

## Voltage Power Optimisation (VPO)<sup>®</sup>

### CASE STUDY

#### HM Prison Service Cardiff Prison

Installed: 31st August 2006  
Report: 20th October 2006



*"We are delighted that the predicted savings of 13% were exceeded (to 16%) giving annual savings in excess of £15,000 and reducing carbon emissions by over 125,000kg. Given the importance of security of supply at this critical site, we can report that the installation was professionally conducted and the working of the site has been perfect. In light of the success of the powerPerfactor we are looking to install units in our other sites around the region. For us powerPerfactor has been the single most effective energy efficiency measure we have introduced."*

**HM Prisons - Christopher Silcox of the Estates Management Group**



### **About Cardiff Prison**

HMP Cardiff is a category B Local/Training Prison, holding male adult prisoners who are drawn predominantly from the surrounding court catchment area in South East Wales.

The 3 Victorian wings have undergone a major refurbishment programme. The prison's capacity was extended in 1996 by the commissioning of 3 new wings and the number of life-sentenced prisoners has increased to 96.

### **powerPerfector unit details**

A pP560kVA/600A unit was installed on 31st August 2006 with a –8% Optimisation setting. Through installation the following results were achieved:

- **16.6% reduction in average consumption**
- **158 tonnes CO2 per year**
- **£17,897 average savings per year**

### **Electrical load**

The prison electrical load includes lighting circuits, heating and ventilation systems, as well as switch mode power supply devices. Of obvious importance are the electronically controlled security systems installed at the site.

## FULL REPORT

### Contents

- **Introduction**
- **Overview**
- **The Savings Report**
  - Savings summary
  - Overall savings
  - Conclusions

### Introduction

powerPerfector optimises the voltage and improves the power quality for a whole site more efficiently than any other technology available. Optimising the supply voltage allows equipment to use only the energy it requires to operate efficiently.

For example, providing a motor with its optimum voltage prevents excess heat and vibration, while delivering the required torque and speed. When these effects are aggregated across a whole site, substantial energy savings are delivered. The Maximum Demand of the site is also reduced — typically by as much as 10% — which will help keep the site within its Agreed Service Capacity and may reduce penalty charges.

Installing a powerPerfector improves power quality on a site considerably. The reactance of some electrical equipment is reduced when voltage is optimised, so there is an overall improvement in power factor. Equipment is protected as the powerPerfector eliminates transients up to 25,000V and harmonics are filtered from the mains, while the balancing of phase voltages maximises the efficiency of three-phase equipment. By optimising the power supply at source, the powerPerfector is able to extend the lifetime of all the electrical equipment on a site, substantially reducing maintenance overheads in addition to the energy savings.

### Overview

Following a process of evaluation to confirm the level of optimisation and suitability of the Cardiff site for a powerPerfector unit, (please see the full evaluation report in the Appendix) a pP560kVA / 800A unit was installed on the 31st August 2006.

The site was run from the standby generator during the 8 hours downtime, so there was no interruption to the operation of the site.

Following installation all electrical equipment has operated normally and there have been no reports of any problems. With further observation over time, our clients tell us that equipment life can be noticeably extended.

## THE SAVINGS REPORT

### Savings summary

Average reduction in daily average consumption	<b>16.6%</b>	<b>£49 per day</b> <b>£17,897 per year</b>
Average projected annual carbon savings	<b>158 tonnes</b>	
Effective base load reduction	<b>12.5%</b>	
Reduction in average reactive power	<b>33.7%</b>	

### Overall savings

powerPerfect has undertaken an analysis of half-hourly data from Cardiff Prison in order to assess the savings resulting from the installation of the powerPerfect unit.

Our analysis shows that, as indicated in figure 1, savings of **20.2%** on average daily consumption have been achieved. These savings are due to a number of measures that the works team have introduced over the course of the analysis period. The following analysis shows the savings attributable to the powerPerfect technology.

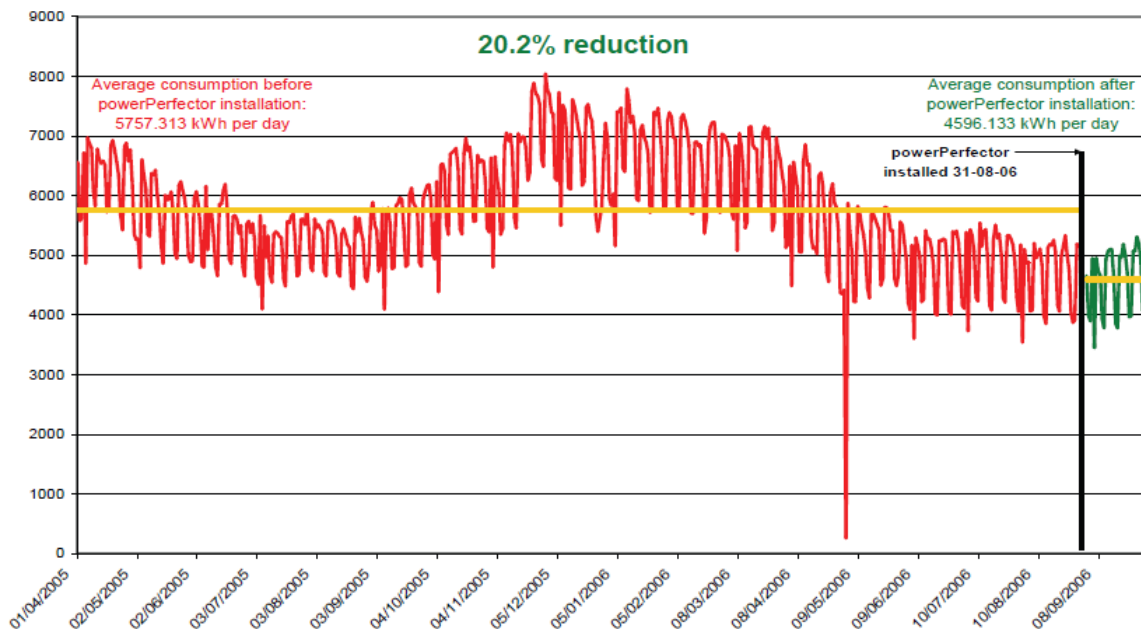


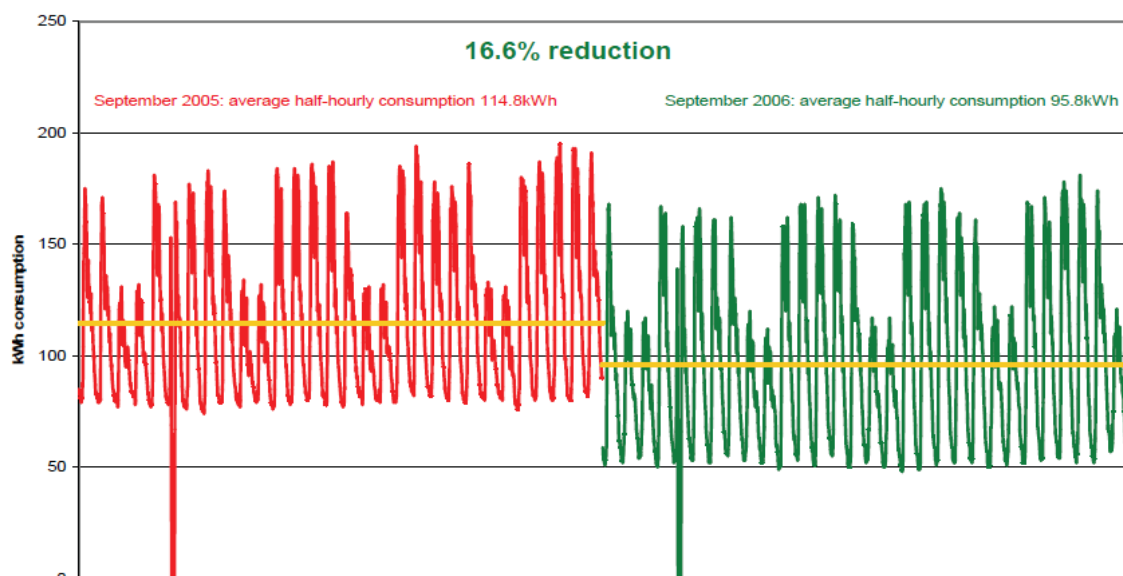
Figure 1—Consumption chart based on all data

**Figure 1** shows a comparison of the average consumption prior to installation of the powerPerfector, and the average consumption during the month following. Clearly, the load changes throughout the year as heating and lighting demands vary, but we see high savings when comparing September 2005 with September 2006, as shown in **figure 2**.

Here we are comparing like-with-like, as we expect load in September 2005 to be very similar to 2006. We have made reference to ‘Degree Day’ data – industry-standard temperature normalisation figures – to ensure that the year-on-year comparison is fair. This indicates very little difference between the required heating loads of September 2005 and 2006 in the South Wales area, confirming the validity of our comparison.

We see that the powerPerfector, in addition to the contribution of other energy-saving measures implemented over the year, has substantially reduced the prison’s electricity consumption. We estimate that carbon emissions of **8.2 tonnes** have been saved this September alone.

#### HMP Cardiff: 1-month year-on-year comparison September 2005 vs September 2006

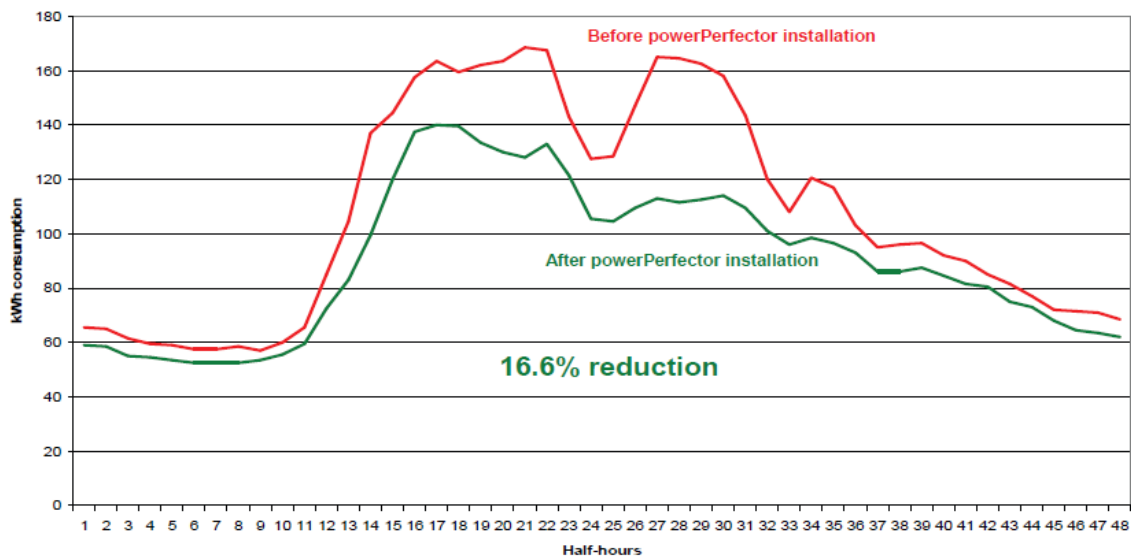


**Figure 2—Half-hourly consumption chart for September 2005 vs 2006**

A closer analysis has been undertaken to determine the savings attributable to the powerPerfector installation. We begin by considering the consumption over a short (two-day)

period immediately before and after installation, shown in **figure 3**. Based on this, the powerPerfector has achieved a **16.6%** saving on consumption, and a **16.9%** reduction in maximum demand. This confirms that the powerPerfector is working as expected, delivering instant savings and improving the site's electrical load capacity by reducing maximum demand.

### HMP Cardiff: 2 days before and after powerPerfector installation



**Figure 3 - kWh consumption over two-day period immediately preceding and following powerPerfector installation**

The powerPerfector optimises voltages across the entire site at all times, so consequently provides considerable savings on the base load. By taking the base load to be the average load between midnight and 3am, shown by the thick line on **figure 4** (overleaf), we see a 7% reduction in base load power consumption from August to September 2006. If we consider, though, that in 2005 power consumption rose 5.5% over the August-September period due to increasing lighting and heating loads, we see that the powerPerfector has neutralised this increase and provided a **further 7%** saving. We therefore have an effective base load consumption reduction of **12.5%**.

### Base load comparison, August 2006 vs September 2006

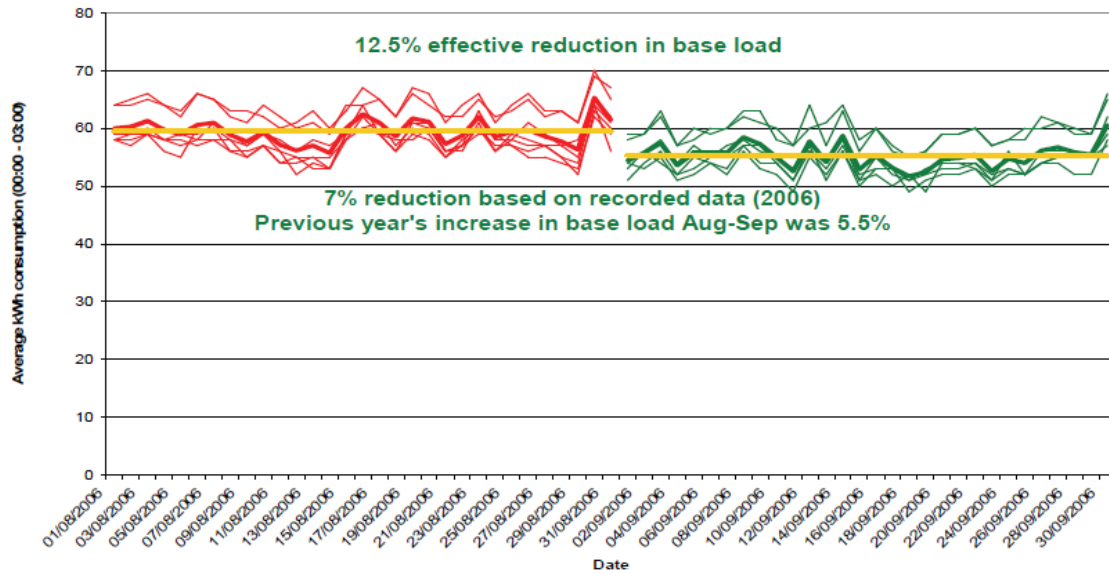


Figure 4—Effect of powerPerfector installation on base load power consumption

### HMP Cardiff: Reactive power August and September 2006

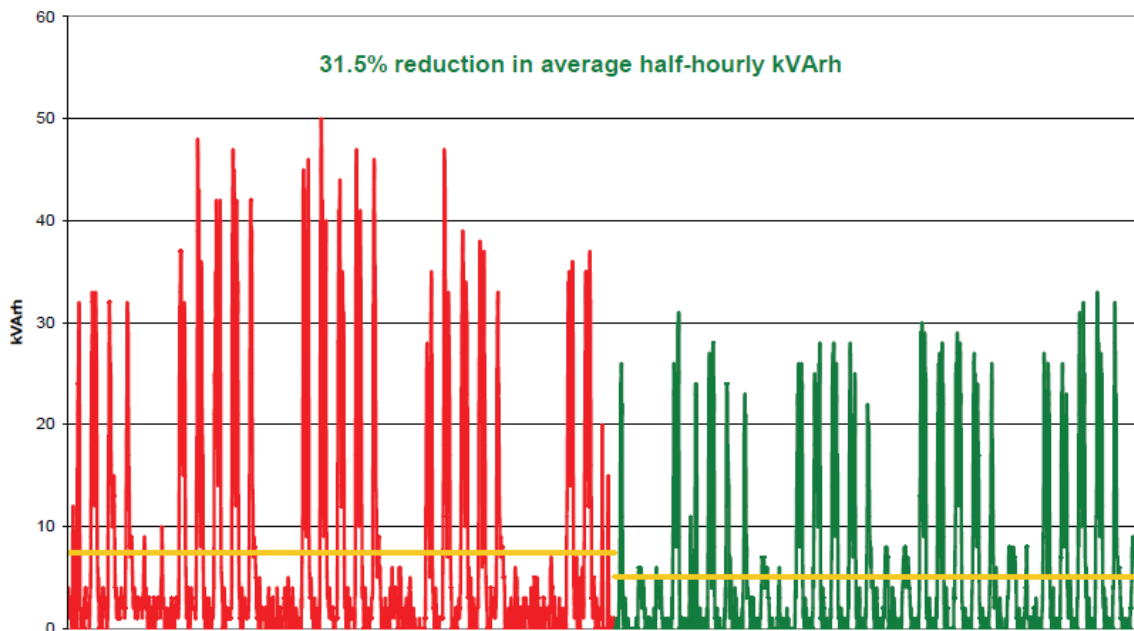


Figure 5—Reactive power August 2006 – September 2006

## Conclusion

The **powerPerfector** is performing as expected. We are delighted to report that there are demonstrable **savings of between 12.5% to 16.6%** in the kWh consumption at Cardiff Prison which, at the middle range, are above expected savings as proposed in the business case. This equates to an annual saving of **158 tonnes** in carbon emissions.

The **reduction in Maximum Demand of 16.9%** will assist substantially in keeping the sites demand below the available capacity, and also allow for a reduction in capacity charges.

Additionally, the site's equipment is being driven more efficiently by the **powerPerfector's** higher quality power output, with improved phase balancing, reduced harmonics and optimised voltage. Many of our clients tell us equipment lifetimes will be extended as a result, giving further savings going forward that are not included in this analysis.

It should be noted that there were no reported problems upon switch over from normal supply to **powerPerfector**.

## 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.

