Using Low Voltage Smart System (LVSS) Data for Intelligent Operations and Customer Support

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1) Introduction and Scope

For the purpose of demand management, the Low Voltage Smart System (LVSS) was piloted in a residential area in the Gauteng province over the last 4 years. The LVSS is an end to end system that enables more efficient management and control of electricity consumption and distribution using real time information. Some of the system value added applications include; revenue management, network planning, energy balancing, metering and billing and outage management. The intent of this paper is to explore benefit cases beyond the initial intent of LVSS and traditional utility use of smart metering systems. The focus is on consumer facing benefits and to use the system as a tool to gain more insight into user behaviour.

Only a small part of consumers have the benefit of falling within the catchment area of LVSS. The paper then explores ways and means to provide benefits to the consumer starting in offline or partly locally networked devices. Such an approach would have the option of reusing existing communication channels and thus relax the reliance on the networking part of LVSS while still benefiting from the aggregation and customer portals provided by LVSS.

The consumer preferences with regards to their perceived benefits of online and offline systems to better manage their consumption and appliances is obtained.

The paper closes off with recommendations for further research in the area of increasing synergy between different market segments for a greater overall consumer experience and overall benefits realization.

2) Energy efficiency by behavioural change

The LVSS system is a hierarchical communication network that links electricity measurement points to an in house display and also to a central monitoring and control server. The LVSS gathers high resolution reading data. The measurement points are located at the service point where mains power is connected to the premises. The LVSS also relays real time usage data to in house display called the Electricity Demand Display Instruments (**eddi**).

2.1) Initiative 1: As part of a residential demand management pilot, focusing mainly in the Midrand and Lonehill area in Gauteng, end customers were issued with the **eddi**. The **eddi** is a plug and play device that shows users their electricity usage for the premises in near real time. Analysing the consumption before and after the issuing of the in-house displays showed a revealing picture. The **eddi** issuing was done in week 8 till

week 11. Energy savings peaked at 10% shortly after the issuing of the displays was concluded and then stabilised at approximately 3 to 4% two months later. This shows that the residents are responding and acting on information that is provided to them. Once people get used to the **eddi,** the savings percentage reduces.

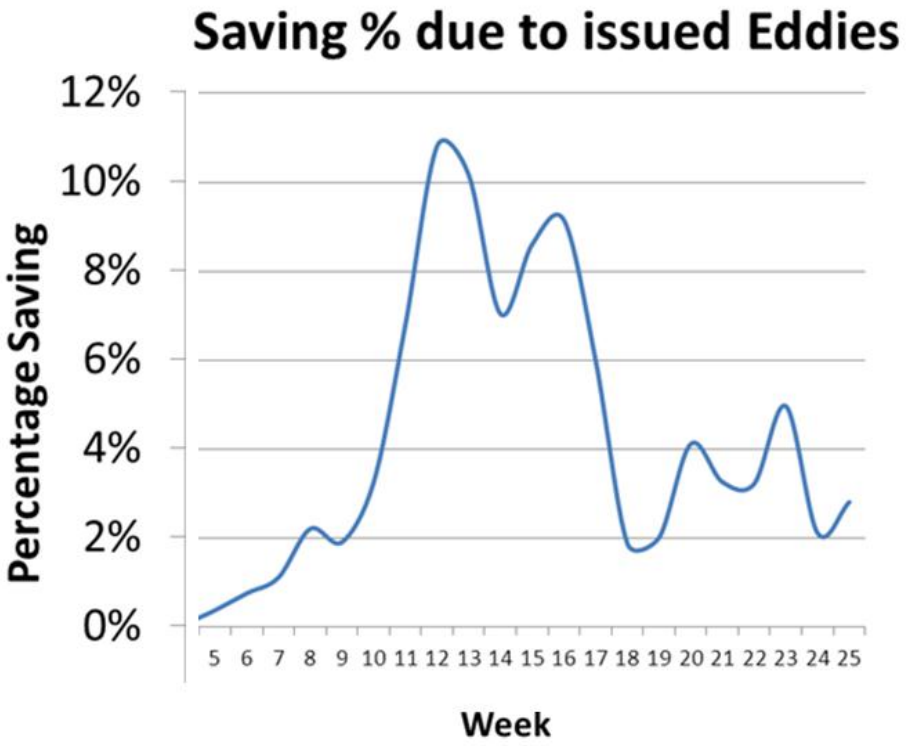

Figure 1: Savings due to real time consumption feedback

2.2.) Initiative 2: On 15 December 2011, SMSs were sent to all customers that were issued with the **eddi** requesting them to switch off their geysers during the December holiday. A comparison was then done on the amount of geyser reheats between December 2010 and 2011.

2.3) Parameters of the study

The analysis was done per mains phase supplied to the premises.

Amount of service points: 820
Amount of service points without geyser switching action: 301 (mostly due to part of the service points being part of a 3 phase supply where one of the phases does not have a geyser)
Measurement data: 23h00 till 3h00
Assumption: Geysers consume >2kW
Assumption: Many customers go on holiday on the 15th of December
Assumption: In summer power exceeding 2kW from 23h00 to 3h00 are geysers

Two approaches of identifying the level of geyser activity were applied. One using a differentiating algorithm to count the amount of geyser reheats and an integration

algorithm, which aggregates the energy contained in geyser reheats over the selected period.

Differentiating equation: Geyser reheats are identified when with a running window P1-P4/(P2-P3) > 800 watts where P1, P2, P3, P4 is the average power in successive 5 minute interval. Once a geyser reheat has been identified the detection is disabled for 15 minutes. Trailing edges after 15 minutes count as a second reheat.

The geyser reheat energy is determined by summing of energy for the time duration where the power levels exceed 2 kW.

The above will also detect high powered air conditioners and under floor heating. The intent of the equations is for trend comparison and not intended for absolute geyser characterisation.

In terms of weather it was confirmed that December 2010 and 2011 had similar climatic temperature profiles so that temperature compensation is not required.

2.4) Results from different algorithms

Algorithm 1: Counting the geyser reheat, reduction year on year = 1.5%.

Algorithm 2: Aggregating energy used by geysers, energy reduction year on year = 1.3%.

The conclusion underlined by both algorithms is that SMS communication to consumers to switch off their geysers on a specific date prior to the December holidays has had an insignificant effect.

When aggregating the energy used, an interesting observation is that consumers reduced their consumption by approximately 5% in year on year comparison. There is a multitude of driving forces for such reduction.

Amongst these initiatives is the issuing of the **eddi** and the accessibility of web based electricity usage profiles to consumers through the LVSS system.

	Total – geyser in 1/10 of kWh	Geyser Energy in 1/10 of kWh	Reheat counts
2010 first half of December	**17.58**	**2.56**	**0.67**
2010 second half of December	**17.87**	**2.27**	**0.60**
2011 first half of December	**16.66**	**2.45**	**0.68**
2011 second half of December	**17.07**	**2.15**	**0.60**

Table 1: Average non geyser load, geyser load and geyser reheat counts from 23h00 – 3h00 (including phases where no geysers were detected)

From the analysis it became clear that the amount of geyser reheats do not equal to the amount of energy that is being used for reheating (See Figure 2). What is interesting to note is that the energy used during 23h00 till 3h00 is largely attributable to non geyser appliances.

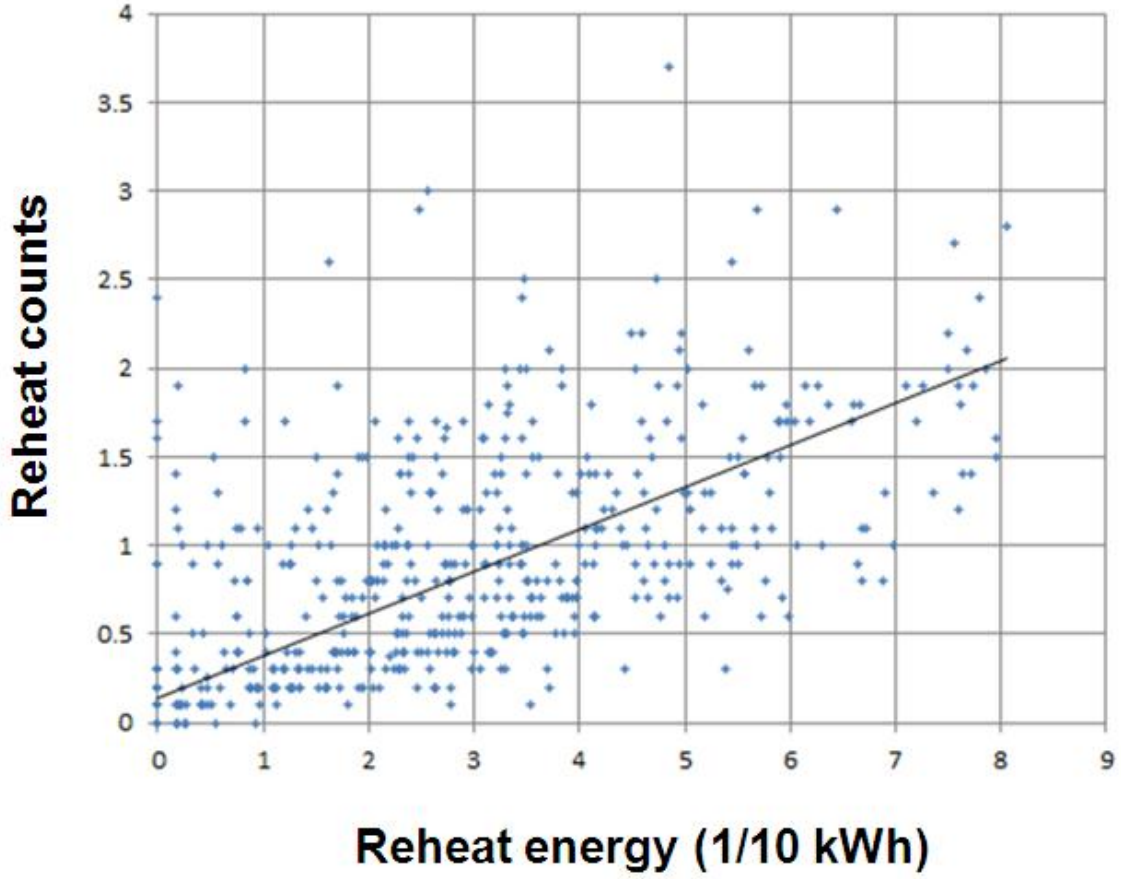

Figure 2: Average reheat counts and reheat energy(1/10 kWh) per mains phase from 23h00 till 3h00 during December 2010, 2011 (Excluding phases where no geyser was detected)

From Figure 2 one sees a spread of reheat energy of 1 to 8. Part of this can be ascribed to geysers that are forced to reheat at night by timers. It may also be that there is air conditioning equipment on at night which has a similar consumption to geysers. From analysing graphs of the raw data manually, it was confirmed that a big spread of efficiency gains can be achieved from geyser insulation. The information of geyser efficiency spread could be used to plan a more targeted rollout program yielding higher benefits.

2.5) Scenarios from consumption graph analysis

Analysis of the consumption graphs was done to ensure that the data from the algorithms was correct. At the same time it provided some insight on the correctness of the assumptions made. The analysis of graphs was done on mains phases where there were 1 or more reheats during the 4 hour period.

The assumption that many higher LSM residential users go on holiday during December holidays was proven to be incorrect.

Another interesting observation from analysing the raw data is to determine how many timers are installed that push out reheats into the period 23h00 till 3h00 and how many geysers are off the grid.

The analysis of the raw data in graph form confirmed the results from the algorithms that the amount of people acting on 16th on the SMS campaign was neglible. However it was noted that people had already switched off their geysers before the SMS was sent in December 2011. In December 2010 however, less users had switched off their geysers. This could be attributed to the various power awareness campaigns that had occurred throughout the year.

Multiple communication initiatives and price increases are having a noticeable effect on consumer behaviour.

3) Consumer Questionnaire

In order to get a better understanding of consumer behaviour and needs, a list of questions was distributed. The aim of the questionnaire was to get an understanding of the consumers view on offline and online energy efficiency initiatives.

Questionnaire findings:

a) If you had access to a tool that breaks down the costs of your appliances so that you can make more informed decisions on whether to install items such as a geyser blanket, solar geyser, LED lights etc. would you use it? (YES- 98%)
b) Would you be more willing to invest in home improvements that save power if you can see a definite reduction in your electricity bill? (YES- 100%)
c) Would you be interested in enjoying the added feature of having a remote energy analysis done on your household to determine if your appliances are working efficiently? (YES - 81%)
d) Would you install a “smart” timer that can detect when you’re at home (via the Bluetooth on your cell phone) to ensure that your geyser is switched on? *Note this could reduce your insurance premium as there is no risk of geyser failure while you’re away so your response time to the damage is much quicker. Timer / occupancy aware smart timer / no timer (36%, 47%, 16%)
e) Do you react to the Eskom power alert messages (YES - 85%)

What is clear from the questionnaire is that the more internal the locus of control that is provided to the customer the higher the acceptance. Options that reduce the customer's level of control have lower preference levels. One item where customers differed on whether it provides them a higher internal locus of control was the comparison of the smart timer compared with a normal timer. The benefit of automation however convinced the larger number of participants to rate the occupancy aware smart timer as being their preference.

Point to point

a. Would consumers use tooling if available to them, to assist them in improving on appliance level efficiency (98%),

Different tools exist on the market that measures the consumption of appliances. Both plug based and Distributed Board (DB) based products are available.

Part of the analysis work for the paper was done in an area that has no LVSS coverage. A smart phone application that uses the magnometer to sense current flowing in its vicinity was used. The accuracy provided is sufficient for energy efficiency base lining and improvements. Offline measurement capabilities like these when packaged and marketed appropriately may address a certain need in the market.

b. Will invest in home improvements when I can see direct savings in the electricity bill (100%)

In the general comments field of the questionnaire, a few of the consumers elaborated on their energy efficiency measures they had implemented (switching to heat pumps and solar geysers). One response highlighted the need for a business model and switching support to alternative sources for energy other than for geysers only.

Smart phones have significant processing power to plug the captured data into different models which can reside on the smart phone or pulled on demand into the smart phone. Due to operator detection, the conversion of electricity consumption to cost can be automated, simplifying the interpretation of information

c. Appliance level efficiency analysis results available from a central server (81%)

With accurate per premises data one can target specific non efficient geyser owners**.** One may be able to convince more people by being able to show them the before and after results. One concern that shimmers through with the result is that some people may be hesitant to use this service due to privacy and / or technological complexity concerns.

d. Timer / occupancy aware smart timer / no timer (36%, 47%, 16%)

Although only available to date in concept, consumers instinctively approve of a 'Smart Timer' that can sense premise occupancy and only switch on heavy users when someone is at home using proximity sensing. Consumers are interested in this option especially if there is a monetary benefit due to a reduced financial cost / risk in the case of geyser failure. Besides better management of a geyser failure, switching off the

geyser when no one is at home will also result in electricity savings. How substantial the reduction of geyser failures is when electricity is being switched off when no one is at home would be a subject for a further study.

The high level of interest in automation of geyser switch off and switch on is also an indication that consumers prefer mundane tasks to be automated.

e. Power alert information

A surprisingly high number of consumers that responded to the questionnaire indicate that they respond to power alert information by switching off appliances in the house. There was a request to make the power alert information available on the **eddi**.

With a lot of the younger generation using the internet more than the TV showing the power alert on an interface rather than the TV such as the eddi would make sense. Have not mentioned what they switch off (will provide insight into what consumers deem as heavy users)

4) Using the LVSS Data for Operation and Maintenance

The LVSS gathers high resolution reading data. The measurement points are located at the service point where mains power is connected to the premises.

Monitoring of normal geyser operation can be done through geyser reheat analysis especially in cases where there are repeatable detectable reheat occurrences*. It will work well if there is no interference with appliances that exhibit similar switching profiles and power use as for instance under floor heating.*

“Smart Timers” are a natural candidate for optimising geyser lifetime operation. If a geyser is on for a period longer period that say 6 hours while it was operating normally before, it is a likely sign of a fault condition. Smart timers with a buzzer can alert such conditions.

Risk of geyser failures occuring while no one is at home may be reduced by deploying “Smart Timers” that are aware of the occupancy of the premises. Only switching on the geyser when people are at home may be a way to reduce consequential damage due to quicker attendance to the fault condition by residents.

Table 3 provides a breakdown of options of how to serve the interest of different stakeholders with different offline and online based appliance management solutions. The items that are starred(*) need further study to fully quantify.

Initiative	Utility benefits	Consumer benefits	Insurance benefits	LVSS potential benefit	Comment/ Recommendation
SMS campaign to switch off geyser by utility	Low*	Medium*	Medium*	Measurement	Campaign should potentially be done jointly by insurance company and Utility for higher uptake.
Timer	High	Low	Potentially negatively affected*	M&V for RMR rollout	Increased potential of geyser failure when person not at home due to reheat shifting out of peak time
Offline Smart Timer, phone appliance measurement	High	Medium Measurements, alerts	Potentially negatively affected*		Customer gets more benefits measurement from Smart Timer. *Should be considered*.
Offline occupancy aware timer	Medium – More load when the consumer is at home	Medium May not have enough time to heat up	Medium*		May be in conflict with online due to security concerns *Could be considered as an intermediate step prior to full networking.*
Part time online timer using smart phone as carrier	Medium* Quality of service info Fast rollout, low existing comms network	Medium* Can view information on web consoles. Negative	Low* Can obtain measurement information to audit claims	Quality of service for utility Consumer portal and smartphone gateway Audit info for insurance	*Could be considered as an intermediate step prior to full networking*
Online smart timer through PLC network	Large* On demand load shifting and quality of service	Medium* Remote control of appliance and online consumption Negative due to ceding control, privacy concerns	Medium* Can obtain measurement information to audit claims.	Consumer portal and smart phone gateway, Network and load management	Will need additional agreement / communication with consumer as whether and when online control may be used.
Secure transaction /identity tokens sent to online timer in premises		Medium*			Future benefits for more secure identity management in the online world

Table 3: Optimising convergence benefits to different stakeholders from offline automation to networked appliance control connectivity.

5) Conclusion

The LVSS system provides additional value which can be unlocked through automatic and manual analysis of the fine grained reading data. Different parties i.e. utility, consumer and third parties for example, insurance companies, may benefit from the data.

However there are rollout speed and cost impacts to rollout an end to end system with its own communication system. Also having measurement and control on the appliance provides direct information reducing the need for complicated analysis and verification of reading data in agregate form.

A further benefit of consumer focused solutions is that these may be applicable in larger markets than just the South African context. Smart grid technologies have quite a lot of country dependencies.

A combination of top down rollout of LVSS and a bottom up approach of rollout of appliance control devices, such as the “Smart Timer”, that may be networked in future may be an approach that allows value to be unleashed quickly, meeting the needs of different stakeholders.

The emergence of smart phones and their networking capabilities opens up another opportunity namely part time network access. Using smart phones as the carrier for measurement information to a central LVSS reduces the need for custom communication networks and thus faster rollout. Privacy and cost of transmission are issues that may impede consumer opting for relaying information through their smart phones.

Exploiting benefits associated with convergence between service sectors may be a topic for further study i.e. installation of appliance control units that benefit the utility, consumer and insurance industry all interfacing to one common platform.