A Case for Incorporating Standby Generators into the South African Electricity System

D van Es
Senior Researcher, Energy Research Centre, University of Cape Town
Email: denis.vanes@uct.ac.za

K F Bennett
Director, Energy Research Centre, University of Cape Town
Email: kevin.bennett@uct.ac.za

Abstract

This paper examines how existing standby generators may benefit the South African electricity system. Eskom, the national electricity utility, supplies 92% of South Africa's electricity needs at a price to consumers that is the lowest in the world, making it virtually impossible for alternative generation to compete. Installed electricity generation capacity is 38 154MW with a reserve margin of 8-10%. Eskom would prefer a margin closer to 15% but demand growth for the next year will reduce the margin further, to 3.75%. One response has been to introduce a demand management programme The country has begun to suffer more frequent outages, particularly during winter when demand is highest. One aspect of the management programme is to shift the two daily peaks to the 'valleys'.

Eskom estimates a possible 3 000MW capacity available from standby generators. The research should deliver a more accurate figure, as well as the location of these generators, particularly with respect to network constraints. Also considered are issues of synchronisation with the grid, emissions, noise and other environmental impacts associated with the operation of distributed generation, as well as the contractual conditions under which such an arrangement may be possible.

Keywords: South Africa, Eskom, standby generators, demand side management, demand response, electricity supply constraints

Introduction

The national utility, Eskom, generates and transmits 92% [1] of the electricity used in South Africa. It was, until very recently, a parastatal and is now regarded as the supplier of last resort. In the 1980s Eskom built several new power stations in anticipation of high economic growth. The assumed growth did not materialize, with the result that some of these power stations were not brought into service. The opposite is now the case. South Africa is experiencing an unusually high economic growth rate (estimated at between 4.5 and 5% per annum [5]) and the estimated consumption of electricity in July 2007 increased by 5.6%

compared with July 2006 [6]. However, there has been a failure to act in good time to ensure continuity of supply. Added to this is the significant lack of maintenance to the distribution systems, generally the responsibility of local authorities. As might be expected, conditions are ripe for unplanned outages.

Installed electricity generation capacity is 38 154MW [2] with a reserve margin of 8-10% [3]. Eskom would prefer a margin closer to 15% but a demand growth of 2 000MW for the next year will reduce the margin even further, to 3.75% [2].

The Western Cape is at the end of the national transmission system from the north of the country and has an additional vulnerability as a result. In early 2006 the capacity of the transmission system was reduced following the freak coincidence of soot and mist on the lines. This arose at the same time as the failure of the only power station in the region following the discovery of foreign material in the rotor of one of the two sets. This is a nuclear powered plant and the other generating set was being refuelled. Unplanned outages followed and a programme of 'rolling blackouts' had to be instituted while Eskom hurriedly engaged the community in a rapid execution of demand side management.

Eskom instituted a national demand side management (DSM) programme about five years ago. It was slow to start and targets were not achieved. The current target is only 152MW per year and is lower than earlier targets. There is talk of quadrupling this in the very near future but the accelerated programme is not yet in evidence. In any event, the DSM contribution will be no match for the growth in demand.

The 2006 interventions in the Western Cape were successful in that the magnitude of the outages was significantly reduced. The two major contributors to this were the replacement of incandescent lamps with compact fluorescent ones, and a public participation campaign with requests to control demand broadcast over television channels. A very small number of standby generators owners were signed up to run their machines at peak times.

Standby Generators

There are a number of privately-owned standby generators serving industry, institutions, and commercial buildings. Various suppliers have estimated that more than 5 000 units were installed during 2006 alone. These units are seldom used and therefore represent an opportunity to be employed for the simultaneous benefit of the owners and the electricity utility. The supply shortages during the Western Cape winter of 2006 demonstrated that the generators could be employed to good effect during peak demand periods, providing relief to the national grid supply.

South Africa currently enjoys the lowest electricity tariffs in the world as a result of the availability of historically cheap coal and the fact that the cost of generation plant has been amortized. Even if the Regulator allows Eskom's application for tariff increases of the order of 18% per year for the next several years, the cost of electricity would still be relatively low. Consequently, independent power producers and distributed energy suppliers find it difficult to make a financial case for Eskom to buy their output. However, for business and other organizations the loss of revenue and the opportunity to function properly far outweighs the cost of electricity. The number of generator installations is set to increase on the back of this concern.

Standby generators have conventionally been installed in large buildings, shopping malls, hospitals, and factories, amongst others. Until about 18 months ago, these generators would only run if and when they were tested. For the most part, a generator is a vastly underutilized asset. Eskom had previously estimated the installed generator capacity as at least 1 000MW [7]. Many more large generators have been installed following the national electricity supply crisis and the estimate has increased to 3 000MW [4].

Generators are usually connected to serve internal emergency or critical circuits in the event of a failure of the grid supply. Non-critical functions are left without power at these times. In most cases the standby power is not synchronized with the external supply and there may be a delay before even the critical circuits are re-energized. Further, the 2006 experience in the Western Cape showed that generators are often rated far above the load to which they are connected.

Those facilities with grid synchronized generators would be able to supply into the grid but, to date, none does. Apart from the relatively high running cost mentioned elsewhere, grid supply from small generators would entail further costs for additional protection and safety measures.

However, one could envisage the possible use of standby generators as a demand response option. The intention would be to operate the generators at times of stress, either when there is insufficient supply or when a network constraint arises. In preparation for this intervention, the generators would need to be (re-)connected to as much load as their ratings allow and these circuits would have to be separable from the others in the facility when the generators operate. The generators thus operate to remove demand from the network, preventing outages, rather than as a result of outages. It is possible for generators to be safely connected to the grid and supply excess power into the grid but the complexity and cost is thought to make this unlikely for the near future.

Generators are typically diesel-powered and they are not particularly well sound attenuated, especially the exhaust. More frequent operation would clearly give rise to increased sound and gas pollution if mitigating measures were not introduced. Sound absorbing enclosures and exhaust ‘silencers’ are common place but more would have to done to deal with the quality of the exhaust gas. Catalysts are possible and bio-diesel would be a way of making the operation virtually carbon neutral.

Operating costs consist of fuel and maintenance. Since long-term operation is not common place, representative maintenance figures would have to be established for extended operation. Fuel costs vary with the international price of oil. Eskom uses gas turbines to meet peak demands and it is likely that Eskom’s marginal cost at peak times is similar to the fuel cost of operating a diesel powered standby generator.

An article in the June issue of the *Building Services Journal* gives the maintenance costs of combined heat and power units as less than 1p/kWh for machines rated between 200 and 600kW(e). This converts to R0.14/kWh. It is common knowledge that Eskom paid standby generator operators R1.60/kWh to run their machines during peak times in the 2006 crisis in the Western Cape. The total cost to operate is therefore of the order of R1.74/kWh. This cost excludes amortization of the purchase and installation costs which may be regarded as ‘sunk’, given that the generator owners would have taken account of this in their overall facility costs.

It is possible that generator operation would be ‘called’ in areas where there are network constraints. Having these assets at the point of demand gives immediate relief and means that the cost of transmission and distribution lines is saved, at least in the short term.

Operation and Control

Data collected thus far indicate that there are thousands of standby generators dotted over the country. Even if one were to concentrate on large machines, early indications are that there are many more than the number of conventional power stations under Eskom's control. Harnessing the output from a large number of small assets requires a different approach by the national utility since conventional wisdom points to a large centralized system.

Eskom does have a subsidiary organization that makes it possible to co-ordinate, manage and regulate the entire load shedding process over a number of customers. However, a multitude of small generators may prove unmanageable for the existing organization. There are examples in other parts of the world and it should be possible to draw on these. For instance, there is Flexitricity in the UK and EnerNOC in the USA. These systems allow for an aggregator to negotiate with the smaller suppliers and sum their loads for onward sale to the utility.

Similarly, maintenance conditions could be monitored remotely. The basic technology to do this exists and only requires that appropriate schedules and alarms be incorporated.

Implications

The major benefit is undoubtedly the possibility to rapidly strengthen the electricity supply and transmission infrastructure, restoring reliability to the system. Much of the 'hardware' is in place. Some sites may require wiring modifications but these are not major and could also be quickly achieved. The process could start by switching large sets manually following a telephone request and graduate to full automation as the communication links are installed. DSM funds are available and could readily be applied to implement the necessary changes.

Social Benefits

As a developing country South Africa has managed to supply electricity to over 70% of the population. Remote rural areas and some informal settlements are still without electricity or have a very limited supply, further depressing economic opportunity.

Community social benefits would be significant and extensive, given that the widespread incorporation of generators would reduce the likelihood of outages and allow the broader community to continue benefiting from having an electricity supply. It is also possible that the use of private generators could allow the utility to reallocate some of its capital from generation to distribution, thereby facilitating further electrification to as yet unsupplied houses in rural and poor areas.

Given an appropriate legislative environment, one could foresee the possibility of community-based entrepreneurs acquiring generators to supply electricity locally via a mini-grid which would automatically isolate from the national grid during a regional or national outage. Poor people – who are often hardest hit – could, therefore, continue to receive electricity and it would not be just major businesses that benefit from this technology.

It is surely the case that those homes far from the national grid (as in rural areas) have a relatively high cost of provision via the conventional distribution system. In this case it may be cost effective for local entrepreneurs (perhaps in conjunction with the utility) to establish remote mini-grid systems using generators.

Generators have a particular additional benefit in that they simultaneously supply a considerable quantity of thermal energy (heat). This heat can readily be converted into domestic hot water and refrigeration which could be used on a pay-as-you-go basis by the community, whether rural or informal peri-urban. The refrigerators could be used to store perishable foods or medicine.

The establishment, operation, and maintenance of the generators and ancillary systems offer employment opportunities. It is suggested that biofuel is used to power the generators. The growing, harvesting, and processing of the crop offer yet more employment opportunities, particularly in rural areas. The resulting economic upliftment would bring about improvements in health, education, security and reduce the incidence of crime.

Experience Elsewhere

We have found a few references to the sharing of standby generators with utilities in other parts of the world. These are generally in the USA where the electricity tariff is higher than in South Africa. There are many other references to distributed generation but none of these falls into the DSM category – they are seen as independent power producers. We have not found literature relating to southern African considerations, and there is no evidence here of a strategy to employ such a resource. (The 2006 actions in the Western Cape were crisis measures and did not amount to a long-term strategy). We are, therefore, dealing with a relatively novel approach since standby generators have only recently been considered as assets under a demand response programme. The test for South Africa is whether such an opportunity exists in a very low tariff market place.

Our own observations and anecdotal evidence suggest that in other parts of Africa and India, for instance, the ability to supply electricity from the grid is so constrained that consumers acquire and run their own generators for their specific needs. There is thus little scope for these units to be operated in order to relieve the grid but they may well be considered as suppliers to the grid, should they have capacity available when the grid needs it. We foresee that the same sort of control system may also be applied in these cases.

Research Considerations

An early task is to determine not only the geographical location of the generators but also their capacities. Where possible, connection details to the circuits in the facility should also be determined.

Initial attempts at collecting information have been very successful. Several large property portfolio holders have willingly provided us with lists of their generator details. One of the largest generator suppliers has also provided us with a list of machines which they have sold. We will cross reference information from suppliers with that gained from operators. There are many more operators to be contacted, including supermarket chains, public and private hospitals, hotel groups, telecommunications backbones, and public building managers.

Inevitably there will be local supply constraints where demand growth has outstripped the transmission or distribution network. Our work will attempt to identify these locations and match generator availability against the constraint. It is possible that the utility may consider installation of (temporary) generators under its DSM programme.

We expect to find that there is a single national price for fuel. Of greater importance here is the availability of sufficient fuel and its storage on site for extended operation. Related to this is consideration of exhaust gas discharge into the local environment, probably urban, and any specific local authority by-laws that may apply.

We anticipate that there may be reluctance from some generator owners to 'share' their sets with the network. One reason may be the increased cost of maintenance. Our research would try to establish the conditions for a 'willing seller, willing buyer' contract between generator owners and the utility. As has been mentioned above, purely financial considerations from the supply side currently make extended operation of standby generators difficult to justify in South Africa. We will consider the possibility of reduced fuel cost for bulk purchases and the possibility of having taxes removed or reduced. The results of these considerations should broadly define the acceptable range of operation.

Although this research is focussed on the contribution from generators, both the qualitative and the quantitative findings would inform a much bigger picture about the place for demand response on the one hand, and for distributed generation on the other.

Future Direction

The press has often carried news items about Eskom's plans to double its generation capacity to about 80 000MW over the next 20 years. While the country's coal is likely to remain relatively cheap and Eskom's ability to extract high efficiencies from its power stations has to be recognized, the cost of construction is such that the selling price of 'new' power will rise faster than inflation. South Africa has a very high specific CO_2 output as a result of the preponderance of coal firing. Environmental concerns are likely to demand cleaner conventional systems which would undoubtedly increase the cost of a unit of electricity. One likely result is the widening of the peak period over which standby generation would become financially viable.

This is relevant as the comparison has only considered the costs at the point of generation. Nearly all of our electricity generation takes place near the coal fields in the north of the country and regions, like Cape Town and the burgeoning west coast, are served via transmission lines over a distance of 1 500 km or more. Energy losses along these lines average 8% and can be of the order of 15% at peak times.

Perhaps the biggest challenge is the philosophical shift from a centralized supply model to a distributed one. Clearly large centralized units are attractive because of the (possible) economies of scale and the relatively simpler incorporation into the grid. On the other hand, it is their scale that goes against them when it comes to the required redundancy for maintenance. At such times a large proportion of the reserve has to be removed which may reduce the margin to unacceptable levels. It also means that a large financial asset is not being worked. Smaller, modular units may offer more flexibility and greater opportunity to match load requirements.

Conclusion

The cost of new generation in South Africa has been quoted as R17.5M/MW and the cost of DSM measures at R3.3M/MW [8]. Power stations take many years to construct and commission while DSM interventions can usually be completed within one year. The case in favour of DSM is thus easily made. It is even more easily made when the capital cost of a generator has been covered by a facility owner or operator. We estimate that the cost of modifications to the generator connectors at a facility may be of the order of R10-15 000. This small sum means that a relatively large amount is then available to provide the generator owner with an incentive over and above the operating costs since Eskom would have had to bear these anyway. For example, a 500kW generator should be able to attract a total incentive of R1.65m over, say, the next five years. This is equivalent to R0.66/kWh assuming a daily run time of four hours for 250 days per year. To put this in perspective, the

Eskom time-of-use tariff that would apply to a large industrial or commercial user is R0.56/kWh. This is the highest energy rate and only applies during peak periods for the three high demand months. The rates are lower at other times of day and for the remaining 9 months of the year.

On the face of it there appears to be a good case for both Eskom and the generator owner to participate in such a programme. Eskom quickly ‘gains’ a generator for approximately one fifth of their anticipated construction costs and the owner receives a reasonable contribution towards ultimate replacement costs.

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