Background and Business Context

The current system constraint that has seen load shedding been implemented as a necessary means of stabilizing the national grid, is set to continue until the new build programme is completed. The Power Conservation Program (PCP) calls for a sustained national load reduction of 3000MW over the next four years in order to avert load shedding, the effects of which are negative to the economy and national growth and also to the Eskom brand credibility. Demand is expected to outstrip supply with the situation only marginally improving after 2015 as shown in Figure 1 below. Several countries face a similar energy crisis but ageing power plants that are rapidly approaching their full life expectancy and challenges with funding models for new build capacity compounds the problem for Eskom. The utility is thus faced with the following options – either to increase the supply capacity by investing in new power plant or put in measures to decrease the demand by effective demand management measures. As Eskom have an immediate capacity shortfall both scenarios will need to be addressed. These solutions are both necessary to ensure a combination of long and short terms strategies in dealing with the current energy crisis.

![Figure 1: Supply and demand projections 2010 to 2016](image)

DMP and power purchase options also provide short terms solutions but may have an economic impact on Eskom and the South African economy in the long run.

The Utility Load Manager (ULM) is an innovative device that has been developed entirely in South Africa jointly by Eskom, Sustainability and Innovation and EON Consulting. The ULM was principally developed as a total solution to assist in alleviating generation capacity, network and system constraints by limiting the residential sectors load and averting any future load shed conditions.
The systems control methodology is patented locally and is regarded as a world first. A global patent application has also been awarded.

The ULM system is designed to operate as a Virtual Power Station (a stand-alone fully integrated system) that is capable of integrating all end-use consumption data with Eskoms systems and infrastructure. It is a real time, residential load management system that allows the utility to limit residential loads as opposed to block load shedding. This provides an effective demand response (DR) mechanism to the utility that is flexible, scalable and interoperable across regional and national control centres. The residential sector represents 17-20% of the total system load and is a significant contributor to the both the morning and evening peak resulting in an overall national load factor of 72%. The ULM targets the residential sector by actively engaging the customer and installing system of hardware devices in the LV network.

Figure 2. Functional layout of ULM System

Basic Operation of ULM System

Figure 2 is a schematic layout illustrating the principles of operation of the ULM. The system will comprise a backend system, field hardware as well as a customer display unit. The ULM enables load to be limited at end-user level via central control point that will be located at Eskom National Control. More than 6740MW of load can be
displaced during network constraint periods with the national implementation of the ULM in the residential sector alone.

During periods when Eskom is experiencing severe system and network constraints, the system controller can limit the supply to the residential sector to any predetermined value (between 5 and 60 Amperes) in terms of the MW load reduction required to stabilize the network at that particular time. The signal is immediately sent via General Packet Radio Service (GPRS) to a master controller unit located in the mini-substation. The master controller unit then sends a signal via Power Line Carrier (PLC) to remote master located in the kiosk or stubby box. The remote master controls the respective individual home and sends the message to a display unit located in the home notifying the customer that he is entering into a load limiting period and that load needs to be switched off to meet the required limit – display unit is shown in Figure 3. The display units show/depict the instantaneous consumption of the household as well as the kWh consumption in “Real Time”. This allows the household to see the consumption of the household change as and when electrical devices/appliances are switched on and off. When the power utility has a supply or network constraint, a message can be sent to the display unit, instructing the household user to limit their power usage. If the household conforms to this limit, by switching off appliances and conforming to the required power limit imposed, the household will continue to get this limited power for the period/duration of the load limit period (the period whereby the supply/network constraint is experienced). However, if the household does not conform to this imposed load limit, and continues to exceed the limit in terms of power usage, that household will be automatically disconnected from the electrical network. The household can then SMS to a specified number and get reconnected for a few minutes and then has to conform to the imposed limit, or will get cut off again for non conformance. Should this process may take place a few times; the household will get cut off for the duration of the load limiting period. The power limit or ration drives behaviour and allows the customer to operate low consumption appliances like CFL lighting, fridge, television set, alarm system etc. whilst keeping off high consumption stoves, space and water heaters in order to conform to the set limit.

The signal process takes micro seconds from control to end-user and the end-user has 5 minutes (duration can also be predetermined by Control) to respond in terms of curtailing load. The entire network response in terms of total MW load reduction can be achieved with 15-30 minutes.
The ULM system has also been designed specifically to ensure a very quick implementation rollout, with minimal impacts to the existing network design and specifically for the use on all existing reticulation networks. The system is also not installed in the end-users' house or even on the said property which makes it very easy and accessible for installation teams to ensure fast roll out as it is installed in the Mini substation and the Kiosk or stubby box as shown in Figure 4 below.

Figure 3 – Display unit located in household

Figure 4: ULM Remote master installation in Kiosk or stubby box

The research pilot project consisted of 20,000 ULM units installed in the Midrand area resulting in a total load displacement achieved of 15 – 20%.

The project has been hugely successful and as a result the technology has been identified as the technology option for National implementation. National implementation (Large scale...
roll out) of the ULM system in over 8 million residential customers will displace in excess of 6750MW of load and will cost between 8 – 12 billion Rand to implement.

The results from the pilot project and the resultant benefits derived from the implementation were above expectations proving that the original MW savings were calculated conservatively. The following graphs show the achieved capacity reduction during morning and peak loading. The most exiting part of the pilot project is that the ULM system algorithm ensures that the come-back load is totally in line with the existing or reference load on the network, this will ensure a large degree of network stability unlike other relay type systems which compound the problem.

Phase 1 of the ULM pilot project involved the installation of 20 000 units in the Eskom installed base for LSM 8 to LSM 10 customers. Figure 5 shows the results from a recent pilot run of the system during the morning peak. 143 customers were selected within the pilot and given a load limit of 2kW. An average reduction of 1.3kW per customer was achieved with the system resulting in total reduction of 185kW off system peak for the sample. This can be projected to over 5200MW of system peak reduction for 4m customers.

![Sample Sum Actual vs Sample Sum Reference (Tuesday 03 Nov 2009)](image)

Figure 5: ULM system used during a morning system peak period

Figure 6 shows the system in operation during an evening peak in a summer month. During this pilot, 134 customers were given a load limit of 2kW. Customer response showed a total reduction of 1.2kW per customer across the sample. There was an average reduction of 160.8kW off the system peak for the sample. This can be projected to an average reduction of over 4800MW of system peak for 4m customers.
Figure 6: ULM system used during an evening system peak period
In addition to the intended design criteria (morning and evening peak reduction) Figure 7 below shows that there is a significant amount of load that can be reduced during the daytime. This makes the ULM an effective demand management tool in terms of managing customer behaviour and improves efficiency at end-user level.

Figure 7: ULM system used during Midday peak period

The Pilot project was well received by the customers and independent audit conducted by University of Free State shows the technologies acceptability by the end-use customers that participated in the project.
Finding 1: Households demonstrated positive experience with and perceptions of the load limiter device

Figure: 8 Households perceptions of the load limiter device

It is envisaged that Eskom, Distribution and the various Metro’s and Municipalities will maintain and operate the ULM systems as part of their current operational and maintenance function.

Future of ULM in Eskom and other system networks

The ULM will be used as a tool to avert load shedding as mentioned above and once Eskom has sufficient generating capacity and Load Shedding is no longer a threat, the system can be used to its full potential as per design functionality. Eskom and the various Metro’s and Municipalities have a significant problem in terms of revenue management and South Africa currently experiences non technical losses of between 5 and 9 billion rand per annum in this regard.

The ULM system is designed specifically to assist in managing revenue and energy streams with real time reconciliation of all parameters. The system will enable and facilitate the following:

- The ULM system is able to capture near real time load flows at a LV level. This is a first for Eskom as traditional energy balancing methodologies relied on statistical metering data reconciliation with monthly sales data on a retrospective basis. Energy Losses determination with automated energy balancing at end-user and bulk levels.
- Revenue management and reconciliation of energy consumed
- Energy Protection against theft with tamper proof with tamper alarms notification
- Creates a direct communications platform into the house (bi-directional communication system) for customer communications and notifications
- Accessible and available Data from the consumer base that can be used for ISEP, Network Planning, Demand Forecasting, Consumer behaviour understanding
- Assist Eskom field services in terms of maintenance and problem solving as it enables Low Voltage Customer network link data and network fault finding at real time. This will also improve Distribution field service response time to fault conditions as the system will identify the fault before the consumer calls the call-centre
- TOU Metering data – check meter facility
- Enables the utility to reduce Carbon Emissions

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