# SA'S VIRTUAL POWER STATION
# 800MW'S... AND COUNTING

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## ABSTRACT

Eskom introduced its first large scale Demand Response (DR) initiative in 2007 in the form of the now well known Demand Market Participation (DMP) initiative and coined the Virtual Power Station (VPS) terminology. Almost 5 years later and with over 800MW of "dispatchable' Negawatts available, the VPS continues to grow. The effectiveness of the VPS is discussed as well as the learning points and future potential in SA.

## INTRODUCTION

While load shedding is the most extreme measure a utility can adopt to manage a capacity shortfall, other initiatives based on voluntary customer load curtailment (NegaWatt Generation) have been widely implemented internationally as well as in South Africa for many years. Eskom has in the light of the Capacity constraints in SA started implementing its "Virtual Power Station" (VPS). The VPS enables the National System Operator to schedule customer load reduction in much the same way as normal generation plants are dispatched. A variety of demand response programmes are being catered for within the VPS, including customers with standby generation and ripple control systems. Eskom has also historically included a number of its largest customers in an interruptible load program under the Demand Market Participation (DMP) initiative, which contributes the largest number of Negawatts to the VPS.

The paper describes the approach taken in the development of the VPS, progress to date as well as the technology being employed. The potential and need for demand response in SA is examined. It is concluded that this NegaWatt generation capacity through initiatives such as Eskom's Virtual Power Station can dramatically reduce the reliance Eskom has on meeting reserve margin needs with costly gas turbine generation plant. As at July 2011, a total of 854 MW was certified for VPS dispatching and actively utilised in the mix of SA power stations.

## VPS – HOW IT WORKS

While the "Virtual" Power Station appears similar to a physical Generator to the System Operator, it cannot be dispatched for extended periods due to the customer impact. It is ideally suited to meet a Utility's short peak demand or Reserve requirements. Eskom thus operates the VPS in this mode and has two primary requirements: viz. Supplemental Reserve and Instantaneous Reserve. Customers participating on the Instantaneous Reserve Market must curtail their load within 10 seconds of notification but need only provide this load reduction for a maximum period of 10 minutes. Customers participating on the Supplemental Market however would be given longer term notification (minimum a half an hour to a day ahead) but would be required to reduce their load for a minimum period of two hours.

These programs have been in place for over three years under Eskom's Demand Market Participation (DMP) initiative and have now been incorporated into the VPS to enable efficient and automated dispatch.

### VPS Supplemental Reserves

Figure 1 below illustrates an aggregated supplemental reserve event for an individual customer. The mode of operation is described below:

- Contracted customers are obliged to reduce load on instruction, for a certain number of hours (min 2), within a certain period from instruction by Eskom National Control.

- Customers are dispatched by the VPS via an automated VOIP interactive voice response phone call (plus possible electronic dispatch).
- Load reduction once only per day for a minimum of two hours. (One customer with dual fuel systems is able to curtail for up to16 hours.)
- Customer bids are recorded on a day-ahead basis.
- Customer is sent a day ahead schedule
- Customers are dispatched by the VPS – only if required by National Control
- Customer is paid a standby payment (factored by performance) as well as an energy payment for load reduced.
- Automated meter reading of 30 minute data is a prerequisite.
- Only Eskom's large customers currently participate

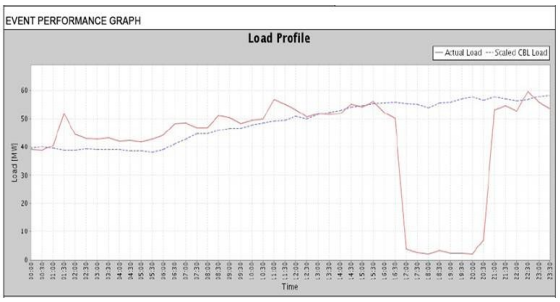



**Figure 1. Supplemental VPS Dispatch**

In Figure 1, the load reduction is calculated using historic consumption based 'base-load'. The difference between this base-load and actual load over the contract period is the energy value the customer is compensated for. Half hour metering is thus essential. Other methods can be used to determine load reduction, depending on the initiative e.g. using a dynamic customer "base-load" or consumption just before the event etc.

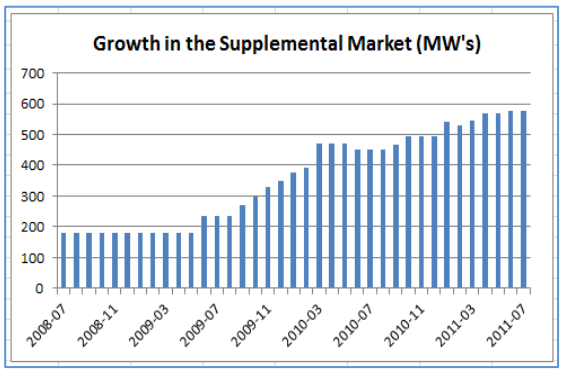



**Figure 2. Growth in the Supplemental Market**

The initial successes of the program and the increased National System Operator requirements have led to a steady growth in the market. As at July 2011, almost 600 MW is certified from 19 customers (Figure 2. Above)

Due to the differing system support requirements around SA, the VPS has been split into four regionally based units viz. KZN, W Cape, E Cape and Gauteng Central. (Figure 3 below). This has major benefit for National Control as it enables VPS units to be dispatched where the system is geographically most vulnerable.

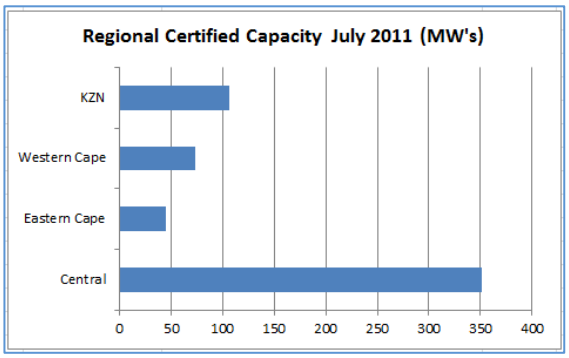



**Figure 3. Certified Capacity by Region**

A major contributing factor to Eskom not having to resort to load shedding over the past two years is has been the VPS. The 'energy' provided per month is outlined in Figure 4 below, with a maximum of 50 000 MWh's being supplied by the VPS in November 2010.

There is little predictability in VPS operation and contrary to expectation and no seasonal trend. As the VPS provides system reserve support, it operates only when the system is under duress and when traditional reserves are limited. Planned and unplanned generation plant outages or higher than forecast demand would typically result in periods of high utilisation.

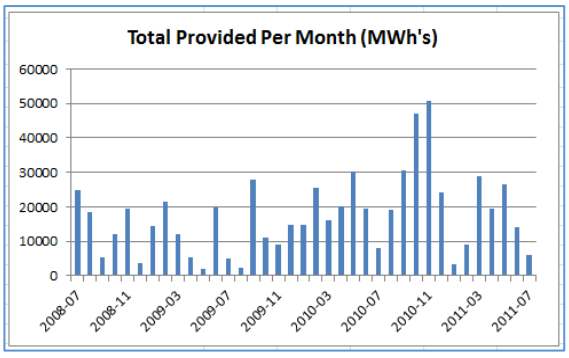



**Figure 4. Total Energy provided per Month (MWh's)**

In July 2011 as illustrated above, less than 5 000 MWh's of VPS load was dispatched due to Eskom's high generation plant availability over the 2011 Winter period and numerous large customers making use of the high tariff season (MegaFlex) to undertake plant maintenance programs. October and November 2010 were the highest utilisation months due to lower than planned Eskom Generation plant availability.

The performance of the VPS Central Region (350MW) is shown in Figure 5 below, illustrating the variance in performance due to the variance in the customer load characteristics. The range is from 120% to about 80% of scheduled load, although the average is well above 90% of the scheduled value, thus making the VPS a reliable resource for both the National System Operator and Eskom National Control. Customers are compensated for actual performance between up to 150% of the contracted energy value.

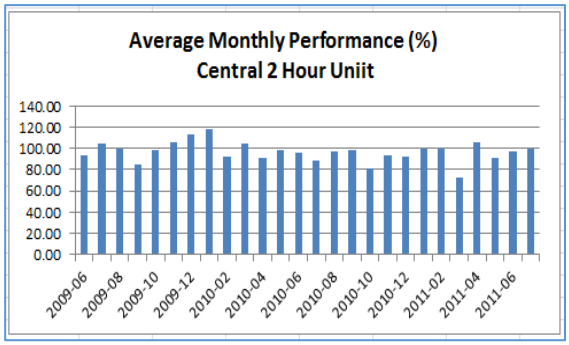



**Figure 5. Average Monthly performance (%) of the Central 2 Hour Unit.**

**VPS Instantaneous Reserve participation**

As response is required in under 10 seconds, the system frequency is used as the 'trigger' for response. Customers participating on the Instantaneous Reserve market require an on-site load controller which is enabled directly from the VPS but dispatched automatically through an under-frequency load controller. The mode of operation is described below:

- Once the system frequency reaches 49.65Hz, load reduction is required within 10 seconds and maintained for up to 10 minutes (minimum 1 minute) **or** when the system frequency recovers to 49.85Hz.
- A maximum of 2 dispatched events per day.
- Frequency and/or reaction/monitoring time may be adjusted when system is very tight to avoid unnecessary tripping
- Customer bids and makes the selected load available on a day-ahead basis.
- A day-ahead schedule is sent to the customers and they are dispatched only in response to system under-frequency events
- Customer is paid a standby payment (factored by performance)
- No energy payment
- Special metering requirements are necessary (4 second data – kW & Hz)
- Only Eskom's large customers are currently participating as the metering and control costs are relatively high.

Figure 6 below illustrates a customer's load reduction as the system frequency drops and load restoration as the system frequency recovers.

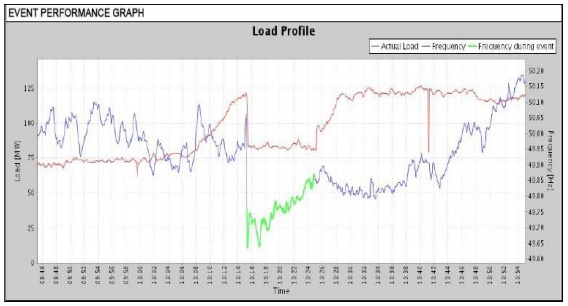



**Figure 6. Instantaneous Reserve VPS Dispatch**

Certified Instantaneous Reserves total 279 MW which is split into three regions viz Western Cape, KZN and Central (Figure 7 below). As the event trigger is system frequency and the set points are identical, if all units are scheduled, they should (theoretically) respond at the same time to a system under-frequency event. Eskom National Control normally also schedules all three units together unless there are regionally specific constraints.

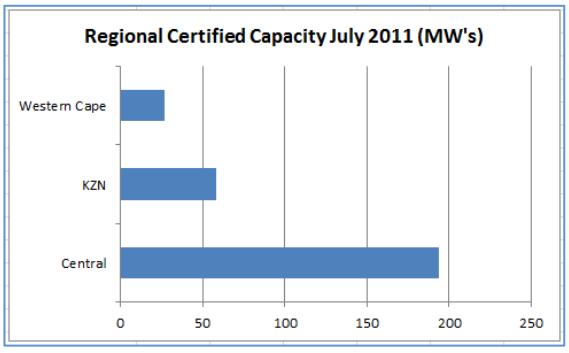



**Figure 7. Certified Capacity by Region**

While the load 'interruption' is automated based on the under-frequency trigger, VPS

only provides the signal and the obligation to interrupt lies with the customer. This is important from a legal liability perspective.
Figures 8 and 9 below shows the number of dispatches and MW's achieved over the past three years. A maximum of 18 dispatches were recorded in a single month (Jan 2010) illustrating the high utilisation of the instantaneous reserves and probably avoiding serious system incidents and load shedding.

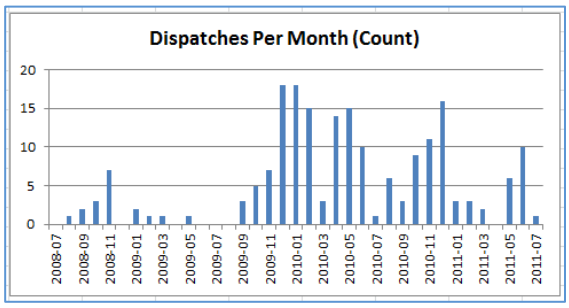



**Figure 8. Number of dispatches per month.**

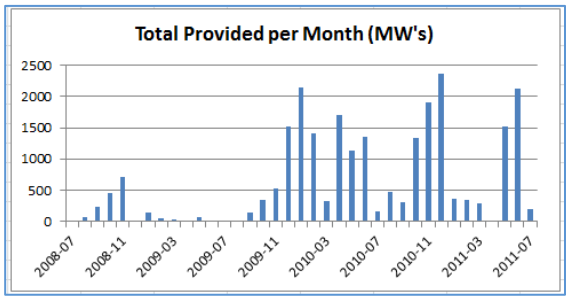



**Figure 9. Total MW's provided per month.**

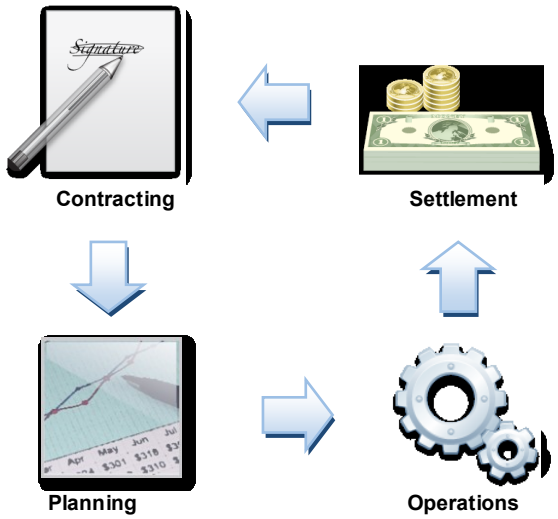
## CUSTOMER BENEFITS

While customers are compensated financially as described below, an important indirect benefit for participants in the VPS programs is the guarantee that they would be excluded from any forced load shedding initiatives in the event that Eskom has capacity constraints.
Compensation is based on the following:

- Supplemental Reserve customers are compensated with 'Energy payments' based on the MWh reduction calculations. There are a few methods that can be used and these are agreed upfront with the customer. Availability/standby payments are also made if the customer is scheduled but not dispatched, although these payments are relatively low.
- Instantaneous Reserve customers are also compensated through an availability/standby component but the primary incentive is the R/MW demand reduction over the 10 minute period. Due to the variance and short time period of the reduction, no energy payments are made.

## VPS PROCESS AND COMPONENTS

There are 4 primary functions making up the VPS viz. Contracting, Planning, Operations and Settlements as illustrated below:




- **VPS Contracting** is the main customer interface where new demand response programmes and their customers and other aggregators can be captured, updated and deleted. It is here that each customer's individual constraints are stipulated.
- **VPS Planning** is where customers can bid their load into the VPS on a day ahead basis. The forecasting, aggregation and communication of the bids is then conveyed to the National System Operator at National Control. The National System Operator then provides aggregate schedules to the VPS. The VPS disaggregates the schedules into individual customer schedules.
- **VPS Operations** is where the schedule confirming each customer's available load for the following day is sent to each customer. Operations are also responsible for handling the dispatch process. Once the VPS receives a call from Eskom National Control requesting dispatch, an automated voice telephone system is used to contact customers and confirm their participation in the pending event. Operations is also responsible for acquiring meter data, measuring performance and sending out the event reports to the participants and National System Operator after the event.

- **VPS Settlements** is responsible for handling the remuneration of each customer for their participation according to their performance.

With the VPS's comprehensive logging and audit trail, discrepancies between the customer and the SO are avoided. The VPS keeps detailed event records and meter data making the entire process completely transparent for all participating parties.

## THE FUTURE OF THE VPS IN SA

While currently only Eskom's large customers are being utilised within the VPS, following the success of the initiatives to date, Eskom is planning to expand its Demand Response initiatives and start including the smaller industrial and commercial loads under its now well publicised "Demand Response Aggregation Pilot Program". In this initiative, an initial 500MW of load has been targeted in order to test the commercial aggregation approach, with a further 1100MW planned to be incorporated in the Eskom Virtual Power Station by 2013. Eskom is currently in the process of selecting suitable Aggregators for the first phase.

Residential load can also be incorporated within the VPS, particularly when integrated with Smart Metering systems. Numerous pilot and small scale projects are being undertaken within both Municipalities and Eskom in response to the DOE's Regulation 773 of 18 July 2008.

Another potential participant group could be customers having imbedded or standby generation (e.g. backup diesel generators). While incentives for utilising this type of load would need to be substantially greater than they currently are, these types of programmes have been very successfully deployed internationally e.g. UK, USA and France.

The basic business case with the VPS or any Demand Response initiative is that it is generally more cost effective to 'provide' low load factor NegaWatts from the customer base than to incur the cost of new (gas fired) peaking plant. While in some instances the running costs of a Demand Response program may be comparable with a supply side option e.g. standby diesel generation, the avoided capital cost of the peaking plant invariably sways the business case in favour of the Demand Response initiative.

### VPS and the Smart Grid Evolution

There has been much focus in recent years on the 'Smart Grid' which achieves distributed control through a network of automated real time load monitors and switches e.g. smart meters which automatically limit or shed load under certain network conditions. The VPS would in time interface with these systems, thus enabling central National Control to further add to the MW's available for dispatch.

Electricity grid management in general is moving from a traditional load-following approach towards load-shaping strategies in which demand-side resources are managed to meet the available generation and the grid's power delivery capabilities at any given time. With the integration of more and more renewable and variable generation technologies onto the network, this flexibility becomes critical.

## CONCLUSION:

The VPS has proven to be a reliable alternative to the provision of Generation reserves over the past four years, with the full potential for the VPS and Demand Response in general still to be realised. Substantial growth in the number of MW's under VPS control is thus anticipated over the next few years as the country is supply constrained.

The VPS will play a key role in the Smart Grid architecture of the future, enabling Utilities to optimise usage of their electrical networks in an environmentally beneficial manner.

## ACKNOWLEDGEMENTS

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