Voltage Power Optimisation (VPO)®

CASE STUDY

Keble College

Installed: December 2010
Report: April 2011

"With a pay-back of less than four years, the decision to invest in a powerPerfector unit was an easy one to make on financial grounds, and the prospect of higher electricity costs and carbon taxes in the future only strengthened the case. The college is equally committed to a responsible approach to carbon emissions. The combination of financial and environmental benefits looked on paper, to be overwhelming. The reality has turned out to be as good as predicted."

Roger Boden
Bursar

Keble College

power Perfector
energy saving like no other

About - Keble College

Keble College is one of the largest of the constituent colleges of the University of Oxford with 410 undergraduate and 235 graduate students. It was the wish of the founders in 1870 to extend access to the University more widely, and the College has a continuing commitment to inclusiveness. The College prides itself on the academic achievements of its students, and aims to offer a supportive environment in which learning can flourish. Keble is a vibrant community whose students excel not only academically, but also in music, drama, and sport.

How powerPerfector were able to help - Keble College

After Keble College sent its annual electricity consumption details, it was possible to give a provisional quote for a powerPerfector unit and the energy savings that would be expected. A voltage logger was then sent for one week, which recorded the voltage level in the building by connecting it into a regular mains socket. It was found that the average voltage at the site was 245 volts (V), 15V higher than the nominal supply in the UK. After a survey of the site by a powerPerfector Approved Contractor, the installation took place. There was no noticeable change to the operation of the building, although continuous carbon savings were instantly being made every day at the site. 3 months after the installation the electricity consumption was analysed to find a reduction of **8.5%**, equating to annual carbon dioxide emissions saving of **65.7 tonnes**.

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Getting the source right

powerPerfector is the world's only Voltage Power Optimiser, giving energy, carbon and cost savings by efficiently optimising a site's supply voltage. By optimising the voltage, electrical equipment runs more efficiently and consumes less energy. The declared electricity supply in the United Kingdom is now, as a result of European Harmonisation, 230V with a tolerance of +10% to -10%. This means that effective voltage can be anywhere between 207V and 253V depending on local conditions. Most electrical equipment manufactured for Europe and the UK is rated at 220V and operates more efficiently at this level. Forcing appliances to operate at a higher voltage in the UK (242V is the average supply level) leads to significantly higher energy consumption, increased heat losses and a reduced life span. Optimising voltage with powerPerfector brings your supply voltage to the "higher efficiency" operating range of your equipment. Without this, the 'raw' supply voltage to your site is likely to be at the top end of the range of voltages your electrical equipment can tolerate. As well as reducing energy consumption, this reduces the strain on your equipment, extending its lifespan according to many of our clients. It is estimated that 90% of sites in the UK are operating at too high a voltage and could therefore benefit from installing a powerPerfector.

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Savings Summary for – Keble College:

- Reduction in average kWh consumption: **8.5 %**
- Projected annual carbon dioxide emissions savings: **65.7 tonnes**
- Projected annual financial savings: **£7,900**

A 420kVA powerPerfector unit with a 10 **%** optimisation setting was installed at, Keble College on 29th December 2010. A three month post-installation analysis was conducted. The analysis shows that the electricity consumption at Keble College has been **8.5%** lower than the expected levels for the time of year. This equates to a projected annual carbon dioxide emissions saving of at least **65.7 tonnes** and an annual financial saving of at least **£7,900**. The method of analysis is detailed below.

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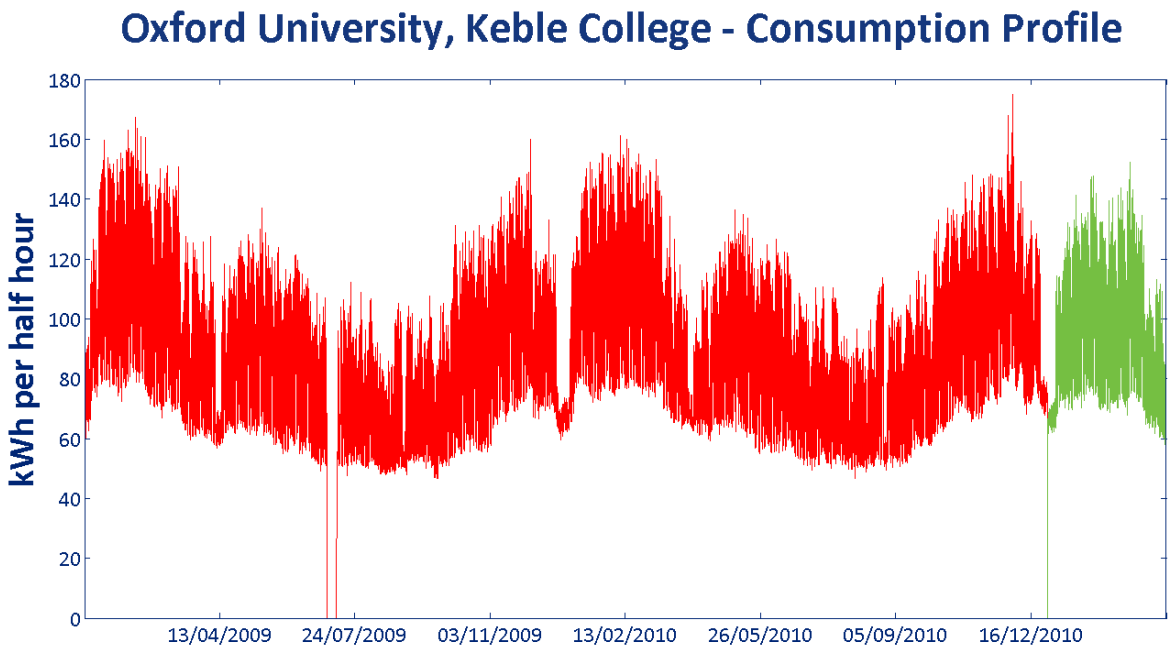
Analysis

Consumption Profile

The chart below shows all available kWh data for Keble College, from 1st January 2009 to 29th March 2011. Data before installation is shown in red and after installation in green.



The consumption profile above is typical of colleges and universities: consumption is heavily influenced by term and holiday dates. Consumption is immediately reduced following installation, with an apparent reduction in maximum demand and baseload.

Peaks in consumption are observed in winter months, suggesting that this site's consumption pattern is affected by seasonal variation in external temperature. However, the correlation between consumption and external temperatures is relatively poor (R^2 of 0.3). Consequently it is not possible to accurately model and predict consumption using a Degree Days analysis (further details of this analysis available on request). Instead a 'year-on-year' analysis will be used to determine the reduction in energy use at this site.

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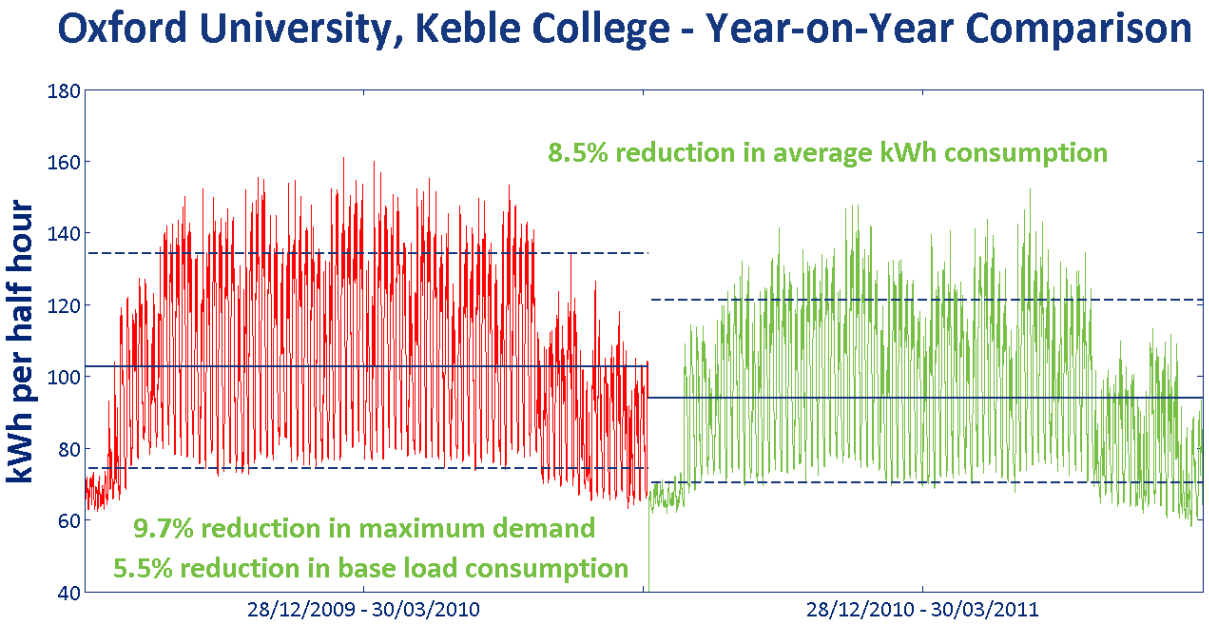
Savings Analysis

Because consumption varies according to the seasons, it is necessary to ensure that the post-installation data is compared with a period of time where both external and on-site conditions were similar. This is the purpose of a year-on-year analysis: it compares consumption for all of the post-installation-data with consumption for the same period in the previous year. The result is charted below, and shows a reduction of 8.5%.



The chart overleaf is a “pre-installation” year-on-year comparison: by looking at consumption for the two months immediately before installation and comparing it to the same period in the previous year, we are able to establish the trend that consumption was following prior to the powerPerfector installation. The chart below shows that prior to the powerPerfector installation consumption was increased by 7.3% in comparison with consumption the year before.

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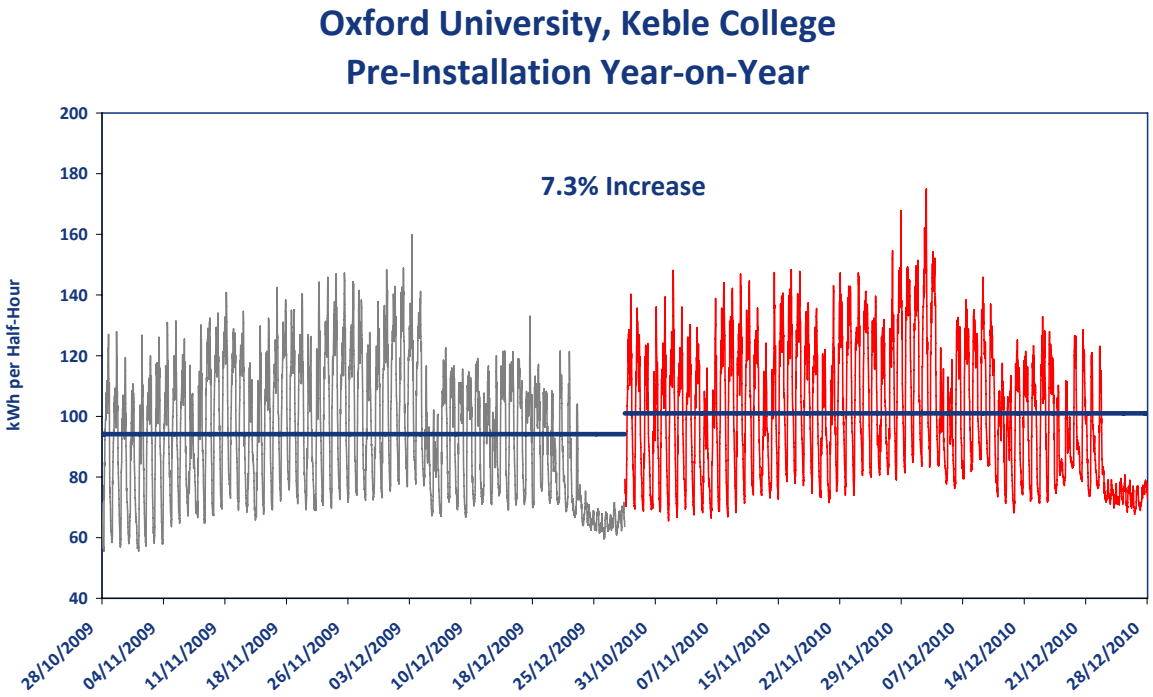

Assuming that this increasing trend was to be prolonged after the installation date, the powerPerfector has not only offset this increasing trend, but it also achieved a further 8.5% reduction. Overall, the full year-on-year analysis therefore shows a reduction in consumption following the powerPerfector installation in the region of 15-16%. However, in order for the conclusions of this analysis to be conservative, the increasing trend will not be taken into account in this analysis.

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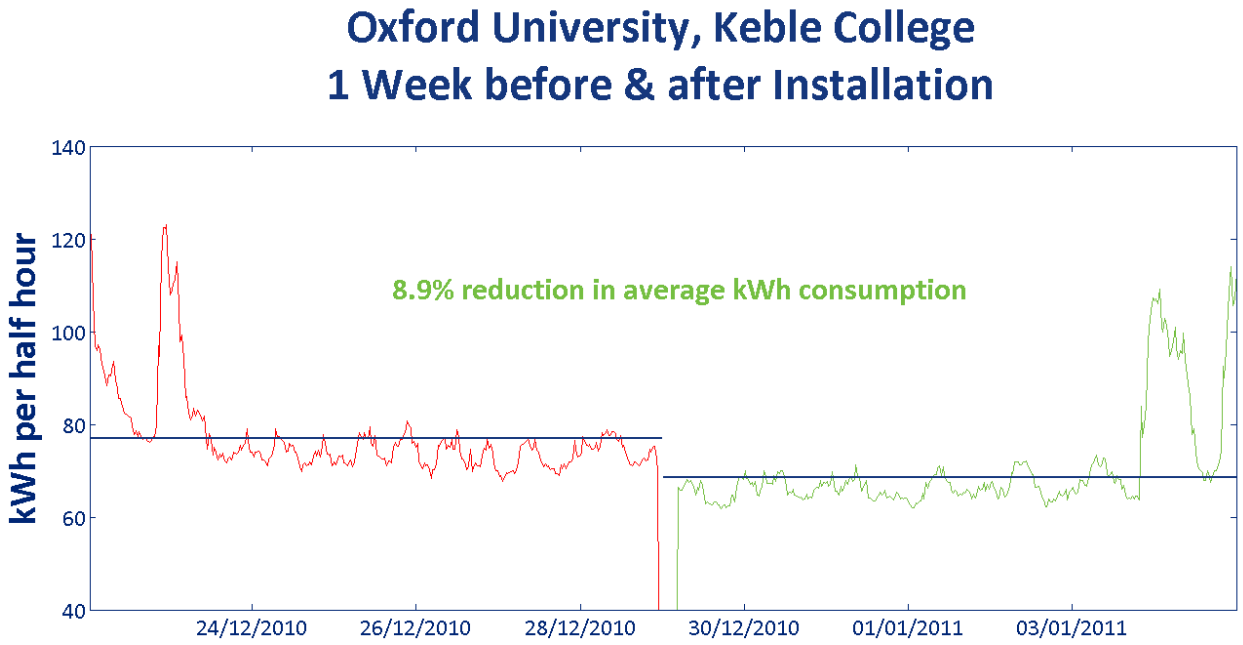
For illustrative purposes, the immediate effect of the powerPerfector installation (consumption in the week before and after installation) is displayed in the chart below. It shows a reduction in energy consumption of 8.9%. This figure supports the level of savings calculated using the year-on-year analysis.



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Conclusions

In conclusion, using three months of post-installation kWh data, the electricity consumption at Keble College, has been at least **8.5%**lower than the expected levels for the time of the year since the installation of the powerPerfector. This equates to a projected annual carbon dioxide emissions saving of at least **65.7 tonnes** and an annual financial saving of at least **£7,900**.

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Voltage Power Optimisation Additional Benefits

The ability of VPO® technology to reduce energy (kWh) consumption on a site is well documented, but the technology also provides a range of other benefits. These all contribute to creating a more efficient, robust and reliable electrical supply for your site, and provide further financial benefits on top of the reduced energy costs.

Reduced maintenance burden

- Optimising voltage with powerPerfector brings your supply voltage to the "higher efficiency" operating range of your equipment. Without this, the 'raw' supply voltage to your site is likely to be at the top end of the range of voltages your electrical equipment can tolerate. As well as reducing energy consumption, this reduces the **strain** on your equipment, and many of our clients tell us that this increases its lifespan.

- For example, a lightly-loaded **induction motor** operating at an optimum 380V instead of a 'raw' 415V experiences less heating and vibration, reducing wear on bearings and prolonging its life.

- The life of **incandescent light bulbs** is almost doubled by optimising their supply voltage.

- Most equipment benefits from the lower **'pressure'** when voltages are optimised. Other examples include Variable Speed Drives – which are particularly sensitive to over-voltage – and the capacitor banks in Power Factor Correction systems.

- When these effects are **aggregated**, the benefit to your site of extended equipment lifetimes and reduced replacement costs will be substantial. The exact saving is difficult for powerPerfector to quantify, but we estimate it to give you a 10%+ reduction of your maintenance and capital replacement costs.

Improved power factor

- Optimising supply voltages reduces the **reactance** of electrical equipment, as it prevents over-excitation of magnetic components. The effect of this is to reduce the level of wasteful **reactive power** in the electrical system. Reducing reactive power improves **power factor**, and the powerPerfector typically improves power factor by 3-10%.

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- The **maximum demand** of a site is expressed in kVA (incorporating both real and reactive power). So reducing reactive power reduces the maximum demand of a site, which will lead to reduced kVA demand charges, Agreed Service Capacity (ASC), and increase spare capacity for further growth. (8% optimisation = 6%-10% reduction in MD normally)

- Power factor **penalty charges** – which are now uncapped in the UK – can be avoided if your power factor is above 0.95. These may appear on your bill as 'reactive power charge', 'kVAr charge', 'use of system charge' or 'availability charge'. If your power factor is at around 0.9 at the moment, the powerPerfector could remove your exposure to these charges.

- In general, the strain on your electrical infrastructure is reduced if power factor is good. If your system is carrying a high proportion of reactive power, impedances and voltage-drop will be excessive, and overall **efficiency** will be low. The powerPerfector improves the electrical efficiency of your site.

- The powerPerfector yields many of the same benefits as **Power Factor Correction**, but does not use capacitors, which can be prone to failure. Instead, it helps correct the underlying cause of poor power factor, while saving energy.

Lower harmonic distortion

- The powerPerfector is able to **filter harmonics** on the mains incomer. Harmonic distortion is on the increase, leading to apparently random failures of electronic equipment.

- As the site is protected from mains-borne harmonics, disruptions to the operation of sensitive **electronic equipment** that could otherwise result from intolerance to harmonic distortion are minimised.

- By preventing harmonics from entering the secondary side of the **HV supply transformer**, the powerPerfector is able to improve the transformer's efficiency and increase its effective capacity. Customers whose utility meter is on the HV side of their transformer will see higher savings as a result.

- The threat from damaging **resonance** effects is reduced as harmonic distortion is lower, as is the risk of failure of Power Factor Correction capacitors.

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- The **efficiency** of any equipment containing magnetic components is improved – contributing to energy savings – as the heating effect of harmonics is reduced. This in turn extends operating life by postponing the breakdown of insulating materials.

Reduced neutral currents

- As well as providing general harmonic filtration, the powerPerfector helps to reduce the level of **triplen harmonics** on a site, by balancing the three phase voltages.

- In addition to the benefits listed above, this leads to reduced **neutral currents** and temperatures – even though the neutral cable does not pass through the powerPerfector – as triplen harmonics accumulate on the neutral. Lower neutral currents are always desirable, and with an increasing proportion of non-linear loads generating more harmonics than ever before, undersized neutrals are a potential risk on many sites.

Improved phase voltage balance

- The operation of **three-phase equipment** – particularly induction motors – is much more efficient if the phase voltages are closely balanced. For large industrial sites that are heavily dependent upon such loads, balancing phase voltages at an optimum level with powerPerfector can yield energy savings of over 20% in motors.

Protection

- A powerPerfector makes an electrical supply more robust, and your site better protected. **Transients** – which are very brief surges in voltage from the grid – are eliminated by the powerPerfector, provided they are less than 25,000V.

- This level of protection is able to prevent transients from causing catastrophic damage to equipment, but it also prevents smaller, more common transient events that act to degrade equipment over time. This prolongs the expected life of electronic equipment.

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