WELCOME

SAIEE
ENERGY STORAGE CHAPTER

UNLOCKING AND ENABLING STORAGE AS A SECTOR FOR SOUTH AFRICA

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PANELISTS

SAIEE ENERGY STORAGE CHAPTER

Barry MacColl

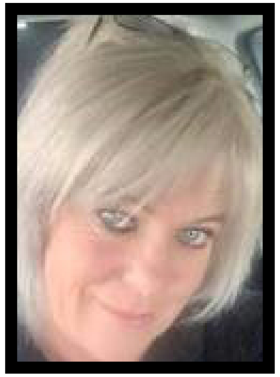
Senior Regional Manager – The Electric Power Research Institute

Dr Pathmanathan Naidoo

Professor of Research in the Faculty of Engineering and the Built Environment – University of Johannesburg

Frederic Verdol

Senior Power Engineer World Bank



Joanne Dean

Executive Director at Enerj Carbon Management

Paul Vermeulen

Chief Engineer: Renewable Energy – City Power

Siju Joseph

Manager: Ancillary Services - Eskom

Sy Gourrah

President of SAIEE

Chandima Gomes

Professor of high voltage engineering University of Witwatersrand

AGENDA

SAIEE ENERGY STORAGE CHAPTER

DAY 1 – 3rd November

Unlocking and Enabling Storage as a sector for South Africa

- 11.00 - President of SAIEE, Mrs Sy Gourrah, welcome address
- 11.15 – Chandima Gomes – Chair of Energy Storage chapter
- 11:30 – Frederic Verdol – Battery Storage Developments in SA
- 11:45-12:45- Q&A and panel discussion - Frederic Verdol, Professor Naidoo, Paul Vermeulen

Concluding comments from Professor Naidoo

DAY 2 – 04th November

Unlocking and Enabling Storage as a sector for South Africa

- 11.00 Introduction and welcome by Joanne Dean
- 11.15 – Barry MacColl– Which tools and research are required in SA, to fast track enabling the sector and gaining confidence of all players?
- 11.30 – Paul Vermeulen– Is the municipal grid ready?
- 11:45 – Siju Joseph –System operator – A System Operator's perspective on Energy Storage
- 12:30-13:30 – Q&A session moderated by Professor Naidoo and Frederic Verdol

Word of thanks from Joanne Dean

WELCOME ADDRESS

Sy Gourrah

President of SAIEE

Sy Gourrah has been part of the energy industry in South Africa for over 25 years. She started her career as a Consultant and later was appointed as the City Electrical Engineer for East London. With more than two decades of experience as an electrical engineer, Sy Gourrah also holds a number of qualifications including a Bachelor in Engineering (Electrical & Electronics), Masters in Business Administration and Government Certificate of Competency.

Currently, she is the Business Development Specialist for Transmission & Distribution & EPC within Actom. She recently launched the SAIEE Women in Engineering Chapter which will strive to promote women interests and champion empowerment programs within the SAIEE and broader electrical engineering fraternity.

Chandima Gomes

Professor of high voltage engineering - University of Witwatersrand

Chandima Gomes is the current chairman of the SAIEE Energy Storage Chapter. He is the professor of high voltage engineering at the University of Witwatersrand, the chair of ESKOM Power Plant Engineering Institute (EPPEI)- HVAC and the director of the Centre of Excellence in High Voltage Engineering (CEHVE). Chandima has published over 300 research papers in lightning protection & earthing, renewable energies, EMI/EMC, discharge physics and several other subjects.

CHAIR OF ENERGY STORAGE CHAPTER

South African Institute of Electrical Engineers

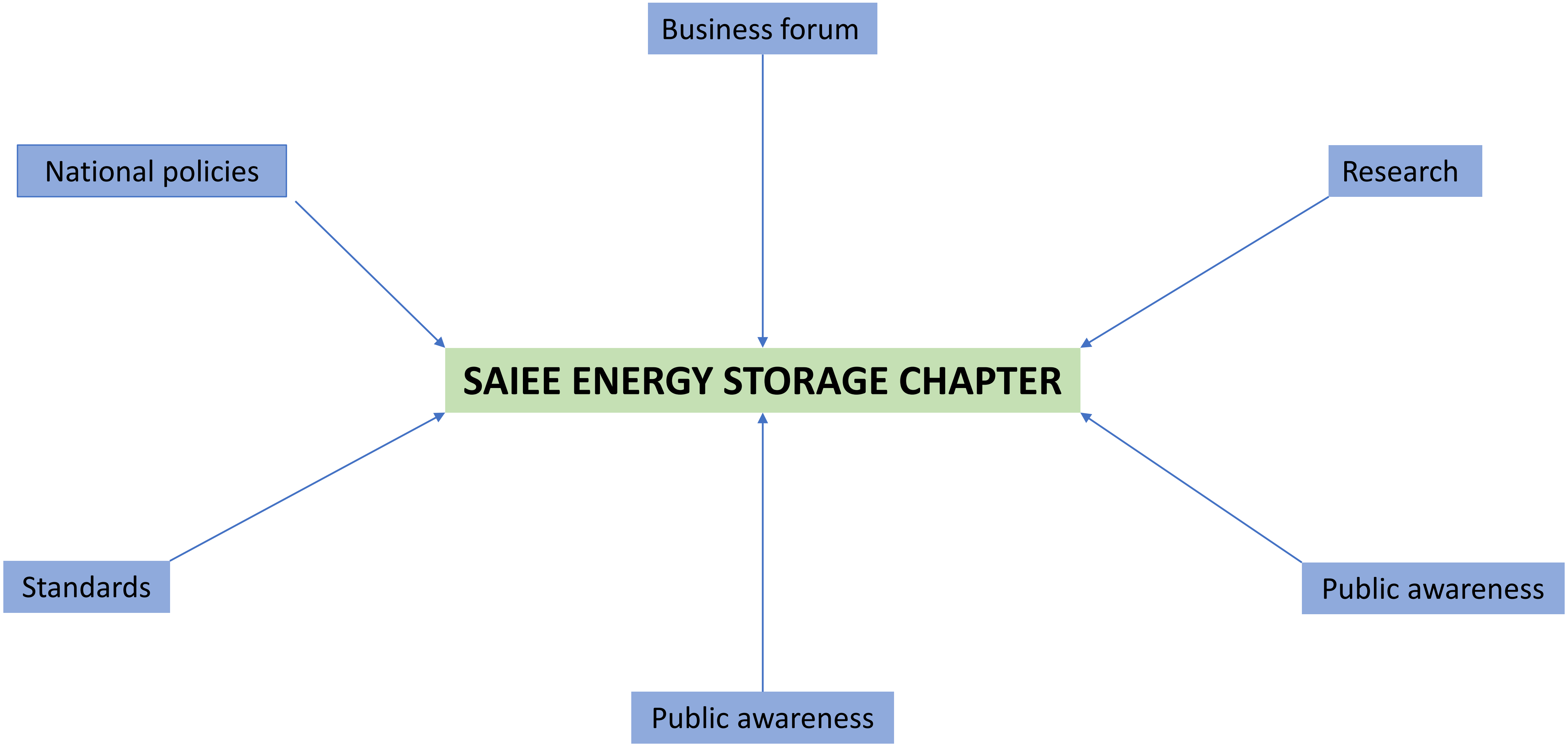
SAIEE ENERGY CHAPTER: WHAT WE ARE FOR

Chandima Gomes, *PhD*
Chairman, Energy Storage Chapter, *SAIEE*

Energy storage systems have a wide spectrum of time scales; From minute-scale to years

Why the recent boom in Energy Storage as a research & business topic?

- The rapid development and expansion of REs which provide fluctuating power
- Mobile systems, specifically vehicles, are inclining towards non-fossil fuel energy
- The healthy competition between battery storage systems and hydrogen as an energy carrier
- Smart intelligent power grids are increasingly dependent on stored energy – for energy quality and optimization
- Possibilities of converting fossil fuels into storable energy with minimal carbon footprint


Business forum
National policies
Research
SAIEE ENERGY STORAGE CHAPTER
Standards
Public awareness
Public awareness

Specific Objectives

- To develop a communication platform for researchers, academics, industrialists and commercial sectors to share knowledge, data & information, human resources, facilities and other resources for the betterment of the energy storage sector.
- To encourage the publication of national experience at local & international platforms.
- To organize educational, training & awareness programs; develop & distribute printed/electronic materials, on energy storage technologies to enhance the knowledge and/or skills of researchers, academics, industrialists, engineers and public.
- To assess current knowledge gaps within SAIEE members and future skill needs within the South African scientific communities, to proactively prepare competencies for the energy storage local development
- To develop and maintain a database on funding and research opportunities for the energy storage communities in South Africa.

Specific Objectives

- To support/assist the government on the development and promotion of relevant policies on energy storage.
- To support/assist SABS on the development and implementation of standards and guideline development.
- To support the Department of Environment Forestry and Fisheries on environmental impact
- To support relevant authorities with development of the proposed Section 18 Waste planned for SA for the life cycle of the storage and the extended producer responsibilities.
- To develop and research a model that can become available to supply party as well as end-user for transparency that can assist in optimizing the application of both the stand-alone or co-located systems.
- Increase the recognition of SAIEE by
  - Ensuring that the prominent role-players of the industry participate in the Chapter.
  - Promoting effective communication with decision-makers and maintain focus on their needs to provide a valuable contribution to SAIEE.

Our Team

Chandima Gomes (Chair)

Malcolm Low (Deputy Chair)

Portia Petersen Gumede (Secretary)

Mfanasibili Nkonyane (Treasurer)

Scebile Ntombela

Mike Barker

Prof. Pat Naidoo

Esrom Malatji

Joanne Dean

Frederic Verdol

Dr. H. Luo

Nduduzo Khumalo

This is an open invitation to all of you

Join our a team, in the journey towards an energy-sufficient South Africa

Please drop and email to
chandima.gomes@wits.ac.za

Frederic Verdol

Senior Power Engineer – World Bank

Frederic is a Senior Power Engineer at the World Bank. He has over twenty years of experience in power systems planning and operation. He started developing battery storage projects since 2008 for the power utility EDF. Frederic holds a nuclear engineering degree and a systems optimization master's degree from Paris School of Mines.

BATTERY STORAGE DEVELOPMENTS IN SA

SAIEE Energy Storage CHAPTER – LAUNCHING Webinar

BATTERY STORAGE Development in South Africa

Johannesburg

November 03, 2020

Frederic Verdol

Senior Power Engineer

WORLD BANK GROUP
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PRESENTATION OUTLINE

1. Battery Storage Technology and Markets
2. Making The Case for Battery Storage in South Africa
3. Eskom Battery Storage Program

1. BATTERY STORAGE TECHNOLOGY AND MARKETS

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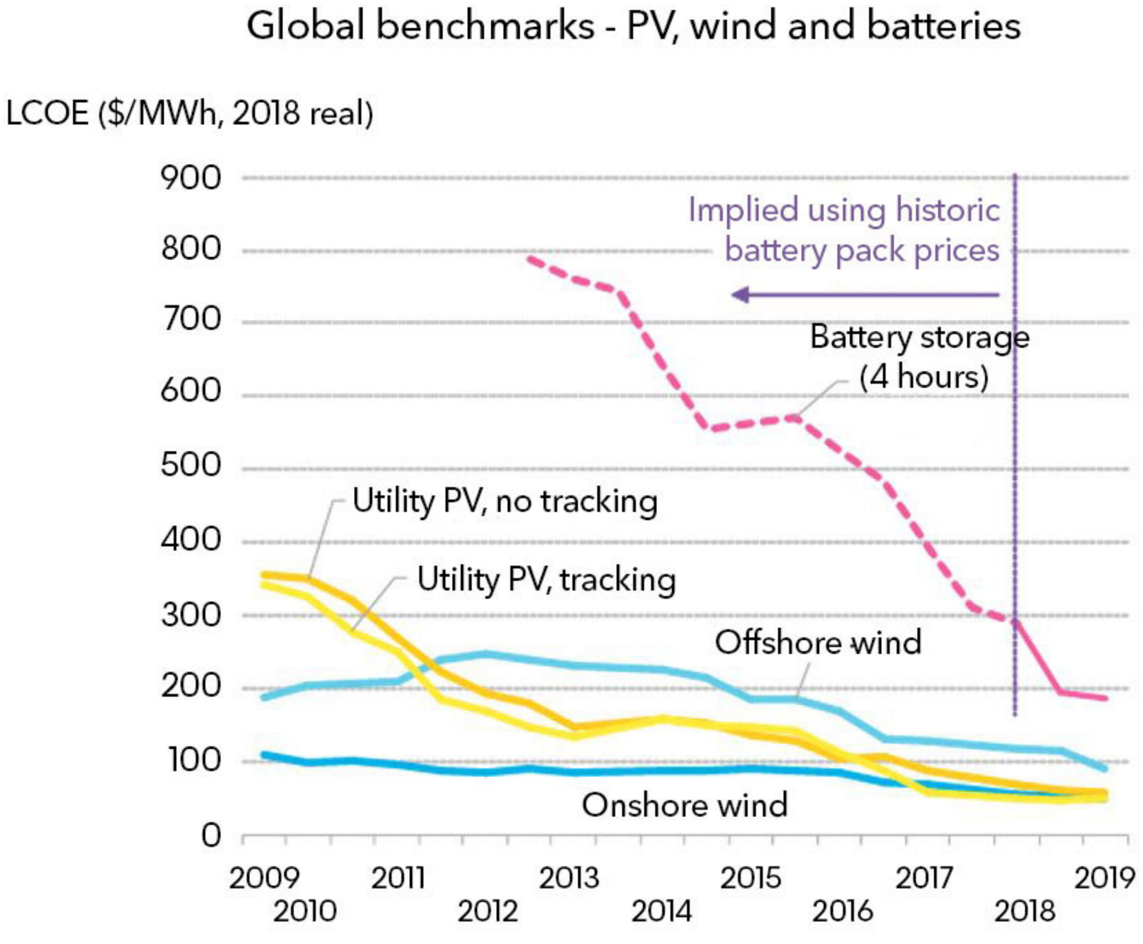
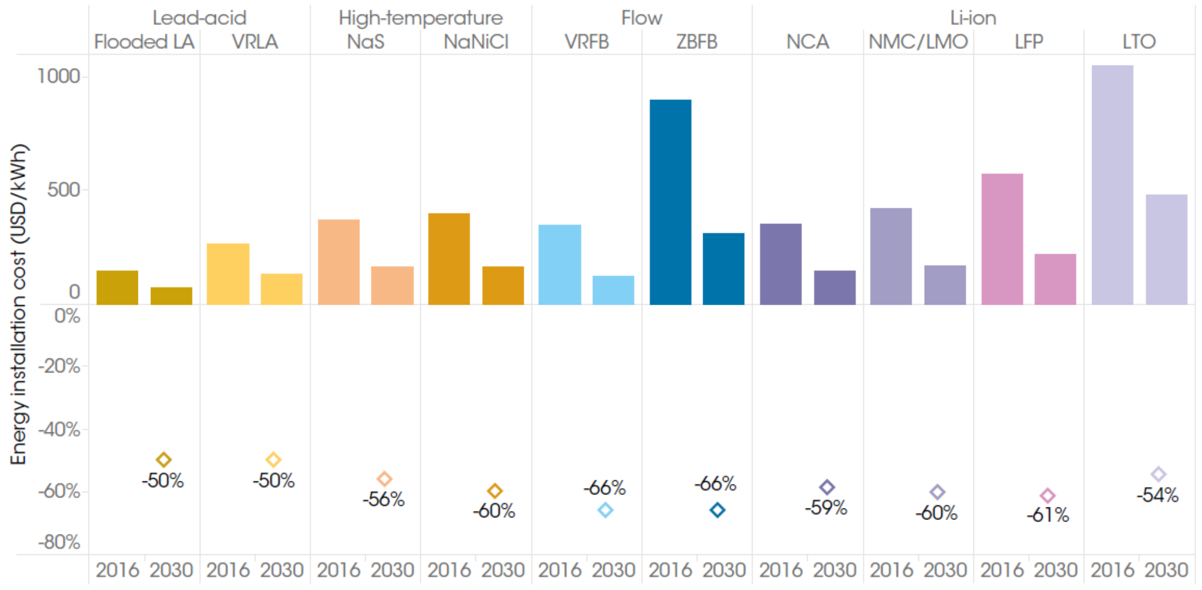
Battery Storage, Fastest Cost Drop of All Grid Scale Clean Technology



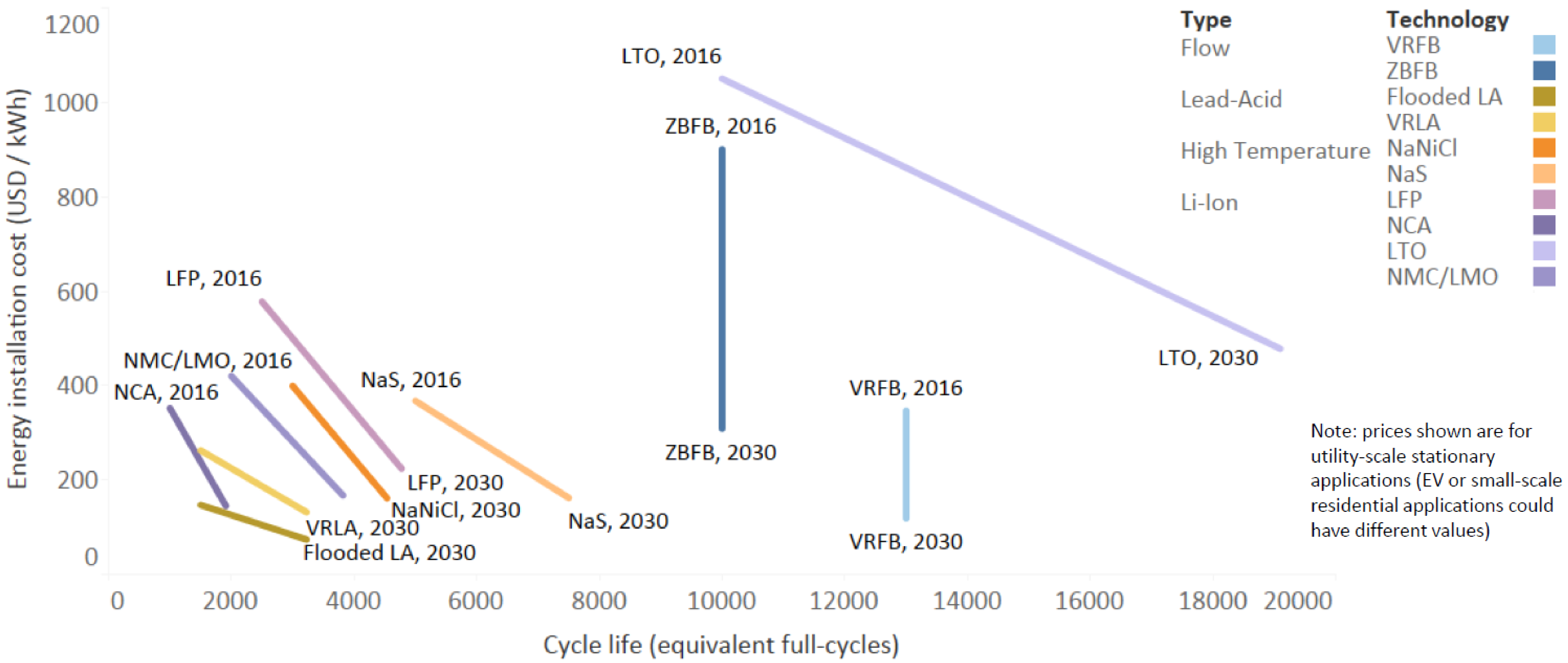
Source: BloombergNEF. Note: The global benchmark is a country weighed-average using the latest annual capacity additions. The storage LCOE is reflective of a utility-scale Li-ion battery storage system running at a daily cycle and includes charging costs assumed to be 60% of whole sale base power price in each country.

- LCOE for Lithium-Ion Batteries has fallen by 72% since 2012, 40% since 2018 to c$15/kWh (*Lazard 2020*).
- As technology matures, lifetime, technical performance and security also improve.
- All electrochemical battery technologies have similar trends, although market is (still) predominantly driven by Lithium-ion for electric vehicles.
- Perspectives for further technology cost reduction by 2030 are



Note: LA = lead-acid; VRLA = valve-regulated lead-acid; NaS = sodium sulphur; NaNiCl = sodium nickel chloride; VRFB = vanadium redox flow battery; ZBFB = zinc bromine flow battery; NCA = nickel cobalt aluminium; NMC/LMO = nickel manganese cobalt oxide/lithium manganese oxide; LFP = lithium iron phosphate; LTO = lithium titanate.

Grid Scale Battery Cost Trends to 2030 by Technology – Sharp Declines



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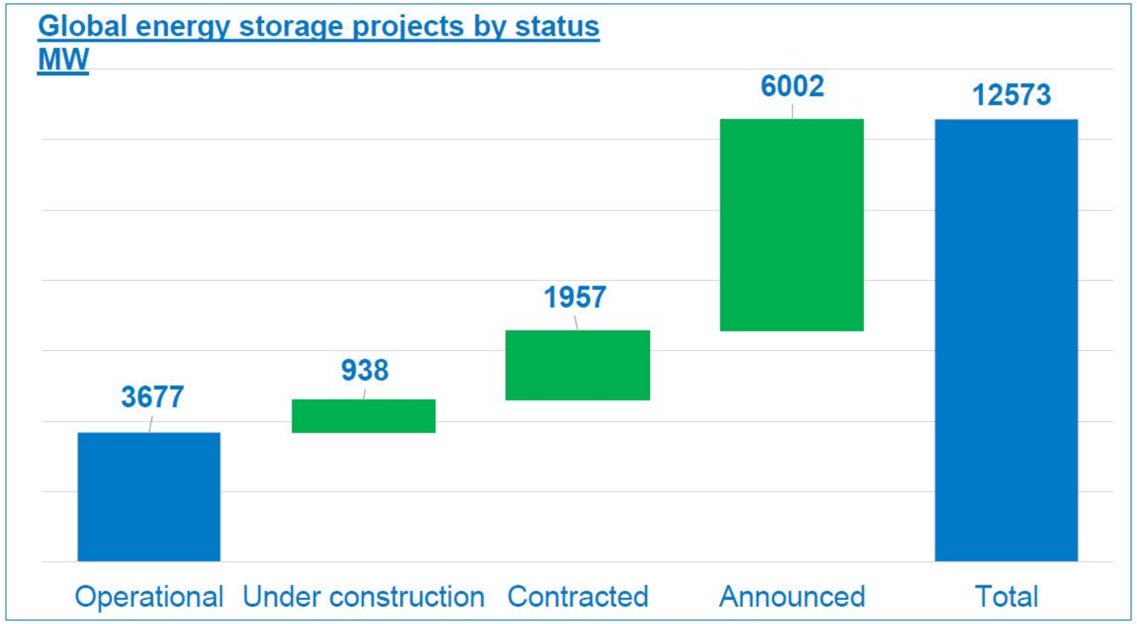
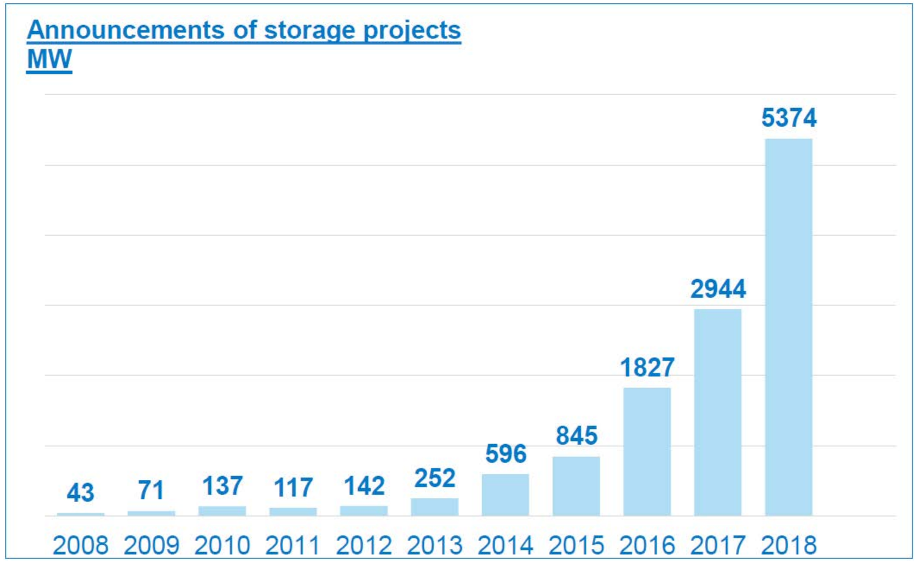
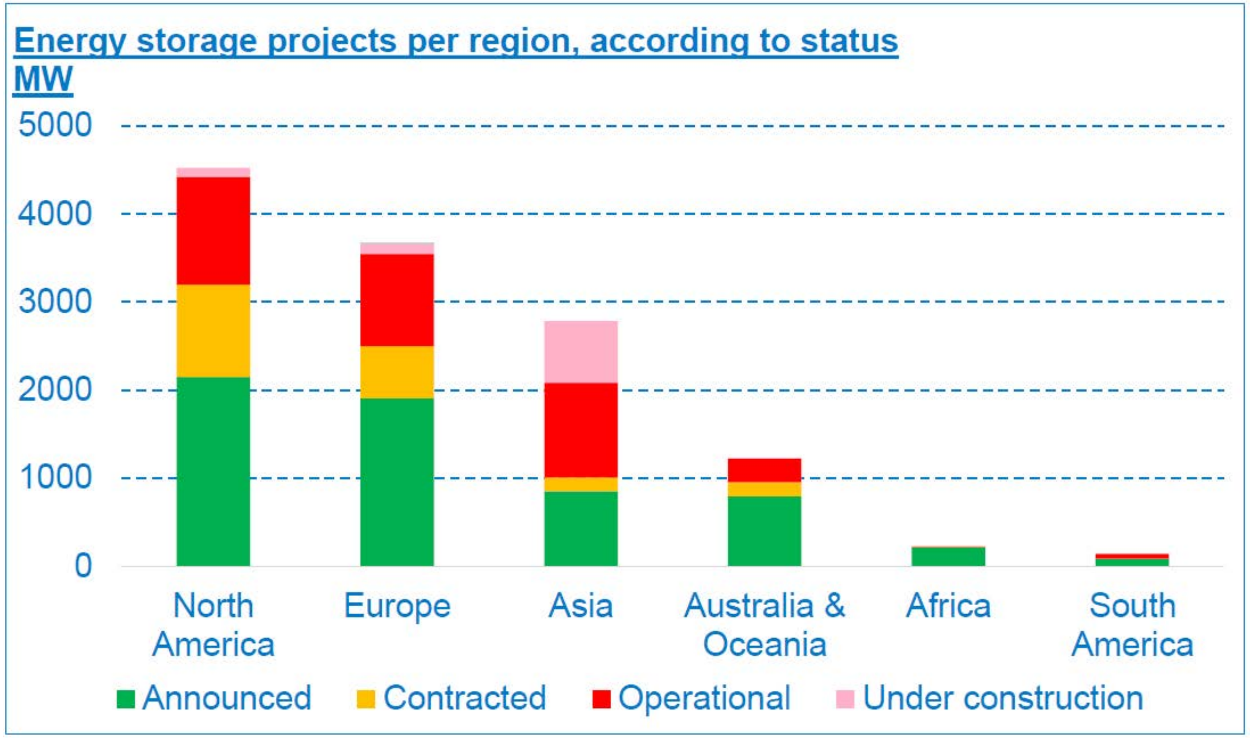
More – and Bigger - Grid Scale Battery Storage Projects



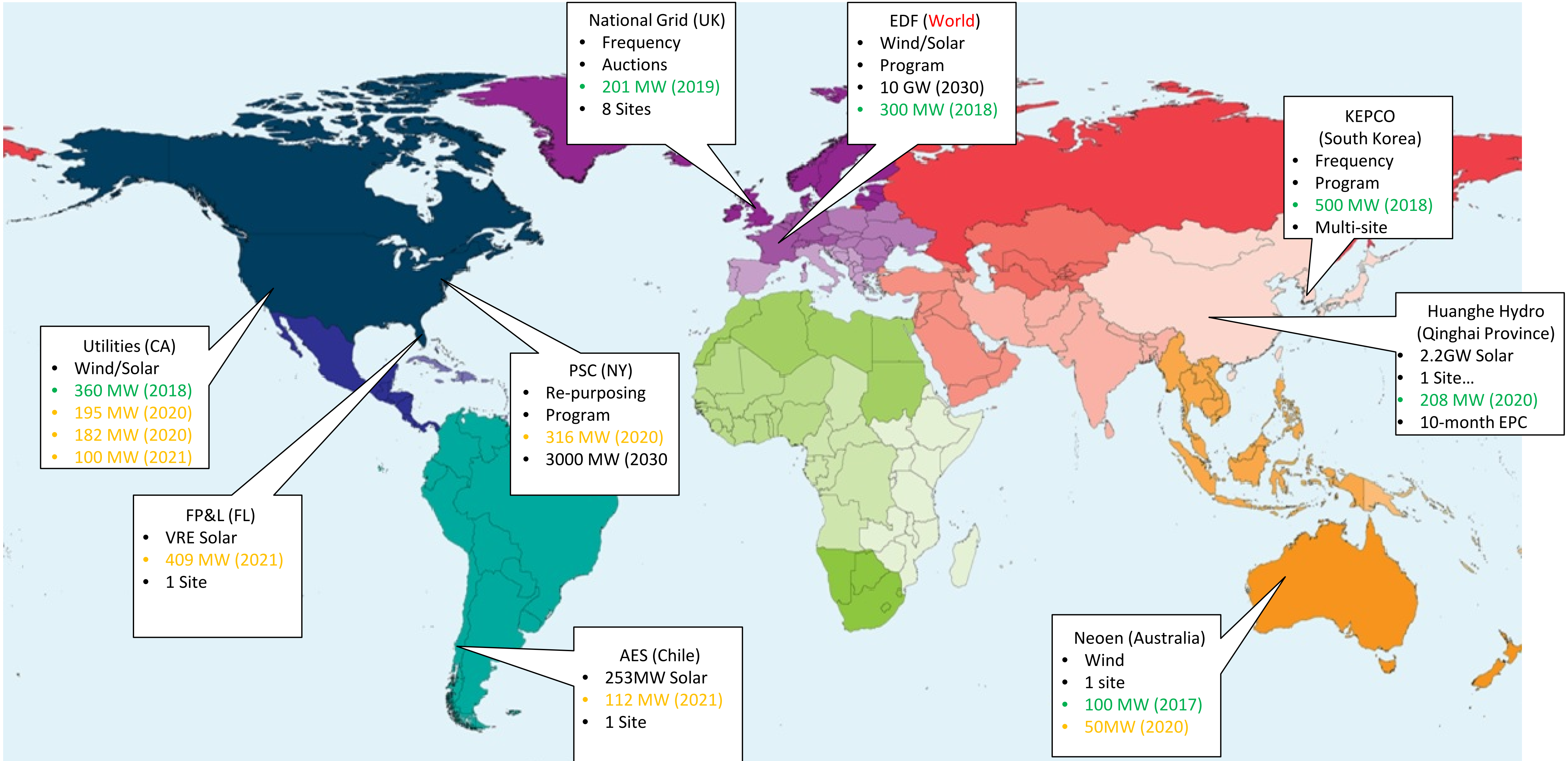
- 16 GW market by end 2019, 70% of projects being at development stage.
- Easy to implement: Modularity, 'Plug-and-play' (containerized), assets easy to displace/remove.
- Very competitive and dynamic market.
- Regional markets growth linked to Electric Vehicles, Wind/Solar or/and Minerals Development





Grid Scale Battery Storage Technology Now Beyond Test Phase

7,000+ MW in Operation, 15,000+ MW under Construction, Large Programs in most of Large Utilities



2. BATTERY STORAGE IN South Africa GRIDS : WHY NOW?

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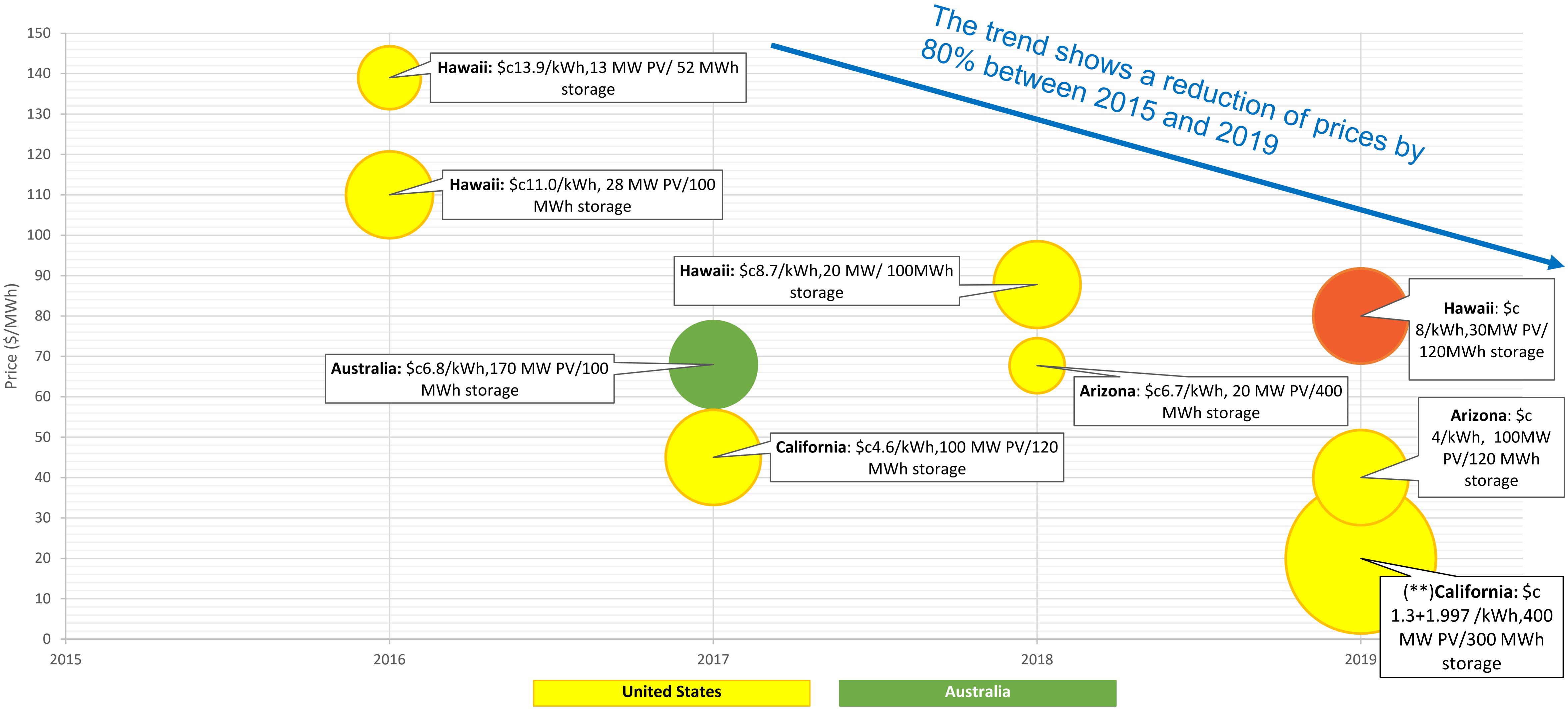
Battery Storage is THE Key Enabler for SA Post-Covid Green Economic Recovery

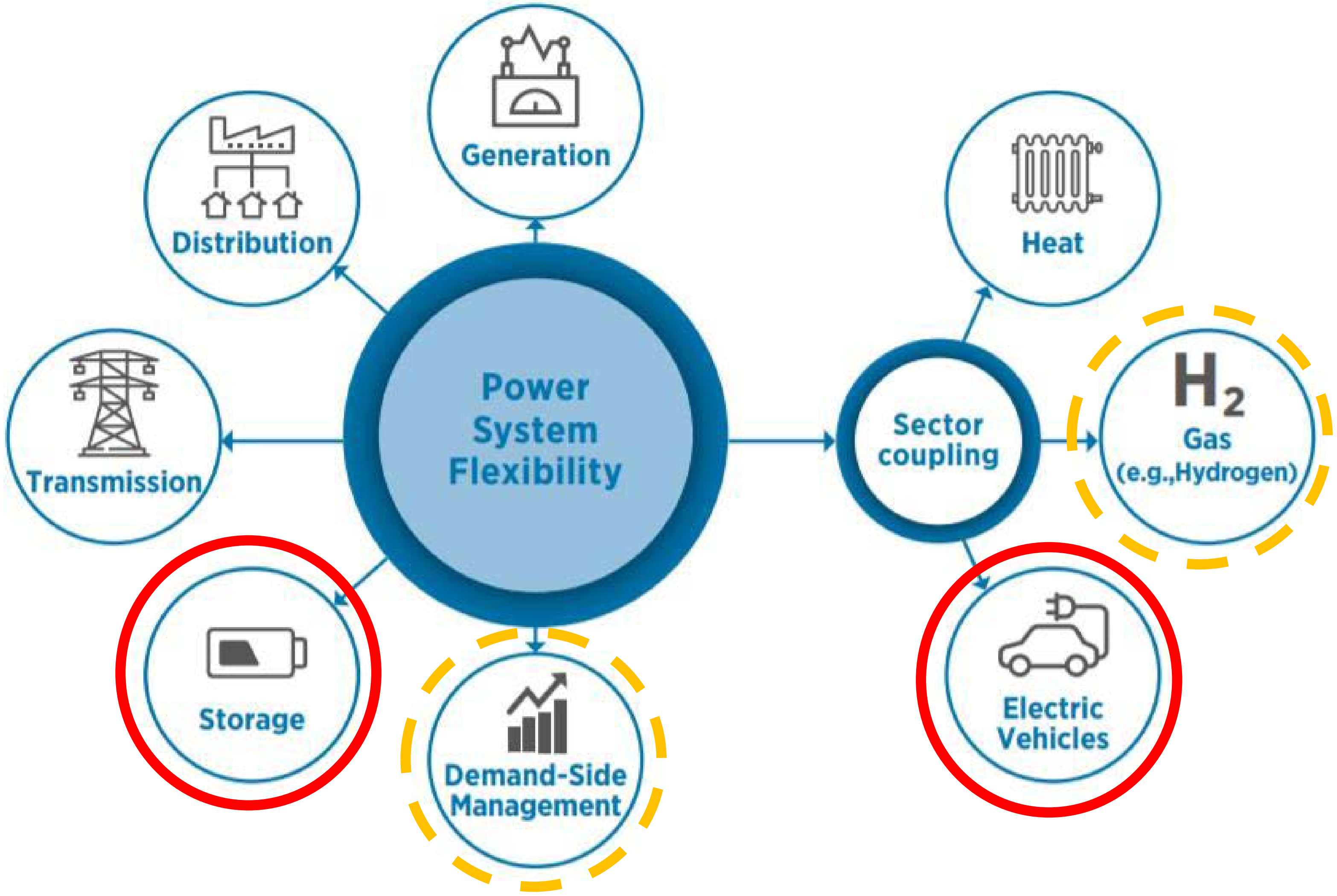
PV + Storage now provides dispatchable, cost competitive power



(*) The size of the bubble indicates storage capacity of the plant (MWh). However, it is difficult to infer relation to price trend in terms of inverter capacity to battery storage vs total PV capacity. (**) Nevada has lowest of PPA of 2.3$c/kWh, storage capacity still needs to be confirmed

Battery Storage Could Help Eskom Improving its Service Reliability

For its Flexibility Needs that are Increasing as the Energy System is Modernizing



Viable Energy Storage Applications in South Africa Grids

- PV/Wind Integration and management
- Re-purposing of closing coal sites
- Better economic dispatch of thermal assets (CO_2 savings)
- Less reliance on peakers (OCGT)
- Imports of cheap Hydropower

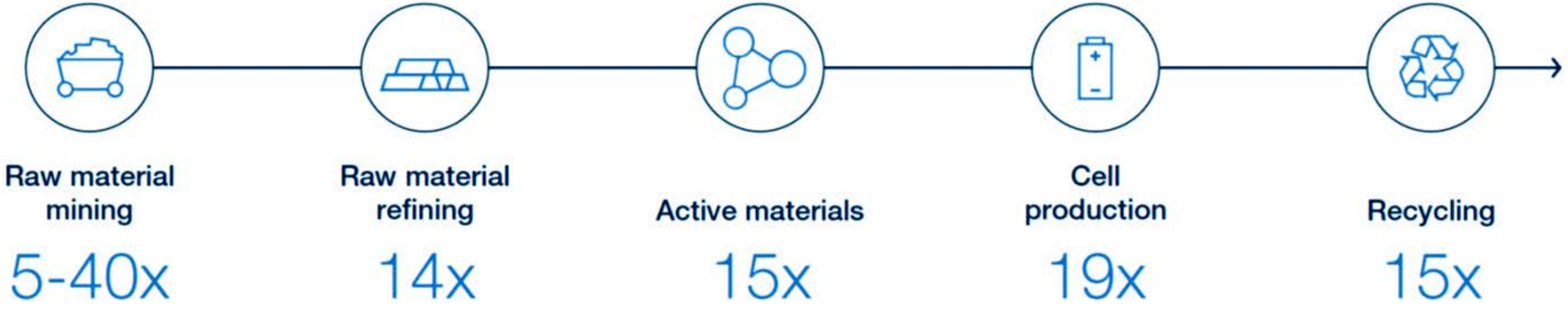
- Grid investment deferral (Tx and Dx)
- Grid stability (inertia, voltage and frequency control, local, national)

- Better integration of rooftop PV
- Back-up for Commercial customers
- Management of Prosumers
- Security of Supply for strategic customers
- Universal access to remote communities

South Africa Can Be in All Segments of the Battery Storage Value Chain

Battery Storage Value Chain Scale Up Potential (Global)

- Global Battery Value Chain Scale up by 2030 (Source: WEF / Global Battery Alliance report, Sept. 2019) :



- Battery Storage Global Investments to reach $620 billion by 2040 (Forbes, June 2019)

Support Battery Storage Value Chain Development in South Africa is getting traction

- Preparation of enabling environment for battery storage industrialization (DTI, NT, DEFF, NERSA, IDC)
- Battery Storage targets in the IRP, proposals including storage from the private sector (RMI4P RFI).
- Need to develop strategic cooperation with manufacturing countries (China, South Korea) but also with mineral rich neighboring countries

3. ESKOM BATTERY STORAGE PROGRAMME

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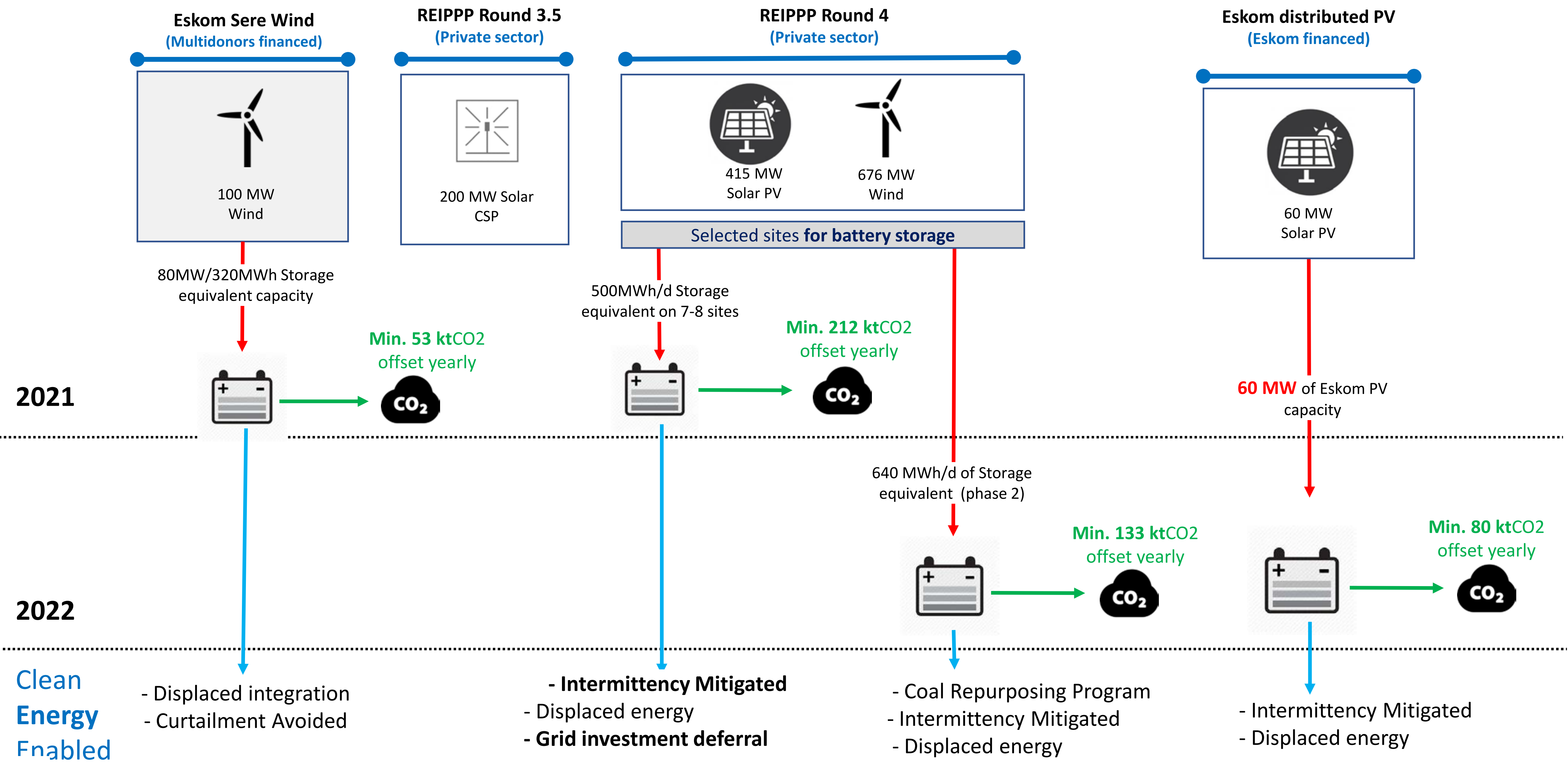
Eskom Battery Storage Program will Enable VRE Integration



Expected Benefits for SA, beyond The Eskom Program

Demonstration Effect, Transformational Potential

Utility perspective

- **From a 'traditional' electricity producer to a modern energy manager function**
- **With incoming 2,330 MW of Wind and Solar IPPs by 2021, good timing to acquire 'plug and play' tools for Grid stability and re-skilling critical mass of utility staff**
- **Lessons from large-scale battery program useful to better integrate future** decentralized / **rooftop solar capacity**
- **More flexibility and more dispatchable clean energy thanks to the batteries, allowing to decommission old coal plants**

South Africa perspective

- **In a period of economic recovery, reliability of electricity supply is critical to attract private investment (industry, manufacturing)**
- **Scale up of battery technology to complement rapid expansion of** least cost **energy,** critical for SA's Recovery
- **South Africa may be the only country in Africa** where Integration and industrialization in the **entire battery storage value chain (mining, manufacturing, operation) is feasible.**

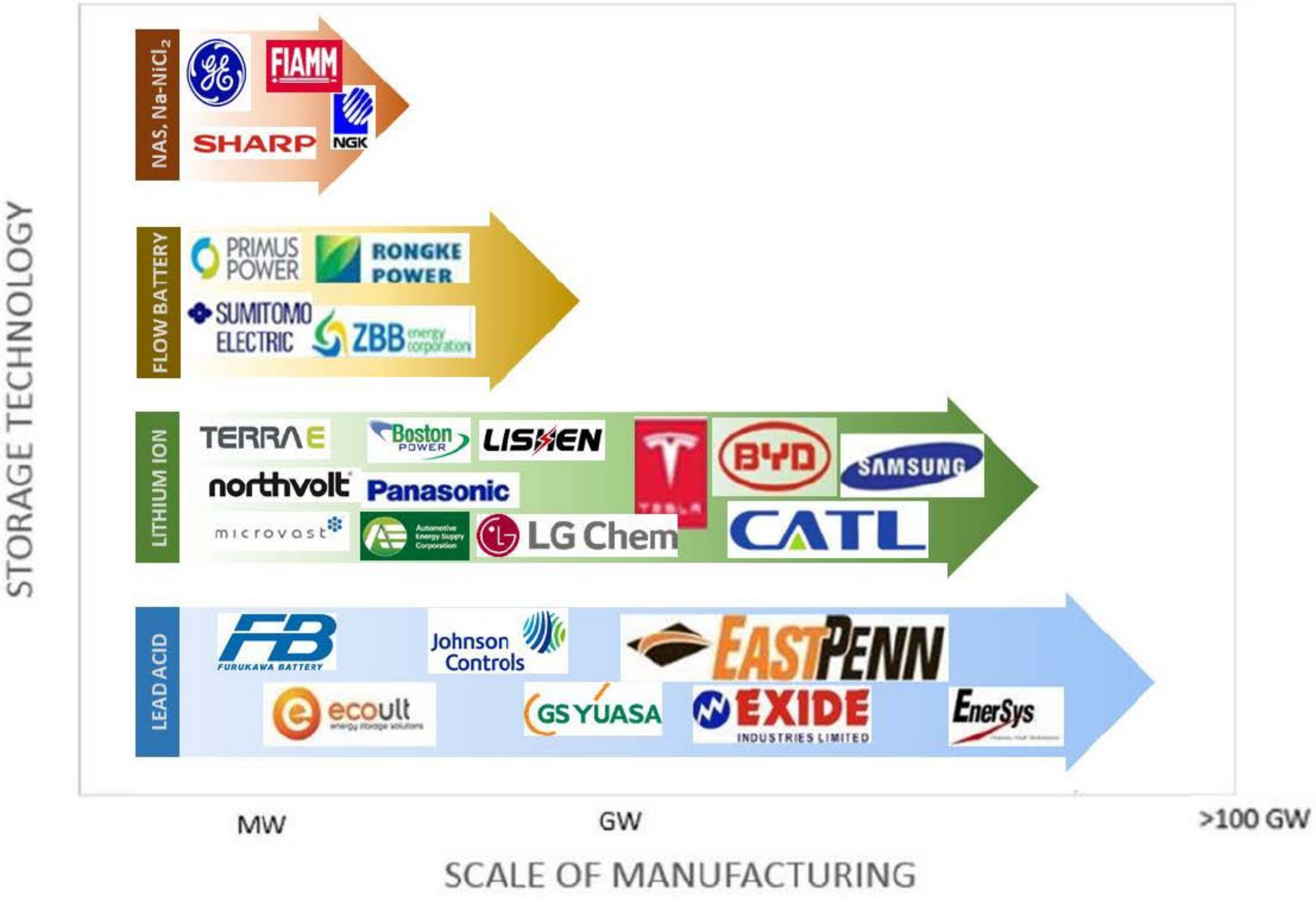
Africa region and Global perspective

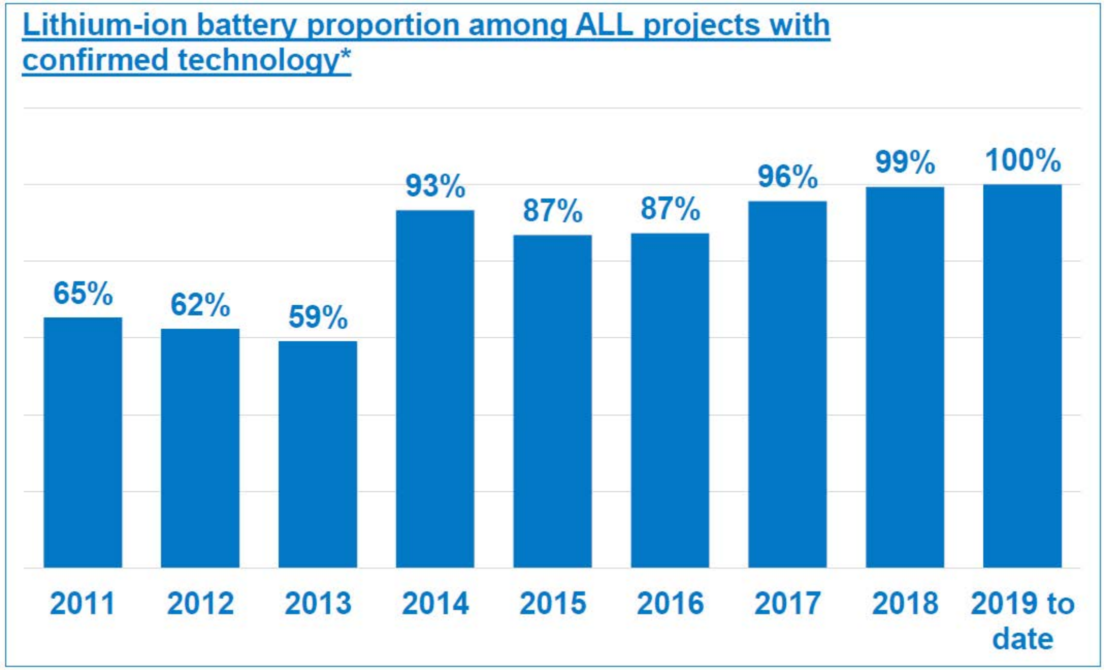
- **Over 6,000MW grid-scale batteries in operation worldwide, But NO battery connected to a grid in Africa**
- **Demonstration effect in South Africa will enable battery technology to expand faster in Africa (market pioneer advantage).**

Ngiyabonga! (Thank You!)

Global Battery Manufacturing and Market Trends by Technology

LITHIUM ION DOMINATES THE MARKET

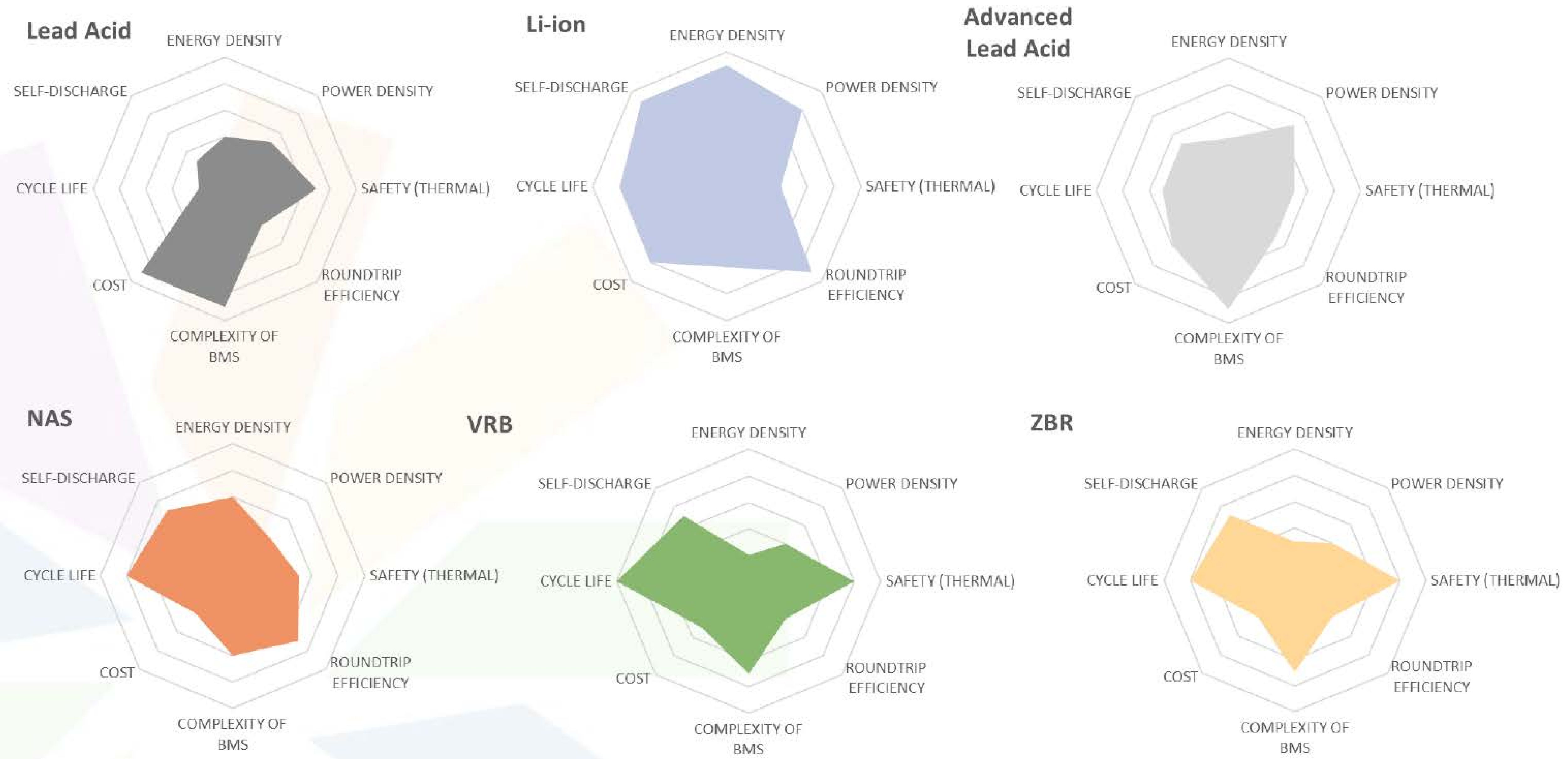




- Lithium-ion dominates the grid-scale battery market

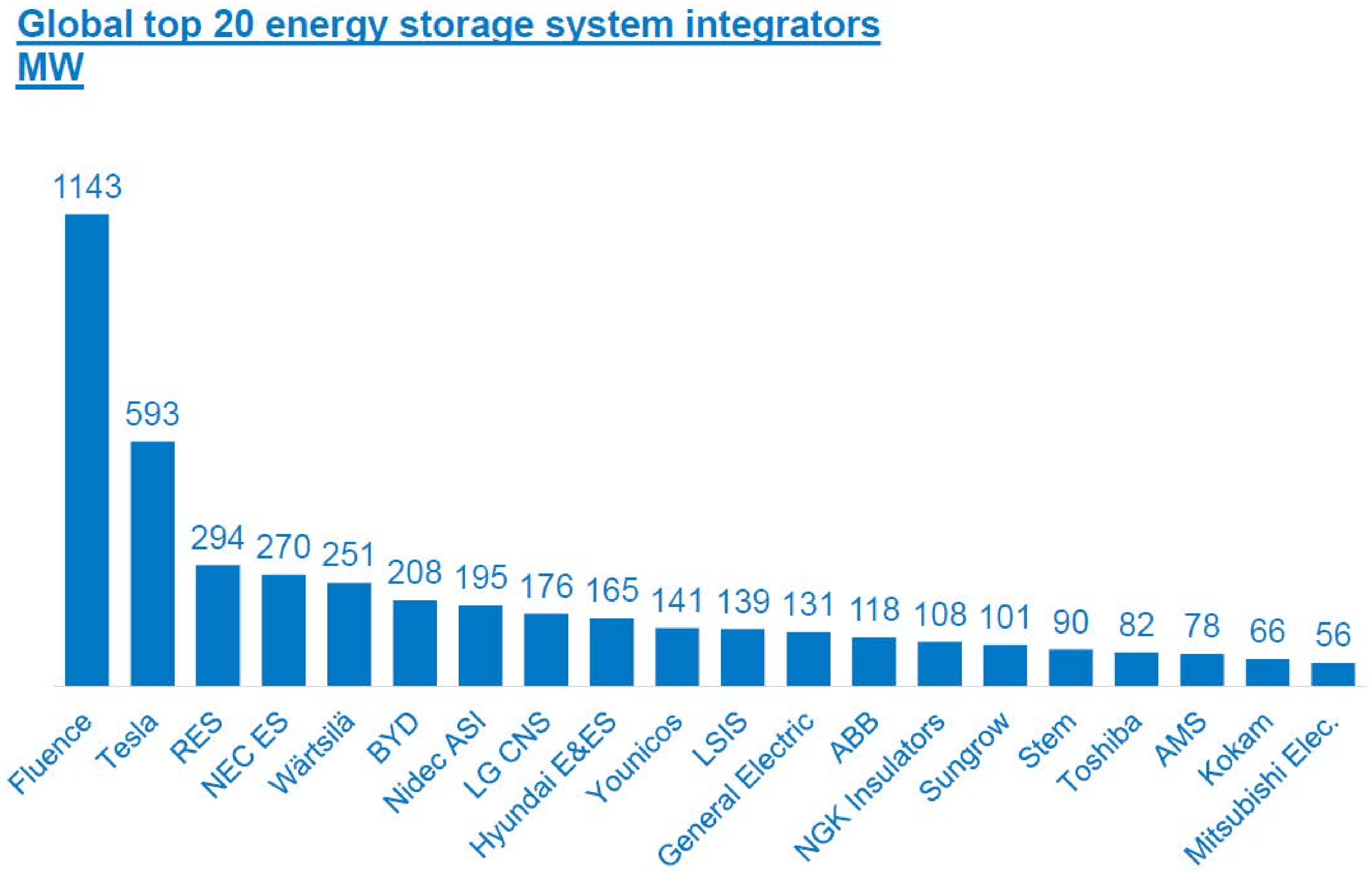
- LEAD ACID battery leads the energy storage market in production and sales.
- LITHIUM ION batteries have fastest growth, manufactured in the GW scale, for several uses (portable, transportation, grid scale).
- FLOW batteries currently manufactured on a MW scale. Production likely to scale up significantly in the next 3-5 years.
- HIGH TEMPERATURE batteries in a nascent scale of manufacturing

Comparison of Battery Technologies (Source: GESA, 2018)



Market Development: Grid Scale Battery Storage Integrators

Over 130 energy storage systems integrators, many are new: consolidation is happening



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Chief Engineer: Renewable Energy – City Power

Sy Gourrah

President of SAIEE

Chandima Gomes

Professor of high voltage engineering University of Witwatersrand

Q&A
& Panel Discussion

WELCOME
Day 2

SAIEE
ENERGY STORAGE CHAPTER

UNLOCKING AND ENABLING STORAGE AS A SECTOR FOR SOUTH AFRICA

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AGENDA

SAIEE ENERGY STORAGE CHAPTER

DAY 2 – 04th November

Unlocking and Enabling Storage as a sector for South Africa

- 11.00 Welcome to day 2 and overview of Agenda
- 11.15 – Barry MacColl– Which tools and research are required in SA, to fast track enabling the sector and gaining confidence of all players?
- 11.30 – Paul Vermeulen– Is the municipal grid ready?
- 11:45 – Siju Joseph –System operator – A System Operator’s perspective on Energy Storage
- 12:30-13:30 – Q&A session moderated by Professor Naidoo

Word of thanks and concluding remarks from Professor Naidoo

Barry MacColl

Senior Regional Manager - The Electric Power Research Institute

Barry MacColl is the Senior Regional Manager for the Electric Power Research Institute covering Africa, South East Asia and Oceania. Barry joined EPRI from Eskom Holdings, where he worked for 26 years in various positions.

Recognized for his holistic view of the business, Barry moved into a strategic planning and integrated risk management role. He was promoted to General Manager of the Research, Testing and Development Business Unit in 2012, the last position he held before joining EPRI. Barry has a Bachelor of Science (Electronic Engineering) degree from the University of KwaZulu Natal and a Masters of Business Administration from Rhodes University.

WHICH TOOLS AND RESEARCH ARE REQUIRED IN SA, TO FAST TRACK ENABLING THE SECTOR AND GAINING CONFIDENCE OF ALL PLAYERS?

Which tools and research are required in SA to fast track enabling the sector and for gaining confidence of all players?

SAIEE Energy Storage Chapter Launch

4 November 2020

Barry MacColl
Senior Regional Manager
bmaccoll@epri.com
+27 83 440 2169

About EPRI, www.epri.com

ELECTRIC POWER RESEARCH INSTITUTE

- EPRI conducts **research and development** relating to the **generation**, **delivery** and **use of electricity** for the benefit of the public.

- EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including **reliability**, **efficiency**, **affordability**, **health**, **safety** and the **environment**.

- **EPRI members** represent 90% of the electricity generated and delivered in the United States with international participation extending to nearly **40 countries**.

Social Media: Facebook | LinkedIn | Twitter | YouTube

EPRI Technical Leadership Team

Mark McGranaghan
VP, Innovation

Technology Innovation

Neil Wilmshurst
VP, Nuclear & Chief Nuclear Officer

Nuclear Power

Andrew Phillips
VP, Transmission & Distribution Infrastructure

- 34- Transmission Asset Management Analytics
- 35- Overhead Transmission
- 36- Underground Transmission
- 37- Substations
- 39- Transmission Operations
- 40- Transmission Planning
- 51-Transmission & Distribution: Environmental Issues
- 60- Electric & Magnetic Fields & Radio-Frequency Health Assessment and Safety
- 161- Information and Communication Technology
- 173- Bulk System Renewables & Distributed Energy Resources Integration
- 183- Cyber Security for Power Delivery & Utilization

Daniel Brooks
VP, Integrated Grid and Energy Systems

- 94- Energy Storage & Distributed Generation
- 174- DER Integration
- 178- Resource Planning for Electric Power Systems
- 180- Distribution Systems
- 197- Environmental Aspects of Fueled Distribution Generation & Energy Storage
- 200- Distribution Operations & Planning
- 201- Energy, Environmental, & Climate Policy

Rob Chapman
VP, Sustainability & Electrification

- 1- Power Quality
- 18- Electric Transportation
- 55- Ecosystem Risk & Resiliency: Wildfire & Extreme Events
- 62- Occupational Health and Safety
- 170- Customer Technologies
- 182- Understanding Electric Utility Customers
- 195- Endangered & Protected Species
- 198- Energy Sustainability
- 199- Electrification

Tom Alley
VP, Generation

- 49- Coal Combustion Product Management
- 54- Fish Protection
- 63- Boiler Life & Availability Improvement
- 64- Boiler & Turbine Steam & Cycle Chemistry
- 65- Steam Turbines- Generators & Auxiliary Systems
- 66- Advanced Generation & Bulk Energy Storage
- 68- Instrumentation, Controls, & Automation
- 69- Maintenance Management & Technology
- 71- Combustion & Fuel Quality Impacts
- 75- Integrated Environmental Controls
- 77- Continuous Emissions Monitoring
- 79- Combined Cycle Turbomachinery
- 87- Materials & Repair
- 88- Combined Cycle HRSG & Balance of Plant
- 104- Balance of Plant Systems & Equipment
- 108- Operations Management & Technology
- 165- Carbon Capture & Storage
- 185- Water Management Technology
- 192- Environmental Impacts of Renewables
- 193- Renewable Generation
- 194- Heat Rate Improvement
- 196- Water Quality
- 203- Air Quality & Multimedia Characterization, Assessment, & Health

Energy Storage Program Priorities
Pillars to Support Transition from R&D to Operations

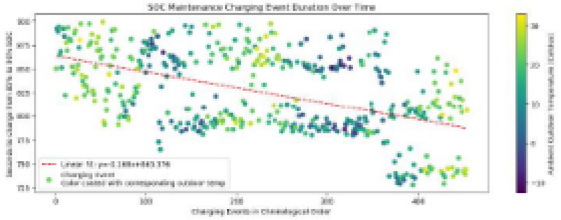
PERFORMANCE AND RELIABILITY

Building a Field Track Record

consistent data definitions

objective evaluation

shared industry databases



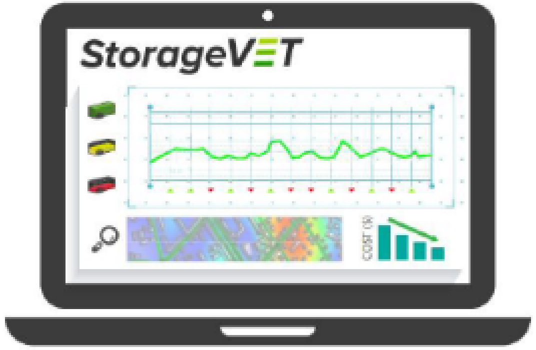
MODELING AND ANALYSIS

Design / Operations Optimization

high value site identification

sizing and optimization

project operations and valuation



www.storagevet.com

www.der-vet.com/

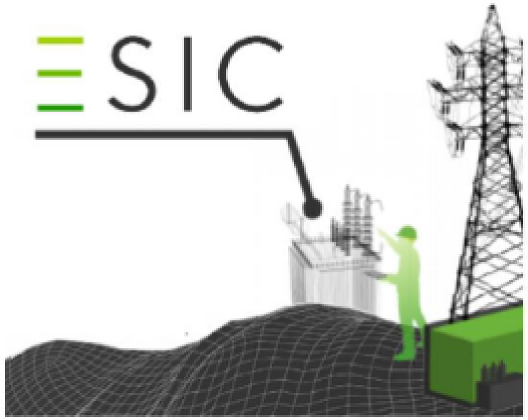
IMPLEMENTATION

Project Best Practices

safety and security

controls integration

knowledge transfer



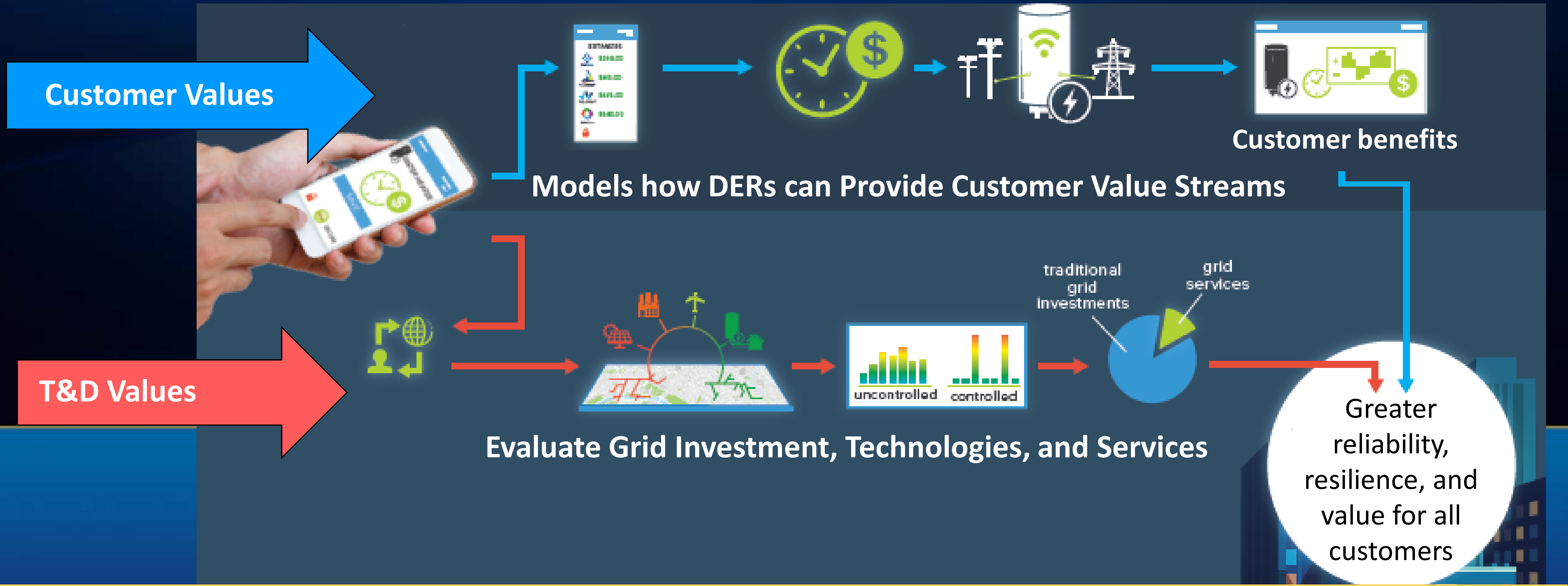
www.epri.com/esic

The SAIEE has access to a host of publicly available resources – use them first!

https://www.epri.com/pages/sa/epri-energy-storage-integration-council-esic?lang=en-US

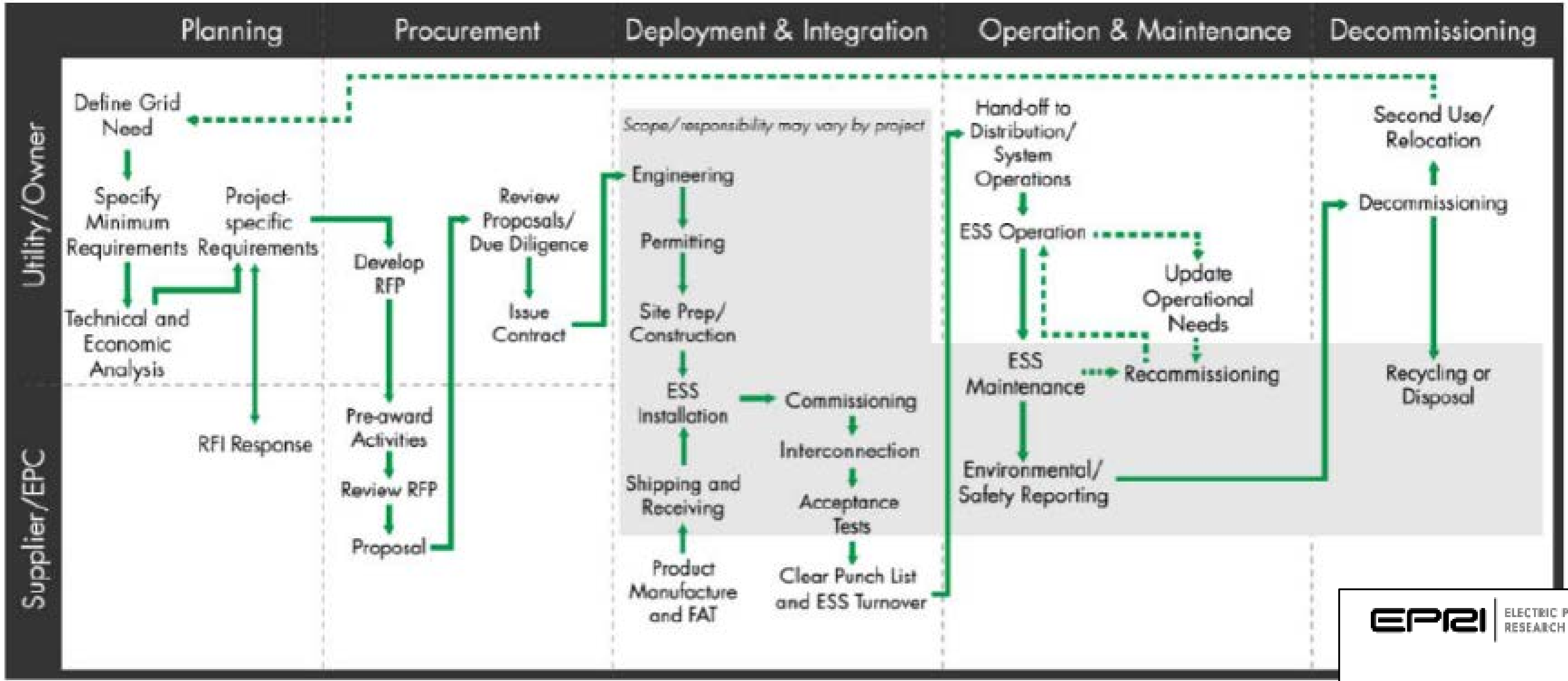
ESIC Energy Storage Implementation Guide
ESIC Energy Storage Request for Proposal Guide
ESIC Energy Storage Technical Specification Template, v3.0
ESIC Energy Storage Test Manual
Electrical Energy Storage Data Submission Guidelines
ESIC Energy Storage Reference Fire Hazard Mitigation Analysis
ESIC Energy Storage Safety Incident Gathering and Reporting List
ESIC Energy Storage Modeling Bibliography
Common Functions for Smart Inverters: 4th Edition
ESIC Energy Storage Commissioning Guide
ESIC Energy Storage Cost Template and Tool v2.0
Energy Storage Safety: 2016
StorageVET and supporting documentation

DER-VET is Validated, Transparent, and Accessible Microgrid Valuation and Optimization Tool



DER-VET is a robust technical analysis and economic optimization tool used for the design of microgrids and DER deployments that is a publicly-available, open source software platform

What are the logical steps to implementation?

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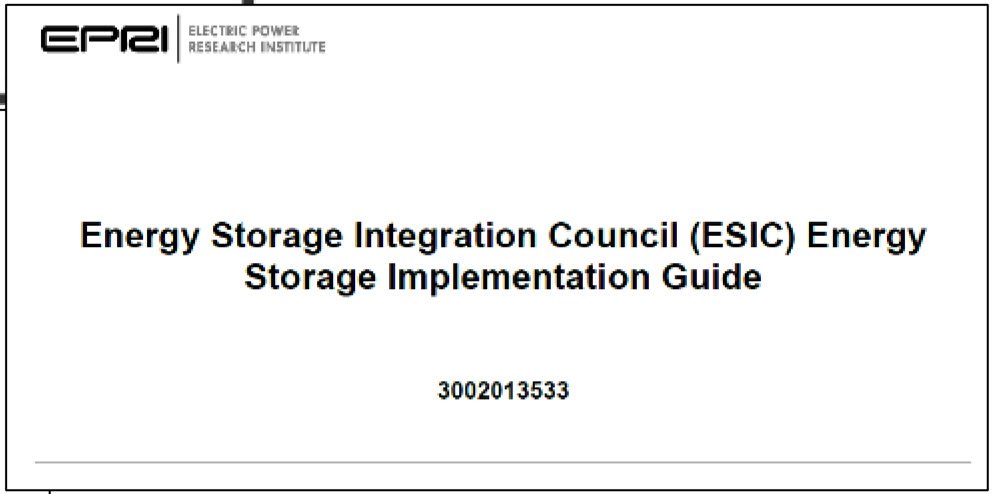
ESIC Energy Storage Request for Proposal Guide

3002017242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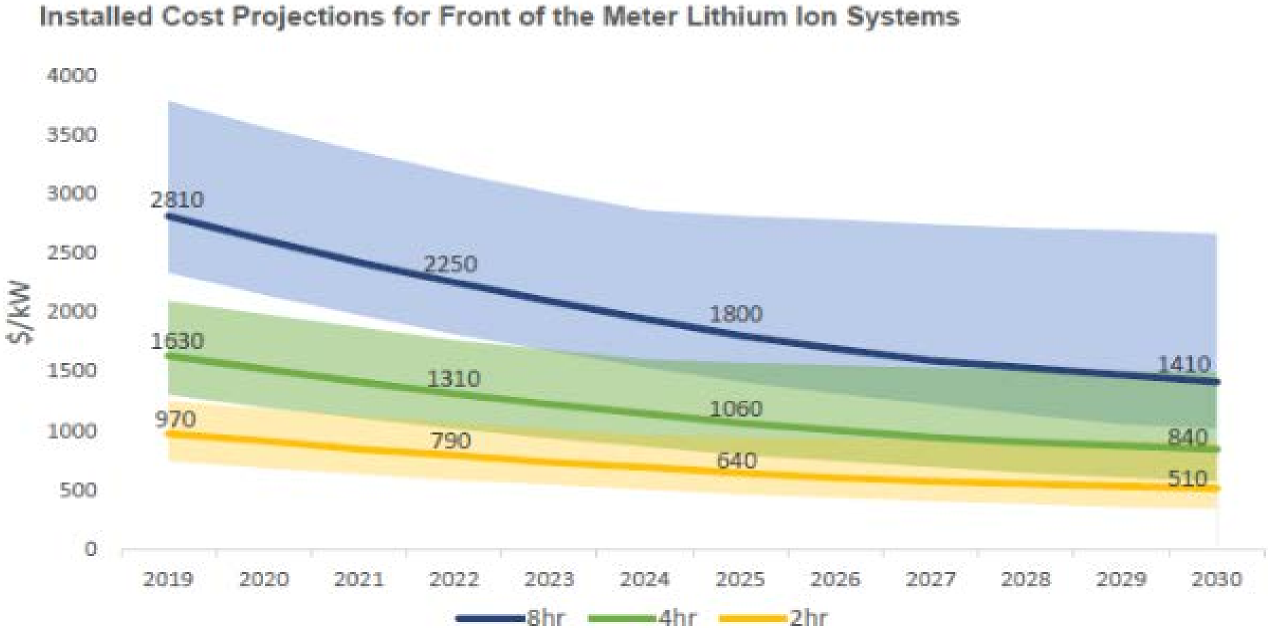
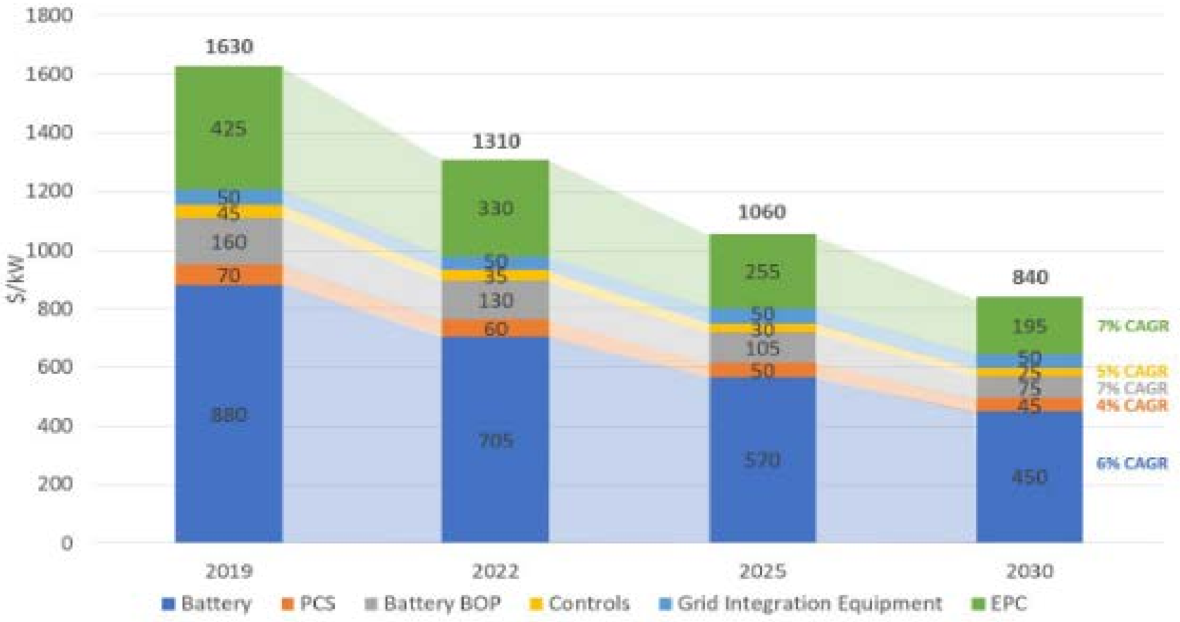
Energy Storage Integration Council (ESIC) Energy Storage Implementation Guide

3002013533

Lithium Ion Installed Cost Projections





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Energy Storage Technology and Cost Assessment: Executive Summary

3002013958

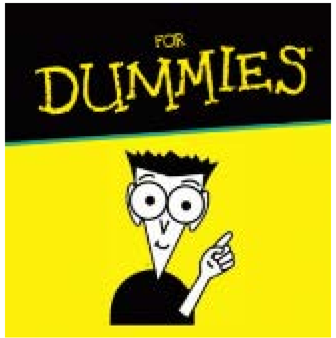
Project Manager
Erin Minear

December 2018

So what research is required in South Africa?

My view?....a managers' dummies guide....

1. What problem can energy storage solve? *Who has the problem*?
2. What energy storage technologies can I use right now? Proven?
3. What are the system cost and performance figures? Really.
4. What is the value to me? Have I solved the problem?
5. Where would I put these things?
6. How do I pay for them? What are my funding options?
7. Who will operate and maintain them?
8. Can I localize any of this? What about jobs?
9. What regulations do I need to enable this?
10. Are these things safe? Do they harm the environment?



FUTURE STATES: ENERGY STORAGE FOR 2025

These target future states were collaboratively developed as visions for the beneficial use of energy storage.

https://www.epri.com/research/products/000000003002019722





SAFETY	ELECTRICITY RELIABILITY	ECONOMICS	ENVIRONMENTAL RESPONSIBILITY	INNOVATION
Community resilience use cases viable	Energy storage asset reliability characterized and enhanced	Planning and operational modeling validated and applied	Reduced emissions with energy storage applications	Cross-industry disruption awareness and integration
Safety practices established	Energy storage controls integrated and interoperable	Multi-use applications enabled	Sustainable life cycle implemented	Future workforce available and trained
Asset hazards characterized and minimized	Planning and maintenance practices established	Project capital and soft costs reduced	End-of-life impacts minimized	Technology advancements accelerated

SAFETY

COMMUNITY RESILIENCE USE CASES VIABLE

Solutions are developed and demonstrated to support a range of customer and community resilience applications for disruptions and disasters.

Gaps:

- Quantification of resilience value for communities
- Energy storage public safety use definition
- Community and customer awareness of options
- Coordination of customer and utility assets

SAFETY PRACTICES ESTABLISHED

Codes, standards, and best practices for integration and operation of energy storage support the safety of all.

Gaps:

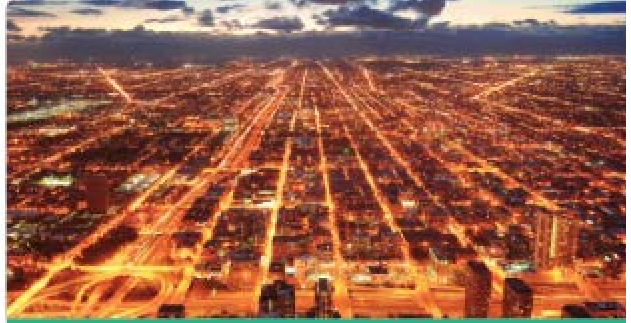
- Public safety guidelines
- Installation, transportation, and handling safety guidelines
- Operator guidelines
- Maintenance guidelines
- Incident response protocols
- Design and manufacturing safety practices

ASSET HAZARDS CHARACTERIZED AND MINIMIZED

Safety hazards are characterized and mitigated with informed and comprehensive approaches to reduce the probability and severity of safety events.

Gaps:

- Battery thermal runaway characterization and mitigation
- Siting risk management practices
- Emerging storage technology safety information and analysis
- Failure modes and effects analyses
- Fire hazard testing and models



ELECTRICITY RELIABILITY

ENERGY STORAGE ASSET RELIABILITY CHARACTERIZED AND ENHANCED

Robust operational data shared through standardized metrics and testing inform planning, operations, and maintenance decision making.

Gaps:

- Operational data availability
- Analysis and benchmarking of available technology data
- Reliability models for utility planners and operators
- O&M practices and asset management

ENERGY STORAGE CONTROLS INTEGRATED AND INTEROPERABLE

Energy storage control systems support multiple-use applications and interoperability with utility systems to support predictable, reliable, and flexible operations.

Gaps:

- Open standards for communications and controls
- O&M practices and asset management
- Cyber security, including firmware upgrade verification
- Business continuity

PLANNING AND MAINTENANCE PRACTICES ESTABLISHED

Calibrated models and best practices support power system planning and O&M practices to maximize predictability and optimize maintenance.

Gaps:

- Reliability and performance data, planning tools and method
- Operational practices for degradation management
- Failure characterization and predictive maintenance
- Maintenance approach consistency

ECONOMICS

PLANNING AND OPERATIONAL MODELING VALIDATED AND APPLIED

Methods and models for valuation support robust and economically optimized project planning, operation, and integration into utility practices.

Gaps:

- Project operational case studies
- Benchmarked modeling software
- System and portfolio planning tools and methods
- Valuation of long-duration storage and hybrid systems such as solar-plus-storage

MULTI-USE APPLICATIONS ENABLED

Utilization and value streams are maximized through innovative business models, advanced controls, and financing.

Gaps:

- Utility planning processes and tools
- Multi-stakeholder shared operations
- Regulatory frameworks
- Warranties and performance guarantees
- Controls and optimization methods

PROJECT CAPITAL AND SOFT COSTS REDUCED

Project life cycle costs are minimized through improved energy storage technologies and products, reduced soft costs, and financing and insurance tools.

Gaps:

- Project design optimization
- Project deployment practices
- Interconnection and permitting processes
- Risk and insurance accessibility
- End-of-life options
- Ensured equipment supplies and service

ENVIRONMENTAL RESPONSIBI

REDUCING EMISSIONS WITH ENERGY STORAGE APPLICATIONS

High renewables adoption, electric vehicle use, delivere electricity efficiency, reduced emissions from existing generation fleet, and ecosystem protection are suppor

Gaps:

- Documented use to reduce emissions
- High renewable scenarios
- Long-duration storage applications
- Metering and emissions accounting
- Emissions cost and value streams

SUSTAINABLE LIFE CYCLE IMPLEMENTED

Materials selection and extraction practices, manufact transportation, and deployment practices consider and minimize negative impacts to environment and society.

Gaps:

- High social and environmental impact materials
- Life cycle assessment (LCA) data
- Procurement decision-making criteria
- Global supply chain diversity and resilience
- Materials certifications and traceability throughout li
- Material supply adequacy

END-OF-LIFE IMPACTS MINIMIZED

Safe disposal, recycling, and reuse of energy storage sy components minimize negative environmental impacts energy storage projects at end of life.

Gaps:

- Safe and responsible recycling and disposal
- End-of-life utility planning and contracts
- Economic recycling processes for lithium ion batteri
- Validated battery second-life products and applicatio

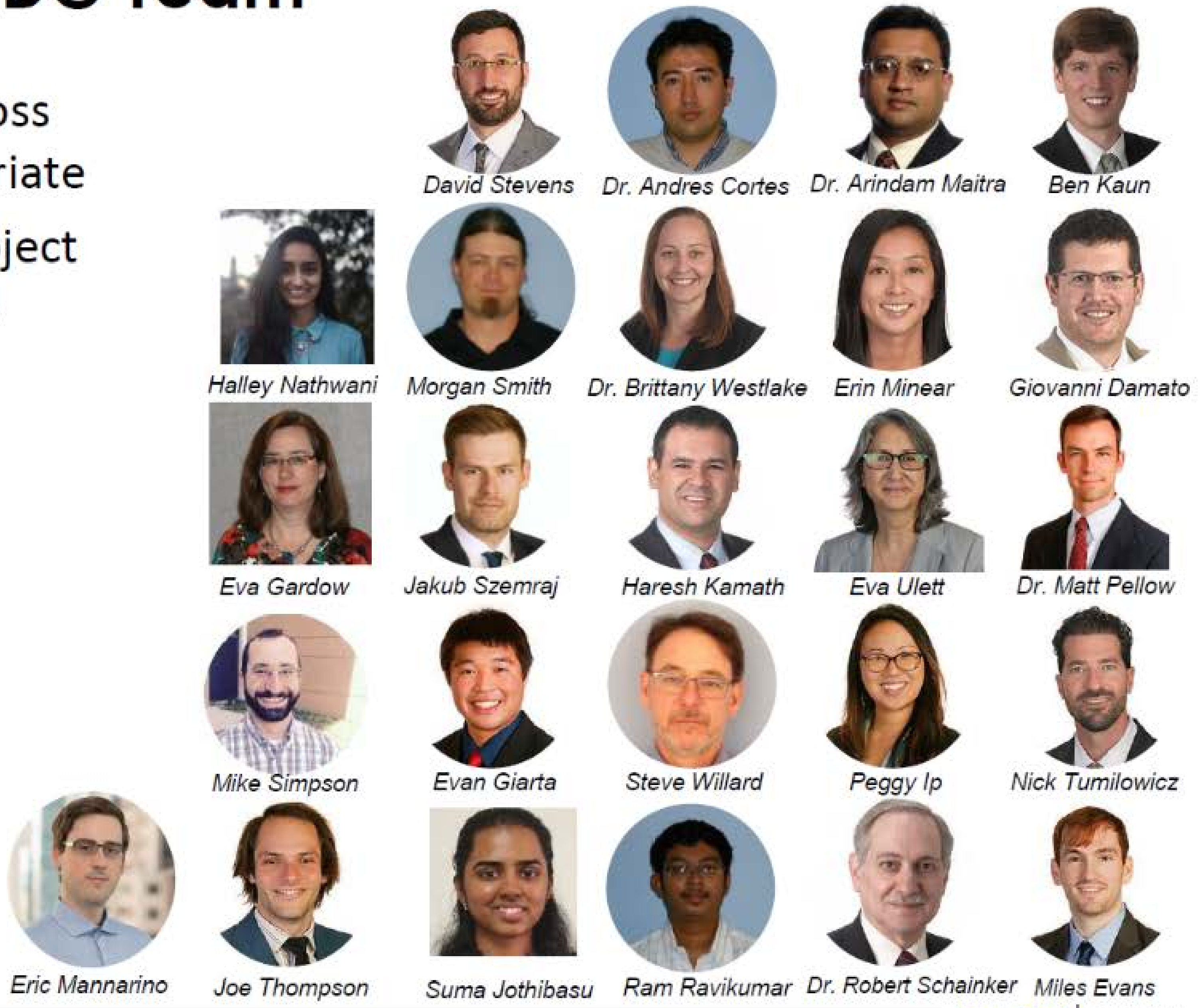
Together…Shaping the Future of Electricity

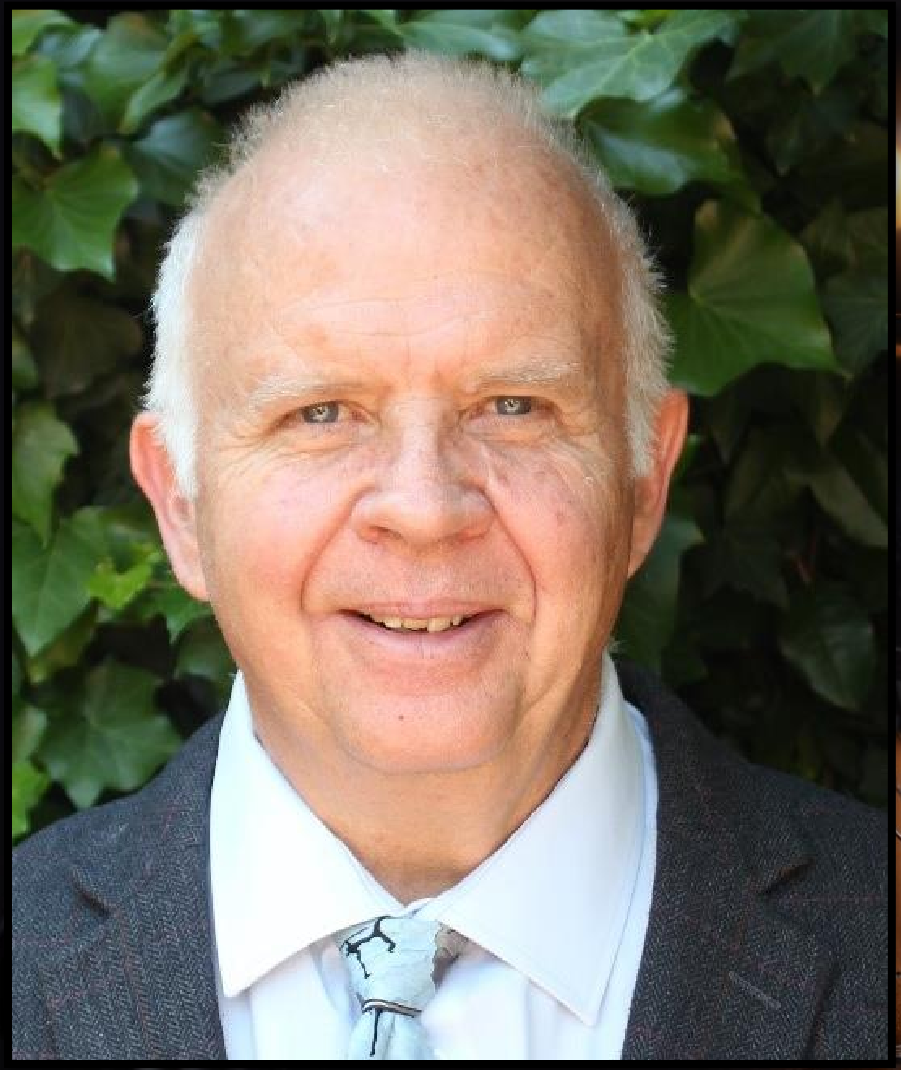
Barry MacColl

- Barry MacColl is appointed as the Senior Regional Manager for the Electric Power Research Institute covering Africa, South East Asia and Oceania. He is based in Johannesburg.
- Barry joined EPRI from Eskom Holdings, where he worked for 26 years in various positions.
- His early career years were spent in the Cape commissioning and maintaining control and instrumentation equipment and converting Eskom's systems from electromechanical and discreet component systems to those based on digital technologies. He was appointed as the manager of the telecommunications, protection, control and DC systems as well as a Regional control centre and ultimately became accountable for the planning, design, construction, commissioning, maintenance and refurbishment of all control plant equipment in the Eastern Cape.
- Recognized for his holistic view of the business, Barry was then moved into a strategic planning and integrated risk management role. He moved into the company's R&D group in 2007 and was promoted to General Manager of the Research, Testing and Development Business Unit in 2012, the last position he held before joining EPRI.
- Barry has a Bachelor of Science (Electronic Engineering) degree from the University of KwaZulu Natal and a Masters of Business Administration from Rhodes University. He is married to Carey, has three children and loves to spend time cycling and fishing in beautiful South Africa.

EPRI Energy Storage & DG Team

- Cross-functional and working across multiple programs where appropriate
- Diverse experience levels and subject matter expertise from ideation to hardware pilots
  - Technology evaluation and testing
  - Economic and grid analysis
  - Controls
  - Safety
  - Field deployment





Paul Vermeulen

Chief Engineer: Renewable Energy - City Power Johannesburg

Paul joined the Johannesburg City Council Electricity Department as a Telecommunications Technician, his career progressed to include substation tele-control with its evolution into SCADA systems. He managed the full SCADA function for a period of ten years. He currently holds the relatively new post of Chief Engineer: Renewable Energy at City Power, and in 2014 completed the BSc (Hons) degree in Energy Studies at UJ.

He is also presently a Board member and Chairman of the Policy and Regulation committee of SAESA, the Southern African Energy Storage Association.

IS THE MUNICIPAL GRID READY?

Unlocking and Enabling Storage as a Sector in South Africa

Are Municipal Grids ready?
What needs to be done to get things ready?

Presentation by
Paul Vermeulen
Chief Engineer RE, City Power
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083 278 3903

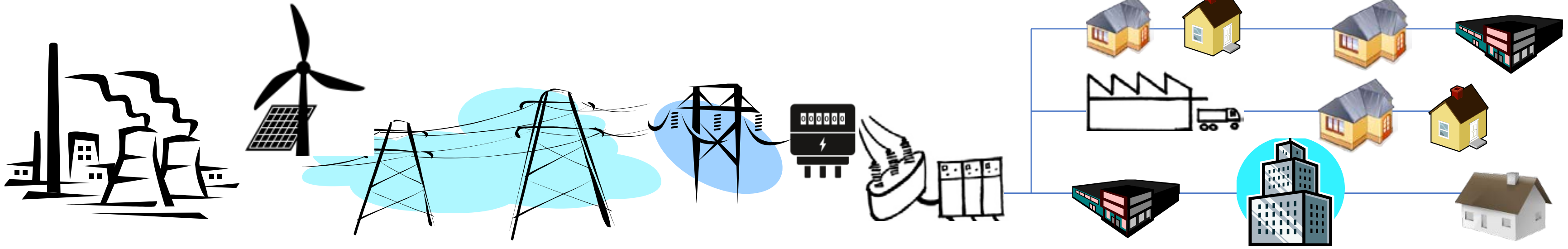
South African Institute of Electrical Engineers

SAESA South African Energy Storage Association

Electricity grids are key to an efficient, interconnected energy system

- The grid is often taken for granted and we do not properly acknowledge its properties
- The public generally just see it as an 'infinite source of electricity'
- However, it is *the* classic network and literally connects everything together
- What happens at one node of the grid has an impact on other nodes
- **Those connected to the grid form part of an interconnected community**
- **Distribution Grids allow us to take full advantage of load diversity**
- **Distribution Grids allow us to take separate or simultaneous advantage of centralized and distributed energy sources**
- **By matching generation to load, good grid design enables the optimization of the energy system**

Without well maintained and properly functional transmission and distribution grids, there can be no transition to a 'new energy mix'



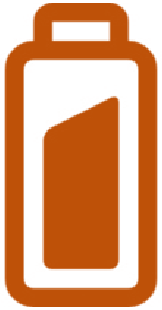
The impact is also felt on this part

And vice-versa

When something changes on this part of the grid -

To properly define Energy Storage, we should note that:

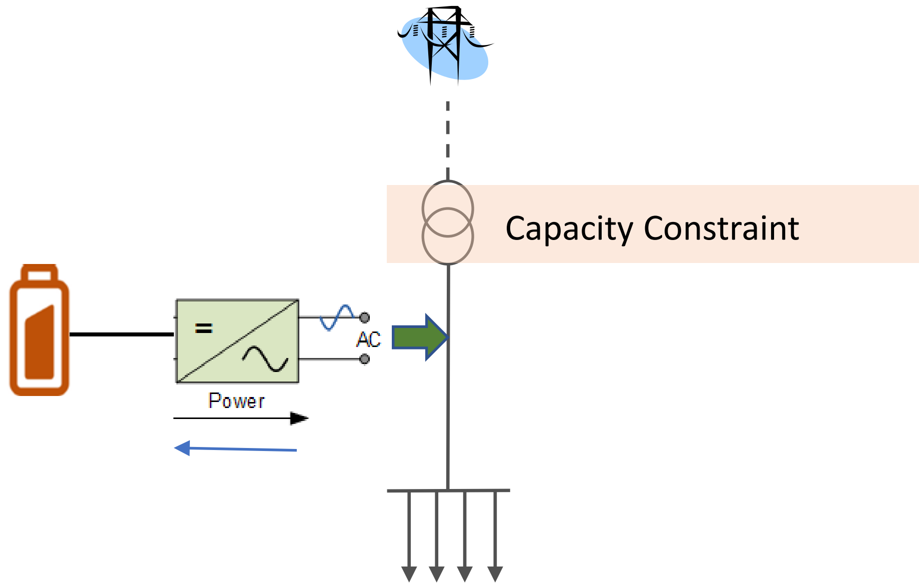
- Energy storage is not a primary energy source, but is very usefully a means by which we can change the time that any primary energy source is actually utilized.
- This means that it is a powerful energy management tool and should not only be confined to a renewable energy supporting role. (Storing of surplus)
- Energy storage can as effectively be used in support of generating technologies that operate best by providing constant baseload power, such as coal and nuclear based generation. (Storing of low cost off-peak capacity)
- To financially optimise their systems, electricity system operators must always aim to recharge energy storage systems from the cheapest energy source available



It is disappointing that the current rules applicable to the RMPPP preclude using storage together with both renewable as well as conventional energy sources to balance and economically optimise the power system.

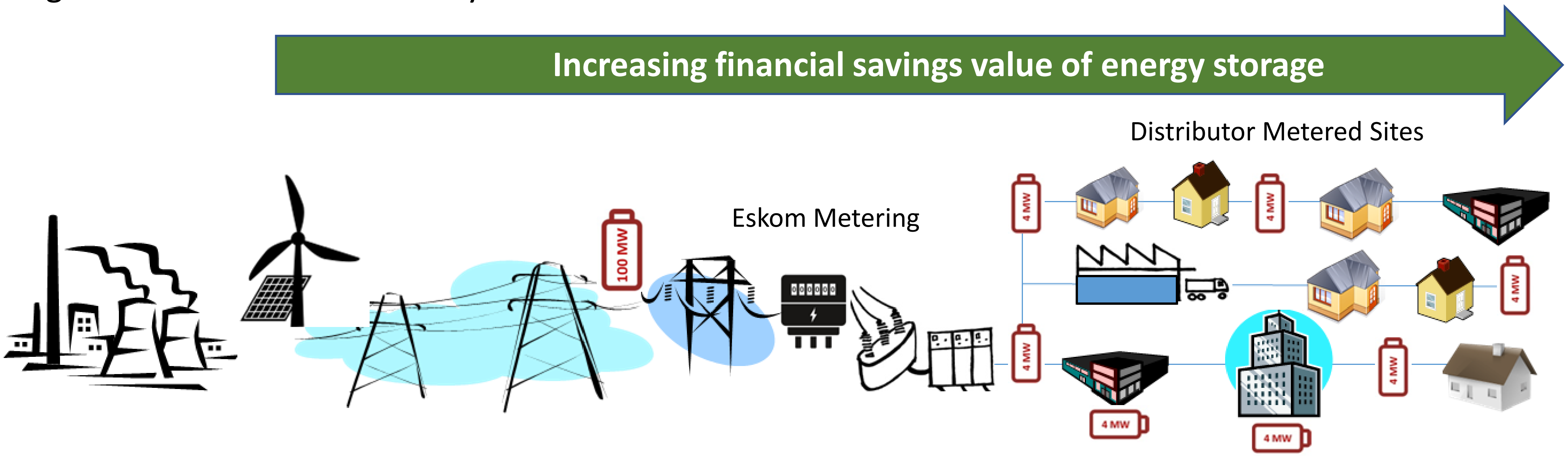
Storage can also change the timing of Tx and Dx network utilization

- The location of an energy storage facility can also be used to change the time at which the upstream grid is used to transfer energy from a generating source to where it will ultimately be consumed.
- Locally stored energy can be dispatched to serve localized peak loads and de-load the upstream distribution networks
- This means that energy storage is a very powerful load management tool in the hands of Distribution Network Operators
- Storage can be scheduled to behave as a load when actual load is low, and as a source when the load is high – clipping the peaks and filling the valleys
- It may be sensible to consider energy storage as being an integral part of our Distribution systems, rather than being seen as an ancillary service to the Generation and Transmission industry.



There is higher value for Storage that is connected within Distribution Networks

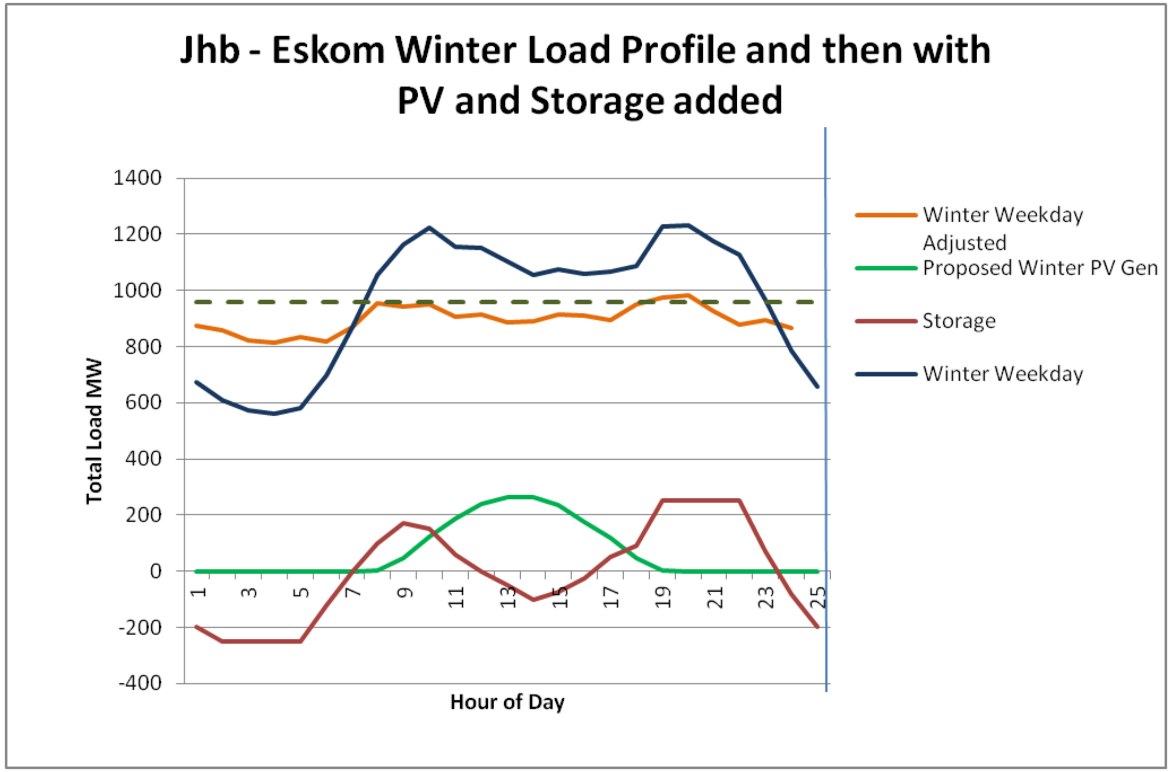
- There is added value, the so-called 'stacked' value – of putting energy storage assets deeper into the electricity distribution network, instead of focusing only on large, transmission connected energy storage systems.
- Energy storage assets connected beyond the utility meter have a higher financial savings potential than equivalent transmission connected assets.
- There is a good correlation of the 'high load' conditions that simultaneously affect generation, transmission and distribution networks, so connecting the storage assets at Distribution level does not diminish the benefit to the generation and transmission sectors
- The proviso is that the transmission system operator must be empowered with the right to control all the energy storage assets connected to the system.



Enhanced Value of Storage connected within Distribution Networks

The enhanced benefits include:

- An opportunity to use the assets for daily arbitrage to reduce energy procurement costs and manage peak demand
- A step change in the security of supply at an end customer's premises, particularly where load shedding is imposed on the system
- A means to reduce distribution network bottlenecks and avoid costly network upgrades
- Supporting densification and unlocking development where the constraint is the peak load / capacity needed only over a relatively short duration in the evening.
- Provide a means to integrate growing renewable energy capacity without creating a troublesome 'Duck Curve' load profile for the distributor



In this example the load profile can be largely flattened with a coordinated combination of:

- 350 MW of PV generation
- 250 MW (1650 MWh) energy storage

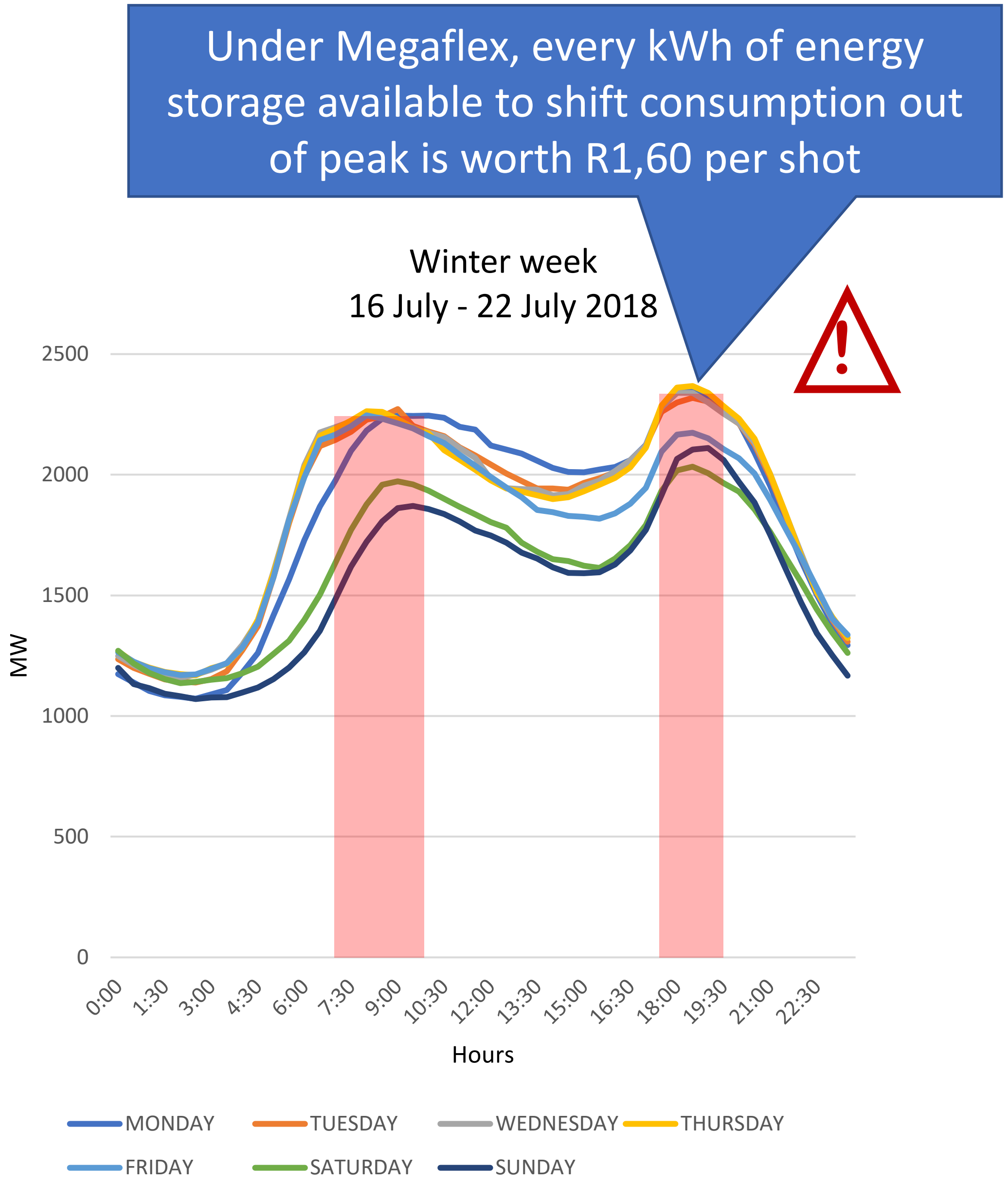
It is quite clear that Distribution networks really are *in need* of the functions and features that distributed Energy Storage facilities can deliver.

And it is clear that storage is needed at the right scale to be effective.

So, what needs to be done within the Municipal Distribution environment to prepare for and promote Energy Storage?

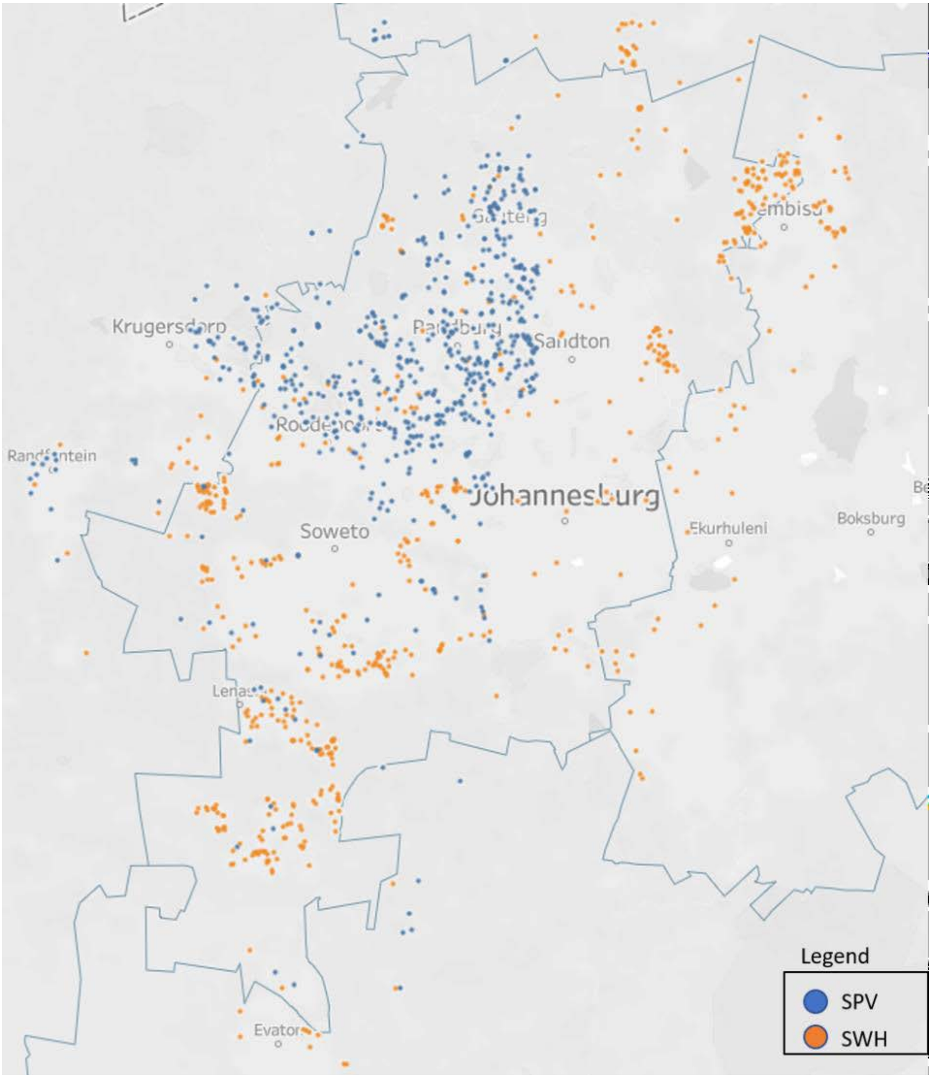
Promoting tariff arbitrage within the Commercial and Industrial Sectors

- Energy arbitrage is the base business case for distributed Energy Storage assets
- Eskom's tariff restructuring plans include converting all municipal accounts related to the on-sale of electricity to a new 'Muniflex' TOU tariff, to signal the need to reduce load during peak periods.
- Properly functional municipal Time of Use Tariffs and metering must be implemented to pass on the tariff signals to end customers
- High load factor customers have in the past complained that it is difficult to respond to TOU tariffs
- If such a customer can be convinced to invest in energy storage as a backup against load shedding, they will then also have invested in a new means to respond to the TOU tariffs
- Carefully designed municipal TOU tariffs are needed to promote such investment in energy storage, together with direct engagement with these key customers
- Once a critical mass is reached, the 'fleet' of energy storage assets can be included in a worthwhile Demand Response program



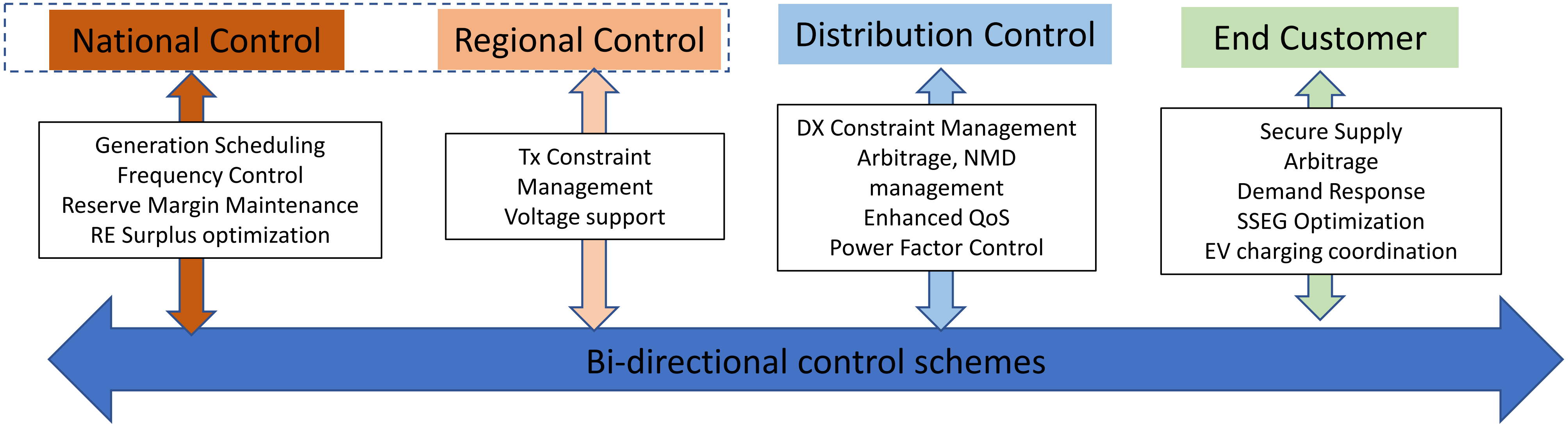
Enabling arbitrage within the residential sector

- The time is long overdue for the implementation of residential time of use tariffs, particularly for 60 A and above residential service connections. This is the sector responsible for the killer winter evening peaks.
- In the event customers change to the TOU tariff and do not change their behaviour, the cost of peak energy is at least passed on, reducing the municipality's risk to excessive peak energy costs
- Where residential TOU tariffs are applied, hybrid PV systems can immediately make a valuable contribution to energy shifting
- The City of Johannesburg in conjunction with the C40 Cities Network commissioned a study with the University of Johannesburg, Faculty of Engineering and the Built Environment, to determine the number of solar water heaters and PV systems installed in the Metro.
- Based on 2015 aerial photos, 33 803 PV systems were found with a prediction confidence of 73,7 %. A large number of these are hybrid residential systems, installed in response to load shedding.



Enabling both public and private investment in Energy Storage

- It does not really matter who owns the storage assets – it can be the end customer, the distribution company, the transmission company, the generation company or an IPP, as long as the assets are made part of the total energy system and are operated to the system's overall benefit.
- How energy storage systems should be controlled must be defined and implemented from the start….
- To enable private investment, appropriate tariff signals are needed to create the business case for these assets.



The Battery Energy Storage Grid Connection Code working group is working on defining the control signals that will apply to the different categories of energy storage systems

Defining the means to aggregate and control embedded Energy Storage

The two most basic control signals for any energy storage system are:

- A signal to indicate when the system should release its stored energy;

  and

- A signal to indicate when the system should take in energy and store it;

More complex signals are those that indicate what control mode the system should apply together with the above:

- Power Factor Control
- Reactive Power Control
- Voltage

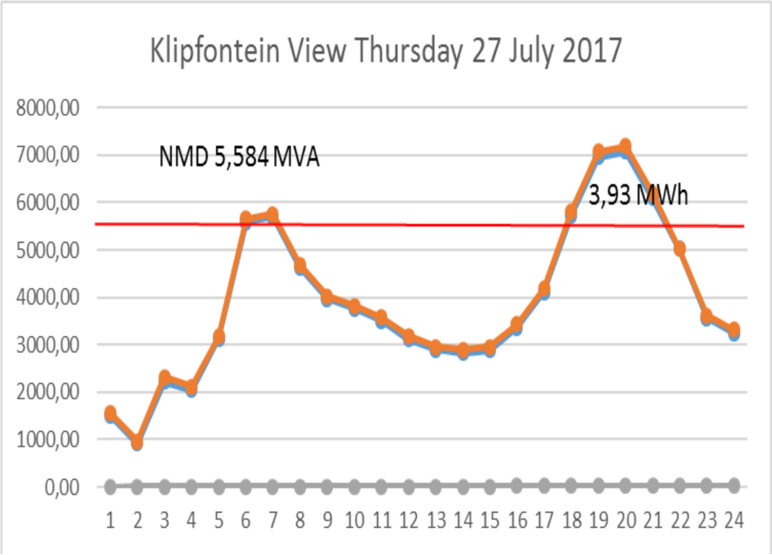
The degree of remote control that needs to be applied depends on the class (size) of the energy storage system. In addition to TOU tariff signals, SCADA systems need to now include control of storage

	System Category				
Aspect	**A1**	**A2**	**A3**	**B**	**C**
Capacity	0-13.8 kVA	13.8 - 100 kVA	100 kVA - 1MVA	1 - 20 MVA	> 20 MVA
Tariff Signal Driven	X	X			
Basic SCADA Control			X		
Full SCADA Control				X	X

Energy Storage to avoid NMD penalties, defer upgrades and unlock stalled township development

The key is to empower the planning Department-

- Introduce Energy Storage as a technology option to network planners, with relevant training on power rating and capacity factors – sweet spot seems to be around C3 e.g. 1MW power rating with a 3 MWh capacity
- Even a relatively modestly sized energy storage system can make a big difference in reducing NMD penalties
- DATA IS KING! Good quality load profile information is key to properly design energy storage systems:
    - Focus on recording reliable load profile data from whatever sources are available:
    - SCADA systems
    - Quality of Supply monitoring systems
    - Smart metering systems
- Begin the design of standardised, modular energy storage solutions that are aligned to common MV distribution feeder cable capacities and final distribution transformer (mini-sub) ratings



Electric Vehicles – mobile energy storage systems

City Power recently conducted an Electric Vehicle feasibility study where it was shown that:

- The requirements for EV charging are relatively small in energy volume terms, however the network capacity required to support EV charging can be substantial.
- The most important message from our study is that 'dumb charging' must be avoided at all costs
- In the case of residential charging, tariff and metering systems that will result in cheap, night time off-peak charging must be put in place.
- In the case of publicly accessible fast charging infrastructure, new policy is needed to manage available distribution network capacity and to define the control systems that will be required to 'max out' available capacity without tripping the system

Type	Setup	Rating (kW)	Typical Use	Charge time	Price Range[2]
Level 1 (AC, 1P)	Wall socket	3	Home	11 hrs	
Level 1 (AC, 1P)	Wall mounted / Stand	7.4	Home & Public	8 hrs	R5k - R35k
Level 2 (AC, 3P)	Stand	22 - 44	Home & Public	45-240 min	R30k – R50k
Fast Charge (DC)	Stand	30 - 60	Public	45-105 min	R200k – R500k

In Conclusion –

- Energy storage brings added value to the Distribution business
- 60% of the country’s distribution assets are in the hands of Municipal Distributors
- Eskom’s BESS program has started with large, transmission connected facilities and will expand into the Eskom distribution environment
- In terms of utility, Energy Storage seems to be more of an integral part of the distribution industry than part of the generation and transmission industry.
- The Distribution Industry has a lot to gain from Energy Storage and so should prepare for it as well as promote its up-take.

Thank You

Synopsis

- Energy storage is not a primary energy source, but is very usefully a means by which we can change the time that any primary energy source is actually utilized.
- Energy storage can also be used in support of generating technologies that operate best by providing constant baseload power such as coal and nuclear.
- This means that it is a powerful energy management tool and should not be restricted to exclusive use only in support of renewable energy.
- The location of the energy storage facility can also change the time at which the distribution grids are used to convey the energy from its source to where it will ultimately be consumed.
- This means that Energy Storage is also a powerful load management tool in the hands of the distribution industry, with good operational correlation and co-benefit aligned to the needs of the generation and transmission industries.
- It will be critical to have enough storage brought into our electricity transmission and distribution systems as soon as possible, in order to facilitate a smooth transition from a system dominated by fossil fuel energy sources to one dominated by renewable energy.
- There is added value - the so-called stacked value – of putting energy storage assets deeper into the electricity distribution network, than what can be realized by focusing only on large, transmission connected energy storage systems. The point to be made is that energy storage behind the utility meter has a higher economic value than the transmission connected assets, provided the transmission system operator is empowered with the rights to control all the energy storage assets connected to the system.
- These enhanced benefits include a step change in the security of supply at an end customer's premises, particularly if load shedding is imposed on the system, an ability to use the assets for daily arbitrage to reduce energy costs, as well as a means to reduce distribution network bottlenecks to avoid costly network upgrades or unlock stalled housing projects where the constraint is additional peak capacity needed only over a relatively short period of time, typically in the evening.
- 60% of the country's distribution assets are in the hands of municipal distributors. Energy storage has added value to, and seems to be more part of the distribution industry than the generation and transmission industry. Municipal distributors have a lot to gain from Energy Storage and so should prepare for and promote its up-take.

Siju Joseph

Manager: Ancillary Services - Eskom

Siju Joseph heads up the Ancillary Services department at the System Operator (SO) in Eskom. He is currently the alternate member for the SO at the Grid Code Advisory Committee hosted by NERSA and he has been actively involved in the compiling of the draft BESF Code. He also represents the SO in designing certain IPP programs.

A SYSTEM OPERATOR PERSPECTIVE ON ENERGY STORAGE

SAIEE Energy Storage Chapter Launch

A System Operator perspective on Energy Storage

Presented by

Siju Joseph

04/11/2020

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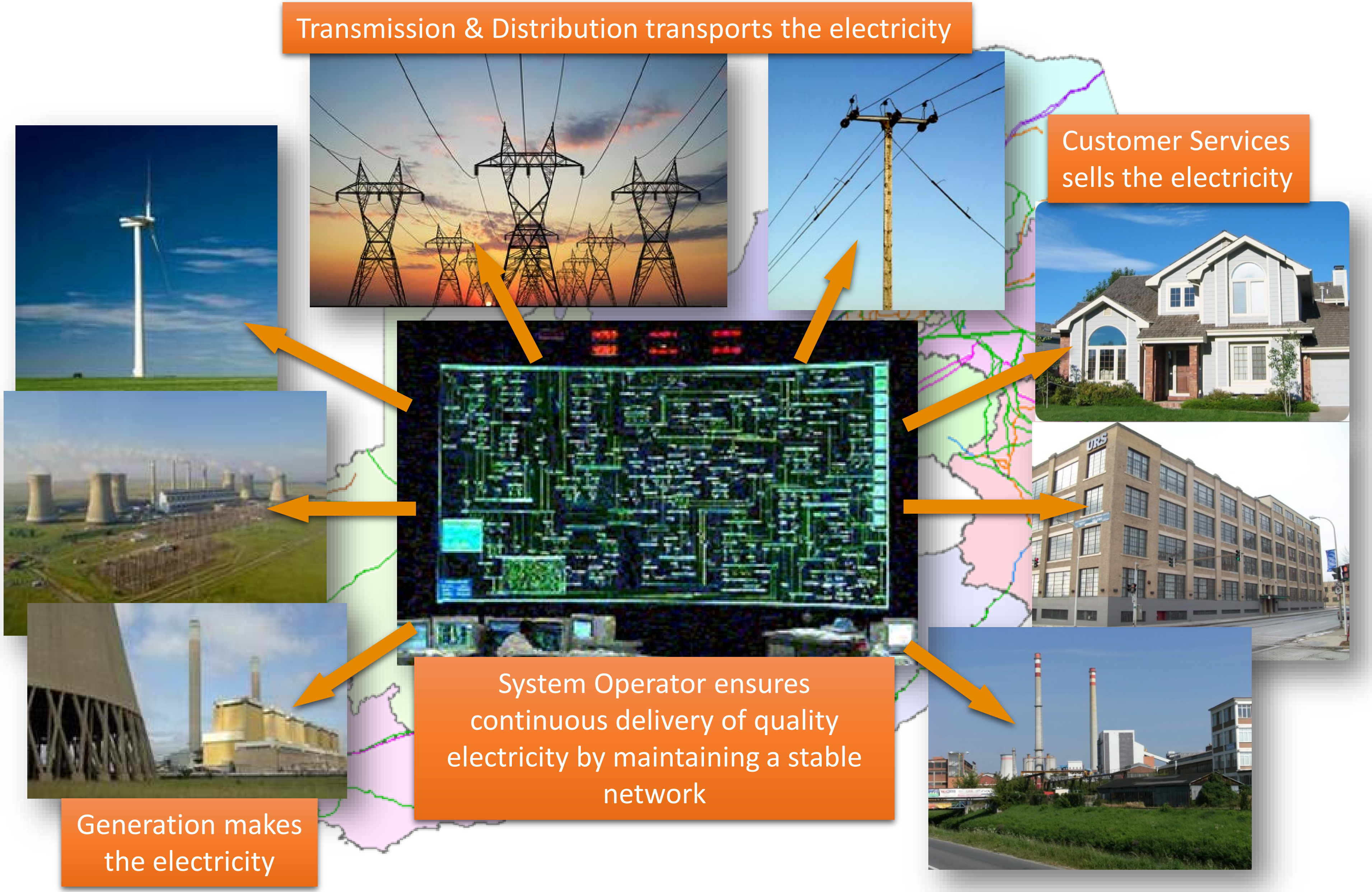
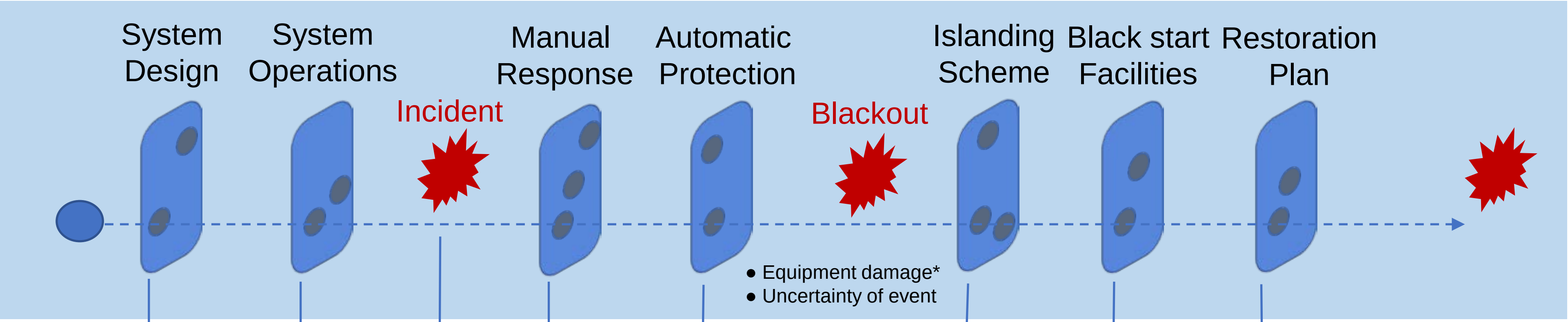
Who is the System Operator?



How does the SO ensure reliability and security?



- General Grid Code compliance (e.g. generator specs, two facilities)
- System Operations best practice (reserves, skills)
- Network flexibility beyond design criteria (e.g. reactors)

- Operational planning (reserves)
- Outage scheduling (Tx, Gx risk assessments and decisions)
- Real-time operations/response
- Protection implementation
- Situational awareness (visibility)

- Response procedures (incl. Load shedding protocols, manual island)
- Control room skills/intuition (knowledge and experience)
- Third party (Munic control rooms)

- Special protection schemes (automatic under-frequency, low voltage, reverse-power, transient stability, out-of-step, inter-lock, power system stabilizers, sub-synchronous resonance, etc)

- Coal automatic unit islanding (new units > 200MW) at identified Power Station
- Islanding procedures (tested)
- Power station operator skill/intuition to manage the unit
- Resources (e.g. fuel oil as required)

- Blackstart facilities Procedures (tested)
- Power station operator skill/intuition to manage the restart
- Resources

Speed of restoration Increase exponential based on islanded units

Blackstart vs. Selfstart (supply auxiliaries of another relevant unit)

SO mandate: “To control the operation of and be responsible for **the short-term reliability** of the Interconnected Power System as defined in the South African Grid Code”.

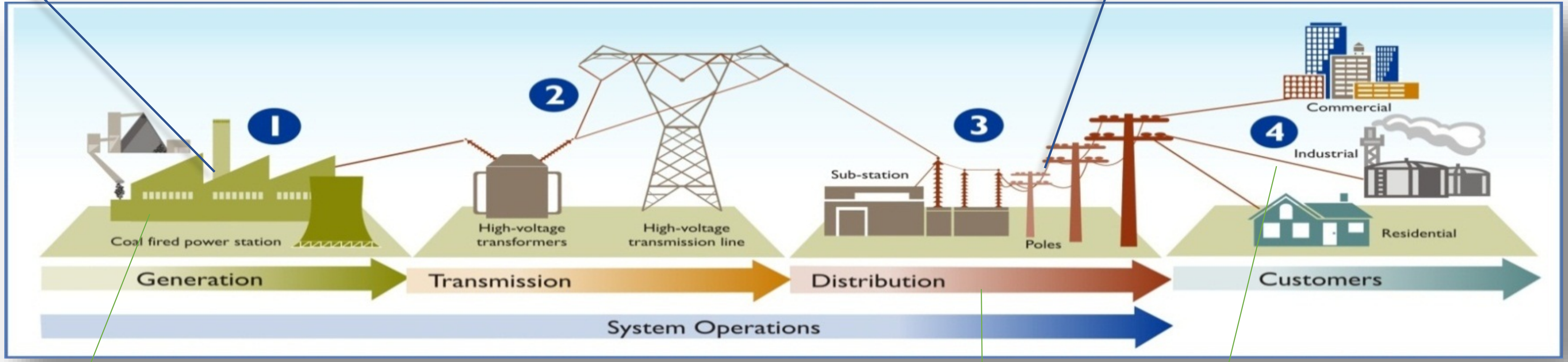
Contents

Impact of RE on system operation

Traditional challenges of the System Operator (SO)

contingencies

Variable demand and uncertainty



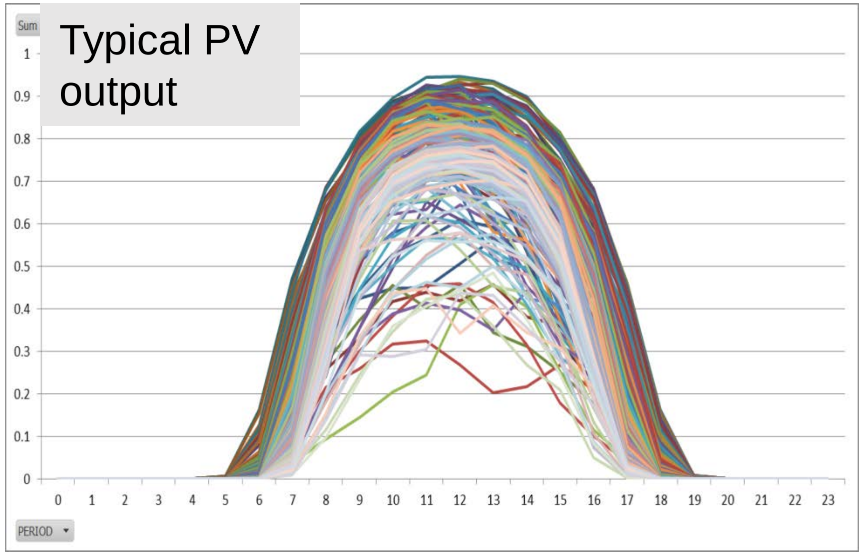
Future challenges of the SO

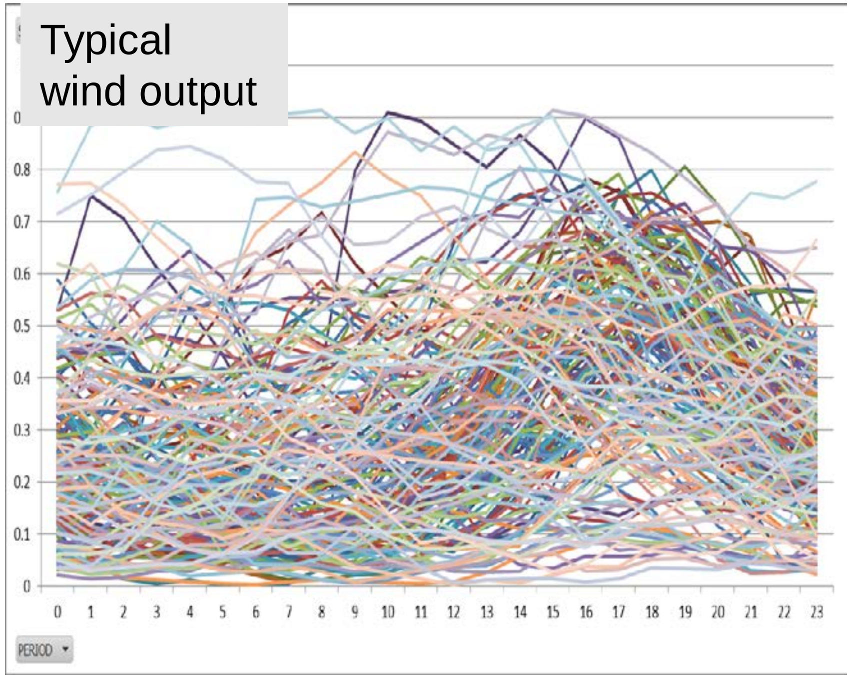
Variable renewable energy

Distributed energy resources

Roof top PV and E-vehicles

Variability of RE output





- This variability will require future generators to be **more flexible** as more of the thermal units reach their plant life.

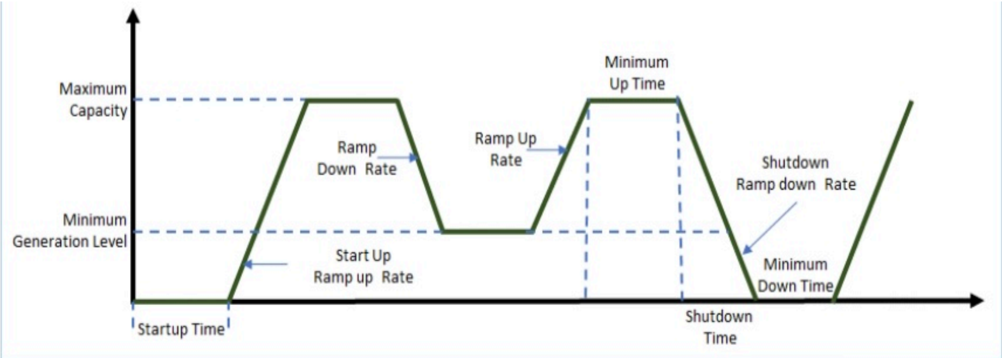
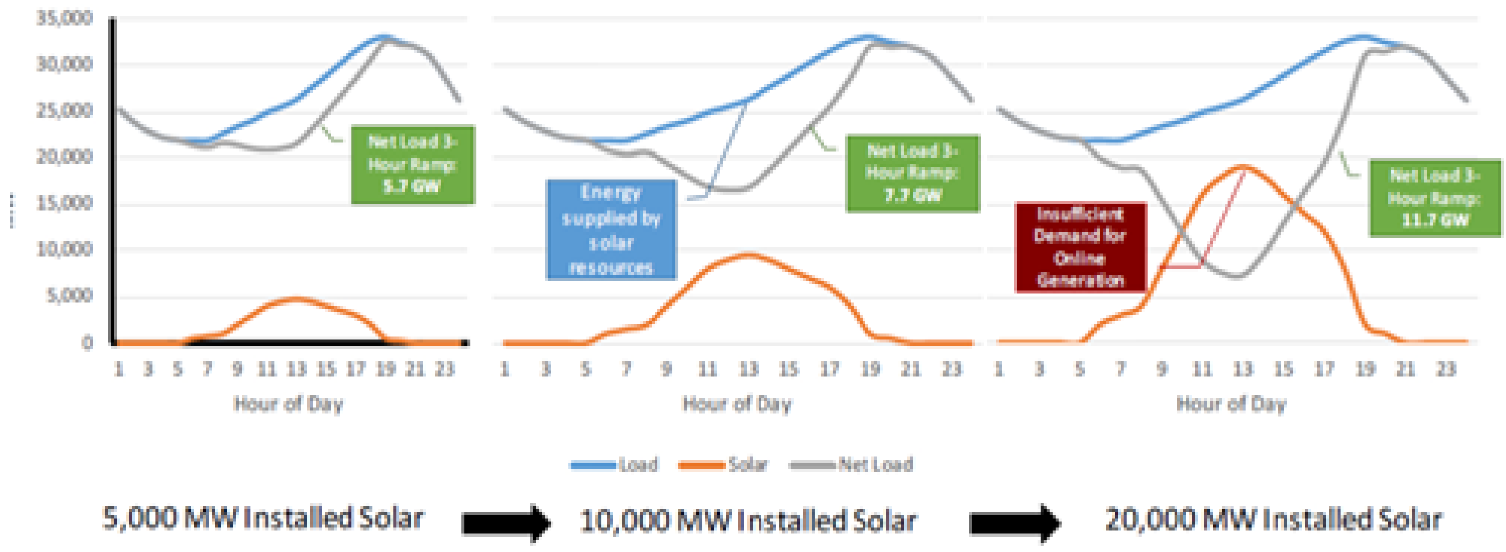


Figure 2. Flexibility attributes of generators

Source: Adapted from Agora 2017

Flexibility- ramp rates example

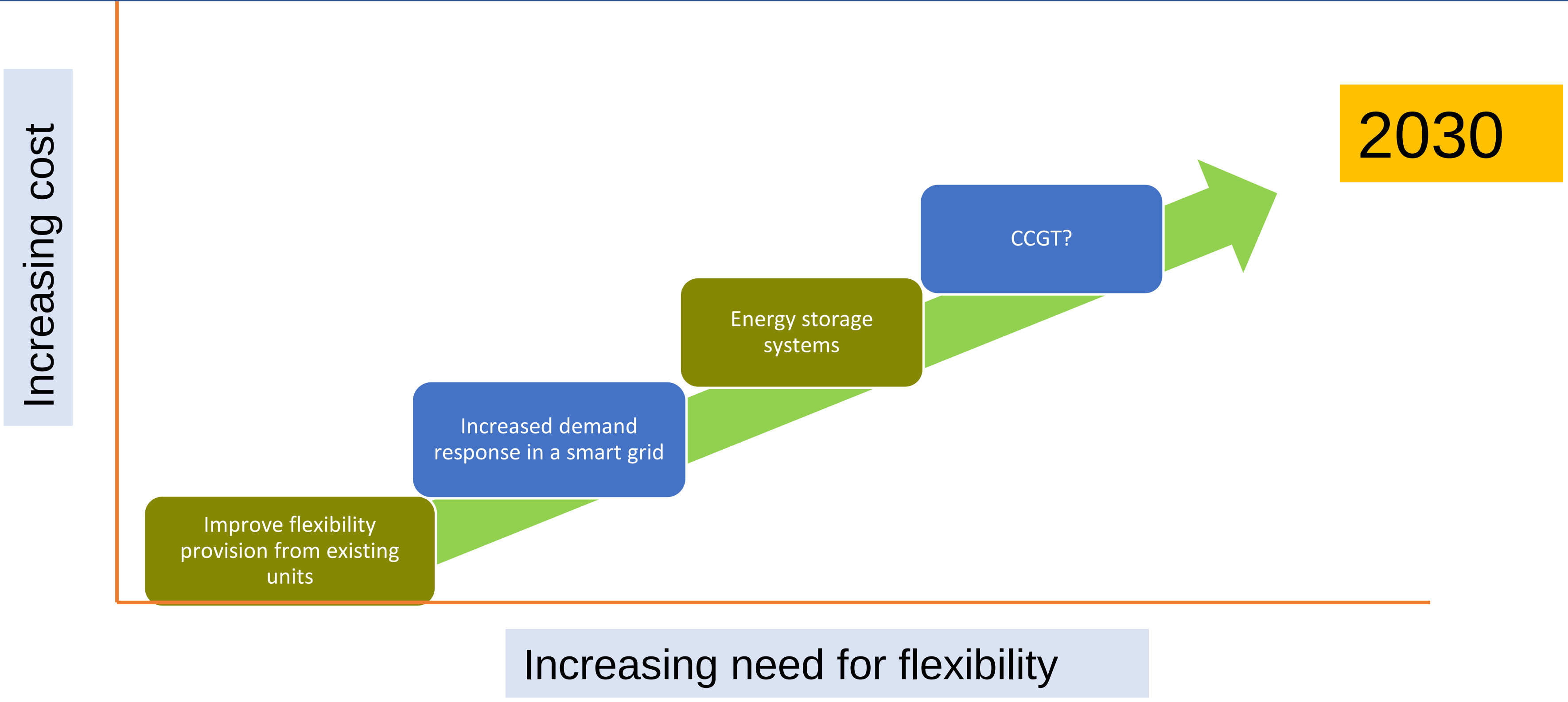


Example of increasing solar resources leading to increased ramping requirements

(Source: NERC, 2019 Long-Term Reliability Assessment)

Need for flexibility in the future

- Successfully managing the evolving grid comes down to ensuring the grid is **flexible enough** to handle the characteristics of new resources and capitalize on their capabilities to the benefit of customers.
- Ancillary services are used to provide that flexibility in most utilities



FERC definition

- “A resource capable of **receiving electric energy** from the grid and storing it for **later injection of electricity** back to the grid regardless of where the resource is located on the electrical system.”

ES providers

- pumped hydroelectric storage, compressed air energy storage, flywheels, and **batteries (BESS).**

- **Ingula is a pumped storage**
- **1332MW/ 14hours**

- Chemical batteries “density” of energy is perhaps better compared to the pumped storage?.

EXCITING FUTURE

- RE + ES?
- Long term storage? Hydrogen? CAES?
- Spawning new service providers such as Aggregators?
- IoT or smart-grids?

Contents

(AS) Grid Code Definition

- Services supplied to the *NTC* by *generators*, *distributors* or *end-use customers*, necessary for the reliable and secure transport of power from *generators* to *distributors* and other *customers*

Why and what services

- The *System Operator* shall be responsible for the provision of all short-term reliability services for the *IPS*. These include restoration, the balancing of supply and demand, the provision of quality voltages and the management of the real-time technical risk

Ancillary Services Technical Requirement

- Published yearly on the Eskom website
- States what is needed to ensure system reliability
- Assists with procuring the services

AS Products/Services

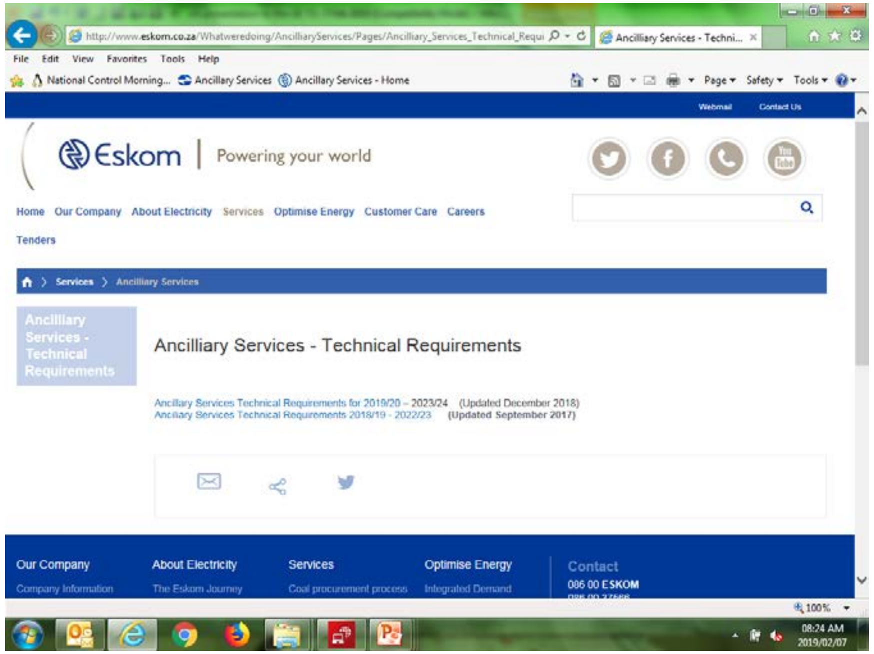
Reserves
(Generation & Demand Response)

Energy Imbalance
(Constrained Generation)

System Restoration Services
(Black-Start & Islanding)

Reactive Power
(Voltage Control)

AS Technical Requirements



(https://www.eskom.co.za/Whatweredoing/AncilliaryServices/Pages/Ancilliary_Services_Technical_Requirements.aspx)

- Reserves requirement

Reserve	2020/21 MW	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW
Operating	2200	2200	2200	2200	2200
Emergency	1600	1600	1600	1600	1600
Total	3800	3800	3800	3800	3800

- **Blackstart requirements**

- **The GC requires SO to have at least 2x black-start facilities for restoration purposes.**
- **Facilities to be located in a suitable location for restoration purposes**
- **SO to ensure that the facilities are tested every three and six years as detailed in the SAGC**
- **SO to determine minimum additional requirements to ensure that those suppliers are capable of providing the service.**
- **.**

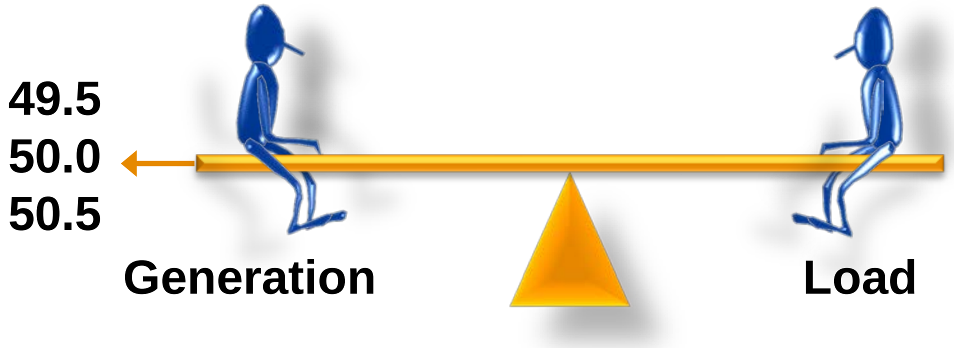
Eskom Generation

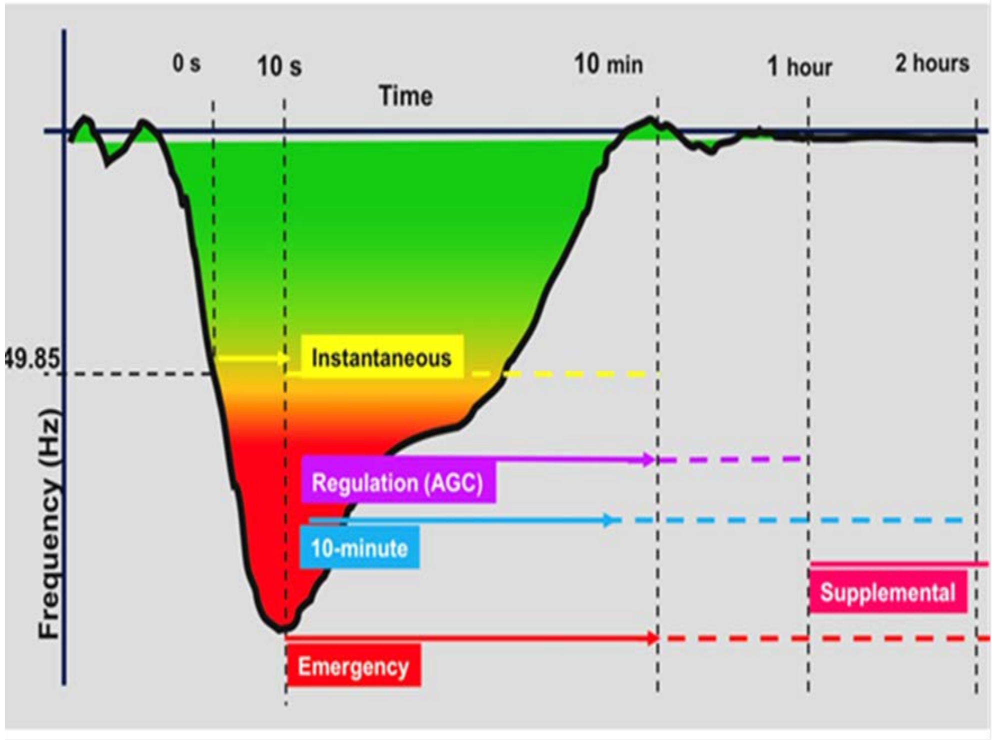
- SO procures ancillary services from Eskom Generation, mainly from the coal units and Pumped storage

Demand Response

- Contracts with large customers to avail their load to be used in case it is needed. There is currently almost 850MW IDR and 350MW of SDR.

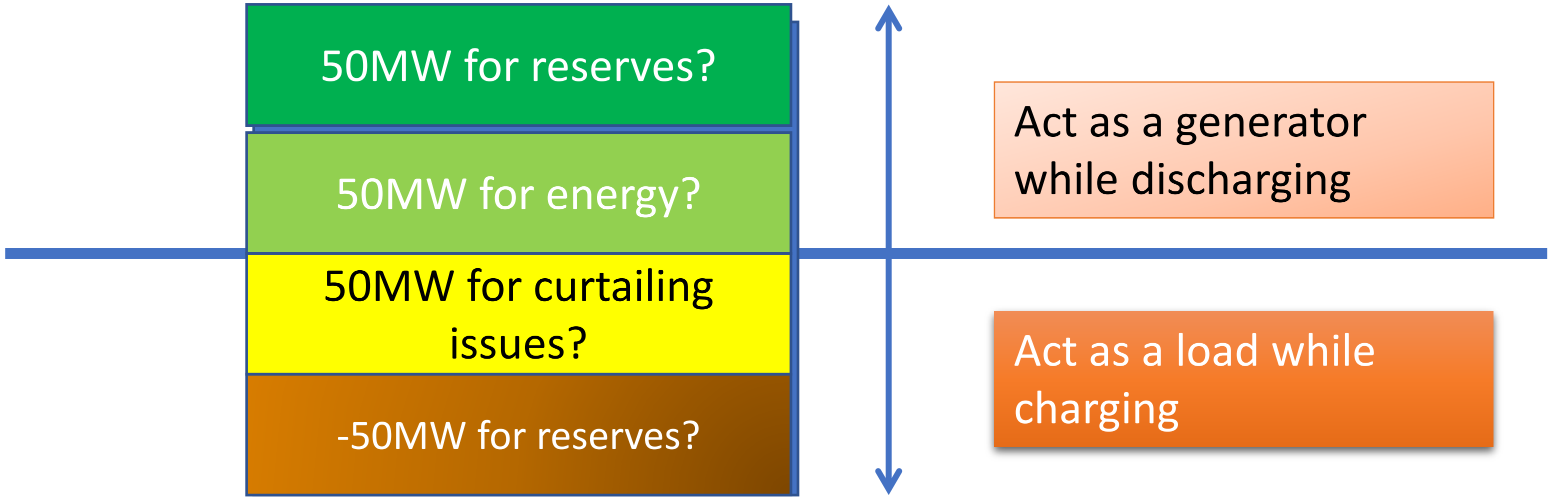
FUTURE: BESF providing ancillary services





BESF- the veritable **Swiss knife** for power systems?

IDEAL 100MW BESF



- In future the BESF will assist with **fast frequency response** (millisecond response)
  - This COULD greatly assist the system with issues such as inertia (synthetic).
- BESF could provide the much **needed flexibility** (min gen, ramp rates, start-up/shut-down times)
- The System Operator **constantly evaluates** the IRP and other inputs to determine if the system may require other types of ancillary services

Examples of possible SO contracting

ENERGY SUPPORT REQUIREMENTS

- The BESS shall have capability to be operated to provide capacity to meet the **energy demand** on the grid.
- On a daily basis, the **expected hourly availability** of the BESS capacity shall be submitted to the System Operator by the BESS Owner.
- During the hours that BESS is contracted for energy, its **capacity shall be made available** for supplying energy to the grid.
- Scheduling and dispatch of BESS capacity to supply energy will be done as per **Scheduling and Dispatch Rules**

ANCILLARY SERVICES REQUIREMENTS

- The System Operator requires the following reserves for ancillary services from the BESF

Reserve type	% MW Available capacity	Maximum response time (Full activation)	Maximum required duration to maintain response	Notification time	Typical dispatches
Instantaneous	+/-100%	400 milliseconds	10 minutes	Automatic	2/day
Regulating	+/-100%	4 seconds	1 hour	Automatic	300/hour
Ten minute	+/-100%	1 minute	2 hours	1 minute	2/day
Supplemental	+/-100%	1 minute	2 hours	10 minutes	1/day

Contents

Drivers for BESF Code Development

- **Technology advancement** that define the future power grid
- Limited resources for **ancillary services** on the utility grid
- **Intermittent generation** sources can reduce reliability on the electrical grid.
- **Lack of technical requirements** for Storage technologies in the Grid Code which results in confusion for developers and Network Service Providers when new connections are requested.

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- The BESF Code is still in draft phase. Fruitful interactions have taken place with the industry through the GCAC's IET process
- The draft code is to be submitted to NERSA early November

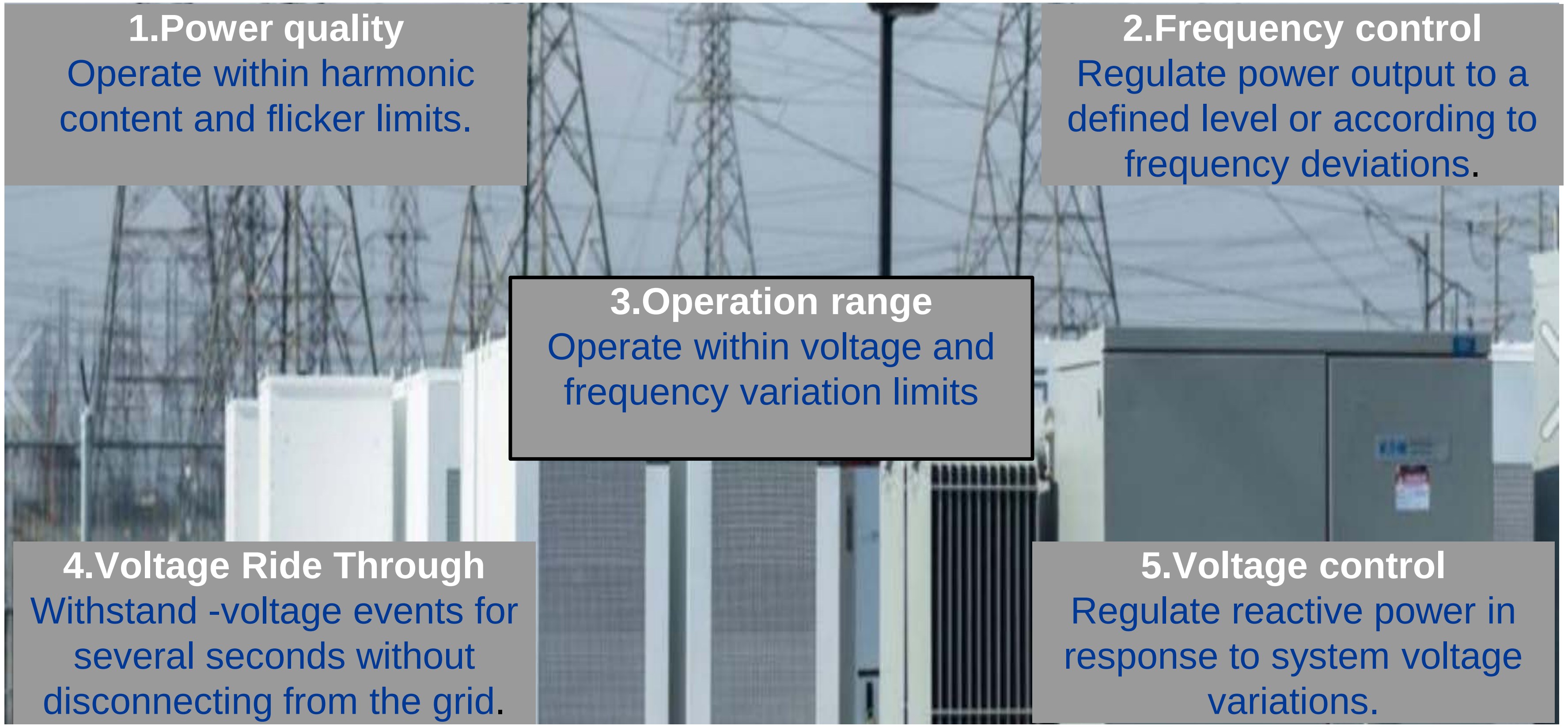
Draft BESF Code outline

CONTENTS

Category	Rated power of *BESF*		
A	>0	to	< 1 MW
A1	>0	to	≤ 13.8 kW
A2	>13.8 kW	to	<100 kW
A3	≥100 kW	to	<1 MW
B	≥1 MW	to	<20 MW
B1	≥1 MW	to	<5 MW
B2	≥5 MW	to	<20 MW
C	≥20 MW	-	-

Note: For a category A *BESF* connected to multi-phase supplies (two- or three-phase connection at the *POC*), the difference in installed capacity between phases may not exceed 4.6 kW per phase

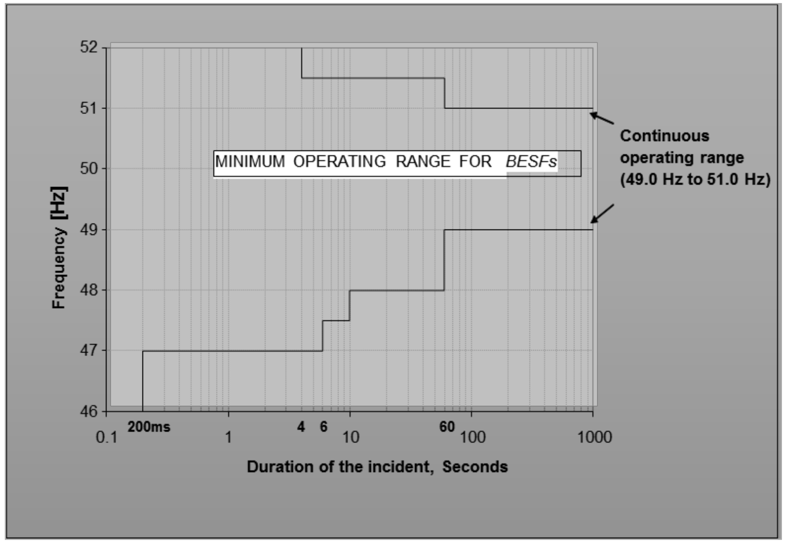
Technical Aspects Regulated by BESF Requirements at POC

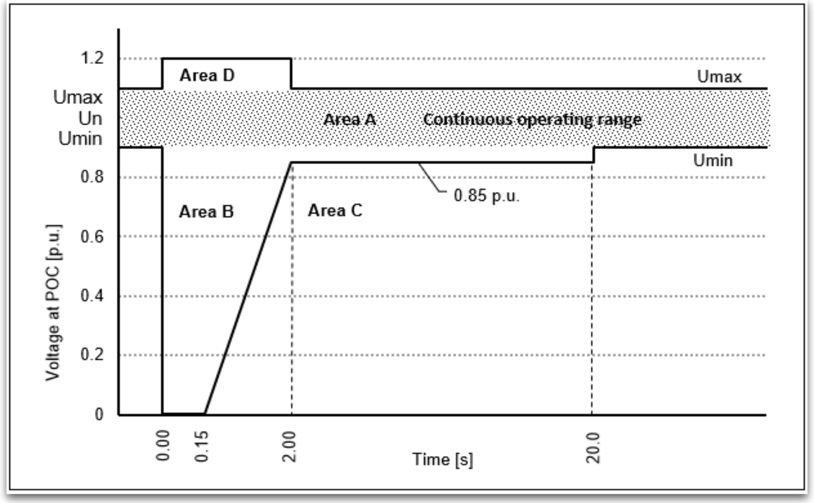


Other requirements: Signals, Communication & Control, Plant Models, etc.

Examples of technical capabilities

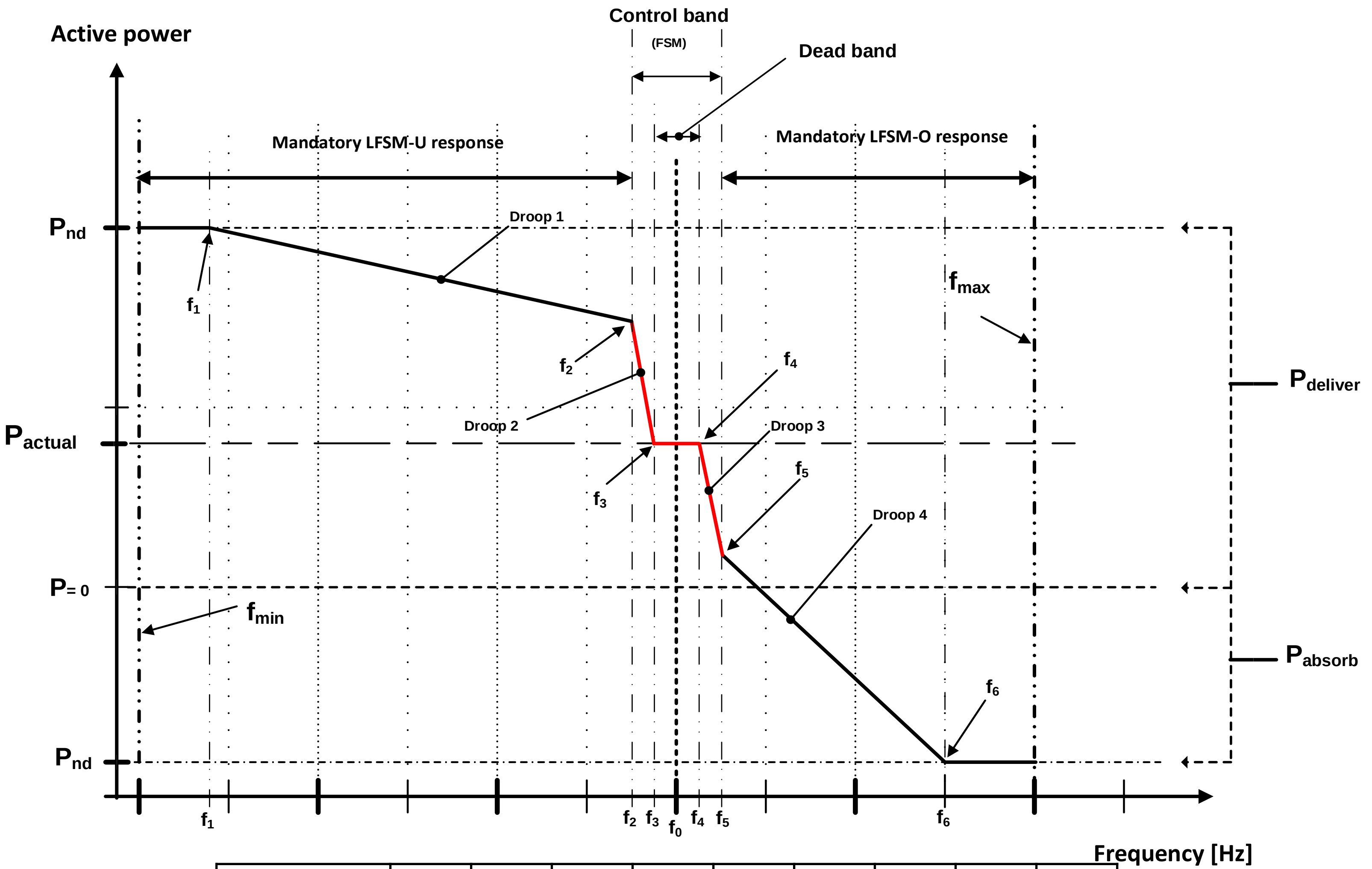
- The BESF shall be designed to be capable of **operating continuously** within the POC **voltage** range and **frequency** specified under normal operating conditions described in this grid connection code while reducing the active power as little as possible.





- **VOLTAGE RIDE THROUGH**: The BESF shall stay connected to the network & keep operating following voltage dips & surges caused by short circuits or disturbances on any or all phases in the network

Frequency response – Normal frequency range



Parameter	f_{min}	f_{max}	F_0	f_1	f_2	f_3	f_4	f_5	f_6
Frequency [Hz]	47.00	51,50	50.00	47.50	49,50	49.85	50.15	50.50	51.10

Thank you

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