CASE STUDY

OFGEM
9 MILLBANK

Voltage optimisers

Installed: November 2008
Report: July 2009

About Ofgem

Ofgem is the Office of Gas and Electricity Markets. Ofgem protects consumers of gas and electricity by promoting competition and regulating the companies that run the gas and electric networks. It is Ofgem's role to shape the future of electricity and gas supply in the UK; because of this it is paramount that we are efficient in the internal use of energy.

How voltage optimisation helped Ofgem

After an 18 month study of the benefits of voltage optimisation which included observing units in action within London and using voltage loggers which recorded the voltage level in the building it was found that the average in the building was 245 volts (V), 25V higher than the nominal supply required in the UK.

After the installation analysis was completed which found an average reduction in electricity consumption of 9.1% which is equivalent to an annual carbon dioxide emissions saving of 165,700kg.

How it works (in brief)

Voltage power optimisers work by efficiently regulating the supply voltage to give energy, carbon and cost savings.

With voltage optimisation electrical equipment runs more efficiently and consumes less energy.

The declared electricity supply in the United Kingdom is, as a result of European harmonisation, 230V with a tolerance of +10% to -6%. This means that the actual voltage can be anywhere between 216V and 253V depending on local conditions. Most electrical equipment manufactured for Europe and the UK is rated at 220V and operates most efficiently at this level. Forcing appliances to operate at a higher

voltage in the UK (242V being the average supply level) leads to significantly higher energy consumption, increased heat losses and a reduced life span.

Kim Pivett, Head of Building Services at Ofgem writes about the powerPerfector installations:

"As part of Ofgem's continuing commitment to reducing its impact on the environment two powerPerfector units were installed at its London premises in November 2008. They have now been operating for over a year and, through the careful analysis of utility data, it is clear that an average reduction in electricity consumption of 9.1% has been achieved. This is equivalent to an annual CO_2 saving of 165.7 tonnes. The savings in consumption and associated emissions are also going a long way towards helping us achieve our Sustainable Development Action Plan targets.

We are also delighted with the ancillary benefits of powerPerfector, particularly the protection it provides from transients (or spikes), the extension of equipment life due to reduced strain and reduced kVA demand charges.

The technical bit……

Savings Summary:

- Reduction in average kWh consumption: **9.1%**
- Projected annual carbon dioxide emissions savings: **165,700 kg**
- Projected annual financial savings: **£27,800**

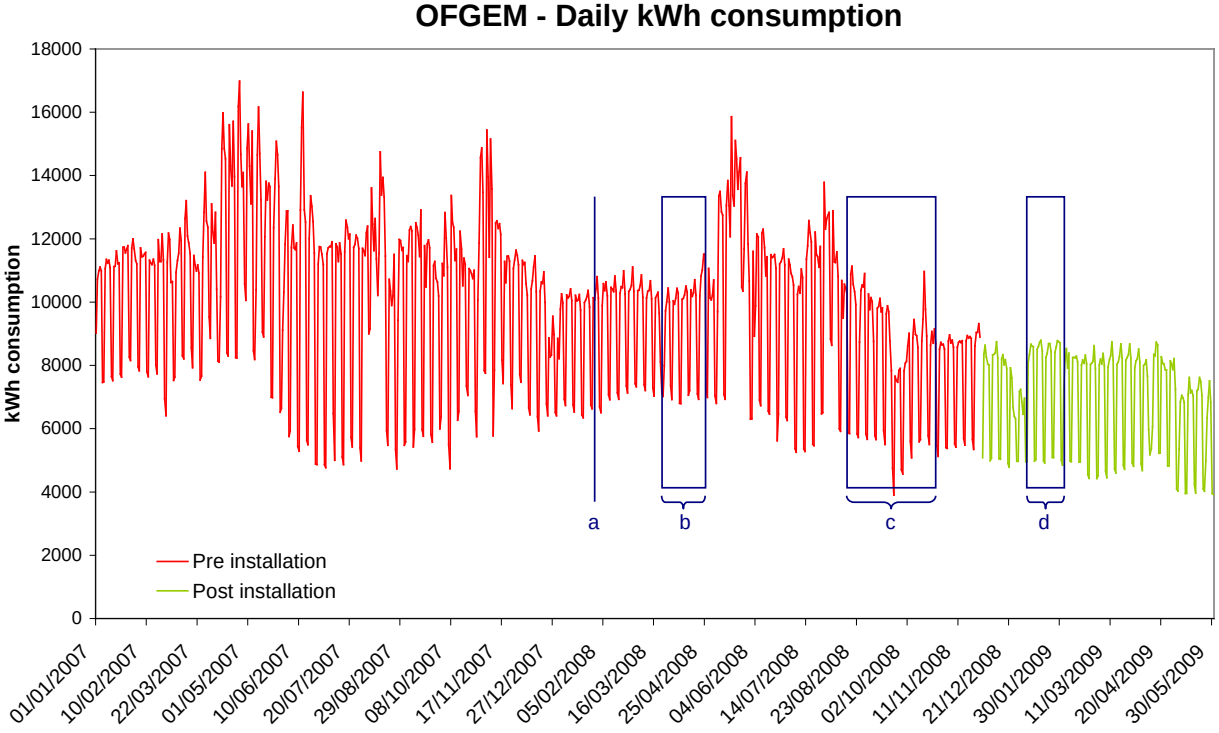
Two 1,250kVA powerPerfector units with 8% optimisation settings were installed at Ofgem's London headquarters on the 29th November 2008.

The following is an updated analysis of the electricity consumption and the CHP plant output for the site up to 31st May 2009.

A number of other energy-saving measures have been implemented on site since January 2008, so it is necessary to take these into account in order to present a reliable energy saving level attributable to the powerPerfector installation.

We conclude that the average daily consumption has been reduced by **9.1%** which equates to a projected annual carbon dioxide saving of approximately **165,700 kg**. The method of analysis is outlined in the following report.

The daily consumption for the site from 1st January 2007 to 31st May 2009 is shown in the chart below. The electricity consumption before installation is shown in red with the consumption after installation in green. These figures were determined by adding the daily readings of the electricity supply to the daily CHP electricity output readings.



The sections on the chart, labelled a-d, correspond to the other energy-saving measures implemented on site:

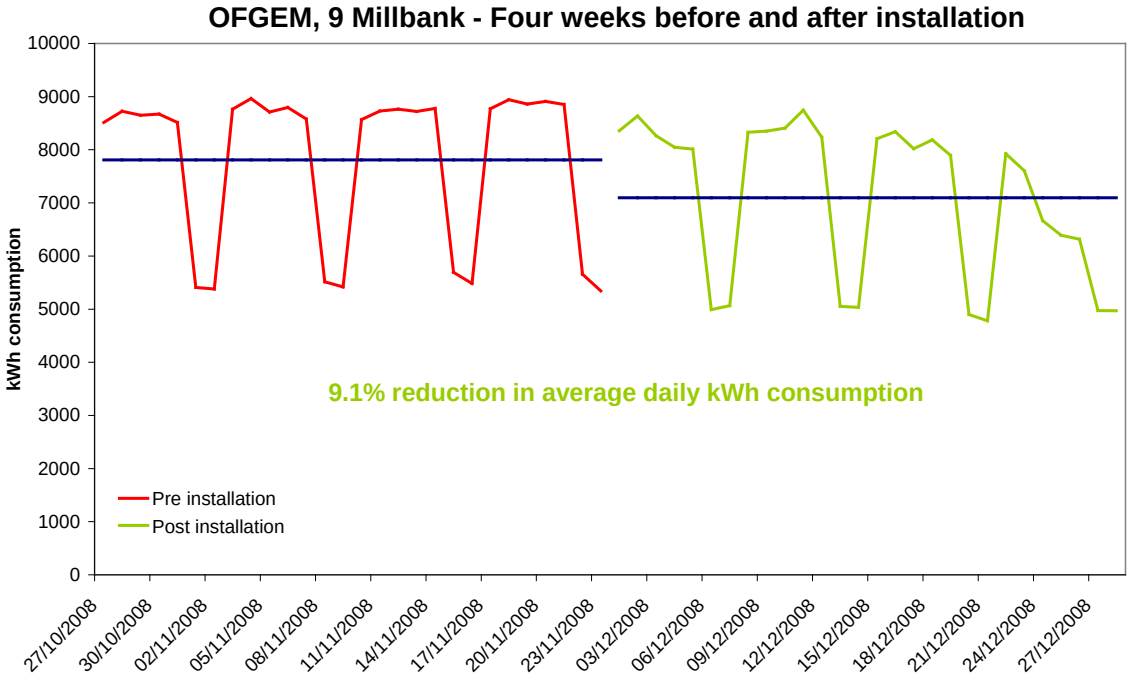
a: February 2008 - restaurant lighting was changed to T8.

b: March/April 2008 - a number of variable speed drives were installed along with modification of the boiling humidifiers to ultrasonic.

c: September/October 2008 – common area light fittings changed from 50W to 11W; this took two months to complete.

d: January 2009 – scene setting lighting was changed from 100W halogens to a mix of 10W and 15W fittings; this took one month to complete.

In order to fairly assess the savings attributable to the powerPerfector installation, it is most appropriate to compare consumption during periods where the site's conditions are broadly similar. The period between changes c and d, immediately before and after installation provides a good basis of comparison and is shown in the chart below. When considering the four weeks before and after installation there is a **9.1%** reduction in average daily kWh consumption.



In conclusion, analysis of the kWh data shows there is a 9.1% reduction in average daily kWh consumption. This equates to a projected annual carbon dioxide saving of approximately **165,700 kg** and an annual financial saving of £27,800.

The powerPerfectors are also ensuring that the building operates at a higher level of efficiency as well as benefiting from improved power quality and protection from transients of up to 25,000V.

The ability of voltage power optimisation 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 and provide further financial benefits on top of the reduced energy costs.

Reduced maintenance burden

- Optimising voltage with powerPerfector matches the supply voltage to the equipment's "higher efficiency" operating range. Without this, the 'raw' supply voltage is likely to be at the top end of the range that the electrical equipment can tolerate. As well as reducing energy consumption this reduces the strain on equipment, extending its lifespan.

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

- Most equipment benefits from the lower **'**pressure' when voltages are optimised. Other examples include variable speed drives – which are particularly sensitive to overvoltage – and the capacitor banks in power factor correction systems.

- When these effects are aggregated the benefit of extended equipment lifetimes and reduced replacement costs is substantial. The exact saving is difficult to quantify but we estimate it gives a 10%+ reduction in 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 and agreed service capacity (ASC) and increase the spare capacity for further growth (8% optimisation normally results in 6%-10% reduction in maximum demand (MD)).

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

- In general, the strain on the electrical infrastructure is reduced if the power factor is good. If the 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 electrical efficiency.

- 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 powerPerfector protects against 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 leading to higher savings.

- 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.

Protection

- A powerPerfector makes an electrical supply more robust and the building better protected. Transients, which are very brief surges in voltage from the grid, are eliminated by the powerPerfector provided they are lower 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.