THE VIRTUAL POWER STATION:
A NEW AGE IN DEMAND SIDE MANAGEMENT

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ABSTRACT

The Virtual Power Station (VPS) is a platform that provides the Eskom System Operator (SO) with a means to optimally schedule all Eskom's controllable demand side resources. It presents the SO with a consolidated view of all available 'Negawatts' at any given time, along with cost profiles for dispatch, in much the same way as conventional power station scheduling. The VPS thus effectively increases available system reserve capacity, thereby decreasing the need for emergency generation, brown outs and black outs. Eskom currently has nearly 650MW available through this mechanism.

INTRODUCTION

The VPS provides a very effective mechanism for achieving peak shifting and in some cases peak removal, thereby improving overall system performance, decreasing the cost of capacity provision and postponing the need to build costly new generation capacity and/or network capacity. It provides the SO with a resource with similar characteristics to a peaking power station or many smaller widely distributed peaking stations.

The approach taken in creating the VPS was to make it indistinguishable from physical power stations from an operational (SO) point of view. Thus when additional load is needed because of an unexpected shortage or an expected peak, the SO can dispatch the VPS as he would perhaps an emergency or supplemental generator. This distributed 'Negawatt' generation is also the cleanest energy source available to the SO and can be deployed faster than any physical energy source of similar capacity.

VPS COMPONENTS

Figure 1 presents an example of an actual dispatch deployed by the SO through the VPS. This is an excerpt from the aggregated performance report for that event.

EVENT PERFORMANCE	
Total Energy Shed	163.303 MWh
Total Load Reduction	54.434 MW
EVENT PERFORMANCE RATING	
Performance Percentage	98.97%
Performance Rating	SUCCESSFUL

EVENT PERFORMANCE GRAPH

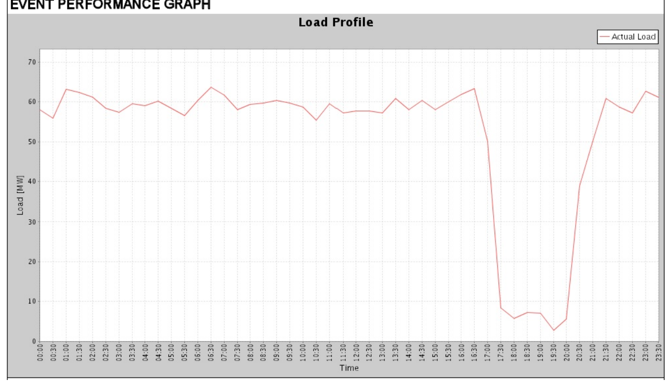

Figure 1: Example of VPS Supplemental Reserve Event Report

There are essentially two types of customers currently incorporated within the VPS viz. those that can reduce load for up to two hours but require prior notification (10min to day-ahead), termed supplemental reserve customers, and those that can interrupt within 10 seconds of notification but can only provide the SO with a 10 minute (max) load shed interval, termed instantaneous reserve customers. These programmes 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.

Figure 1 above illustrates an aggregated supplemental reserve event and Figure 2 below, an instantaneous reserve event for an individual customer. While the supplemental customers generally curtail load manually following an interactive voice notification via phone/cell, the instantaneous customers would have an on-site load controller which is enabled directly from the VPS but dispatched automatically through an under-frequency load controller. When the supply frequency drops below a certain point, these customers' controllers automatically shed load and allow the system frequency to recover within the 10 minute period. In Figure 2, while the customer managed to reduce load by 71.8MW, the contractual reduction was 128MW and thus termed "unsuccessful". There would therefore be some contractual and financial settlement consequences for the customer in question.

EVENT PERFORMANCE	
Total Load Reduction	71.807 MW
EVENT PERFORMANCE RATING	
Performance Percentage	56.10%
Performance Rating	UNSUCCESSFUL

EVENT PERFORMANCE GRAPH

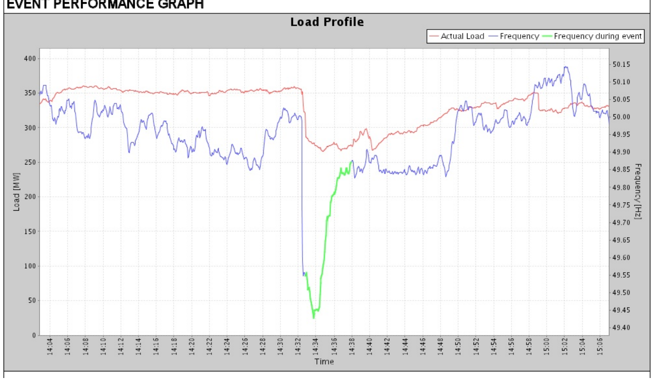

Figure 2: Example of Instantaneous Event Report

Other loads to be scheduled through the VPS in future include customer standby generators, with pilot studies completed and the product being developed for release by Eskom.

The VPS can effectively include any type of schedulable Demand Side Management (DSM) effort, from ripple control systems through to household level smart metering and Advanced Metering Infrastructure (AMI). Additionally, because of the holistic approach taken in the function development of the VPS, it will perform all contracting, planning, operations, and settlement functions where necessary.

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 (smart meters), which automatically limit or shed loads under certain network conditions. It is also envisaged that the VPS would interface with these systems, thus enabling central control (SO) to further add to the MW's available for dispatch.

INTERNATIONAL DEMAND RESPONSE RESEARCH

A comprehensive research of comparable international solutions was performed at the onset of the VPS project, with most information being found under the banner Demand Response (DR) programmes. It is clear that DR and VPS type solutions are urgently needed by utilities all over the world. California, USA, which is plagued by energy related problems and controversies, has some of the most advanced DR technology and comprehensive literature on the subject.

Most of today's DR solutions have two major challenges:

- System Operators need to balance load in real time and cannot tolerate delays in the dispatch process, but the DR systems often have a cumbersome dispatch notification process that goes through multiple channels and multiple hands. The lag time often makes involuntary load shedding the only option available to the SO on short notice. For non-automated systems, where no hands-off system exists that perform the task of curtailing the electricity consumption automatically, participants in a load-reduction programme require even more time between notification and the actual load-reduction event depending on the process used for powering down.
- Manageability is not built into the systems, thus over-utilisation of participating customers and other contract breaches by beleaguered utilities become problematic.

An effective VPS would need to effectively handle the dispatch notification process, making it fast, direct and error-free, thus enabling real-time load balancing. It would need to have a strong planning component that aggregates individual contract limitations and spreads the available load against a long term forecast. Other qualities expected of a VPS include:

- Wide range of flexibility;
- Trust – security, integrity, and assurance of performance;
- Control – manageability, serviceability,

measurement and adaptability.

The benefits for a centralised VPS were noted:

- Provision of an efficient mechanism to dispatch ‘Negawatts’, thus enabling load shift from a broad customer base;
- A broad view of available load enables System Operators to make optimal scheduling decisions;
- Centralised bidding and customer contracting;
- Centralised planning, in emergency and time-ahead planning horizons;
- Centralised risk management and decision support;
- Centralised administration enables auditable and cost effective verification and settlement;
- Centralised operations and support, from participant bidding decision support, all the way through back-office operations and IT system support;
- The mechanism provides some competitive forces through the bidding process, thus ensuring cost effective load curtailment is achieved;
- A transparent process gives customers the assurance that they are not cross subsidising others through fair compensation across and within industries/customer groups;
- Improved system reliability.

The VPS's advantages over a large, individual conventional power station included:

- Environmental benefits;
- Faster implementation time;
- The speed with which the VPS can modify its capacity and energy delivery curves;
- Effects of supply from a VPS are distributed, effectively reducing network constraints.

The barriers to successful VPS or DR type programmes were noted as:

- Risks and costs in the establishment;
- Risks and costs in the incentive schemes paying for operations;
- End-user preference for simplicity/luxury.

As research deepened, the various concepts such as AMI, Smart Metering, and holistic DR began to overlap into the overall idea of a Smart Grid. The main deliverables of the Smart Grid are touted as:

- Increasing reliability, efficiency and safety of the power grid (prevent outages, lower CO_2 and lower electricity bills);
- Enabling decentralised power generation so consumers can be both energy client and supplier (provide consumers with interactive tool to manage energy usage);
- Inclusion of flexibility to power consumption at the client's side and supplier selection (enables distributed generation, solar, wind, biomass, etc.);
- Increase GDP by creating more new, "clean" energy jobs related to renewables, plug-in electric vehicles, etc.

The VPS, when deployed in a distributed, decentralised architecture, would enable the above.

A 2007 report, ‘Power to Save: An Alternative Path to Meet Electric Needs in Texas’ prepared for the Natural Resources Defense Council (NRDC), concludes that Texas’ growing energy needs can be met at lower cost by using new incentives for businesses and consumers in the state, and by requiring utility companies to invest in cost-effective energy savings before they spend money on expensive new plants. According to the report, together these strategies would yield nearly $50 billion in savings and other economic benefits to Texas over the next 15 years, with an investment of $11 billion – a dividend of more than four to one. Other VPS type products claim they will 'make DR 100 times better by reducing costs by a factor of 10 while increasing speed and functionality by a similar amount'. The VPS will therefore justify the initial costs of development and deployment many times over.

FUNCTIONAL SPECIFICATIONS

The establishment of the VPS programme in South Africa was preceded by:

- Selection of technology;
- A technology cost effectiveness analysis;
- Development of an implementation plan;
- Development of procedures for monitoring and evaluation.

The technologies used were chosen on the basis of ease and speed of development. Thus, Enerweb reused as much code as possible, accessing an extensive in-house library geared specifically for such systems, preferring to configure rather than to write new front ends and back end processes.

The VPS consists primarily of a central processing station linked to a number of participating sites where manageable load exists. Remote metering (high resolution in some cases) at the supply or billing point of each site is considered a necessity for VPS participation.

The various VPS-participating sites bid in their availability to shed load on a day-ahead basis. Each site is configured on the VPS system with its own set of constraints, which will determine whether a site's bid is accepted or not. The VPS aggregates the selected individual bids and offer it to the Eskom Power Pool (EPP) as a larger amount of available load. The EPP schedules the VPS load to be available the next day in accordance with system load forecasts. The VPS disaggregates the received schedule again into site-specific standby schedules, which are distributed to the sites as a formal notification of standby for the following day.

On the day that the SO requests load reduction from the VPS, the VPS would request the assistance of the participating sites that were scheduled to be on standby. The individual sites would proceed to reduce the requested amount of load at the instructed time. Upon completion of such load reduction events, meter data are collected from each site to measure individual performance and also to calculate settlement amounts due.

The major functionalities of a fully-fledged VPS system have been identified as:

1. **Contracting** is responsible for implementation of new products / obtaining DR programmes, as well as management of the customer contracts. Additional functionality such as CRM, Document Management, Help Desk and all other customer facing functionalities are housed under the Contracting portion of the VPS.
2. **Planning (Aggregation)** is responsible for producing bids, operation schedules, identification of new products/gaps, medium term plans and risk management. It is responsible for managing the available contracted capacity based on an 18 month forecast received from the SO. It interfaces daily with the EPP by sending bids that are aggregated using the 18 month forecast, customer parameters and market bids, and receives back an aggregated schedule which it disaggregates for individual customer scheduling.
3. **Market Operations** is responsible for the day-to-day operations of the markets, including gathering and verifying bids, participant administration, market parameter management and market closing. Market Operations also include a bilateral contract interface, trade reporting and publication of the market results.
4. **Operations** is responsible for load shedding (customer notifications / confirmations, shed signals, etc), measuring customer load behaviour and providing IT services such as hosting and communications, including the management of field devices. Once it receives a disaggregated schedule from Planning, Operations sends the confirmation to individual customers. National Control (NC) dispatches VPS by placing a call to the VPS operator and informing them that they require any number of MW's less than or equal to the amount scheduled on the previous day by EPP. The VPS then notifies customers through a automated telephonic system.
5. **Settlements & Performance** performs the physical and financial settlements. This includes the acquisition of metering data, depending on the VPS operational requirements, performance and financial reporting for individual contracts and EPP. Settlements will also handle all billing and invoicing.

On the 1st of July 2008 the prototype of VPS went live. The prototype is a DMP focused subset of the full functionality of the VPS. It largely implements Planning and Operations, but also implements the critical parts of all the other functionalities. Figure 3 details the implementation scope of the prototype.

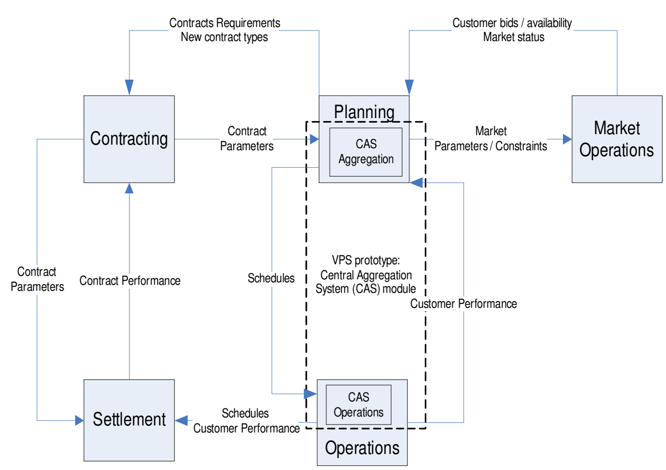

Figure 3: The scope of the VPS Prototype

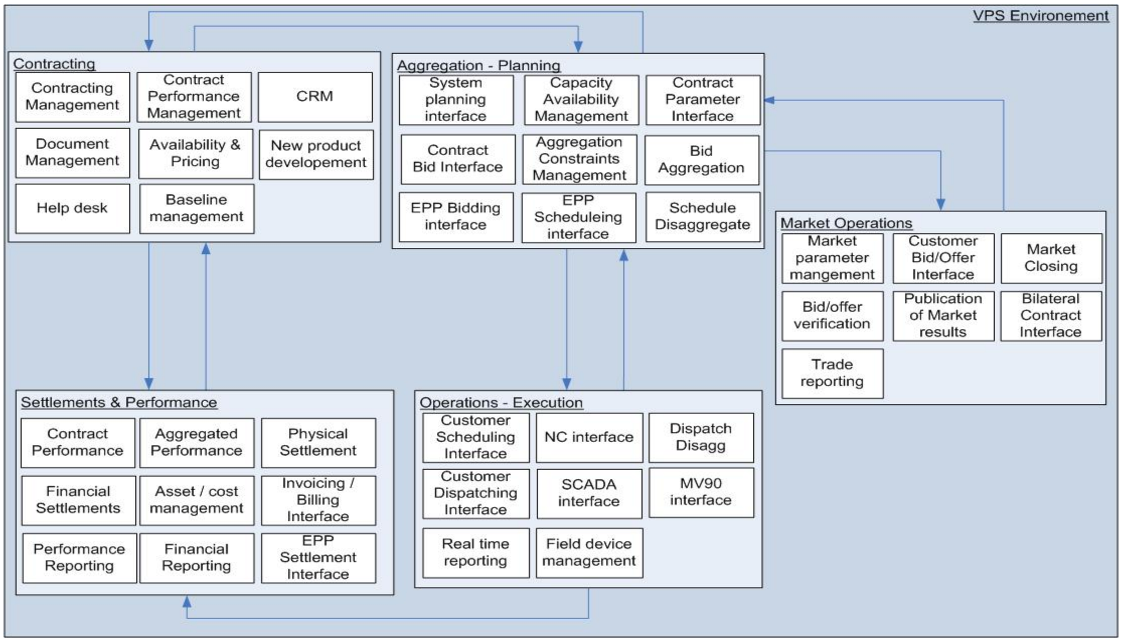

Figure 4: Functional Decomposition of the VPS

Figure 4 presents a more detailed functional decomposition envisaged for the VPS.

All participants have so far expressed satisfaction with the way the VPS prototype interfaces with legacy systems and the Systems Operator finds it much easier to manage and dispatch demand side resources.

CONCLUSION

Greater real time control of the load is indispensable to the future of all utilities and saving energy to accommodate increasing demand is far more preferable to building new power stations. Projects such as the VPS world over are making headway towards achieving these ends. Thus the VPS has been designed and built such that integration into the current system is easy, with all the complexities of DR abstracted, yet all the associated advantages still accessible.

Trends in public attitudes towards energy related matters show a willingness to take greater responsibility in the management of their own power usage. Incentivised DR programmes, standby generation and price responsive consumer behavior are increasingly popular amongst consumers because they understand that the alternative could be generalised load shedding. The VPS provides a solid and generic platform for the implementation and management of these initiatives.

RECOMMENDATIONS

Because the VPS supports a decentralised architecture, each municipality or RED could deploy and manage its own VPS. The potential of a VPS methodology, combined with an enabled AMI, could yield thousands of MW's and avoid the construction of peaking power plant. Municipalities could make their flexible customer load available to the national SO's thus ensuring a much more secure power supply scenario in South Africa.

With the roll out of the AMI, a finer implementation of DSM will be achievable. Implementations of these VPS managed DSM products will reach into the home and allow utilities to monitor, schedule and dispatch, in real time, significant load not currently available.

REFERENCES

1. information from:
Introducing Smart Meters in South African Utilities Compiled by Makwarela ME

2. information from:
http://www.mce.gov.au/assets/documents/mceinternet/SmartMetersInfoPaper20070123163

300.pdf

3. information from:
http://en.wikipedia.org/wiki/Smart_meter

4. information from:
http://en.wikipedia.org/wiki/Smart_grid

5. information from:
http://www.smartgridnews.com/artman/publish/article_159.html

6. Literature Scan: International Virtual Power Station Programs prepared by Dirkie Weyers