Power Alert: An Innovative System to Control Residential Loads Under Peak Conditions Using National TV

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ABSTRACT

The Western Cape region of South Africa experienced severe power supply problems between February and August 2006. The reason for this was that Eskom, the electricity supply utility, lost one of its nuclear supply units. Forecasts predicted a winter shortfall of 300 MW for the region out of an average supply of about 4000 MW. It was clear that if something could not be done to reduce demand, power outages would be experienced. The main concern was the evening peak between 18:00 and 21:00, due to the high evening load.

Eskom sent out a request for proposals to energy solution providers and ESCOs to come up with solutions to the crisis. The problem was that there was not enough time to implement solutions like residential hot water control systems in the 625,000 households of the Western Cape. The total residential load was around 1,200 MW.

Energy Cybernetics, an energy solution provider, came up with the solution to use the national TV broadcaster to inform the public on the status of the electricity supply network between 18:00 and 21:00 on weekdays. Energy Cybernetics and Yardstick implemented the project for Eskom. It was called power alert.

Power alert made use of real-time total electrical load data obtained from Eskom's national control centre to identify when the electrical supply was under strain. Predictive modeling was also used to determine the total electrical demand for the Western Cape based on real-time data, historical data, and predicted weather conditions. The

real-time predictive modeling was then used to predict the demand of the Western Cape 30 minutes, 60 minutes, and 24 hours in advance.

An online computer system and application was also developed that connected the power alert control centre to the broadcasters control centre. This provided the power alert control centre with the capability to change any message to be broadcast within five minutes.

The real-time predictive modeling was used to predict the total electrical demand and consequently the expected level of strain. The level of strain was then prioritized according to four status levels. The status levels were:

- Green—Indication that there was no strain on the electrical supply of the Western Cape.
- Orange—Indication that there was strain on the electrical supply.
- Red—Indication that there was increasing strain on the electrical supply and that load shedding was imminent.
- Brown—Indication that there was significant strain on the electrical supply and that load shedding was in progress.

Based on the strain level experienced at that time, the public was asked to switch off certain appliances, thereby relaxing the strain on the network and preventing power outages.

Power alert was deployed within three weeks and was in operation from April 2006 until the nuclear power station came again online during August. No further power outages were experienced during this period except for two short occasions: one when there was a transmission line failure, and two when Eskom lost a second unit on the nuclear power station. The power station tripped on a Thursday evening and it was too late to inform the public. Power outages were experienced for the whole next day until the first power alert message was flighted on Friday afternoon at 18:00. The demand then started to drop and continued to drop further as more messages were broadcast. No additional power outages were experienced from 18:30 onwards until the unit came back on line on Sunday.

Independent measurement and verification results showed that power alert achieved impacts of up to 180 MW when red and brown messages were broadcast. Power alert achieved a total savings of more than 19,000 MWh over this period. The total cost to implement and operate power alert was about US$3 million, resulting in an average peak reduction cost of US$156 per MWh or 15.6 c/kWh.

With all the initiatives, Eskom reduced the demand in the Western Cape by more than 400 MWs over a period of three months.

The project has been a huge success, and Eskom decided to roll power alert out nationally as well as to other regions. Because the project will reach a bigger audience, the expected cost for the national power alert will come down to US$56 per MWh or 5.6 c/kWh.

Eskom is also looking at expanding power alert to the commercial and industrial sectors. This will be done by "hard wiring" the power alert control center to non-essential loads in these sectors and controlling them when the networks come under pressure.

PROJECT BACKGROUND

The Western Cape region of South Africa experienced severe power supply problems between February and August 2006. The reason for this was that Eskom, the electricity supply utility, lost one of its nuclear supply units. Forecasts predicted a winter shortfall of 300 MW for the region out of an average supply of about 4000 MW. It was clear that if something could not be done to reduce the demand, power outages would be experienced. The main concern was the evening peak between 18:00 and 21:00, due to the high evening load.

Eskom sent out a request for proposals to energy solution providers and ESCOs to come up with solutions to solve the crisis. The problem was that there was not enough time to implement solutions like residential hot water control systems in the 625,000 households of the Western Cape. The total residential load was around 1,200 MW.

The only way in which such a campaign could succeed would be to make use of continuous feedback to the public regarding the status of the electrical distribution network and how it can participate to avoid power blackouts in the Western Cape.

Energy Cybernetics, an energy solution provider, came up with the solution to use the national TV broadcaster to inform the public on the status of the electricity supply network between 18:00 and 21:00 on weekdays. Energy Cybernetics and Yardstick implemented the project for Eskom. It was called power alert.

Power Alert Description

The aim of the power alert control center was to control the residential loads in the Western Cape, that was made up of 625,000 households.

The power alert control center made use of real-time total electrical load data obtained from Eskom's national control center to identify when the electrical supply was under strain. Predictive modeling was also used to determine the total electrical demand for the Western Cape based on real-time data, historical data, and predicted weather conditions.

The level of strain was prioritized according to four status levels. The status levels were:

- **Green**—Indication that there was no strain on the electrical supply of the Western Cape.
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Based on the strain level experienced at that time, the public was asked to switch off certain appliances, thereby relaxing the strain on the network and preventing power outages.

MW Targets

Figure 1 shows a demand profile as well as how it was expected the power alert control center would change the demand profile.

At point 1 the power alert control center forecast when the load will have a yellow status and communicate it to the broadcaster to be broadcast on SABC 1, 2, and 3 for the time slot before the occurrence. The broadcasters then air the yellow status flag at point 2. The load is influenced, but at point 3, the power alert control center forecast that the load will continue to increase and when it will have an orange status level. The broadcaster then airs an orange status level (point 4), which influences the load. At point 5, the load again gradually increases and the power alert control center forecast shows when the load will be in the red zone. The broadcasters then air a red status level at point 6 on instructions from the power alert control center. The forecasts (point 7) show that the load will be in the red zone, and at point 8 in time a red status level is again broadcast. The next forecast (point 9) shows that demand is decreasing and instructs the broadcasters to air an orange flag in the next time slot. At point 10, the orange status level is aired. Residential consumers can then start to switch some of their loads on again. This process of relaxation continues until a green status level is broadcast and after the forecast at point 13 indicates the fact.

The expected impact with power alert messages being broadcast only on SABC 1, 2, and 3 was 122 MW.

INSIDE THE POWER ALERT CONTROL CENTRE

This paragraph presents how the power alert control center operated. Data requirements are given: how the data were applied during the modeling phases, how the power alert barometer levels were calculated, and lastly how the messages were made available to the SABC ready for broadcasting.

Data Requirements of the Power Alert Control Center

Inputs required by the power alert control center included the following:

- Historical energy data,
- Historical temperature data,
- Current energy data,
- Forecasted minimum and maximum temperatures, and
- Supply limits and DMP availability.

Operation of the Power Alert Control Center

The power alert control center operated in three modes:

- Normal operation,
- Tracking and evaluation, and
- Emergency conditions.

The power alert control center based on historical data, real time data, and Eskom Forecasts, generated all status levels. The codes were

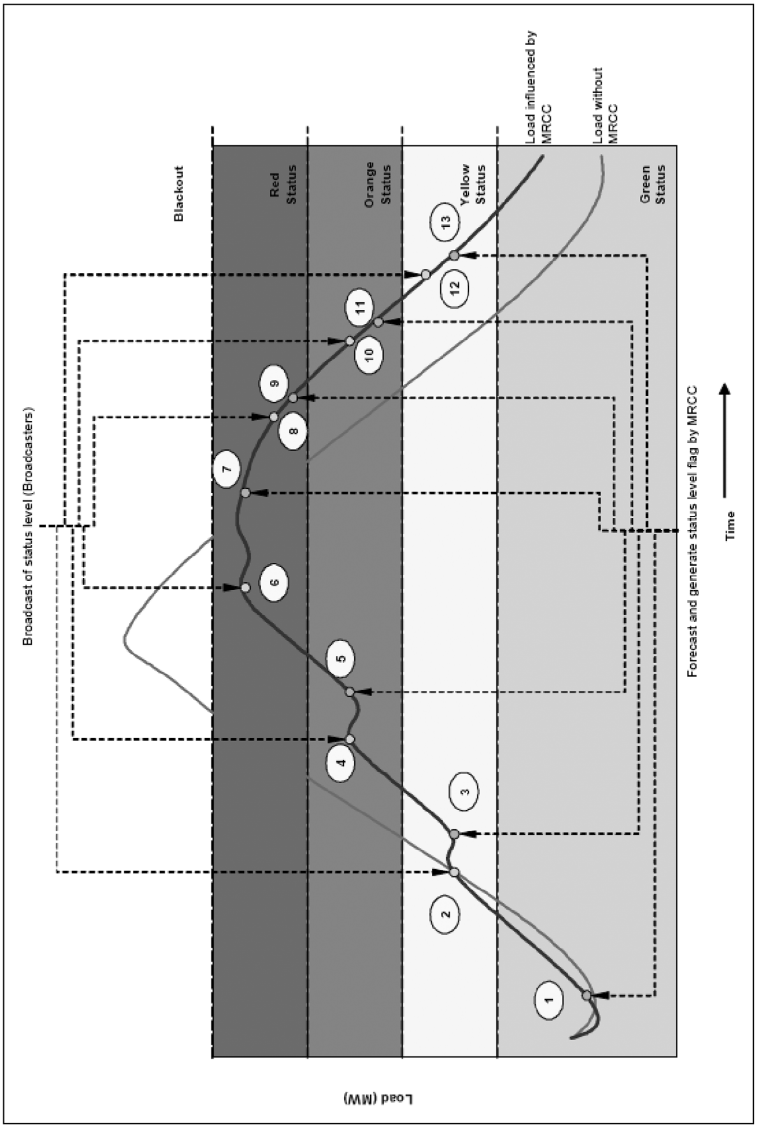

Figure 1. Expected demand profile due to power alert control center influences.

then approved by Eskom and broadcast on weekdays during the evening peak on SABC 1, 2, and 3.

Getting the Message to the SABC

On a daily basis, the profile was forecast and barometer values assigned in 10-minute intervals. This was preloaded in the power alert control center and served as the default for the day. These preloaded codes were also accepted by the network engineer on a daily basis and sent to the SABC. If no problems occurred during the day, these codes were broadcast by the SABC.

The power alert control center continuously tracked the actual demand profile. In cases when major variations were detected, messages could then be altered real time and sent to the SABC. The text fields were then updated according to what was published on the URL of the power alert control center and broadcast by the SABC. Any message could therefore be changed or removed in less than ten minutes.

Figure 2 shows the power alert graphics and text fields that were on TV.

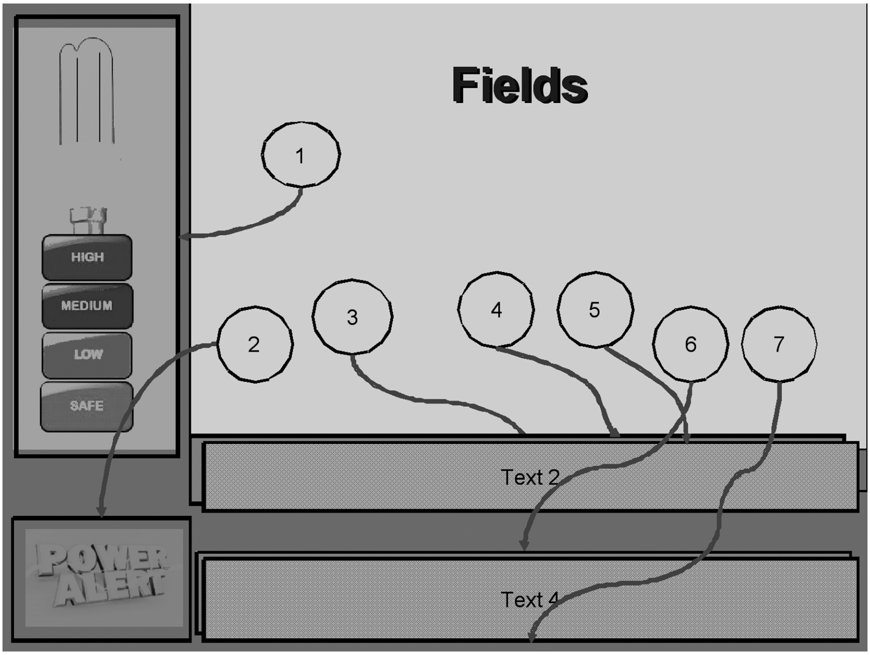

Figure 2. Power Alert graphics as seen on TV and text fields.

ACHIEVEMENTS

MW Impacts

Table 1 and Figure 3 show the average weekday impacts that were measured and verified (M&V) by the University of Cape Town M&V team.

Table 1. Average Weekday Impact in MW

Average impact [MW]	18:00	18:30	19:00	19:30	20:00	20:30	21:00
May	99	61	40	27	-29	-169	-202
June	152	132	126	105	75	31	-18
July	172	150	171	129	126	55	-18
August	182	120	147	116	89	3	-44

The most notable impact of power alert was seen on 9 June, 2006. Koeberg went off-line on the 8th of June at 18:00. For the eighth, all power alert messages were cancelled due to the trip. On the ninth, brown-up and brown-constant messages were broadcast. Load shedding was done throughout the day in the Western Cape.

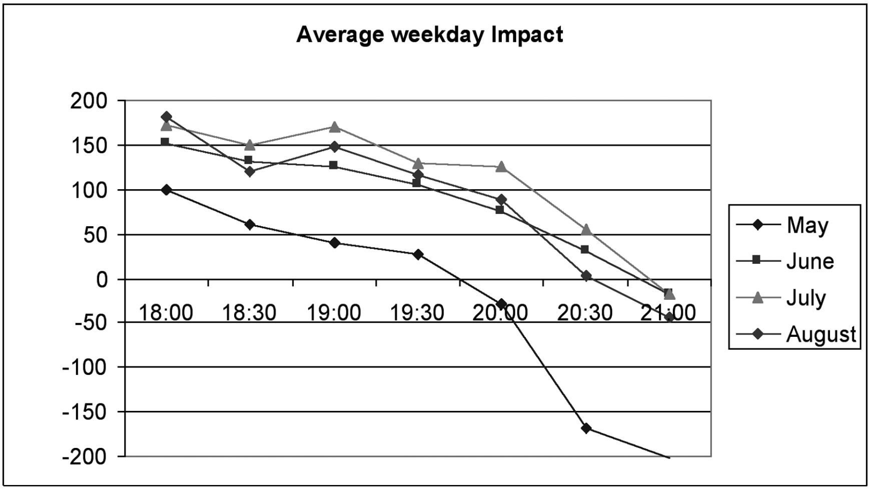

Figure 3. Average Weekday Impact

The first power alert message was broadcast at 18:00. Load shedding in the Western Cape stopped at 18:00 and no load was shed throughout the rest of the evening of Friday the 9th. The whole of the Western Cape was with electricity during the evening and over the weekend, even though Koeberg was off-line. Koeberg was back online on Sunday.

Figure 4 shows the demand profile of the Western Cape from 18:00 and also the power alert messages broadcast. Notice the sharp drop in demand when the 18:00 brown-up power alert message was broadcast. Also note the change of slope in the demand profile at 18:30 when the second brown-up power alert message was broadcast. The average impact achieved on 9 July between 18:00 and 20:00 was 291 MW, and for the period 18:00 to 21:00, it was 245 MW.

Technological Achievements

Many technological challenges were overcome during the establishment of the power alert control center. Most of these challenges were IT related: getting relevant data from Eskom, processing the data, and publishing the final message for broadcasting to the SABC. Probably

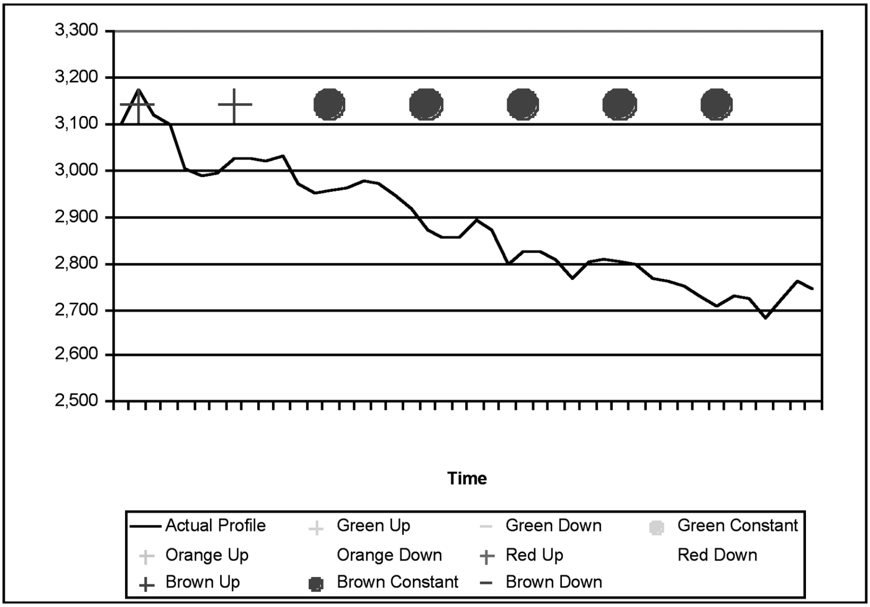

Figure 4. Demand profile of Friday 9th of June, 2006.

the most impressive achievement in the flow of data was establishing an IT link with the SABC.

Despite the MW impacts achieved by the power alert control center, another major achievement was to establish a direct link between the power alert control center and the SABC so that power alert messages could be altered in 10-minute intervals. Messages could therefore be either pre-loaded at the power alert control center ready for publishing and broadcasting by the SABC, or changed in real time.

CONCLUSIONS

The power alert control center proved to be a valuable tool to control the residential load during the evening peak. The public in the Western Cape responded to the power alert messages broadcast on television and thereby kept power outages to a minimum during the winter. Power outages during the operational period of the power alert control center have occurred only when Koeberg tripped (8 & 9 June 2006) and when one of the TX-lines tripped (22 June 2006). The power alert control center therefore contributed significantly to the 400 MW that had to be saved to avoid power outages in the Western Cape. It was also seen that impacts achieved by the power alert control center could only be sustained when the public was constantly reminded to conserve electricity.

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