69TH AMEU CONVENTION

1 – 4 October 2023

CSIR International Convention Centre

Confronting South Africa's Electricity Crisis in the context of a 'Balanced Just Energy Transition' (BJET) and the need for a reliable and resilient national electricity grid

JUST How much Embedded Generation can be connected to your networks?

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Overview

- Capacity calculating manually using NRS 097-2-3 criteria
- Capacity calculated using hosting capacity analysis tools
  - NRS 097-2-3 criteria (MV/LV transformers)
  - MV Networks
- Comparison of results

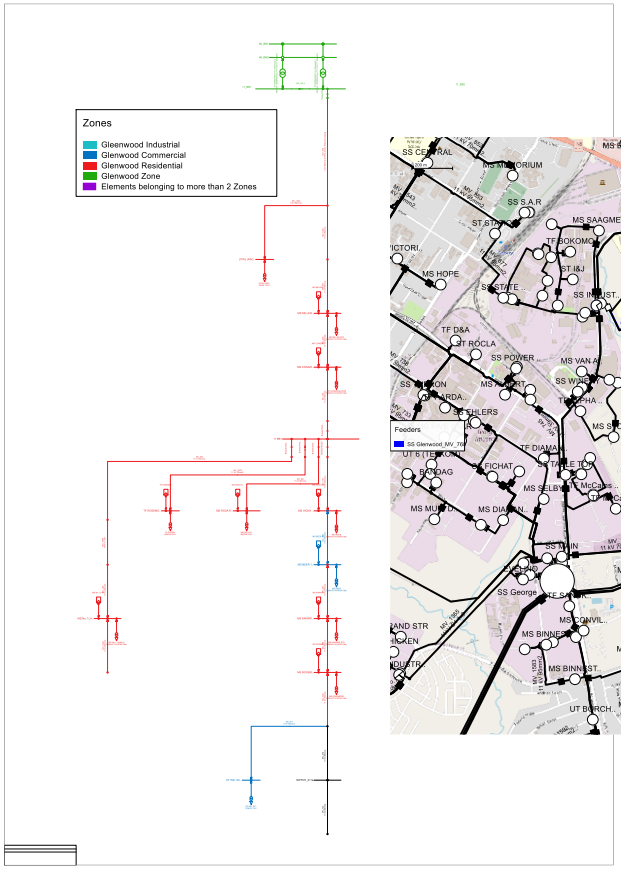
Introduction

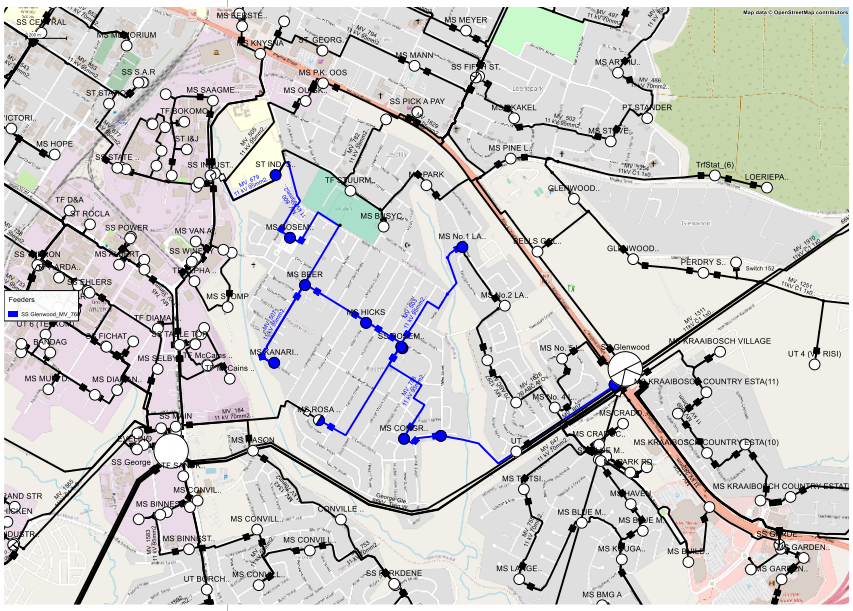
- Municipalities are inundated with Embedded Generation (EG) connection applications, largely driven by
  - Load shedding
  - Relaxing of EG licensing regulations

- The results of comparing a hosting capacity analysis of a municipal network against the results achieved using NRS 097-2-3:2023 limits, will be presented

Simulation Model of Feeder Analysed

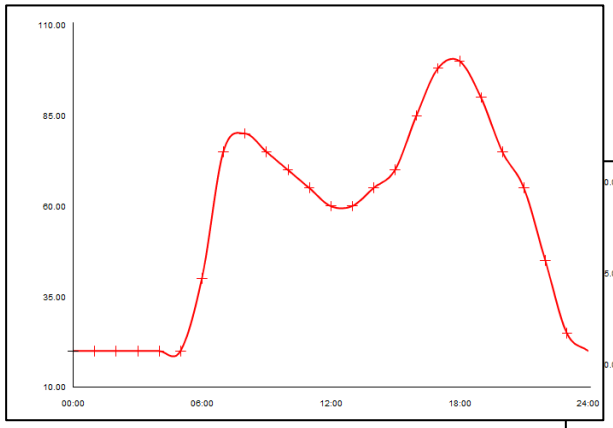
- Actual feeder from municipality selected for the studies
- Contains a blend of residential and commercial customers.
- Contains 4 425 kVA of MV/LV transformer capacity.

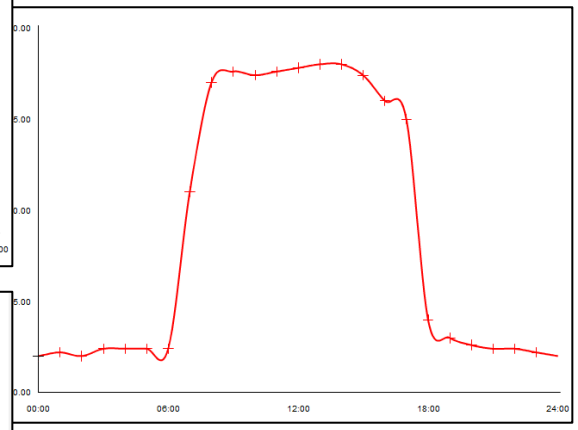


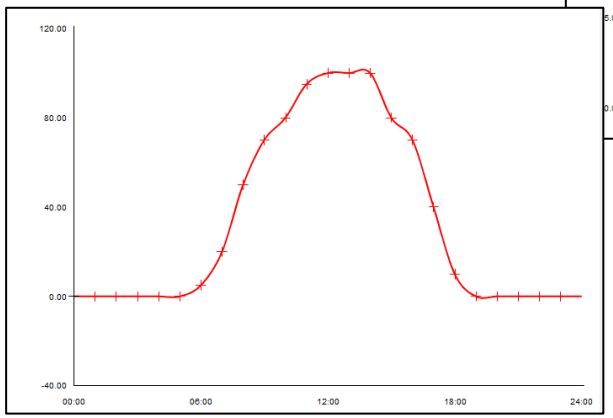


Simulation Model of Feeder Analysed

- Load profiles were derived for each customer class.
- PV generation profile also derived
- Normalised and applied to the load on the MV/LV transformer

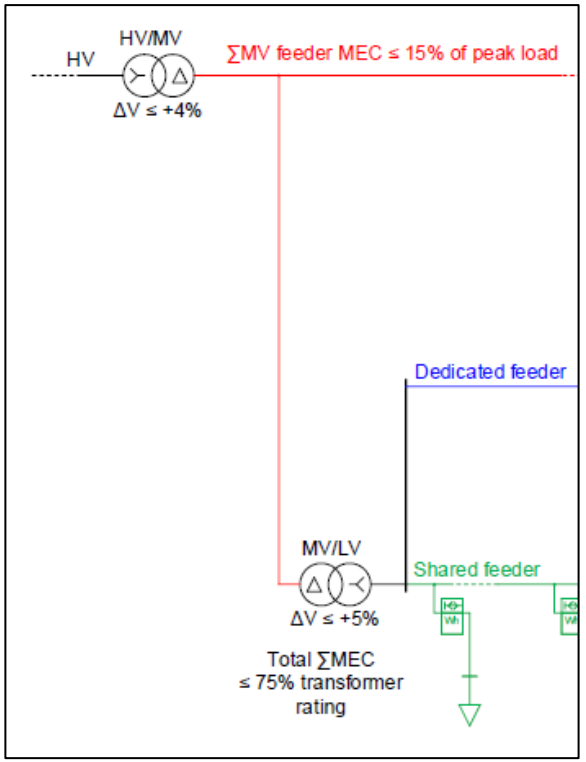






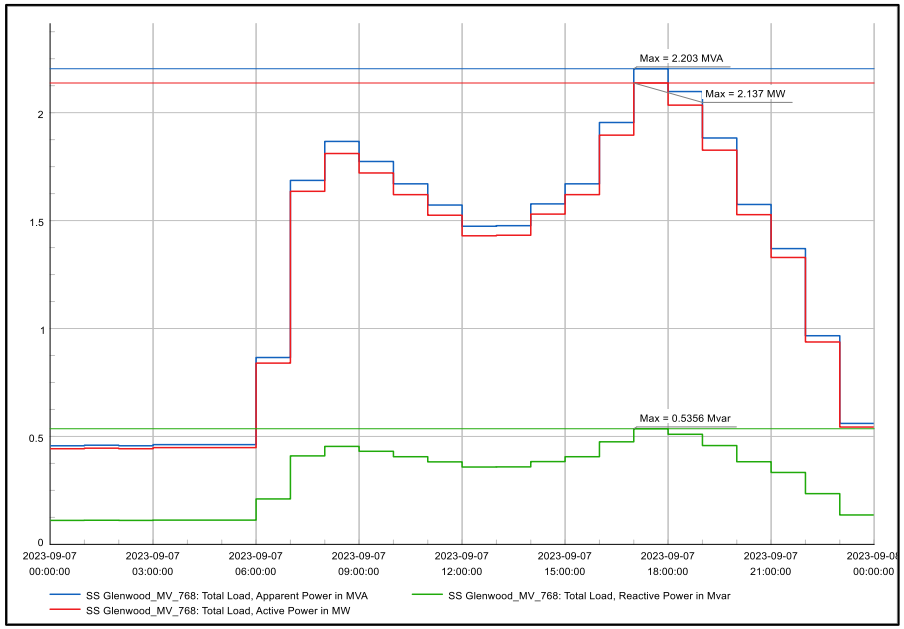
Capacity Calculated using NRS 097-2-3
NRS 097-2-3 Criteria

- The total maximum export capacity (MEC) (i.e., shared LV generation and dedicated LV generation) supplied by a MV/LV transformer should be less than 75% of the MV/LV transformer rating.
- The total MEC supplied by a MV feeder should be less than 15% of the MV feeder peak load.
- Maximum voltage drop/rise in the MV/LV transformer should be less than 5%
- Maximum voltage drop/rise in the HV/MV transformer should be less than 4%



Capacity Calculated using NRS 097-2-3
Study Assumptions

- Feeder load profile shows
  - Minimum load = 443kW
  - Maximum load = 1 432kW
- All MV/LV transformers can have EG connected.



Capacity Calculated using NRS 097-2-3
Study Results: <75% of MV/LV Capacity

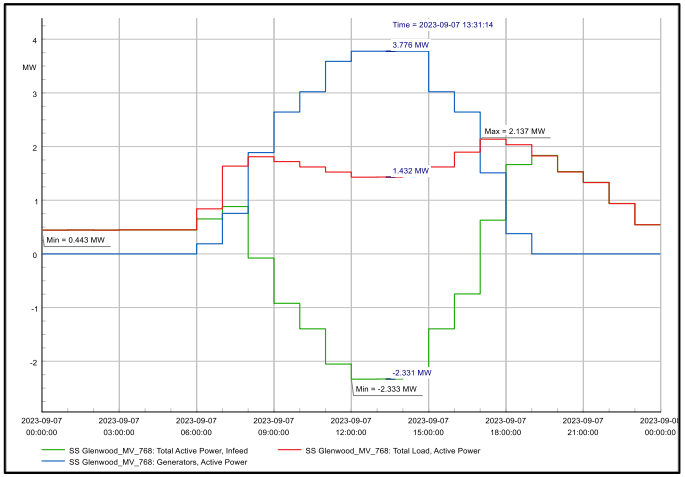
- Total EG capacity at each MV/LV transformer is 75% of transformer rating + minimum transformer loading.

Transformer Name	Trf Rtd.Pow. [kVA]	75% of Trf rating [kVA]	Min Load [kVA]	NRS MEC (75 trf + Min Load) [kVA]
MS BEER	500	375	51	426
MS CONGREGATION	500	375	66	441
MS HICKS	500	375	84	459
MS KANARIE STR	500	375	41	416
MS MILLER STR	500	375	32	407
MS No.1 LAVALIA	500	375	54	429
MS ROSA REST	500	375	71	446
MS ROSEMORE	500	375	48	423
ST IND. SCHOOL	100	75	2	77
TF ROSEMORE	300	225	7	232
UTWL (RACEC)	25	19	1	20
TOTAL	**4425**	**3319**	**457**	**3776**

- Total = 3 776kW

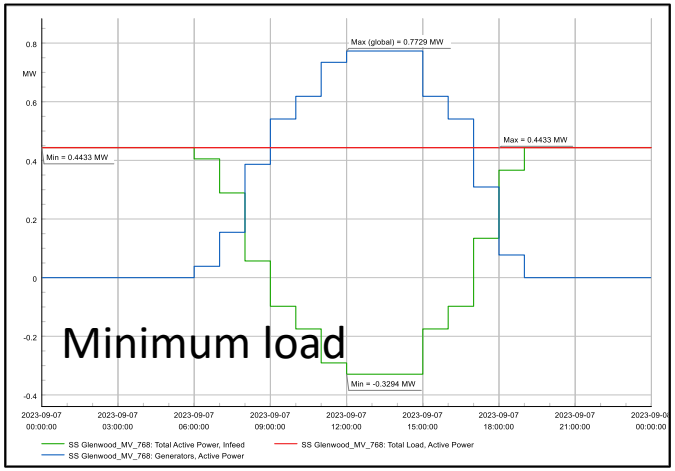
Capacity Calculated using NRS 097-2-3
Study Results: <15% of Peak Feeder Load

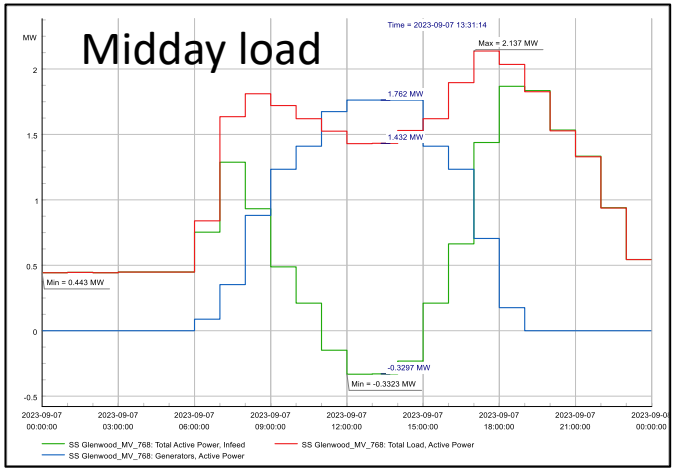
- 15% of peak load = 330kW (0.15x 2203kW)
- Adding this to the peak load = 2 503kW EG capacity.
- However peak load does not occur when peak generation occurs (midday)
- Also considering <75% criteria = 3 776kW, its clear that reduction is required if 15% criteria is to be met as well.



Capacity Calculated using NRS 097-2-3
Study Results: <15% of Peak Feeder Load

- Minimum load = 443kW therefore capacity = 773 kW
- Midday load = 1 432kW therefore capacity = 1762 kW

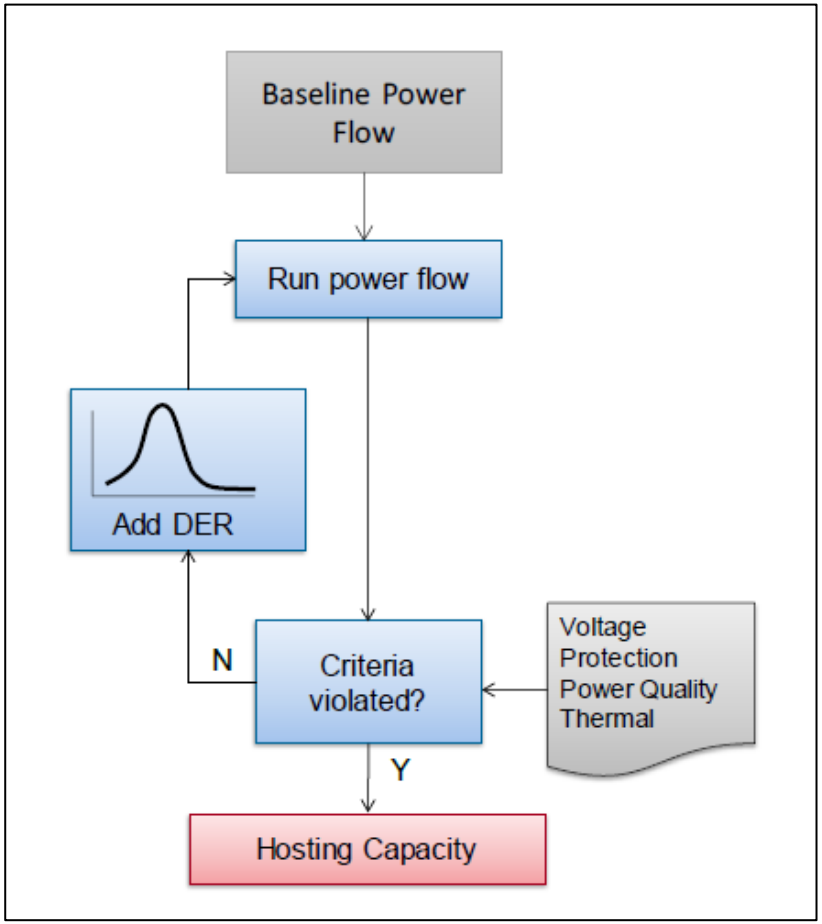




	MEC ≤ 75% of the MV/LV transformer rating	MEC ≤ 15%of feeder peak load	
		Mid-day load	*Min load (conservative)*
Total MV_786 feeder SSEG (kW)	**3776**	**1762**	**773**

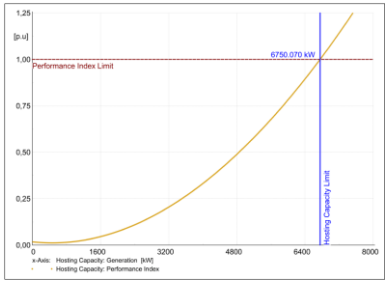
Capacity Calculated using Hosting Capacity Analysis: Methodology

Hosting capacity is used to determine the amount of distributed energy resources (DER) that can be connected to a feeder without violation of pre-defined system constraints, compromising the power quality and without requiring any network expansion or strengthening.



Capacity Calculated using Hosting Capacity Analysis: Criteria

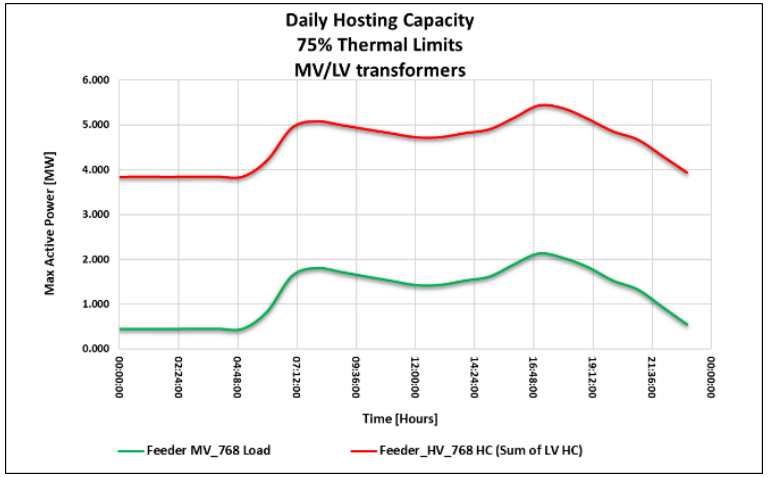
- <75% of capacity for MV/LV transformer (LV connected EG)



- MV Feeder < 75% of rated capacity
- voltage limits were set to 1.1 p.u upper limit and 0.9 p.u lower limit, as per the NRS 097-2-1.
- Maximum feeder voltage rise was set to a maximum of 3%.

Capacity Calculated using Hosting Capacity Analysis: MV/LV transformer <75% rating

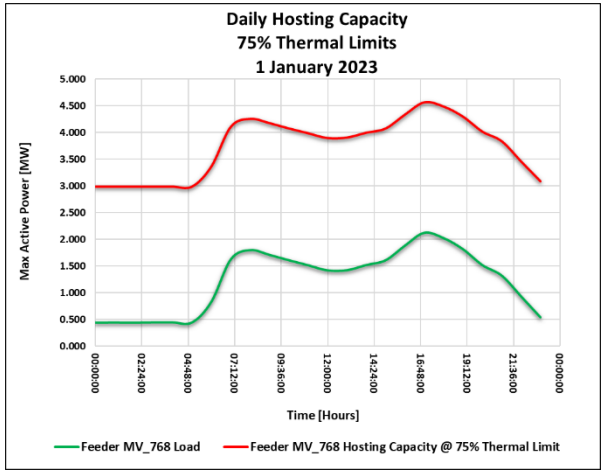
- Results are a function of the load
- Results are as expected close to hand calculation .



Transformer Name	Trf Rtd.Pow. [kVA]	75% of Trf rating [kVA]	Min Load [kVA]	NRS MEC (75 trf + Min Load) [kVA]	Hosting Capacity 75% Thermal Loading 12PM [kVA]	Hosting Capacity 75% Thermal Loading 2AM [kVA]
MS BEER	500	375	51	426	434	612
MS CONGREGATION	500	375	66	441	451	574
MS HICKS	500	375	84	459	464	611
MS KANARIE STR	500	375	41	416	425	354
MS MILLER STR	500	375	32	407	416	329
MS No.1 LAVALIA	500	375	54	429	437	389
MS ROSA REST	500	375	71	446	453	577
MS ROSEMORE	500	375	48	423	431	512
ST IND. SCHOOL	100	75	2	77	79	85
TF ROSEMORE	300	225	7	232	238	246
UTWL (RACEC)	25	19	1	20	20	21
TOTAL	**4425**	**3319**	**457**	**3776**	**4310**	**3845**

Capacity Calculated using Hosting Capacity Analysis: MV feeder Analysi

- Feeder loading capacity limited by thermal limits
- Results are a function of feeder loading.



Terminal	Thermal Limits Max Active Power [MW]	Voltage Limits for Terminals Max Active Power [MW]	Voltage Limits for Feeders Max Active Power [MW]
	2023 75%	2023 1.1 Max. 0.9 Min	2023 3% ΔV
UTWL (RACEC) 11_BB	2.50	134.58	100.02
TF ROSEMORE 11_BB	2.14	38.66	9.17
SWTCH_213b	2.52	24.98	6.37
SWTCH_211a	2.55	9.82	2.61
ST IND. SCHOOL 11_BB	2.56	10.86	2.88
SGEAR_210	2.56	10.87	2.88
Node_98	2.67	27.58	6.97
Node_121	2.67	26.50	6.73
Node_119 (Feeder Max)	**3.90**	**134.58**	**102.58**
Node_108	3.90	132.66	40.18
MS ROSEMORE 11_BB	2.69	12.36	3.26
MS ROSA REST 11_BB	2.72	23.54	6.06
MS No.1 LAVALIA 11_BB	2.67	24.98	6.39
MS MILLER STR 11_BB	3.90	132.02	36.06
MS KANARIE STR 11_BB	2.79	19.02	4.92
MS HICKS 11_BB	3.26	31.90	7.82
MS CONGREGATION 11_BB	3.81	125.62	20.12
MS BEER 11_BB	3.03	24.66	6.24
11 BB1	3.64	39.26	9.23

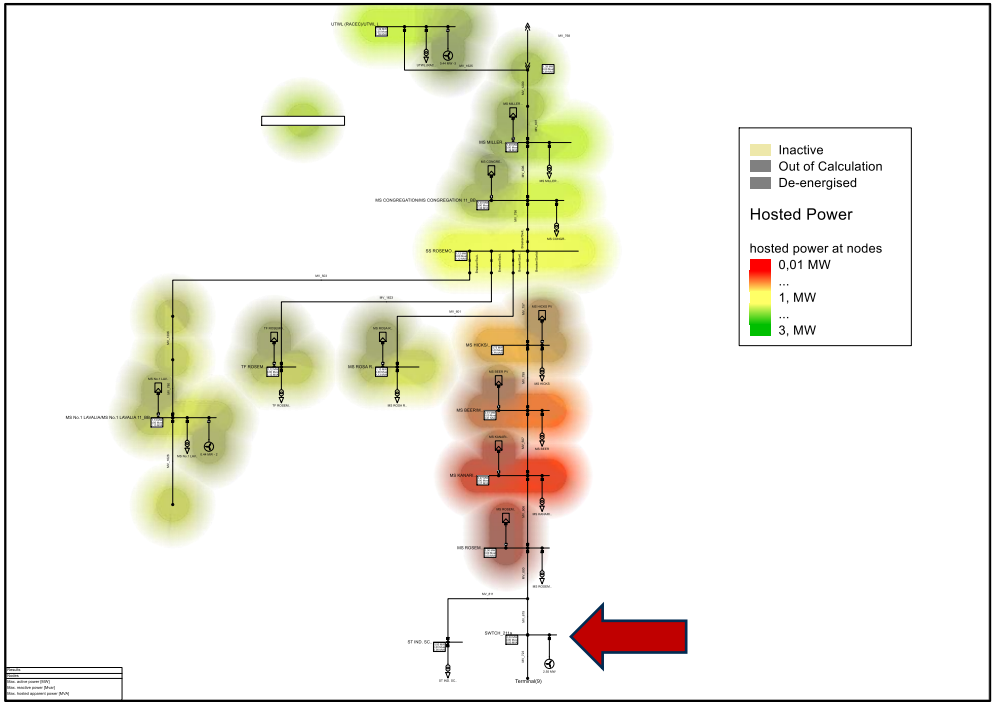
Hosting Capacity Analysis: Location of New EG

- Study done to check the impact of new EG on the results calculated by the hosting capacity tool.
- New EG added to different parts of the feeder and the impact on the total EG compared to no previous EG.

Terminal 2023/01/01 12:00:00 75% Thermal Limits	Thermal Limits Max Active Power [MW]								
	No New DER	2.55 MW End	2.55 MW End Δ HC	3 MW Middle	3 MW Middle Δ HC	3 MW Top	3 MW Top Δ HC	3 MW Top + 0.6 MW End	3.6 MW Δ HC
UTWL (RACEC) 11_BB	2.50	1.39	1.11	0.91	1.59	0.90	1.60	0.30	2.20
TF ROSEMORE 11_BB	2.14	1.12	1.02	0.64	1.50	0.90	1.24	0.30	1.84
SWTCH_213b	2.52	1.13	1.39	0.64	1.88	0.90	1.62	0.30	2.22
SWTCH_211a	2.55	**0.00**	**2.55**	0.26	2.29	0.90	1.65	0.30	2.25
ST IND. SCHOOL 11_BB	2.56	0.00	2.56	0.26	2.30	0.90	1.66	0.30	2.26
SGEAR_210	2.56	0.00	2.56	0.26	2.30	0.90	1.66	0.30	2.26
Node_98	2.67	1.13	1.54	0.64	2.03	0.90	1.77	0.30	2.37
Node_121	2.67	1.13	1.54	0.64	2.03	0.90	1.77	0.30	2.37
Node_119	**3.90**	**1.39**	**2.51**	**0.91**	**2.99**	**0.90**	**3.00**	**0.30**	**3.60**
Node_108	3.90	1.39	2.51	0.91	2.99	0.90	3.00	0.30	3.60
MS ROSEMORE 11_BB	2.69	0.00	2.69	0.26	2.43	0.90	1.79	0.30	2.39
MS ROSA REST 11_BB	2.72	1.13	1.59	0.64	2.08	0.90	1.82	0.30	2.42
MS No.1 LAVALIA 11_BB	2.67	1.13	1.54	0.64	2.03	0.90	1.77	0.30	2.37
MS MILLER STR 11_BB	3.90	1.39	2.51	0.91	2.99	**0.90**	**3.00**	0.30	3.60
MS KANARIE STR 11_BB	2.79	0.27	2.52	0.26	2.53	0.90	1.89	0.30	2.49
MS HICKS 11_BB	3.26	0.75	2.51	**0.26**	**3.00**	0.90	2.36	0.30	2.96
MS CONGREGATION 11_BB	3.81	1.30	2.51	0.82	2.99	0.90	2.91	0.30	3.51
MS BEER 11_BB	3.03	0.51	2.52	0.26	2.77	0.90	2.13	0.30	2.73
11 BB1	3.64	1.12	2.52	0.64	3.00	0.90	2.74	0.30	3.34

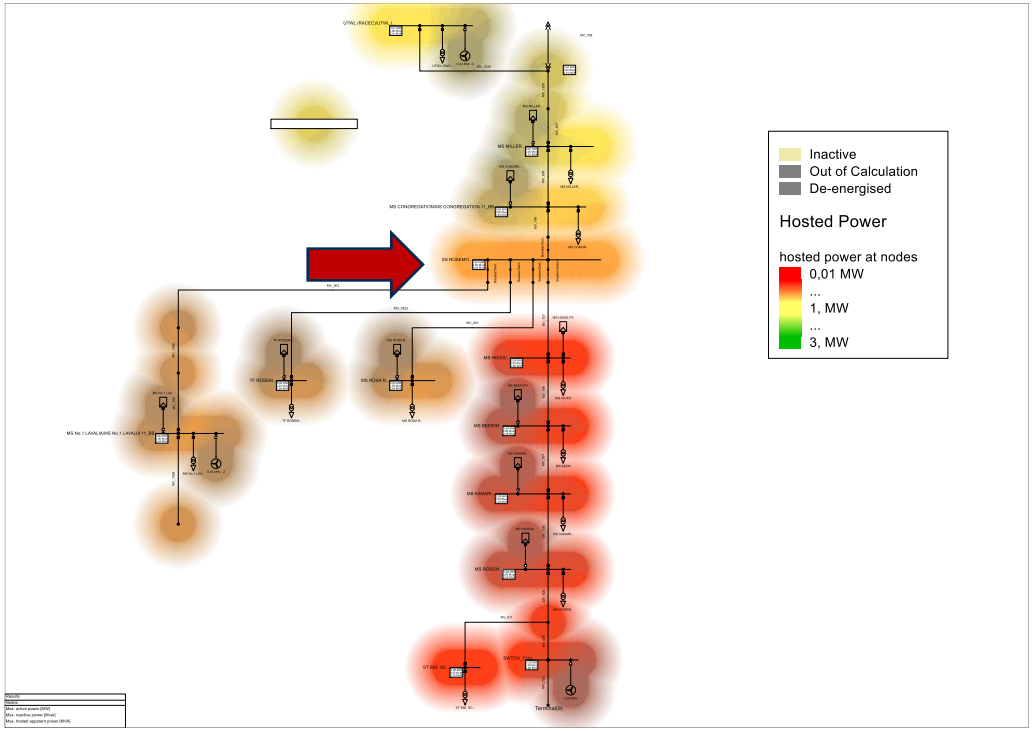
Hosting Capacity Analysis: Location of New EG

- 2.55MW EG added to the **end of the feeder**.
- Limiting component reduced to 1.39MW capacity.
- Middle of feeder constrained.



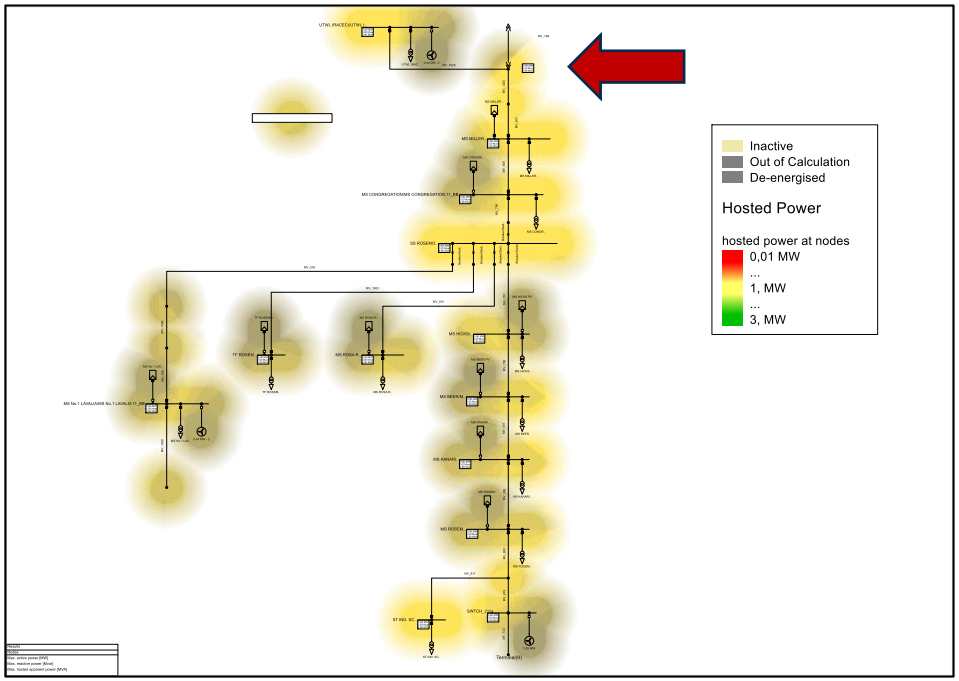
Hosting Capacity Analysis: Location of New EG

- 3 MW EG added to the **middle of the feeder**.
- Limiting component reduced to 0.91 MW capacity.
- End of feeder constrained.



Hosting Capacity Analysis: Location of New EG

- 3 MW EG added to the **beginning of the feeder**.
- Limiting component reduced to 0.9 MW capacity.
- Remaining capacity distributed along feeder



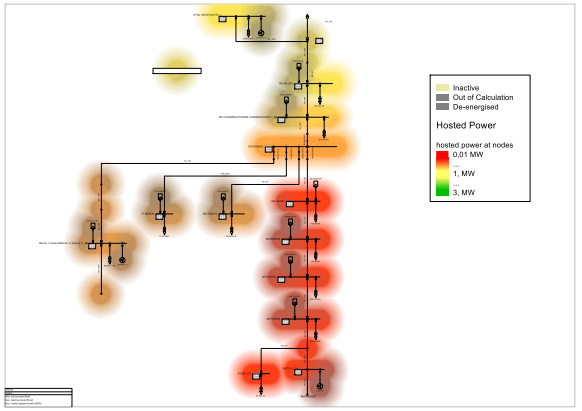
Conclusions

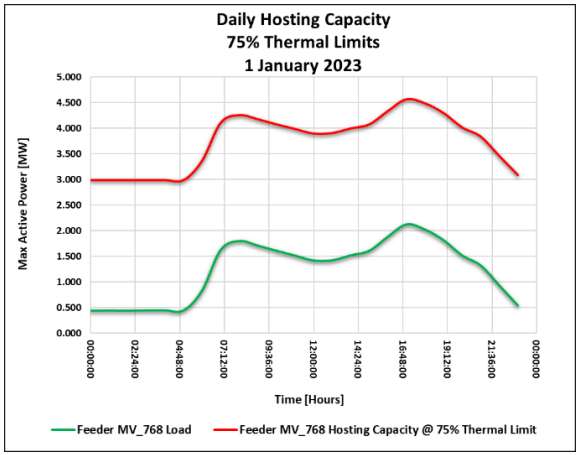
- NRS 097-2-3 calculations provide conservative results as compared to the hosting capacity analysis methods, especially the <15% of MV feeder maximum loading criteria.
- In the feeder studied, the thermal constraints were dominant in determining the hosting capacity, both for LV and MV connected EG.

NRS-097-2-3	kW	Hosting Capacity LV connected EG	kW	Hosting Capacity MV Feeder	kW
MEC ≤ 75% of the MV/LV transformer rating	3 776	MEC ≤ 75% of the MV/LV transformer rating	3 845	<75% thermal	3900
MEC ≤ 15% of feeder peak load	773 (min feeder load)	MEC ≤ 75% of load profile	3 845 (min feeder load)	Voltage range	134 580
	1762 (midday load)		4 310 (midday load)	Feeder voltage rise <3%	102 580
				Load profile (<75% thermal)	2 990 to 4 550

Conclusions

- MV connected EG, will affect the amount of EG that can be connected other parts of the network. Continuous assessment of the feeder capacity must be conducted as new MV connected EG is added to the feeder.
- The hosting capacity is a function of the daily load profile, thus, the maximum hosting capacity can be determined in a range that is a function of the feeder load profile.

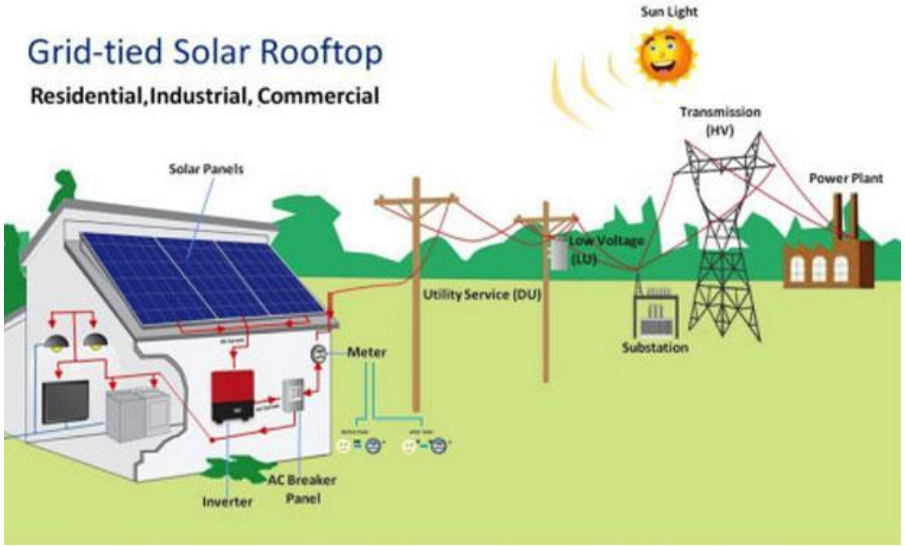




Conclusions

JUST how much EG can be connected to your networks depends on;

1. The total existing load on the feeder
2. The load profile of the feeder
3. The appetite of the municipality to go above the limits specified by NRS 097-2-3.



69TH AMEU CONVENTION 2023

Confronting South Africa's Electricity Crisis in the context of a 'Balanced Just Energy Transition' (BJET) and the need for a reliable and resilient national electricity grid

Thank you!

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CITY OF TSHWANE IGNITING EXCELLENCE