Green Group Conserving Volts

A "green group" traditionally tries to conserve and protect the environment but a "green" group at Bathurst has conserved "volts" – strange but true. Their project to conserve "volts" is a process called Conservation Voltage Reduction (CVR) which is about lowering the electricity supply voltage level to conserve energy, and reduce demand and carbon dioxide emissions.

The Bathurst Community Climate Action Network (BCCAN) received NSW Office of Environment & Heritage funding to implement a trial Conservation Voltage Reduction project to see the benefits to the environment and if the project could be rolled out across the state.

This case study looks at lowering voltage levels at the Bathurst campus of Charles Sturt University (CSU) and the benefits gained.

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BCCAN's project aimed to link with large electricity users who would benefit from reductions in peak demand and energy usage due to CVR and which would also benefit the environment. The project was also designed to explore possible business models which community energy groups could use to access any carbon credits or energy reduction funds from CVR to fund community energy projects

Voltage Levels

Australia has had a 240 volt electricity supply since 1926 that was focused towards the higher end of an allowable voltage range (though I am led to believe that Western Australia was 250 volts at one stage). With an international rationalisation of voltage to 230 volts, planned in 1983 and introduction in Australia in 2000, a lowering of voltage is now possible.

Benefits in Lowering Voltage Levels

The benefits of lowering the voltage to around the nominal 230/400 volts are:

1. Reduction in the quantity of energy used and so the electricity bill is reduced;
2. Reduction in the peak amount of energy used or what is generally called demand. Larger energy users not only pay for the energy used but also for the peak demand and so any reduction in peak demand will also help reduce the electricity bill for the site. Demand charges are typically half of a large customer's electricity bill.
3. Reduction in CO_2 emissions (which is of particular interest to BCCAN);
4. Extended life of electrical equipment;
5. Reduced maintenance e.g. light globes won't need to be changed as often;

Equipment that Save Energy from Lower Volts

Not all types of electrical equipment respond with a reduction in energy usage to a reduction in supply voltage as shown in Figure 1 (table from the Office of Environment & Heritage's document "i am your guide to voltage optimisation: is it right for you?")

Equipment type	Energy/Voltage Sensitivity
Incandescent lamps	✔
Fluorescent lamps (inductive ballast)	✔
Fluorescent lamps (electronic ballast)	✘
Fluorescent lamps (high frequency)	✘
High intensity discharge lamps (inductive ballast)	✔
Induction lamps	✘
LEDs	✘
Motors: linear (fixed)	✔
Motors: permanent magnet	✘

Equipment type	Energy/Voltage Sensitivity
Motors: variable speed	?
Refrigeration (uncontrolled)	✔
Refrigeration (controlled)	?
HVAC (flow controlled)	✔
HVAC (flow uncontrolled)	✘
Heating: coil/resistance	✘
IT equipment	✘
Uninterruptable power supply (UPS)	✘
Equipment with inverters (surge protection)	✘

Figure 1 – Effects of Voltage on Energy Consumption on Various Types of Equipment[i]

Trial Site

The site for this trial project was at the Charles Sturt University campus at Bathurst. Twelve transformers were assessed for a reduction in voltage at the site and a high level assessment of electrical equipment was carried out to determine the suitability of the application of CVR.

One transformer did not have any available adjustment for lowering voltage and so was discounted from the project. Another three transformers were also discounted for simplicity reasons due to energy efficiency works that were in progress. This left eight transformers that were assessed as able to have their voltage lowered. Three transformers could be lowered by 2.5%, four transformers by 5% and another transformer by 7.5%. Savings were estimated at $10,000/year and CO_2 savings of 61 tonnes/year.

Green Credit Options

The National Emissions Reduction Fund was initially considered as a source of funding but the anticipated savings were too small for the project to be eligible. Energy Savings Certificates issued under the NSW Energy Savings Scheme were then considered. Unfortunately, by this time the project had commenced with no nomination form signed with an Accredited Certificate Provider and so the project had not been accredited and no Energy Savings Certificates could be issued. Variations in the load from month to month and the lack of correlation with independent variables made determination of accurate energy savings and therefore Energy Savings Certificates difficult.

Voltage Adjustment Mechanism

The different ways to lower voltage levels to achieve a reduction in voltage to electrical equipment are:

- Using Conservation Voltage Reduction (CVR):
  - Adjust the voltage regulation relay settings at zone substation transformers and/or at voltage regulators in the field;
  - Rotate the tap changer knob on the transformer (with the power off) to adjust the transformer winding (refer Figure 2), which is the low cost option chosen for this project;
- Installing a voltage optimiser at the electrical installation. Voltage optimisers are series devices and so all the load current flows through them and they adjust the voltage output. These provide typical savings of up to 12% but cost more.

The ability to lower voltage will depend on the available adjustment of transformers and the existing voltage levels.

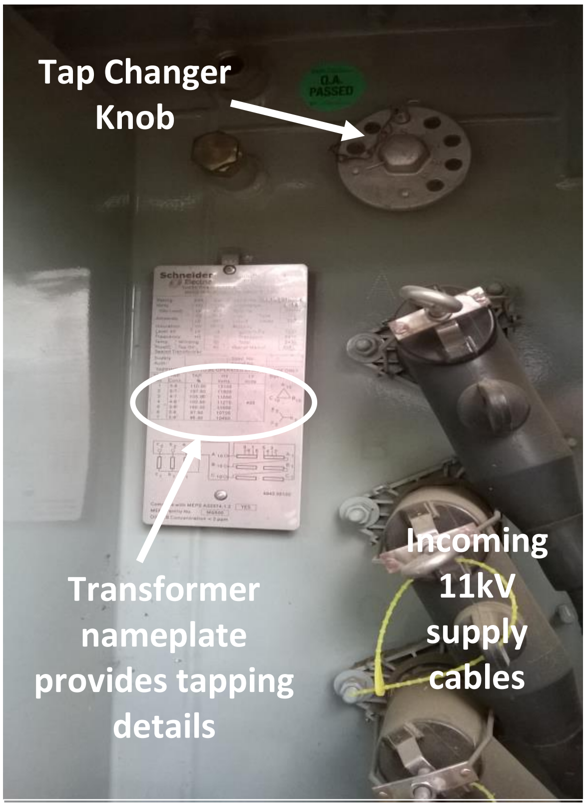

Figure 2 – Transformer Showing Tap Changer

Voltage Optimisers versus Conservation Voltage Reduction

Voltage optimisers are likely to produce greater energy and demand savings than CVR as the voltage output is generally regulated to a near constant value but this does depend on the type of optimiser (refer table following). Voltage optimisers and CVR have various positives and negatives – these are explored in Figure 3.

Item	Voltage Optimiser	Conservation Voltage Reduction
Implementation cost	Expensive	Cheap and may be no additional costs if implemented with normal maintenance
Payback	Longer	Immediate or short-term depending on implementation costs
Space requirements	Space will be required for the unit with appropriate ventilation	No additional equipment or space required
Spare parts	System redundancy should be considered	Nil
Complexity	Install and maintain	Set and forget
Operational costs	Will needs some maintenance and may need replacing if damaged	Set and forget but should monitor voltage levels
Maintenance	Will need some maintenance	No additional maintenance required
Voltage regulation	Depends on the type of optimiser used: • Fixed percentage – lowers voltage same as CVR • Dynamic – maintains within a certain range • Constant output – mains a constant voltage output to equipment	Simply lowers voltage and does not perform any voltage regulation
Cost, energy, demand and CO_2 reduction	Up to 12% quoted [1]	0.6 to 1% for every 1% voltage dropped (see Literature Review section)
Electrical losses	Additional heating and losses	Nil extra

Figure 3 - Voltage Optimiser versus Conservation Voltage Reduction

Results of Trial

Voltage levels lowered as expected with the graph in Figure 3 showing the voltage levels before the transformer tap was dropped by 5% and the voltage levels after the change.

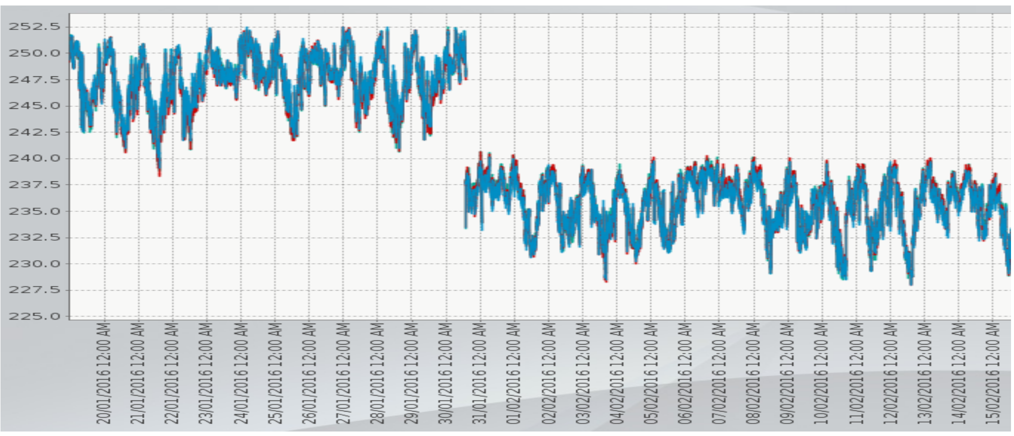

Figure 3 - Voltage Levels Before and After the Tap Change at One Substation

Raw energy savings were better than expected and calculated at 94,970 kWh and $7,760 for the six-month period from February to July 2016 but these figures hold no statistical relevance or accuracy due to the lack of correlation with independent variables.

Demand savings were also better than expected and were estimated at $2,220 for the three-month period from February to April 2016. A different time period was used to that for energy savings due to data collection issues.

Further detail on the raw energy and demand savings is contained within our full report at - http://powerlogic.com.au/electrical-policies-and-procedures_105_2008376636.pdf

CO_2 savings could not be accurately calculated due to lack of correlation with independent variables.

Conclusions

Conservation Voltage Reduction (CVR) can result in significant energy, demand and maintenance savings and generate worthwhile numbers of Energy Saving Certificates but this is all dependent on the size of the installation, the type of installed electrical equipment, correlation with independent variables and the existing voltage levels. The cost of CVR is minimal when compared with voltage optimisers and in fact some voltage optimisers only do what CVR performs.

Linking with a voltage consultant and an Accredited Certificate Provider in the early stages of the project is essential. Using the flowchart provided in the full report will help to ensure the success of any CVR project.

The real question is whether this type of project is viable for a community group such as BCCAN and large electricity users, like CSU, to link together? Community groups will need to find large energy user(s) that are willing to work with them. Skilled voltage and energy consultants will be necessary to prevent problems. The lack of measuring equipment and the cost of the consultants are likely to take any Energy Savings Certificate revenue that might be generated and the community group might be out of pocket if the energy savings are less than expected.

CVR does however provide a real opportunity for distribution network businesses to reduce greenhouse gas emissions but they are unlikely to be eligible for any Energy Saving Certificates. There are also no other incentives for them to reduce their customer's energy usage and their resulting income. It would take government intervention for network businesses to lower their voltage levels and this should occur if we as a country are serious about reducing greenhouse gases. A whole system level lowering of voltage levels would reduce any business opportunity for community energy groups to negotiate further reductions in voltage at a local level.

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[i] Office of Environment & Heritage's "i am your guide to voltage optimisation: is it right for you?"