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SAESA South African Energy Storage Association

SYSTEM BENEFITS OF ENERGY STORAGE HOW STORAGE CAN SOLVE EVENING PEAK AND LOAD SHEDDING CHALLENGES

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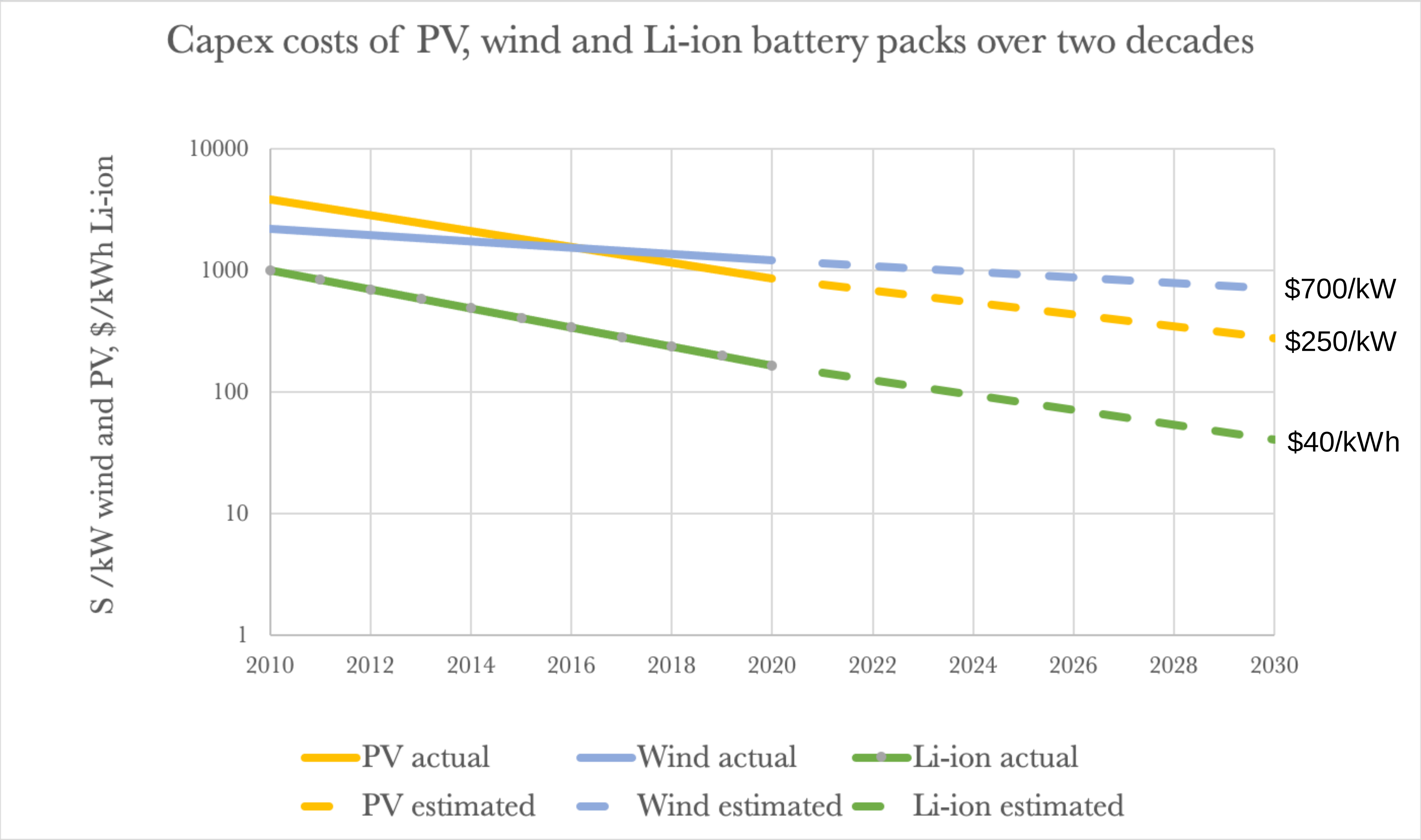
Presented by:

1. Paul Vermeulen, City Power Chief Engineer
2. Clyde Mallinson, Energy Consultant
3. Vally Padayachee, AMEU Strategic Adviser

Storage requirements in a fully decarbonised electricity system in South Africa

- How much storage capacity?
- How many hours of storage?
- What kinds of storage?

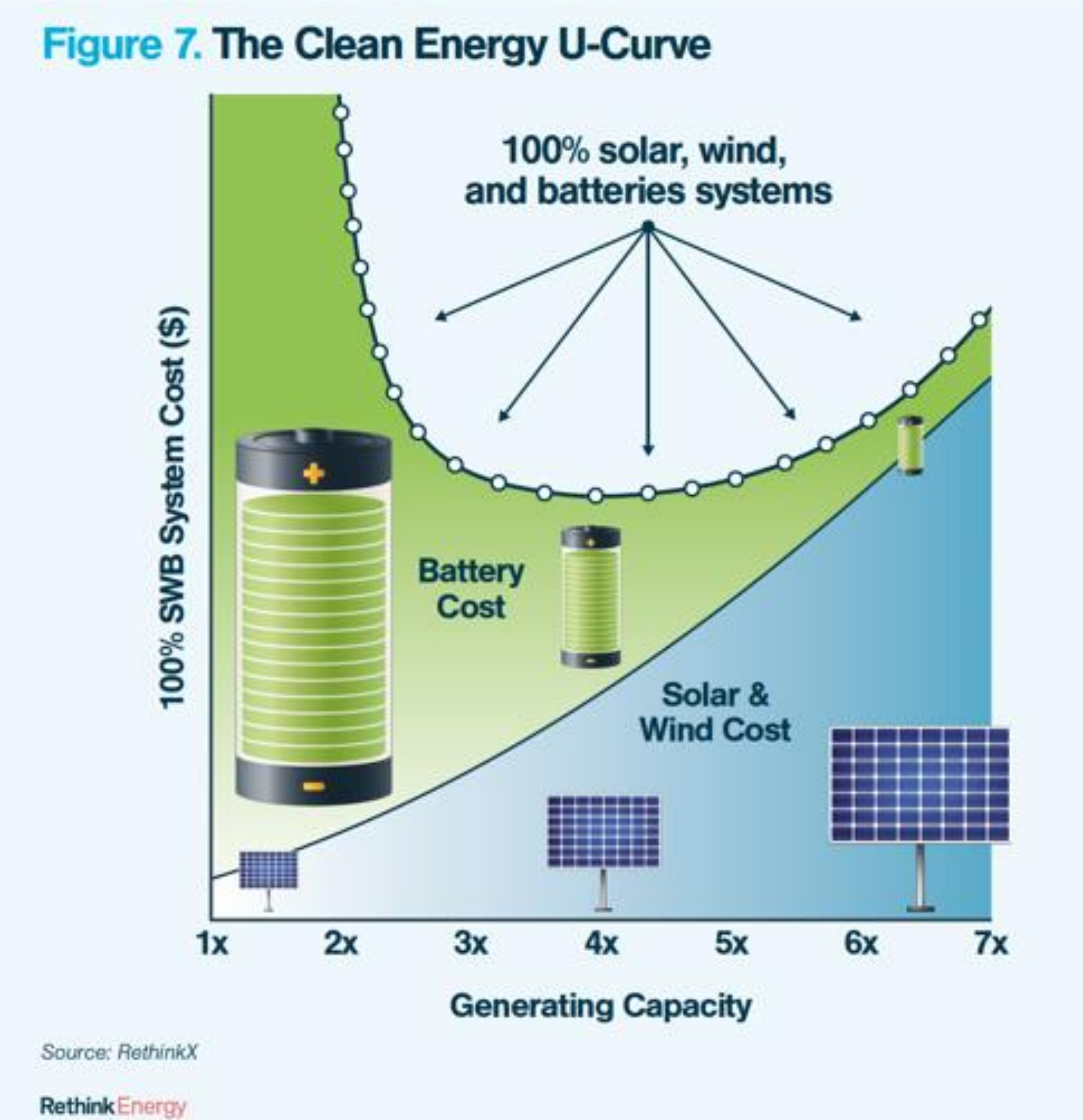
Price reductions in solar PV, wind and storage



Electricity consumption comparisons

Region	Annual Demand (TWh)	Average hourly Demand (GW)	Peak hourly Demand (GW)	Peak Demand Date and Time
California	285	32.5	63	5pm September 1 2017
Texas	414	47.2	81.5	4pm July 13 2018
New England	122	13.9	25.7	6pm August 29 2018
South Africa	231	26.4	34.1	7pm 21 July 2019

The clean energy U-curve



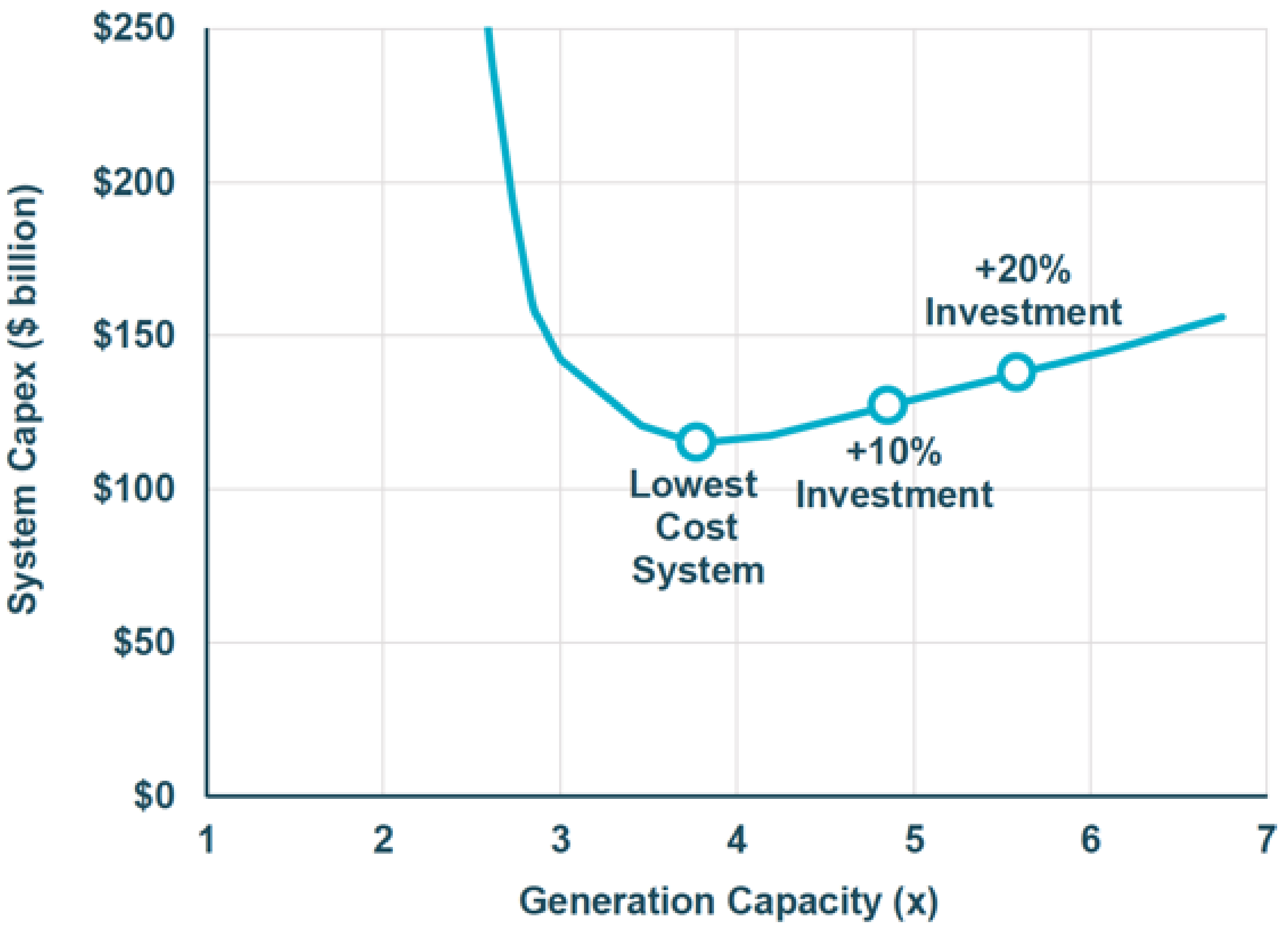
There are an infinite number of combinations of solar, wind and storage that can meet the system needs for full security of supply, 24/7/365.

Not all solutions carry the same price tag. We can either chose to build more solar and wind, with less storage, or less solar and wind, with more storage.

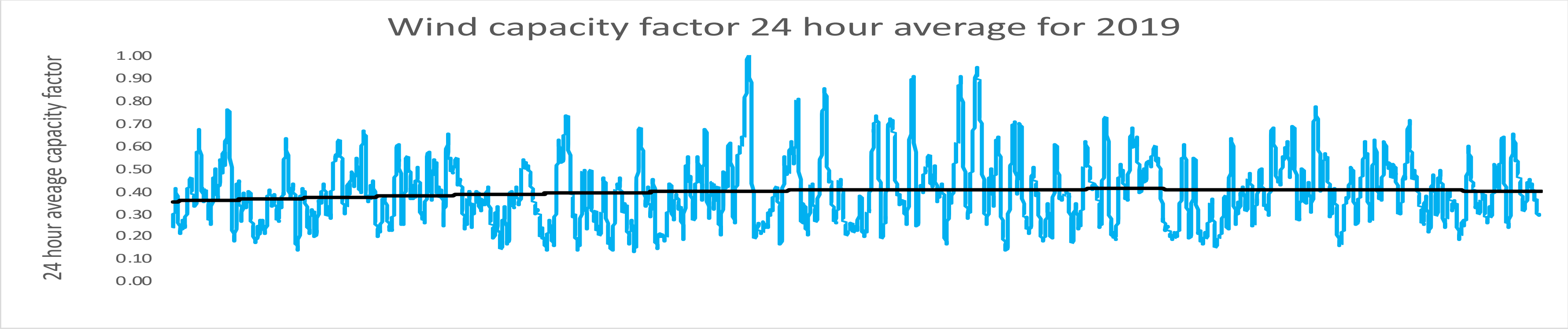
For each region, based on expected technology price changes, there is an optimal combination, represented by the minima on the U-Curve – the so-called “sweet spot”.

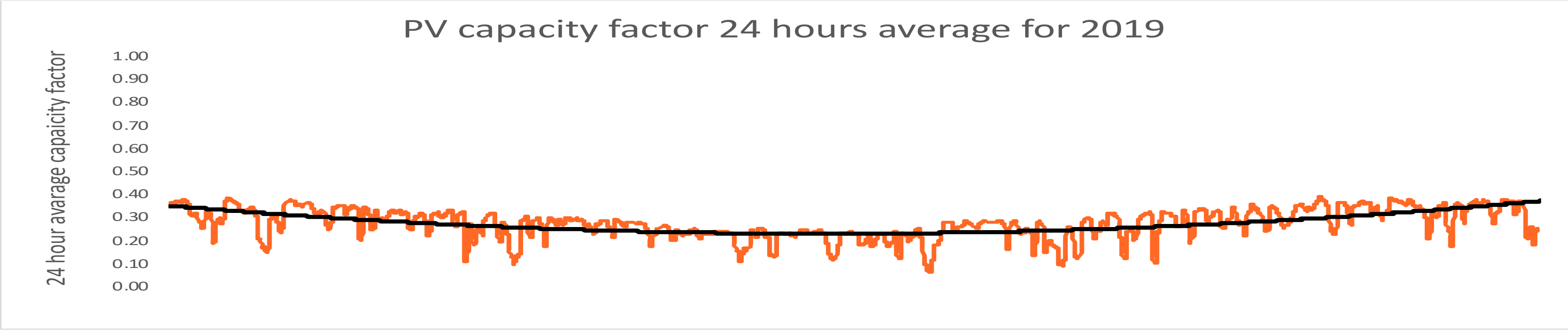
The clean energy U-curve for California

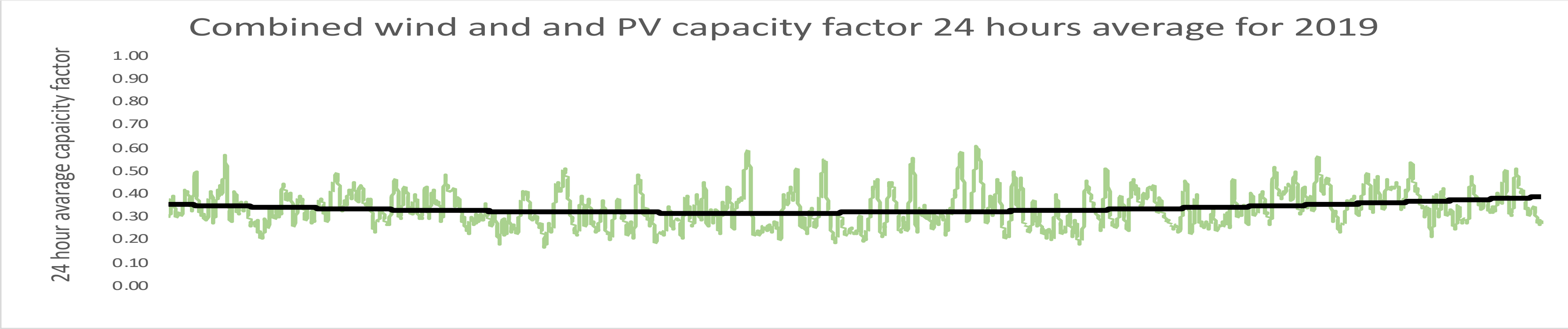
Figure 12. The Clean Energy U-Curve for California



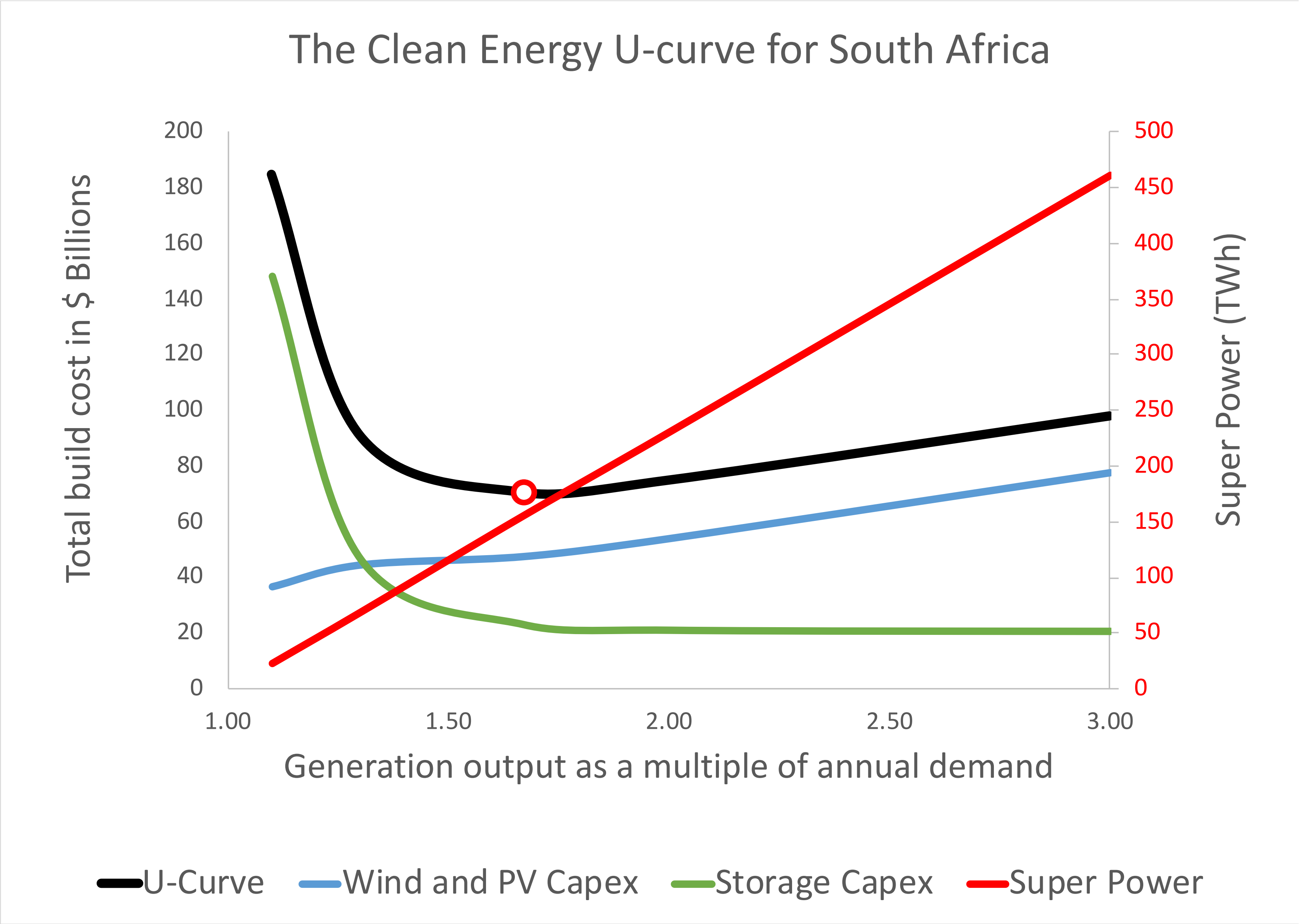
Wind and solar resources of South Africa







The clean energy U-curve for South Africa



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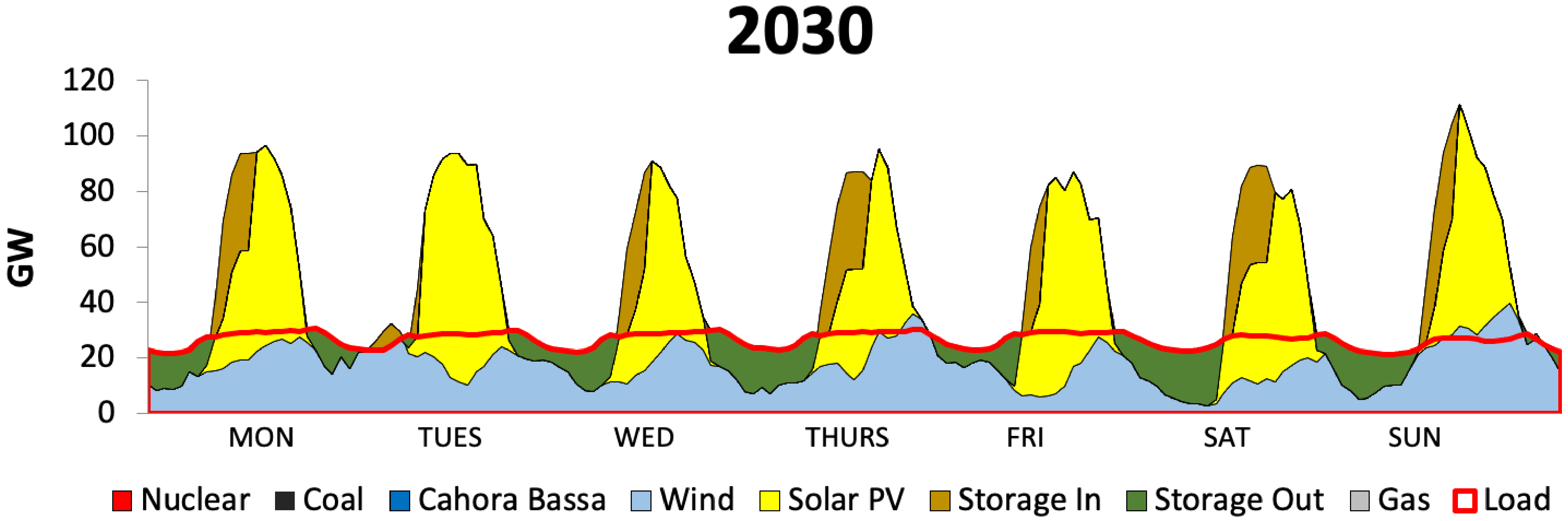
Storage requirements in a fully decarbonised electricity system in South Africa

Generation Capacity (x annual demand)	1.10	1.30	**1.67**	2.00	3.00
Hours BESS	100	29	8.9	8.9	8.3
BESS % Capex	80	51	30	29	21
Super Power TWh	**22**	**68**	**155**	**230**	**461**
Solar PV (GW)	56	65	101	143	230
Wind (GW)	35	41	40	33	40
Storage (GW)	35	35	35	35	35
Storage (GWh)	3500	1015	312	312	291
Battery Capex $b	148	47	23	21	21
Wind and solar Capex $b	37	45	48	54	78
Total Capex $b	185	91	**71**	75	98

Storage requirements in a fully decarbonised electricity system in South Africa

101GW PV, 40GW Wind, 35GW/312GWh Storage



231 TWh + 155 TWh super power

Storage requirements in a fully decarbonised electricity system in South Africa

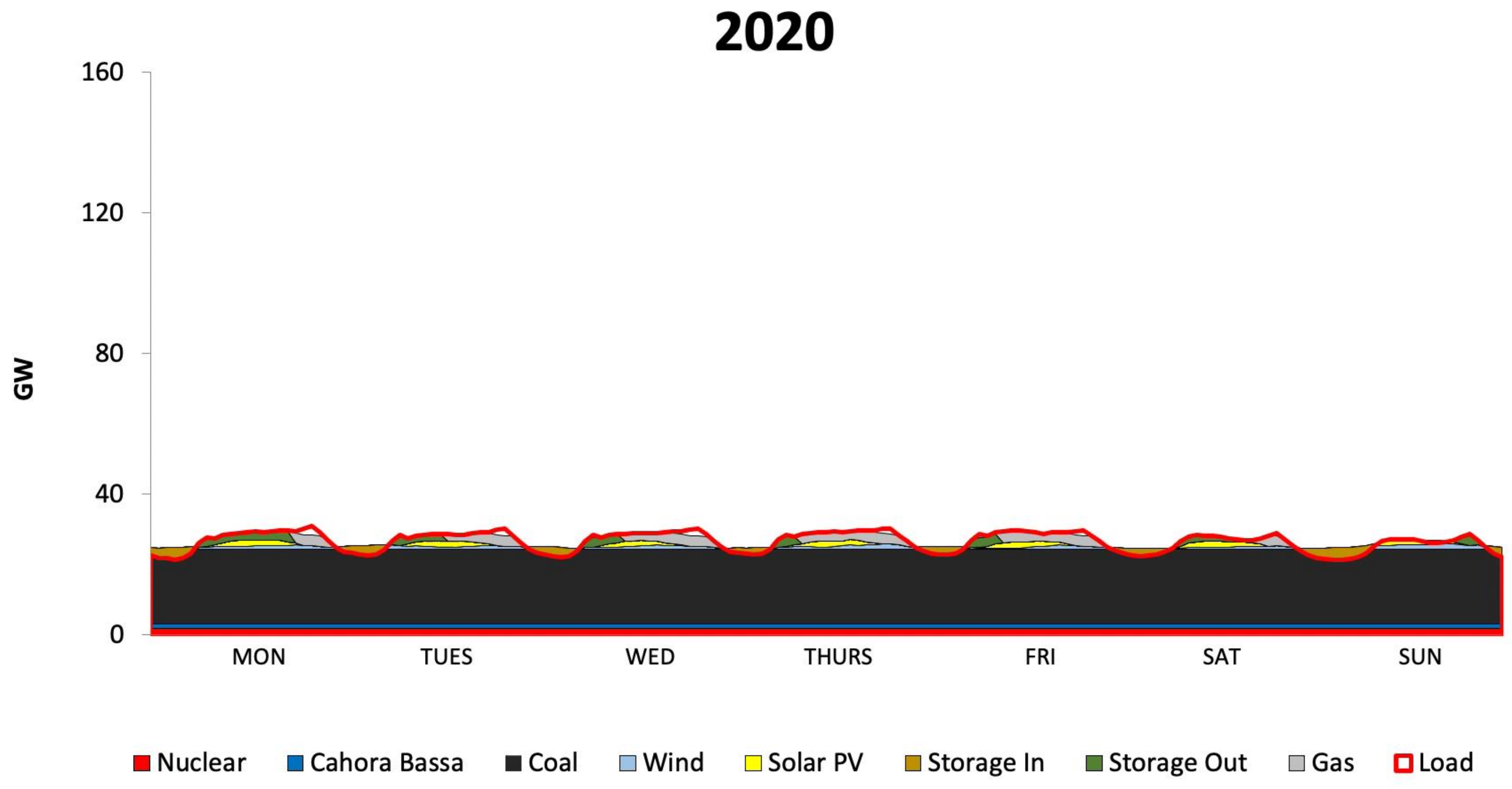
Proposed new IRP through to 2040

Year	Wind GW	Cum. Wind GW	Solar GW	Cum.Solar GW	Storage GWh	Cum. Storage GWh
2021	1.5	1.5	3.0	3.0	8.0	8.0
2022	1.6	3.1	3.4	6.4	8.6	16.6
2023	1.6	4.7	4.0	10.4	9.3	26.0
2024	1.7	6.4	4.5	14.9	10.1	36.0
2025	1.8	8.2	5.2	20.1	10.9	46.9
2026	1.9	10.0	6.0	26.1	11.8	58.7
2027	1.9	12.0	6.9	33.0	12.7	71.4
2028	2.0	14.0	7.9	40.9	13.7	85.1
2029	2.1	16.1	9.1	49.9	14.8	99.9
2030	2.2	18.3	10.4	60.3	16.0	115.9
2031	2.2	20.5	11.3	71.6	16.2	132.1
2032	2.2	22.6	12.3	83.9	16.5	148.6
2033	2.2	24.8	13.4	97.3	16.8	165.4
2034	2.2	27.0	14.6	111.9	17.0	182.5
2035	2.2	29.2	15.8	127.7	17.3	199.8
2036	2.2	31.4	17.2	144.9	17.6	217.4
2037	2.2	33.6	18.7	163.7	17.9	235.2
2038	2.2	35.8	20.4	184.1	18.2	253.4
2039	2.2	38.0	22.2	206.3	18.4	271.8
2040	2.2	40.2	24.1	230.4	18.7	290.6

Some of the different types of storage that will be required

- Conventional electro-chemical batteries;
- Flow batteries;
- Pumped storage, including underground pumped storage in old mines;
- High temperature thermal storage systems;
- Hydrogen storage;
- Super capacitors;
- Compressed air storage;
- Cryogenic storage;
- Mechanical gravity storage; and
- EV V2G storage.

The disruptive change: 2020 - 2040



Municipal power utility perspective (1)

1. Key drivers for a utility customer for energy storage may be bill savings, increased self-consumption of distributed generation, or resiliency.
2. Customers under a time-of-use and/or demand charge rate structure may look to Behind-the Meter(“BTM”) energy storage as a way to save on utility bills.
3. Then there are customers who may want BTM energy storage to help provide backup power in case of an outage
4. From the standpoint of utilities, it is important not only to understand these types of customer motivations, but to consider implications for the power sector.
5. For example, as customers utilize BTM energy storage to alter their load and lower their electric bills, utility revenue decreases.
6. The issue here is not inherently that utilities are earning less money, but that utility costs may not be decreasing in correlation.

[Source: https://www.publicpower.org/blog/get-front-behind-meter-energy-storage]

Municipal power utility perspective (2)

7. Another potential concern is “grid defection,” which is when a customer disconnects from the main grid. This issue has been flagged as more customers consider pairing distributed generation with BTM energy storage. However, grid defection has not taken off as it is not currently cost effective or technically possible in most places.
8. BTM energy storage can also bring benefits and new opportunities for utilities.
9. Since BTM energy storage can reduce peak demand and alleviate stress on the system, this may provide an opportunity to defer or avoid investment in infrastructure upgrades.
10. For utilities that pay wholesale power suppliers for demand or capacity, BTM energy storage could help lower those payments.
11. BTM energy storage can also help address the challenge of renewable energy intermittency by charging during times of excess generation and discharging during periods of high demand.
12. Many utilities offer demand response programs to help manage peak demand, and BTM energy storage can be another technology option for customer participation in such programs.

[Source: https://www.publicpower.org/blog/get-front-behind-meter-energy-storage]

Municipal power utility perspective (3)

8. If BTM energy storage reduces peak demand, it can consequently improve the utility's load factor, increasing system efficiency.
9. Furthermore, utilities can explore providing new service offerings for BTM energy storage customers such as being the asset aggregator or owner.
10. Services associated with BTM energy storage that are not performed by the utility could be executed by a third party.

[Source: https://www.publicpower.org/blog/get-front-behind-meter-energy-storage]

Association of Municipal Electricity Utilities (Southern Africa)
Est 1915
AMEU

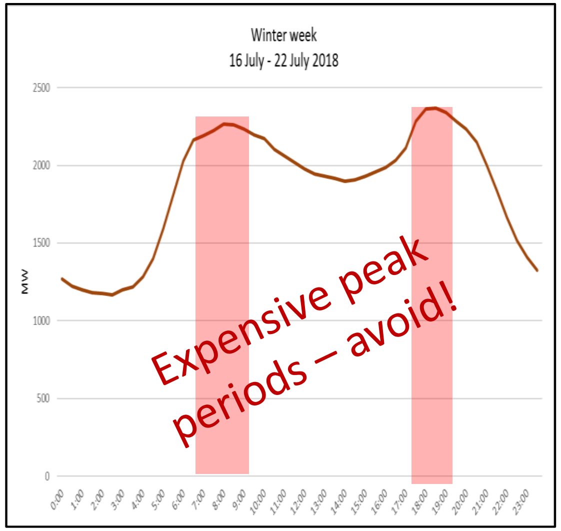
The Tariff Arbitrage Principle

- Time of use tariffs are implemented to change the behavior of the end consumer
- TOU tariffs are time differentiated and have expensive periods, typically when loads are high that stress the power generators and distribution networks. Prices reduce at off-peak times.
- **Arbitrage is the practice of storing last night's off-peak, cheap energy for use during today's expensive peak energy period**
- The base business case for storage is to do this every day to save costs. This is how it 'earns its daily keep' and pays for itself!

Megaflex Time of Use tariff 2021/22 - Local authority

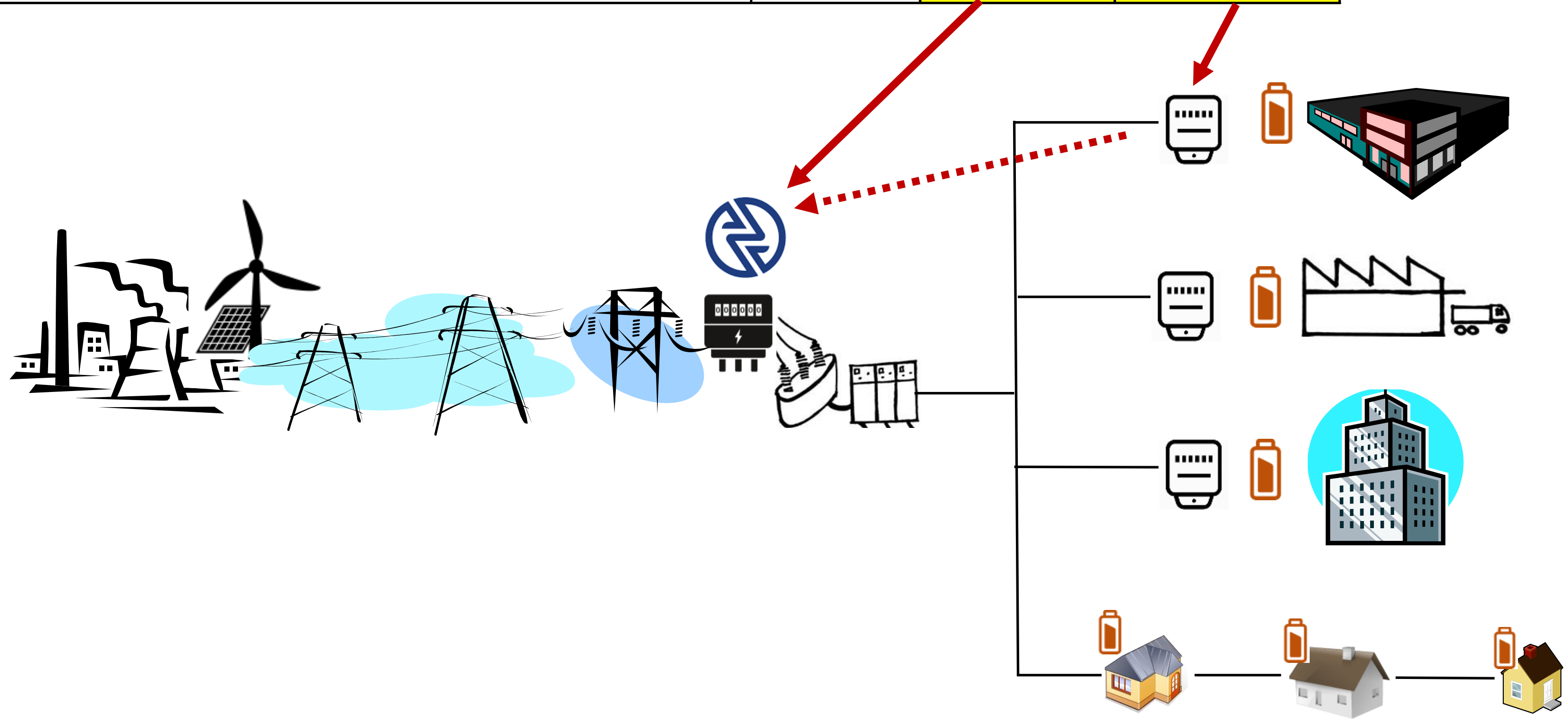
		Active energy charge [c/kWh]											
Transmission zone	Voltage	**High demand season** [Jun - Aug]						**Low demand season** [Sep - May]					
		Peak	*VAT incl*	Standard	*VAT incl*	Off Peak	*VAT incl*	Peak	*VAT incl*	Standard	*VAT incl*	Off Peak	*VAT incl*
≤ 300km	< 500V	**437,10**	*502,67*	**133,01**	*152,96*	**72,58**	*83,47*	**143,10**	*164,57*	**98,76**	*113,57*	**62,95**	*72,39*
	≥ 500V & < 66kV	**430,21**	*494,74*	**130,35**	*149,90*	**70,79**	*81,41*	**140,34**	*161,39*	**96,58**	*111,07*	**61,29**	*70,48*
	> 66kV & ≤ 132kV	**416,64**	*479,14*	**126,21**	*145,14*	**68,55**	*78,83*	**135,92**	*156,31*	**93,56**	*107,59*	**59,34**	*68,24*
	> 132kV*	**392,65**	*451,55*	**118,95**	*136,79*	**64,59**	*74,28*	**128,08**	*147,29*	**88,15**	*101,37*	**55,02**	*64,31*

Winter 6:1 **Summer 2,3:1**



Energy arbitrage – the mutual benefit

Arbitrage mutual savings benefit to distributor and end customer			
		City Power	LPU Customer
Net average value of daily energy arbitrage	c/kWh	140,88	127,67
Daily network and demand charge savings potential	c/kWh	58,46	282,51
Total potential daily energy arbitrage and demand charge reduction value of 1kWh storage	c/kWh	199,35	410,18



The arbitrage savings realized by all TOU customers at the municipal distributor's meter are reflected up to the Eskom meter.

Depending on tariff structures, distributors may realize a greater energy savings than their TOU customers.

The customer may realize a greater demand charge savings, however, this depends on their peak demand coincidence factor.

Storage benefits for the Municipal Electricity Distribution Industry

With arbitrage as the 'base business case' for Energy Storage, the benefits are –

- Reducing Bulk Electricity purchasing costs
- Avoiding Notified Maximum Demand (NMD) Penalties

'Bonus' benefits are –

- Protecting the Economy from load shedding: the 'Whole Business UPS' concept
- Relieving overloaded distribution infrastructure
- Unlocking constrained property development
- Peak demand management, outage reduction (DSM)
- Optimizing renewable energy utilization

Energy storage is not a primary energy source. It is used to change the time that the output from any low-cost primary energy source is consumed.

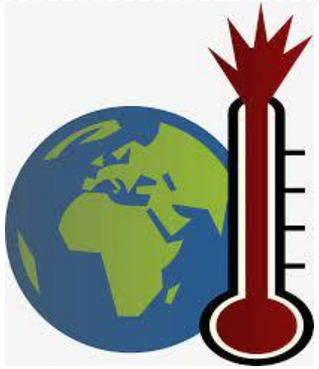
Energy storage embedded in municipal networks on its own has significant DSM value and is vital for integrating a mix of diverse new energy sources beyond the Eskom meter.

For every MW of renewable energy permitted on a municipal network there should be a corresponding investment in energy storage.

Embedded energy storage is key to enable a smooth energy transition

What do electricity customers want?

- Uninterrupted, continuous and reliable supply – ‘always on’
- Lower cost electricity supply
- Energy options, and the freedom to exercise their options
- Cleaner energy supply with lower impact on climate change



Energy Storage is a key enabler for both the Customer’s and the distributor’s objectives

As there is clearly a mutual need for energy storage, what are the real-world opportunities?

The property developer and storage

Chamberlain Hardware Store, Struben's Valley

- Developer applied for a150 kVA new service connection for a new 'mega-store' for the chain.
- City Power's network is constrained in that area, and was only able to offer limited capacity of 100 kVA.
- The developer returned with a proposal to take the 100kVA available and install a PV system coupled with an energy storage system as a solution to the capacity limitation, City Power agreed to the proposal.
- Off-peak night time energy from City Power is used to charge the energy storage system to power the business from 7am until around 9 am.
- The PV generation is strong enough to make up the shortfall over the day, and re-charge the energy storage for after 4pm when the business reverts to battery until the business closes at 6 pm, repeating every day.
- The cost of the combined solar plus storage in this case was overcome by the benefits of being able to establish a new store.
- The City has a new rate-paying business
- City Power has a new customer with a remarkably flat load profile.

The same concept can apply to residential developments

CHAMBERLAIN

Commercial and Industrial sector

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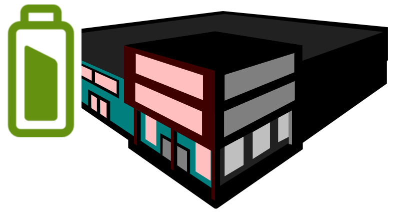


A business community concept for overcoming load shedding together – Distributors promote investment in energy storage by their Key Customers where:

- Storage is used for daily arbitrage duty and creates the base business case
- The high cost of unserved energy – a ‘business dependent’ factor creates the second business case
- An opportunity to target MW scale energy storage facilities at key customer sites
- Deploy with ‘plug and play’ modular containerized solutions available from the Energy Storage Industry
- Scheme provides immediate relief from load shedding for participants
- Sites connected to the distributor’s SCADA system to aggregate the systems from day one
- When a critical mass is reached, distributor dispatches the stored energy and won’t need to shed anyone
- When load shedding is a thing of the past, the distributor will bid the aggregated capacity to the Demand Response market on a shared savings basis to the new ISMO.

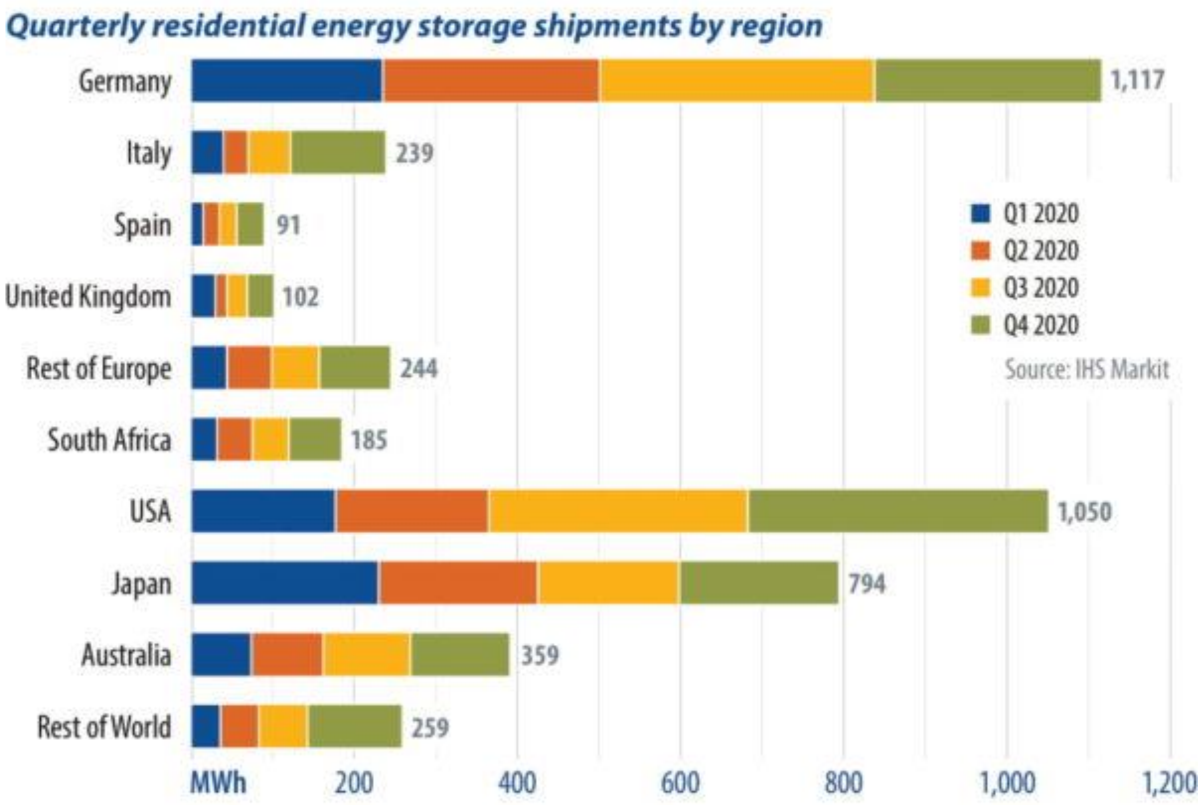
COUE: Economic Effect	Direct Effect(R GVA/kWh)	Total Effect (R GVA/kWh)
Agriculture	11.55	42.21
Mining	13.06	54.05
Manufacturing	5.84	54.64
Electricity and water supply	7.70	29.31
Construction	204.10	385.55
Trade	[illegible]	136.90
Transport and communication	87.29	348.64
Finance	105.77	400.22
Community services	159.39	319.37
General Government	66.62	80.33
Total Economy	**23.81**	**84.16**

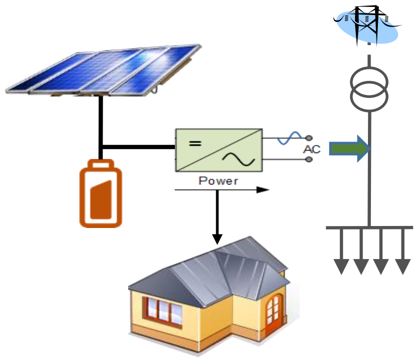
Minnaar, Ulrich & Crafford, Jackie. (2017). Cost of Unserved Energy in South Africa.

The sectional title residential sector

- The sectional title residential sector makes a significant contribution to the evening peak demand problem. There are over 5000 flats or complexes in Joburg alone
- Energy Service Companies (ESCOS) are offering 'whole complex' UPS systems using lithium ion battery packs.
- Supply continuity is the main selling point of this concept
- The energy package can include PV panels to provide lower cost energy overall and to re-charge the batteries
- These sites are 'TOU tariff migration ready'
- Distributors can partner with Body Corporates and ESCOs to move the sector onto Time of Use tariffs, to effect a positive load profile change.
- Where successful, there is a mutual benefit as costs reduce for both the end customer and the distributor.
- Even conservative uptake within critical substation zones will reduce load during the evening peak, reducing outage frequency due to high loads.

The mid to upper income residential sector





- IHS Markit reports that South Africa is the sixth largest residential energy storage market in the world.
- 200 MWh capacity was delivered in 2020, largely to avoid the inconvenience of load shedding.
- Funded by the C40 organization, UJ has concluded a project that used AI to analyze satellite images to identify PV system installations across Johannesburg.
- 6000 were identified on the City Power networks, largely unregistered residential systems, most likely hybrid systems
- City Power will implement a normalization program and migrate these customers onto the NERSA approved residential TOU tariff
- If each is able to reduce demand by just 1kW during the 2 hour evening peak period, 6MW demand reduction and energy shift of 12 MWh, worth R5,2 million per annum would accrue.

Question and Answers Session

SAESA | South African Energy Storage Association

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Membership enquiry email:
Secretariat@saesa.org.za