Renewable energy integration and energy storage

Power Transmission in Africa, conference presentation

31 January 2019

A brief introduction

A little about me…

- CEO and Co-Founder of Bushveld Energy, an energy storage solutions company and part of London-listed Bushveld Minerals, a large, vertically integrated, vanadium company in SA
- Since 2015, BE is focused on vanadium redox flow battery (VRFB) technology, developing projects across Africa and establishing manufacturing in South Africa
- Chair of Board of South Africa Energy Storage Association (SAESA) and chair or Energy Storage Committee for Vanitec, the global association of vanadium producers
- Previously a consultant in Russia and across Africa, focusing on power sector strategy and project delivery, and co-author of 2015 report “Brighter Africa”

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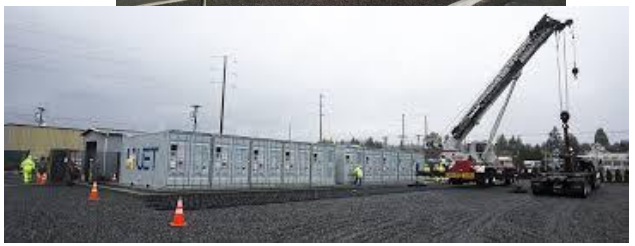
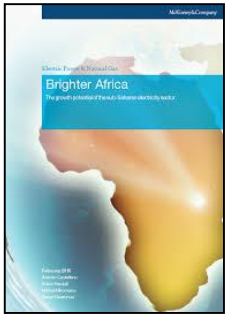




SOURCE: Bushveld Energy

Battery storage (BESS) in particular offers many confirmed benefits for a power system, as well as individual customers

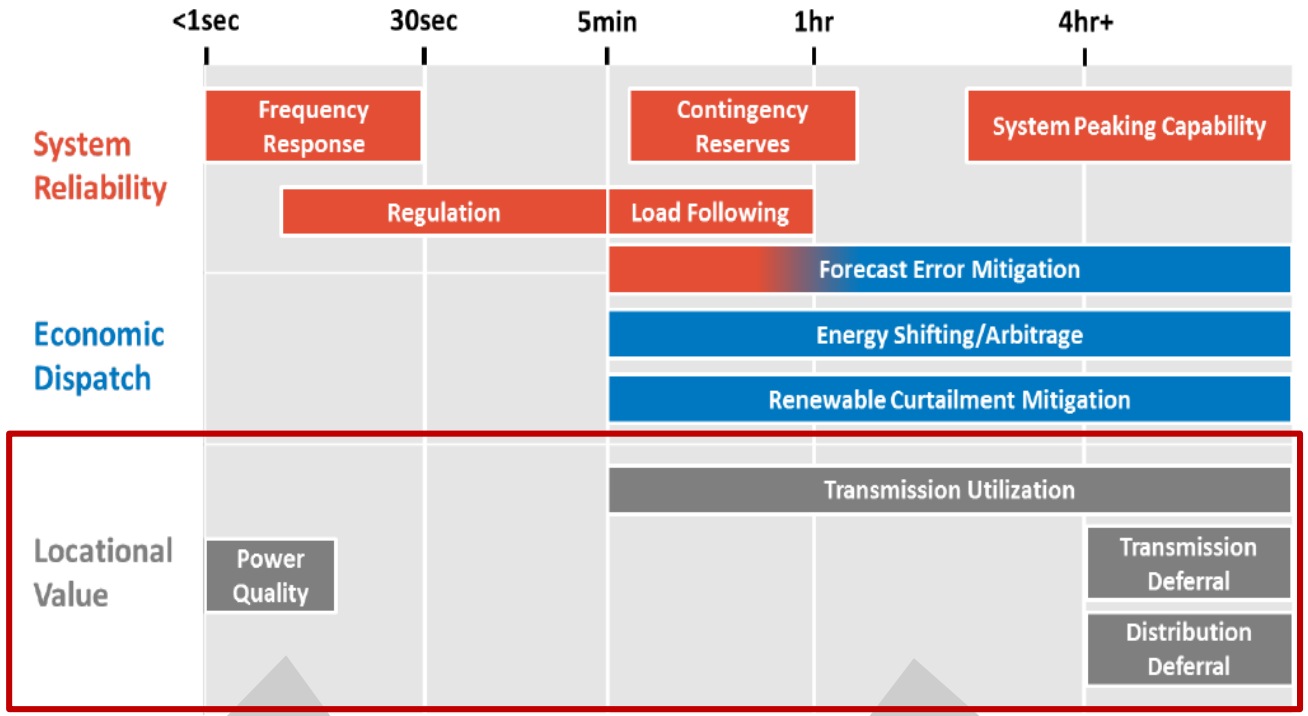
Today's focus

Similar to how **trans-mission** lines move electricity **from one location to another**, **energy storage** moves electricity from **one time to another**

While oil and coal, are examples of "stored energy," our focus is **reusable means to store energy**, such as batteries ("electro-chemical storage), but also heat, mechanical devices, etc.

Different types of storage and storage technologies are relevant for different applications, often determined by the **amount of time stored energy is required**

Utility scale energy storage use cases and their relevant time scales



Can only be provides by distributed storage technologies, usually of 1-10MW size

Other benefits such as
- Technical loss reduction
- Time shifting of losses
- System resiliency

Source: PGE IRP Draft (Nov 2016)

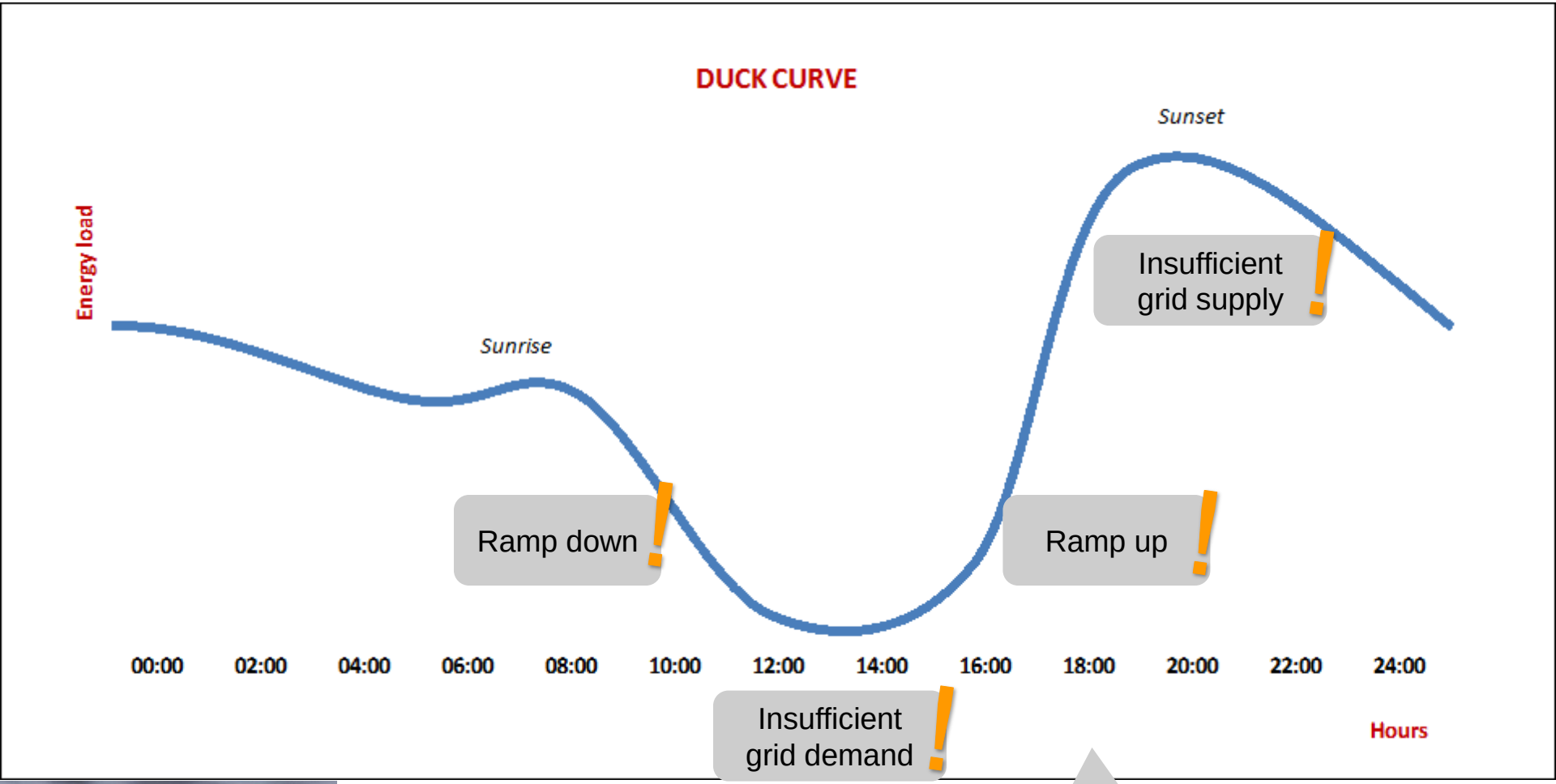
We will cover three examples of renewable integration challenges posed to transmission networks that could be addressed by BESS

A **Decreased overall system utilisation and requirement for "network overbuilding"**

B **Regional integration challenges that do not appear on national energy models**;

C **Deferral of network expansion, especially in radial grids**

A The typical risks of adding significant renewable energy, especially solar, to a power system are often summarised in the “duck curve”



These are usually considered an issue of power generation

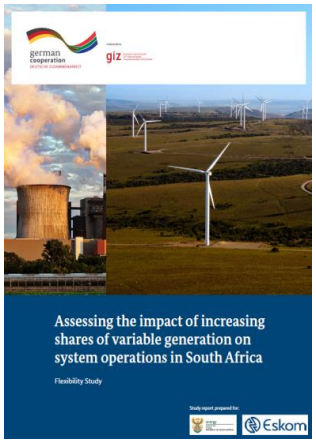
A A recent report for Eskom and the DoE highlighted a number of benefits of distributed energy storage to South Africa power system operations

Discussed further

A recent report for Eskom and the DoE assessed the impact of renewable energy on SA system operations

Report context

- Based on generation forecasts from the draft IRP 2016 and 5-10GW of rooftop solar PV;
- Considered national system requirements in 2020 and 2030 due to increasing renewable penetration and potential integration challenges collectively known as the "duck curve;"
- Overall, the report concluded that **SA's system could absorb all planned renewable generation through 2030.**



While not focusing on energy storage, the report's conclusions and analyses noted 5 factors quite valuable for South African energy storage business case

I. **Cycling cost** of non-renewable generation (such as coal) would **increase to 300%** of current levels by 2030 to USD0.86/MWh due to steeper ramp rates. Storage can also absorb major **voltage fluctuations** and reduce transformer tap changer activity (reducing Tx maintenance costs).

II. The **Operating Reserve and Emergency Reserve** would need to **increase up to 80%** from 3-6pm. Energy storage could **provide** both of these types of **instantaneous reserves;**

III. Overall **power system utilisation (Dx, Tx and Gx) would fall significantly** due to the addition of renewables by 2030. Significant deployment of **distributed energy storage in the Dx grid** would increase utilisation;

IV. To cope, SA **would need to build 7.3 GW of CCGT and 4.6GW of OCGT in new gas generation**. Much of this "mid-merit" capacity could **be replaced by energy storage**, as is already happening in the US and China;

V. The study **excludes but recommends assessment of localised system challenges**, such as voltage control. This localised value is another well-tested benefit from distributed energy storage.

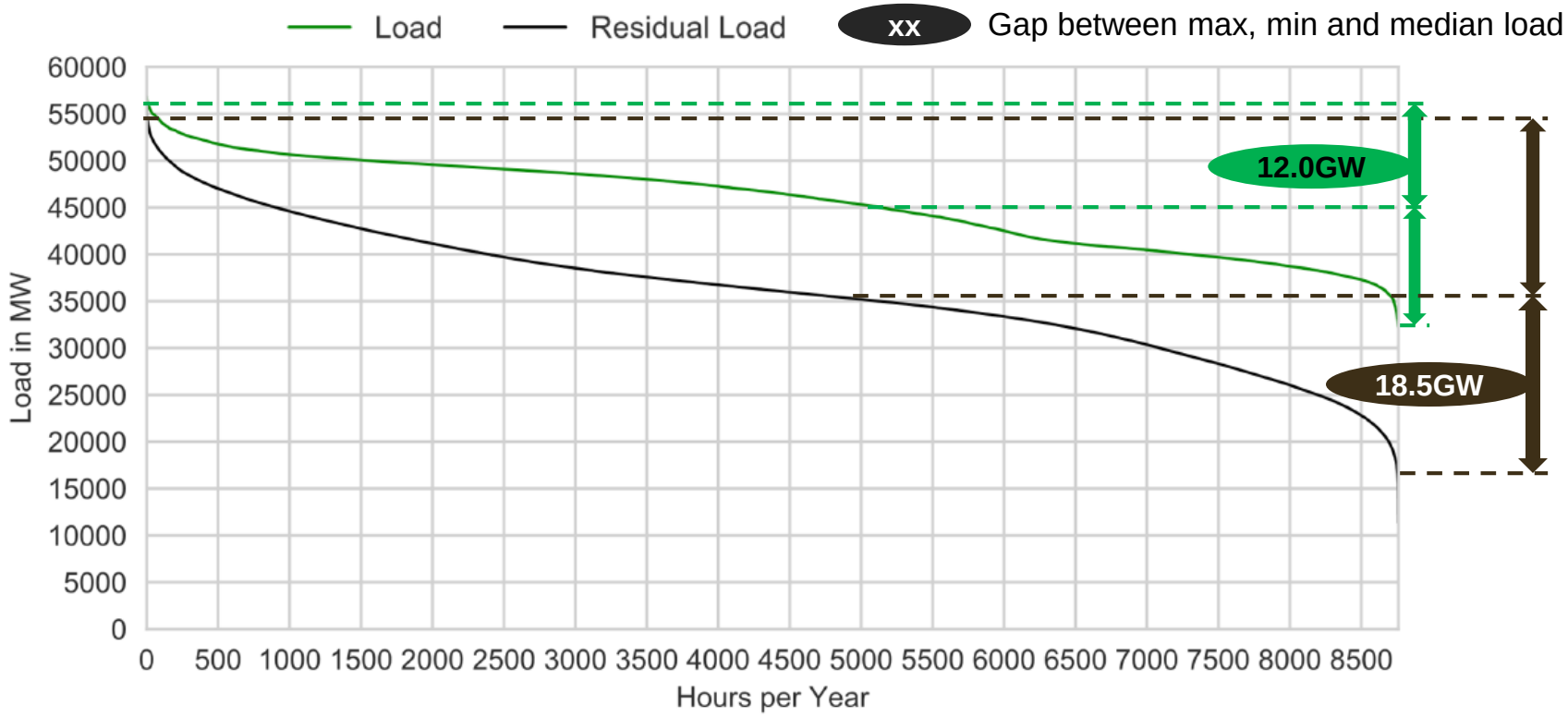
"Distributed battery storage…would help to reduce Operating Reserve requirements and cycling costs by storing power during mid-day and feeding it into the system during evening hours."

- Recommendations and outlook (page 65)

SOURCE: "Assessing the impact of increasing shares of variable generation on system operations in South Africa - Flexibility Study," September 2017

A Overall, South Africa's power system utilisation would fall significantly due to the addition of renewables by 2030

The addition of renewable energy reduces South African system utilisation, as the gap between maximum, minimum and median load increased by over 50% by 2030

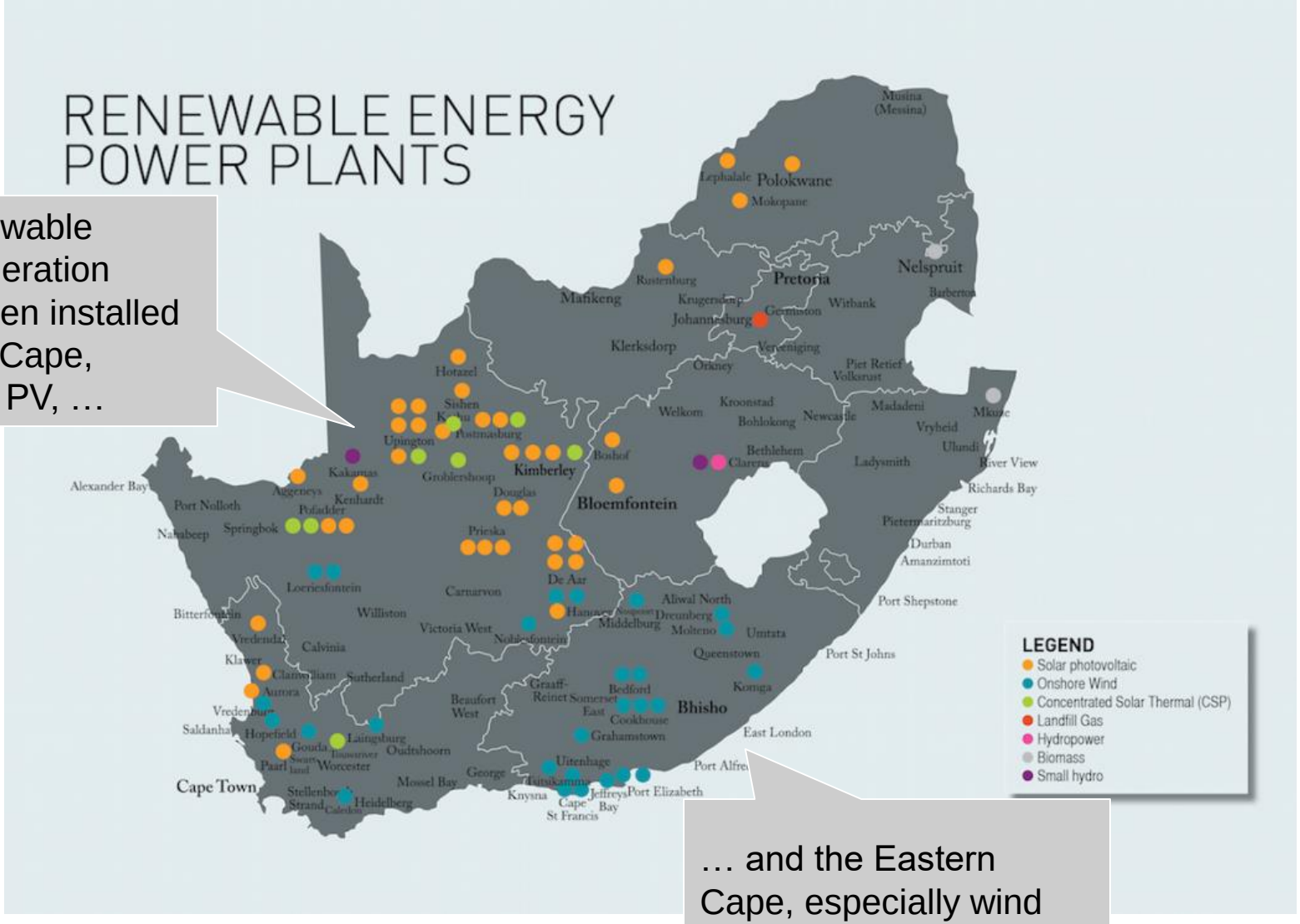


- Lower system utilisation means that especially Distribution and Transmission are utilised much less, requiring **overbuilding and overspending**
- Installation of **distributed energy storage** throughout South Africa's grid directly **improves utilitsation** of the system by reducing the maximum load and increasing the minimum load, bringing the system into better balance

SOURCE: "Assessing the impact of increasing shares of variable generation on system operations in South Africa - Flexibility Study," September 2017, Figure 39: Impact of VRE on the Residual Load (2030, Scenario A + 20GW rooftop PV); Bushveld Energy analysis

B There is currently a regional misalignment between new renewables and existing transmission and distribution infrastructure in SA (1/2)

Most new Renewable Energy IPP generation capacity has been installed in the Northern Cape, especially solar PV, …



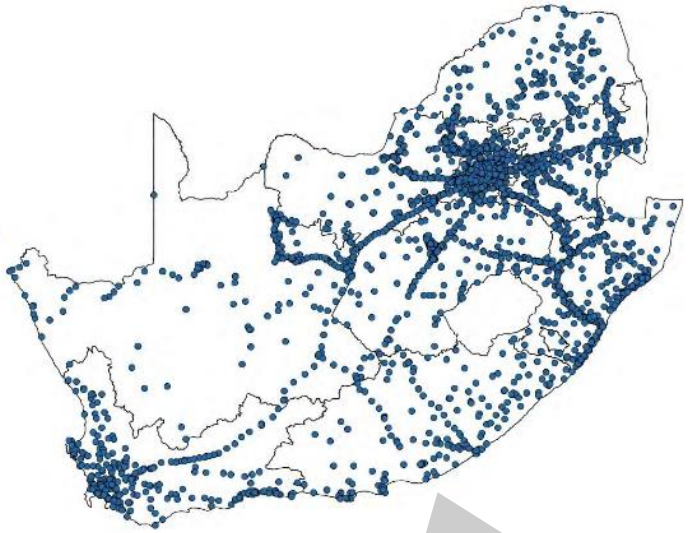
… and the Eastern Cape, especially wind

Source: Eskom, DOE

B There is currently a regional misalignment between new renewables and existing transmission and distribution infrastructure in SA (2/2)

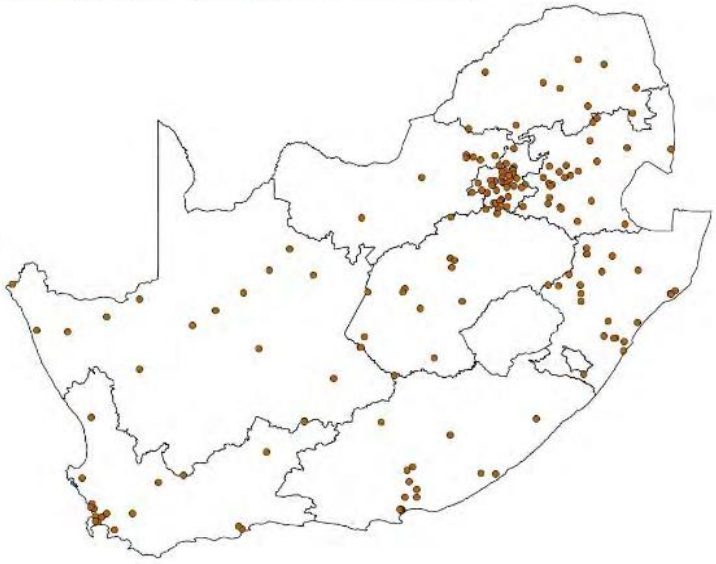
Yet, those two provinces have the least installed transmission and distribution capacity in the South African power system

Installed Distribution transformation capacity 101 197 MVA[1]



1: Eskom Integrated Report 2016

Installed Transmission transformation capacity 143 440 MVA[1]



1: Eskom Integrated Report 2016

- This creates multiple challenges locally that may not appear in national models (e.g. CSIR, IRP), such as
  - Power evacuation constraints
  - Power quality
  - Demand and load imbalance
- Strategically positioned energy storage would alleviate these locational challenges

Source: Eskom, DOE

C A couple of case studies from Texas, USA, show the immense value of BESS in deferring transmission expansion

Context to grid constrains at Two small, remote communities served by long power lines

Comparison of BESS vs traditional capacity expansion options

	Traditional option	Battery storage option

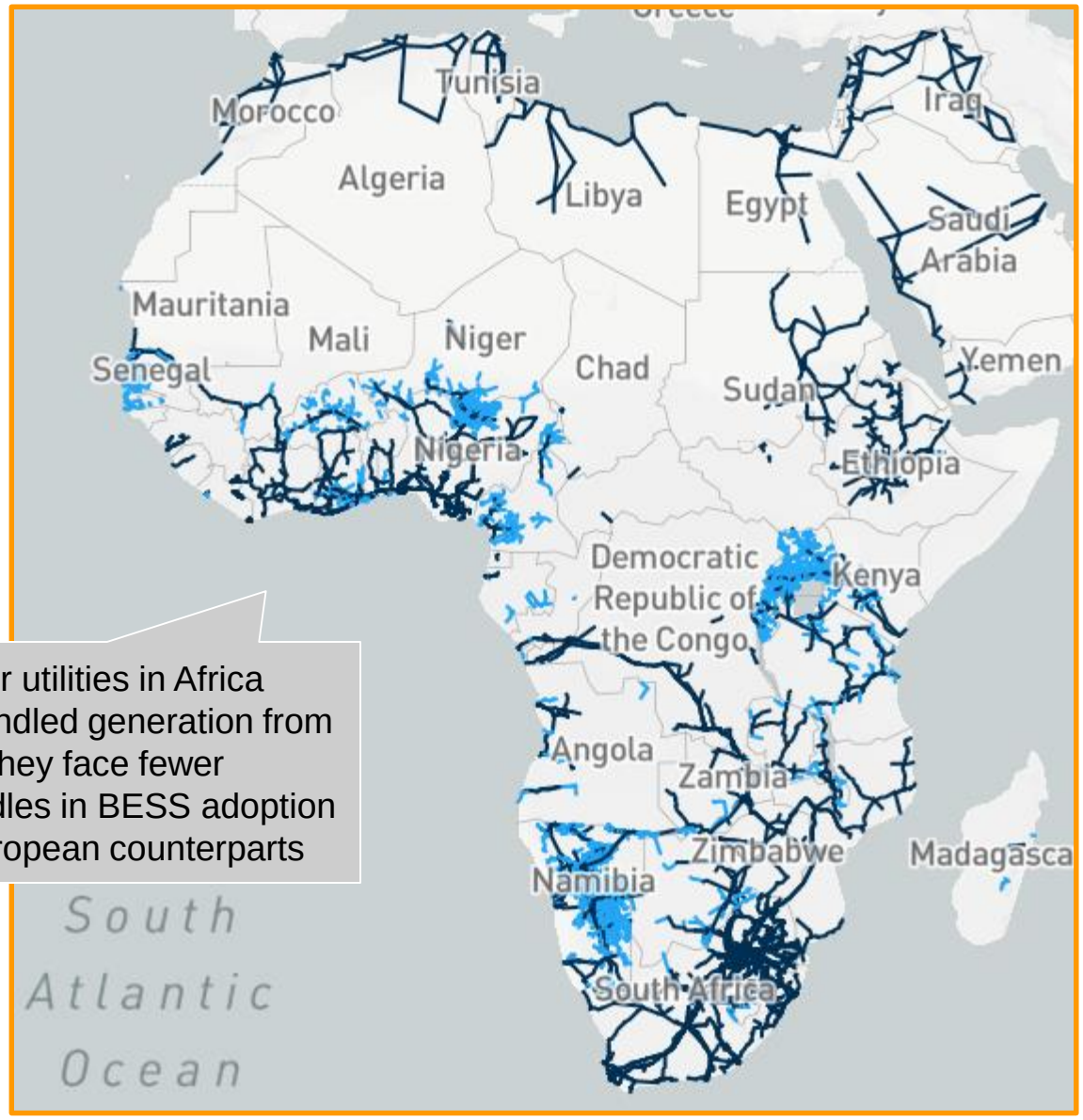
• 217 customers in Woodson, Tx:
  • Served by a radial 12-mile distribution feeder;
  • Experiencing 3 times the number of outages of the utilities average customer;
	• Construction of a new transmission line and substation;
	• Cost of USD **$6 - $17.2 million;**
		• Installation of 1MW/2MWh battery;
		• Cost of USD **$1.6 million**;

• 273 customers in Paint Rock, Tx:
  • Served by a single 1.0 MW distribution substation;
  • Peak load on the Paint Rock substation transformers is 1.1 MW, a 10% overload;
  • Impossible to add any new electrical load without expansion;
	• Substation upgrade;
	• Cost of USD **$5.3 million**;
		• Installation of a 500kW/1,000kWh battery;
		• Cost of USD **$700,000**;

- In both cases, **installation of BESS represented a savings of 73 - 86**% over traditional options;
- Despite the clear performance and financial benefits to the utility and community customers, the projects remain blocked due lack **of regulatory clarity** whether generation or transmission companies are allowed own storage assets.

Source: www.elp.com

C How many such applications are there among Africa's radial and disconnected Transmission networks?

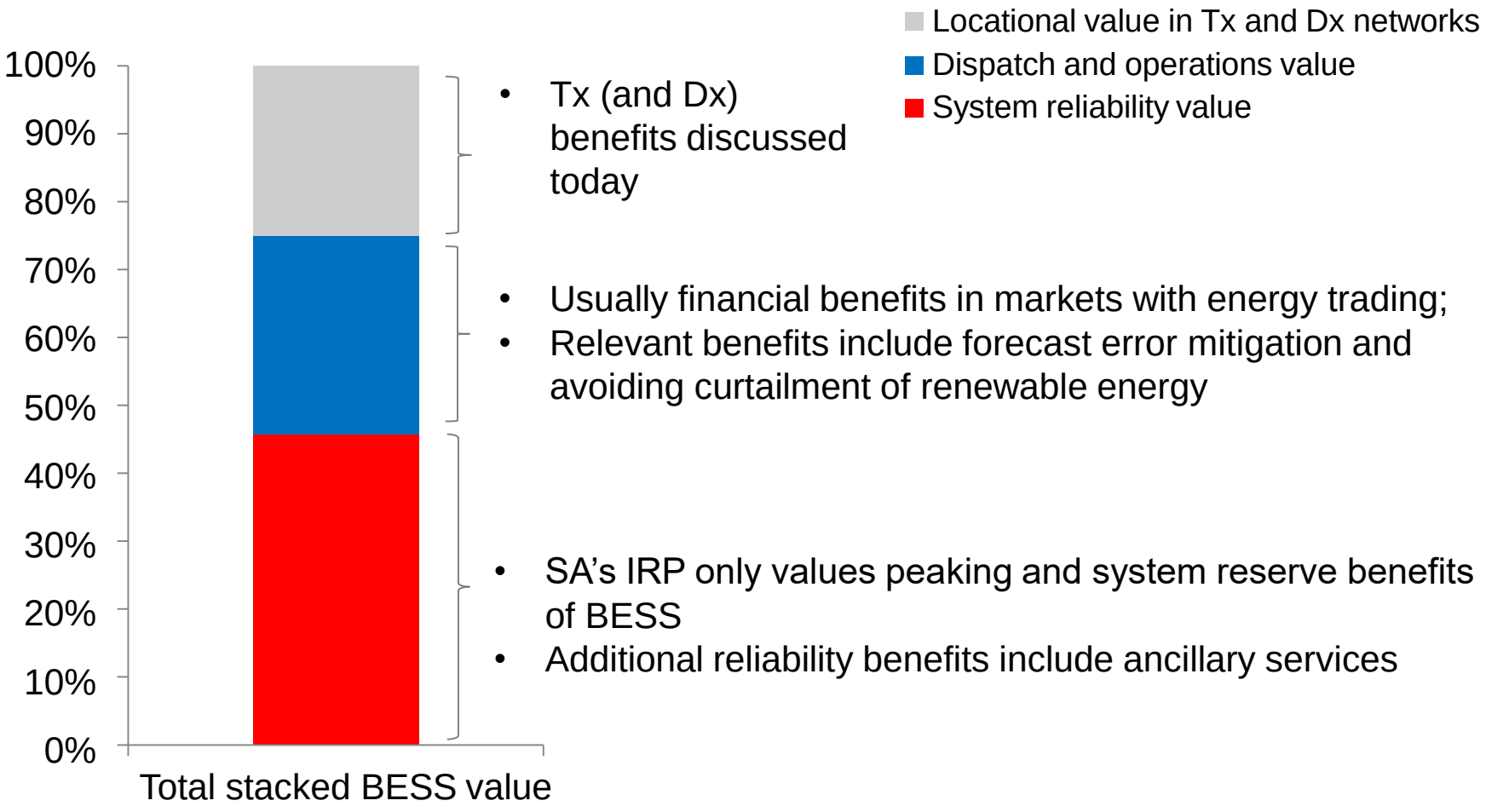


As many power utilities in Africa have not unbundled generation from transmission, they face fewer regulatory hurdles in BESS adoption than US or European counterparts

Source: Africa Electricity Grids Explorer, World Bank

Remember that the Tx benefits of distributed storage can actually be added on top of their value to system capacity and operations

A single battery, well-located within the power system has the ability to provide value across capacity and system operations on top of the discussed Tx benefits



- Tx (and Dx) benefits discussed today

- Usually financial benefits in markets with energy trading;
- Relevant benefits include forecast error mitigation and avoiding curtailment of renewable energy

- SA's IRP only values peaking and system reserve benefits of BESS
- Additional reliability benefits include ancillary services

Source: Bushveld Energy IRP comments

Thank you
for your attention