

Voltage Power Optimisation (VPO)[®]

CASE STUDY Theatre by the Lake

Installed: January 2011

Report: August 2011



“Fortunate to be located in the heart of the Lake District, Theatre by the Lake takes its environmental responsibilities very seriously. We are proud to be able to demonstrate savings in electricity consumption following installation of our powerPerfactor Voltage Power Optimisation unit. By improving the electrical efficiency of our building it is satisfying to know that not only are we reducing costs, we are also preserving the life of the expensive and sensitive equipment required for our theatrical productions. The financial savings we are now seeing and those we will continue to make into the future can now be redistributed to other areas, including the work we carry out as a charity.

With regards to the guidance, expertise and service provided by powerPerfactor and their installation contractors, we could not be happier. Every step of the process was delivered as promised, on time, on budget per quotation and with minimal disruption. The early Sunday morning install meant that our box office didn't need to close to customers, and we were of course up and running again in time for our next show.

We were also delighted to be able to see instantaneous results. Immediately following installation, the high voltage indicator light on the UPS linked to our servers went out for the first time in its history, causing great excitement in our I.T. department!”

Paul Roberts,
Building Services Manager, Theatre by the Lake





About Theatre by the Lake

Theatre by the Lake is the only new English Regional Producing Theatre to have been built with National Lottery funding. It opened in August 1999, since when it has produced and presented over 5,000 performances. Theatre by the Lake is a year-round professional producing and presenting theatre which provides a service through the performing arts to communities of, and visitors to, Cumbria. The building houses a 400-seat Main House, a newly-extended 100-seat Studio, a coffee shop and bars, two gallery spaces, meeting and conference facilities and a rehearsal room.

How powerPerfector were able to help Theatre by the Lake

After the Theatre by the Lake 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 to it in to a regular mains socket. It was found that the average voltage at the site was 253 volts (V), 23V 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. 6 months after the installation the electricity consumption was analysed to find a reduction of **10.2%**, equating to annual carbon dioxide emissions saving of **22,400 kg**.

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.

Savings Summary for the Theatre by the Lake:

- Reduction in average kWh consumption: **10.2 %**
- Projected annual carbon dioxide emissions savings: **22,400 kg**
- Projected annual financial savings: **£4,300**

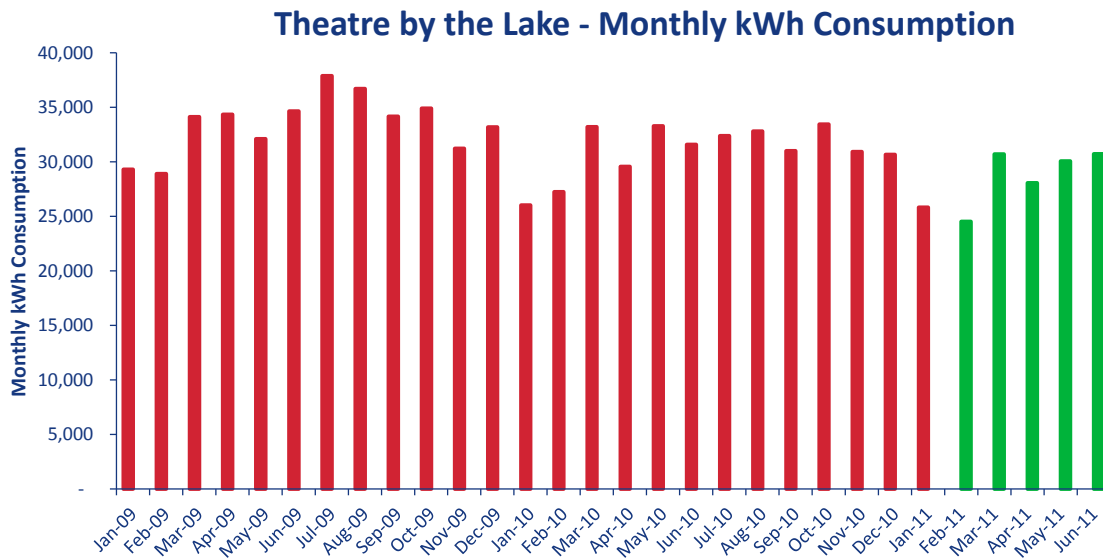
A 210kVA powerPerfector unit with an 11 % optimisation setting was installed at the Theatre by the Lake on 30th January 2011. A six month post-installation analysis was conducted. The analysis shows that the electricity consumption at the Theatre by the Lake has been **10.2%** lower than the expected levels since the installation of the powerPerfector. This equates to a projected annual carbon dioxide emissions saving of approximately **22,400 kg** and an annual financial saving of **£4,300**. The method of analysis is detailed below.



Analysis

Consumption Profile

The chart below shows all available kWh data for the Theatre by the Lake, from 1st January 2009 to 30th June 2011. Data before installation is shown in red and after installation in green.



The consumption profile above shows that energy consumption at the site varies seasonally. Energy consumption is higher in the warmer summer months indicating that there is a relationship between electricity consumption and external temperature.

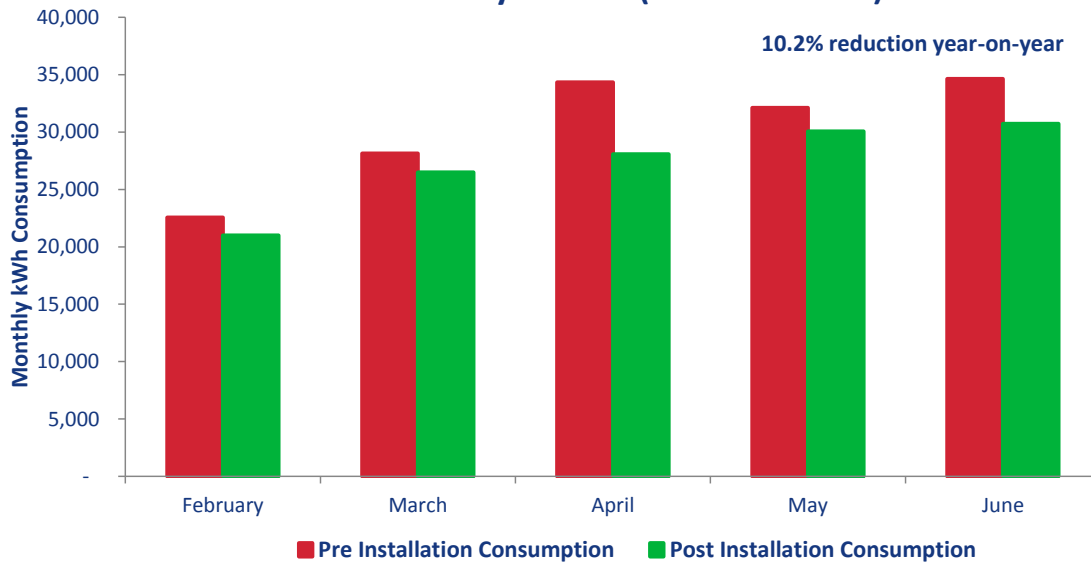
However correlation between external temperature and actual energy consumption at the site is poor with an R^2 value of 0.46, therefore 'Degree Days' analysis is not a reliable method of modelling predicted energy consumption, (further details of this analysis available on request). Consequently a year-on-year analysis will be used in the following section to determine the magnitude of the energy reduction at the site.

Savings Analysis

A year-on-year analysis compares consumption for the post-installation period with consumption for the same period in the previous year. The purpose is to compare consumption during times of comparable building usage and external temperatures. Therefore it is important when carrying out year-on-year comparisons that two periods are chosen that are representative of the typical energy use on the site.

The time periods used in the year-on-year analysis are February to June 2010 and February to June 2011.

Theatre by the Lake - Year-on-Year Comparison February to June (2010 and 2011)



The result is charted above, and shows a reduction of 10.2%.

The comparison assumes that the pre and post installation operating conditions at the site remain the same.

Conclusions

In conclusion, the electricity consumption at the Theatre by the Lake has been **10.2%** lower than the expected levels since the installation of the powerPerfector. This level of kWh reduction equates to a projected annual carbon dioxide emissions saving of approximately **22,400 kg** and an annual financial saving of **£4,300**.

The powerPerfector is also ensuring that the site operates at a higher level of efficiency, as well as benefiting from improved power quality and protection from transients of up to 25,000V. Further details about the benefits of Voltage Power Optimisation are appended to this report.

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%.
- 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.
- 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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