Western Cape Government

FOR YOU

Department of Economic Development and Tourism

Energy workshop

Energy storage

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Energy storage: Context and framing

- The economy and job creation capabilities of the Western Cape are constrained by low energy security. The province is well suited to low-carbon generation to increase resilience, but this will not happen without sufficient infrastructure being in place.

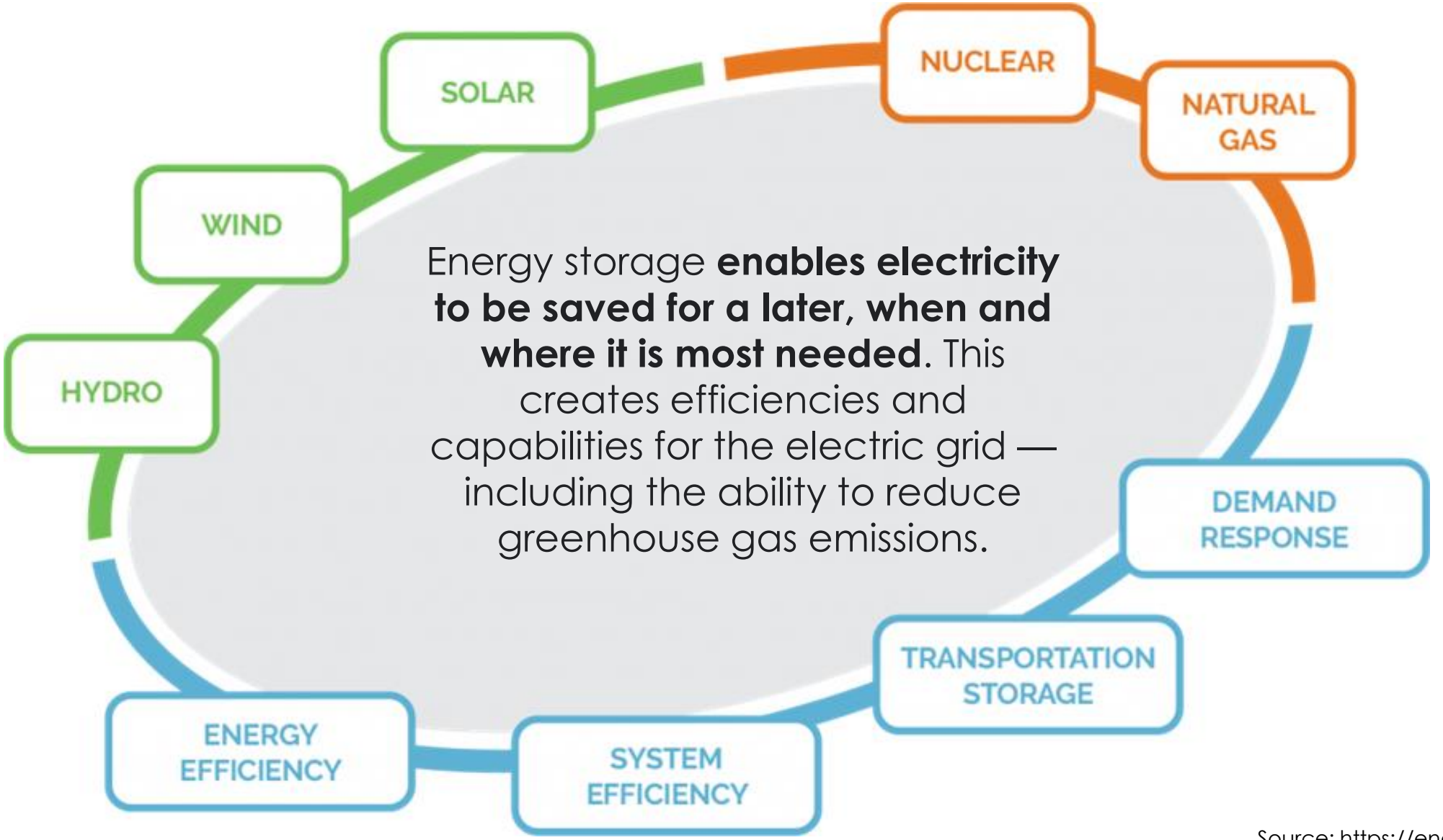
- While renewable sources will be vital in the energy mix, these are not applicable 24x7 and hence storage is required. The prevailing theory is that battery storage is the way forward, but this assumption needs to be rigorously tested, and if found to be true, considered optimally in the Western Cape context as other technologies are emerging.

- Work is aimed at enabling the upgrading and/or development of energy infrastructure and improved grid stability for increasing low carbon energy penetration and to eliminate load shedding in the Western Cape.

- Development of a strategy and bankable business case that looks to provide the right grid infrastructure in the right place at the right time.

Overview and main energy storage technologies

Energy storage: Value statement



Energy storage **enables electricity to be saved for a later, when and where it is most needed**. This creates efficiencies and capabilities for the electric grid — including the ability to reduce greenhouse gas emissions.

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Source: https://energystorage.org

Requirements and constraints for energy storage

Modular and scalable

High capacity (measured in MWh)

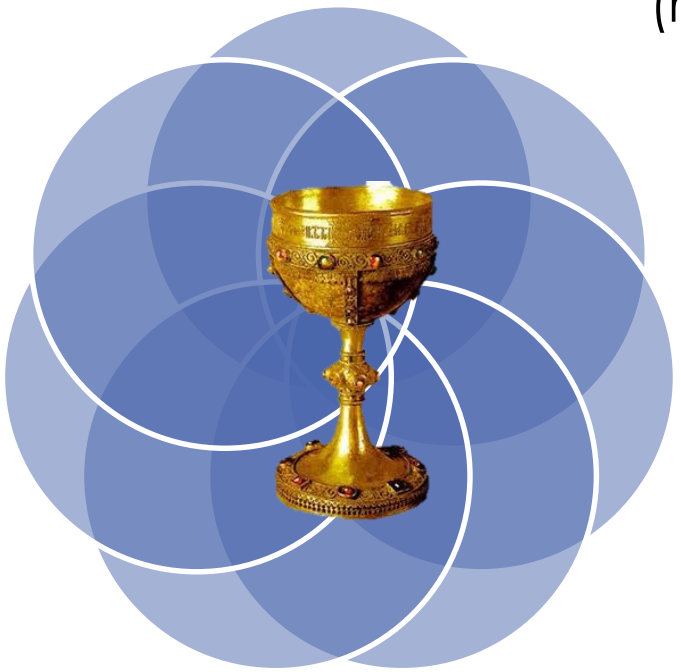
Solid business case : capex, opex & benefits e.g. deferral of capex

Easy and safe to use and operate

Sustainable - low environmental footprint

Engineering parameters (time related, location)

Technical maturity and related skills required



Main categories of energy storage

Batteries

- A range of electrochemical storage solutions, including advanced chemistry batteries, flow batteries, and capacitors

Thermal

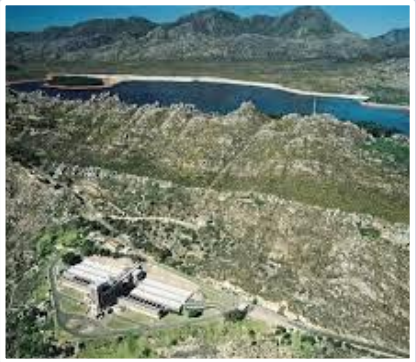
- Capturing heat and cold to create energy on demand or offset energy needs

Mechanical

- Other innovative technologies to harness kinetic or gravitational energy to store electricity

Hydrogen

- Excess electricity generation can be converted into hydrogen via electrolysis and stored



Pumped hydropower

- Creating large-scale reservoirs of energy with water

Source: https://energystorage.org/why-energy-storage/technologies/

Qualitative Comparison of Energy Storage Technologies

Category	Technology	Development stage for utility scale grid application	Typical duration of discharge at rated power capacity	Response time	AC route trip efficiency	Lifetime
Electrochemical (Batteries)	Lithium-ion	Widely commercialized	0. 3 - 8 hrs	20 ms - s	86 - 88%	10 years
	Lead -acid	Widely commercialized	1- 1.6 hrs	5ms -s	79 - 85%	12 years
	Flow	Initial commercialization	0.3 - 20 hrs	Sub-seconds to seconds	65 - 70%	15 years
	Sodium-sulphur	Initial commercialization	1 - 7 hrs	1ms - sec	77 -83%	15 years
Mechanical	Pumped-storage hydropower	Widely commercialized	1h - 40 days	Sec - 2min	80%	40 years
	Flywheels	Widely commercialized	0.3 - 1 hrs	4ms - 1 s	86% - 96%	20 years
	Compressed air energy storage	Initial commercialization	0.5 - 26 hrs	1 min - 15 min	52%	30 years
Thermal	Thermal energy storage	Initial commercialization	2 - 48 hrs	Several minutes	90%	30 years
Chemical	Hydrogen production and fuel cells	Pilot stage	1 - 32 hrs	Sub-second	35%	30 years
Electrical	Superconducting magnetic energy storage	Initial commercialization	ms - 8 sec	<100 ms	97%	20 years
	Super-capacitors	R&D stage	ms - 1 hr	8ms	92%	10 - 15 years

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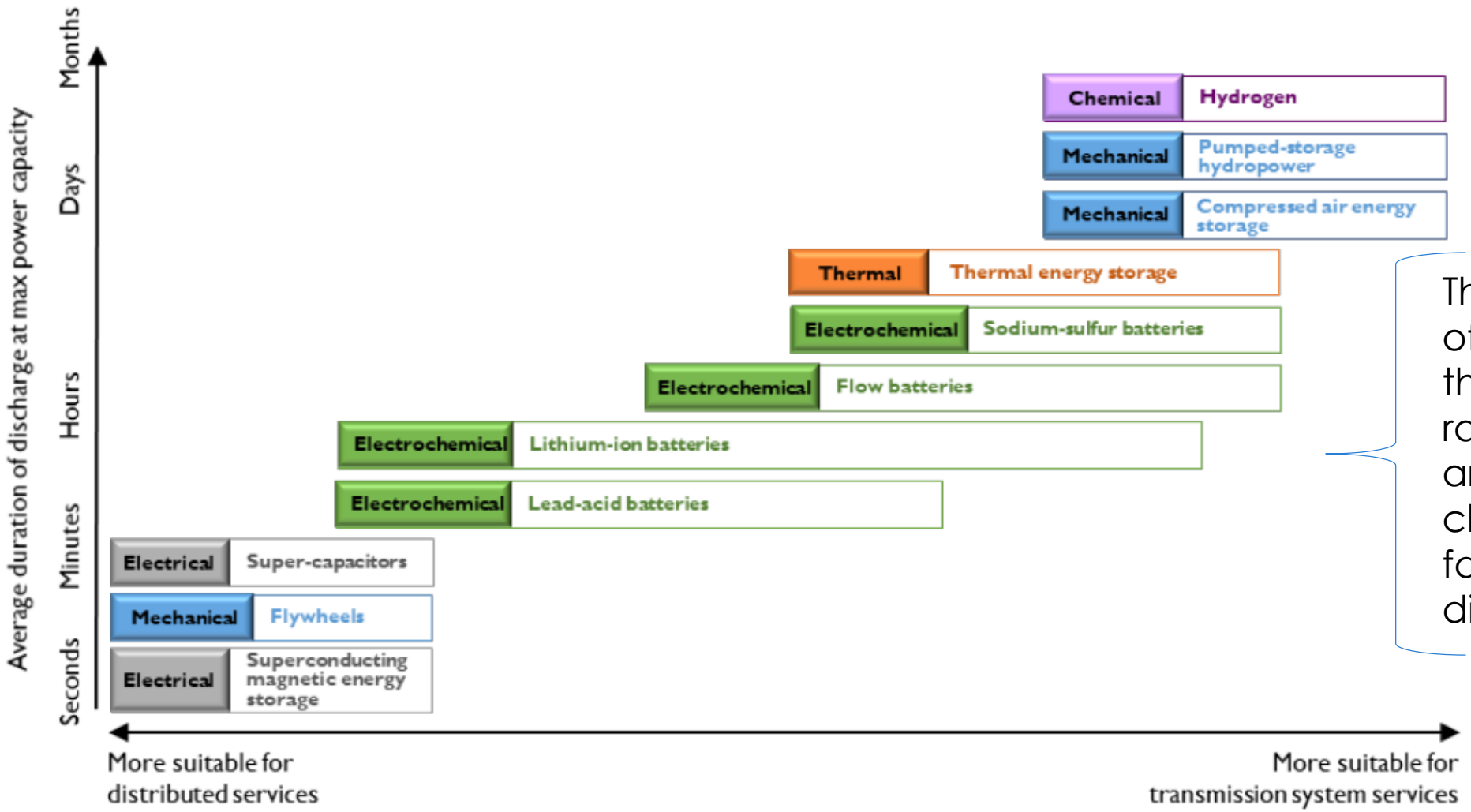
Source: USAID / Power Africa, An Introduction To Battery Energy Storage Systems (BESS), June 2022

Overview of Energy Storage Technologies and the Services



The focus (for the balance of this report) is on BESS as these have the widest range of applications that are relevant to the challenges municipalities face in managing distribution systems.

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Source: USAID / Power Africa, An Introduction To Battery Energy Storage Systems (Bess), June 2022

Energy storage options for South Africa

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

Source: USTDA

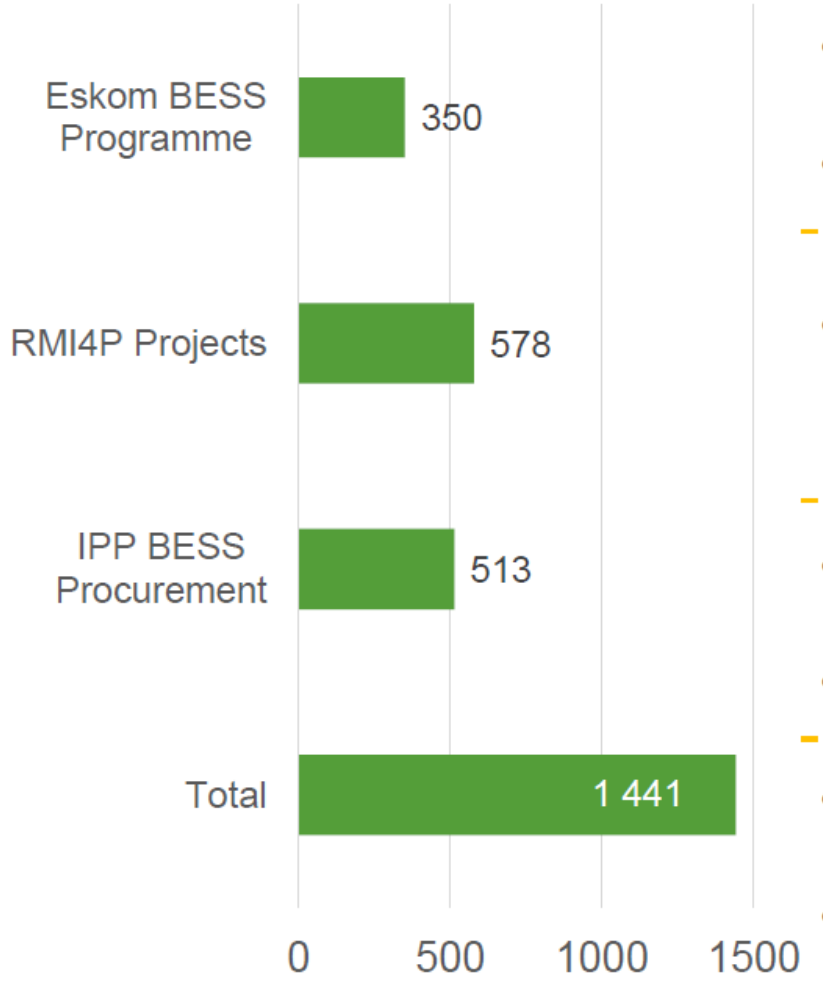
Battery Energy Storage Solutions (BESS)

Grid scale battery storage plants

- BESS (battery energy storage system) is a familiar concept from everyday usage but on a massive scale.
- Can be outdoor in substation-like applications or indoor in a clean, data centre-like applications.
- World's largest facility is 1600MWh (400MW for 4 hours).
- Scatec's Kenhardt projects in the Northern Cape, part of the RMIPPPP, will have a total solar capacity of 540 MW and battery storage capacity of 225MW/1,140MWh.
- ~4MWh per 40' container
- Can be located near load or at near the generation facility

South Africa's Battery Storage Market in 2021

Expected or existing utility scale storage procurement in South Africa during 2021, MW



- SA utility ESKOM tendered in April 2021 for 198 MW as part of a World bank funded BESS programme;
- A further 152 MW is expected later in 2021

- 7 projects featuring a total of 578MW in battery storage co-located with Gx assets were awarded as IPPs in Q1 and Q2 2021

- ESS-specific IPP round announced for H2 2021 by DMRE for 513MW
- Amount is driven by allocation in the SA IRP 2019

- A total of over 1400 MW of utility scale storage is being contracted in SA alone during 2021
- Most is likely to be installed during 2022

Source: Eskom, IPP Office, DMRE, Bushveld Energy analysis

Eskom BESS programme

- The R11-billion BESS programme is being funded through a World Bank loan.
- The entire programme is for 360 MW/1440 MWh and is being delivered in two phases.
- The BESS primary use case would be for national peak shaving purposes for 4 hours a day for at least 250 days of the year.
- Charging will be conducted during off-peak periods or when the network conditions permit.
- Contracts awarded to two suppliers for projects with a combined capacity of 199 MW/833 MWh.
- Several projects in the Western Cape.

BESS Phasing and Energy targets

Eskom

- The following BESS scope was applied for PFMA application to DPE and NT. The aim is to achieve 1,440MWh/day or 525GWh/yr of energy shifting

Phase 1

200MW/800MWh of distributed battery storage

Phase 2

160MW/640MWh of distributed battery storage
+ 60MW of PV
+ Virtual Power Plant (VPP)
+ Asset Performance Management (APM) system

Deliverables

Phase 1 to be completed **30 June 2023**

Phase 2 to be completed **31 Dec 2024** (Development work and technical due diligence is on going for phase 2)

*Sites subject to due diligence

Source: Eskom presentation to Breede Valley municipality, 30 May 2022, and Engineering News, Eskom signs battery contracts with Pinggao and Hyosung as part of R11bn roll-out, 22 June 2022

Eskom BESS project: Phase 1

- Eskom will fully own the assets, but there will be a fixed operating and maintenance period of five years with the successful vendors after the start of commercial operation.
- Investments valued at about R5-billion (so ~R25m/MW or R6m/MWh based on simple division)
- Final stages on pre-contract discussion in March 2022.

BESS Phase 1 Sites

Eskom

Distribution Operating Unit (OU)	Name	BESS (MW)	Daily Capacity (MWh)	Total Annual Energy (MWh)	PV (MWp)	Use Case
WC	Skaapvlei	80	320	116 800	-	Ancillary Service , Energy Support
EC	Melkhout	35	140	51 100	-	Ancillary Service , Energy Support,
KZN	Elandskop	8	32	11 680	-	Load Shaving
KZN	Pongola	40	160	58 400	-	Ancillary Service , Energy Support
WC	Hex	20	100	36 500	-	Ancillary Service , Energy Support,
WC	Graafwater	5	30	10 950	-	Energy Support ,Load Shaving
	Paleisheuwel 11kV	6	24	8 760	-	Ancillary Service , Energy Support
	Paleisheuwel 22kV	3.5	21	7 665	-	Energy Support , Load Shaving
NC	Rietfontein	1.54	6.16	2 248.40	2.04	Load Shaving
	TOTAL Phase 1	**199.04**	**833.16**	**304 103**	**2.04**	

The main applications include (Use Case):

- Reactive power (RP) in networks with low fault levels and/or poor RP support;
- Load shaving (LS);
- Energy support (ES); and
- Ancillary services (AS) such as frequency support.

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Source: Eskom presentation to Breede Valley municipality, 30 May 2022, and Engineering News, Eskom readies for R5bn first phase of battery storage roll-out, 10 March 2022

Eskom BESS project: Phase 2

BESS Phase 2 Sites

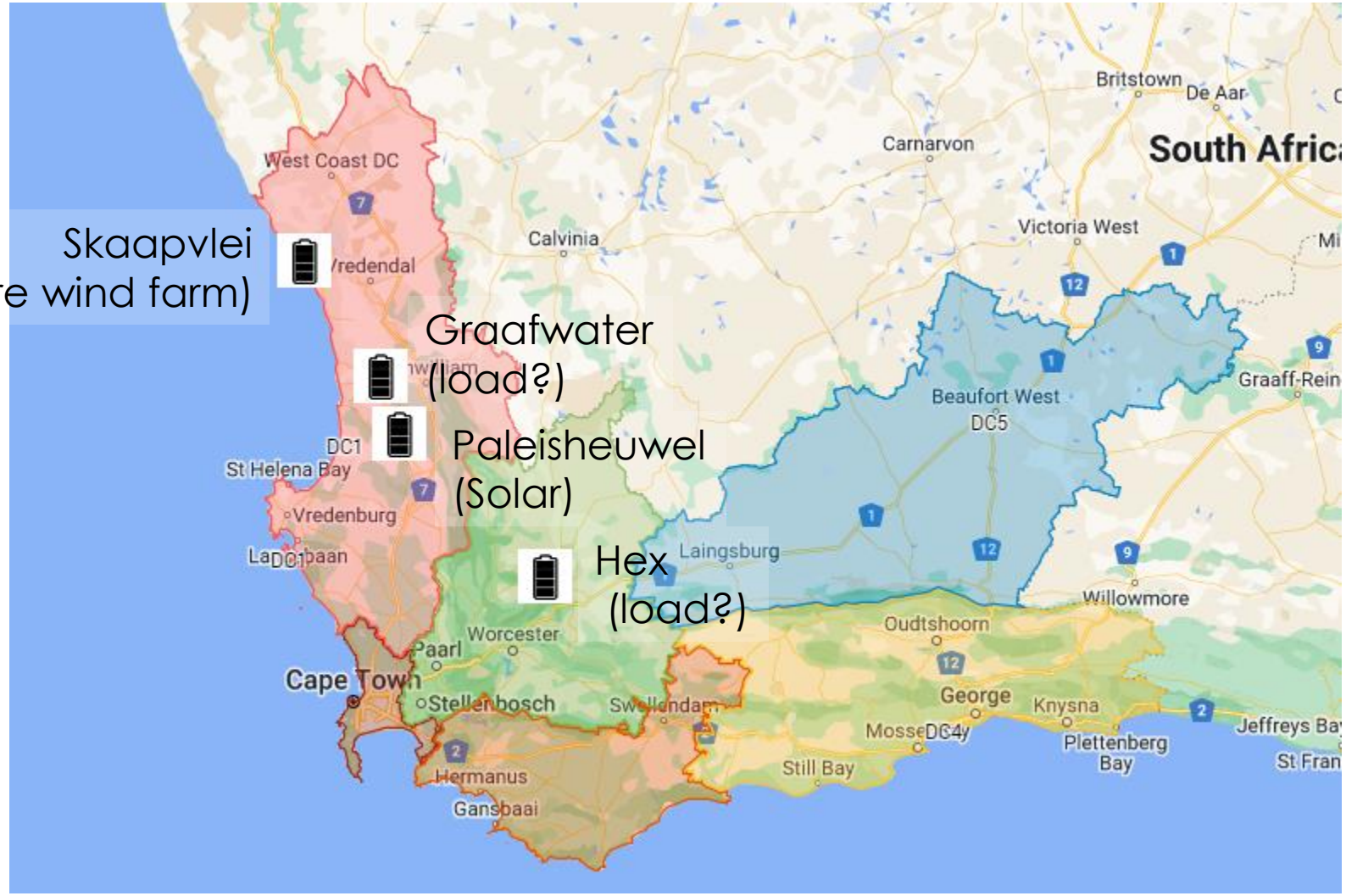
Eskom

Project name	MW output	Daily MWh capacity	Total annual energy (MWh)	Use case
Witzenberg (WCOU)	17	68	24 820	Reactive power, ES
Ashton (WCOU)	17	68	24 820	Reactive power, load shaving, ES
Cuprum (NCOU)	70	280	102 200	AS & ES
Kiwano (NCOU)	40 (plus 58 MW PV)	200	73 000	AS & ES
Total Phase 2	**144**	**616**	**224 840**	

The main applications include (Use Case):

- Reactive power (RP) in networks with low fault levels and/or poor RP support;
- Load shaving (LS);
- Energy support (ES); and
- Ancillary services (AS) such as frequency support.

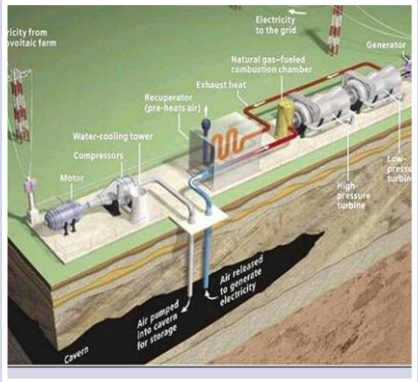
Eskom BESS Phase 1 locations



Other notable projects and developments

City of Cape Town

State of the art for other storage techniques



Liquid air energy storage (LAES)

- Current approaches from 5MW to 100 MW.
- Current projects include:
  - 250MWh in Manchester, UK
  - 300MWh facility in Spain
  - 400MWh system in Vermont, USA
- Possible relevant to local oil & gas sector with related skills

Compressed air energy storage (CAES)

- Air stored in cavern. Old approach, but modernized
- 2019: 2.2MW / 10MWh storage to the Ontario Grid.
- Long-duration energy storage (LDES) project in Broken Hill, NSW, Australia plant capacity is 200MW and 1500MWh (elsewhere stated as 1800MWh).
- Completion due in 2025. Project's economic life to 2075

Carbon dioxide storage

- CO2 in a closed loop system
- CO2 liquified and stored in thermal vessels
- 200MWh in storage capacity
- Used by utilitiess, independent power producers, grid operators, industrial applications and remote mining
- Demonstration mode only

Mechanical

- Other innovative technologies to harness kinetic or gravitational energy to store electricity
  - Flywheels: Flywheel energy storage systems (FESS) up to 20MW in 20 carbon fiber flywheels levitated in a vacuum chamber. Cited at 80MWh
  - Gravity battery: 120 meter cranes lift and stack concrete blocks, each weighing 32 tons, increments of 10MWh, 100MWh in build

Hydrogen

- Excess electricity generation can be converted into hydrogen via electrolysis and stored
- Tanks
- Underground caverns for high volumes

Summary and conclusions

Summary and conclusions

- There are many current and candidate grid storage solutions
- Lithium-Ion BESS offer the widest range of applications that are relevant to the challenges municipalities face in managing distribution systems.
- The Eskom BESS project is making progress with contracts signed and sites identified. These should be on-stream by June 2023.
- Current BESS have an expected life-span of 10 years only. The replacement costs vs opportunity cost needs to be considered
- There are opportunities in other technologies that have characteristics relevant to the Western Cape.

Thank you