

Voltage Power Optimisation (VPO)[®]

CASE STUDY

Defra Nobel House

Installed 8th December 2007
Report April 2008



"Five powerPerfector units have now been installed on the Defra Estate since March 2007, with a further nine planned in October. We are already delighted with the savings delivered (more than 150,000kWh and over 17,000kg of carbon) and are planning to accelerate installation of powerPerfector throughout our estate."

**Anita Collier, Head of Built Environment
Sustainability Team - Estates Division - Defra Estates**

About Nobel House

A major refurbishment of the Defra London HQ, Nobel House, was completed in 2005 with the building achieving the BREEAM (Building Research Establishment Environmental Assessment Method) rating of 'Excellent', making it one of the most sustainable offices in Europe.

The project was also awarded the Royal Institute of Chartered Surveyors (RICS) Sustainability Award for 2006. As part of the ongoing powerPerfector rollout across the Defra estate Nobel House was evaluated for installation to improve the sustainability of the building still further.

powerPerfector unit details

On 8th December 2007 two 560kVA powerPerfector units both with 8% optimisation settings were installed at Defra, Nobel House (the site has two supplies which are bus-coupled). The following is an analysis of the half-hourly electricity consumption data for the site up to 16th March 2008.

- **13.4% reduction in daily average consumption**
- **14.8% reduction in base load**
- **28.6 tonnes CO2 per year**



Electrical load

The office electrical load includes lighting circuits, heating and ventilation systems, and the site has a combined heat and power system.

FULL REPORT

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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 Nobel House site for a powerPerfector unit, two pP560kVA / 800A units were installed on the 8th December 2007.

A scheduled shut down of the site was required, with the work carried out over a weekend.

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

Reduction in daily average consumption	13.4%
Projected annual carbon savings	28.6 tonnes
Effective base load reduction	14.8%
Reduction in daily average maximum demand	12.3%

Overall savings

As shown in the charts below, the electricity consumption in the period following installation (when the site's CHP plant was online) is found to be **13.4%** lower than a comparable period the previous year when the CHP was also online. The method of analysis is outlined in the following report. To assess the effect of installing the unit we consider the total electricity consumption for the site (which is found by combining the consumption of the two electricity supplies and the output of the site's CHP plant), shown in the chart below (figure 1).

The weekly electricity consumption before installation of the powerPerfactor is shown in red and the consumption after installation is shown in green. An **11.9%** reduction in average weekly kWh consumption is evident following the installation of the powerPerfactor units.

DEFRA Nobel House - total site consumption

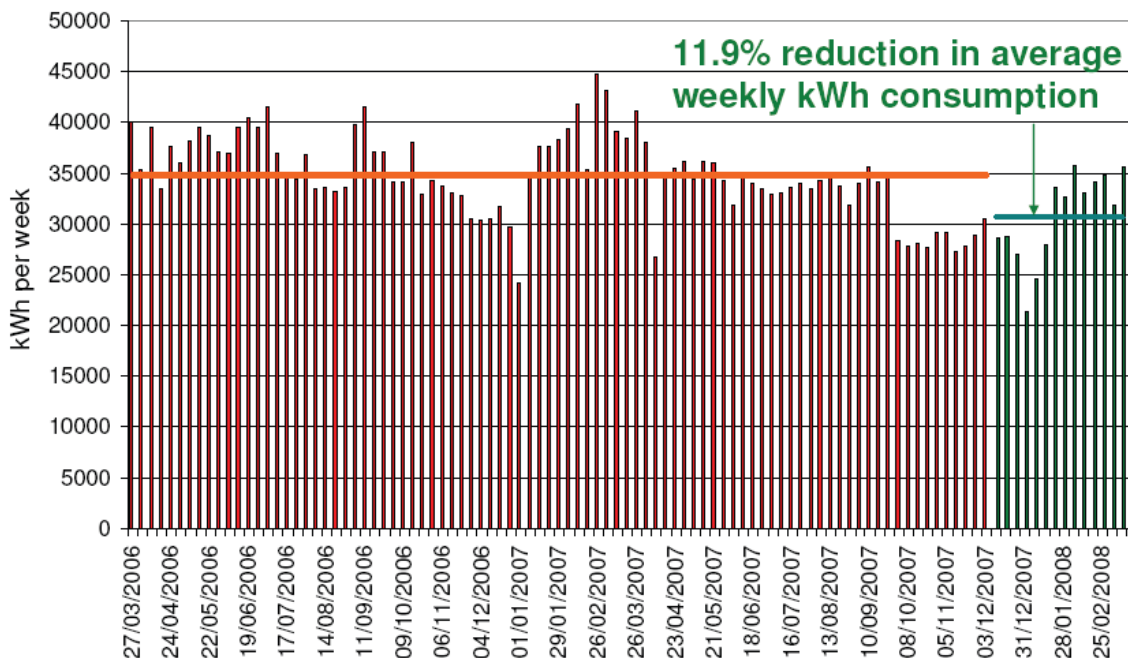


Figure 1

It is also interesting to examine the total combined half hourly consumption of the site, shown in the chart below (**figure 2**). This is obtained by calculating an average half hourly output for the CHP plant, obtained from the weekly CHP meter readings, and combining this with the halfhourly data for the two electricity supplies.

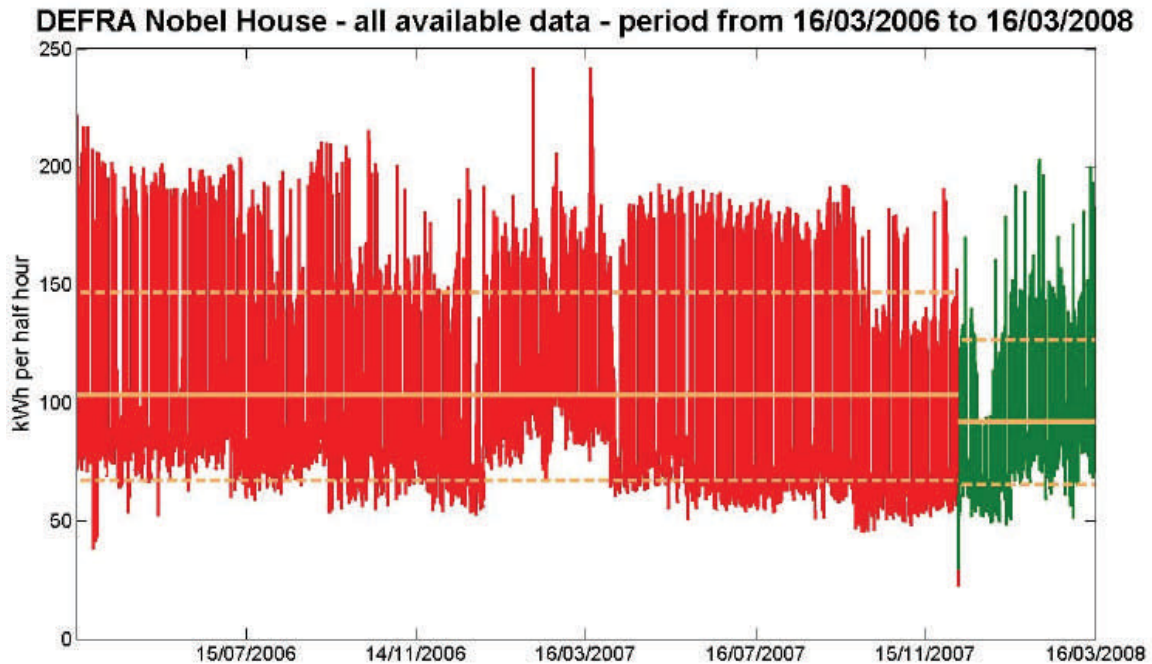


Figure 2

It should be noted that the site's CHP plant was online from 02/01/2007 to 02/04/2007 and also from 04/12/2007 to 31/12/2007 and 15/01/2008 to 16/03/2008 (i.e. encompassing almost the entirety of the post installation data). The change this causes to the site's electricity consumption is visually apparent in the chart above. Thus to enable a valid assessment of the savings attributable to powerPerfector it is necessary to compare these two time periods. Additionally, the consumption between the installation and 15/01/2008 is excluded from this analysis as it is atypically low (partly due to the Christmas/New Year holiday).

The consumption profile for 02/01/2007 to 02/04/2007 and 15/01/2008 to 16/03/2008 is shown in the chart below. A **13.4%** reduction in kWh consumption is observed, in addition to a **12.3%** reduction in average daily maximum demand and a **14.8%** reduction in base load.

DEFRA Noble House - periods with CHP online

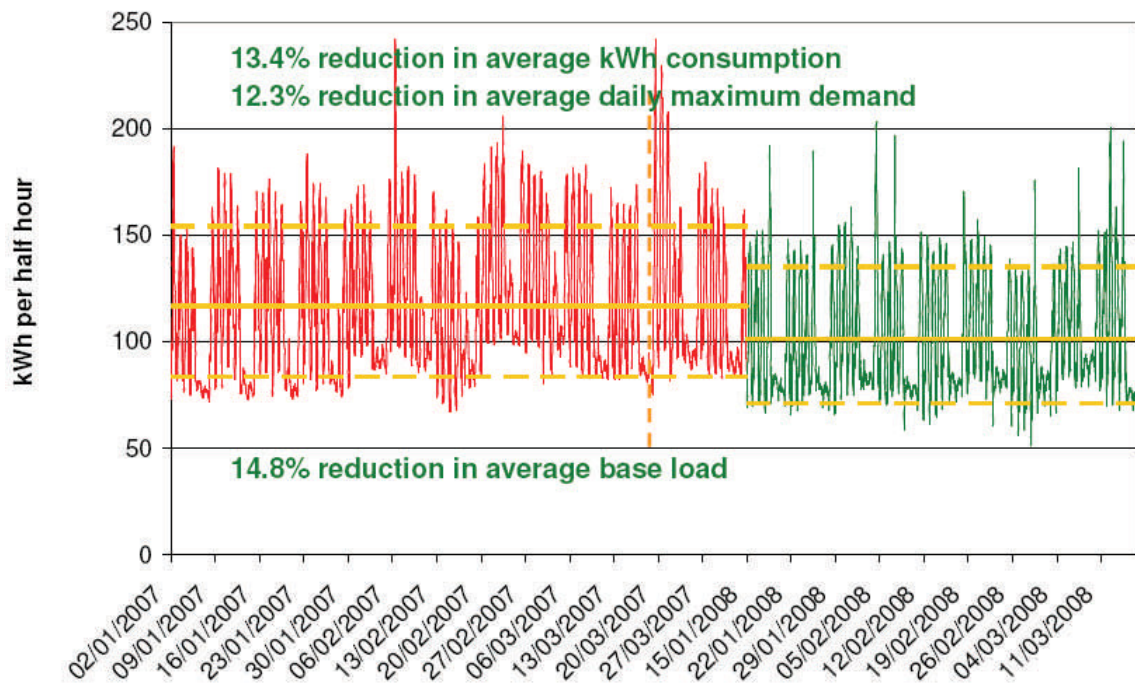


Figure 3

Conclusion

In conclusion, analysis of the electricity consumption since the installation of the **powerPerfector** indicates that post installation consumption is 13.4% lower than the consumption for a comparable period the previous year.

The **powerPerfector** is ensuring that the site operates with a high level of efficiency, as well as benefiting from improved power quality and protection against transients of up to 25kV. 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 and there is no requirement for ongoing maintenance, beyond the standard 5 yearly electrical checks required for all electrical equipment.

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.

