Feedback on the Proposed Eskom Energy Storage Test Farm

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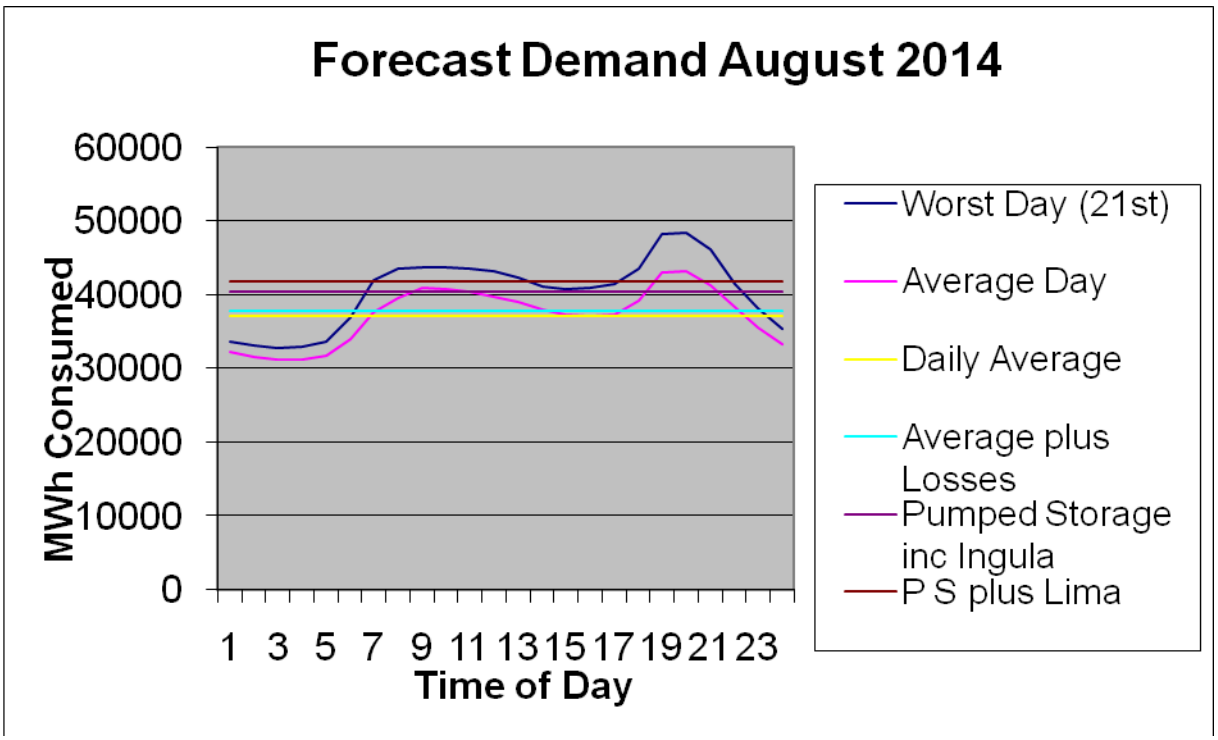
Eskom is the seventh largest utility in the world and has long recognized a need for energy storage within its system. A detailed analysis of the hourly load forecasts for 2014 showed that on a typical winter's day, during August 2014, the average forecast demand is expected to be approximately 38GW, and the peak will exceed the average by 7.5 GW during the evening peak period and by approximately 4GW during the extended morning peak. This fluctuation can be met in a number of ways; by spinning reserve, gas turbine peaking stations, pumped storage, or battery based energy storage. The choice between the solutions is simply one of "total" economics, which should include allowances for environmental and pollution costs.

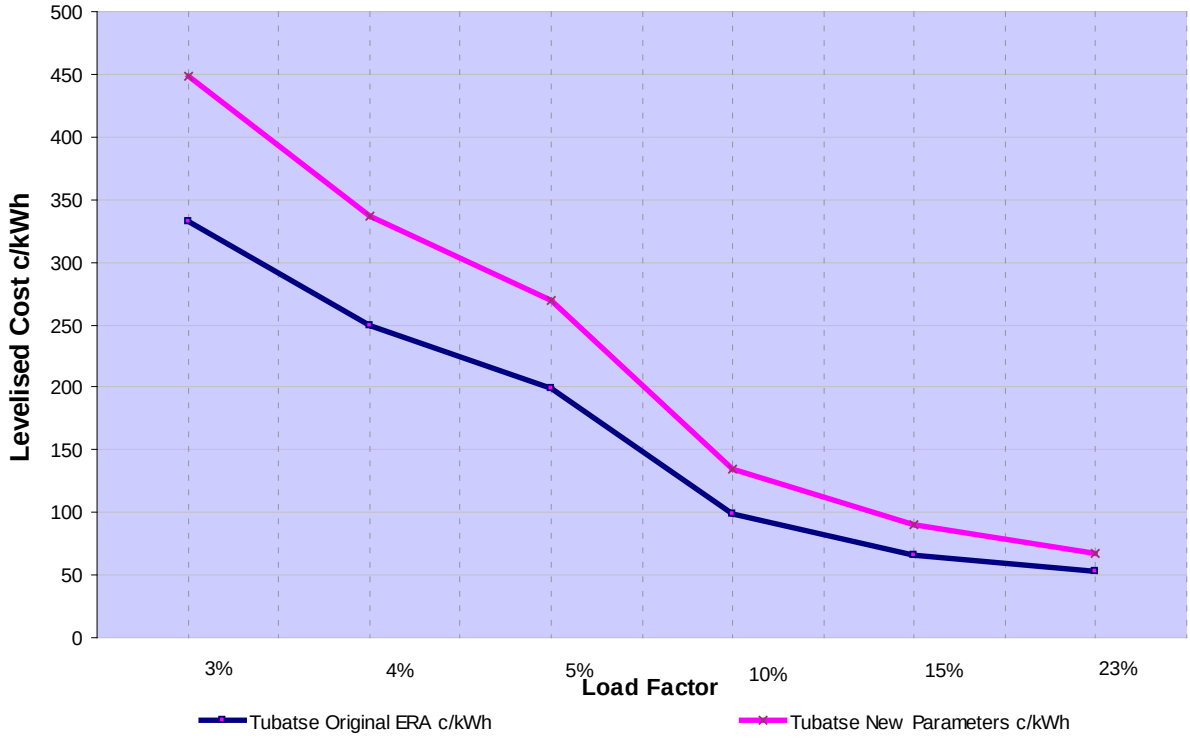


Eskom's present base load capacity is 38 GW, mainly from coal based power stations, plus some nuclear. In addition, Eskom has a further peaking capacity of 5GW, from gas turbines (2GW) and several pumped storage and hydro schemes, totaling almost 3GW. By 2013 a further 3,800MW of base capacity will have been added by the return to service of mothballed stations, and an additional 1600MW of pump storage will have been added by the commissioning of the Tubatse pumped storage scheme. In addition, the construction of two new coal fired base load stations of 4,800MW each have been commenced and should be commissioned progressively from 2013, giving a capacity expansion of 1600MW per annum.

2014	Base Load	43.4 GW	Average Load	38GW
2014	Peaking Turbines	2.0 GW	Morning Peak	42.5 GW
2014	Energy Storage	3.0 GW	Evening Peak	48.0 GW
2014	TOTAL	48.4 GW		

It can therefore be seen that the supply situation in 2014 will be extremely tight, assuming the forecast economic growth is achieved, which in the light of recent worldwide occurrences may be doubtful. Ideally, a further 2GW of peaking capacity will need to be added by 2014 to supplement the increased base load. Given that the base load capacity is also under severe pressure, one argument is simply to commission a third new station immediately, but this may not be the optimum solution. The cost of a new base load coal fired station is R 20m/MW, with a lead time of 6 years prior to first commissioning. If this base load station is used purely to meet peak demands, which are estimated at an annual duty cycle of 3.86%, the cost per kWh of producing this power (in 2008 prices) is R4.06/kWh. Alternatively, gas turbine production costs have increased hugely over the past year and are a direct function of the international oil price. At a forecast oil price of $75 per barrel (and who knows what the price will be in 2014?) the estimated cost per kWh of meeting peak demand using gas turbines will be R 4-6.00/kWh (2008 prices). To both of these figures should be added a pollution cost for carbon production.

The use of energy storage to meet the peak demands is an obvious solution, but the costs involved must make economic sense. Pumped storage is ideally used to balance demand over a week's duration, with the top dam being filled over a weekend, when industrial demand is low and emptied throughout the weekday daily peak. Typically, Eskom's pumped storage schemes run as a generator for a maximum of 16 hours per day, Monday to Friday, and are replenished for the rest of the time. This gives a typical duty cycle of 23% load factor, which is the economic cost point that Eskom has considered for the building of new pumped storage facilities. At this load factor the estimated costs of new facilities (in 2008 prices) is R0.55c/kWh. However, most of this cost is a fixed cost, derived from the capital investment in new dams and pump/turbines. To use this facility at a load factor of 3.86% would therefore give a cost per kWh of R3.28. However, the recent constraints of the world capital market have made funding of new capital projects more difficult and Eskom has a R360bn expansion programme for base load expansion. The capital cost of the Tubatse project will be in excess of R25bn, which in conjunction with the other demands for capital is currently considered too expensive and the project has been put on hold. The capital cost of R15.6m per MW is not far different to the cost of building new base load generation plant.



Eskom has been monitoring the development of advanced batteries for the last 10 years and believed that the time was ripe for this technology to come to the fore, for short duration peak support. Ideally, the additional 2,000 MW of capacity needed in 2014 could be supplied most economically by batteries. The advanced battery industry has not yet reached commercial status, although several demonstration systems have been installed and it is hoped that before 2014, the industry would have attained a reasonable stage of development and commerciality. Eskom therefore decided to investigate the establishment of a test and proving facility to pre-qualify approved systems for installation into Eskom's grid in 2014. Eskom therefore went out on an open expression of interest to establish the interest of the various suppliers of appropriate technologies.

The technologies covered by the invitation included lead-acid, vanadium redox, zinc bromine, sodium sulphur, and sodium nickel chloride. Lithium ion batteries, ultra-super-capacitors and flywheels were not included in the invitation as all the current development work appears to be focused on power quality, rather than load shifting. Eskom achieves its power quality control via the existing pumped storage schemes and therefore would not consider the value of this aspect of energy storage in the value proposition for the project.

In view of the unproven nature of such systems, it was decided that Eskom would not purchase systems outright, but would rather enter into an agreement with the various suppliers to purchase the peak load output of the battery systems for a minimum period of 4 years, after which Eskom would negotiate with the suppliers based on performance. An off peak supply price of R0.20c/kWh was offered to the suppliers, who were asked to provide a price per kWh to supply 6 hours per day of peak output, with a 2 hour discharge in the morning and a 4 hour discharge in the evening. This high duty cycle was chosen to allow accelerated testing of the battery systems and also to allow suppliers to amortise their capital cost over an accelerated period. Comparative costings, with other means of meeting the peak demand, would be carried out at the same duty cycle (ie. 25%) and also at the predicted duty cycle in commercial operation of 3.86%.

The popular size for a utility scale battery has been 1.2MW, as used by AEP, which was indicated as being suitable to most of the other manufacturers. However, manufacturers were free to offer alternative sizes if this suited their particular battery better. In the event, all manufacturers replied with offers based on the 1.2MW unit.

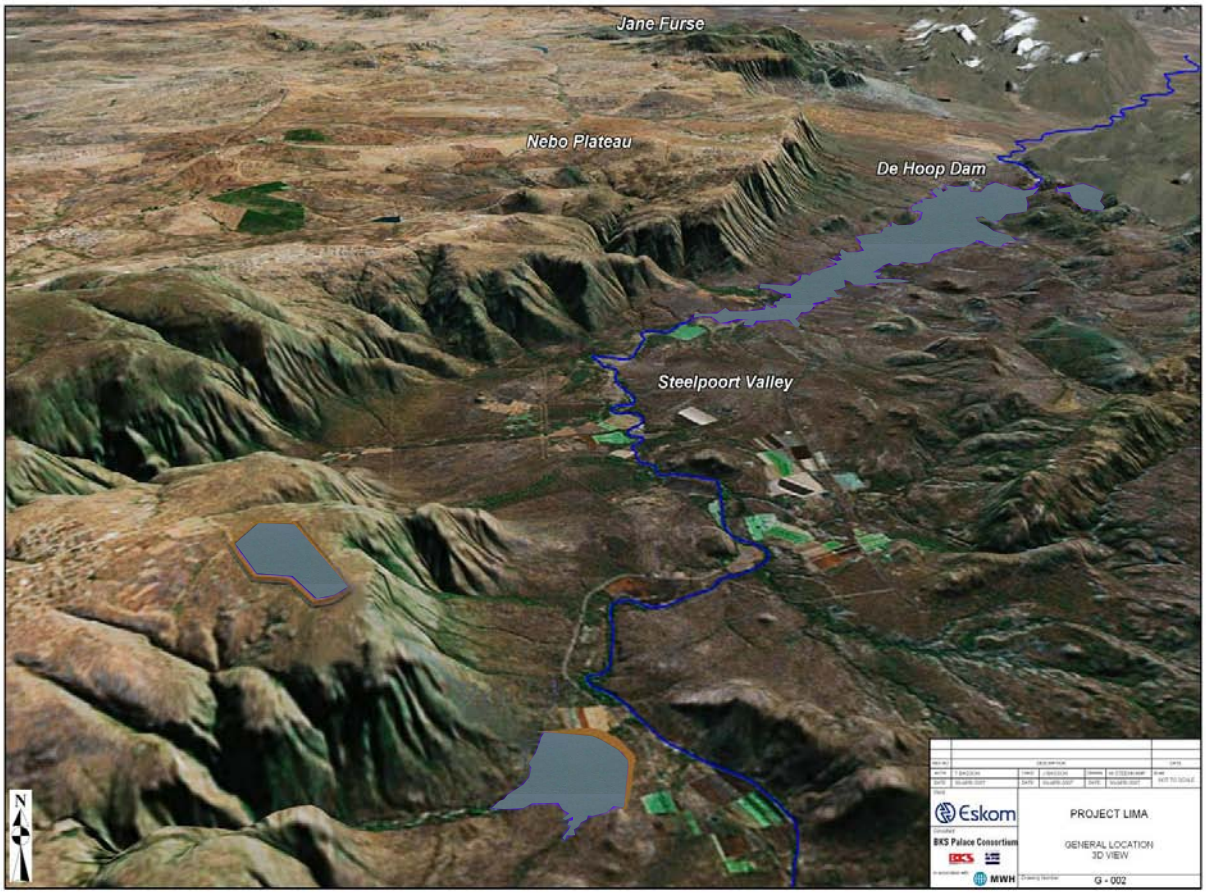
It was acknowledged that the test and proving facility would be a world first and that the costs would be high. The general dictum used in the industry is that costs will halve in the first 5 years once the systems are commercially available. We therefore expected the supply costs to be double those expected in future commercial applications. In addition, we recognized that by putting the capital cost and risk of successful operation of the systems back onto the suppliers, there would be a premium to pay. Prices were therefore expected to be of the order of treble the cost of supplying the power, at a 25% duty cycle, using pumped storage. This gave a budget cost of R 1.65/kWh, after allowing for the extra costs of investing in the technology at an early stage.

In the event the costs were considerably higher than this. We do not believe that it would be fair to identify specific suppliers, but the following table shows the prices offered.

Company	**Supply Price per kWh**
Anticipated budget	R 1.65
A	R 4.65
B	R 6.80
C	R 3.50
D	R 4.17
E	R 3.00
F	Offered small module for test FOC
G	Refused to supply on a performance basis.

As can be seen, the average price is R 4.42, which is more than nine times the equivalent cost of pumped storage at the same duty cycle. Even after allowing for the developmental increment in cost associated with a new technology, this is three times the project budget cost.

It was therefore decided that the Test and Proving Facility was not yet an economic option and that we would put the project on hold, until such time as the cost of advanced batteries becomes more competitive. In the meanwhile, Eskom has identified a total of 76 potential sites for pumped storage schemes and is investigating alternative designs which could make the use of pumped storage more suited to short duration grid support.



Eskom has also approached several advanced battery manufacturers with a view to developing a low cost battery specifically for the utility industry and invites any other companies who wish to participate in this development to contact the speaker during this event.