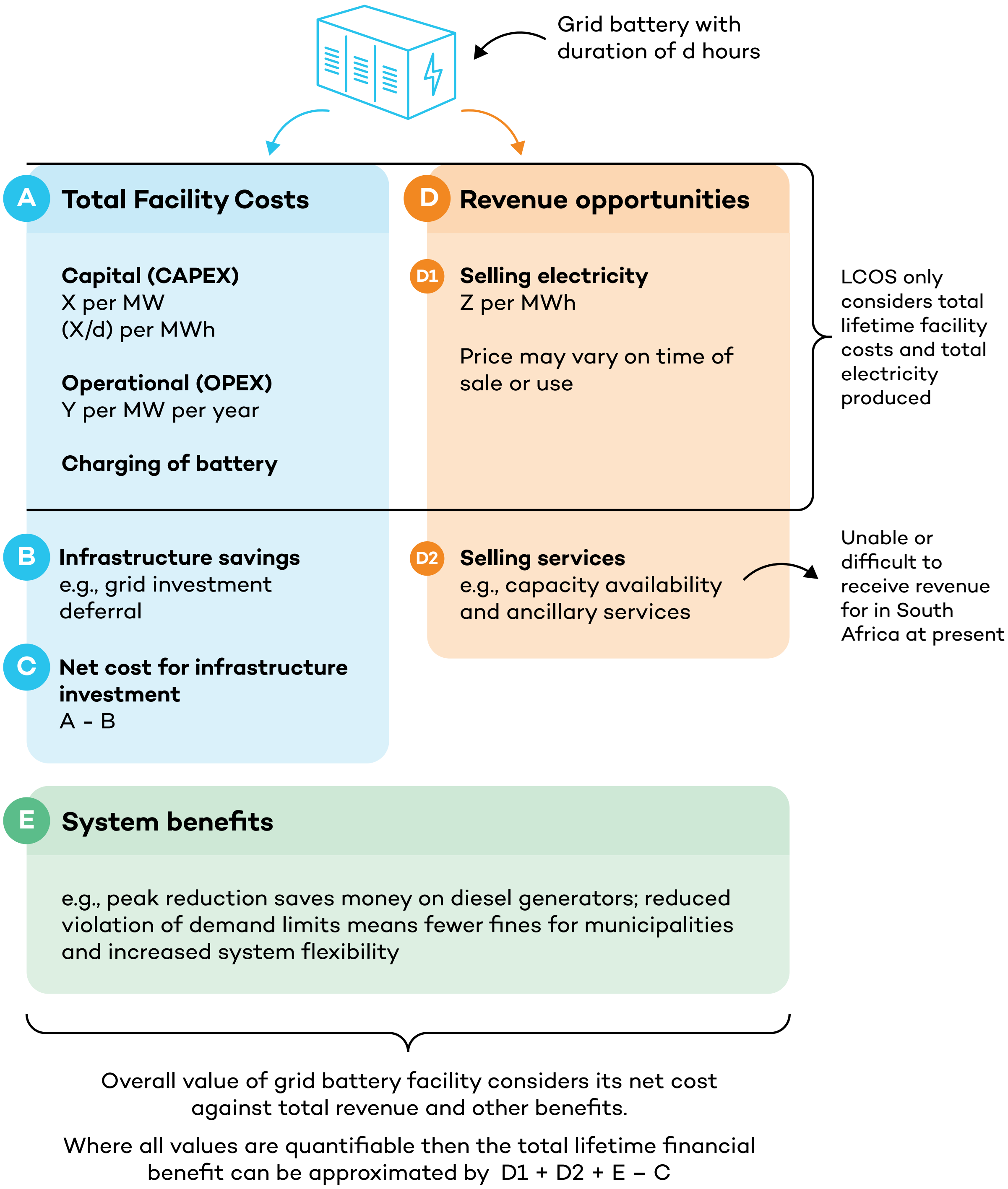
In the public discourse on grid batteries, it is even possible that infrastructure and energy costs may be conflated. Part of the reason this can happen is that the same unit may be used. As a BESS facility will have a power and a duration rating, the infrastructure costs can be given per MWh (of energy storage available). However, the cost of electricity provided by the BESS may also be given per MWh (of electric output).

[15] Due to multiple combinations of grid use cases and possible services provided, along with the level each is required in a particular system. This will also vary with each BESS technology.

The Importance of Value, Not Just Cost

Interview responses showed that when decisions on BESS investment are made, there is widespread support from energy planners and system operators to recognize the overall value that grid BESSs provide rather than just focusing on a single measurement like LCOS. Figure 2 shows some factors that can affect the overall value of a BESS facility.

Figure 2. Basic value assessment of a grid battery



Source: Author diagram.

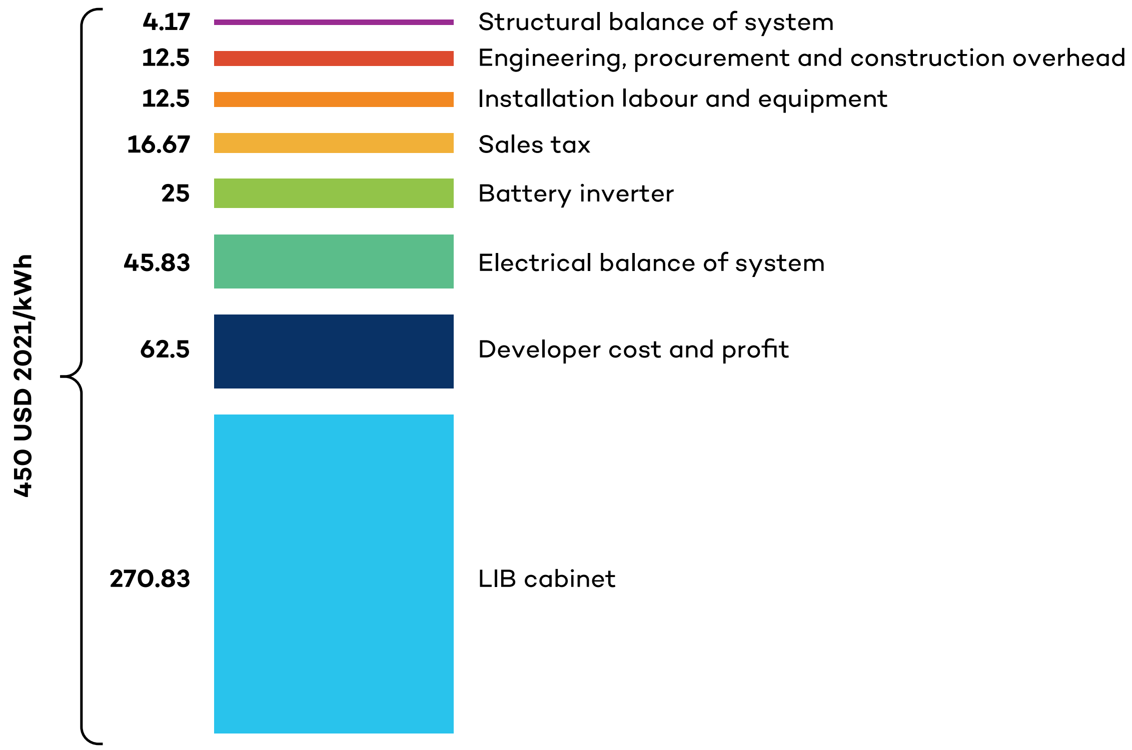
Cost-Reduction Strategies

While a shift in thinking to assess the overall system value of BESS facilities is prudent, there is still a need to reduce the total lifetime costs where possible. However, many of the cost-reduction strategies will come with trade-offs.

For example, data from the National Renewable Energy Laboratory (NREL) shows that as the duration of a fixed power capacity of LIBs increases, the the capital cost for storage (USD/kWh) decreases but the system cost (in USD/kW) increases (NREL, n.d.). This is analogous to buying milk in bulk at the grocery store, where the larger the volume you buy, the cheaper the unit price, but the more you need to pay in total upfront. In this case, longer duration may also give more flexibility and a wider range of services for the system operator.

In a typical LIB system, the battery itself generally has the highest single cost. Producing the cells and packs and assembling them into the cabinet in South Africa could substantially reduce this cost, compared to importing completed batteries, and will have co-benefits such as job creation and increased value chain opportunities. However, the trade-off in this case is the significant time and financial investment needed to develop value chains and skills base. A full analysis could identify other areas (such as tax) where the cost could be reduced.

Figure 3. Example of the installed capital cost breakdown for a 60 MW LIB of 4-hour duration (USD 2021/kWh)



Source: Data is drawn from NREL, n.d.

Box 3. Risk: Increases in raw material prices

The raw materials used in batteries are traded globally and are subject to price fluctuations. While the costs of utility-scale batteries have been falling in recent years, raw material prices could influence this trend. For example, the price of lithium-ion battery packs and cells decreased by over 80% from 2013 to 2021 but then increased by 7% in 2022 due to an increase in critical mineral prices, the related impacts of COVID-19 supply chain disruption, and the war in Ukraine[16] (Bloomberg NEF, 2022; Bullard, 2023). In 2023, the price dropped to a record low (Bloomberg NEF, 2023), and most predictions are for a continued, gradual decline in costs till 2030.

However, this expectation could prove wrong if the increased demand for battery minerals outpaces supply and exerts upward price pressure. In addition to increased demand for utility-scale batteries, as more countries impose mandates to switch to electric vehicles over the next decade,[17] demand for materials for these batteries will increase. Conversely, increased material demand could also lead to enough investment in new suppliers to meet the need and produce no price spikes.

Capital Versus Costs

During the research interviews, a theme emerged that **issues related to grid battery cost are often rooted in concerns around access to affordable capital.** So, even where the lifetime project costs are already justifiable, there may be short-term financing hurdles because these types of projects are so capital intensive.

This perspective also applies to renewables plus BESSs. For example, CityPower (a municipal electricity services provider) calculated that it is financially better over a 20-year period to install solar and BESSs for dispatchable power than a gas turbine. However, the initial cost for the hybrid system may be up to three times that of the turbine, so the challenge is access to capital (research interviews).

Suggestions

- Support the development of levelized value of storage or other measures that can assist decision-makers in evaluating the total value of grid BESS investments.
- In the short term, while the sector is dependent on imported components or complete batteries, have a diverse range of suppliers.
- Local production and beneficiation of critical minerals to battery grade (particularly vanadium) could shield South Africa from potential battery cost increases if coupled with local battery assembly.
- Recycling and reusing batteries effectively extends the life of critical raw materials and reduces the need for new supply.

16 Russia exports significant global proportions of vanadium (25%), nickel (15%), and aluminum (5%), which are all used in batteries. Trade sanctions could disrupt these markets (Organization for Economic Co-operation and Development, 2022).

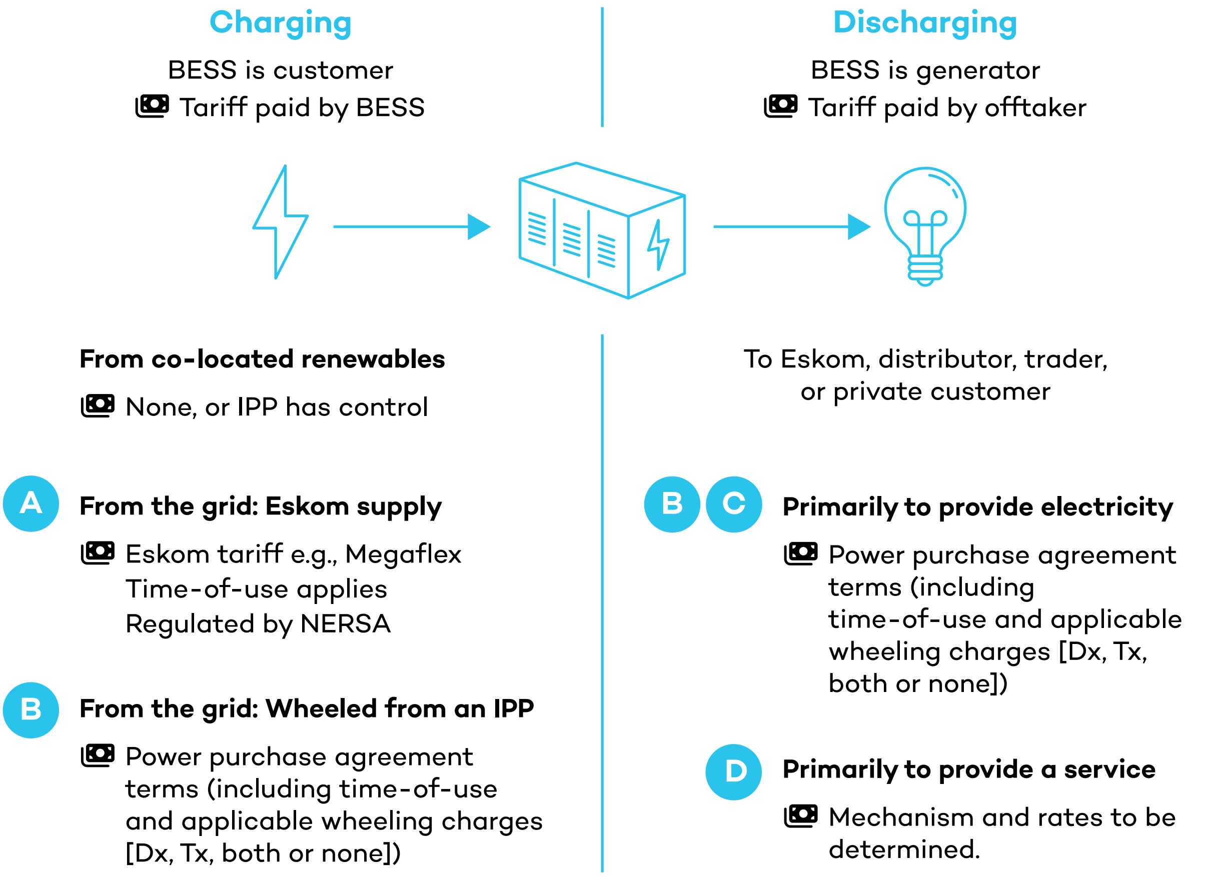
17 For example, 80% of new vehicles sales in the United Kingdom must be electric by 2030 (Jolly, 2023).

- While a localized power system may technically only need 1–2 hours of storage in the near future, economically, it may be better to invest in longer duration. This needs a proper assessment in each case.

Tariffs and Revenue

The business case for a BESS is highly dependent on electricity tariffs. These can be split into charging and discharging tariffs. The location of the charging source and customer within the network also affects these tariffs. Interviewees raised concerns that can be grouped into four main challenges, as discussed below, and marked "A" to "D" in Figure 4.

Figure 4. Factors influencing charging and discharging tariffs for a grid battery



Source: Author diagram.
Note: IPP = Independent Power Producer, Dx = Distribution, Tx = Transmission.

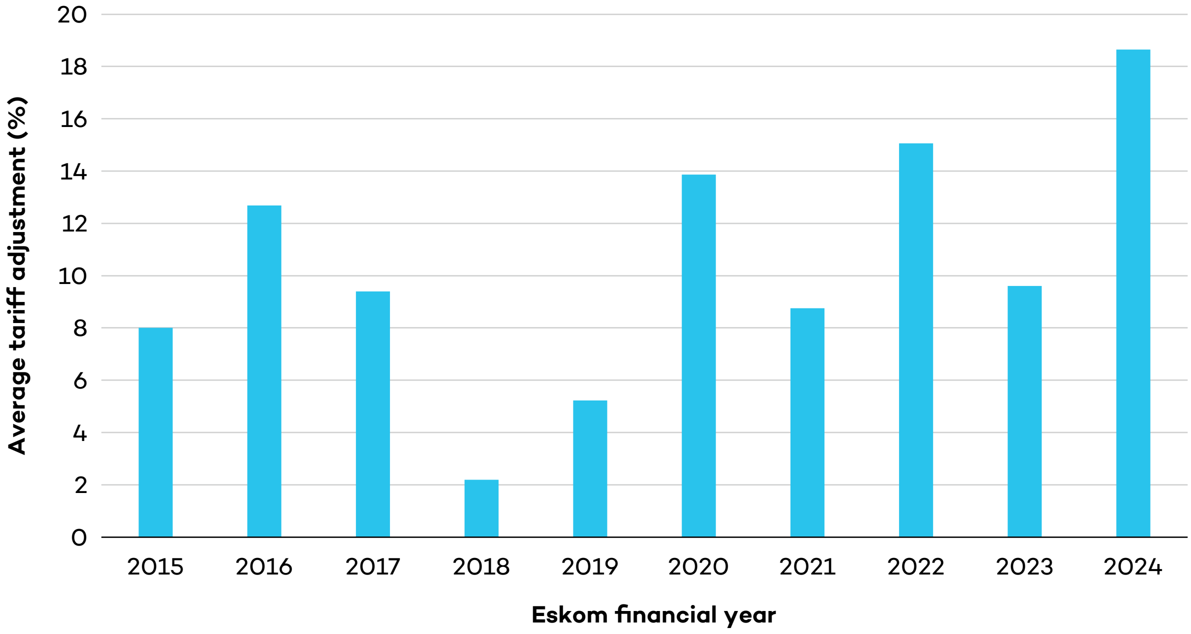
A No Long-Term Indication of the Price Path of Eskom Tariff Increases

If a municipality builds a BESS and charges it from the grid, it will be billed according to Eskom tariffs.[18] This cost will be a combination of applicable tariffs for the electricity itself plus charges for using the network and other services and administration. Every year, NERSA determines what tariff increases are allowed based on Eskom's proposals (Eskom, 2023b).

The problem is that the final Eskom tariff increases are not predictable, not aligned with inflation, and not known for more than one year in advance. Figure 5 shows the erratic nature of average Eskom tariff increases for the last 10 years. As the cost of electricity is a major input cost for a BESS facility that charges from Eskom (some or all of the time), this tariff increase mechanism means that the operator will not be able to accurately estimate future running costs. Having no long-term electricity price path has led some potential BESS developers to decide against entering the South African market (research interviews).

BESSs that are co-located with a renewable energy plant will be less affected by Eskom charging tariffs, as most charging will be done from surplus renewables supply.

Figure 5. Eskom average tariff increases from financial years 2015 to 2024



Source: Eskom, 2023b.

Note: Eskom financial years run from April 1 to March 31. For example, financial year 2015 runs from April 1, 2014, to March 31, 2015.

[18] Conversely, national grid battery procurement tenders have had a fixed charging rate.

B Uncertainty Around Wheeling Tariffs and Billing

Wheeling is the movement of electricity from a generator to a consumer via a third-party grid (i.e., neither the generator nor the consumer owns the grid section that is being used). While the current laws and regulations allow for wheeling, a National Wheeling Framework (including standardized tariffs) is still in development as of May 2024. Therefore, the details of a wheeling transaction depend on the unique agreements developed between all parties involved.

Municipalities have had trouble getting their proposed wheeling tariffs approved by NERSA, so some use a credit system. However, updating municipal billing systems to facilitate wheeling with these credits has been challenging (South African Local Government Association et al., 2023).

Eskom is piloting a Virtual Wheeling Platform, but this would not reduce the need for standard charges across distributors (T. Creamer, 2023a). However, the way wheeling is done could change. A new mechanism of Electricity Credit Tokens has been proposed to resolve some problems with existing wheeling models (Steyn et al., 2023).

So, whether the BESS is a customer (while charging) or a generator (while discharging), these uncertainties around wheeling models, implementation, costs, and revenue collection are a concern for potential BESS developers.

C Determining Tariff for Bulk Electricity Supply

There is an ongoing debate in South Africa about overall electricity tariff reform, including topics like how Eskom can achieve cost-reflective tariffs and which customers pay time-of-use tariffs. While this discussion is beyond the scope of this report, these overall tariff reforms will impact BESS operators.

D Insufficient Opportunity to Gain Revenue From Services

A central theme that emerged in the research interviews is that of revenue stacking (or value stacking). This is the ability of a single facility to derive income from multiple grid services and thus have multiple revenue streams.

Interviewees highlighted that the value of multiple services that BESSs can offer should be recognized by decision-makers in the energy sector, as this helps justify the capital investment. From the BESS operator perspective, revenue stacking is a business model that monetizes these grid services. Internationally, evidence from many electricity markets has shown that a BESS model may be unprofitable if it can only derive revenue from one or a very limited set of grid services (Yamujala et al., 2022). In South Africa, in the private market, some interviewees already see an opportunity for BESSs purely based on arbitrage.[19] If grid BESSs continue to drop in cost, then the future business case from single or limited revenue streams will become stronger, but the point remains that it is much better for potential BESS developers if they have access to more revenue streams, and this reduces the need for potential subsidies.

[19] Arbitrage is the strategy of storing electricity when prices are low and selling it when prices are high.

Grid BESSs are new in South Africa, and as such, there are not yet business models for all the possible grid services. Furthermore, optimizing revenue stacking (including forecasting and scheduling of services) requires intelligent energy management and trading software, with integrated real-time access to electricity market data, which can be a challenge in a developing BESS market (USAID, 2022a). Access to revenue stacking could lead to a lower price for bulk electricity supply from the BESSs compared to a situation where revenue stacking is not available.

Suggestions

- There is a lot of work to do on tariffs across the board as they are all interrelated, and several Eskom tariff increases are not BESS specific.
- Decide on the best wheeling model, then adjust tariffs accordingly. Open-source billing software could help with current municipal billing issues for wheeling credits.
- Prices for BESS services need to be established. Eskom and other potential offtakers should start this process in conjunction with battery storage stakeholders, which can feed into the development of a market for ancillary and other services.
- Identify any elements of the regulatory framework that may need to change to allow revenue stacking.
- Remuneration models should include fixed long-term payments for capacity availability and variable payments for electricity and services.

Finance and Funding

There is limited information on existing funding and finance for national-level grid batteries in South Africa, as only a few facilities are operational, under construction, or have reached financial close. These projects fall into three broad categories.

First are the **Eskom BESS projects**.[20] Phase 1 received funding from the World Bank, but it is uncertain how the Phase 2 projects will be financed. A condition of Eskom's Debt Relief package from the National Treasury is that "Eskom's capital expenditure is restricted to transmission and distribution" (National Treasury, 2023). As batteries can assist with the grid and defer network upgrade costs, these projects may be allowed by the debt relief conditions.

Second are the BESS components (total 640 MW/2,425 MWh) of the preferred bidder projects under the **Risk Mitigation Independent Power Producer Procurement Programme (RMI4P)**. These renewables plus BESS projects received financial support from a range of South African banks, development finance institutions, and investment holding companies (research interviews).

Third are projects under the **Battery Energy Storage Independent Power Producer Procurement Programme (BESI4P)**. The four preferred bidders (total 360 MW/1,440 MWh) under the first bid window announced in November 2023 are likely to receive finance

[20] Phase 1: eight projects (199 MW/833 MWh), Phase 2: four projects (144 MW/616 MWh)

from Standard Bank (research interviews). As of May 2024, the second and third bid windows are at the request-for-proposal stage.

These three cases demonstrate that grid battery projects can get finance in South Africa. However, the terms of the debt (e.g., interest rates) are important, and there are a range of factors that may increase the cost of capital and limit access to affordable finance (research interviews):[21]

- As a new, disruptive technology, some lenders do not yet have a detailed understanding of technical components and are not yet comfortable with committing to these projects. In addition, higher perceived risks may lead to higher borrowing rates.
- A lack of experience and local case examples means there is no track record of successful projects to build investor confidence.
- There is some concern over some specifications in government battery tenders.
    - For example, BESI4P bid windows 1 and 2 have a qualification criterion of 730 discharge cycles per annum (each cycle at 100% of the contracted capacity for 4 hours). The power purchase agreement period is 15 years. This level of battery use will result in a major refurbishment requirement by about halfway through the project life, which introduces a financial risk, as these future costs are uncertain due to exchange rates. This increases the cost of capital. A shorter contract period, fewer cycles, or shorter cycle length could have reduced the need for refurbishment and allowed lenders to provide better finance terms.
- The inability to access revenue stacking means that BESS projects may not yet be at a competitive price point.
- Certification and guarantees. What is the level of certainty and track record that indicates that performance, integration, and longevity levels will be achieved? Lithium-ion is getting there, but other battery technologies are far off.
- Offtakers face financial constraints.
    - For example, many municipalities are in arrears for electricity payments, and it is expected that proposed batteries in these locations would suffer the same issues with payment for services.
- Environmental, health, and safety concerns. Some lenders are still cautious about fire risk, hazardous materials, and waste disposal and the standards relating to these aspects.

Just Energy Transition Partnership

The Just Energy Transition (JET) Investment Plan indicates a need for ZAR 23.1 billion for batteries between 2023 and 2027, and ZAR 44.2 billion between 2023 and 2035 (The Presidency, 2022b). This is an estimate of the requirements and does not mean that any of this

[21] Most of the concerns raised by finance industry representatives are shared with other stakeholders and appear in other sections of this report too.

funding has been secured. The JET Implementation Plan goes further to list which sources[22] could be used for grid batteries (The Presidency, 2023).

The entire Just Energy Transition Partnership (JETP), under which any of this funding may come, is predicated on South Africa committing to—and following through with—a transition away from fossil fuels in the energy sector. The problem is that there is ongoing political support to extend the life of coal power plants, pursue "clean coal" technologies, and push for new high-utilization gas power plants. Some politicians have even actively spoken out against the JETP (Sguazzin, 2023). So, while the JETP does represent an avenue for possible funding for battery projects, it is at risk due to the continued promotion of fossil fuels in the power sector. If the JETP fails, it could make it harder for South Africa to access other climate and green finance.

Suggestions

- Finance – Government, Eskom, the DMRE, and municipalities should work with finance institutions to fully understand their concerns around BESS projects and identify ways to address them to reduce the cost of capital.
- Funding – Government must ensure that the JETP is a success, which includes taking a strong stance and action on fossil fuel phase-out.

4.4 Electricity Sector Framework Challenges

Grid batteries are a relatively new entrant in the South African electricity supply industry. As such, there are multiple hurdles to their widespread adoption, despite their potential positive contributions to the power system. This section summarizes the status quo and concerns with the main elements of the electricity sector framework (including planning, policy, laws, regulations, incentives, and procurement) and suggests actions.

The goal is to improve the energy supply framework in South Africa so that BESSs can make the greatest contribution to enhancing grid function and electricity provision without unnecessary delays.

Planning and Policy

Many plans and policies are connected to grid battery storage, some of which are listed in Appendix E. In this report, we focus mainly on the themes that came out of interviews, particularly relating to battery capacity at a national level, transmission planning, and, to a lesser extent, value chain creation.

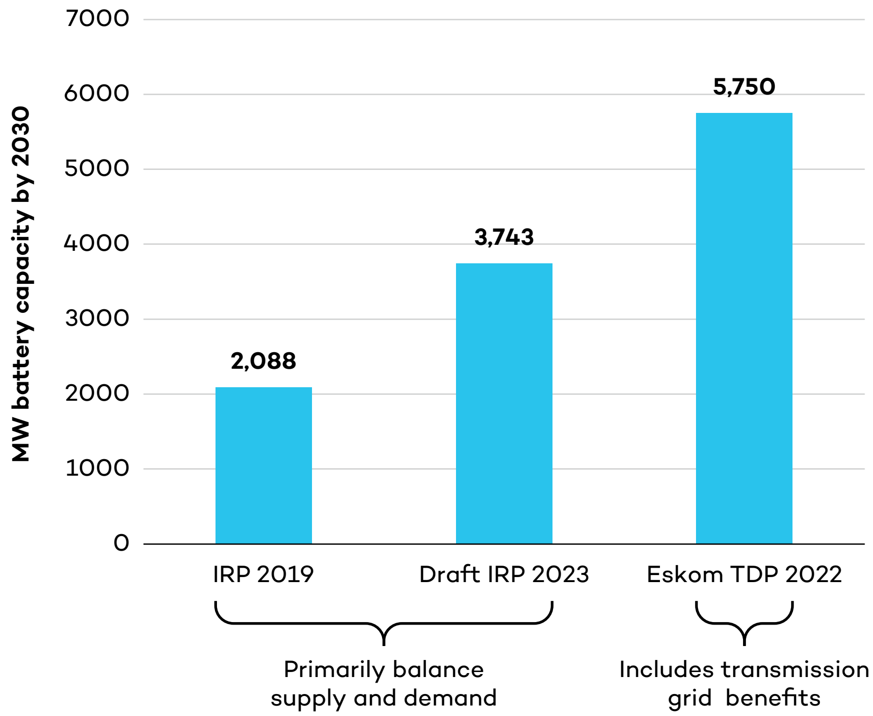
[22] International Partner Group pledges suitable for battery storage projects: Development Finance Corporation (United States), British International Investment (United Kingdom), Private Infrastructure Development Group (United Kingdom) and European Investment Bank (European Union).

Disjointed Planning Leads to Inconsistent Outputs

Research discussions revealed widespread agreement that key energy stakeholders (e.g., government departments, Eskom, and municipalities) are **still not collaborating sufficiently in energy planning**. This can result in inconsistent planning results. Table E1 in Appendix E shows that even government plans from the same year (2022) have different battery capacity values and timelines.

However, a much larger discrepancy is evident when comparing battery capacity additions to 2030 between government and Eskom, as shown in Figure 6. As discussed in Section 2.1, the IRP does not factor in the contribution of batteries to grid functioning, whereas the Eskom TDP does. When the draft IRP 2023 was done, the Eskom TDP 2022 was already published, and it is understood that the DMRE and Eskom modelling teams do interact. Despite this, the Eskom BESS requirements are not reflected in IRP 2023. With national-level procurement based on the IRP, this situation could **result in insufficient deployment of battery storage to optimize Eskom's transmission system expansion.**

Figure 6. Battery capacity in IRP 2019, IRP 2023, and TDP 2022



Sources: DMRE, 2019, 2024; Eskom, 2022a.

Total energy storage (i.e., MWh, not just capacity in MW) is also important and depends on the storage duration. Although the draft IRP 2023 does not indicate storage duration in its modelling, the current national battery procurement, based on modelling in IRP 2019, is for 4-hour duration; Eskom's TDP 2022 also used 4-hour duration (research interviews). So, total battery storage (in MWh) in the IRPs is still significantly less than that in TDP 2022.

Transparency and Access to Planning Information

Two key areas where interviewees cited a lack of access to BESS-related information also relate to the IRP and Eskom system planning.

For the draft IRP 2023, there is insufficient information to understand how batteries are handled. For example, the documents do not say what duration of BESSs is selected or explain how charging time and the effect on capacity factors for BESSs is accounted for. It is unclear if all the battery capacity is anticipated to be stand-alone or if some is co-located with renewables.

Potential developers of hybrid renewables and BESS plants indicated that if Eskom shared more transmission system data, they might be able to assist with projects to get more out of existing grid infrastructure while still complying with the n-1 redundancy and stability requirements.[23] More data would allow developers to work out the quantity and duration of BESSs required to compensate for anticipated curtailment and still have a bankable project (research interviews).

The limited availability of up-to-date information on energy systems has already had serious consequences for South Africa. For example, bid window 6 of the REI4P failed to add any new wind capacity as the changes in grid availability had not been communicated (T. Creamer, 2022b).

Value Chain Development

As indicated in Section 2.2, there are opportunities to develop some segments of the LIB and VRFB values chains immediately, and other elements may become viable in the future. However, this will require planning and policy support.

As of May 2024, there is a draft SAREM, which is an industrial and inclusive development plan for both the renewable energy and storage value chains, by 2030 (DMRE et al., 2023). A Battery Minerals Masterplan is in development, and a Critical Minerals Masterplan has been initiated. These two plans may merge, or the battery one could be incorporated into SAREM (research interviews). The *Electric Vehicles White Paper* outlines a roadmap for increased electric vehicle production, and the battery components and production skills for batteries for electric vehicles will have some overlap with utility-scale battery production (DMRE et al., 2023).

Despite these initiatives, several interviewees saw the need for a national energy storage strategy, which would include pumped storage, emerging storage technologies, and a local industry development pathway.

Municipal-Level Planning

National power supply is a government responsibility, but municipalities are also responsible for electricity distribution and infrastructure services, including water and sewage (that require electricity to function). In the context of rotational power cuts, this has become

[23] An n-1 criterion means that if one component (e.g., a transmission line or transformer) out of a total of n fails, then the remaining components can still handle the total load without disrupting the electricity supply.

a driver for municipalities to look for alternative ways to secure sufficient electricity for service delivery. While work has started at the municipal level for energy procurement from independent power producers (IPPs) and to support increasing small-scale embedded generation (mainly rooftop solar PV), **comparatively little planning has gone into grid BESSs at the municipal level.**

Municipal operations are often guided by national developments, and since grid BESSs are only just starting at the national level, there is limited information for municipalities to build on. Despite this, several municipalities have started investigating grid batteries and are planning installations. For example, the City of Cape Town has already done a detailed locational analysis for the best use of BESSs and developed site-specific business cases (T. Creamer, 2022a).

Suggestions

Overall, there are many groups working in parallel (for example, power system modelling), resulting in a range of plans. Significant effort is spent critiquing government plans once they are produced rather than having direct input to co-create plans from the start.

There appears to be a need for government to **establish multistakeholder collaborative platforms that will develop plans and policies to reach the best outcomes.** Further work is required to design and implement such platforms.

Grid battery:

- As per Section 2.1, there needs to be better coordination and alignment between IRPs and TDPs so that grid battery rollout takes full advantage of the grid benefits that batteries offer, in addition to balancing electricity supply and demand.
- Eskom should provide access to more national planning information and make it as up-to-date as possible. A regularly updated online dashboard on key transmission and distribution parameters could be added to the Eskom Data Portal (Eskom, n.d.)
- Government should shift to open-source modelling software for improved transparency and accountability. PyPSA-RSA is an example of such a model (Meridian Economics, n.d.)
- Thinking through a national energy storage strategy should not distract from finalizing and implementing the SAREM, which is an immediate avenue for planning battery value chain development.
- Expedite consultation and development of the Critical and/or Battery Minerals Masterplans.
- Identify ways to assist municipalities with the information, skills, and budget to do proper assessments of how to include batteries in their infrastructure development plans.

Laws and Regulations

A selection of laws and regulations that may influence grid battery deployment are in Appendix F. In this section, we focus only on those that were of most immediate concern to interviewees.

The Electricity Regulation Amendment Bill

The Electricity Regulation Act (ERA) is the overarching legislation that regulates the electricity supply industry (including generation, transmission, distribution, and trading). As of May 2024, the ERA is in the process of being updated[24] via the Electricity Regulation Amendment Bill (ERAB). This bill is important, as it aims to provide for an open market platform that allows for competitive electricity trading with an independent transmission system operator.

Two main energy storage issues were addressed during interviews:

1. There is no definition, classification, or clarity around the treatment of energy storage in the ERAB.

While this apparently technical detail is symptomatic of the lack of political priority on the issue, there are also several important implications:

- Without regulatory guidance, energy storage is classified as an energy generator by default. This is counterintuitive as energy storage is always a net consumer of energy (since no energy storage technology is 100% efficient).
- Energy storage switches between being an energy generator (while discharging) and an energy consumer (while charging). Not recognizing this dual nature could lead to inconsistency and confusion in how energy storage is treated by other regulations or government decisions.
- Advantages as a network asset are overlooked.

2. Too much control rests with the minister.

The public procurement of new grid batteries is currently included in Section 34 determinations. Under the ERA, NERSA must concur with Section 34 determinations, but the ERAB changes this so that the control will be solely with the Minister of Mineral Resources and Energy.

ERA Schedule 2

Although Schedule 2 is part of the ERA, it can be amended separately from the act itself. The most recent amendment from January 17, 2023, has provided an exemption for generation facilities requiring a licence[25] from NERSA under a range of conditions; this also applies to grid batteries. This is important because obtaining a licence is a lengthy process and acts as a barrier to the quick addition of new infrastructure.

[24] Passed by the National Assembly on March 14, 2024.

[25] Facilities must still comply with the relevant grid code and register with NERSA.

However, the criterion for one of the licensing exemptions is that the generator must supply electricity to one or more customers by **wheeling on a third-party transmission or distribution network.** This means that Eskom or a municipally owned BESS, or an independently owned BESS that supplies Eskom or a municipality on their own networks only, would still require a generation licence.

Grid Codes

NERSA manages a range of grid codes that give technical and operational requirements for the safety, stability, and efficiency of the power system. There are separate codes for the transmission and distribution grids, system operators, and specific technologies (including batteries and renewable energy).

System Operator Grid Codes

A problem revealed during interviews was that the **grid codes do not have enough detail on what services can be procured from energy storage**. Improving the grid codes in this regard could help BESS developers access revenue stacking and assist the system operator in network management (research interviews).

Battery Energy Storage Facilities Code

Developers indicated that the **requirements of this grid code have unresolved commercial consequences.** First, under certain network conditions (such as an increase in frequency), the BESS must switch to charging mode. But if this occurs during a peak period (with high charging tariffs), there is not yet clarity on how these additional costs to the BESS operator will be handled. Second, a range of ancillary services are built into the code, and this may reduce the ability to monetize these from revenue stacking. There are further concerns that for hybrid facilities, there may be contradictions with the renewable energy grid code (research interviews).

Electricity Regulations on New Generation Capacity

Requirements still act as a barrier to uptake. The latest amendments mean that Eskom and municipalities can procure energy storage capacity from IPPs, but they still need to apply to the Minister of Mineral Resources and Energy, and it must align with the IRP. Furthermore, some of the new conditions (such as setting up public–private partnerships) are still too expensive and onerous for most municipalities to achieve.

Municipal Finance Management Act

Municipal representatives indicated that the extensive criteria that must be met for contracts longer than 3 years make the administrative side of grid battery projects very complex and time consuming.

Wheeling

As indicated in Section 4.3, a National Wheeling Framework is in development, which means that there is a regulatory gap around wheeling charges, and if the wheeling model changes, that would also require different regulations.

Suggestions

The status quo reveals a need for more discussion between stakeholders (especially lawmakers, BESS developers, municipalities, and Eskom) on how laws and regulations need to change to allow for optimal deployment of BESSs—in particular, to align with revenue stacking. As battery technology is moving faster than law making, there is also a need to find solutions that can accommodate BESSs within the existing framework while the legal framework catches up.

Specific changes:

- The ERAB should clearly define energy storage and classify it in a way (likely a new category) that recognizes the dual nature of how BESSs function and accommodates the relevant characteristics and services. The implications of this change in other elements of the regulatory framework must be identified and adjusted as required.
- For ERA schedule 2, remove the need to wheel on a third-party network for a licensing exemption or define energy storage and ensure licensing exceptions cover all storage.
- For grid codes, put specific details regarding the services that the system operator can procure into the transmission and distribution grid codes and ensure these align with what energy storage technologies can provide. Each service must be individually defined so it can be bought separately. Curtailment should also be sufficiently covered in the codes.
- NERSA and BESS developers should discuss ways to mitigate any commercial effects from complying with the Battery Energy Storage Facilities Code.
- Municipalities should not need to apply to the minister to procure energy services (including storage) from IPPs, and simple power purchase agreements would reduce red tape and increase uptake.
- Decide on the wheeling model first, then adjust or develop the regulations.

Incentives

Many of the ways to incentivize grid battery projects and value chain development are by overcoming the economic challenges in Section 4.3 rather than more "traditional" incentives like tax allowances. Examples include

- gaining access to revenue stacking,
- enabling funding and financial support, and
- improving the wheeling model.

Tax Allowances

Several sections of the Income Tax Act that currently target renewable energy and energy efficiency could be applied or extended to include energy storage (Broughton & van der Walt, 2022; Mackay et al., 2022; Montmasson-Clair et al., 2021). The allowances below are deductible from taxable income.

- Section 11A, 11D – Allowance for expenditure incurred on research and development

- Section 12B – Allowance for assets that produce electricity from renewable sources (Singh & Canca, 2023)
- Section 12L – Allowance for verified energy efficiency savings
- Section 12I – Allowance for asset investments and training in Greenfield or Brownfield manufacturing projects, but applications ended March 31, 2020 (Department of Trade, Industry and Competition, n.d.)

The draft SAREM also calls for the re-activation of Section 12I to support the development of renewable energy and battery manufacturing value chains (DMRE et al., 2023)

The South African Energy Storage Association or other industry bodies could approach the National Treasury with a request for the Income Tax Act to be adjusted, which can feed into the annual budget review process.

Potential New Tariffs

Predictable BESS Charging Tariffs from Eskom

Since the BESS projects under BESI4P get a fixed charge rate from Eskom (which increases with inflation), a similar concept could be applied to other grid batteries, depending on the use case. This shields BESS operators from unpredictable Eskom tariff increases (Section 4.3). The rate could still be time differentiated to incentivize charging during times of excess solar PV production.

Residential Time-of-Use Tariffs

If residential areas move onto a time-of-use system, as many industrial consumers are, this could provide a large market for BESSs via peak shifting and arbitrage. This would improve the business case for municipal-level BESSs.

Time-of-Supply Tariffs for Renewable Energy

Like what Chile has done, attractive tariffs for differing times of supply would incentivize renewable energy developers to include BESSs, as this could allow them to offer competitive prices even when the renewable energy resource is not normally available.

National Procurement

Each of the three BESS project categories listed in Section 4.3 had an associated procurement process with Eskom or the IPP Office. As it is likely that further grid batteries will be procured through the IPP Office, this section does not look further at the Eskom tender. Municipalities that are considering grid batteries are still mainly in the planning phase.

Risk Mitigation Program

The RMI4P was for dispatchable power to meet set criteria, but most preferred bidders included BESSs in their projects. Energy analysts generally agree that the RMI4P design was suboptimal and led to unnecessarily high tariffs. Although the developers had to come up with smart ways to meet the requirements, the widely held view is that the requirements themselves were not a prudent way to bring the required electricity generation capacity online (research interviews). One of the main issues was a **lack of systems thinking**, where each project must function as an "island" to independently deliver dispatchable power within certain time frames. As such, the RMI4P rules prevent BESSs from charging from the grid, resulting in the oversizing of BESSs, which is part of the reason for higher costs (Mallinson, 2021).

A further issue was that several preferred bidders had significant delays in reaching financial close with a rigid evaluation price. A key reason for this was the increase in multiple input costs (e.g., steel) due to post-COVID global supply chain disruptions. This led to an impasse, as developers were no longer able to meet the fixed evaluation price with the financing agreed at the time of selection.

Battery-Specific Tender

The BESI4P is specifically for batteries, and the bid window 1, 2, and 3 capacities are based on Ministerial Determinations in line with the IRP 2019. The start of BESI4P was delayed—the initial 513 MW, as per the IRP 2019, was meant to come online in 2022, but the tender only went out in March 2023, and preferred bidders were announced in December 2023 (DMRE, n.d.).

The bid windows are location specific for substations identified by Eskom, which allows the BESS to contribute to grid functioning where it is most needed. However, interviewees raised concerns about other features:

- Transparency – the request-for-proposal documents can only be accessed after paying a ZAR 25,000 fee. Even after the bid window 1 preferred bidders were announced, many details of the projects are not publicly available.
- It was not realistically possible for VRFBs to compete with the tender specifications.
- For LIBs, the combination of a 15-year contract period and twice daily cycle frequency at 4-hour duration will mean that at about 8 years, a significant repowering process[26] will be required.
- The IRP 2019 (and draft IRP 2023) has a stop-start approach to procurement, with years of no capacity allocation. This is not conducive to developing a local industry.
- The competitive evaluation stage is 90% price and 10% economic development commitment (wherein local content is only one of several possible ways to score points). This low emphasis on local content does not take advantage of opportunities for local value chain development.
- The specifications may be higher than is required for the necessary functionality. Such a "Rolls Royce" approach would lead to higher costs.

Several interviewees were concerned that competitive price tenders can create "a race to the bottom" and pressure to cut corners (particularly on social and environmental issues such as raw material sourcing for battery manufacture) to get the lowest bid evaluation price. An

[26] As battery performance deteriorates over time, a refurbishment and upgrade of battery components can restore performance to the required levels.

alternative would have an auction based on a fixed price—also known as a feed-in tariff. This is how renewable energy procurement in South Africa was initially envisioned in 2009, but the model was replaced with competitive price in 2011 (Eberhard et al., 2014). Based on this, it seems pragmatic to safeguard social and environmental issues within the current procurement structure.

Suggestions

A general lesson is to procure new generation and storage assets in a way that allows them to interact with each other's existing assets (via wheeling) and for the system operator to then make the best use of an interconnected system of facilities to provide reliable supply.

National-Level Grid Batteries

(i.e., continuation of the BESI4P)

- Competitive tenders based on evaluation price should include a form of indexation (up to a limit and for certain components) to cover cases where there is a universal and unavoidable increase in some input costs.
- Tender documentation should be freely available.
- Have separate tenders for short- and long-duration BESSs. Optimizing the contract period and cycling regime could allow VRFBs to compete and lithium-ion to avoid or minimize a repowering process.
- If government intends to encourage local battery value chain development, then procurement pipelines must be regular and predictable, having steady capacity additions each year that also align with system operator needs.
- To stimulate local value chain creation, there should eventually be mandatory local content requirements—but the key is to find a balance between what is possible to implement immediately and how to increase the requirement over time. Unrealistic targets will jeopardize procurement's success.
- A full review of BESI4P tender specifications with a range of stakeholders is needed to assess if they could be relaxed and still offer adequate functionality and quality of installation at a lower cost.
- Tender documents should clearly stipulate the requirements of suppliers for raw material extraction, processing, and disposal standards, as well as safety standards such as fire prevention systems (see Section 3).

5.0 Priority Actions to Support Strategic Objectives to Enable Grid Battery Storage

This report has provided a range of suggested actions for maximizing benefits, minimizing risks, and solving a variety of challenges linked to grid battery deployment in South Africa. In this last section, we **identify groups of priority actions to support three overarching strategic objectives.**

The first objective is to improve the basis for planning and decision making, which should cover all energy technologies, including grid batteries. The second objective is for BESS operators to access multiple revenue streams—this is the main lever for improving their business models and project bankability. The third objective is to take a pragmatic approach to developing local battery value chains by building on processes that are already underway and that target achievable, short-term goals.

Objective 1: Improve the basis for planning and decision making

During this research, several crosscutting themes emerged, particularly linked to the electricity sector framework. By addressing these through appropriate actions, the overall foundation for work on grid batteries (and other energy technologies) could be improved.

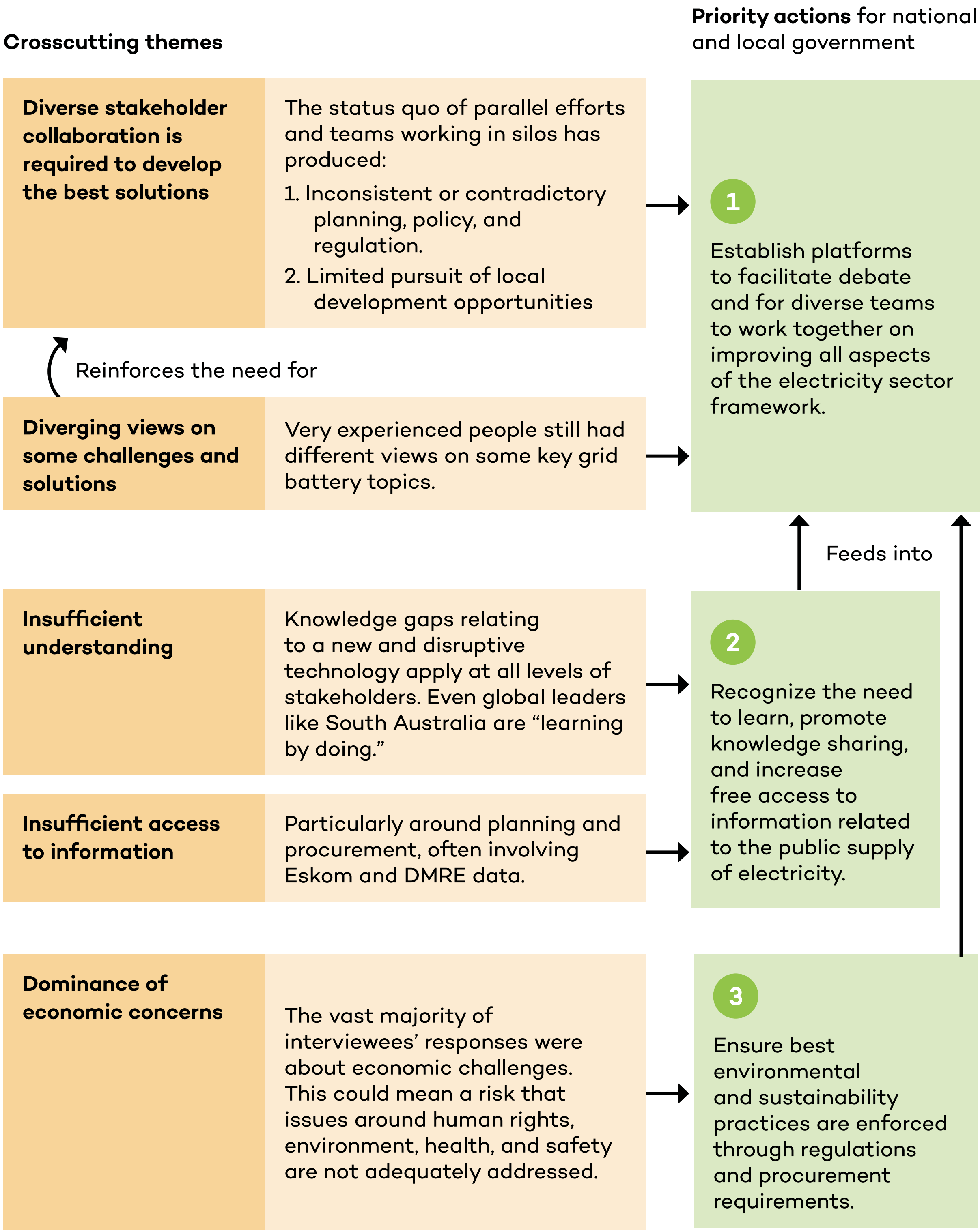
In Figure 7, Action 1, and to some extent Action 2, require more research on how to facilitate collaboration and knowledge sharing between different stakeholder groups, potentially with the assistance of the South African Energy Storage Association. A stakeholder mapping and platform design exercise should identify which groups work directly with each other, at what level, on what topics, and what information they require.

Based on the interviews for this report, two groups (which interact with each other) could be:

1. A planning group—including independent modelling teams, DMRE, and the different Eskom planning teams—that works together to align capacity expansion and grid development plans, which includes an optimal rollout strategy for grid batteries.
2. An implementation group—including battery industry representatives; the IPP Office; finance institutions; the National Treasury; the Department of Science and Innovation; the Department of Trade, Industry and Competition; NERSA; and labour unions—that works together with the planning group to
    a. update laws and regulations to better accommodate energy storage,
    b. improve the BESI4P procurement specifications,
    c. revise relevant electricity tariffs,
    d. determine compensation for ancillary services, and
    e. develop local battery value chains.

Under such a setup, the work of the implementation group covers some of Action 3: getting laws, regulations, and procurement to adequately address human rights, environmental, health, and safety concerns.

Figure 7. Actions to improve the basis for grid battery planning and decision making

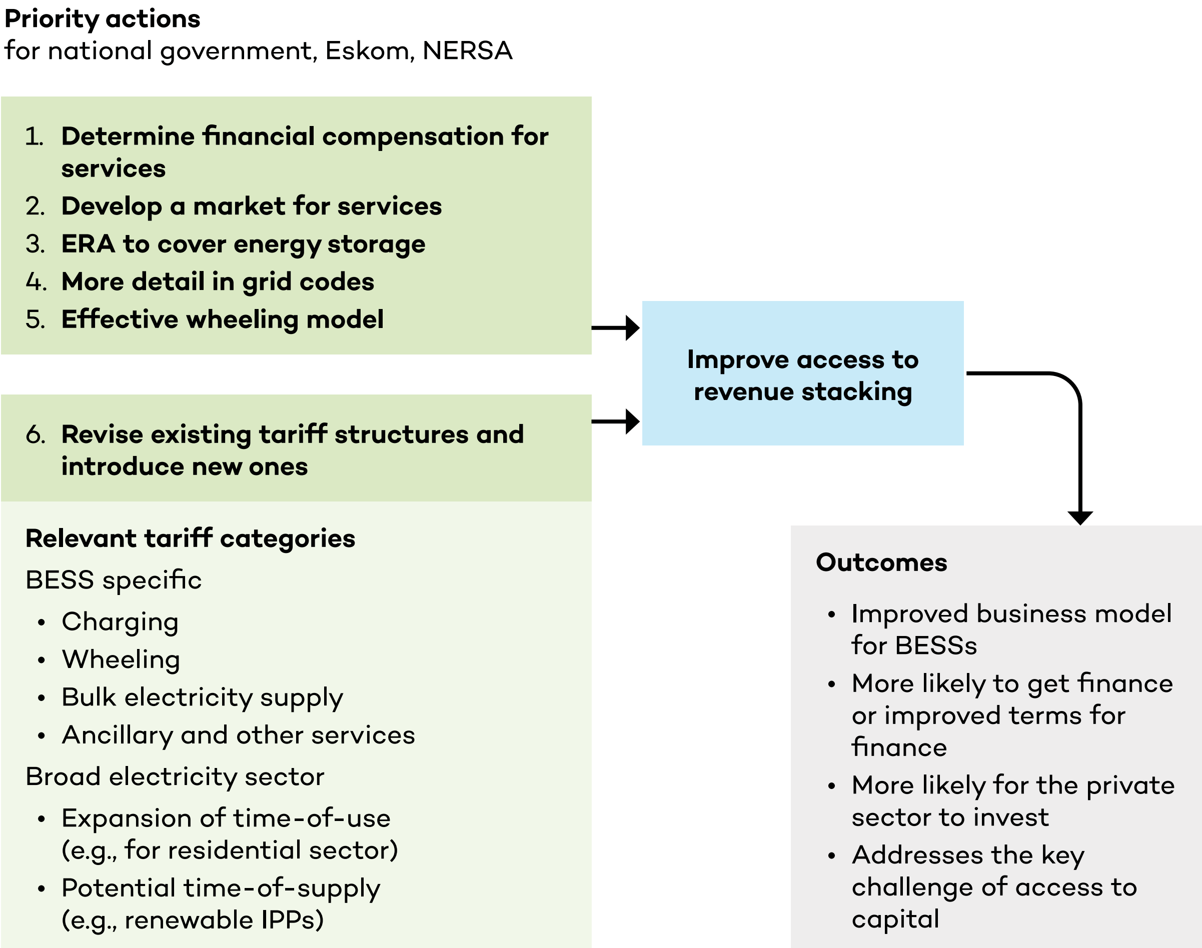


Source: Author diagram.

Objective 2: Facilitate access to multiple revenue streams

A primary concern among potential BESS developers was access to multiple revenue streams (revenue stacking), and an overall challenge was access to capital for upfront installation costs. These are linked, as revenue sacking can ultimately improve access to capital. So, a priority action is to work on the actions that enable revenue stacking.

Figure 8. Actions to enable revenue stacking



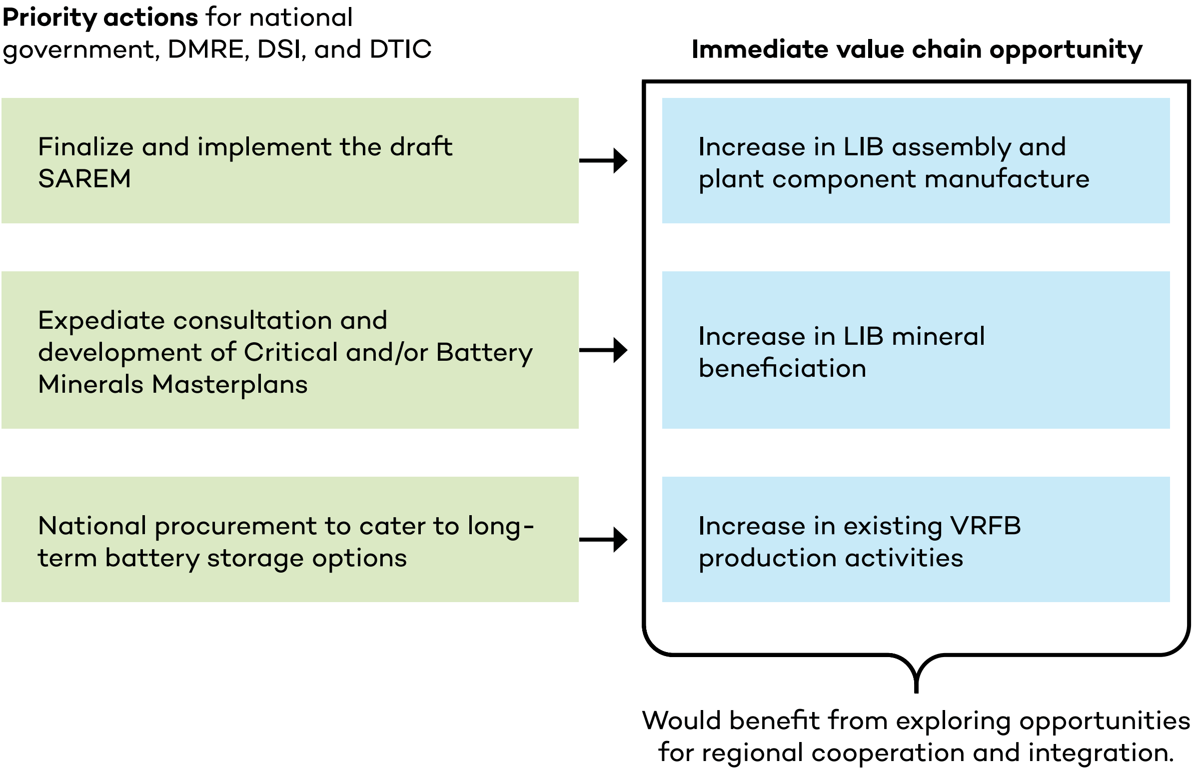
Source: Author diagram.

Objective 3: Support immediate local value chain opportunities

There are several ways to support the immediate opportunities for LIBs and VRFBs, but the priority actions seem to be working with existing elements linked to government processes.

Both LIB and VRFB value chains have mining, mineral beneficiation, and battery assembly opportunities, but there needs to be a local market for these products, as the international market is dominated by established players.

Figure 9. Actions to support immediate local value chain opportunities



Source: Author diagram.

Note: DSI = Department of Science and Innovation, DTIC = Department of Trade, Industry and Competition

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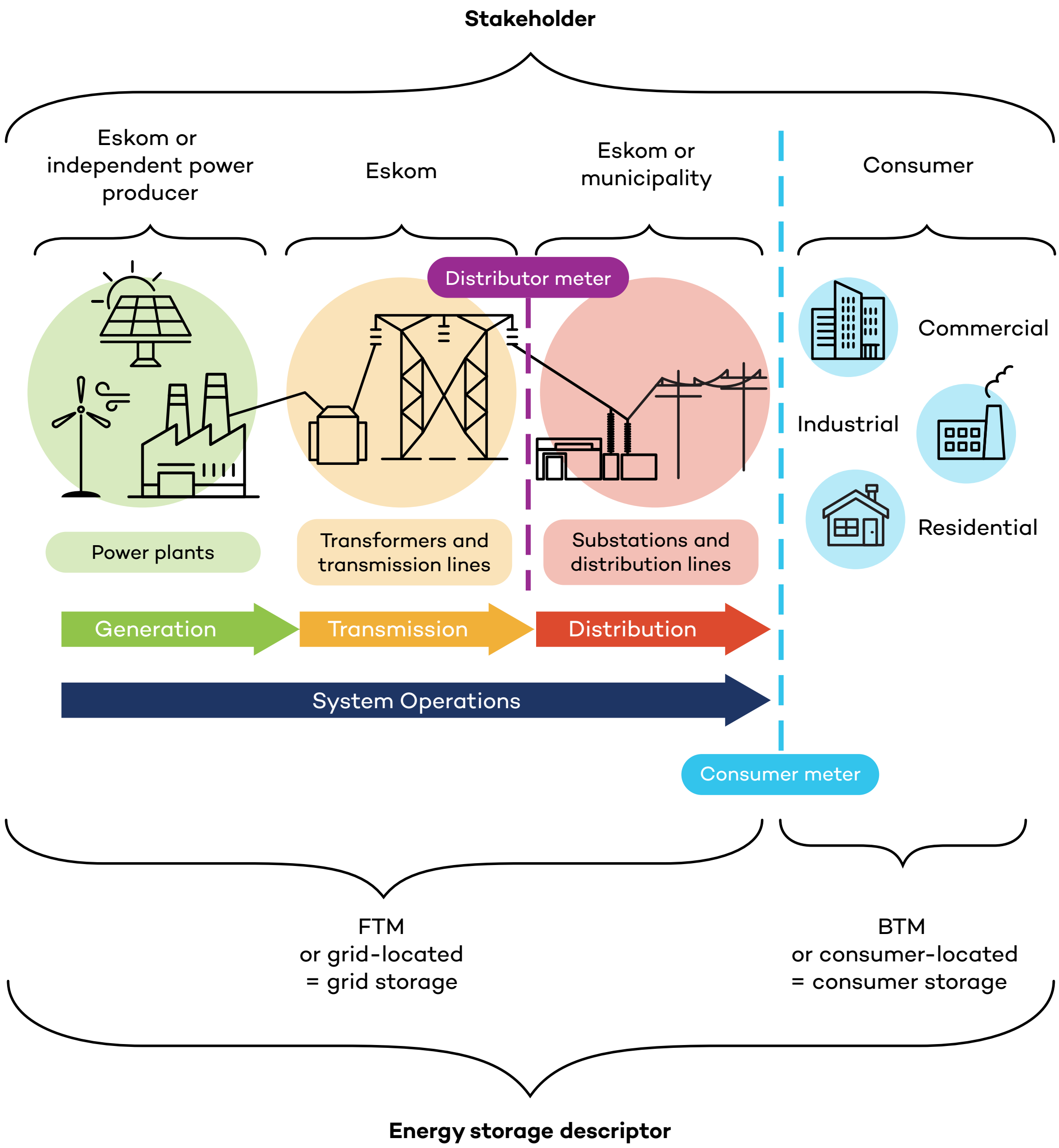
Appendix A. Battery Storage Type Based on Location Within System

Figure A1. Energy storage described by location within the electricity system



Source: Halsey et al., 2023.

The term "utility scale" is used for facilities with a capacity greater than the minimum limit.

This threshold level is generally between 1 MW and 10 MW (depending on country or context), but utility-scale projects can be built either as grid or consumer storage. In South Africa, the National Treasury recommends using 10 MW as the threshold for utility scale (National Treasury, 2022).

Appendix B. South Africa-Specific Energy Storage Studies

The table below is not exhaustive, but it includes some important South Africa-specific studies on energy storage that are publicly available.

Table B1. Studies on energy storage in South Africa

Institution, Date	**Title**	**Study aims or scope**
LSF November 2023	*Manufacturing Localisation Potential in Renewable Energy Value Chains: Battery Energy Storage Localisation Potential*	An overview of LIB and VRFB value chains and prioritizing localization potential in South Africa (Barnes et al., 2023).
Trade & Industrial Policy Strategies August 2023	*Localising Vanadium Battery Production for South Africa's Energy Security*	Explores the potential for a VRFB market in South Africa, levelized costs, building local industry, and competitiveness (Moshikaro & Pheto, 2023).
Customized Energy Solutions (World Bank) February 2023	*South Africa & Southern Africa Battery Market & Value Chain Assessment Report*	Explores opportunities for developing battery value chains in South Africa, including demand analysis and opportunities and suggested development scenarios, including job creation and contribution to GDP. Case studies: Europe, India, the United States, China, and Thailand (Customized Energy Solutions, 2023).
National Advisory Council on Innovation April 2022	*Assessing the Viability of Utility Scale Energy Storage: Policy Study*	Assesses market viability for utility-scale energy storage; provides policy recommendations and investment priorities. Case studies: India, the Philippines, and Australia (Broughton & van der Walt, 2022)
Res4Africa 2022	*Regulatory Assessment of Battery Energy Storage Systems in South Africa*	Assesses market design, use cases, procurement, ownership, and remuneration in case study countries (United Kingdom, California, and Chile); offers policy and regulatory recommendations (Mackay et al., 2022).

Institution, Date	**Title**	**Study aims or scope**
Trade & Industrial Policy Strategies March 2021	*Opportunities to Develop the Lithium-Ion Battery Value Chain in South Africa*	Explores opportunities for South Africa to have a role in the lithium-ion battery value chain. Covers mining and beneficiation capabilities, manufacturing capabilities, and future options (Montmasson-Clair et al., 2021).
U.S. Trade and Development Agency 2017	*South Africa Energy Storage Technology and Market Assessment*	An extensive study assessing technology choices, economics, finance, development impact, environmental concerns, laws, and regulations. However, much has changed in energy storage (particularly batteries) since the study was published in 2017 (Kritzinger et al., 2017).

Appendix C. Grid Battery Capacity Additions in Power System Models

Power system models help inform what electricity infrastructure South Africa should build and when. **The models aim to solve issues around meeting national electricity demand with a variety of supply options over time.** The output results are entirely dependent on the input assumptions, which cover factor technology variables such as the capital cost of power stations, fuel costs, construction time, and estimates for future electricity demand. Different modelling teams also use different software.

A modelling run with no further restrictions is often called an unconstrained scenario. The question usually posed is, "What is the cheapest way to meet South Africa's power needs?" A second layer of ambition-related constraints can be added to this baseline. These could cover factors like water use, air pollution, and greenhouse gas emissions. For example, to meet international climate change commitments, South Africa will have an economy-wide carbon budget and a corresponding budget for the power sector (2020–2050). So these next sets of scenarios provide a theoretical solution to a more detailed question: "What is the cheapest way to meet South Africa's power needs—but within certain aspirational parameters?"

A third layer can then apply real-world adjustments (also called policy adjustments) to the model outputs. This layer could include limitations to what is deemed possible or desirable in terms of variables, such as annual build rates for technologies or grid limitations. For example, building lots of batteries in one year and none for the next 4 years is not practical for an industry, as there needs to be a regular project development pipeline.

The energy storage outputs to 2030 for published scenarios from five of the main modelling teams in South Africa are given in Table C1. Several of these studies ran their models to 2050,[27] and over this time horizon, between 33 GW and 65 GW of BESSs are built (National Business Initiative et al., 2022). However, the energy landscape is changing so fast that predictions beyond a few years become increasingly unreliable. Therefore, the rationale is that the models are regularly updated as input assumptions change, and models reflect the latest developments in available technologies and circumstances.

In addition to the longer-term power system models in Table C1, Meridian Economics also did short-term modelling work in June 2022. This plan on how to end rotation power cuts by early 2024 included connecting 814-MW batteries to the grid by 2024 (Steyn et al., 2022).

The Energy Council of South Africa is conducting its own modelling for the period up to 2034, which will be finalized in 2024 (research interviews).

[27] Partly to allow for carbon budgets over 2020–2050 to be applied to the power sector.

Table C1. New battery storage capacity to 2030 in published power system modelling outputs

Group*/ Type	Date published	Model run end date	First new BESS	New BESS capacity to 2030 (GW) **	Scenario notes Carbon budgets for the power sector are 2020–2050
DMRE Government	2019	2030	2022	2.1***	Integrated Resource Plan (IRP) 2019: policy adjusted, renewable energy build limited
	2024	2030	2025	3.7	Draft IRP 2023: emerging plan, not finalized
ESRG Academic	2020	2050	2026	11	Least cost, no carbon budget
			2024	18	Least cost, Paris Agreement-aligned carbon budget of 2.27 Gt
	2022	2050	N/A	0****	Full economy model. Least cost unconstrained (either no carbon budget or carbon budget of 2 Gt to 2.2 Gt)
Meridian Think tank	2020	2050	2022	3	Least cost, no carbon budget
		2050	2023	3.4	Least cost, reality adjusted
		2050	2022	3.8	Least cost, 2.8-Gt carbon budget, reality adjusted
	2024	2050	2025	5.2 to 6.6	19 different scenarios covering a range of economic, implementation, plant performance, and carbon budget considerations
NBI Business consortium	2021	2050	2030	1.3	3.5-Gt carbon budget
Wartsila Company	2022	2030	2023	6	No constraints, no carbon budget

* Full group details: DMRE = Department of Mineral Resources and Energy, ESRG = Energy Systems Research Group at the University of Cape Town, Meridian = Meridian Economics and the Council for Scientific and Industrial Research, NBI = National Business Initiative (with Business Unity South Africa and Boston Consulting Group)

** Rounded to the nearest 0.1 GW.

***The DMRE was not technology specific for energy storage in the *Integrated Resource Plan 2019*, but the tender has subsequently gone out for batteries.

**** Batteries built after 2030

Sources: DMRE: DMRE, 2019, 2024; ESRG: Marquard et al., 2023; McCall et al., 2020; Meridian: Meridian Economics, 2024; Roff et al., 2020; NBI: NBI, 2021; Wartsila: Wartsila, 2022 and additional data received directly from modelling teams.

The model outputs in Table C1 also contain varying amounts of flexible, dispatchable generators (such as gas turbines or engines) to complement renewables. Another school of thought is that only renewables and energy storage are required as the power system develops and that this will still be a least-cost system if the ratios are correct (Dorr & Seba, 2020). In this vein, independent energy analyst Clyde Mallinson produced an alternative Integrated Resource Plan in 2021 for South Africa, which builds only solar, wind, and 29 GW/116 GWh energy storage to 2030 (T. Creamer, 2021; research interviews).

Appendix D. Battery Technology Choices for South Africa

Lithium-Ion Battery

Early adopters of utility-scale battery storage tended to opt for either sodium-sulphur or lead-acid batteries. However, since around 2014, lithium-ion batteries (LIBs) have dominated in all grid use cases (United States Agency for International Development, 2022b), and approximately 90% of global utility-scale battery storage now comes from LIBs (Zhu et al., 2022).

One type of LIB, lithium nickel manganese cobalt oxide (NMC), accounted for 60% of all batteries used in grid-energy storage globally[28] in 2019 (International Energy Agency [IEA], 2020). However, this situation is rapidly changing with the growth of lithium ferrophosphate (LFP) batteries, which the IEA now calls "the preferred choice for grid-scale storage" (IEA, n.d.). Similarly, the National Renewable Energy Laboratory (n.d.) stated that since 2021, LFP is "the primary chemistry for stationary storage" for new builds.

South Africa mirrors this trend, in that the first grid batteries under construction form part of the Eskom BESS project and the RMI4P (Halsey et al., 2023). All of the first six projects tendered under Eskom BESS Phase 1 and the majority of hybrid projects[29] signed under the RMI4P are LFP batteries (research interviews).

LFP batteries have overtaken NMC, mainly because they are cheaper to produce. They are also safer, as they are less susceptible to thermal runaway.[30] While LFP batteries are less energy dense than NMC batteries, this is generally not a problem in stationary grid applications (Murden, 2022). LCA research demonstrates that LFP batteries have the least overall environmental and social costs of all LIB battery types (Yudhistira et al., 2022).

Vanadium Redox Flow Batteries

Another battery choice that is likely to make headway in South Africa is the vanadium redox flow battery (VRFB). One motivation for VRFBs is that they are more suited to providing longer duration than LIBs. This battery is likely to gain traction because of South Africa's large vanadium reserves (fourth largest in the world), pre-existing vanadium processing skills, and because a South African company, Bushveld Minerals (and its subsidiary Bushveld Energy), in partnership with Industrial Development Corporation, is in the early stages of attempting to localize VRFB production in South Africa. Having reserves of vanadium in South Africa is important because the vanadium electrolyte is the most expensive component, comprising 30% to 65% of the total battery cost, depending on the system (Moshikaro & Pheto, 2023).

[28] Mainly due to spill over from electric vehicles, where NMC is dominant chemistry.

[29] Kenhard 1-3, Oya Energy Hybrid Facility, Umoyilanga Energy, ACWA Power Project DAO

[30] Thermal runaway occurs when battery cells enter an uncontrollable self-heating state that can destroy the battery, release gases, and cause fires or explosions.

Compared to LIBs, there is less information available on utility-scale VRFBs, simply because the production and use of large-scale VRFBs is a relatively new phenomenon. The limited number of life-cycle assessments that have been undertaken on VRFBs indicate that their useful lifespan is likely to be "much longer than Li-ion batteries" as they are able to undergo as many as 15,000 cycles (Chowdhury et al., 2020; Trovò et al., 2023).

This longer life expectancy, together with the higher recyclability of VRFBs over LIBs, led researchers to tentatively conclude that VRFBs are more environmentally sustainable than all existing LIB chemistries (da Silva Lima et al., 2021). VRFBs are also safer than some other battery chemistries, as they do not burn easily and can operate within a wide range of ambient temperatures without additional cooling (Huang et al., 2022).

Appendix E. National Government Plans

Table E1. Varying grid battery capacity allocations in national government plans

Plan	Capacity of battery storage, timeline
Integrated Resource Plan (IRP) 2019 October 2019	513 MW of energy storage to come online in 2022, and a total of 2,100 MW by 2030. All this storage capacity is later indicated as batteries (DMRE, 2019).
National Infrastructure Plan 2050 March 2022	800–1,000 MW battery storage by 2023/2024 (Department of Public Works and Infrastructure, 2022).
Actions to end load shedding July 2022	Accelerated procurement of the 2.1 GW battery storage capacity in IRP 2019 (The Presidency, 2022a).
Just Energy Transition Investment Plan December 2022	At least 2.688 GW batteries by 2030 (The Presidency, 2022b).
Draft IRP 2023 January 2024	513 MW of energy storage (from IRP 2019) is delayed and will come online in 2025. A total of 3,743 MW by 2030 (DMRE, 2024)

In addition, in July 2022, the National Planning Commission made a recommendation for 5 GW of storage to be built by July 2024 (National Planning Commission, 2022).

Appendix F. Laws and Regulations

Table F1. A selection of relevant laws and regulations for energy storage

Laws, bills and regulations	Purpose and important BESS-related points (in bold)
Electricity Regulation Act (ERA) 2006 Amended in 2007	• Establishes a national regulatory framework for the electricity supply industry. • Makes the National Energy Regulator the custodian and enforcer of the ERA. • Section 34 details how the minister can issue a determination to procure new generation capacity. • **No definition, classification, or clarity around the treatment of energy storage.** • **No definition of ancillary services.** (The Presidency, 2006)
ERA Schedule 2 Amendment date: December 15, 2022 Corrected: January 7, 2023	• Contained within the ERA, it must be read with the ERA, and definitions must follow from the ERA. • Can be amended by the minister separately from the entire ERA. • Covers exemptions from the obligation to hold a licence issued by the National Energy Regulator of South Africa (NERSA). • Specifically, any generation facility that supplies electricity to one or more customers by wheeling (over a third-party network) is exempt from licensing, provided that the facility has a connection agreement on the node where the customer's assets are physically connected to the grid. • These facilities must still register with NERSA and comply with relevant codes. • **Under current interpretations, the above licence exemption also applies to grid BESSs (stand-alone or hybrid).** (DMRE, 2023a, p. 2)
Electricity Regulation Amendment Bill In process. Introduced into Parliament on August 23, 2023	• Expand the scope of ERA and functions of NERSA. • Establish the Transmission System Operator and assign its duties, powers, and functions to the National Transmission Company South Africa. • Provide for an open market platform that allows for competitive electricity trading. • **Still no definition, classification, or clarity around the treatment of energy storage.** • **Ancillary services are defined, but no links are drawn between energy storage and the provision of ancillary services.** (DMRE, 2023b)

Laws, bills and regulations	Purpose and important BESS-related points (in bold)
Electricity Regulations on New Generation Capacity 2011 Amended 2016, 2020	• Latest amendments (separate from the Electricity Regulation Amendment Bill) now **allow municipalities to procure energy storage services from independent power producers, but municipalities must still apply to the Minister of Mineral Resources and Energy to do so, and it must align with the IRP.** • The municipality must comply with the Municipal Systems Act, the Municipal Finance Management Act, and the Municipal Public–Private Partnership Regulations, depending on the mechanism of procurement. (DMRE, 2020)
The South African Grid Code: The Network Code Version 10.1 January 2022	• Administered by Eskom, approved by NERSA. • For the Transmission System • Contains connection conditions for generators, distributors, and end-use customers • Covers the standards used to plan and develop the transmission system. • **No definition of storage or mention of batteries.** (NERSA, 2022c)
The South African Grid Code, The System Operation Code Version 10.1 January 2022 Amended February 24, 2023	• Defines the obligations of the system operator and other participants. • Defines a range of services that are considered ancillary services. • **No coverage of energy storage or batteries as ancillary service providers.** (NERSA, 2022d)
Distribution Network Code Version 6.2 January 2022	• Sets the basic rules of connecting to the distribution system. • Ensures that all users of the distribution system are treated in a non-discriminatory manner. • Specifies the technical requirements to ensure the safety and reliability of the distribution system. • **No specific coverage of energy storage or ancillary services.** (NERSA, 2022a)
Distribution System Operating Code Version 6.2 January 2022	• Sets out the responsibilities and roles of operators of the distribution system. • **No specific coverage of energy storage or ancillary services.** (NERSA, 2022b)

Laws, bills and regulations	Purpose and important BESS-related points (in bold)
Battery Energy Storage Facilities Code Version 5.3 March 2023	• Primary objective is to specify the minimum technical and design grid connection requirements for Battery Energy Storage Facilities connected to or seeking connection to the South African electricity transmission system or distribution system. • These minimum requirements for some battery categories include the ability to perform certain ancillary services, such as voltage support and frequency stabilization, but do not cover compensation for such services. (NERSA, 2023)
Eskom's Ancillary Services Technical Requirements for 2024/25 – 2028/2 November 17, 2023	• Technical parameters that a BESS will need to meet to supply Eskom with ancillary services. • "Renewables and battery energy storage shall not be considered for black-start until such time that the grid-forming inverter technology reaches maturity in a restoration context in South Africa." • "Battery energy storage shall not be considered for unit islanding certification." (Eskom, 2023a)
Municipal Finance Management Act	• Aims to secure sustainable management of financial affairs within local government entities. • Contracts beyond 3 years require consultation with national departments and local communities.

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