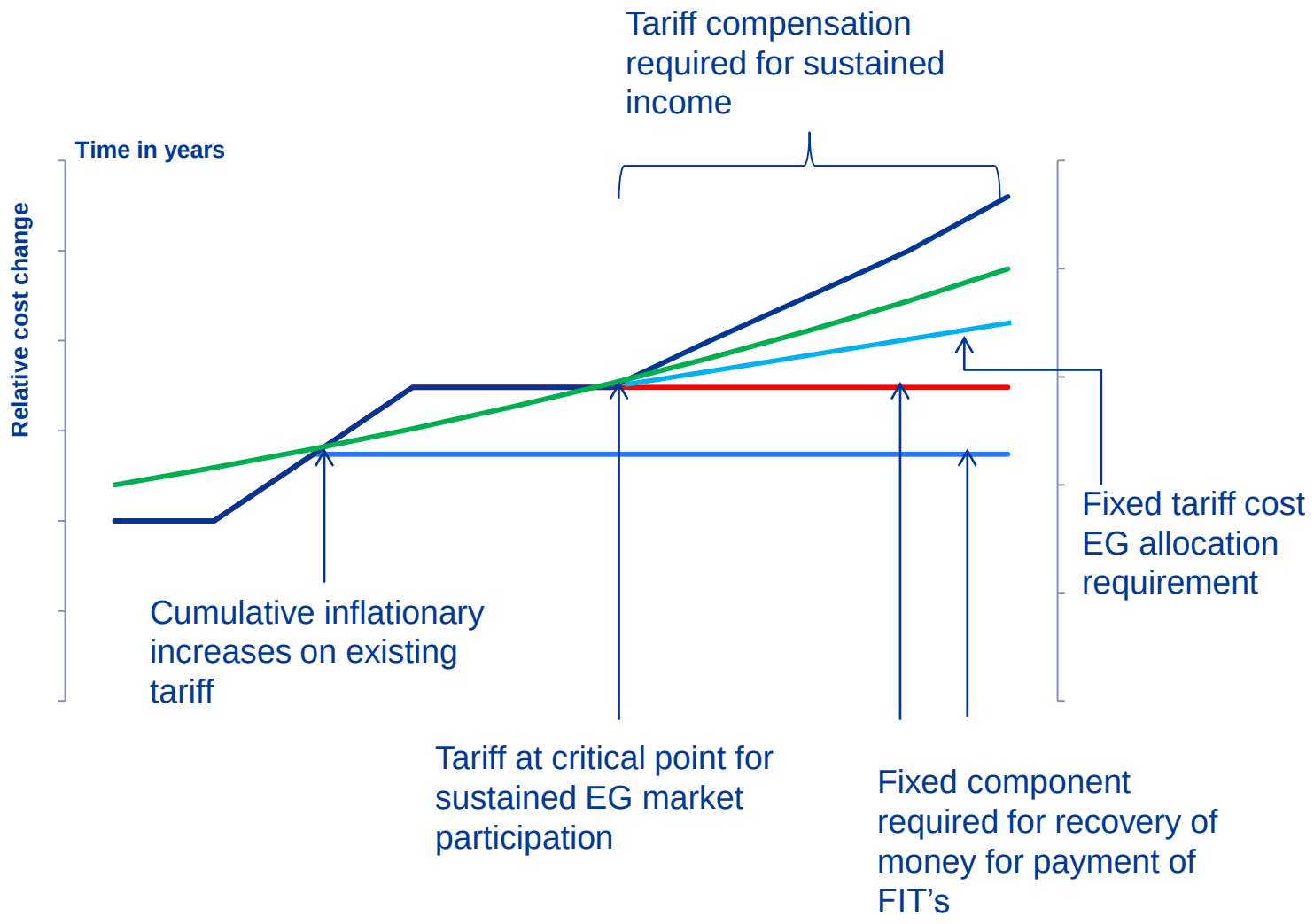
Ravi Moonsamy

Investigating the financial recovery of embedded generation in medium voltage distribution systems

Simplistic representation of Utility tariff growth on EG market penetration



Levelised capital and O&M requirements for different technologies in Rands/Million/kW

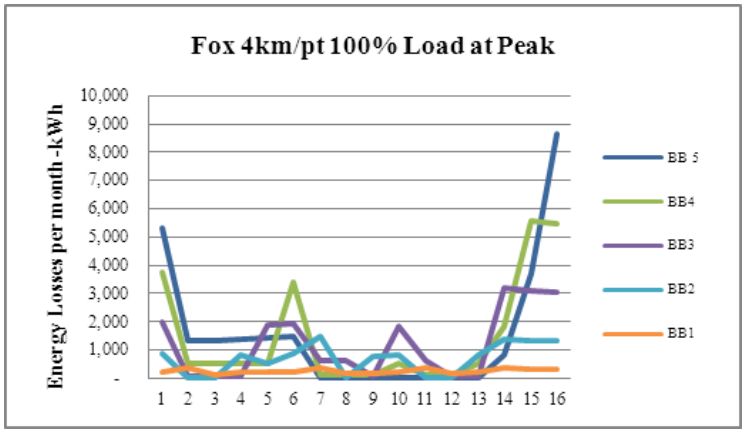
Technology	*System size*	*Cost items*	*2013*
Crystalline PV	0.25 MW	System price	25.23
	1.0 MW	System price	20.44
	10.0 MW	System price	19.86
Thin film PV	0.25 MW	System price	22.13
	1.0 MW	System price	17.94
	10.0 MW	System price	17.42
Annual O&M for new installations in 2013-R/Wp/yr			
Crystalline and thin film	0.25 MW	O&M	0.271
	1.0 MW	O&M	0.220
	10.0 MW	O&M	0.213

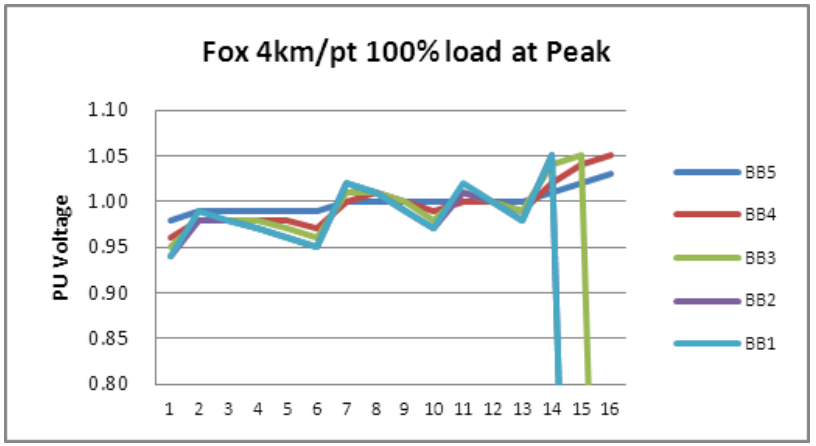
Technology	System size	Cost items	2013
Gas Turbine	Two 2x2x1 MW	Total Plant cost, Overnight	29,382
Annual O&M for new installations in 2013-R/kW/yr			
Gas Turbine	6x750MW	Fixed + Variable O&M	1,006

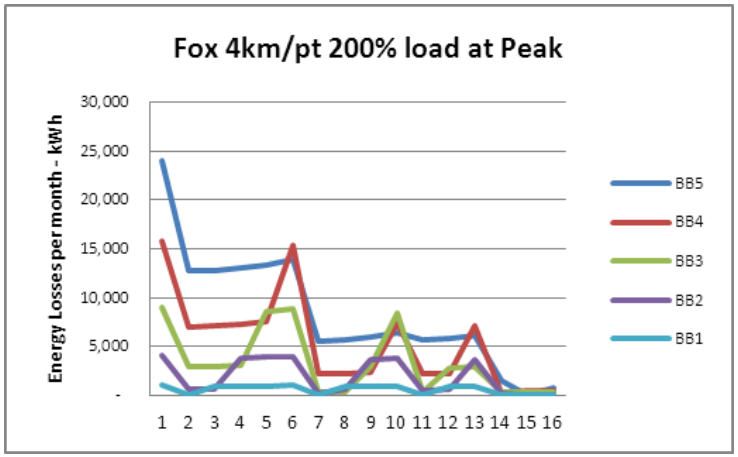
Technology	System size	Cost items	2013
Wind	10x2 MW	Total Plant cost, Overnight	20,164
	25x2 MW	Total Plant cost, Overnight	18,925
	50x2MW	Total Plant cost, Overnight	18,044
	100x2MW	Total Plant cost, Overnight	17,204
Annual O&M for new installations in 2013-R/kW/yr			
Wind	10x2 MW	Fixed + Variable O&M	372
	25x2 MW	Fixed + Variable O&M	349
	50x2MW	Fixed + Variable O&M	332
	100x2MW	Fixed + Variable O&M	317

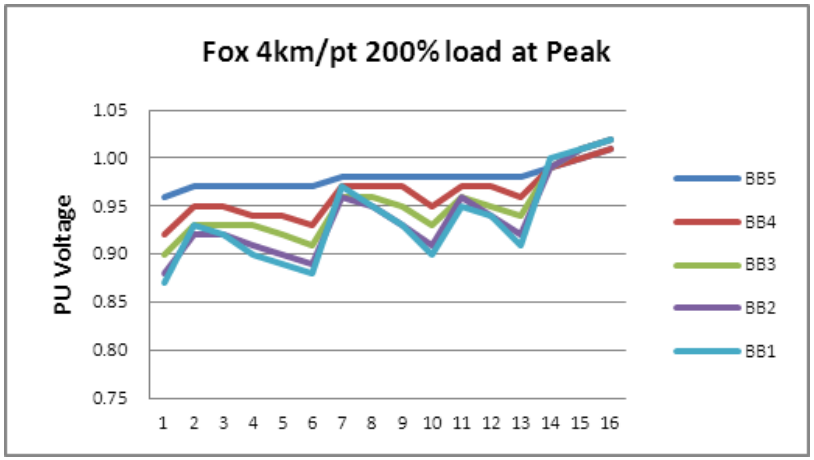
Technology	System size	Cost items	2013
Biomass	Forestry Residue	Total Plant cost, Overnight	39,625
	Solid waste	Total Plant cost, Overnight	79,679
Annual O&M for new installations in 2013-R/kW/yr			
Biomass	Forestry Residue	Fixed + Variable O&M	1,195
	Solid waste	Fixed + Variable O&M	3,117

Energy losses per month for various network configurations and EG combinations

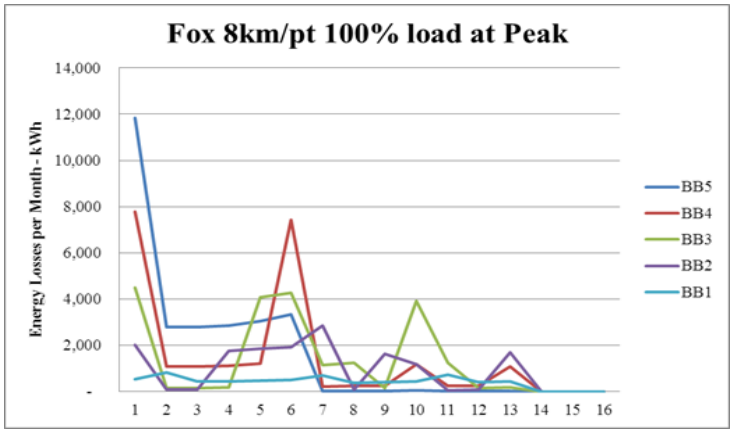


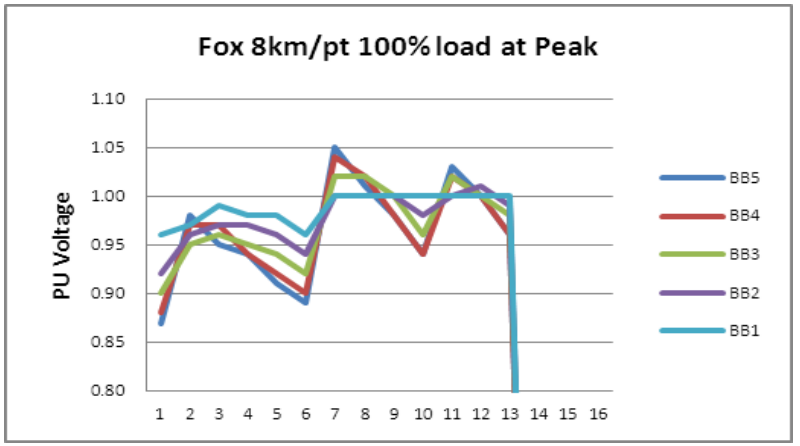


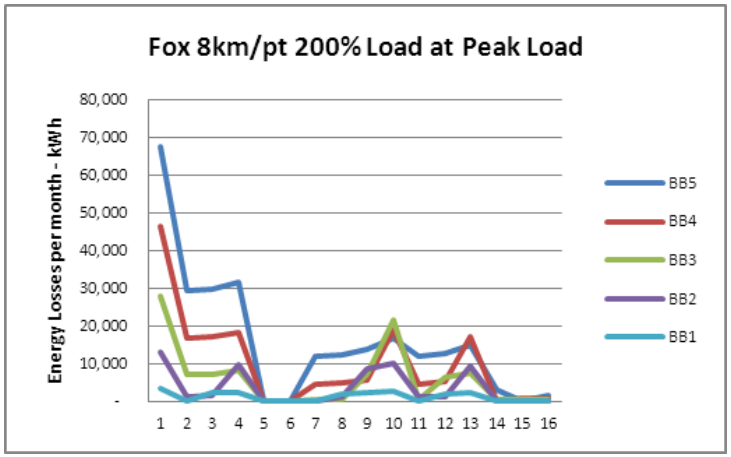


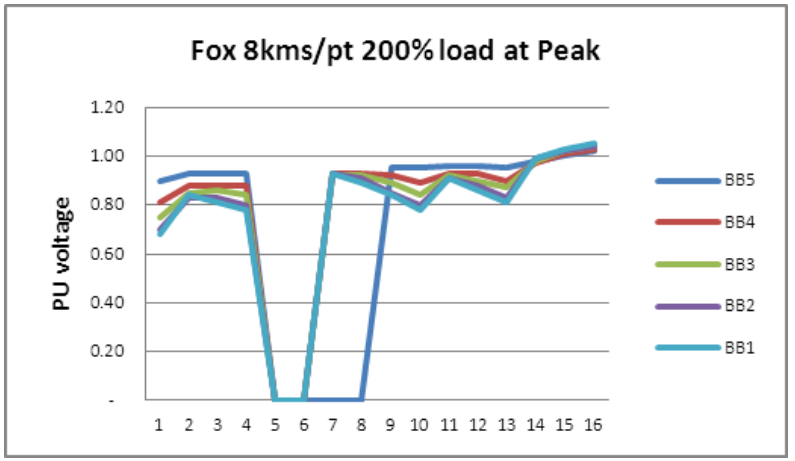


Energy losses per month for various network configurations and EG combinations



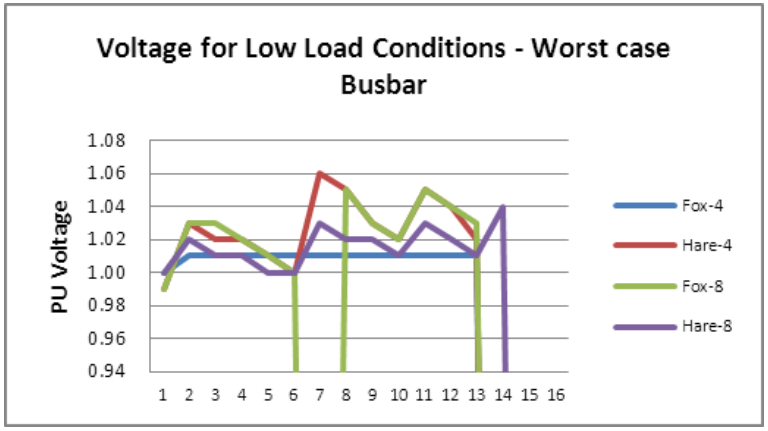






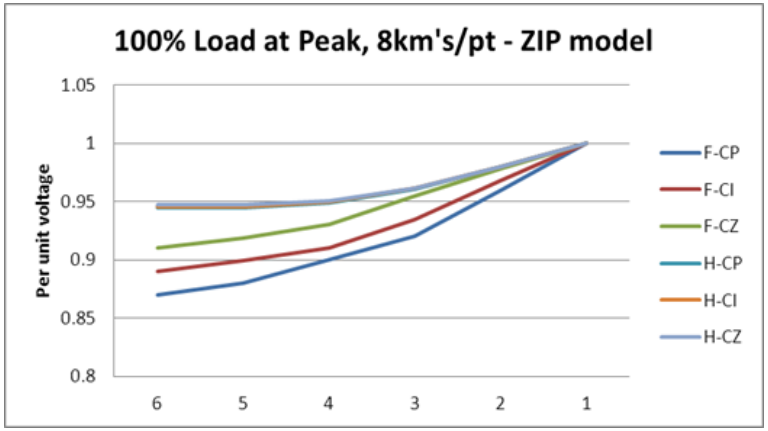
Energy losses per month for various network configurations and EG combinations

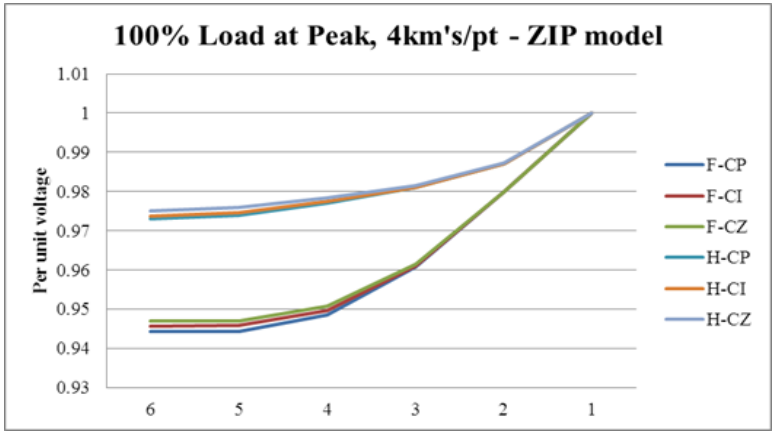
- Generation that is furthest away from source has a higher effect on losses
- Reversing power flows due to EG lead to an increase in losses.
- At low levels of EG volume penetration in stressed networks, EG volumes have to be greater than 50% and located at a distance greater than 20% of the length of system
- To fulfill all conditions, EG must be less than 20% Peak load and greater than 40% of total length from source



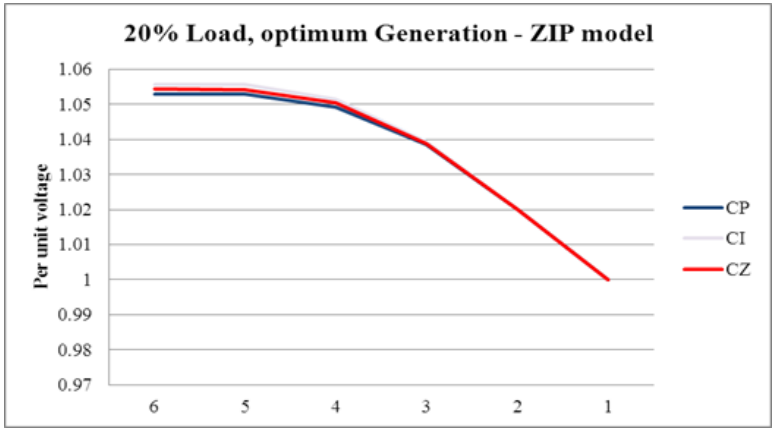
- Higher load factors allow for greater volume penetration of EG
- Only with operational flexibility of EG will sustainable capacity be created on the system

Effect of using different load models





TOU	Conductor Type (F - Fox, H - Hare), length (4km's or 8km's)			
	F4-100%	***F4-200%***	***F8-100%***	***F8-200%***
Peak	-2%	-10%	-10%	-10%
Std	0%	0	0	0
Off- Peak	2%	2%	5%	2%
TOU	Conductor Type (F - Fox, H - Hare), length (4km's or 8km's)			
	H4-100%	***H4-200%***	***H8-100%***	***H8-200%***
Peak	-1%	-3%	-4%	-5%
Std	0%	0%	0%	0%
Off- Peak	1%	1%	5%	3%



Levelised capital recovery possible in R'000/MW

System Configuration	Statistic	MARR 5%	MARR 7%
Fox Conductor, 4kms 100% Peak Load	Max R'000/MW	R 5,700	R 5,008
	Min R'000/MW	R 1,707	R 3,508
	Avg R'000/MW	R 2,087	R 1,834
Fox Conductor, 8kms 100% peak load	Max R'000/MW	R 5,700	R 5,008
	Min R'000/MW	R 1,707	R 1,500
	Avg R'000/MW	R 2,571	R 2,259
Fox Conductor, 4kms 200% peak load	Max R'000/MW	R 2,013	R 1,768
	Min R'000/MW	R 2,013	R 1,768
	Avg R'000/MW	R 2,013	R 1,768
Fox Conductor 4kms 200% peak load	Max R'000/MW	R 3,993	R 3,508
	Min R'000/MW	R 1,591	R 1,397
	Avg R'000/MW	R 2,080	R 1,827
Hare Conductor 4kms 100% peak load	Max R'000/MW	R 5,700	R 5,008
	Min R'000/MW	R 1,707	R 1,500
	Avg R'000/MW	R 2,232	R 1,929
Hare Conductor 8kms 100% peak load	Max R'000/MW	R 5,700	R 5,008
	Min R'000/MW	R 1,707	R 1,500
	Avg R'000/MW	R 2,283	R 2,006
Hare Conductor 4kms 200% peak load	Max R'000/MW	R 5,700	R 5,008
	Min R'000/MW	R 1,707	R 1,500
	Avg R'000/MW	R 2,232	R 1,929
Hare Conductor 8kms 200% peak load	Max R'000/MW	R 3,993	R 3,508
	Min R'000/MW	R 1,707	R 1,500
	Avg R'000/MW	R 2,127	R 1,850

- MARR calculated for 20 years
- Income calculated for 7 TOU configurations for all generator combinations and with 90% of income generated attributed to O&M in table.
- Highest amount of capital raised with the least amount of generators on the system
- Dispersed EGs should be owned by single entities to maximise capital requirements
- Need regulations to prevent unfair advantages as a result of locking Utilities into long term contracts which limit system performance
- Multiple EGs that operate in different periods affected by about 5%-10% for a SAIDI of 48hours

Combination	All periods	Only Peak	Only Std	Only off-Peak	Peak & Std	Std & Off-Peak	Peak & Off-Peak
No Gen							
One Gen							
Two Gens					1 Peak + 1 Std	1 Std + 1 Off-Peak	1 Peak + 1 Off-Peak
Three Gens Combination 1					1 Peak + 2 Std	1 Std + 2 Off-Peak	1 Peak + 2 Off-Peak
Three Gens Combination 2					2 Peak + 1 Std	2 Std + 1 Off-Peak	2 Peak + 1 Off-Peak
Four Gens Combination1					1 Peak + 3 Std	1 Std + 3 Off-Peak	1 Peak + 3 Off-Peak
Four Gens Combination2					2 Peak + 2 Std	2 Std + 2 Off-Peak	2 Peak + 2 Off-Peak
Four Gens Combination3					3 Peak + 1 Std	3 Std + 1 Off-Peak	3 Peak + 1 Off-Peak
Five Gens Combination 1					1 Peak + 4 Std	1 Std + 4 Off-Peak	1 Peak + 4 Off-Peak
Five Gens Combination 2					2 Peak + 3 Std	2 Std + 3 Off-Peak	2 Peak + 3 Off-Peak
Five Gens Combination 3					3 Peak + 2 Std	3 Std + 2 Off-Peak	3 Peak + 2 Off-Peak
Five Gens Combination 4					4 Peak + 1 Std	4 Std + 1 Off-Peak	4 Peak + 1 Off-Peak

Key points of interest

- Increase of system impedance leads to an increase in EG switching operations required
- Although the highest amount of capital raised comes from highest volume of EG, the highest levelised capital that can be raised comes from having the least amount of generation. This implies single entity EG operation is most capital friendly
- There would be high competition to lock in long term contracts as the seed capital that can be raised beyond existing contracts decreases substantially.
- There is not enough regulations around this type of commercial ventures
- Operational performance is key and hence will attract added focus

Key points of interest

- There will have to be a minimum threshold of non-technical losses in order to increase the amount of EG in the system.
- The level of non-technical losses also affect the loss allocation in improving system performance.
- As the amount of EG increase load expansion is placed at risk
- The highest yield of approximately R5Million per MW investment potential with a yield of 5% MARR per year, is not sufficient to justify the investment at the system marginal price to install expensive renewable energy technologies
- Subsidisation of the tariff received by the independent EGs would be a means to ensure that competition in this sector could be introduced but overall cost recovery mechanisms will result in higher tariffs for load customers

Key points of interest

- Subsidisation with careful and well-structured regulations and management of EG is needed in order to ensure that the system can be operated and managed without negative effects to the customer load base.

- It is recommended that the best practise regulation for EG should include, but not be limited to:

  - Simple and transparent rules for connection, cost recovery and incremental energy loss apportionment.

  - Only shallow charges to be used as the system average cost recovery is a better method to recover upstream costs.

  - Use of system charges need to be developed differentiated by voltage, location and time of use.

Thank you