# Voltage optimisation

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Voltage optimisation has been a popular technology in recent years. In the correct situation it is a relatively straightforward technology to provide energy savings and, because it affects the incoming supply, it can offer a reduction on total electrical consumption in one installation. However, the key aspect to remember with this technology is that it will not necessarily be right in every situation, so care is needed and an appropriate assessment is required. This article will discuss first the technology and then the appropriate way to conduct an assessment in order to see whether voltage optimisation is feasible or not.

The UK for many years had a standardised supply (phase-to-neutral) voltage of 240V 36 per cent, whereas continental Europe had a nominal supply level of 220V. Since 1st January 1995, the nominal voltage across Europe has been harmonised at 230V, with a supply tolerance in the UK of 230V -6 per cent to +10 per cent (216-253V), while in continental Europe the tolerance has been

230V -10 per cent to +6 per cent (207-244V). This meant that there was no incentive for suppliers to make any real change, as the old supply limits lay almost entirely within the new limits.

## Supply tolerances

From 1st January 2008, new supply tolerances of 230V 3 10 per cent (207-253V) came into force. In a 1996 report, the former Institution of Electrical Engineers (now Institute of Engineering and Technology) recommended that for safety reasons all electrical equipment needed to be tested across the range 230V -14 per cent to +10 per cent, so all equipment produced since then should be capable of working from 198V to 253V. Most equipment is manufactured to operate at 220V.

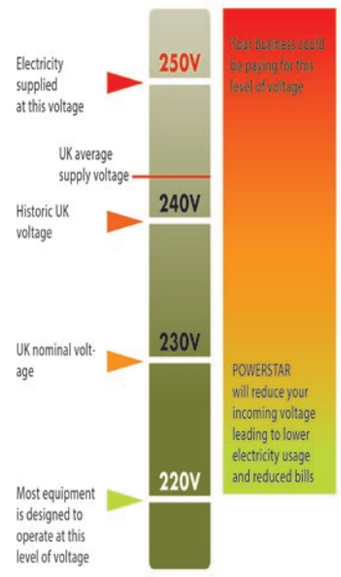


**Figure 1: Overview of Voltage in the UK**

Therefore with the UK legacy of 240V (the average is 242V) and equipment being 220V there is a gap between the supply voltage and what voltage equipment is required.

This 'over-voltage' means that energy consumption, and thus energy bills, can be significantly higher in most buildings than required. Consequently, this 'over-voltage' also presents an excellent opportunity for savings.

This is based on Voltage = Current x Load (I x R).

Where load remains constant, a reduction in voltage will see a corresponding reduction in current. For example a 5 per cent reduction in the voltage of a motor shall result in a 5 per cent reduction in current at all times except when the motor is on full capacity. When a motor is required to produce its full power capacity it will do so regardless of the input voltage.

Power is a function of both voltage and current so a reduction in both results in a reduction in power. Power = I2 x R

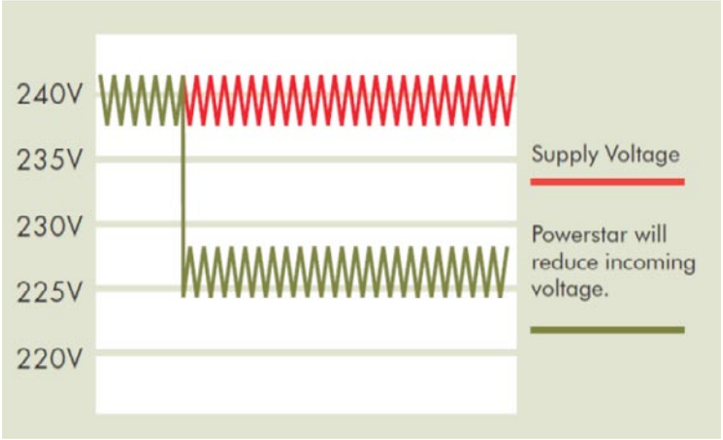


**Figure 2: Illustration of Voltage Optimisation actively reducing the Voltage**

Most voltage optimisation devices work by systematically managing the peaks and troughs of power generated in a building, aiming to reduce and stabilise the oversupply of power on the low voltage (LV) side, at the distribution point, to provide the optimum voltage.

## Adjusting supply voltage

The name voltage optimisation is generally centred actively on adjusting the supply voltage as it comes into a building or site, in order to meet the demand voltage. For example it comes in at 242V and the equipment adjusts this to 230V for use in a building. However, there is a slight cloud over the naming of this – should it be 'optimisation' or 'regulation'? Some manufacturers call voltage optimisation the act of adjusting the voltage with the intervention of a piece of equipment. Whereas others say voltage optimisation also includes improving the power quality of your supply (like the harmonics). Where the power quality is not being actively improved it is simply voltage regulation and not optimisation.

Voltage optimising, depending on what manufacturer you speak with, may mean either regulation on its own or both regulation and optimisation. For our purposes, we are simply terming the act of dynamic adjustment of the voltage

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as voltage optimisation and we are not going into the naming convention of this technology (the manufacturers find it hard to agree).

Therefore, voltage optimisation is the installation of equipment that is actively monitoring and controlling the voltage from the incoming supply and to the distribution within a building or site. Figure 2 illustrates what the voltage optimisation equipment does.

Figure 3 right shows the actual energy consumption for a site that has successfully installed Voltage Optimisation.

## Biggest impact

While voltage optimisation can undoubtedly have the single biggest impact on energy consumption, numbers are easily quoted. As such, building and facility managers need to look out for suppliers that misleadingly tout their products as voltage optimisation solutions, in particular those that promise unrealistic price and payback periods.

Here are a few key factors to consider:

**knowledge is power:** it is not enough just to know that a voltage optimisation system will help save energy and money, while reducing a building's overall impact on the environment. It is important to also understand where, when, and how much energy is being consumed, and then to effectively act on that knowledge by looking at a solution that is tailored to your building or site's needs. Voltage optimisation should be seen as an engineering solution that is properly researched and assessed. This means that it is not simply good enough to look at the incoming voltage and the energy consumption and simply work out a payback from that.

**one size does not fit all:** virtually all sites can benefit from reducing and controlling their voltage, regardless of building type, size or location. Voltage optimisation technology has been successfully integrated into a diverse range of projects, including hospitals, educational facilities, commercial buildings, local council sites, hotels and the retail sector. To ensure optimum savings and performance, a comprehensive analysis of a building or site's power conditions should be completed before installation. As each site is different, with its own unique infrastructure and specific load requirements, a voltage optimisation strategy should be customised to ensure that savings are maximised.

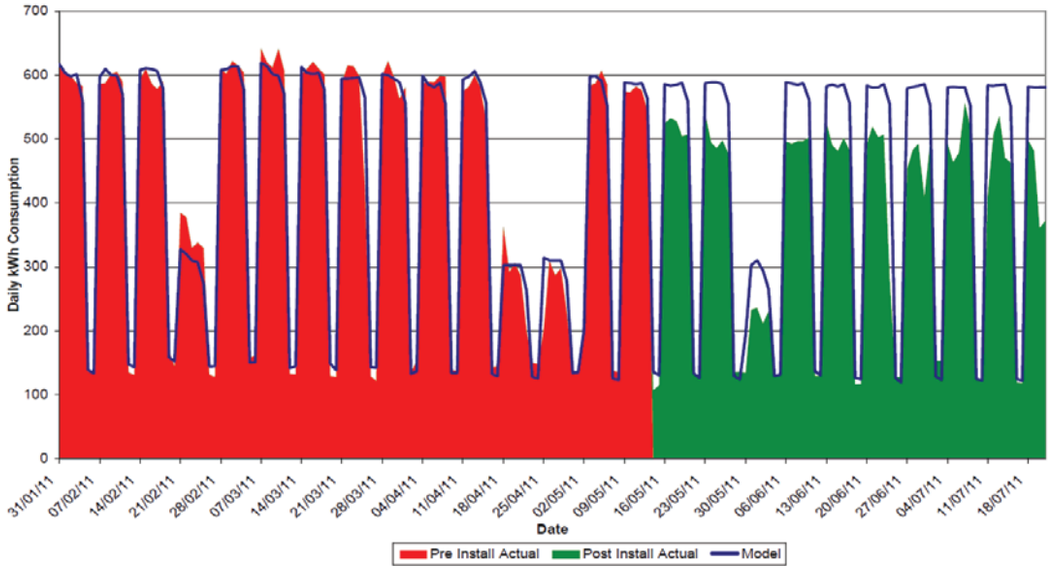
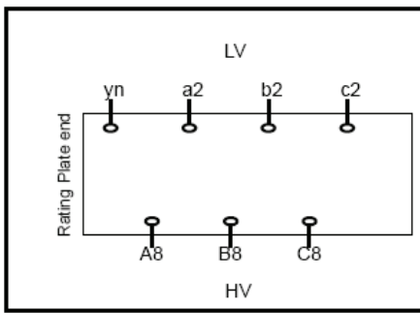



**Figure 3: Overview of Voltage Optimisation before and After Installation**

**do not settle for sub-standard substitutes:** installing the right type of voltage optimisation system is essential to ensure that electrical equipment never receives more or less than the required minimum voltage for correct operation – important during power dips and surges. Installing voltage optimisation systems should ensure that equipment will operate as efficiently as possible at all times, that the lifetime of equipment will be maximised, and that maintenance costs are reduced.

**if the price sounds too good to be true, it probably is:** while the most important aspect of sustainability should be the impact on the environment, 'business is business' and bottom line considerations often also have to be taken into account. However, many companies make promises of savings that they can't keep, and payback claims that they can't substantiate. Mainly this is because the figures are based on a quick calculation of the energy consumption and the incoming voltage. As conditions and loads differ from site to site, the size of the benefit will vary, with savings being determined by the type of system used and site specifications. A properly sized and designed voltage optimisation system will deliver a payback period after installation typically ranging between 0.8 and 2.5 years.




| HV Turn % | Switch position |
|---|---|
| 105 | 1 |
| 102.5 | 2 |
| 100 | 3 |
| 97.5 | 4 |
| 95 | 5 |

**Figure 4: Example of Transformer Tapping's**

**future changes:** it should also be noted that some equipment does not benefit from voltage optimisation as optimisation occurs in the equipment itself, for example, high-frequency lighting or variable speed drives. Therefore, in any assessment it is essential to consider what other energy-saving projects you are planning to undertake or even if a change of use is likely. There are many cases of voltage optimisation being installed on the basis that it will provide on-going savings and then the lighting being upgraded, consequently eroding the voltage optimisation savings.

**tapping down transformer:** in a lot of cases (if the transformer is owned by you and not the supplier), the transformer may have tapping settings that allow you to step down the voltage of the incoming supply at the transformer. Typically, a transformer has two minus tappings and two positive tappings, with each tapping being either 2.5 per cent or 5 per cent each time. Therefore,

if you have a steady load and the voltage in the building is below 230V a transformer may benefit from manually tapping to -2.5 per cent or 5 per cent (depending on the incoming supply voltage you start with). This either negates the need for voltage optimisation or reduces the benefit. However, the voltage optimisation does offer an additional saving on top of this as well as provide a dynamic adjustment to the incoming voltage. The latter may in some circumstances be thought of as safer from interruptions in the supply – once the transformer is tapped down you would need to change the settings if the incoming supply changes. If tapping down is safe and there is confidence to do so, then the payback for the addition of voltage optimisation is not the savings from the incoming voltage, say 242V, to the optimised level, but instead the difference from the tapped down voltage (say -2.5 per cent gives 235V) and the optimised, i.e., 235V to 230V and not 242V to 230V.

## Assessment items

• need to understand what the voltage demand is;
• need to understand what it is like throughout the site and not just at main incomer;
• need to understand margins of safety in the security of supply (not H&S but intermittence);
• not all equipment will provide a saving including some IT, HF lighting, VSD etc.

## Assessment steps

• perform voltage survey at incomer, far point and various points in circuit;• identify electricity hierarchy by voltage and power;• review findings of survey;• review patterns with item usage;• review benefits of low cost tapping down (it may still need an engineer's time to tap down); and• review additional benefits of voltage optimisation (if tapping down is possible).

Figure 5 shows a logging of a building are two points. It shows the voltage characteristics are very different and so this needs to be considered.

In addition to voltage optimisation there are other considerations to review at the time of evaluation:
• condition and age of transformer;
• what is the condition and age of your transformer?; and
• what are the losses? Are they known?

New transformers have lower losses and a better maintained transformer will perform better. If the age of the transformer means it is coming to the end of it useful life, there may be an opportunity to have a new transformer with voltage optimisation integrated.

Other power quality issues include:
• are there harmonic issues?; and
• is there an opportunity with power factor correction.

In both these circumstances there will be an opportunity to remedy these issues and voltage optimisation at the same time, but only with some manufacturers. The opportunity would allow you to look at the following items and receive a payback for the installation from the voltage savings:Targeting of equipment use:
• out-of-hours use;
• baseload reduction;
• technical limits

## Understanding energy

Energy management techniques should not be overlooked. Savings from understanding energy use will still offer low to no cost opportunities.

Voltage optimisation may need revising, with changes to the use and equipment. So with this known, it would be prudent to review the future benefits and if there are any long term disadvantages. It is worth repeating that not all equipment will provide a saving so be wary of big claims from manufacturers.

In addition to possibly negating savings with other items, such as installing high frequency lighting, each item of equipment installed needs to be assessed and not just provide a focus on a percentage saving from total energy consumption.

Many voltage optimisation providers will carry out the survey and/or provide the equipment to carry out a voltage survey yourself – take advantage of this to ensure that your project is assessed properly. Ultimately, voltage optimisation is one of the simplest and most cost-effective ways to reduce carbon emissions while realising significant savings on energy consumption – but only if it is suitable to your building/site.

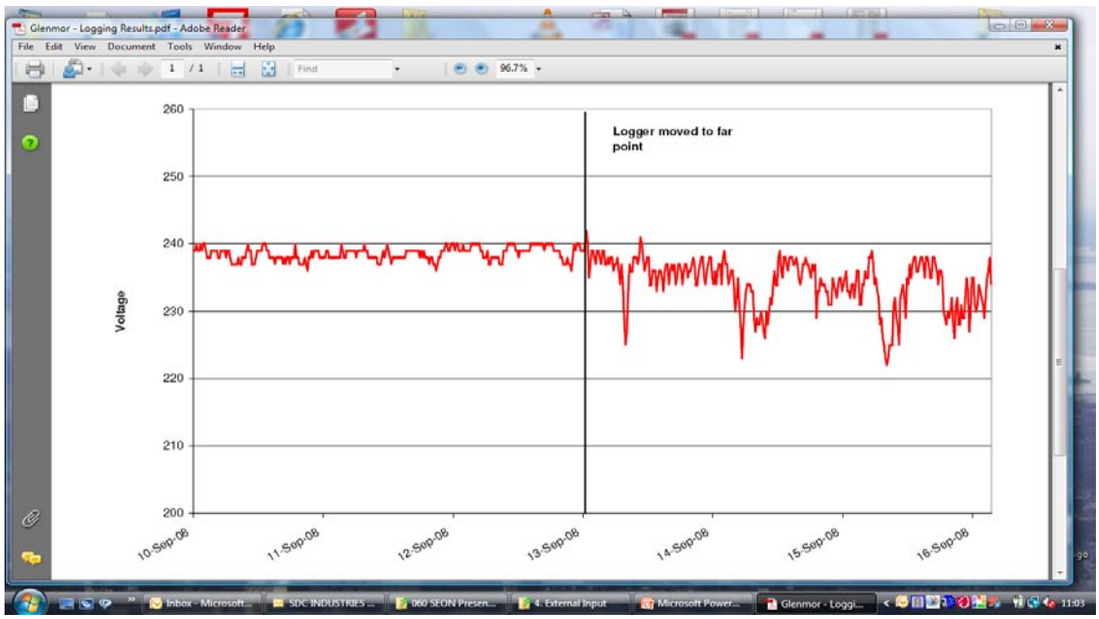



**Figure 5: Example of Voltage Logging in a Building**

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**MARK THROWER, MANAGING EDITOR**

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Completed answers should be mailed to:

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## SERIES 11 MODULE 4: QUESTIONS

## VOLTAGE OPTIMISATION

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

**1. What was the year of the first harmonisation of the voltage in Europe?**
☐ 1993 ☐ 1995 ☐ 1997 ☐ 1999

**2. What is the average voltage in the UK?**
☐ 250V ☐ 242V ☐ 230V ☐ 220V

**3. Some voltage optimisation equipment can also:**
☐ improve power factor? ☐ improve harmonic distortion?
☐ improve voltage and energy use? ☐ all of the above?

**4. When assessing voltage optimisation what things do you not need to consider?**
☐ incoming supply voltage;
☐ future planning of equipment;
☐ whether tapping down the transformer is possible;
☐ the maximum demand during the day

**5. What equipment items show little benefit from voltage optimisation?**
☐ high frequency lighting and variable speed drives
☐ motors and drives
☐ desktop computer and high frequency lighting
☐ variable speed drives and desktop computers

**6. The voltage remains the same throughout the circuits in a building?**
☐ true ☐ false

**7. What will voltage optimisation achieve, if used in the correct situation?**
☐ reduction in energy consumption
☐ improve the transformer performance
☐ improve energy monitoring ability
☐ highlight vacant energy use

**8. When calculating the payback period for voltage optimisation, it should be calculated from**
☐ savings from the incoming voltage to the optimised voltage;
☐ savings from the tapped down voltage to the optimised voltage;
☐ savings from 8 per cent of the annual energy consumption
☐ none of the above

**9. Most equipment in the UK is designed to operate at what voltage?**
☐ 240V ☐ 230V ☐ 220V ☐ 110V

**10. Power is a function of**
☐ voltage and current ☐ voltage and watts
☐ kilowatts and current ☐ voltage and kilowatts