

Voltage Power Optimisation (VPO)[®]

CASE STUDY

NORFOLK & WAVENEY NHS MENTAL HEALTH TRUST Julian Hospital

Installed: June 2009

Report: September 2009



"The first assessments show that we have at least met, or even slightly improved on the initial energy saving predictions, leading us to look at further installations in some of the Trusts other properties... Together with other initiatives the installations are helping the Trust move towards meeting the new Carbon Reduction Commitment."

Robert Forster, Estates Manager for the Trust

About Norfolk & Waveney NHS Mental Health Trust and Julian Hospital

The Trust was established in 1994 and is dedicated to the care and recovery of anyone experiencing mental ill health or substance misuse. It provides a range of specialist mental health services to nearly 800,000 people from all age ranges across Norfolk and north Suffolk. It works in partnership with other statutory and non-statutory bodies that provide services to people suffering mental ill health, and as a partnership Trust it also provides integrated health and social care services. Julian Hospital is located in Norwich, Norfolk. It assesses and cares for older people with mental health problems such as dementia and depression through occupational therapy.

How powerPerfector were able to help Norfolk & Waveney NHS Mental Health Trust

After receiving the annual electricity consumption details for Julian Hospital, it was possible to give a provisional quote for a powerPerfector unit and to outline the potential for energy savings. A voltage logger was then sent for one week, which recorded the voltage level in the building by connecting it to 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 on a Thursday. Analysis following the installation showed that there was an average reduction in kWh consumption of **16.8%** attributable to the powerPerfector installation, equating to annual carbon dioxide emissions saving of **102,300 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 Julian Hospital:

- Reduction in average kWh consumption: **16.8%**
- Projected annual carbon dioxide emissions savings: **102,300kg**
- Projected annual financial savings: **£15,600**

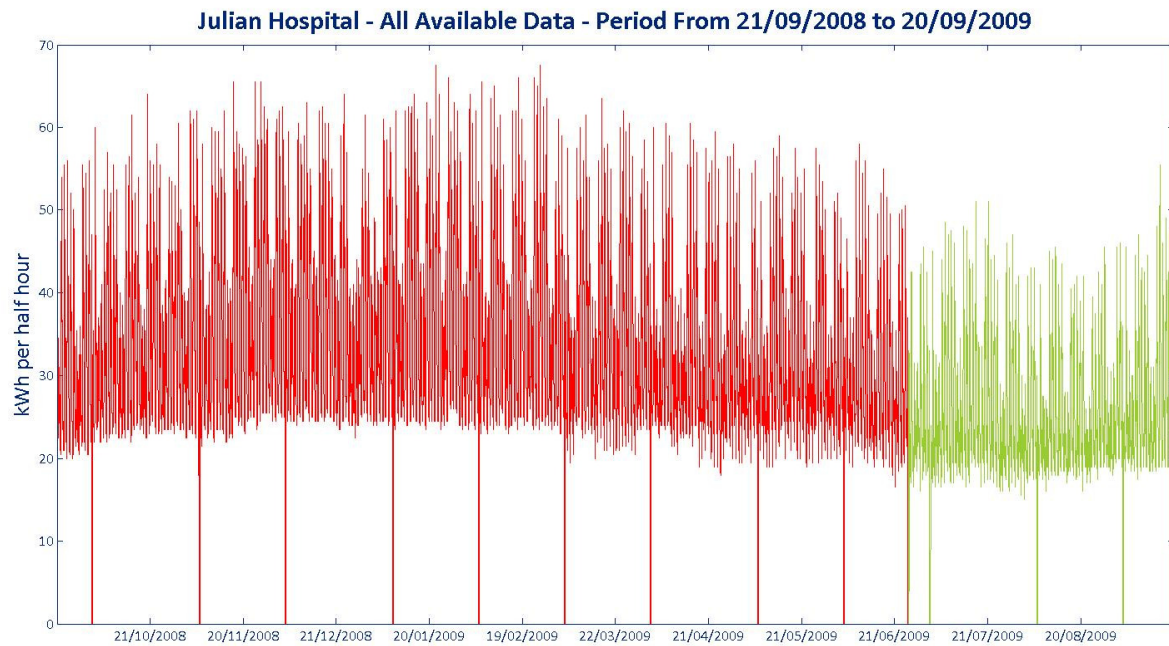
A 350kVA powerPerfector unit with a 9% voltage optimisation setting was installed at Julian Hospital on 25th June 2009. The following report is an analysis of the half-hourly data for the site up to 20th September 2009. It concludes that there is an average reduction in kWh consumption of **16.8 %** compared to expected levels. This equates to an annual carbon dioxide saving of **102,300 kg** and an annual financial savings of **£15,600**.



The method of analysis is outlined in the report.

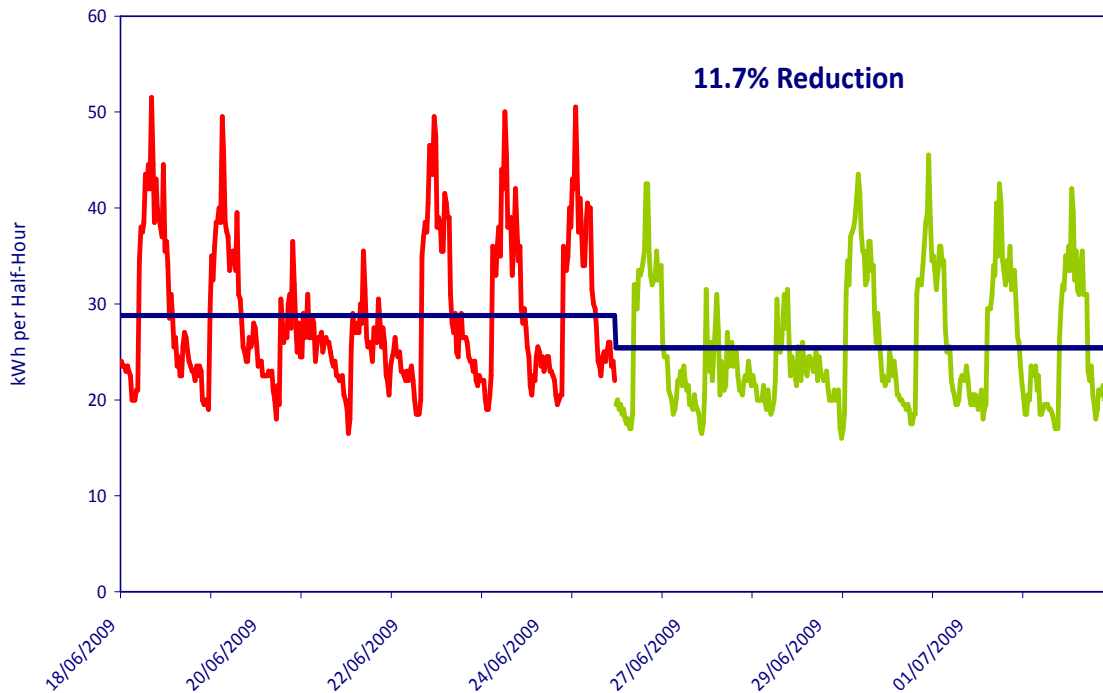
Analysis of all the available data from 21st September 2008 to 20th September 2009 (below) shows that the average level of consumption has been reduced since the powerPerfector was installed, but it is also clear that the energy consumption at the site is following seasonal variations and is lower in the summer months. Therefore some of

the reduction in energy consumption could be attributable to the time of year the powerPerfector was installed. Shutdowns also happen on a regular basis at the site, but it does not seem to affect the load or the consumption.



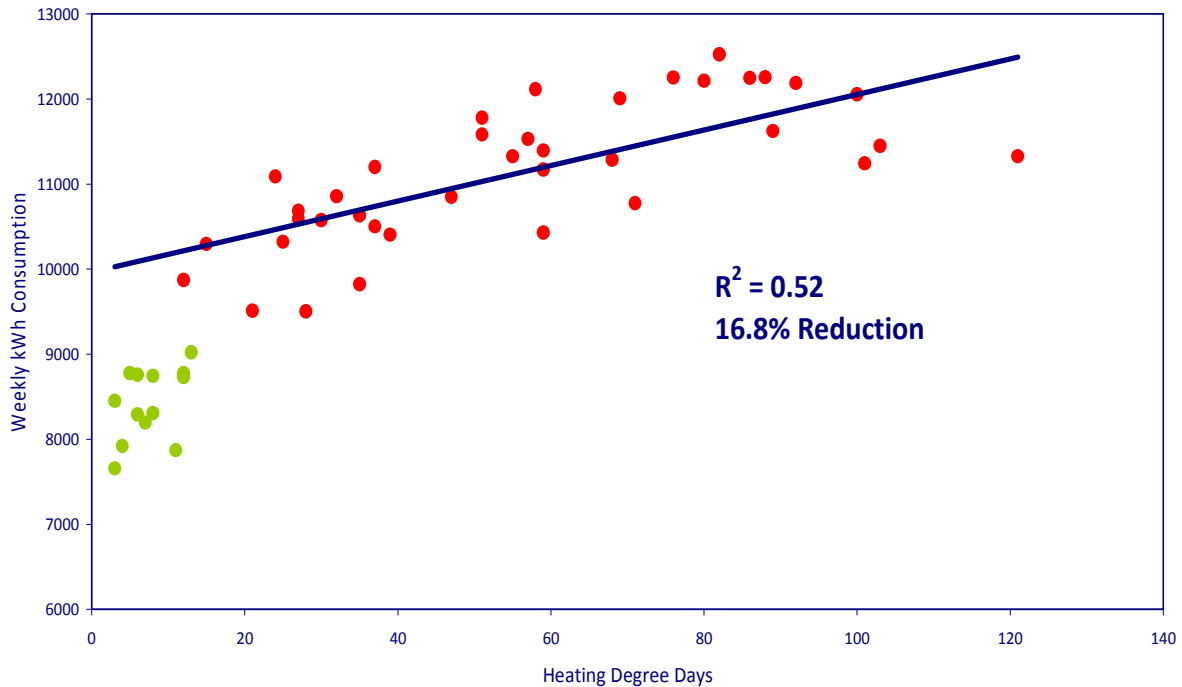
Since only about a year of data is available, no year-on-year analysis can be performed. Instead, we will try to see what instant impact the powerPerfector had on the site's consumption by plotting a chart displaying consumption for a week before and after installation. This method of analysis shows savings of **11.7%**, as seen below, confirming that the powerPerfector is functioning as it should be.

Julian Hospital - 1 Week before and after Installation



Although this type of analysis gives a clear idea of the immediate benefits of the powerPerfect for Julian Hospital, it doesn't take into account possible variations of temperature. The savings figure mentioned above cannot therefore be used to assess accurately the savings for this site, as we saw above in the "all data" chart that the Hospital's consumption was following a seasonal trend. Those variations can have an influence on consumption and therefore increase or decrease the value of the savings figure. The best way to assess this is to perform a Degree Days Analysis. Degree Days are calculated from Met Office temperature data for regions in the UK and represent the difference in external temperature and a baseline temperature for a given period of time. Since the consumption seems to be higher in winter months, heating degree days, with a base temperature of 15.5°C, have been used to produce the analysis below.

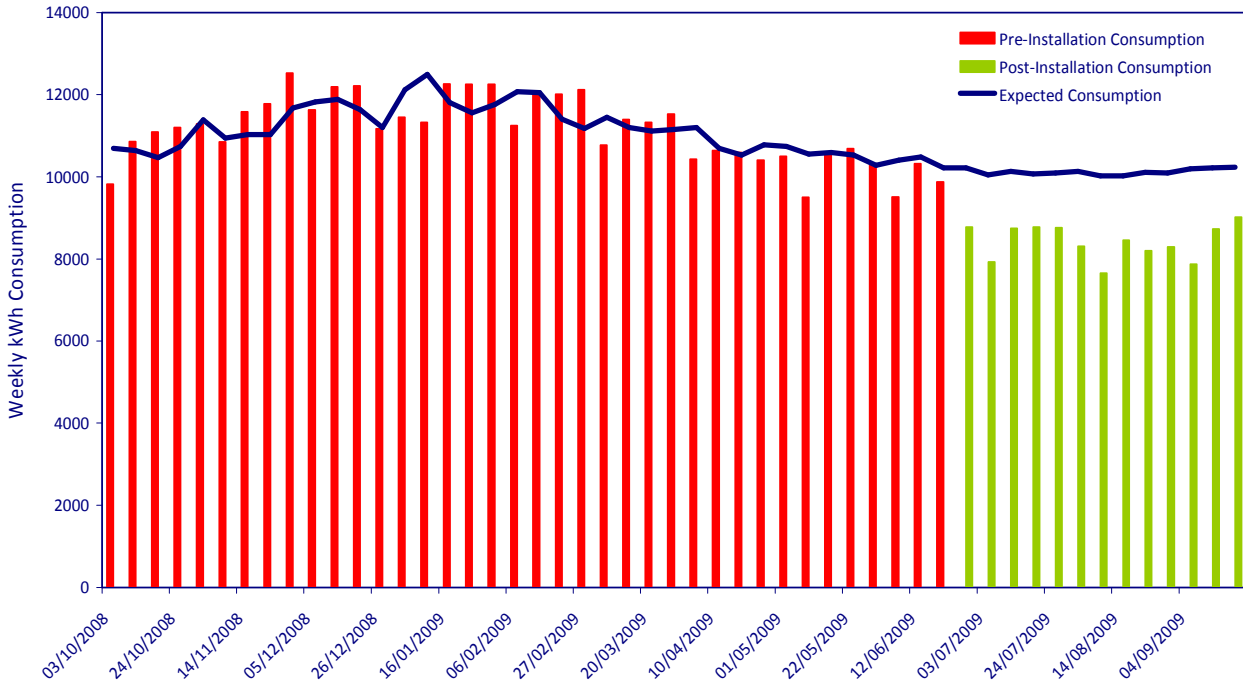
Degree Days Analysis



The R^2 value of 0.52 confirms that the correlation between external temperature and energy consumption is good (0 showing no correlation and 1 a perfect correlation). The green dots in the above graph represent the weekly consumption after installation of the powerPerfector plotted against the weekly degree days, and the red dots represent the data from before installation. The blue line is the regression line of the pre installation consumption data. The chart shows that, having taken into account the external temperature, the energy consumption at the site has been, on average, **16.8%** lower than would have been predicted had the powerPerfector not been installed. This analysis will need to be replicated once more data has been acquired, in order to be able to compare the green dots above with red dots for the same period (i.e. from June to September), and therefore to ensure the full accuracy of the savings figure.

The findings from the Degree Days analysis are confirmed when the expected against the actual consumption is plotted. The consumption is displayed in red columns before installation, and in green columns after. The blue line shows the expected consumption trend calculated with the external temperatures. It is clear from this chart that the post installation data is lower than expected for the post-installation period.

Actual Vs Expected Consumption



In conclusion, the One Week Pre and Post analysis and the Actual against Expected Consumption chart support the **16.8%** savings figure from the Degree Days analysis, confirming that this is an accurate measure of savings. This equates to a projected annual carbon dioxide emissions saving of approximately **102,300 kg** and an annual financial saving of **£15,600**. A final analysis will need to be conducted once more data has been acquired to ensure the full accuracy of the savings.

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 powerPerfactor 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 powerPerfactor improves the electrical efficiency of your site.
- The powerPerfactor 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 powerPerfactor 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 powerPerfactor 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 powerPerfactor 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.

