Traction Energy Management solutions for Energy Efficiency and loadshedding

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INTRODUCTION

The Passenger Rail Agency of South Africa is responsible for the management and operations of a passenger rail in South Africa. The electrical power supply for running these operations is supplied by Eskom grid and the Municipalities.

The price of electricity has been increasing drastically over the past 15 years from 2008 (Figure 1), even though the energy consumption is relatively constant. SA has been experiencing loadshedding. These are reasons for bulk energy users to find ways to reduce energy cost and consumption.

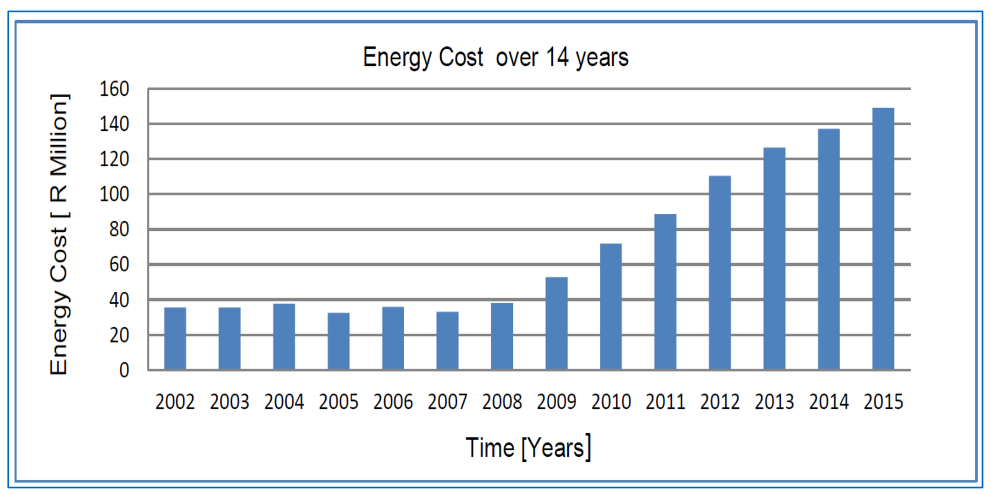

Figure 1: Energy cost over years.

This poster considers the following energy management solutions:

- Regenerative braking (existing & new fleet capable)
- Reversible traction substations and/or energy storage
- Time shifting
- Load shifting
- Increase Notified Maximum demand (NMD)
- Extension of 33 kV AC distribution network

Savings of more than R 10 million per year has been realized.

RESEARCH PLAN & APPROACH

The approach on this research is based on experimental data measured on the Western Cape PRASA network (substations & Trains). Some data used is sourced from the utilities i.e. Eskom & Municipalitiy (City of Cape town).

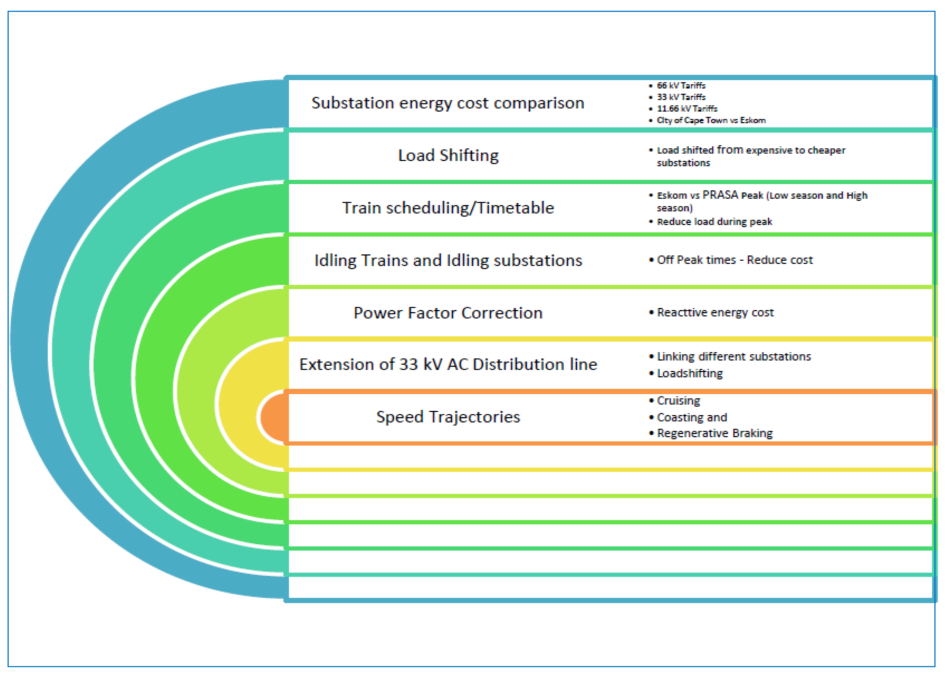

Figure 2: Research Elements.

The chart (Figure 2) shows the research elements considered in this poster.

RESULTS

Regenerative braking test results for an 8.07 km distance are sown in Figure 3 for a 10M3 Train set from Salt River to Kenilworth stations.

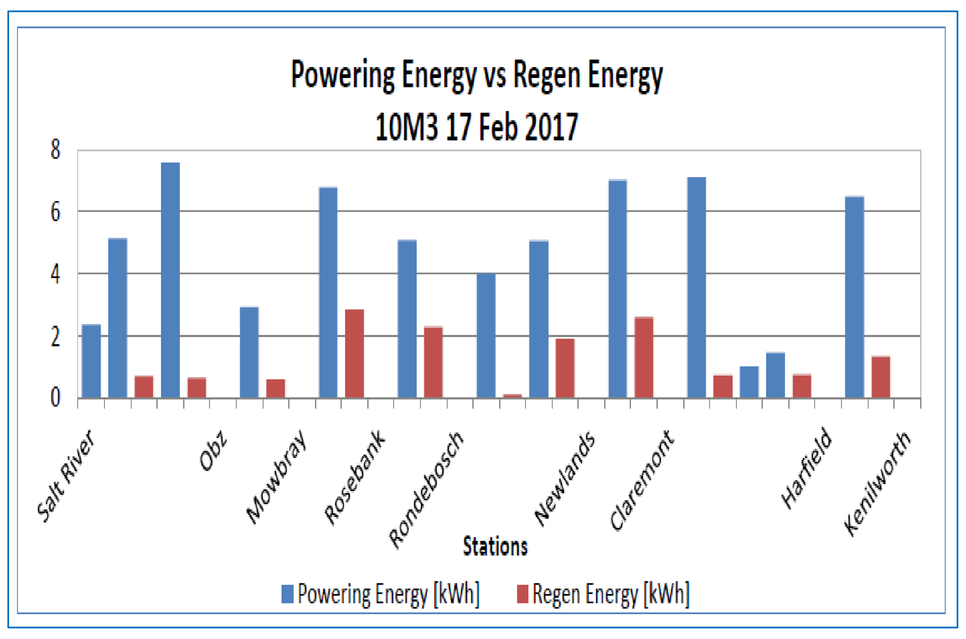

Figure 3: Energy savings with Regen. Braking

Unfortunately, this energy (23.63%) was dissipated through resistor banks. The new trains deployed by PRASA have the regenerative braking capability and therefore the entire fleet will have regen. This means that the new Trains should have Battery banks or at least traction substations to be modified to be **reversible**. The regenerated energy will then be fed back to 11 kV AC and 33 kV AC network for Signaling supply as well as for traction network in other nearby sections of the network before feeding it back to the Eskom grid. Energy storages (Battery or flywheel) would also assist in harnessing the regenerated energy instead of dissipating it.

Time shifting requires changes in the timetable and this is normally the last resort since it affects commuters.

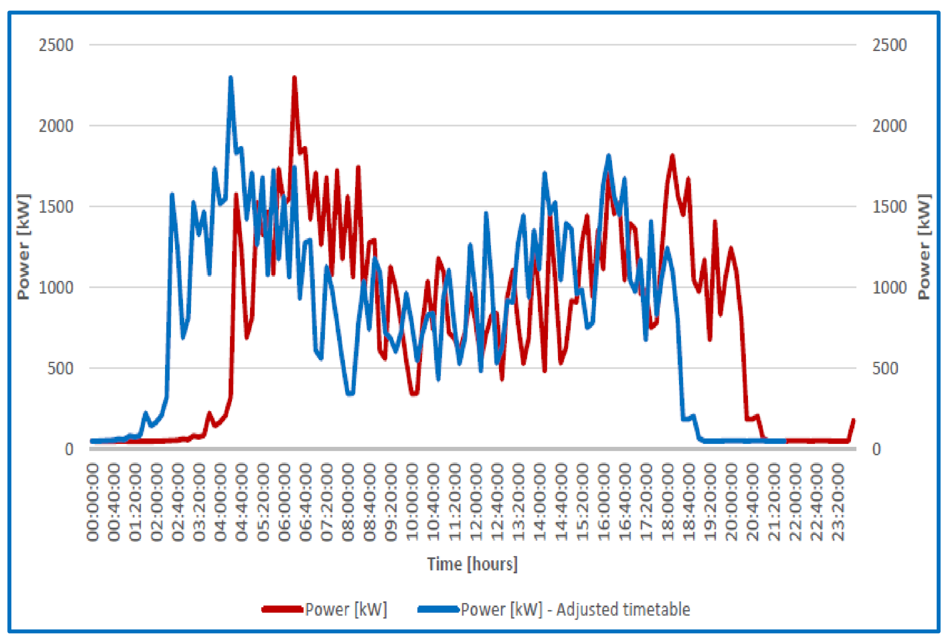

Figure 4: Service starting time shifted by 2 hrs.

Eskom tariffs are high during high season which is from June to August each year and the rest is low season. The (Figure 4&5) shifted timetable (2hrs) yields the savings of R 533 889.98 in the 3 months period and further savings for the 9 months low season period would also be realized. The adjusted timetable has 2 hours shifted from peak to off-peak period for morning and afternoon peak period.

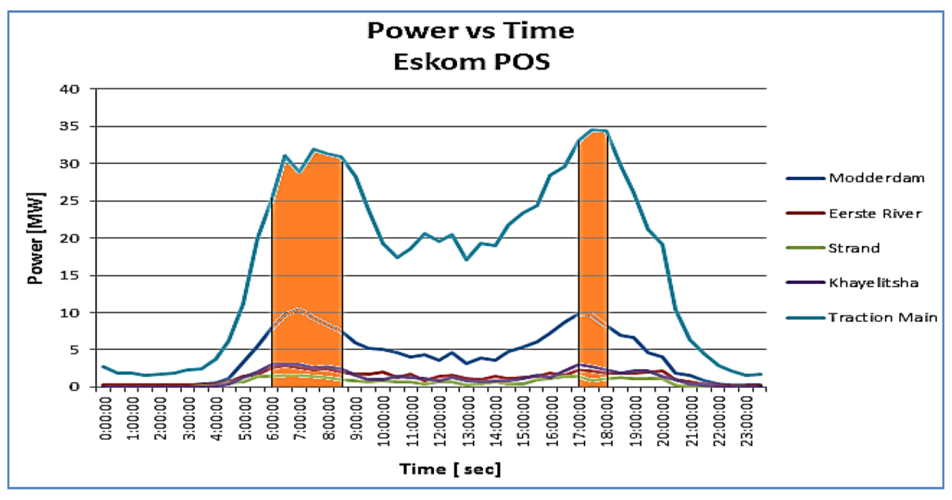

Figure 5: Eskom peak times vs PRASA (High Season period).

Load shifting method is used to transfer load from substation A to B and vice versa. This is done by lowering voltage at substation B busbar for current to flow from substation A (high potential). This allows loads (trains) to draw current from low-cost substations since Eskom has expensive (33kVAC subs) and low-cost (66 kVAC) substations and municipality supplies are also cheaper during off-peak periods.

The Municipality tariffs are high during peak times compared to Eskom since they have KVA demand charge as shown in Table 1.

Table 1: Load shifter from Lentegeur (Municipality) to Nyanga (Eskom)

Energy Consumption Peak Time Only	Lentegeur Substation		Nyanga Substation 54 640.65 kWh
	54 640.65 kWh	1 918.942 kVA	
Energy Consumption Cost for Low Season/month	R 38 248.46	R 394 726.37	R 49 143.80
Low Season Period (9 Months)	R 344 236.14	R 3 552 537.33	R 442 294.20
Energy Consumption Cost for High Season/month	R 38 248.46	R 394 726.37	R 150 819.12
High Season Period (3 Months)	R 114 745.38	R 1 184 179.11	R 452 457.36
Yearly Energy Cost (LS & HS)	**R 458 981.52**	**R 4 736 716.44**	**R 894 751.56**
Total Cost	**R 5 195 697.96**		**R 894 751.56**
Load Shifting Cost Savings	**R 4 300 946.40**		

Energy savings through switching OFF idling trains during non-service periods may yield R 8.4 Million per year Figure 5. Extension of 33 kVAC distribution line allows for use of cheaper substations (Figure 6).

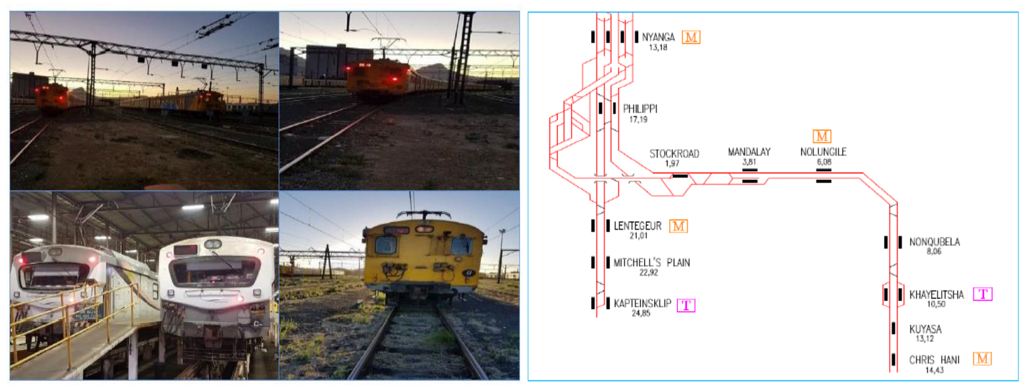

Figure 6 & 7: Idling Trains & Extension of 33kVAC line.

CONCLUSION

The results obtained from the measured data and analysis shows that energy of up to 30% can be saved through regenerative braking. Energy cost is also reduced through time shifting and load shifting. This regen energy can be harnessed through energy storage devices (Battery, Flywheel & supercapacitors) as well as through reversible traction substations to use on PRASA 11 kVAC and 33 kVAC networks for Signaling and traction networks.

Energy can also be saved by switching idling trains at night and during off-peak periods, this is linked to availability of trains when needed during start-ups. The energy savings can be realized by speed trajectories i.e. efficient train driving techniques through training of drivers on predetermined speed profiles for energy efficiency.

LITERATURE CITES

1. A. Bani & K. Awodele; Assessment of Energy Management Opportunities in a DC Traction Network, IEEE Africon 2017 Proceedings
2. A. Bani; Energy Efficiency, Power Quality and Reliability Evaluation of a Traction Electricity Network, Masters research, University of Cape Town, 2022.

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