Virtual power station uses customer standby generating capacity

by Mike Rycroft, features editor

The virtual power station (VPS) concept combines a number of separate distributed resources to behave as a single larger resource, to make additional generation capacity available on the grid. The resources may be generation plant or curtailable loads. Eskom has recently added its own generation to the portfolio of its demand management program.

The VPS concept has been adequately described in other articles [1, 2] and will not be covered in detail here. Briefly, removing customer loads from the grid in a controlled and coordinated manner, either by voluntary load curtailment or self-generation using plant intended for emergency generation, increases the amount of power available to other users on the grid, i.e. creates a virtual power station. The principle may also be applied to embedded renewable energy generation in distribution networks, where generation within the distribution network effectively releases centralised power generation to the grid.

The principle of load curtailment through the demand market participation (DMP) program has been in successful operation since 2005, and the self-generation option has only come into play recently. This article focusses on the self-generation option.

Virtual power stations

The VPS concept may be implemented in several ways.

Centralised control of distributed small generators

The first type is a network of several small power stations that are run like a single system and are ideally suited for renewable sources of energy [3]. This type of virtual power plant can help improve grid stability by making controlling power available in the minute-reserve range. One of the new virtual power plants enables the Munich, Germany municipal utility company to run six of its cogeneration modules, five hydroelectric facilities, and one wind-power plant more efficiently and economically than if they were operated separately. The operation schedule minimises the costs of generating electricity and operating the facilities within the virtual power plant network.

Centralised control of load curtailment (demand management program)

The second type consists of a network of customers participating in voluntary load curtailment programs. This system is the basis of the DMP program run by Eskom. Customers contract to curtail part or their entire load at a predetermined time for a predetermined period on notification by The VPS. Two types of contract exist:

- Instantaneous reserve – customers who reduce their load within 6 s, to try and bring frequency back to normal.
- Supplemental reserve – customers who curtail their demand within 10 min for at least two hours.

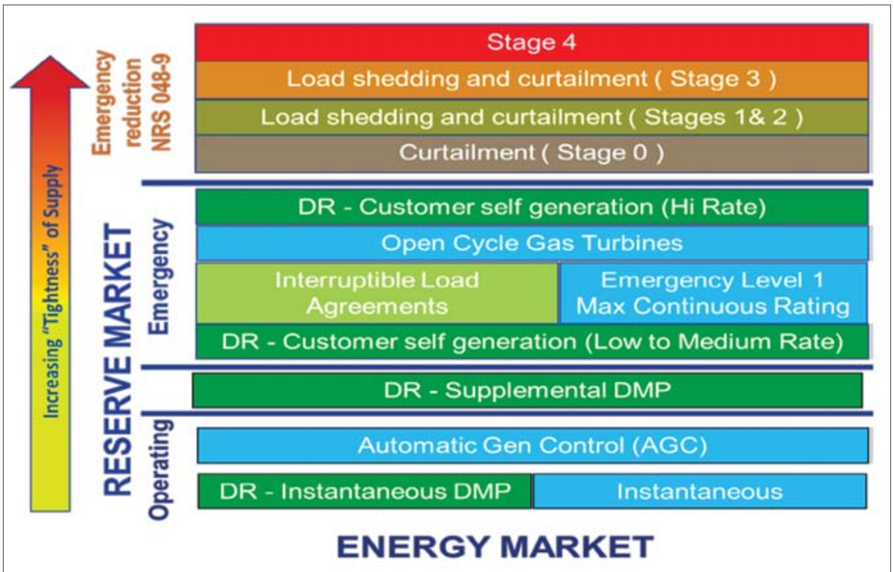

Fig. 1: Reserve generation capacity hierarchy.

Curtailment of loads has the effect of releasing generation capacity to the grid. Customers bid their curtailment capacity on a day-ahead basis, and the bids are consolidated by the VPS and forwarded to the network control centre. Day at a time contracts are issued and the customer responds on notification from the VPS. Customers are paid for participation. The disadvantage of such a system is that the customer loses the load during the period of participation.

Centralised control of self-generation

The third approach involves transferring the full or partial customer load to standby or other own generation plant under control of the customer for the contracted period. The advantage of this approach is that the customer simply removes the load from the network but does not lose any load. This approach has recently been added to the Eskom emergency generation program.

Self-generation VPS

"There are a lot of customers connected to the grid who have large standby plant that could possibly be used to free up capacity on the grid in emergencies", says Ferdi Becker, chief advisor product implementation of Eskom Integrated demand management. "When we started on this concept as an addition to the DMP program we thought that because there were so many standby generators that we might be able to use, it would be an easy task to contract the customers to participate."

But they found that standby generators would be very difficult thing to use in this type of application, both from an Eskom perspective, and from the customer's point of view.

"The two things that make this programme difficult are the cost of fuel on the customer side, and the fact that most customers do not have the ability to run in parallel with the grid, meaning that when they switch over there is interruption of supply to the load", says Becker.

Most of the generators are installed for emergency purposes, and will only start up when the supply fails. These machines are not equipped with the technology to synchronise with the grid and then island themselves, and this makes the envisaged operation difficult. In addition the operation requires self-dispatch from the customers, who find it inconvenient and expensive to keep staff on standby, waiting for dispatch instructions from the VPS, especially if the contracted dispatch is outside the normal working hours of the company. This would also require someone to be present while the machine is running and to shut down at the end of the contract period.

Another issue which caused problems is the working profile of the company. Becker explains that there is no gain in asking a company to run their standby plant when they have already shut down for the day, as they have already reduced their load.

Other issues encountered include the reservation of standby plant for specific purposes, such as evacuation of mines in the case of power failures. "Many of the mines have large standby plant on site, but it is reserved for evacuation and cannot be used for other purposes", adds Becker.

Potential customers, such as sports stadiums and other instances that are not in use permanently don't have licences to generate and therefore cannot export power into the system. One of the proposals put to customers was that the dispatch system could replace the monthly test runs, but it was found that some machines were not rated for continuous operation at full load, and if the machine is run for longer than the test run, problems such as overheating were experienced. Synchronising dispatch with the test run schedule did not always work either.

Eskom was able though to find a number of customers that could meet the requirements and were willing to participate. These include

- ABSA Energy Centre
- Lydenburg hydropower
- Mondi Merebank

"Places like ABSA are very suitable for this type of operation because they are always connected to the grid and use the generator to manage their profile from the municipality. They run a 24/7 operation and are available to dispatch at any time", comments Becker.

The VPS is also negotiating with several municipalities who are interested in participating and several customers who have standby plant backed up by downstream no-break systems or who have processes which can tolerate short breaks in supply.

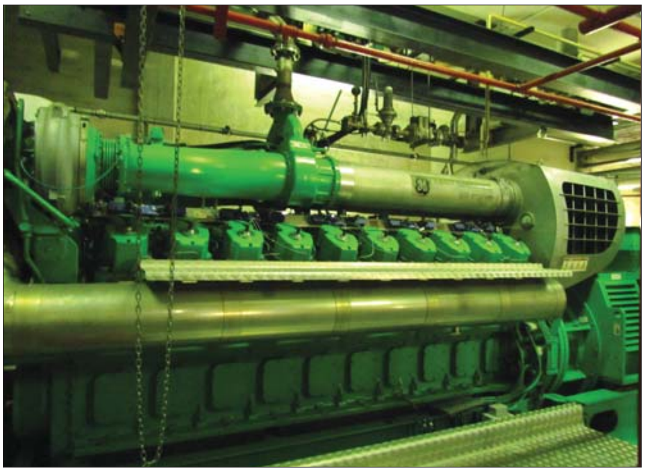

Fig. 2: Genbacher J620 gas engine and alternator.

Fig. 3: Preset Parallel generation program.

Fig. 4: Power balance during normal operation.

Benefits of customer participation

"Customers get paid for the energy that they generate, as well as a fixed standby payment. In addition they save on the cost of grid power, and must enter into a contract on how compensation is calculated. The whole demand response program is very flexible as far as duration of agreements is concerned and everything depends on the customers specific plant conditions at the time whether they can participate or not and by how much", comments Becker.

The contract refers to certified capacity, which is the capacity that the customer has proven can be made available on request. For instance if it is 6 MW for a customer, every day the VPS will bid in that 6 MW on behalf of the customer – stating that they have 6 MW available for the next day and what the kWh price is. Every customer will determine what their price is depending on their fuel source. Payment will be made at the lesser of the customer's bid price or R3/kWh. The bid cannot exceed R3/kWh maximum for generation.

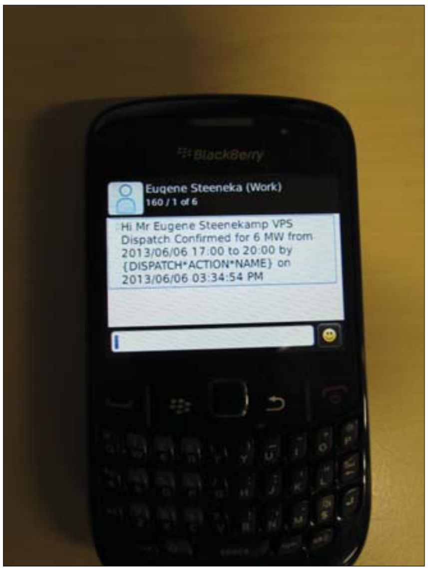

Fig. 5: Dispatch SMS from VPS.

Dispatch procedure and reserve power market

Fig.1 shows the reserve generation capacity hierarchy in merit order of dispatch.

The first reserve available is operating reserve which consists of :

- Instantaneous reserve – this is used to manage frequency and comprises those customers who reduce their load within 6 s for short periods, to try and bring frequency back to normal.
- Automatic generation control, comprising the load following stations if the load increases the generation will increase.

The second reserves are the supplemental reserves, which is also part of the DMP. This includes customers who reduce load for at least two hours.

The next level of reserve is the emergency reserve of which the VPS forms part.

"As we move up the merit order the cost of operating the reserves increases. Self-generating participating customers fall into two classes – those whose price is below R2000/MWh, classed as low to medium rate customers and placed first in the merit order of emergency reserves, and those above R2000/MWh, classed as high rate customers and place last in the merit order of emergency reserves", explains Becker.

The next level reserves consists of interruptible load agreements, NCR i.e. running all generators at maximum levels to try and meet the demand, emergency level 1, where the generators at a few stations will run over their continuous rated capacity for short periods, and finally use will be made of open cycle gas turbines, in that order.

The final stage will be to use high rate self-generating. "There will not be too many of them and we won't use them that often. Most of these would be customers with large standby plants, who would have to change over to standby operation to participate. If you take the customers at the lower rate, because their price is low and they are almost permanently synchronised to the system we would rather use them. According to the systems operator we might only use these customers twenty times per year. But we don't know yet", comments Becker. These customers are the last resort used before the state of load shed is reached.

VPS structure

The VPS is broken up into four regions: Western Cape, Eastern Cape, KZN and the Central region.

The reason is to concentrate generation in areas where there are problems. "It won't help if there is a problem in Western Cape to ask the central to start generation, especially if the problem is network related, as in the case of transmission unavailability", explains Becker. "In that case network specific reserves must be used. If there is a system constraint all regions are dispatched."

"For each of these areas there will be customers who will everyday bid in their availability for the next day. The VPS consolidates the daily information and sends to the system operator who will balance demand and supply for the next day and inform the VPS what additional capacity is needed for the next day. The contract standby schedule is then issued indicating hours required. On the day the participant is informed as required according to demand. The generating profile before the contracted generation period becomes the reference level for the contract. If the participant is not generating the reference is zero. If ABSA, for instance, is already running at 2 MW this becomes the reference.

Case study ABSA energy centre

"The energy centre was established to co-ordinate the energy requirements of the nine buildings comprising the ABSA headquarters in downtown Johannesburg, and to consolidate the electricity supply and reticulation systems into a single controllable entity." says Ken Gafner, of Single Destination Engineering, the company responsible for the project. Previously there were several grid supply points and several standby generators spread around the campus, which led to inefficient operation and wasteful practices. Running a single bank of generator sets at close to full load is far more efficient then running several separate installations below full load, and having centralised control of the generator sets running in parallel with the grid allows ABSA to manage the power drawn from the grid at any time," he adds.

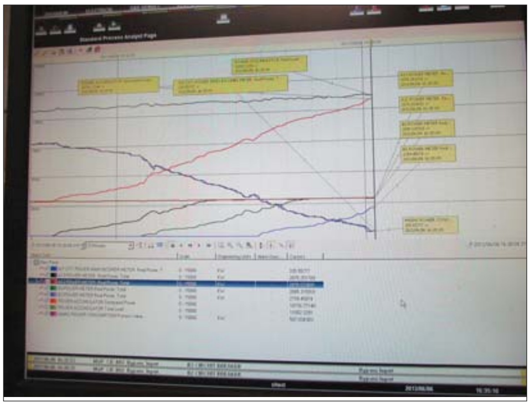

Fig. 6: Start up of generation.

The generator set installation consists of four Jenbacher J620 gas engine alternator sets (Fig. 2), each capable of producing 3 MW, but installed to be limited to 2,8 MW. Gas is obtained from an Egoli gas feed.

"The peak power requirement of the campus is about 12 MW," says Gafner, "but the energy centre limits the power drawn from the grid, especially at peak power periods, and generates the balance by keeping one or two of the four engines running continuously." (Fig. 4).

The parallel generation program is programmed into the system controllers (Fig. 3).

This leaves around 6 MW of reserve power which can be bid into the self-generation program and which can be brought on line easily by starting up the additional generator sets. Fig. 4 shows the power balance with a single machine operating prior to despatch of contracted generation. Dispatch is under control of the energy centre, which is operated under contract by Diesel Electric Services. The operator will dispatch in response to an SMS received from the VPN (Fig. 5).

Having the generator sets already running in parallel with the grid makes the dispatch easy, and allows controlled run-up of the additional engines to take over the site load (Fig. 6).

Summarising the gains already achieved by the energy centre, Gafner points out that before the energy centre was installed, ABSA was using 81 GWh of electricity per year, all drawn from the utility. "As we stand at the moment in phase one of the project, we are drawing 54 GWh and generating 26 GWh on our own."

References

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[2] P Naidoo: "Enabling a virtual power station", Energize November 2011.

[3] B Muller: "Virtual power plants", Siemens pictures of the future, fall 2012.

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