Voltage optimisation Measurement and Verification guidance template

This guide is to be used in conjunction with the EEOS 'Guidance on authenticating and claiming energy credits' (1). The aim of this guidance document is to advise on the situations where voltage optimisation is appropriate and in those situations what M & V approach should be used to verify potential savings. Additional requirements include addressing the persistence of savings and investigating whether there is a reduction in performance/service of eligible electrical loads as a result of voltage reduction. This guidance document is not an endorsement of the technology and each installation will be revised on a case by case basis. This document will be reviewed on an on-going basis.

What is voltage optimisation
Voltage optimisation is a type of voltage management which principally involves reducing the voltage level from that of the incoming supply by using a transformer [(2) (3)]. The aim of voltage optimisation is to reduce energy consumption while maintaining performance of equipment. Voltage optimisers are appropriate for use in situations where a site has a high proportion of voltage dependent loads and where the supply voltage to a site is in excess of the nominal 220 V. As $P \propto V^2$, a 9 % reduction in a sites voltage from 240 to 220 V could <u>in theory</u> deliver energy savings of 15 % i.e. $1 - 0.92^2$. However this relationship would <u>not</u> apply across an entire site because there are only certain equipment known as voltage dependent loads that will show a reduction in energy use with a lower voltage. Ineligible loads have their own electronic control gear, have some feedback control or are constant power devices resulting in no energy saving following a voltage reduction. As energy savings are dependent on load type, the M & V requirements to verify savings are also dependent on load type.
EEIM Intent
The ECM involves the installation of a voltage optimiser either after the main meter or directly before a voltage dependent load on site. Energy savings are accrued because voltage dependent loads on site will show a reduction in energy consumption as a result of the voltage reduction.
Requirements
These requirements are part of the criteria defined for voltage optimisers on SEAI's Triple E register: • Include a technical description of the voltage optimiser including model, power-rating, efficiency, % insertion losses under different rated output loads. What standard is the voltage optimiser manufactured to and is it CE marked? • State the site's initial supply voltage and the final controlled voltage. • Include an inventory of voltage dependent loads on the site that would benefit from the voltage reduction (see tables of eligible and ineligible loads at the end of this template). In the inventory include the details of what sub-metered area this load is in. Voltage dependent loads include incandescent lamps, fluorescent lamps with inductive ballasts

and linear (fixed) speed motors

M&V Approach & Measurement Boundary
Option A retrofit isolation will be used. The measurement boundary is taken around the loads that will benefit from voltage reduction. For a process facility where areas are sub-metered • M & V report for the technology • Sub-meter the energy consumption of each area that contains eligible loads • The types of eligible loads in each area is to be detailed in full • The total sum of savings from the sub-metered areas is to be compared against normalised savings determined from the main meter • Comment on any difference in savings determined from sub-metering and that from the main meter For a site without sub-metered areas: • M & V report for the technology • Sub-meter the energy consumption of a sample of each type of eligible load, before and after voltage reduction took place. • Determine the % saved energy for each sample eligible load • Apply that % saved energy to the baseline energy of unmetered eligible loads while adjusting for run hours, power rating etc. This is to be done across eligible loads that are similar to each other e.g. constant speed pump motors • To ensure the savings are not overestimated, compare the total sub-metered savings to normalised savings from the main meter.
• Identify indirect energy (interactive) effects and discuss their relevance. For example if lights are benefiting from voltage reduction is there any heat replacement effect?
Baseline period
• The duration of the baseline period will be dependent on the types of loads benefiting from the voltage reduction. • If the operating hours of the loads are dependent on seasonality such as chiller or HVAC constant speed pumps then a minimum of 6 months measured data would be required including half of a cooling and heating season. • If the eligible loads are independent of climate then a shorter baseline period is appropriate.
• The independent variables would be specific to the eligible technology included within the measurement boundary. These could include a) HDD for heating systems, b) CDD, flow/pressure of coolant and external air temperature for cooling and refrigeration systems along with operating hours and production volumes.
• Static factors would be specific to the eligible technology included in the measurement boundary. • In the case of lighting the static factors could include occupancy levels or store opening hours, lighting controls, lighting levels, area of each store or the product mix in retail

store.

- Static factors applicable to fixed speed motors are dependent on what the motor is driving. For example if the motor is driving an air-compressor then static factors could include: production levels, leaks in the system, compressed air users and operating pressure.
- If the fixed speed motor is driving pumps and fans for a HVAC system then static factors could include hot water demand, production levels, plant processes, internal temperature and shift cycles

Reporting Period

This will be similar to the details for the baseline period.

Basis of Adjustment

It is necessary to adjust/normalise the sub-metered data in one of the measurement periods to the operating conditions in the other period. For instance, this may be the baseline period, the reporting period or a normalisation period. The data will be normalised to the independent variables, some of which are discussed above.

Analysis Procedure

- Identify the intervals used for analysis, e.g. weekly, monthly.
- Step by step explanation of how savings will be calculated at the end of the reporting period, taking account of both the independent variables and interactive effects
- Identify the equation/algorithm used to reflect the relationship between energy use and selected independent variables, and identify the parameters, e.g. y = 357 x + 8700 where x is heating degree days and y is gas use
- Explain how savings are annualised including any factors used to ensure conservative outcome (where appropriate).

Analysis of Savings

Compare the closeness of the savings calculated from sub-metering and the quantity of savings calculated from the main meter. What is the difference between the two?

Persistence of savings

- Of the eligible loads that are benefitting from voltage optimisation, detail any future replacements or upgrades of these loads that would potentially eliminate the savings from voltage optimisation.

Effect on operation and delivered performance/service

- If fixed speed motors are among the eligible loads, then any reduction in motor speed needs to detailed. The continued suitability of these motors to meet the motor loads needs to be clarified.
- Indicate the proportion of a site's loads that are made up of constant power devices such as IT equipment that do not show savings from voltage reduction but draw more current because of the reduced voltage. Ensure the suitability of equipment to the sum of all the increased currents including the supply conductors, control equipment and protective devices on the distribution board. The operation of the protective devices must not be

compromised (4). • Ensure light levels do not fall below a certain minimum light level. • Ensure the voltage reduction is within the voltage rating of equipment.

Eligible, voltage dependent loads	Explanation/remark
Consume more energy, the higher the supply voltage (5). Typically less efficient than voltage independent loads	
Incandescent lamps	Lower voltage will reduce light output.
Fluorescent lamps with inductive ballast	Lower voltage may reduce light output
Other industrial lighting	Operate satisfactory within operating range. Includes high pressure sodium (SON, SONT), high pressure mercury (MBF), high bay installation
Street lighting	Operate satisfactorily within operating range. Low pressure sodium lamps
Linear, fixed speed motors e.g. for HVAC system components such as fixed speed heating pump motors or AHU fixed speed fan motors	Need to consider impact of motor losses Only where the motor is oversized and lightly loaded may VO be suitable to achieve energy savings (4). A comparatively modest fall in the voltage will result in a much larger reduction in torque capability, causing overheating and decreased life expectancy of the motor. Standard squirrel cage induction motor torque output is proportional to the voltage squared. Therefore a 10 % reduction in terminal voltage will result in a torque reduction of 19 % i.e. $1 - 0.9^2$. It is therefore important that, for standard induction motors, the actual motor load is verified and the continued <u>suitability of the motor post installation of any Voltage Optimisation device is ensured</u>

Table 1: Table detailing the eligible, voltage dependent loads

Ineligible, voltage independent loads	Explanation/remark
i) have electronic control equipment that give a fixed output voltage or ii) has feedback control to ensure a fixed amount of energy to function iii) Include constant power devices, where reducing voltage means device will draw more current	
Lighting – domestic compact fluorescent lamps (CFL)	These are constant power lamps May fail to operate at excessive reduced voltage unless dimmable type
Fluorescent lamps with electronic ballast	Operate satisfactorily within operating range
LEDs	Have the same power demand, regardless of supply voltage.
Motor loads controlled by	Constant power device.

Ineligible, voltage independent loads	Explanation/remark
VSD	Operate satisfactorily within operating voltage range but the current drawn increases proportionally with reduced voltage (4). So the suitability of the supply conductors and control equipment for any increase in current resulting from the reduced voltage must be checked.
Information and computer technology	These are constant power devices and have their own power regulators. They operate satisfactorily within an operating voltage range. If 30 % or more of a site's electrical load is made up of switch mode power supplies (SMPS), such as information technology in particular, the supplying circuit's suitability for the increase in current as a result of the reduced voltage must be verified (4). The summation of all the increased currents from the individual equipment could potentially overheat distribution boards running at or near capacity. The protective devices may also trip spuriously.
Thermostatically controlled resistive load e.g. electric space heating or kettle.	Device requires a fixed amount of energy to function, so reducing voltage will mean it will take longer to boil the kettle.
Lifts	Possible problems and lift manufacturer must be consulted.

Table 2: Table detailing the ineligible, voltage independent loads.

Bibliography

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