CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

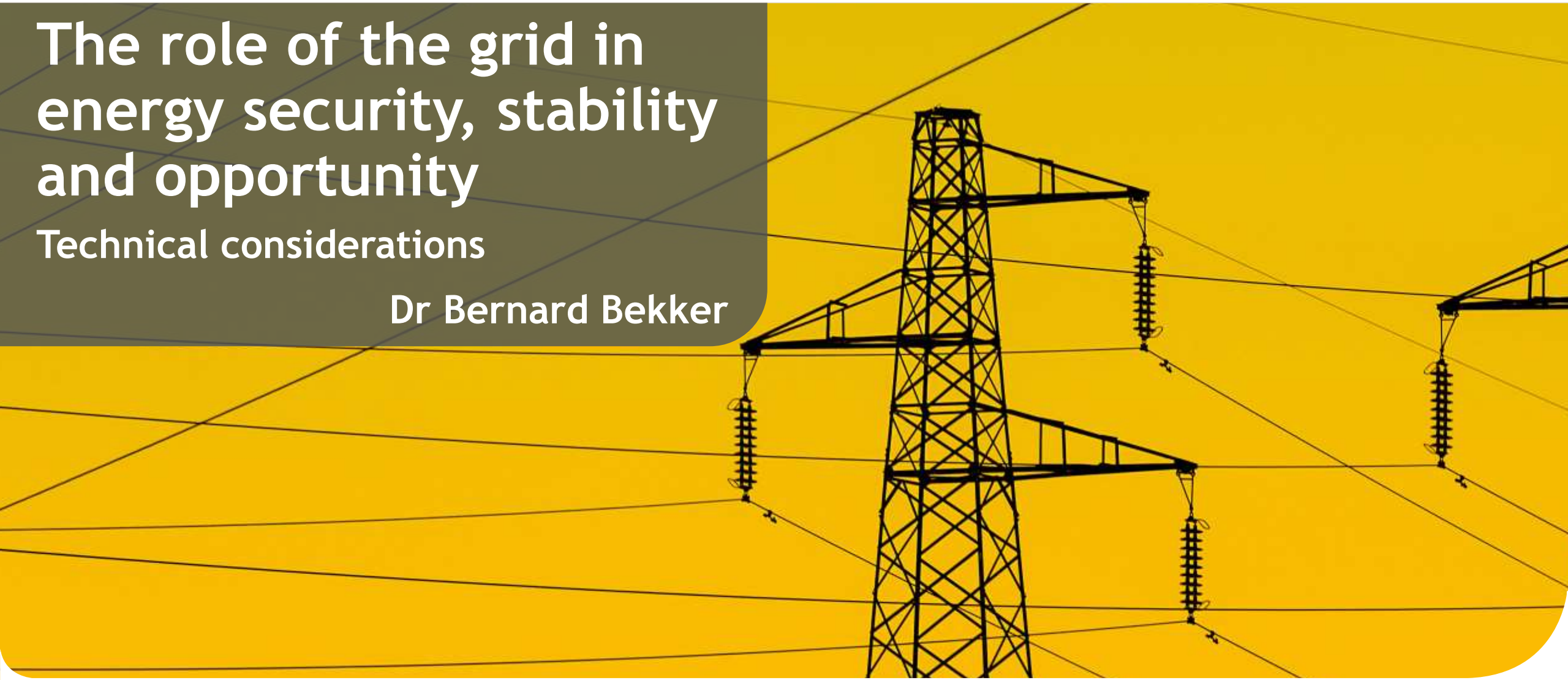
Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

forward together
sonke siya phambili
saam vorentoe

The role of the grid in energy security, stability and opportunity

Technical considerations

Dr Bernard Bekker



Key messages

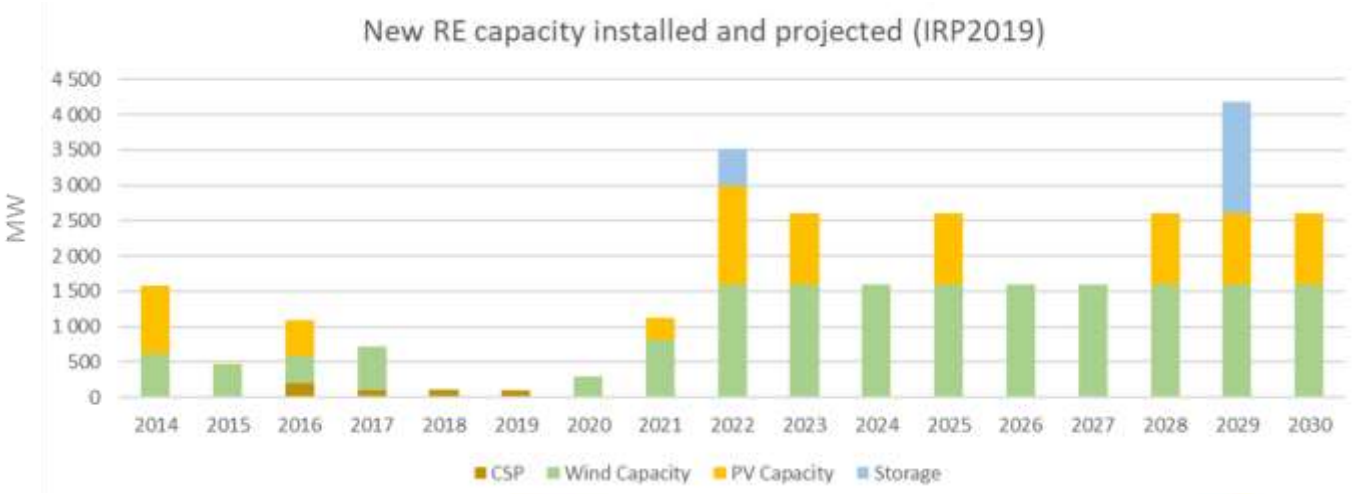
Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

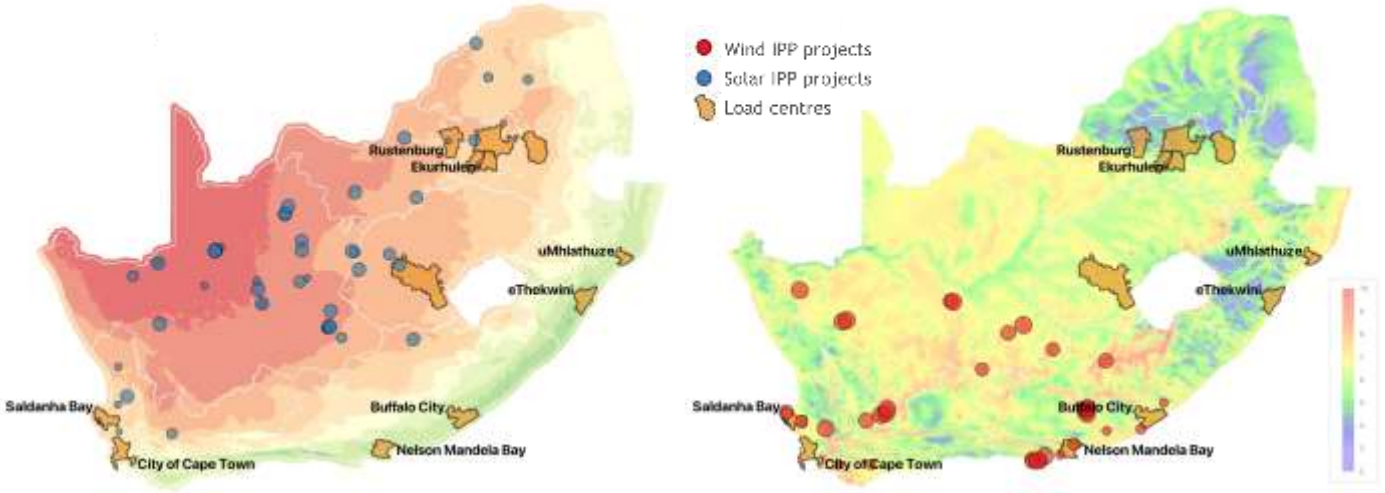
There are sound technical reasons for limiting grid connection capacity, and no quick fixes

Adopt a complimentarity- and “inevitable curtailment”-based view of renewable generation, and adjust pricing accordingly

View inverter-based technologies as solutions, not threats, and adjust regulations and pricing accordingly

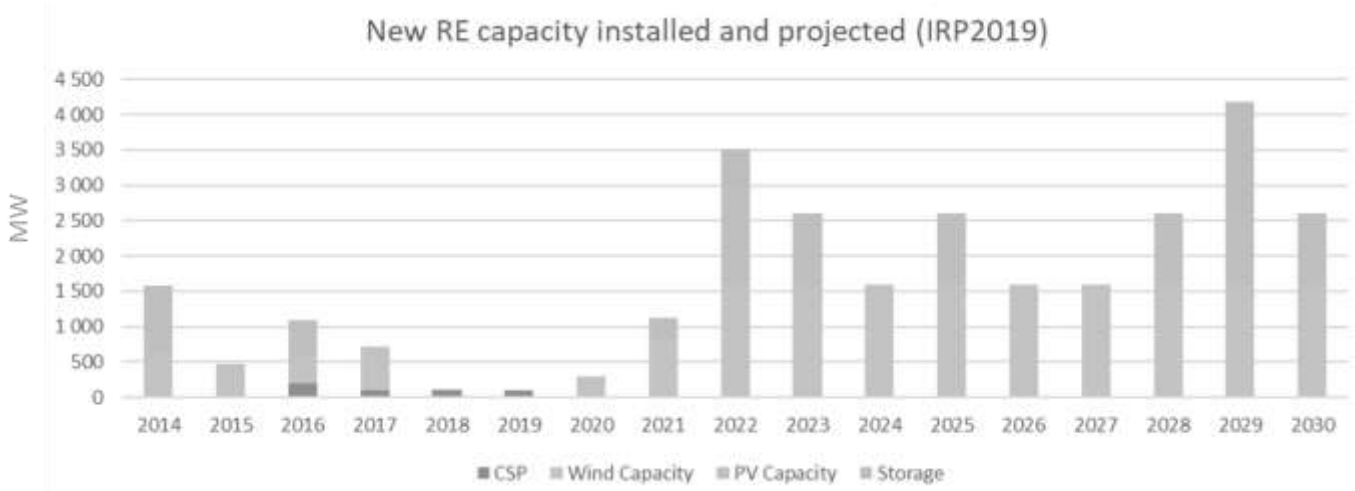
Renewable generation and storage
A great opportunity?

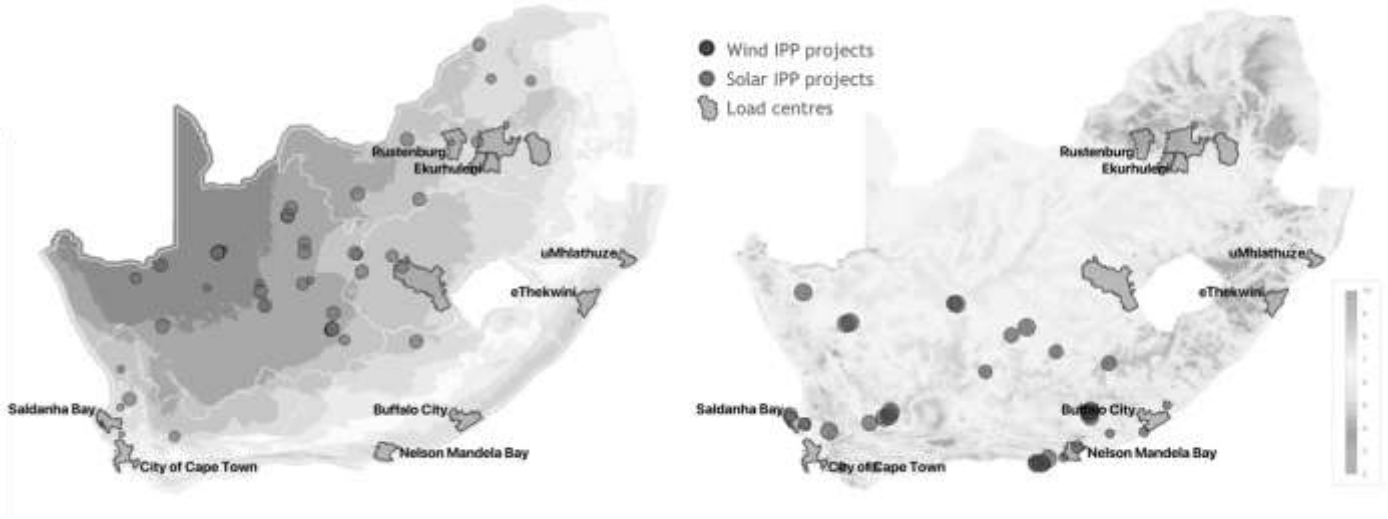


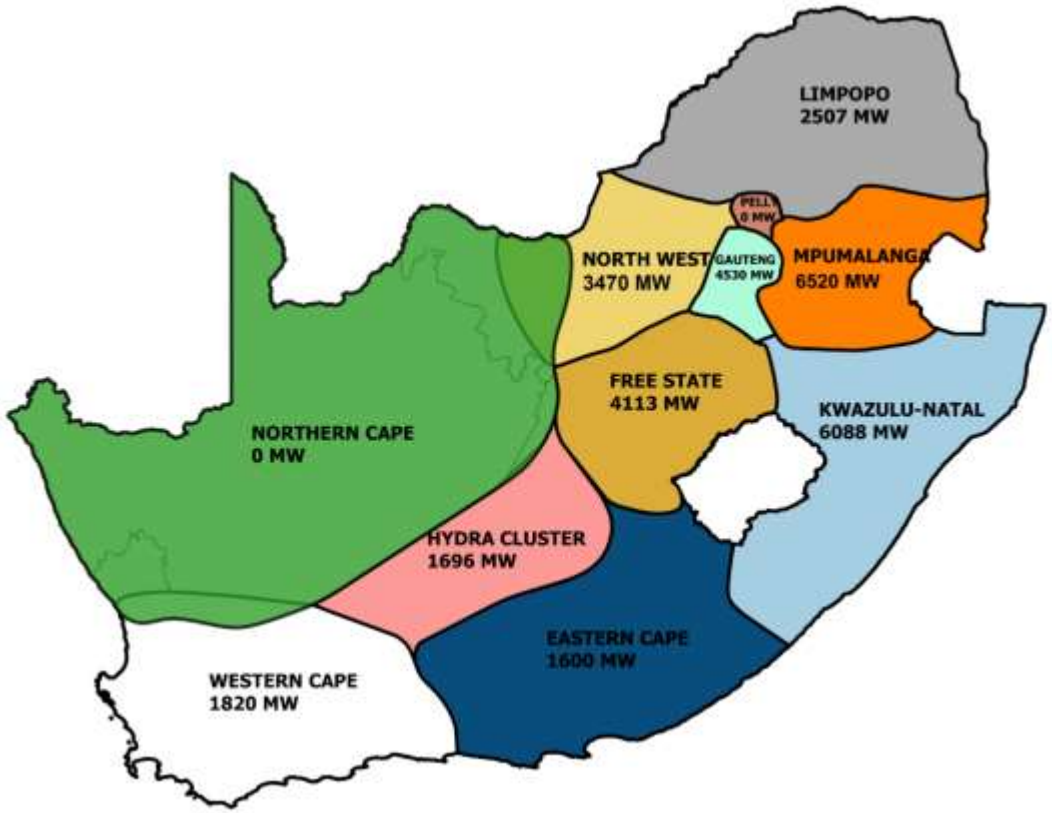


Integrated Resource Plan, DME 2019 | Vermeulen et al, 2022

Grid connection capacity constraints
The elephant in the room

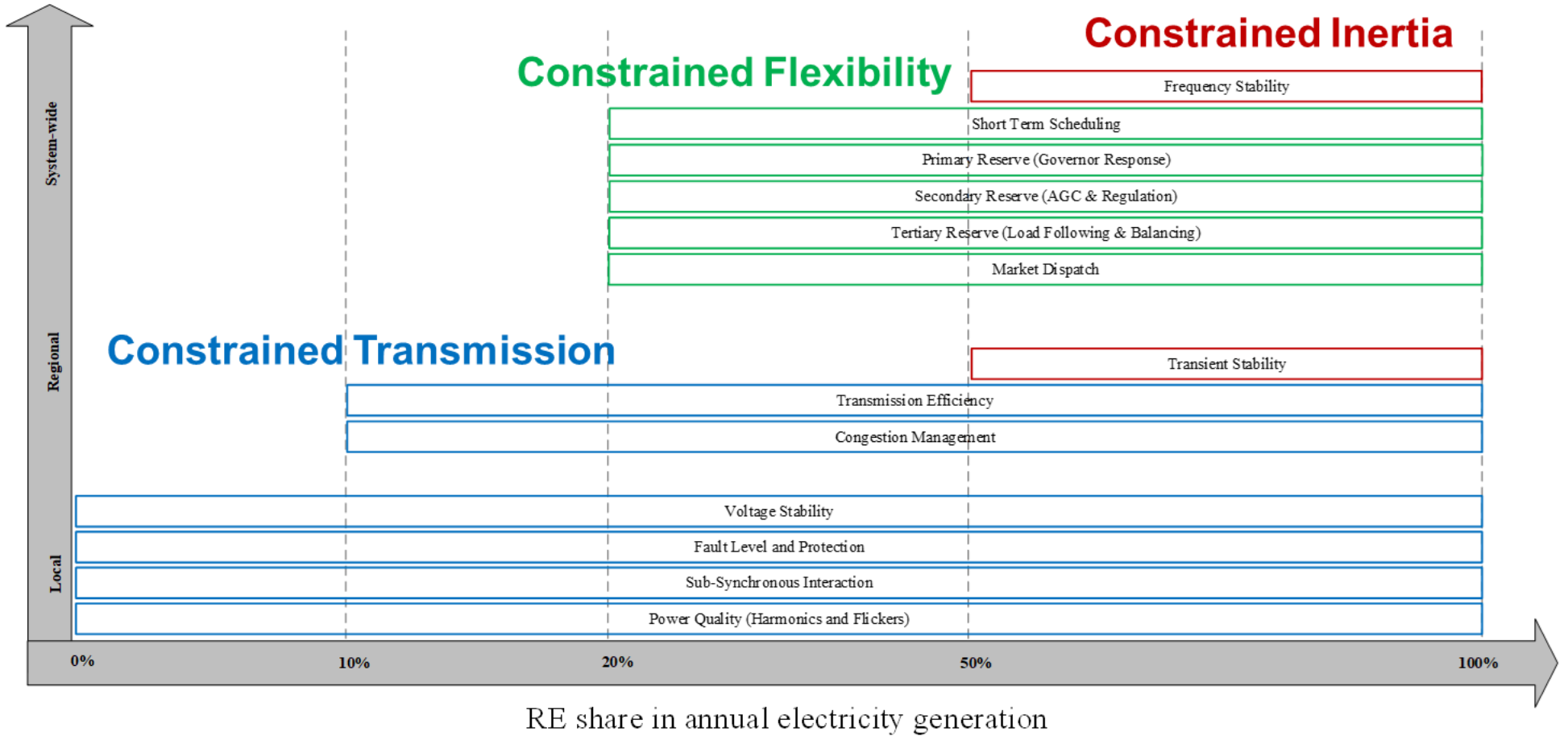






Integrated Resource Plan, DME 2019 | Vermeulen et al, 2022 | Eskom 2022 - Transmission generation connection capacity assessment of the 2024 transmission network

Grid connection capacity constraints
Our problem is not unique



Mararakanye and Bekker 2019 - Renewable energy integration impacts within the context of generator type, penetration level and characteristics

Grid connection capacity constraints
Our problem is not unique

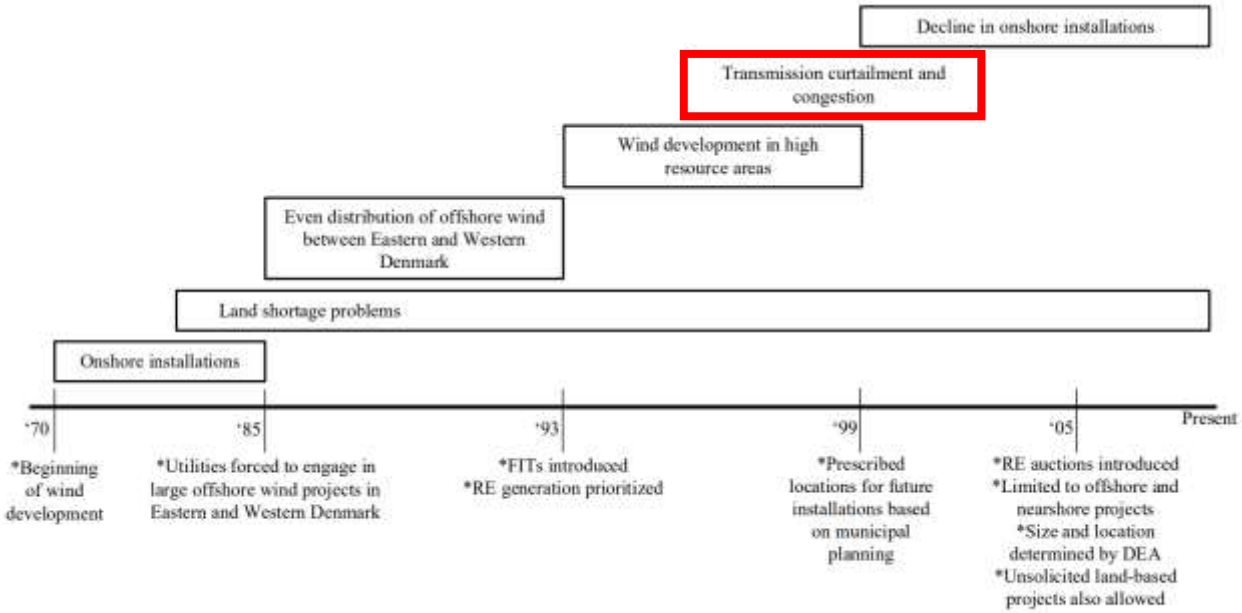


Figure 3: Overview of policy changes and impacts on geographic siting of RE plants in Denmark.

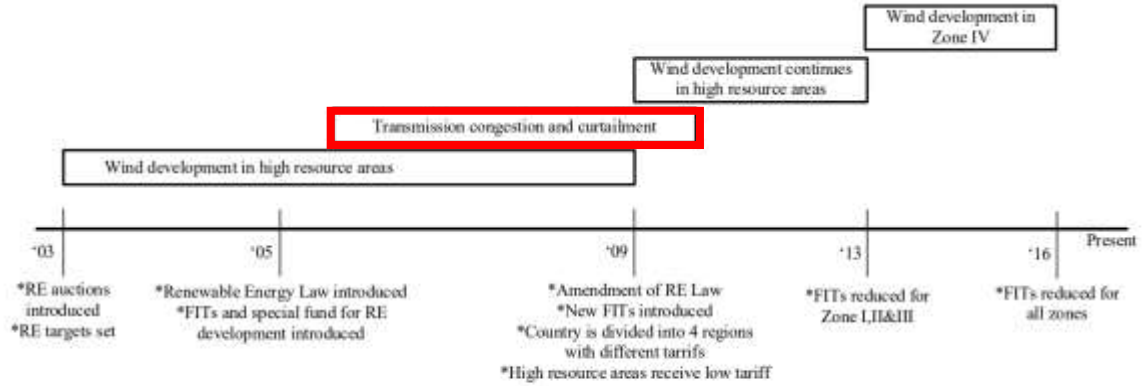
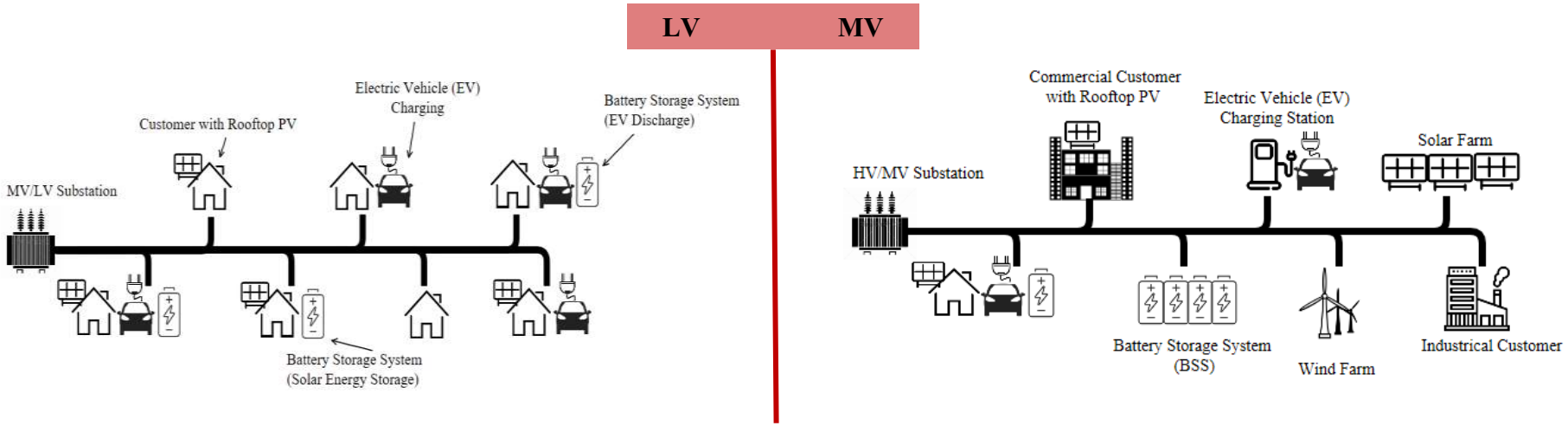


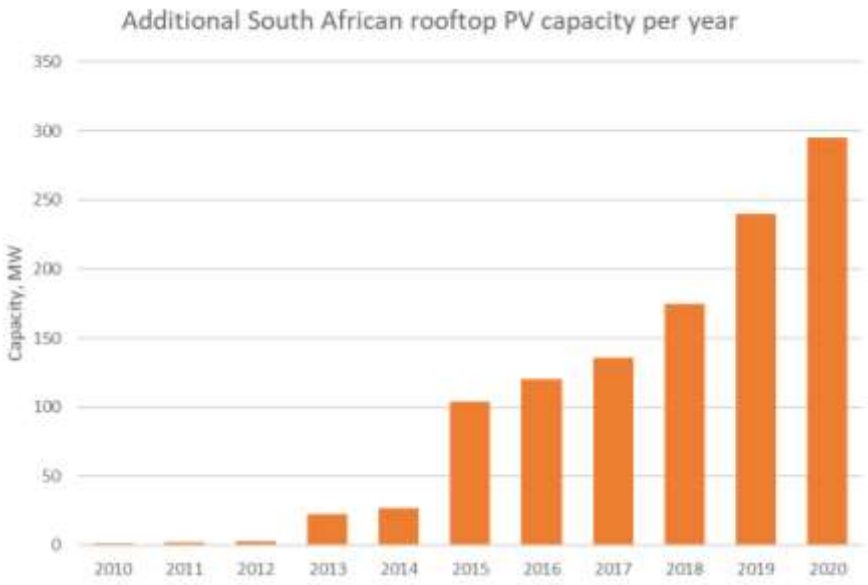
Figure 5: Overview of policy changes and impacts on geographic siting of wind plants in China.

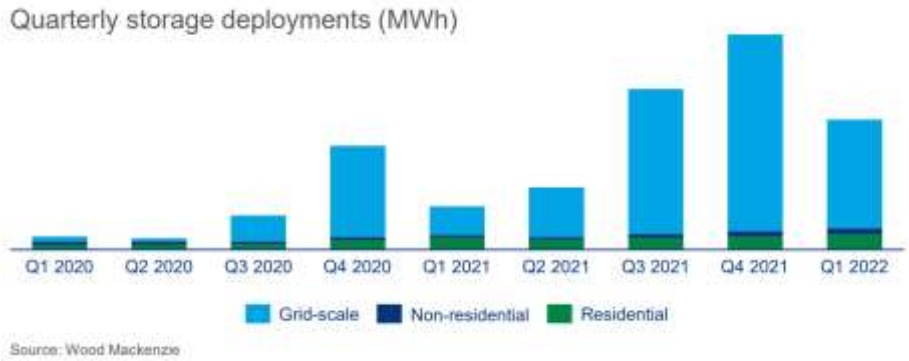
Mararakanye and Bekker 2019 - Renewable energy integration impacts within the context of generator type, penetration level and characteristics

Renewable generation and storage
Is distributed energy resources the solution?

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe



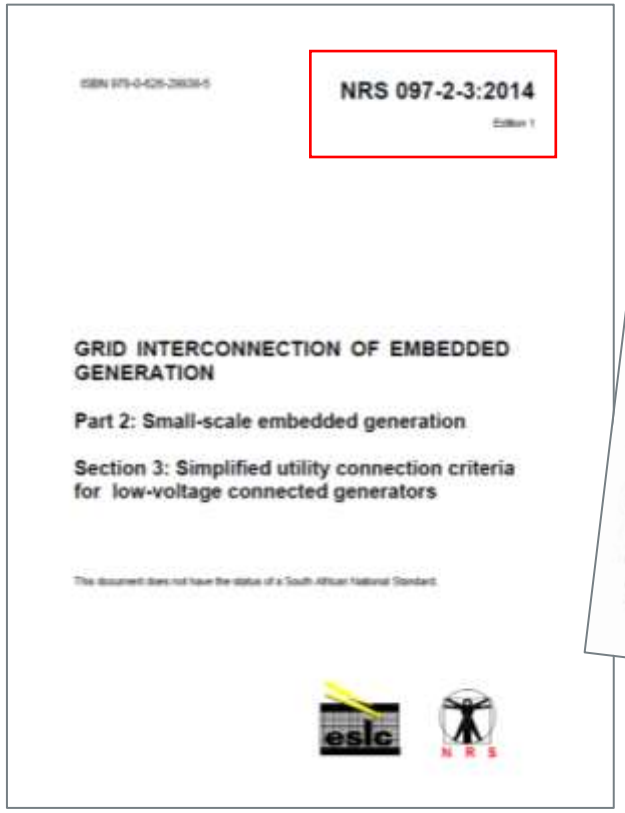




Waswa & Bekker 2018 , Impact of pv small scale embedded generation on south africa's system demand profile | Greencape 2019, IRP 2019 | Wood Mackenzie 2022

Grid connection capacity constraints
The elephant in the room

All LV PV installations limited to these sizes (unless further study is done by customer)



NRS 097-2-3:2014

GRID INTERCONNECTION OF EMBEDDED GENERATION

Part 2: Small-scale embedded generation

Section 3: Simplified utility connection criteria for low-voltage connected generators

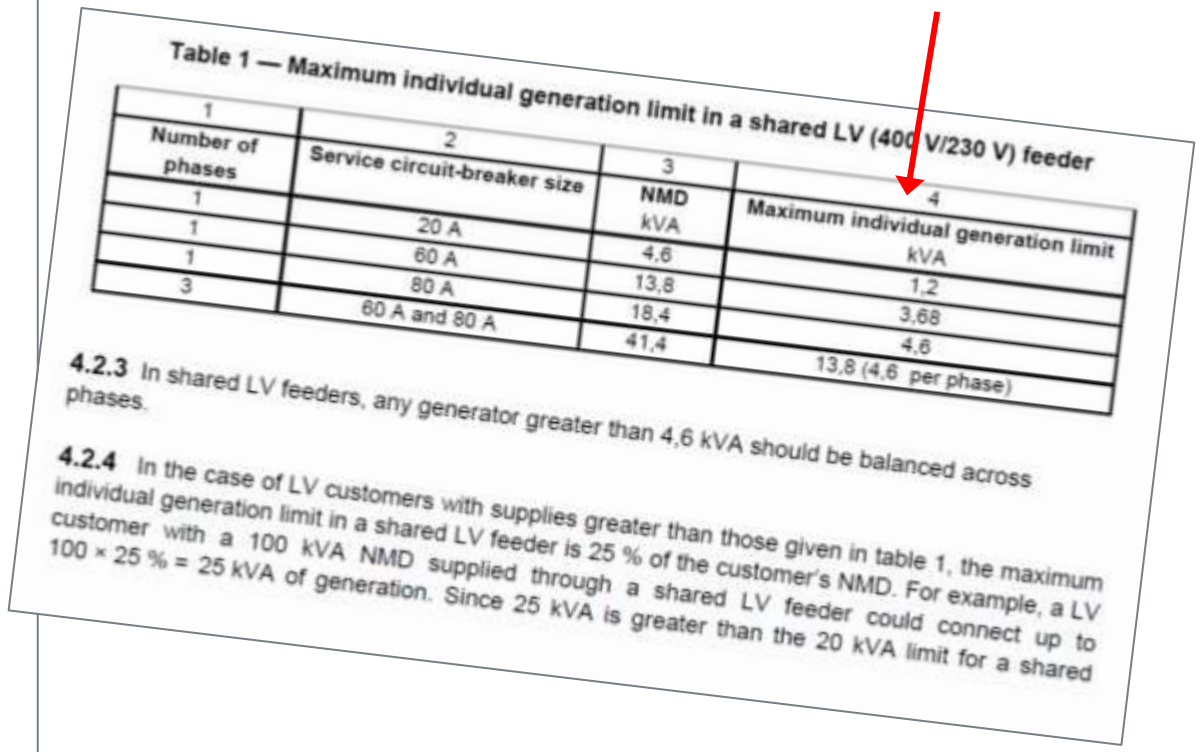


Table 1 — Maximum individual generation limit in a shared LV (400 V/230 V) feeder

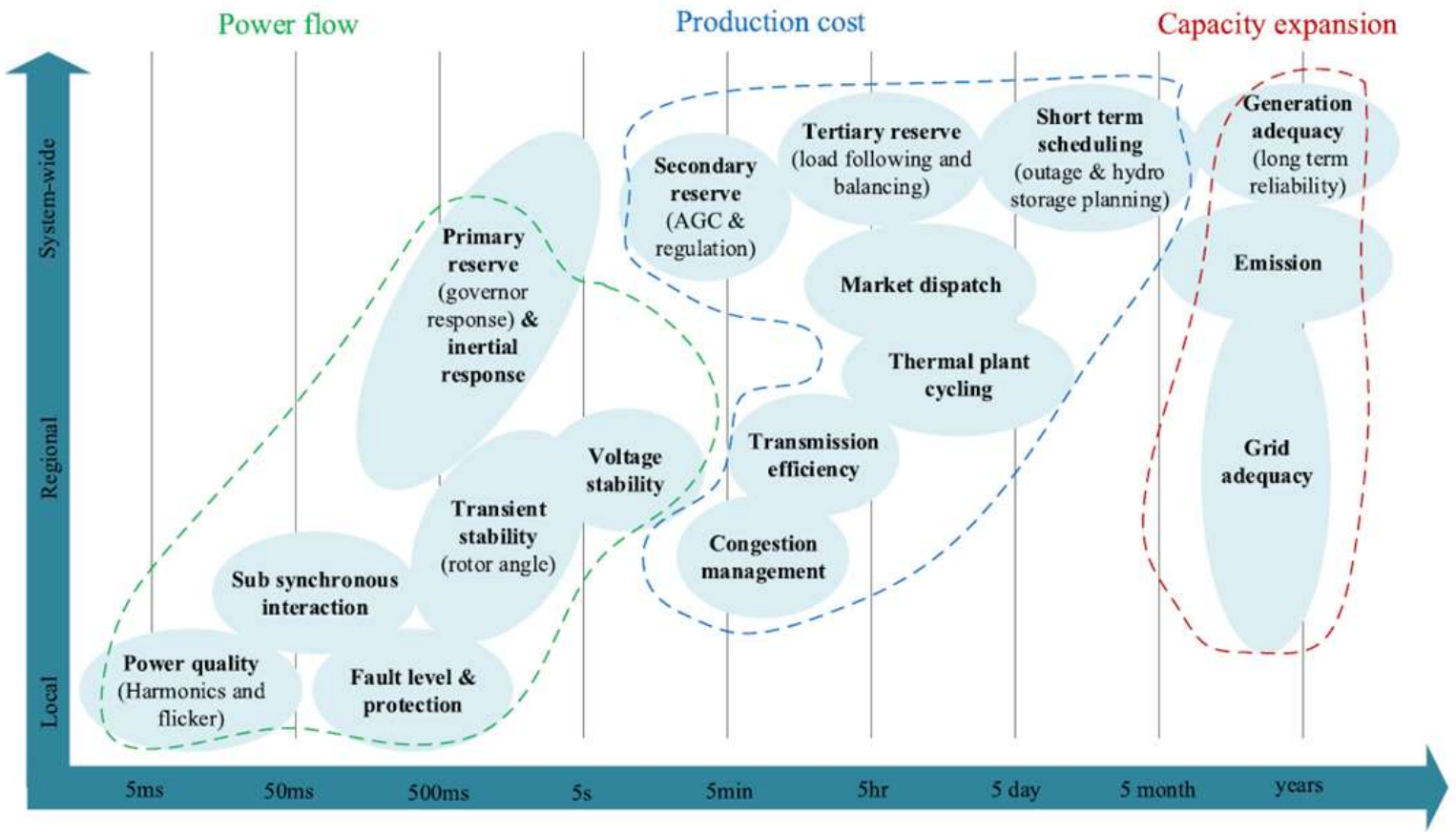
1	2	3	4
Number of phases	Service circuit-breaker size	NMD kVA	Maximum individual generation limit kVA
1	20 A	4,6	1,2
1	60 A	13,8	3,68
3	80 A	18,4	4,6
	60 A and 80 A	41,4	13,8 (4,6 per phase)

4.2.3 In shared LV feeders, any generator greater than 4,6 kVA should be balanced across phases.

4.2.4 In the case of LV customers with supplies greater than those given in table 1, the maximum individual generation limit in a shared LV feeder is 25 % of the customer's NMD. For example, a LV customer with a 100 kVA NMD supplied through a shared LV feeder could connect up to 100 × 25 % = 25 kVA of generation. Since 25 kVA is greater than the 20 kVA limit for a shared

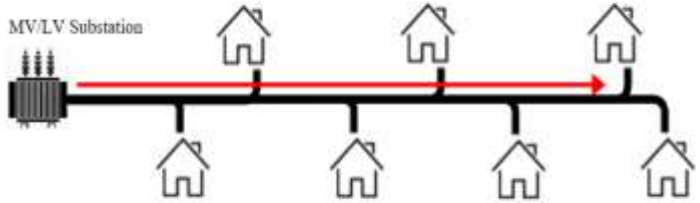
NRS 097-2-3 - Simplified utility connection criteria for low-voltage connected generators.

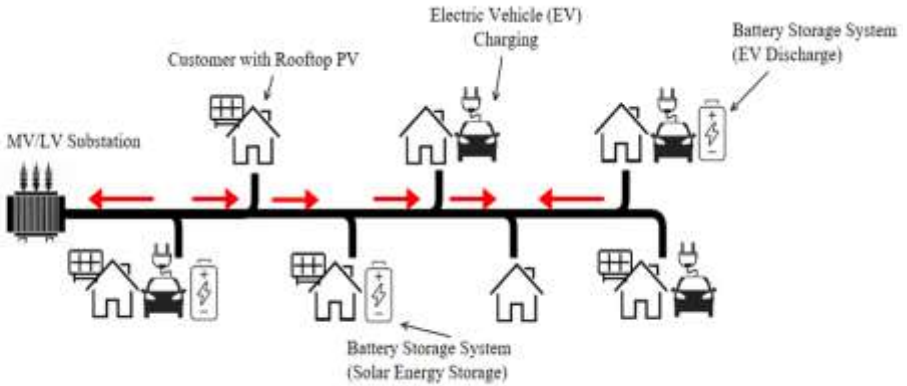
Why constrain grid capacity?
Some technical considerations

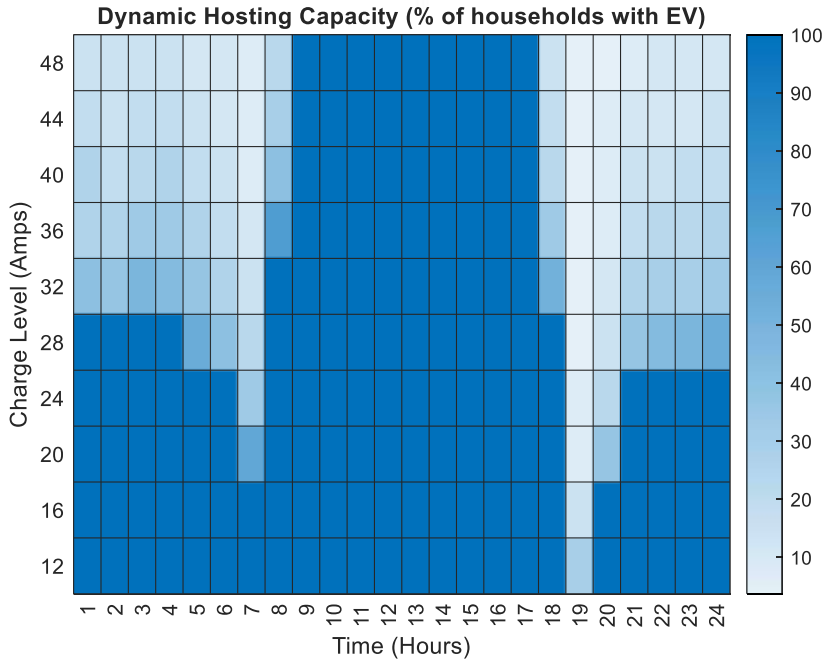


Mararakanye and Bekker 2019 - Renewable energy integration impacts within the context of generator type, penetration level and characteristics

Why constrain grid capacity?
Examples from the distribution grid





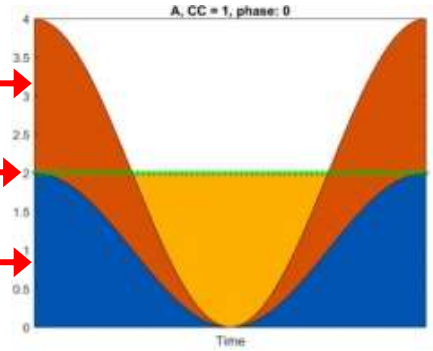


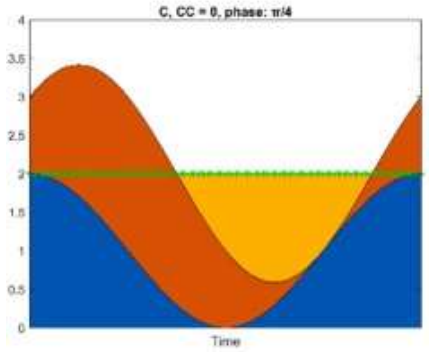
Chihota, Rhoda and Bekker 2022 - preprint

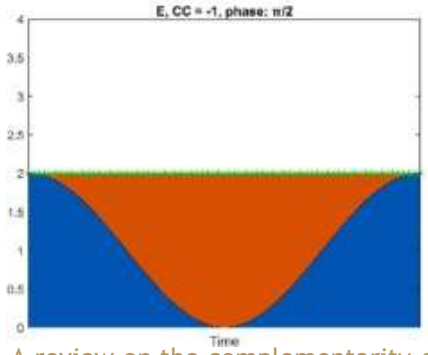
Some ideas on un-constraining the grid
Complimentarity + inevitable curtailment + adjusted pricing

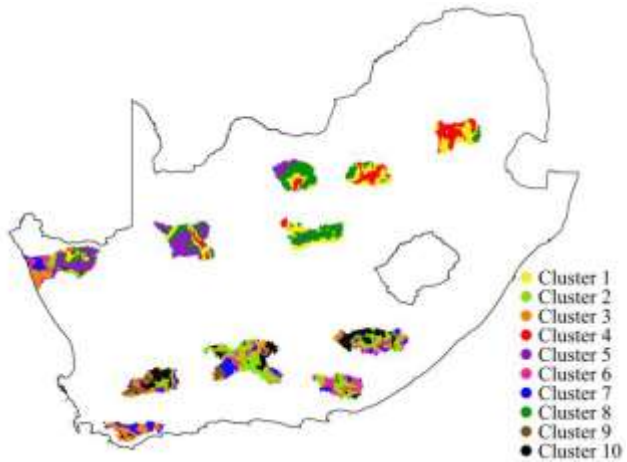
Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

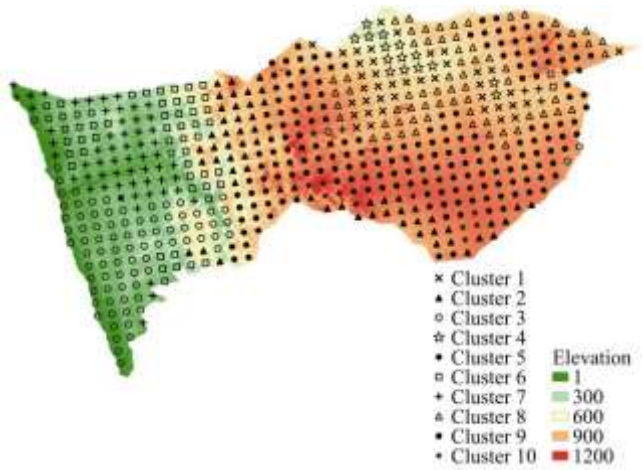
Generator A
Connection limit
Generator B

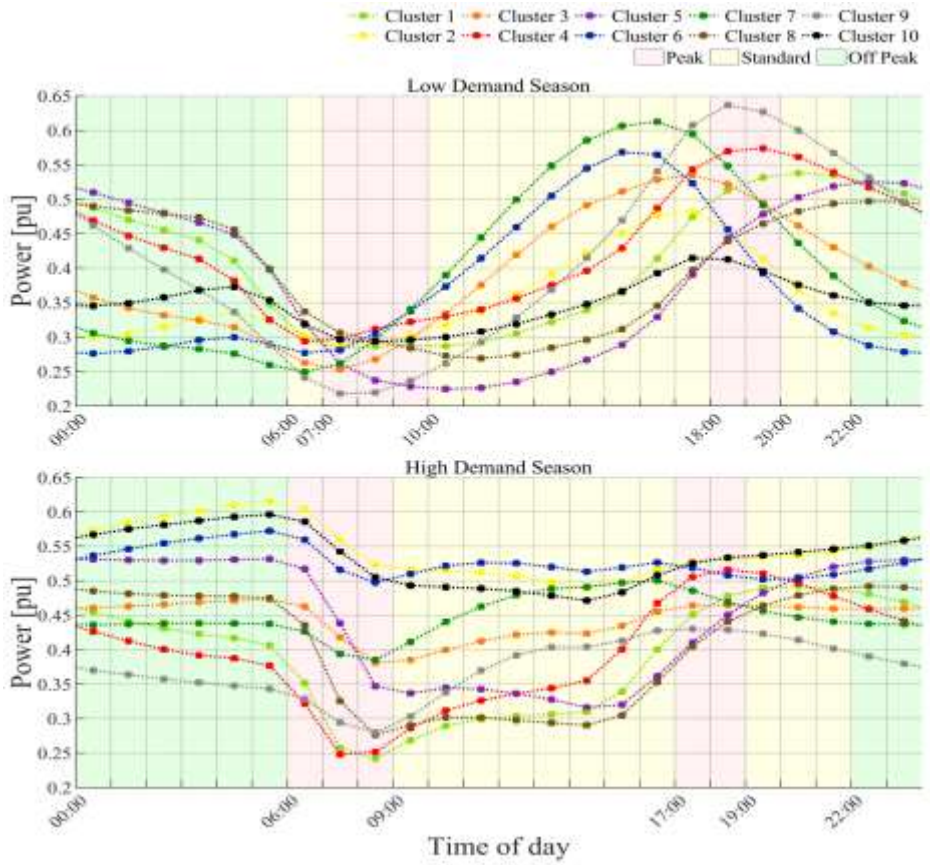






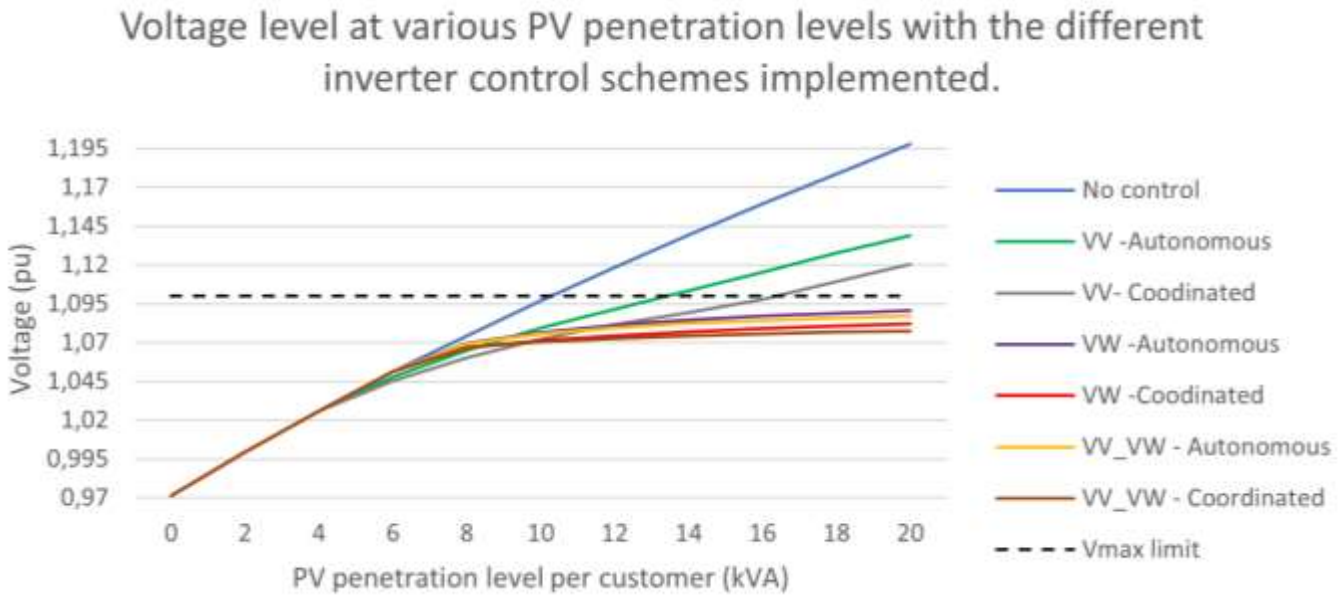


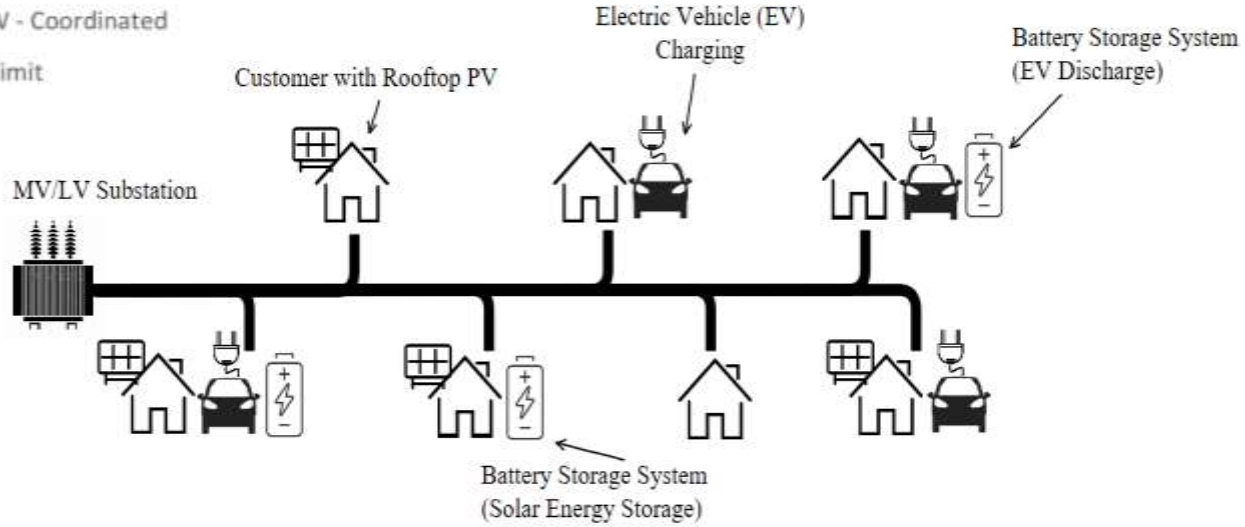




Jurasz et al 2020 - A review on the complementarity of renewable energy sources: Concept, metrics, application and future research directions | Vermeulen et al 2022

Some ideas on un-constraining the grid
View inverter-based technologies as solutions, not threats…





Mararakanye and Bekker 2019 - Renewable energy integration impacts within the context of generator type, penetration level and characteristics

Some ideas on un-constraining the grid
…and adapt regulations and pricing accordingly

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

Static hosting capacity

- Represent worst-case scenario
- Easy to implement (e.g. NRS 097-2-3)

Dynamic, uncoordinated hosting capacity

- Varies by location or time
- Informed by stochastic impact studies yielding a range of hosting capacities
- Implementation is complex

Dynamic, coordinated hosting capacity

- Smart devices that actively respond to local grid conditions
- Grid support sometimes at the cost of customer convenience

Jain, A.K., Horowitz, K., Ding, F., Sedzro, K.S., Palmintier, B., Mather, B. and Jain, H., 2020. Dynamic hosting capacity analysis for distributed photovoltaic resources—Framework and case study. Applied Energy, 280, p.115633.

Key messages

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

There are sound technical reasons for limiting grid connection capacity, and no quick fixes

Adopt a complimentarity- and “inevitable curtailment”-based view of renewable generation, and adjust pricing accordingly

View inverter-based technologies as solutions, not threats, and adjust regulations and pricing accordingly

CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

forward together
sonke siya phambili
saam vorentoe

Thank you
Enkosi
Dankie

Photo by Stefan Els