Energy Partnership
Energiepartnerschaft
South Africa - Deutschland

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

Final Report

Policy Hurdles Impeding Battery Energy Storage Deployment in the South African Market

August 2021

Deutsche Industrie- und Handelskammer für das südliche Afrika
Southern African-German Chamber of Commerce and Industry

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Imprint

Commissioned and published by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Registered offices Bonn and Eschborn, Germany

Project: Bilateral Energy Partnerships in Developing and Emerging Countries
Contact: Secretariat of the South African-German Energy Partnership
GIZ Office Pretoria
Hatfield Gardens, Block C, 1st Floor
333 Grosvenor Street
Pretoria, South Africa
Email: Secretariat-RSA-Energy-Partnership@giz.de
Website: https://www.giz.de/en/worldwide/65749.html
Tel.: +27 12 423 5900

As of 24.08.2021

Design: Edelman GmbH, Berlin)

Text:
Southern African-German Chamber of Commerce and Industry

Deutsche Industrie- und Handelskammer für das südliche Afrika
Southern African-German Chamber of Commerce and Industry

GIZ is responsible for the content of this publication.

On behalf of the
Federal Ministry for Economic Affairs and Energy (BMWi)

CONTENTS

List of Figures & Tables

Acknowledgements

Contributors to the report:

- Mr Alfred Hartzenburg (Project Lead)
- Ms Verny Govindasamy

Several people and organisations made important contributions to this project by sharing their experience, knowledge, advice and encouragement with the authors. It is therefore appropriate to thank the following persons and organisations who contributed indirectly or directly to the completion of this study:

- Mr Jens Hauser – Southern African-German Chamber of Commerce and Industry (AHK)
- Mr Gaylor Montmasson-Clair – Trade and Industrial Policy Strategies (TIPS)
- Mr Paul Vermeulen – City Power and South African Energy Storage Association (SAESA)
- Mr Johan Strydom – GreenCape
- Mr Mikhail Nikomarov – Bushveld Energy and South African Energy Storage Association (SAESA)
- Dr Jarrad Wright – Council for Scientific and Industrial Research (CSIR)
- Mr Barry Bredenkamp – South African National Energy Development Institute (SANEDI)

Acronyms

Acronym	Definition
AHIB	Aqueous Hybrid-ion Battery
AHK	Deutschen Auslands Handels Kammern / German-SA Chamber
BESF	Battery energy storage facility
BOP	Balance of plant
BTM	Behind the meter
CAES	Compressed air energy storage
CAPEX	Capital expenditure
CPP	Critical peak pricing
CSIR	Council for Scientific and Industrial Research
CSP	Concentrating solar power
DEDAT	Western Cape Department of Economic Development and Tourism
DER	Distributed energy resource
DMRE	Department of Mineral Resources & Energy
DR	Demand response
DS	Distribution system
DSM	Demand side management
EDI	Electricity distribution industry
EIA	Environmental impact assessment
EPC	Engineering, procurement, and construction
EPRI	Electric power research institute
ESKOM	Elektrisiteits Voorsienings Kommissie / Electricity Supply Commission
ESS	Energy storage system
EU	European union
EV	Electric vehicle
FITs	Feed-in-Tariffs
FVT	Full value tariff
GDP	Gross domestic product
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HV	High Voltage (supply)
HVAC	Heating, ventilating, and air conditioning
IEP	Integrated energy plan
IFC	International finance corporation
IRENA	International renewable energy agency
IRP	Integrated resource plan
ITSMO	Independent Transmission System and Market Operator
kWh	Kilowatt-hour
LCOE	Levelized cost of energy
LCOS	Levelized cost of storage
Li-ion	Lithium-ion

Acronym	Definition
LNG	Liquid natural gas
LTSA	Long-term service agreement
LV	Low Voltage (supply)
MV	Medium Voltage (supply)
MW	Megawatt
MWh	Megawatt-hour
NaS	Sodium-Sulphur
NBI	National Business Initiative
NERSA	National Energy Regulator of South Africa
NiCad	Nickel-Cadmium
NMD	Notified maximum demand
NRECA	National rural electric cooperative association
O&M	Operations and maintenance
OPEX	Operational expenditure
PB-acid	Lead-acid
PCCS	Power conversion and control system
PCS	Power conversion system
PHS	Pumped hydroelectric storage
PPA	Power purchase agreement
PPP	Public private partnership
PV	Photovoltaic
R	South African rand
R&D	Research and development
RDI	Research, Development and Innovation
REDZ	Renewable energy development zone
REIPPP	Renewable energy independent power producer procurement
RESOLVE	Renewable Energy Solutions model
REV	Reforming the Energy Vision
RMIPP	Risk mitigation independent power producer programme
RPS	Renewable portfolio standard
SA	South Africa
SADC	Southern African development community
SAESA	South African energy storage association
SAIDI	System average interruption duration index
SEZ	Special economic zone
SMME	Small, Medium and Micro-Sized Enterprises
SSEG	Small scale embedded generators
T&D	Transmission and distribution
TIPS	Trade and Industrial Policy Strategies
TOU	Time of Use Pricing
TRC	Total resource cost

Acronym	Definition
TS	Transmission system
USD	US dollar
USTDA	US Trade and Development Agency
VAR	Volt-ampere reactive
WACC	Weighted average cost of capital
Zn-Br	Zinc-Bromine

Executive Summary

Energy storage is gaining traction around the globe and could fundamentally change electricity market dynamics. Global investments into energy storage are expected to be worth up to USD 100 billion by 2025 and more than USD 660 billion by 2040. Currently most of these investments are earmarked for destinations such as the US, China and the EU.

The application of battery storage in South Africa is also slowly gaining pace, approaching the 1 GW mark from a few hundred megawatts just a few years ago. The declining cost and improving viability of battery storage as well as numerous application cases, ranging from generation to behind the meter utilisation, contribute to the uptake of battery storage in the country. Yet, the opportunities that battery storage offers to overcome problems in the South African electricity market, to support a Just Energy Transition and a low-carbon power system, and to contribute to economic development are by far not fully exploited.

Prominent barriers to storage deployment can be traced to the speed with which battery storage technologies and their applications are evolving. This leads to a situation, where regulatory policy and electricity market design is lagging the energy storage technology that exists today.

There is a need for policy, legal and regulatory review and reform to utilise energy storage to facilitate a diversified and competitive power generation and the uptake of distributed generation at scale.

There are encouraging policy statements and commitments from political leaders in government indicating to provide local and international investors with policy certainty and regulatory frameworks and tools including incentives that encourage long-term investment, particularly focussing on energy storage. It is acknowledged that some policy certainty of South Africa's future energy pathway is provided by the Integrated Resource Plan (IRP) 2019 which has outlined a future energy trajectory that adds more solar and wind power into the national power generation mix. As more renewables are integrated into the energy mix, however, there will be an even greater need for storage.

The review of the existing South African policy landscape has identified several areas of short to medium term interventions to improve the regulatory environment and unlock further investments in battery storage, among others:

- Develop appropriate time-of-use tariffs for embedded battery storage to encourage owners to self-consume the stored energy when it benefits the local distributor – for instance to flatten the Duck Curve (timing imbalance between peak demand and renewable energy production).
- Design regulations to allow utilities to both locate and dispatch electricity in embedded battery storage systems, and thereby manage network loads.
- Develop policies to connect public battery storage investments not to the Eskom grid, but the municipal networks to avoid Notified Maximum Demand (NMD) penalties and still create peak energy revenues for Eskom.
- Revise the existing Battery Energy Storage Facilities (BESF) code to provide for specific use cases for utility-scale battery storage. The current BESF code views batteries in the grid as a non-dispatchable form of generation, because most of the Solar PV and Wind grid code parameters were copied to the BESF code.
- Revise the REIPPP criteria to provide a functional specification in the procurement process, focusing on overall system benefits and not simply compliance with a narrowly

defined technical specification. This will keep bidders mindful of the need to serve the intended beneficiary base and in so doing address overall system objectives.

- Extend IRP modelling boundaries to all end-use customer meters, to factor in the cost benefits of new technologies and options available to distributors.
- Energy storage must feature more prominently in the IRP and be included in the next round of the Renewable Energy Independent Power Producer Procurement (REIPPP) Programme. Business and government will need to continue to fund R&D and business in particular, should continue to invest in energy storage projects. This will require new levels of collaboration and strategic partnerships between government, higher education institutions, and industry.

It is recommended that an industry and government forum be formed that would initially have the task of outlining a common vision for the energy storage technology sector in South Africa and ultimately developing an implementation plan, as well as a national innovation ecosystem. The Department of Science and Innovation (DSI) confirmed that this had begun, stating "a consortium of local universities, science councils and the private sector is being put in place as part of a broader Research, Development and Innovation (RDI) roadmap."

The promotion of the energy storage ecosystem, paired with South Africa abundant reserves of key materials for battery storage technologies, such as manganese, vanadium and the platinum group metals, could establish South Africa in the global value chain for battery storage technology.

To build on the countries potential, visionary leadership is needed from key public and private stakeholders. South Africa should, "be bold, start soon, fail fast, and learn quickly."

1. Market Context

South Africa's existing electricity infrastructure is insufficient to meet demand, which is resulting in load shedding, excessive use of diesel to run peaking plants and billions of Rands in lost business. Significant further expenditure will be required in the years ahead to bring new generation sources online, to upgrade the transmission grid, to address the backlog in electricity distribution maintenance, to upgrade an ageing fleet of coal-fired power stations for environmental compliance and to replace those stations reaching end of life.
The adoption of energy storage technologies could provide a cost-effective way of improving South Africa's electric grid. Specifically, the adoption of energy storage could offset the need to use diesel and other fossil fuels for peaking and baseload power, provide backup power for commercial and industrial operations during periods of grid constraint, and increase the capacity of the electricity grid to successfully integrate renewable electricity generation sources, especially intermittent power sources such as solar and wind.

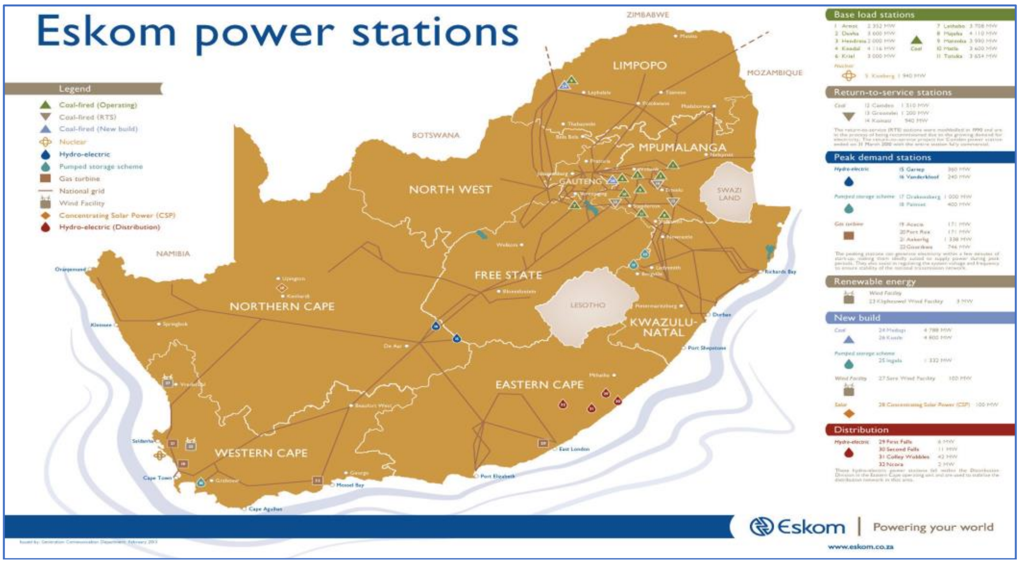

Figure 1 Map of Existing and Planned Eskom Power Stations

The following section lists the 8 key drivers of international battery storage markets.

Key Market Drivers

a) **Cost and performance improvements**. Particularly relating to lithium-ion batteries, driven by expanding electric vehicle markets and related manufacturing economies of scale, costs are dropping while performance is improving.
b) **Grid modernization.** The growth of battery storage goes hand-in-hand with grid modernization efforts, including the transition to smart grids. Batteries help to unlock the full potential of smart technologies, and vice versa.
c) **Global movement toward renewables.** Broad support for renewable energy and emissions reduction is also driving adoption of battery storage solutions. This is especially apparent in the corporate and public sectors.
d) **Participation in wholesale electricity markets.** Battery storage can help balance the grid and improve power quality regardless of the generation source. Leading nations are revamping their wholesale market structure to allow batteries to provide capacity and ancillary services.
e) **Financial incentives.** An increase in the availability of financial incentives for storage investment reflects the growing awareness of policymakers of the range of benefits battery storage can deliver throughout the electricity value chain.
f) **Phase-outs of FITs or net metering.** Reduction of feed-in-tariffs (FITs) or net metering payments is emerging as a driver of behind-the-meter battery deployments in some countries, as

customers strive to derive maximum value from their rooftop solar installations in the absence of these incentives.

g) **Desire for self-sufficiency.** Motivations for purchasing storage systems are not purely financial. For example, ecological motives, independence from utilities, resiliency, and technical curiosity are all thought to be motivation, similarly, self-sufficiency is a strong driver.

h) **National policy.** Many countries are turning to renewable energy storage to reduce dependence on energy imports, enhance the reliability and resiliency of their systems, and move toward environmental and de-carbonization targets.

1.1 Distribution Infrastructure -Expansion and Refurbishment

South Africa has a 70-billion-rand backlog in distribution infrastructure maintenance and it is estimated a third (R23 billion) of this is required for distribution network strengthening (often required for only short duration peak loads). Upgrade work involves the physical replacement of existing distribution infrastructure plant and cabling which is an expensive and disruptive activity. This problem is however, constraining property development in municipal areas also affecting economic development. Furthermore, the life of aging distribution infrastructure is extended where the networks can be de-stressed through peak load reduction. Well-placed energy storage can permanently avoid or solve a fair share of these problems – particularly since it already pays for itself from daily arbitrage savings.

1.2 Demand Forecast

The Integrated Resource Plan (IRP) is viewed as a generation plan for the country. It is equally important to use it as a transmission and distribution network plan. The Electricity Distribution Industry (EDI) has seen a reduction in volumes of energy sold over the last decade, but has not necessarily seen a corresponding reduction in instantaneous maximum demand. Increasing urbanization, with its characteristic peaky load is expected to continue, as is densification due to residential redevelopment (town house complexes) and the growth in informal settlements, with the latter driving unregulated electricity use. Many distributors have seen an increase in peak demand with an increasing Notified Maximum Demand (NMD) penalty trend, particularly where significant electrification and housing programs are being rolled out. Localized 'pent-up' peak demand growth is stalling property development and overall energy demand will eventually turn and grow again, but ironically, peak distribution network capacity is needed right now to deliver the power. Distributed storage is a perfect antidote to short duration load peaks.

1.3 Demand Side Management

Energy storage systems are powerful Demand Side Management (DSM) tools as they can behave as both dispatched loads and as dispatched energy sources. Storage as a DSM tool will become ever more relevant as increasing self-dispatched renewable energy gets connected to municipal grids. Storage is also a direct 'proxy' for gas and diesel peaking plant and it is not unreasonable that a municipal distributor should aspire to control at least 10% of its peak demand liability using energy storage systems. Specifically, to manage the winter evening peak demand and mitigate stage 1 load shedding, as is currently being done by the City of Cape Town Municipality. It is obviously clear from current Eskom grid performance, that the future prospect of load shedding cannot be ignored.

Figure 3 below tracks the escalating and crippling load shedding profile in South Africa from 2007 to September 2020, a clear opportunity for battery storage mitigation.

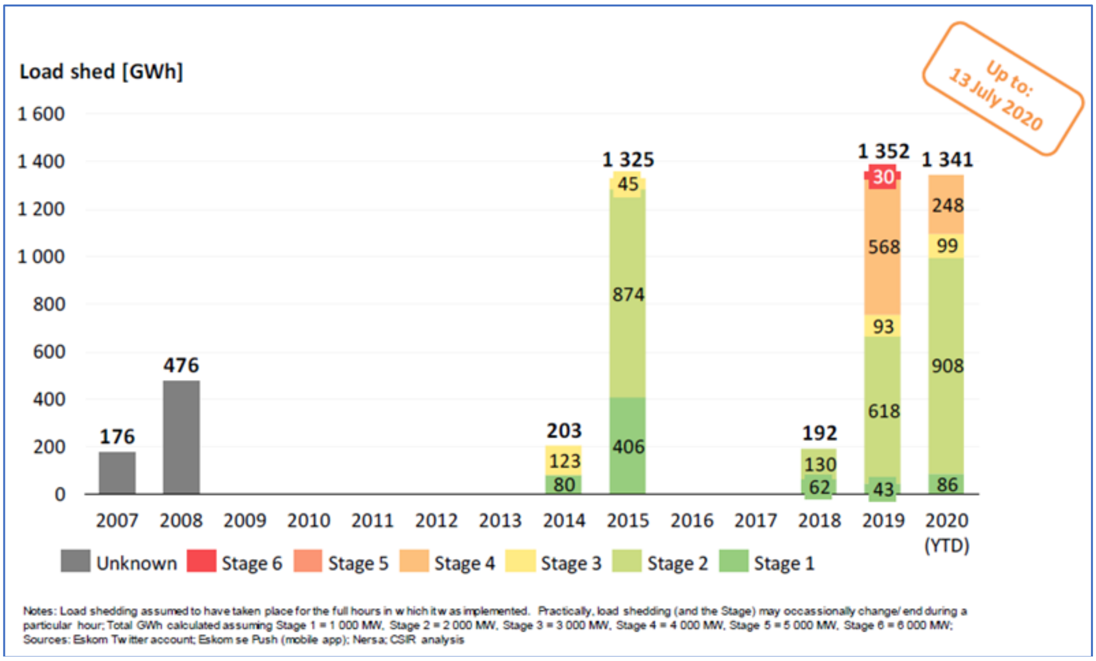

Figure 2 South Africa's Load shedding by Stage (JG Wright, CSIR)

1.4 Challenges to the Enablement of Battery Storage

There are many perceived and real challenges to the wide scale adoption of battery energy storage in South Africa. Considering the high local content requirement, finding competent local project partners that can provide for in-country deployment, engineering, and operations and maintenance (O&M) support is a perceived challenge. Another challenge is South Africa's centralized generation, transmission and distribution system, which limits stakeholder options.
A significant barrier to attracting investment in the development of ESSs in South Africa is unclear and inconsistent energy policies and the regulatory framework has no specific mechanisms to motivate companies to invest in such projects and give them a consistent and reasonable return on investment. Without adequate compensation for ancillary services, energy storage projects lack the revenue opportunity to make the project viable. A repeatedly raised concern of local developers and EPCs is the unavailability of project financing and the fact that the domestic financial sector lacks experience in new energy storage technologies.

Prominent barriers to storage deployment can be traced to the speed with which battery storage technologies and their applications are evolving, and to the multiplicity and flexibility of battery storage, which encounter the following challenges:

1. **Perceptions of high prices.** Costs have been dropping so quickly that decision-makers may have outdated notions about the price of systems, thinking that batteries still cost the same as they did a couple of years ago, or even six months ago.
2. **Lack of standardization.** Participants in early-stage markets, like South Africa, often contend with diverse technical requirements as well as varied processes and policies. Battery suppliers are no exception, making lack of standardization a roadblock to further deployment.
3. **Outdated regulatory policy and market design.** As can be expected with emerging technologies, regulatory policy is lagging the energy storage technology that exists today. Besides wholesale market rules, retail rules will also need to be updated, especially as residential, commercial and industrial interest grows.
4. **Incomplete definition of energy storage.** Energy storage is having an identity crisis, with stakeholders and policymakers around the world and in South Africa, wrestling with how to define fast-acting battery storage.

1.5 Energy Storage and the IRP Modelling

IRP is the most important policy instrument for determining the optimal mix of energy and technologies to deliver the lowest cost energy solution, so it is encouraging that the role and contribution of energy storage was mentioned in the draft IRP 2018. The revised IRP of 2019 targets the following additional electricity storage capacities: 513MW by 2023 and 1575 MW by 2029.

After a recent tender process, up to 1,300MWh of grid-connected energy storage will be deployed in combination with renewable energy in South Africa through a number of large-scale projects. These projects comprise a Norwegian renewable energy developer, Scatec for a 225MW / 1,140MWh, minimum size and capacity of battery storage to be built in the Northern Cape Province as well as an Eskom procurement notice in July 2020 for a transmission connected battery energy storage system of 80MW / 320MWh, minimum size and capacity, to be built in the Western Cape Province, to help reduce shortfalls in the capacity on the grid. Both projects are scheduled for connection to the grid in 2022.

It is unfortunate that a static, non-declining cost and only one parameter was applied in the procurement notice, i.e. the **associated reserve margin value,** considering that there are 30 parameters defined as inputs to the IRP modelling, of which the following 9 parameters positively influence distributed energy storage:

- Distribution Infrastructure; Expansion and Refurbishment,
- The Price Cone,
- Cost of Unserved Energy,
- Demand and Consumption Forecast,
- Demand Side Management,
- Generation Location,
- Own Generation,
- Renewables and
- Reserve Margin.

1.6 IRP Modelling Boundaries

IRP modelling solves for the ‘least cost’ to South Africa at the Eskom meter and to broaden market access for Municipal customers, to new technologies and in particular battery storage, the modelling boundaries need to be extended to cover all end-use customer meters, to factor in the cost benefits of new technologies and options available to power distributors.

Figure 4 below outlines the Eskom generation and distribution, transmission and municipal boundaries, proportional market access and the differentiating tariff structure. The IRP Modelling boundary is demarcated by Eskom distribution to its direct customers comprising 40% of all electricity users and denoted by the dotted red line in table 4 below. Municipal distribution to the remaining 60% of electricity users and denoted by the solid blue line in table 4 is not covered by the IRP modelling boundary. Extending the IRP modelling boundary to include all municipal customers will enable municipalities to better fund the new battery energy storage technologies, so critical in the deployment of battery energy storage systems, especially considering the comparatively higher municipal tariff structure.

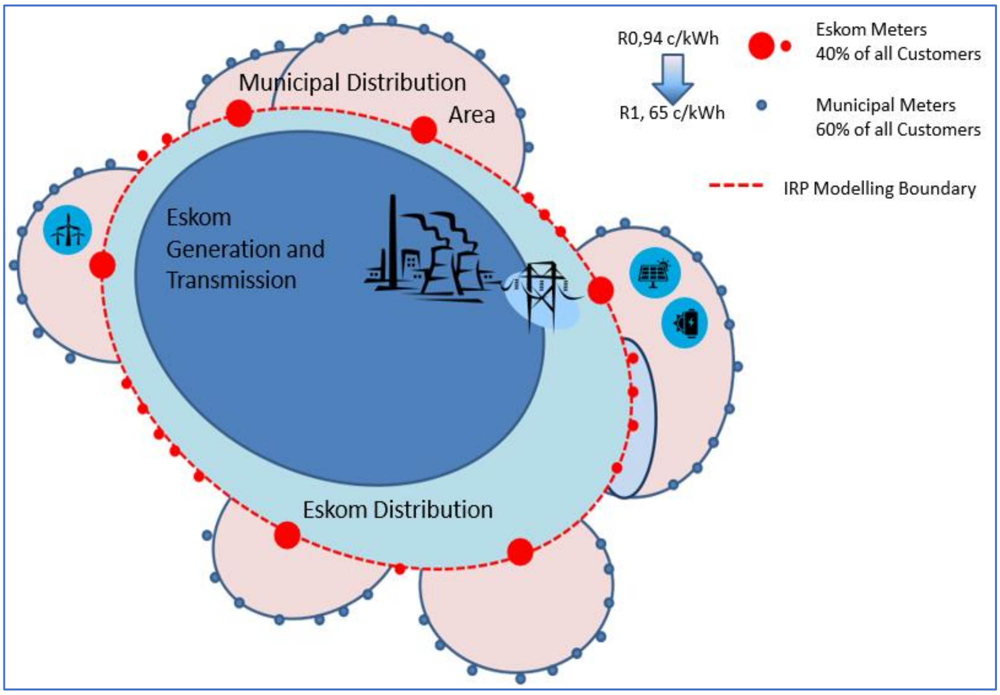

Figure 3: IRP Modelling Boundaries (P. Vermeulen)

1.7 The Price Cone

The price cone is defined as the average price of Eskom power to South Africa. It is however, not a true reflection of the actual end user price since 60% of the end users are on municipal networks and experience additional distribution costs. The IRP as a result excludes any energy or financially efficient measures that could possibly be applied to reduce the additional distribution costs. Most of the country's 'peaky' residential load is connected to the municipal networks. Purchasing on the Megaflex (soon to be Muniflex) tariff, the municipal distributor's price cone is inflated by this load profile. The arbitrage value of energy storage is very high to a non-Eskom distributor (distributors other than municipalities) and aside from geyser control systems, storage is probably the only practical DSM tool available to municipalities, to limit exposure to Eskom peak energy pricing. In addition, municipal distributors are paying dearly on excess NMD charges for short duration residential peaks. Charges can be reduced or avoided altogether by installing storage at any point downstream of the Eskom meter.

2. Battery Storage Case for South Africa

Battery storage options are emerging as the latest trends that will influence the electricity market in the next five to ten years. While battery storage internationally, and in particular in South Africa, still accounts for a small portion of the total power market, this is changing fast, as lithium-ion battery prices drop from $280/kWh in 2018 to an expected $73/kWh or less by 2030 as shown in figure below. The global energy storage market is set to grow from around 4GW of annual deployments in 2019 to more than 15GW per annum in 2024.

Figure 4: Lithium-ion battery prices fell 80% from 2010–2017 ($/kWh)

South African President Cyril Ramaphosa, recently announced the increase of the embedded generation threshold from 1MW to 100MW. The amended regulations will exempt generation projects up to 100MW in size, from the NERSA licencing requirement, irrespective of being connected to the grid. This will remove a significant obstacle from investment in embedded generation projects. This positive change in energy policy is expected to ignite the energy storage market in South Africa.

2.1 Energy Storage Technologies and Applications

Energy storage is the capture of energy produced at one time for use at a later time. Energy storage involves converting energy from forms that are difficult to store to more convenient or economical storage forms.

The three main energy storage use cases of interest to South Africa are:

- Power-to-Power,
- Power-to-Gas / Liquid, and
- Power-to-Heat

This concept note only considers the power-to-power energy storage, i.e. storage systems that provide for electricity-in then electricity-out and Table 1 differentiates the range of applications of each potential service area. The first 3 service categories primarily serve the needs of Eskom and municipalities while the area of greatest interest to battery energy storage developers, keen to enter the South African market is that of “Customer Energy and Management Services.”

Area	Applications	Range
Bulk Energy Services	• Time-shifting of electric energy (arbitrage) • Schedulable capacity • Re-dispatch ("> 15-minute reserves")	100MW+ 600MWh+ Minutes & Hours
Ancillary Services	• Frequency support (reserves) • Voltage support (reactive power) • Bottleneck management (congestion relief / N-1) • Black-start capability	1 – 10 MW+ 3 – 50 MWh+ Seconds & Minutes
Grid Infrastructure Services	• Transmission upgrade deferral • Distribution upgrade deferral	10MW+ 60MWh+ Hours up to Days
Customer Energy Management Services	• Power quality • Power reliability (security of supply) • Energy-charge management (arbitrage) • Demand-charge management (peak shaving) • Island and off-grid	3kW – 100MW 10kWh – 500MWh Seconds, Minutes & Hours

Table 1: Relevant Energy Storage Applications for South Africa (USTDA, Parsons 2015)

Electrochemical battery technologies suitable for consideration in South Africa fall in the following categories:

- **Lead Acid** and Advanced Lead Acid – Tried and tested low - cost batteries
- **Lithium ion, Nickel Cadmium, Nickel metal hydrate-based Batteries** – Good performance, longevity and moderate cost
- **High temperature** batteries (NaS, Na-NiCl2, Mg/PB-Sb)
- **(Redox) Flow Batteries** (VRFB, Zn-Fe, Zn-Br)

Battery technologies such as Vanadium Redox Flow batteries, Zinc-flow batteries, NiCd, NiMh, NaS, Na- NiCl2, Mg-Sb and Li-Sb/Pb battery technologies should be tracked and evaluated for relevance, especially considering that South Africa ranks as one of the world's largest producers of chrome, manganese, platinum, nickel, silver and vanadium.

Figure 5 summarizes the potential of competing energy storage technologies to be mature and competitive over the near, middle and long-term timeframes. This suggests that South Africa should concentrate on technologies that will be mature and competitive through 2030 and those that were expected to be mature and competitive by 2020.

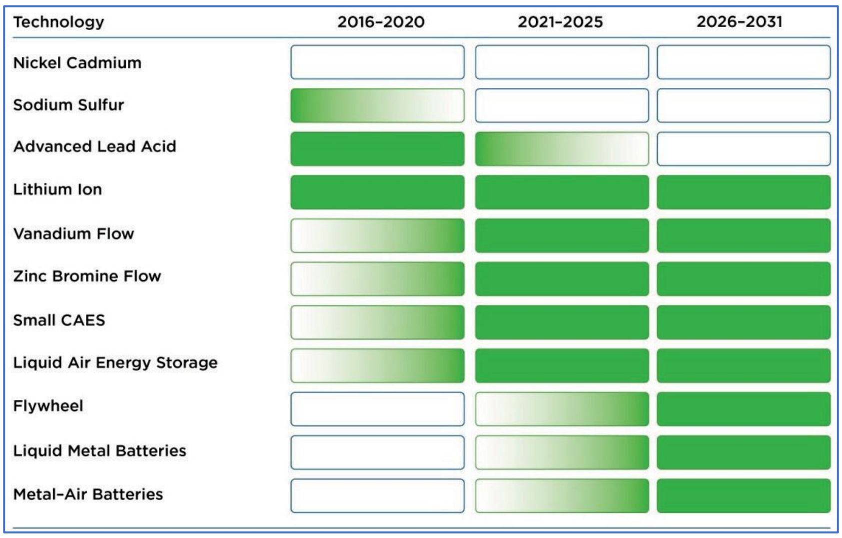

Figure 5 Timeframes for Technology Relevance in South Africa

2.2 South Africa's Energy Storage Market Potential

In South Africa, the energy storage technology based market in utility-scale sized batteries has emerged recently, driven by the IRP provisions by 2030 (513MW by 2023 and 1575 MW by 2029). Behind the-meter (BTM) applications are until now uncommon and limited to a handful of businesses and private customers that have invested in battery technology to ensure energy security for their operations. Currently, the use of battery storage is mostly limited to distribution network operations. Installed battery storage in South Africa is approaching the 1GW mark, from a few hundred megawatts just a few years ago.

Following recent tender processes, up to 1,300MWh of grid-connected energy storage will be deployed in combination with renewable energy in South Africa through a number of large-scale projects. It is expected that 428MW of renewable energy-plus-storage projects will be deployed by early 2022. And the results of the Risk Mitigation Independent Power Producer Programme (RMIPP) indicates that renewable energy + batteries are able to compete with LNG projects.

In the 2020 RMIPP tender it was clear that renewables-plus-storage competed against gas for dispatchable power capacity contracts and comparatively, 1MW of natural gas represents 1MW of contracted capacity, whereas the same dispatchable capacity from renewable energy and storage would represent around 3MW of renewables and 1MW of storage with a storage and discharge duration ranging between 2 to 5 hours, offering an increasingly more attractive utility power option.

Considering the positive trends, the market is projected to grow to R33.4 billion by 2030, with 6.5 GWh installed energy capacity. The positive market outlook is mainly driven by an expected growth of BTM applications (arbitrage, peak-shaving) and power reliability issues.

The battery energy storage application options presented in Table 1, lists the following electricity end-use opportunities, explained below:

- **Power quality**: Battery energy storage systems can output active and reactive power at the same time and can play an important role in the power quality management of distribution networks, viz. mitigating voltage dips and harmonics.
- **Power reliability and security of supply**: Battery energy storage systems can be charged during off-peak periods and discharge when the demand of electricity increases in peak periods and augment grid supply during load shedding intervals.
- **Energy-charge management and arbitrage**: Energy management and arbitrage involves purchasing **more electricity during Off-peak periods**, storing that electricity and discharging it during Peak periods, and in so doing use a storage solution, to generate a revenue stream.
- **Demand-charge management and peak shaving**: With on-site storage, the BES is charged during off-peak periods or with solar energy and then discharged during peak periods to avoid paying peak tariffs.
- **Island and off-grid**: Battery storage systems help to cut costs, especially when paired with diesel generators, by providing reliable and cheaper electricity in isolated grids and to off-grid communities, which otherwise rely on expensive imported diesel fuel for electricity generation and also reducing inefficient generator starts and cold runs.

The following Table provides an overview of the expected storage market growth.

Key	
Not applicable	1
Low need	2
Medium need	3
High need	4

Table 2 South Africa Energy Storage Growth Scenario

	Customer Energy Management Services														
	Power Quality			Power Reliability (Security ofSupply)			Energy-charge Management (Arbitrage)			Demand-charge Management (Peak Shaving)			Island and Off-grid		
	Short-Term (1-5 Years)	Medium -Term (6-10 Years)	Long-Term (11-15 Years)	Short-Term (1-5 Years)	Medium -Term (6-10 Years)	Long-Term (11-15 Years)	Short-Term (1-5 Years)	Medium -Term (6-10 Years)	Long-Term (11-15 Years)	Short-Term (1-5 Years)	Medium -Term (6-10 Years)	Long-Term (11-15 Years)	Short-Term (1-5 Years)	Medium -Term (6-10 Years)	Long-Term (11-15 Years)
Residential	2	2	2	2	3	2	1	1	1	1	1	1	3	4	4
Commercial	2	3	2	3	4	4	2	3	3	3	3	3	3	3	4
Industrial	2	3	2	3	3	4	2	3	4	3	3	3	4	4	4
Utility	3	3	3	4	1	1	1	1	1	1	1	1	1	1	1

The following example presents both the options and opportunities of strategically located battery storage systems on the Eskom grid.

Example 1: Placing a 100 MWh storage system on Eskom's high voltage transmission network can provide the following:

- A means to store surplus renewable energy at a national level,
- Avoid transmission network bottlenecks and
- Provide frequency support (reserve margin) for the national generation industry

Example 2: If the same storage capacity was deployed by twenty-five 4 MWh systems further downstream on the medium voltage distribution networks, the systems could add further value through the following means:

- Energy purchasing arbitrage (routinely, over the life of the plant),
- The alleviation of distribution network bottlenecks and overloads,
- The avoidance of Eskom Notified Maximum Demand Charge penalties,
- The deferment of network refurbishment or network upgrade capital expenditure, and
- Improvement of the power factor over the entire transmission and distribution.

The benefit of these energy storage options to electricity supply networks is summarised below:

- Realizing a significant improvement in the security of supply for customers and
- Providing a measure of standby power to end-use customers, as opposed to the use of expensive diesel generators.

2.3 The Business Case for Energy Storage

At the current price points for Li-ion batteries (locally ranging between R4,000 - R8,000 /kWh) the business case for using battery energy storage for tariff arbitrage or demand reduction is not viable yet. The feed-in-tariffs for SSEG's range between 60 - 110 c/kWh and are usually capped at net-consumption, which strongly discourage the oversizing of embedded generation systems.

Considering that the main reason for installing battery energy storage is load shedding resilience and / or backup power makes a very good battery energy storage case for South Africa in the foreseeable future of constrained grid supply.

The biggest challenge, policy-wise is that battery energy storage is only being used for ***single use*** cases, viz. Utility Variable Renewable Energy (VRE) support as part of the IRP or as load shedding prevention.

The challenge and opportunities are to quantify and incentivise additional ***multi-use cases,*** to encourage grid electricity end-use customers and distribution network operators to invest in energy storage.

The opportunities associated with embracing this energy transition include:

- Increased beneficiation of minerals associated with the energy transition, such as battery minerals,
- The localisation of energy value chains, that leverage the country's solar, wind and human capital resources, and
- The repositioning of South Africa as a leader in new and emerging markets.

This change will see opportunities emerging with one being the potential to develop storage solutions in South Africa, from battery to hydrogen and eventually other clean molecules.

A recent DMRE tender process will lead to the deployment of up to 1,300MWh of grid-connected energy storage in combination with renewable energy in South Africa through a number of large-scale projects under the RMIPPP. Successful independent power producers will receive a 20-year power purchase agreements (PPAs) for energy facilities that can dispatch power to the grid as required by system operator Eskom between the hours of 5:00am and 9:30pm each day. The weighted average price of all preferred bids was R1,575.00 per MWh.

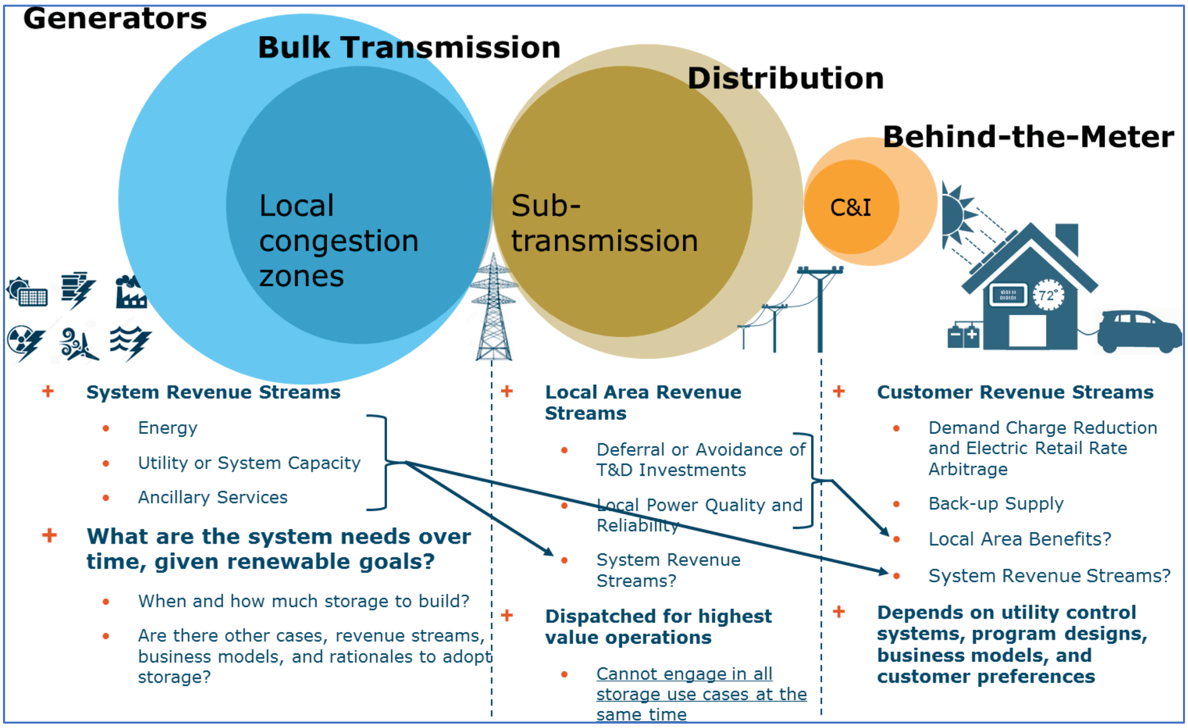

Figure 6 Potential Revenue Stream for Energy Storage

Potential Revenue Streams for Energy Storage

The potential revenue streams for Eskom (bulk transmission), Municipalities (distribution), Commercial and Industrial end-users (behind-the-meter) are listed in figure 6. The customer (**C&I**) revenue streams are covered in greater detail below.

Battery energy storage systems enable the storage and discharge of renewable energy as and when it is needed, which allows businesses to maximise energy efficiency, minimise power interruptions and access new value streams. The value streams available for Commercial & Industrial (C&I) customers to tap into include:

- Reduced network demand charges by reducing peak power consumption,
- A back-up power supply in a constrained grid environment,
- Retail and network price arbitrage,
- Local area benefits through potential network support opportunities with local municipalities and
- System revenue streams through participation in ancillary services markets.

The most attractive C&I revenue streams can likely be demand reduction, back-up power and the ability to access capacity markets as well as potential wholesale markets through virtual power plants, during low demand after hour periods. C&I customers should focus on services that realise the largest savings in the shortest amount of time, and while demand charge reduction offers the highest value to C&I end-users, no single revenue stream is likely to be sufficient to carry the business case in isolation.

Analysis of break-even point of energy storage cost vs. maximum arbitrage potential of the Local Government Megaflex Tariff					
1kWh Storage used for 6 days of the week, one shot per day, to shift 1kWh from peak to off-peak, all year round					
Plant Parameters			**Megaflex Tariff Application**		
			11kV Intake point		
Technology Aspects	Units	Value	**Operational Aspects Energy**	Units	Value
Total Installed Cost of Storage System	$/kWh	400	HV Distribution System Losses	%	4,00%
Storage System Specified Cycle Life	Number	7000	MV / LV Distribution	%	3,00%
Efficiency of Charge and Discharge cycle	%	85%	Value of Winter Evening Energy Arbitrage	c/kWh	246,84
			Value of summer Evening Energy Arbitrage	c/kWh	54,29
Capital Aspects	Units	Value	Loss-less average value of daily arbitrage	c/kWh	102,43
Rand to Dollar Exchange Rate	Ratio	14,4	Average daily rate to re-charge system	c/KWh	43,72
Local cost of Storage	R/kWh	5760	Cycle cost to overcome system recharging losses	c/kWh	8,14
Capital loan interest rate	%pa	5,5%	Cycle savings due shift of losses out of peak	c/kWh	3,07
Capital Loan Term	Years	10	Net average value of daily energy arbitrage	c/kWh	97,36
Cost of Finance	R/kWh	-1741			
Total financed plant cost	R/kWh	7501	**Operational Aspects Network and Demand costs**	Units	Value
Theoretical Plant Life, 6 days p/week, 1 cycle/day	Years	22,4	Peak Period Duration	hours	2
Storage Plant Expected Life	Years	15	Demand reduction potential per kWh of storage	kVA	0,5
Charge / Discharge Cycles required	Number	4693	Monthly network charge per kW	r/kVA	7,63
			Monthly demand charge per kW	r/kVA	28,99
			Daily network and demand charge savings potential	c/kWh	60,23
Total Savings from 1 kWh daily arbitrage over the life of the equipment	Rand	7395,34	* This savings is subject to the system being in operation during the annual half hour peak.		
LCOE over expected plant life, 1 shot per day	c/kWh	159,85	Total potential daily arbitrage value of 1kWh storage	c/kWh	157,59

Table 3 Arbitrage Break-even Cost Point

Table 3 shows the potential daily arbitrage value of 1kWh storage as **157,59 c/kWh** for the local Government Megaflex tariff, compared to the LCOE over the expected life of the battery storage plant of **159,85 c/kWh**. This comparative costing demonstrates that the benefit of battery energy storage, applying the Megaflex tariff, is marginally lower than the levelized cost of electricity “generated” by the storage system. South Africa is clearly at the tipping point, beyond which, battery energy storage systems should present financially viable investment options to developers and EPCs.

3. The Energy Storage Policy Situation

In 1998, the Government White Paper on Energy Policy detailed a policy of restructuring and liberalisation of the electricity supply industry (ESI). To date, not one of the formulated policy objectives in respect of the restructuring of the ESI has been met, even though the 1998 policy document remains in place to this day. This policy uncertainty, together with a rapid turnover of ministerial leadership at the Department of Mineral Resources and Energy, has resulted in integrated planning within the energy and electricity supply sectors being intermittent, uncoordinated and lacking coherence, at best. The planning that has taken place has been done in the absence of a published national Integrated Energy Plan (IEP). Section 6(1) of the National Energy Act 34 of 2008 requires that an IEP be developed, reviewed and published annually by the Minister of Energy. However, to this day, a final IEP has never been published since 2008 when the Act was first promulgated.

Following the publishing of an integrated resource plan (IRP) for electricity, IRP 2010-2030 in 2011, there was a seven-year delay before this was finally updated and replaced with the revised IRP 2019, covering the next decade to 2030. The new IRP 2019 comprise a major new-build comprising 20,6GW of renewable energy and about 5GW of distributed self-generation by electricity consumers, all complimented by 2GW of battery storage.

The IRP 2019 is the main document that covers the planned government-backed energy storage capacity, in which the following capacities are targeted; 513MW by 2023 and 1575 MW by 2029. The IRP does not specify the respective hours (MWh) for these targets, leaving it open to interpretation and it also does not specify the preferred energy storage technology. It is envisioned that batteries and specifically Li-ion should be the leader in this allocation, but the price points are currently very high. From a grid-connected / synced utility storage perspective, the IRP governs the amount of energy storage South Africa needs to meet the demand.

Figure 7 is a schematic on the linkages of the various governing entities with reference to DRET's (which includes battery storage). This mapping of the governmental entities provides an understanding of the various role-players within the regulatory landscape, and ultimately allows the actors to determine a strategic approach regarding engagement and lobbying.

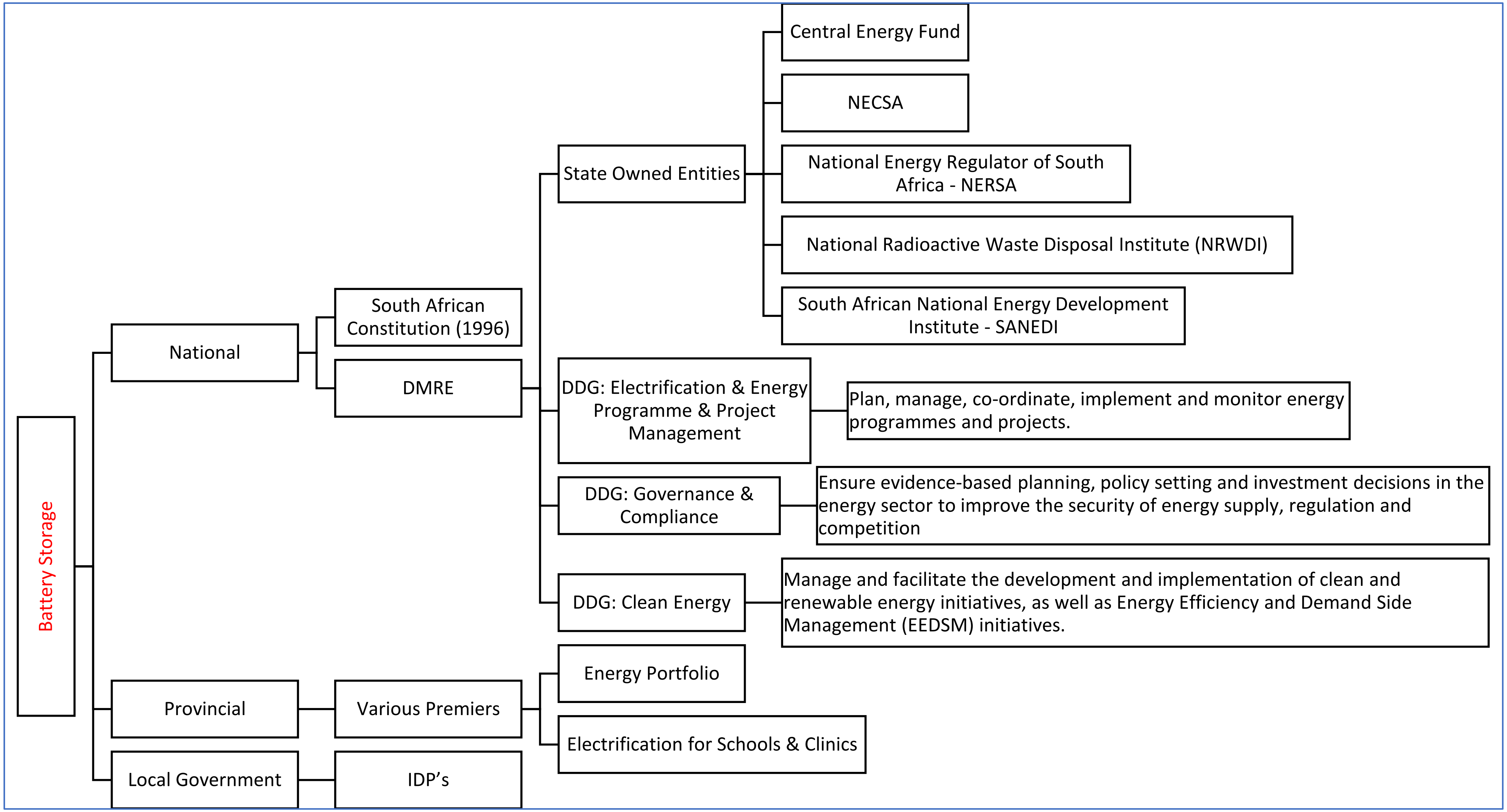

Figure 7 Schematic on the linkages of the various governing entities wrt DRET's

Recently NERSA posted the Battery Energy Storage Facility (BESF) Grid Code, which focuses on utility-scale installations and how these facilities should integrate with the grid.

For SSEGs, battery energy storage is treated as a stand-by generator, which do not require registration with the distribution authority (municipalities), whereas the old Electricity Regulation Act (ERA) required these backup power systems to be registered. The latest ERA 2020 version however does not require registration, leaving municipalities to decide whether they require registration. This creates confusion and requires greater regulatory cohesion and clarity.

3.1 **Policy Analysis**

Within this chapter the policy mix affecting battery storage technology ***within*** the policy framework for distributed renewable energy technologies (DRET) is reviewed by applying the top-down mapping approach outlined in Ossenbrink et al. (2018). It includes the policy mix visualisation of the DRET with an overview of the governing policy strategies and instrument mix. In this regard […] a policy mix is characterized by an overarching strategic intent (such as climate change mitigation) and subsequently reveals the corresponding mix of policy instruments embraced by the focal policy strategy."

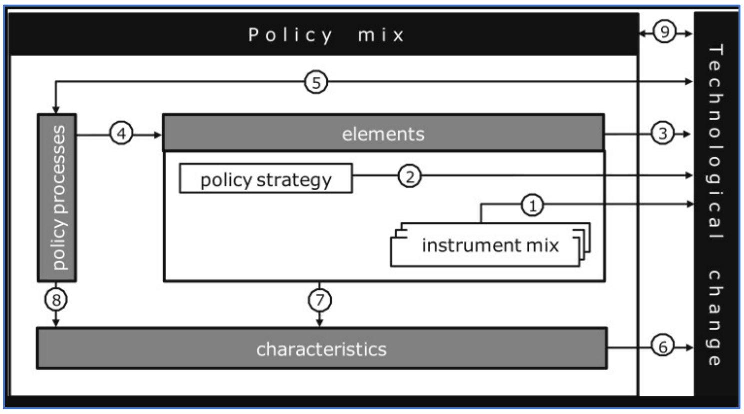

Figure 8 Framework for analysing the linkage between battery storage technology and the energy policy landscape (Rogge, K. S. and Reichardt, K. (2016))

The concept note includes a schematic on the linkages of the various governing entities w.r.t. DRET's (battery storage) (*Figure 7), and* an overview of relevant entities governing battery technologies in South Africa that are responsible for shaping the policy strategy (*see Tables below*). This depicts maturity of the entity and its "political strength" within the legislative landscape. It can be seen that there are many entities that can be targeted in order to play a positive role in shaping policy strategies and instruments to enable DRET of battery storage. As low-hanging fruit, the dtic setting local content requirements for battery technology, would hopefully spur industrial development towards beneficiation and local technology development. In addition, DRET's in the form of battery storage should be included with the 12L incentive scheme to encourage the adoption of battery energy storage projects.

3.2 Overview of relevant entities governing Battery Technologies in South Africa - Entities responsible for shaping Policy Strategy

Parliament – National Assembly (NA) & National Council of Provinces (NCOP)	National Ministry – Ministry of Minerals Resources & Energy (DMRE)	Local Government

Entities responsible for shaping Instrument mix (Instrument Design, Implementation, and Administration)

Entities	**Department: Mineral Resources and Energy (DMRE)**	**Central Energy Fund SOC Ltd (CEF)**
Established	2009	1950's
Mission "	**Mission** "To regulate and transform the energy sector for the provision of secure, sustainable and affordable energy**"** **Legislative Mandate** – to ensure secure and sustainable provision of energy for socio-economic development. The strategic objective derives from the NDP, which envisages that, by 2030, South Africa will have an energy sector that promotes economic growth and development, social equity and environmental sustainability.	• To provide and enable sustainable energy security solutions for South Africa in order to contribute to economic development and alleviate poverty in an environmentally responsible manner. • CEF is to contribute to the security of energy supply of South Africa and the Region through exploration, acquisition, development, marketing and strategic partnership • Strategic partner to the DMRE.
Governance	Appoints the Director-General (DG) – who then in tandem of separately appoints the Deputy Director General (DDG) according to its organization structure."	Report to the Minister of DMRE
Role for battery storage technology as a DRET	***Vision 2014*** "A transformed and sustainable energy sector with universal access to modern energy carriers for all by 2014." ***Vision 2025*** "Improving our energy mix by having 30% of clean energy by 2025."	• Provide thought leadership in energy policy development and other energy initiatives; and • Contribute to security of energy supply and support the deployment of new energy technologies in the country through the acquisition, exploitation and manufacture of appropriate energy solutions [from coal, oil, gas ***and renewable energy*** resources] to meet the future energy needs of South Africa.
Staff	approx. 1,700	1,862
Budget	R 7440 million (2019)	R13 589 million(2018)

Entities	National Economic Development and Labour Council (NEDLAC)
Established	1994
Mission “	The National Economic Development and Labour Council (Nedlac) is the vehicle by which Government, labour, business and community organisations will seek to cooperate, through problem-solving and negotiation, on economic, labour and development issues and related challenges facing the country. Nedlac will conduct its work in four broad areas, covering: • Public finance and monetary policy; • Labour market policy; • Trade and industrial policy; and • Development policy.
Governance	Reports to the Minister of Labour
Role for battery storage technology as a DRET	Government entities often consult with NEDLAC on issues concerning labour and economic development. The statutory body Nedlac brings together representatives from government, organised labour, organised business and the community to consider all socio-economic and labour policy and legislation. Nedlac is South Africa’s apex social dialogue structure.
Staff	26 (2014/15)
Budget	R41,613 million (2019/20)

Entities	National Energy Regulator of South Africa (NERSA)	South African National Energy Development Institute (SANEDI)
Established	Circa 2004	2011
Mission “	To regulate the energy industry in accordance with government laws and policies, standards and international best practices in support of sustainable and orderly development	Leading clean energy solutions provider for a low carbon South Africa. Using applied energy research and resource efficiency to develop innovative, integrated solutions that will catalyse growth and prosperity
Governance	Report to the Minister of DMRE	Report to the Minister of DMRE
Role for battery storage technology as a DRET	• Regulatory participation in off-grid activities • NERSA plays a relatively important role in the off-grid concession programme with regard to setting tariffs • And in determining whether battery storage technology is viable, and the technological boundaries of battery storage deployment.	SANEDI’s energy development agenda is a key part of our country’s energy journey. SANEDI’s portfolio of initiatives are closely attuned to technology advancements, declining technology costs and continued innovation in the energy sector.
Staff	237 (2017/18)	59 (2017/18)
Budget	R316.72 million (Revenue is generated from tariffs and levies paid by the regulated industries)	R59,775 million (2017/18) (The total income for the 2017/18 financial year amounted to R124.85 million of which R59.77 million was government grants)

3.3 Details of The Top-Down Approach: Distributed Renewable Energy Technologies (DRET's) Policy Mix

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Strategy					
National Government					
Reconstruction & Development Programme (RDP)	RDP	Framework	The Reconstruction and Development Programme (RDP) is a policy framework for integrated and coherent socio-economic progress. It seeks to mobilise all our people and our country's resources toward the final eradication of the results of apartheid. Its goal is to build a democratic, non-racial and non-sexist future and it represents a vision for the fundamental transformation of South Africa	Ministry of the Office of the President	1994
White Paper [1]on Energy Policy	WPEP	Framework	This White Paper has been written so as to clarify government policy regarding the supply and consumption of energy for the next decade. The policy strengthens existing energy systems in certain areas, calls for the development of underdeveloped systems and demonstrates a resolve to bring about extensive change in a number of areas. It addresses all elements of the energy sector as practically as it can. (previously completed in 1986)	Department of Minerals & Energy (DME) now falls to DMRE	1998
Non-Grid Policy Guidelines	NGPG	Framework	Non-grid policy guidelines for Integrated national electrification programme (INEP) for rural communities since grid electrification was uneconomical and unsustainable.	DMRE	2001
Energy Security Master Plan - Electricity (2007-2025)	ESMP	Principal Plan	To ensure the supply of reliable electrical power ensures to enable economic growth. This Electricity Master Plan followed a systematic approach in framing its objectives.	Department of Minerals & Energy (DME)	2002
White Paper on Renewable Energy	WPRE	Framework	The White Paper on Energy Policy's position with respect to renewable energy is based on the integrated resource planning criterion of, "Ensuring that an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply options."	DMRE	2003

[1] which is a broad statement of government policy

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Strategy					
National Government					
Integrated Energy Plan	IEP	Framework	Guiding policy which sets framework for: • Development of Electricity, Gas and Liquid Fuel "infrastructure" Plans • Selection of appropriate technologies to meet energy demand • Development of policies and targets	DMRE	2003
Electricity Regulation Act[2]	ERA	Framework	To establish a national regulatory framework for the electricity supply industry; to make the National Energy Regulator the custodian and enforcer of the national electricity regulatory framework; to provide for licences and registration as the manner in which generation, transmission, distribution, trading and the import and export of electricity are regulated; and all connected matters.	DMRE	2006
National Framework for Sustainable Development	NFSD	Framework	Signalled a new wave of thinking that was aimed at promoting the effective stewardship of South Africa's natural, social and economic resources[3]	Department of Environmental Affairs (DEA)	2008
National Energy Act (2008)	NEA	Principal Plan	• Ensure that diverse energy resources are available in sustainable quantities and at affordable prices in the South African economy to support economic growth and poverty alleviation, while taking into account environmental considerations • plan for the increased generation and consumption of renewable energy, a contingency energy supply, the holding of strategic energy feedstock and carriers, adequate investment in appropriate upkeep, and access to energy infrastructure • Data collection, and the promote electricity regulation, energy research and the efficient generation and consumption of energy.	Department: Mineral Resources & Energy (DMRE)	2008

[2] replace the Electricity Act of 1987.
[3] Source - https://www.environment.gov.za/sites/default/files/docs/sustainabledevelopment_actionplan_strategy.pdf

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Strategy					
National Government					
Industrial Policy Action Plan[4]	IPAP	Principal Plan	The Industrial Policy Action Plan (IPAP) is firmly entrenched in Government's overall policy and plans to address the key challenges of economic and industrial growth and race based poverty, inequality and unemployment. IPAP 2018 is a product of the Economic Sectors, Employment and Infrastructure Development (ESEID) cluster. The responsibility for its implementation lies with Government as a whole and a wide range of entities, including SOCs.[5]	Department of Trade and Industry (dti)	2008 (10 iterations)
Integrated Resource Plan	IRP	Principal Plan	The IRP is an electricity infrastructure development plan based on least-cost supply and demand balance taking into account security of supply and the environment (minimize negative emissions and water usage). Provides a blueprint for South Africa's envisaged energy mix. The plan remains within the policy framework of pursuing a diversified energy mix that reduces reliance on a single or few primary energy sources. Informs implementation of the electricity expansion build plan	DMRE	2010
National Development Plan	NDP	Principal Plan	South Africa's *NDP 2030* offers a long-term plan for the country. It defines a desired destination where inequality is reduced and poverty is eliminated so that all South Africans can attain a decent standard of living	Department of Planning, Monitoring & Evaluation	2011
National Climate Change Response Policy[6]	NCCRP	Principal Plan	Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity. Make a fair contribution to the global effort to stabilize GHG concentrations within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner	Department of Environmental Affairs	2011

[4] Source ibid
[5] Source - http://www.dti.gov.za/industrial_development/industrial_development.jsp
[6] Government's National Climate Change Response Policy (NCCRP)was approved in October 2011 and was formally published as a White Paper in the Government Gazette (Gazette No. 34695, Notice No. 757).

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Strategy					
National Government					
National Strategy for Sustainable Development and Action Plan	NSSD	Principal Plans	Proactive strategy that regards sustainable development as a long-term commitment, which combines environmental protection, social equity and economic efficiency with the vision and values of the country.	Department of Environmental Affairs (DEA)	2011
New Household Electrification Strategy	NHES	Principal Plans	Cabinet Approved on 26 June 2013. Could only find a power point presentation and no government gazette. Yet, this is an important piece of work that presents an overview of strategy for universal energy access. Speaks to mini-grids and technology options for the achievement of the 7% universal access by 2025.	DMRE	2013
Grid Connection Code for Battery Energy Storage Facilities (BESF) Connected to the Electricity Transmission System (TS) or the Distribution System (DS) In South Africa	BESF Grid Connection Code	Compliance Framework	The primary objective of the Grid Connection Code for BESF connected to Transmission System (TS) or Distribution System (DS) in South Africa (BESF Code) is to specify minimum technical and design grid connection requirements for battery energy storage facilities connected or seeking connection to the South African TS or DS. The BESF Code will be used together with other applicable requirements of the Grid Code that include Renewable Energy Power Plant (RPP) Code, Transmission Code, Distribution Code, and Scheduling and Dispatch Rules (SDR), as compliance criteria applicable to BESF Code. NERSA is the administrative authority for the Grid Code in terms of section 15 of the Electricity Regulations Act, 2006 as amended. NERSA shall ensure that the Grid Code is compiled, implemented and complied with for the benefit of the industry. Code.[7]	National Energy Regulator of South Africa (NERSA)	Draft 5.2 October 2020
White Paper on Local Government	WPLG	Framework	This White Paper establishes the basis for a new developmental local government system, which is committed to working with citizens, groups and communities to create sustainable human settlements which provide for all needs in a holistic way.[8]	Minister for Provincial Affairs & Constitutional Development	1998
Local Government: Municipal Systems Act	MSA	Framework	The Municipal Systems Act is part of a series of legislation which aims to empower local government to fulfil its Constitutional objects.	Local Governments (municipalities)	2000

[8] Source - http://www.cogta.gov.za/cgta_2016/wp-content/uploads/2016/06/whitepaper_on_Local-Gov_1998.pdf

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Strategy					
Local Government					
Local Government: Municipal Financial Management Act (MFMA)	MFMA	Regulatory Framework	The MFMA aims to modernise budget and financial management practices in municipalities in order to maximise the capacity of municipalities to deliver services to all their residents, customers and users. The Act aims to enable managers to manage, but to make them more accountable.	National Treasury	2004
Instruments					
DMRE					
Free Basic Energy (FBE) programme.	FBE	Subsidy	The Free Basic Electricity Policy (Department of Minerals and Energy, 2003) was designed to provide a subsidy to indigent households, a government acknowledgement that access to electricity did not guarantee use of electricity (based on affordability constraints). Poor electrified households were provided, free of charge, with 50kWh.	DMRE	2003
Free Basic Alternative Energy (FBAE) programme.	FBAE	Subsidy		DMRE	2007
Electricity Regulations on New Generation Capacity	ERNGC	Directive	In May 2011, the Department of Energy (DoE) gazetted the Electricity Regulations on New Generation Capacity (New Generation Regulations) under the Electricity Regulation Act (ERA).[9]	DMRE	2011
Renewable Energy IPP Procurement Programme	REIPPP	Programme	The programme aims to develop South Africa's renewable Energy sector through a competitive bidding process. Of the 57 projects that have reached commercial operation date, 44 projects have already been operational for longer than a year[10]	DMRE	2012
Renewable Energy IPP Procurement Programme	REIPPP	Directive	Determination under section 34(1) of the electricity regulation act, 2006 (act no.4 of 2006)	DMRE	2015

[9] Source - https://www.ipp-projects.co.za/Home/About

[10] Source - https://www.gov.za/sites/default/files/gcis_document/201805/industrial-policy-action-plan.pdf

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Instruments					
DMRE					
Socio-Economic Impact Assessment System	SEIAS	Impact Assessment Tool	Provides detailed assessment of the policy/legislative/ regulations/ other proposal. It identifies (a) mechanisms for monitoring, evaluation and modification as required; and (b) a system for managing appeals that could emerge around the implementation process.[11] Describe the behaviour that must be changed, main mechanisms to achieve the necessary changes. These mechanisms may include modifications in decision making process systems; changes in procedures; educational work; sanctions; and or incentives.	Department of Planning, Monitoring & Evaluation	2018
Ministry of Finance					
Regulations in terms of Section 12L of the income tax act (1962) on the Allowance for Energy Efficiency Savings	12L	Incentive	Encourages efficient use of energy. The 12L incentive offers a tax deduction for taxpayers who implement energy efficiency saving measures. Broadly speaking, the incentive allowed for tax deductions calculated at 45 cents per kilowatt hour (kWh) or kilowatt hour equivalent of energy efficiency savings. During 2015, this allowance amount was increased to 95c/kWh by the Minister of Finance during the Budget Vote speech in March 2015.[12]	National Treasury	2013
Carbon Tax Act 15 of 2019	CTA	Directive	Aims to provide for the imposition of a tax on the carbon dioxide (CO_2) equivalent of greenhouse gas emission	Minister of Finance	2019

[11] Source - http://www.energy.gov.za/IRP/irp-update-draft-report2018/AnnexureE-IRP-SEIAS-Draft-as-Approved-by-DPME.pdf
[12] Source - https://www.greencape.co.za/assets/Revised-12L-Income-Tax-Allowance-on-Energy-Efficiency-Savings-GreenCape-guide.pdf

Policy	Abb.	Type	Brief description of mechanism	Gov. entity/ID	Since (year)
Instruments					
State Owned Entity (SOE)					
Working for Energy	WfE	Programme	Focuses on the provision of energy and other related interventions to improve the livelihood of people in energy-starved communities. The initiative places emphasis on labour-intensive options, targeting employment opportunities for women, youths and people with disabilities. WfE is a cross-cutting initiative that has the potential for extensive public- and private-sector partnership, inter-governmental synergy and cooperative governance within the renewables sector. This kind of initiative is more aligned with the DRETs that form the focus of this research initiative. A number of these project initiatives have been included in the case studies	SANEDI	2010
Green Fund	GF	R&D Funding	The Green Fund is a national fund that seeks to support green initiatives to assist South Africa's transition to a low carbon, resource efficient and climate resilient development path delivering high impact economic, environmental and social benefits. The Fund is managed by the Development of Bank of South Africa (DBSA) on behalf of Department of Environmental Affairs.	Development Bank of South Africa (DBSA)	2012

3.4 Policy Mix Findings - Outcome of the top-down approach

All the analysed policies with an effect on Distributed Renewable Energy Technologies (DRET) (policy mix) in 2021 and the policy instruments are listed according to the year they came into effect (vertical axis) and categorized by type (horizontal axis); all abbreviations and features of the corresponding policy elements are detailed in Section 3.3 (Source (Ossenbrink *et al.* 2019, pp. 19f.))

Strategy

Enablement of the Deployment of the Battery Storage Technology

RDP (1994)	ESMP (2002)	NFSD (2008)	IRP (2010)	NSSD (2011)
WPEP (1998)	WPRE (2003)	NEA (2008)	NDP (2011)	NHES (2013)
NGPG (2001)	ERA (2006)	IPAP (2008)	NCCRP (2011)	**WPLG (1998)***
MSA (2000)*	**MFMA (2004)***			

*** Local Government**

Instrument Mix (Rogge and Reichardt 2016)

Year	Economic Instrument – Demand Pull Economic Instrument - Technology Push	Regulation – Systemic *Programme*	Informatio n – Systemic
2003	FBE (2003)		
2007	FBAE (2007)		
2008		SEIAS (2018)	
2010		WfE (2010)	
2011		ERNGC (2011)	
2012	GF (2012)	REIPPP (2012)	
2013	12L (2013)		
2015		REIPPP (2015)	
2019	CTA (2019)		
2020		BESF (2020)	

The domain of Battery Storage Energy Technologies

Table 4 Outcome of Top-Down Approach (Ossenbrink et al. 2018)

The analysis reveals that the focal policy mix for battery storage technology contains 17 strategies comprising 10 policy instruments.

The key findings of the evaluation of the focal policy mix with regards to energy storage is captured below:

a) **Time Frame**

Although DRET's have only recently become prevalent and topical of late, DRET's (often referred to as non-grid technologies) were already identified in 1998, in the White Paper on Energy Policy. Therefore, it was felt that DRET's should be evaluated from the dawn of democracy in 1994 to the present (2021), to have a view of the actions within the policy mix analysis over the timeframe of 27 years.

b) **Strategic Intent**

The top-down approach was used to evaluate the focal policy mix for the enablement of DRET's in South Africa. DRET's in this study refer in part to, mini/micro grids solar and home systems (SHS's) and battery storage.

c) **Vertical and Horizontal**

The analysis was confined to the borders of South Africa, excluding the Southern African Development Community (SADC) region. This was owing to the governance structure within the Republic. Post democracy, the various levels of the government were decentralised, into 3 spheres of governance viz., national, provincial and local government. Each had their own mandates, and accountabilities. Coordinating and oversight committees were created to facilitate transversality, and co-operative governance. During 2000–2001, fundamental changes were made to the approach of electrification. Together with the decentralisation of service delivery functions, the integrated development planning (IDP) process was established. This devolved the provision of electricity and gas reticulation to local government, while the integrated national electrification programme (INEP) vested with the then Department of Minerals and Energy (which has changed in composition and name with each new political dispensation)[13].

d) Policy Strategy and Instruments

Data was collected in relation to battery storage and DRET's via internet searches of publicly available data that included laws, regulations, strategies, power point presentations, documents, etc... Owing to the time constraints, no interviews were conducted, and the search for data of synergistic interactions from other policy strategies and instruments were not included. There are many research and development (R&D) initiatives that include government agencies (e.g. South African Renewable Energy Business Incubator (SAREBI)), public-private partnerships (PPP's), GreenCape, within the DMRE an agency called SANEDI and other state-owned entities (e.g. the Industrial Development Corporation (IDC) and the Development Bank of South Africa (DBSA) wherein exist programmes and mandates with respect to funding and implementing R&D aimed at accelerating the socio-technological transition to a low carbon economy, which includes battery energy storage. In addition, civil society actors like non-governmental (NGO's) and community- based organisations (CBO's) were excluded in the formulation of policy strategy and instruments governing battery energy storage.

e) Focal Policy Gaps

The top-down mapping exercise revealed that the overarching strategic intent of non-grid electrification and DRET's are clearly articulated within the policy strategy which identified 17 documents, yet the policy instruments amount to only 10 initiatives. An identified gap exists with regard to the linking of innovation and R&D aspects. It is acknowledged that the former is not easily accessible owing to the fragmentation of the science and technology initiatives. One has to know how to make the linkages with all relevant programmes and stakeholders and address the deeper issues, in order to accelerate the diffusion of the DRET's. There is an urgent need for a coordinated innovation and R&D platform which enables all stakeholders to make input and contribute to the formulation of effective policy and instruments for battery energy storage. Sadly, untapped donor funded studies and initiatives lie within (Government) departmental repositories, which don't align to the current overarching strategy documents and plans.

The instrument mapping also depicts a number of null periods between 1994 to 2002, 2004 to 2006, 2009, 2014 and 2016 to 2018, which is indicative of a lack of translation of strategy into actionable items.

A key recommendation from the study on DRETS, viz. "*Sustainability of DRET's*" (year of publication unknown), is the establishment of a dedicated off-grid management authority, but currently there are only 2 DMRE staff working on the implementation of DRET's at a national level. A bottom-up approach may assist in developing workable financial models and technology solutions, inclusive of informal settlements and rural environments.

Studies like Rogge and Reichardt (2016) propose an interdisciplinary framework, to link the policy mix to technological change that is comprised of;

i) **Policy Processes** (policy making and implementation)

ii) **Policy Elements** (strategy and instrument mix) and

[13] *White Paper on Local Government, 1998*

iii) **Policy Characteristics** (consistency of elements, coherence of processes, credibility, comprehensiveness and taking cognisance of the dimensions such as policy field, governance level, geography and time).

Owing to the dynamic and layered nature of technological change, policy adaptation and policy learning are crucial (Rogge et al. 2016). This framework may help in bridging the gap between niche and regime actors. Owing to our minerals and energy complex and the energy intensive economy, regime landscape actors influence the transition pathway. The lead departments of Energy and Mineral Resources have been joined and separated over the 26 years since 1994.

3.5 NERSA Licensing Requirements

Assuming that distributed storage is classed as generation, most storage on municipal grids will either be in the 0 to 1.0 MW or 1.0 to 10.0 MW ranges.

If battery energy storage falls in the 0 to 1.0 MW range, it will be covered by Schedule 2 amendments and the embedded generation allocation in the IRP. In this case, a distributor registration process overseen by NERSA will apply.

If battery energy storage falls in the 1.0 to 10.0 MW range, Ministerial dispensation is no longer required, however the new generation regulations require a feasibility study be completed as part of the 'lite' licensing requirements. *These are not showstoppers, but the rules are required.*

The mandate of the **National Energy Regulator of South Africa** (NERSA) is to regulate the energy industry in accordance with government laws, policies, standards and international best practices in support of sustainable development.
NERSA's strategic objectives are to efficiently and effectively:

- implement energy policies and laws;
- implement relevant energy regulations; and
- identify, develop and implement relevant energy rules

3.6 Renewable Energy Grid Code Compliance

The Renewable Energy grid code is detailed, clear and closely defines what is required. It focuses on curtailment. And also requires consideration of criteria for the opposite, "consumption" approach. In the case of deliberate islanding, micro-grids require a review of standards and HV regulations to manage grid operations, so that a potential new service and revenue stream can be realized, through negotiations with key customers to locate the storage facilities at their premises, in which case the distributor can provide a measure of secure standby power to the customer in the event of network outages.

4. Recommendations

The vexing policy challenge is how stored energy is valued in the IRP: Whether it is equivalent to gas-peaking plant cost and whether it could be equivalent to the least cost 'whatever is available' plus round-trip losses and own capital cost. In which case, off peak coal energy will be the preferred choice for recharging energy in the foreseeable future, and a short term boost for coal. Later however, when renewable energy penetration improves, the system can be changed to recharge from the 'zero cost' surplus renewable energy.

4.1 Adoption of Smart Energy Storage Policies

The three policies recommended below are low-hanging fruits, amongst others, that could be developed in the short to medium term to support battery energy storage.

4.1.1 Cost of Unserved Energy

To protect the economy, the best location for South Africa's energy storage assets is on the customer's premises and to run the sites as power islands during grid outages or load shedding. This can keep the economy going and at the same time maintain revenues for the distributors, as they restore their grids or meet load shedding mitigation requests. If businesses were to have large scale storage systems, they could participate in a Demand Reduction program that will have the same effect as the buy-back programme, yet allow economic activity to continue as normal. Contribution of storage could reduce the cost of unserved energy, viz. a potential reduction in loss = (R70/kWh) x System Average Interruption Duration Index (SAIDI) for that part of the network.

4.1.2 Own Generation – Renewable Energy plus Storage

Shopping centres, office parks and hospitals are making investments in rooftop PV to reduce energy costs, which is good for the economy as a whole. PV works well with loads such as air conditioning that correlate well with production demand profiles and in this way, self-consumption can be maximised and the full benefit of the investment realized. Where correlation is poor, an energy storage system can be used to optimize the investor's self-consumption.

Compliance with an appropriate time-of-use tariff that signals to the investor when to self-consume the stored energy to benefit the local distributor, brings financial reward and is a win-win situation. The energy storage plant can be offered to the utility to both locate and dispatch and thereby manage network loading. There is a growing international trend, led by California and China, where investment in renewable energy systems is conditional to a corresponding investment in energy storage to flatten the Duck Curve. This may be one of the policy options South Africa should consider.

4.1.3 Generation Location

Eskom currently finds itself in a position where as part of a World Bank loan condition for their new build coal stations, they are required to invest in around 600 MWh of energy storage in support of renewable energy. These storage assets will most likely be placed on the Eskom networks. They could be of greater national benefit if they were placed on ailing municipal distribution networks to give some financial relief to Local Government. This can be done by creating a 'virtual Eskom intake-point' on the municipal network, that can avoid Notified Maximum Demand (NMD) penalties and still create peak energy revenues for Eskom.

If strategically placed, the virtual intake-points could also unlock stalled development which would increase energy demand, which Eskom and the economy welcomes. This investment option, while not mentioned in the draft IRP2018 and revised IRP2019, would have maximum impact if installed on the weakest municipal networks and maintained with Eskom expertise.

4.2 Recommendations for IRP Iteration

Besides the three smart grid recommendations outlined above, Government is encouraged to consider the following differentiation of energy storage types in the next IRP iteration:

- Create technology specific allocations for energy storage types to ensure an optimal mix, as is done for generation technologies,
- Establish different categories for energy storage duration, e.g., short, medium, long, seasonal or hourly based rates, and
- Define both aggregate capacity (MW) and energy consumption (MWh) in the IRP allocations.

4.3 General Recommendations

Further general recommendations for consideration and adoption are:

- The distributed energy storage market options must be explored fully, i.e. examine use case stacking and the creation of additional markets for ancillary services or general grid support, instead of solely focussing on the back-up power option.
- We recommend that detailed grid studies be commissioned to investigate the possibility of drawing from the grid at low demand periods in return for feeding into the grid during high demand periods.
- We have too many grid codes that are not comprehensive and fragmented and as a result grid codes are not widely understood. The grid codes should be reviewed and harmonized for more effective application.
- We recommend that Eskom and Municipalities be tasked to undertake grid compliance training for users >1MW, as per the RPP Grid Code as well as the Battery Energy Storage Facility (BESF) Grid Code for interconnection to the grid.
- We recommend that municipalities update their by-laws to treat energy storage as a backup system similar to a UPS, which do not require registration.
- Energy storage vendors should be allowed to manage the capacity of the inverter at the point of supply.
- Large scale users (> 1 MW) should be allocated a dedicated sub-station so that the customer shut downs the whole plant, if embedded, or when the circuit trips, to comply with NERSA requirements.
- Utility-scale batteries need to have its own specific use case. The current BESF code views batteries in the grid as a non-dispatchable form of generation, because most of the Solar PV and Wind grid code parameters were copied to the BESF code.
- We recommend a clear separation between the allocation in the IRP and distributed assets, which is unclear at this point in time, i.e., the revised 2019IRP allocation modelling was based on what is required for the grid, which excludes the role and contribution of distributed battery energy storage in South Africa's energy planning.
- More attractive energy storage incentives are recommended, as current price points are too high resulting in most users opting to use diesel for load shedding backup.
- The use of a functional, rather than technical, specification in the procurement process, focusing on overall system benefits – whether it be time shifting, general grid stability or enabling frequency response – may be a simpler approach.

- Incorporate into the Battery Energy Storage System (BESS), tender design characteristics that serve to benefit locally manufactured energy storage systems. Tight timelines for nascent industries like battery energy storage only serve to benefit China, as is also the case in restrictive technical specifications.

5. Conclusions

Energy and electricity policy, planning and regulation in South Africa requires a visionary formulation of policy positions and actions should be proactive and driven by forward-looking leadership.

There are encouraging policy statements and commitments from political leaders in government indicating a change in mindset, that could lead to the unbundling and restructuring of Eskom and in so doing create a state-owned independent transmission system and market operator (ITSMO) with power planning, procurement, contracting and system operation functions. This would facilitate a diversified, competitive generation sector with non-discriminatory access to the grid on a level playing field for new entrants, incumbent Eskom generators, municipal generators, large public-private partnerships (PPPs), independent power producers (IPPs), distributed generation and self-generation. The stifling regulatory red-tape, technical barriers and complex registration and licensing processes associated with distributed generation, self-generation and wheeling need to be eliminated, or at least streamlined. These include requirements applicable to domestic and small commercial installations up to 100kW, commercial and agricultural installations up to 1MW and industrial and mining installations greater than 10MW.

Government is encouraged to provide local and international investors with policy certainty and regulatory framework and tools including incentives that encourage long-term investment, particularly focussing on energy storage. It is acknowledged that some policy certainty of South Africa's future energy pathway is provided by the IRP 2019 which has outlined a future energy trajectory that integrates more solar and wind power into the national power generation mix. As more renewables are integrated into the energy mix however, there will be a greater demand for storage.

Unlocking stalled investment and the provision of cheaper basic energy services may be a unique challenge to South Africa, that energy storage can resolve.

Policies need to be investigated, created and / or adapted to enable the development of a battery energy storage power sector. The IRP modelling boundaries need to be extended to all end-use customer meters, to factor in the cost benefits of new technologies and options available to distributors.

Energy storage must feature more prominently in the IRP and be included in the next round of the Renewable Energy Independent Power Producer Procurement (REIPPP) Programme. Business and government will need to continue to fund research and development (R&D) and business in particular, should continue to invest in energy storage projects. This will require new levels of collaboration and strategic partnerships between government, higher education institutions, and industry.

It is recommended that an industry and government forum be formed that would initially have the task of outlining a common vision for the energy storage technology sector in South Africa and ultimately developing an implementation plan, as well as a national innovation ecosystem. The Department of Science and Innovation (DSI) confirmed that this had begun, stating "a consortium of local universities, science councils and the private sector is being put in place as part of a broader Research, Development and Innovation (RDI) roadmap." The promotion of the energy storage ecosystem can therefore also play a critical role in post Covid-19 economic stimulus plans.

A just energy transition that includes energy storage technologies must be inclusive. It dictates that society and all sectors of the economy derive benefit, including women, young people, and workers whose jobs may be at risk under future low-carbon energy scenarios. Skills development initiatives should also ensure that no one is left behind and that a green energy skills pipeline is developed to meet the needs of this growing sector. Localisation of a battery energy storage industry has the potential to contribute significantly to a just transition.

6. References

South Africa. 2019. Draft National Climate Change Adaptation Strategy. Notice 644 of 2019. Government Gazette, 4 (42446):1-58, May 06

Department of Energy (DoE), 1998. White Paper on Energy Policy. Pretoria: Department of Energy

Department of Energy (DoE), 2011. Government Notice No. R399. Electricity Regulation Act No.4 of 2006 Electricity Regulations on New Generation Capacity

Department of Energy (DoE), 2012. Non-grid electrification policy guidelines. Pretoria: Department of Energy.

Department of Minerals and Energy, 2007. Free Basic Alternative Energy Policy (Household Energy Support Programme) (Notice 391 of 2007).

South African National Energy Development Institute (SANEDI), 2013. Background. Available from: http://www.sanedi.org.za/background/.

Rogge, K. S. and Reichardt, K. (2016) 'Policy mixes for sustainability transitions: An extended concept and framework for analysis', Research Policy, 45(8), pp. 1620–1635. doi: 10.1016/j.respol.2016.04.004

Ossenbrink, J. et al. (2018) 'Delineating policy mixes: Contrasting top-down and bottom-up approaches to the case of energy-storage policy in California', Research Policy. doi:10.1016/j.respol.2018.04.014

U.S. Trade and Development Agency (USTDA), Parsons, 2015: South Africa Energy Storage Technology and Market Assessment