Study Committee C6

Active Distribution Systems and
Distributed Energy Resources

11130_2022

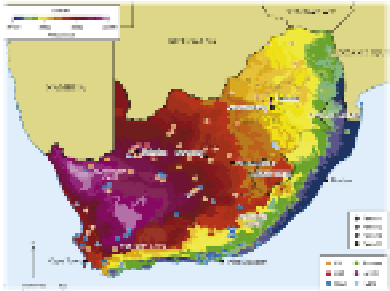
Devising Models for the Integration of DER in Designated Zones in South Africa

Preshaan Jaglal

Eskom

Motivation

- Large penetration of distributed energy resources (DER) due to:
  - Just energy transition.
  - Generation shortage.
  - RMIPPPP & wheeling.
- Environmental and land acquisition challenges results in dispersed applications for IPPs.



REIPP Bid Window 4 Applications – C McEwan (2017)

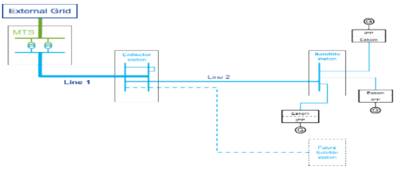
- Independent integration of applications not plausible nor efficient due to substation space, expansion and technical constraints.
- Strategic techno-economic modelling and integration philosophy required to ensure the orderly and economically efficient integration of DER.

Method/Approach

- Strategic approach performed through:
  - Collector station philosophy.
  - Standard building blocks.
  - Screening tools.

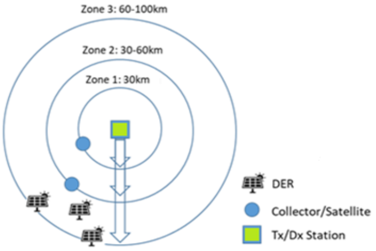
Collector Station Philosophy

- Collector stations to collect large amounts of distributed DER.



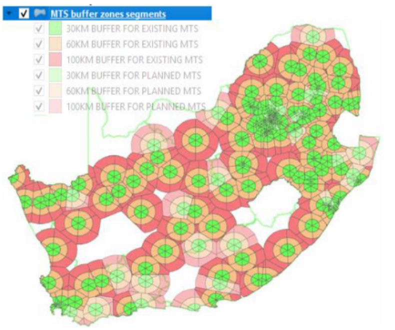
Collector Zones

- Buffer zones created based on distance, technical losses and power evacuation limit investigations.
- Utilized to determine optimal location of collector stations.

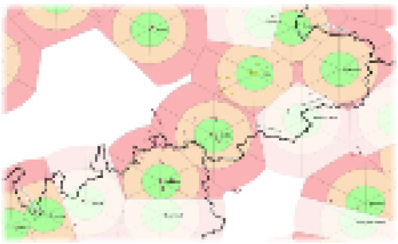


Geospatial Zone Mapping

- Buffer zones applied geospatially to all MTS in South Africa.
- Performed for present and future MTS and IPPs.



Zones Geospatial Mapping – S Malapermal (Eskom 2022)



IPP Overlay – S Malapermal (Eskom 2022)

http://www.cigre.org

Study Committee C6

Active Distribution Systems and Distributed Energy Resources

11130_2022

Devising Models for the Integration of DER in Designated Zones in South Africa

Preshaan Jaglal

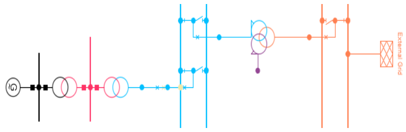
Eskom

Standard Building Blocks

- Standardized configurations (132kV) based off techno-economic assessments.
- Technical assessments:
  - Thermal assessments.
  - Voltage assessments.
- Economic assessments:
  - Capital costing (i.e., hardware, towers, conductors)
  - Operational costing (i.e., technical losses)

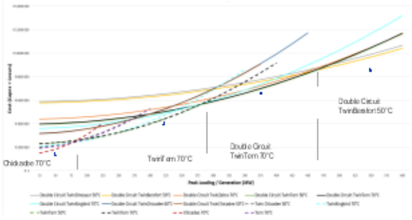
Study Automation

- Study required 1512 simulations per configuration to assess technical and economic criteria.
- Automated assessment through DPL, Python and VBA scripting.



Techno-Economic Line Loading

- Maximum transfer capacity at 132kV:
  - Power evacuation ~ 600MW
  - Distance ~ 100km.



Power Evacuation Level	Proposed Line Configuration	Type	Rating (MVA)
0MW - 100MW	Chickadee 70^0 (up to 30km)/ Tern 70^0	ACSR	128/ 204
101MW - 300MW	Twin Tern 70^0	ACSR	409
301MW - 450MW	Double-Circuit (DC) Twin Tern 70^0	ACSR	818
451MW - 600MW	Double-Circuit (DC) Twin Bersfort 50^0	ACSR	882

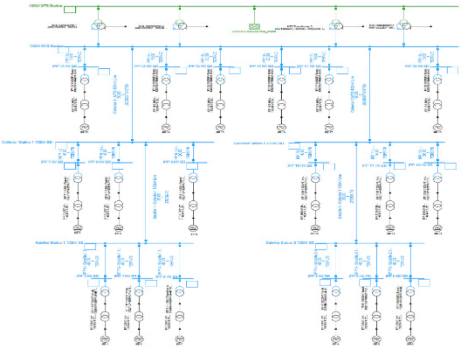
Case Study

Problem statement:

- 12 x 100MW DER applications at various distances to be integrated at 132kV.

Requirements:

- 2 x 600MW collector stations.
- 2 x 300MW satellite stations.



Building block recommendations:

Integration Connection	Evacuation	Selected Configuration	Type	Rating (MVA)
DER Facility Connection	100MW	Tern 70^0*	ACSR	204
Satellite to Collector	300MW	Twin Tern 70^0	ACSR	409
Collector to MTS	600MW	DC Twin Bersfort 50^0	ACSR	882

Results

- Fault level:

Name	Ik'' (kA) – 3 Phase Short Circuit
400kV MTS Busbar	21.57
132kV MTS Busbar	37.45
Collector Station 1 – 132kV Busbar	14.22
Collector Station 2 – 132kV Busbar	14.22

- Voltage regulation and thermal capacity:

Name	Terminal i (V - p.u)	Terminal j (V - p.u)	Loading %
Satellite 1 – Collector 1 Line	1.036	1.032	68.82
Satellite 2 – Collector 2 Line	1.036	1.032	68.82
Collector 1 – MTS Line	1.045	1.036	64.42
Collector 2 – MTS Line	1.045	1.036	64.42

- Rapid voltage change:

Name	Loss of DER	Loss of Satellite 1	Loss of Collector 1
MTS - 132kV BB	0.48 %	1.03 %	1.53 %
Collector 1 - 132kV BB	1.52 %	2.95 %	-
Collector 2 - 132kV BB	0.55 %	1.18 %	1.75 %
Satellite 1 - 132kV BB	2.29 %	-	-
Satellite 2 - 132kV BB	0.60 %	1.29 %	1.91 %

Study Committee C6

Active Distribution Systems and Distributed Energy Resources

11130_2022

Devising Models for the Integration of DER in Designated Zones in South Africa

Preshaan Jaglal

Eskom

Screening Tools

- System stability for the integration of large DER is a concern.
- Decommissioning of power stations and the uptake of inverter-based generation resulting in reduced overall system fault levels with impacts on:

  - Fault ride through.

  - Electromechanical oscillatory stability.
- Screening tools for system stability is therefore required.

Short Circuit Ratio Methods

- Utilized for the initial screening of grid strength in relation to DER integration.
- Various methods available:

  - Short circuit ration (SCR)

  - Equivalent short circuit ratio (ESCR)

  - Composite short circuit ratio (CSCR)

  - Weighted short circuit ratio (WSCR)

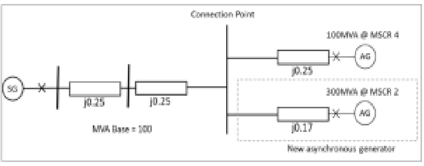
  - Minimum short circuit ratio (MSCR)

Method Comparison

SCR Method	Accounts for nearby ASG	Unique value for all the plants	Accounts for weak electrical coupling between ASG	Accounts for actual impedance between ASG	Accounts for presence of non-active power inverter capacities (i.e., SVCs)
SCR	No	Yes	No	No	No
ESCR	Yes	Yes	Yes	No	No
CSCR	Yes	No	No	No	No
WSCR	Yes	No	Yes	No	No
MSCR	Yes	Yes	Yes	Yes	Yes

SCR Method Comparison – M Le Roux (CSIR 2022)

- Minimum short circuit ratio (MSCR) selected as the most robust screening method.



MSCR Method – M Le Roux (CSIR 2022)

Future Work

- Changing energy policies with the significant transition from synchronous to inverter-based generation plant in South Africa requiring updated building blocks:

  - Collection, transmission and integration of DER at higher voltage levels (i.e., >132kV).

  - Technical assessments under varying grid strengths.

  - Incorporation of contingency requirements.
- Currently embarking on the automation of the MSCR method for system wide stability assessment.

Conclusion

- There is an urgent need in South Africa for an organized, controlled and economically efficient strategy for the integration of large-scale DER.
- The collector station philosophy, standard building blocks and screening tools are proving to be effective approaches in the endeavor.
- Rapidly changing energy policies require the constant need to adjust and improve models .