

Voltage Power Optimisation (VPO)[®]

CASE STUDY

North Norfolk District Council Council Offices

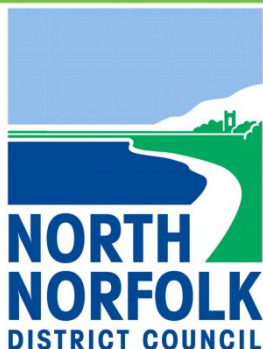
Installed: March 2011

Report: September 2011



"We are really pleased that the powerPerfactor Plus unit is delivering real reductions in our electricity consumption. In the current economic climate reducing our revenue budget is a key issue for the Council and the unit is helping us to achieve this."

Helen Dixon,
Sustainability Coordinator
North Norfolk District Council



About North Norfolk District Council

North Norfolk is a local government district in the county of Norfolk, United Kingdom. Its council is based in Cromer, in an award-winning building which was opened in 1991. The council headquarters can be found approximately 1 mile (1.6 km) out of the town of Cromer on the Holt Road.

How powerPerfactor were able to help the North Norfolk District Council – Council Offices

After the North Norfolk District Council – Council Offices sent its annual electricity consumption details, it was possible to give a provisional quote for a powerPerfactor 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 242 volts (V), 12V higher than the nominal supply in the UK. After a survey of the site by a powerPerfactor 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. Six months after the installation the electricity consumption was analysed to find a reduction of **11.3%**, equating to annual carbon dioxide emissions saving of **37 tonnes**.



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 North Norfolk District Council – Council Offices:

- Reduction in average kWh consumption: **11.3 %**
- Projected annual carbon dioxide emissions savings: **37 tonnes**
- Projected annual financial savings: **£6,600**

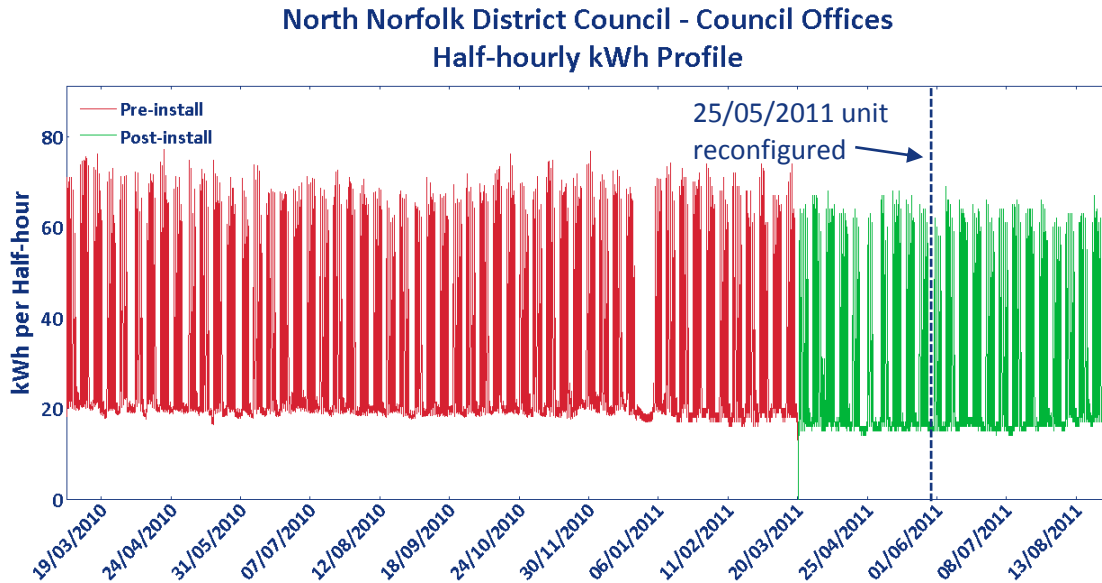
A 210kVA powerPerfector Plus unit was installed at North Norfolk District Council – Council Offices on 20th March 2011. A six month post-installation analysis was conducted. The analysis shows that the electricity consumption at North Norfolk District Council – Council Offices has been **11.3%** lower than the expected levels for temperature since the installation of the powerPerfector. This equates to a projected annual carbon dioxide emissions saving of approximately **37 tonnes** and an annual financial saving of **£6,600**. The method of analysis is detailed below.



Analysis

Consumption Profile

The chart below shows all available kWh data for the North Norfolk District Council – Council Offices, from 1st March 2010 and 31st August 2011. Data before installation is shown in red and after installation in green.



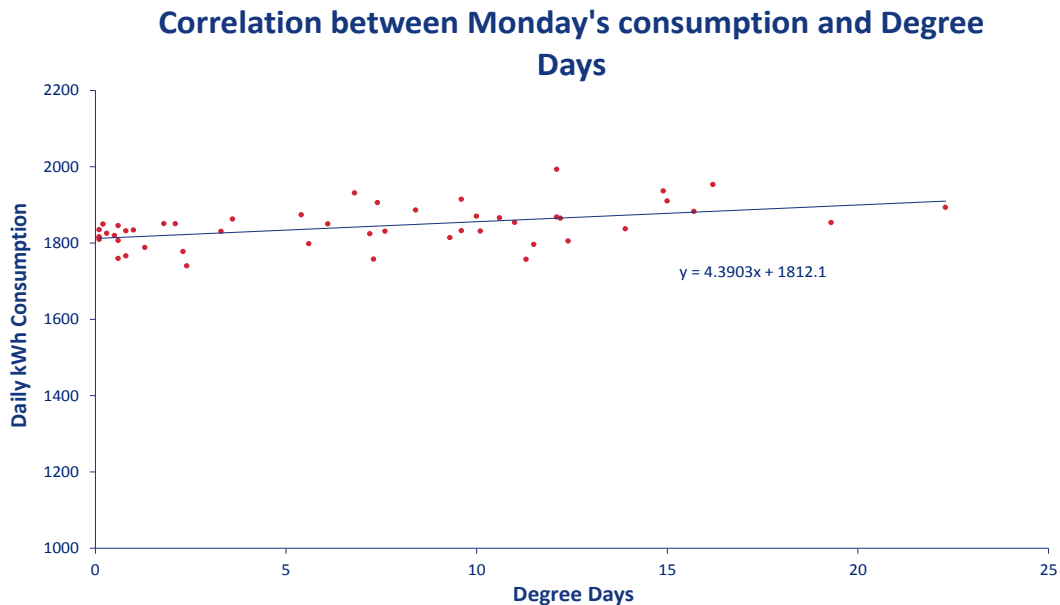
As outlined in the November 2010 pre installation analysis report, the consumption profile above shows some variation over time. A seasonal variation is apparent with consumption increasing over the winter period. This suggests that there is a correlation with external temperatures. Therefore, we have assessed the extent to which correlation with external temperatures can be used to model consumption and provide a baseline against which energy savings following a powerPerfector installation can be reported.

It should be noted that following installation on 20th March 2011 various tests on the IT equipment were carried out, this caused the Voltage Power Optimisation unit to be out of line on numerous occasions. The unit was reconfigured on 25th May 2011, as highlighted in the previous chart. As the unit was not fully operational until 25th May 2011, the reporting period consumption data will be taken from 25th May 2011.

Savings Analysis

An accurate and established method of quantifying the effect of external temperature on energy consumption is known as a 'Degree Days¹' analysis. Degree Days are based on temperature data for regions in the UK and represent the difference in external temperature and a base temperature for a given period of time. Since consumption has been higher during winter months, heating Degree Days (with a base temperature of 15.5°C) have been used to model electricity consumption as described in this section.

A Daily Degree Days model is calculated by quantifying relationships between external temperature and consumption for each day of the week over the pre-install period. As an example, the chart below shows the relationship between heating Degree Days and the total daily consumption on Mondays.



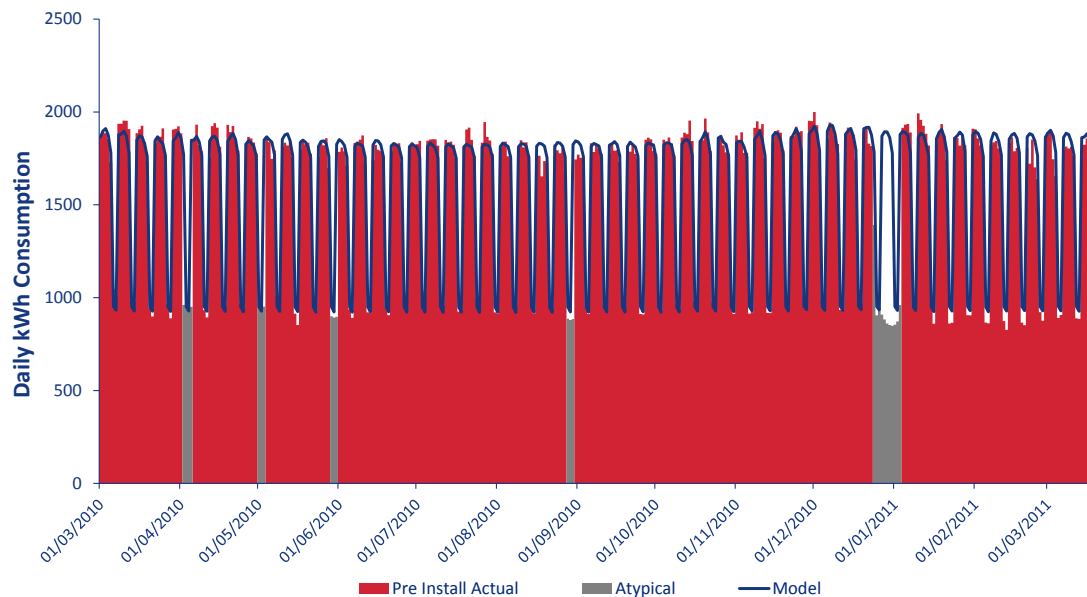
The blue trend line is the line-of-best-fit for the data and indicates that there is a linear relationship between total daily consumption and heating Degree Days. The equation of this trend line quantifies the relationship. Repeating this process for each day of the week results in a set of seven equations, shown in the following table; these equations comprise the Daily Degree Days model of consumption.

¹ Further information on Degree Days can be found at:
http://www.carbontrust.co.uk/resource/degree_days/what_are.htm

Monday:	Expected kWh Consumption =	4.4 kWh per degree day	+	1,812.1 kWh
Tuesday:	Expected kWh Consumption =	4.9 kWh per degree day	+	1,827.1 kWh
Wednesday:	Expected kWh Consumption =	6.7 kWh per degree day	+	1,818.3 kWh
Thursday:	Expected kWh Consumption =	4.8 kWh per degree day	+	1,808.0 kWh
Friday:	Expected kWh Consumption =	2.2 kWh per degree day	+	1,753.0 kWh
Saturday:	Expected kWh Consumption =	0.2 kWh per degree day	+	950.3 kWh
Sunday:	Expected kWh Consumption =	0.7 kWh per degree day	+	921.3 kWh

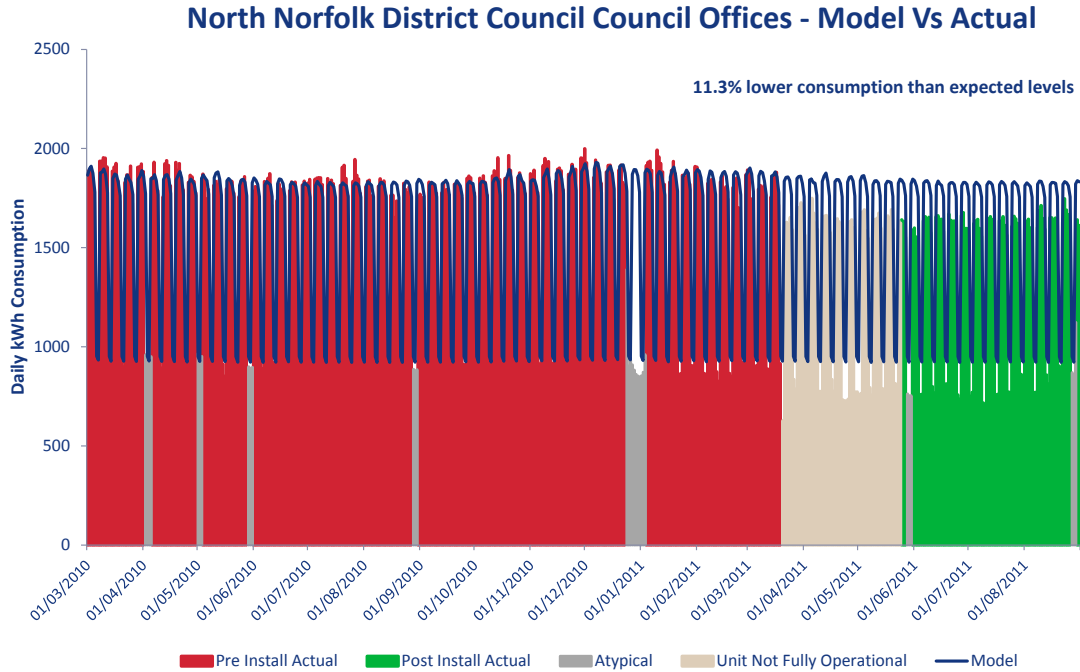
The next graph shows the model calculated using heating Degree Days along with the actual pre-installation kWh consumption data. Red data is pre-installation actual consumption data, the grey data is the Christmas and New Year's period and all bank holidays, these dates have not been used to calculate the model as they are not representative of 'typical' operation of the site. The blue line is the expected level of kWh consumption for the external temperature conditions.

North Norfolk District Council Council Offices - Model Vs Actual



Having calculated the expected level of kWh consumption, it is possible to compare the actual post install data to the level of kWh consumption that would have been expected if nothing had changed at the site. The data shown in red was used for calculation of the expected level of kWh consumption. Due to the installation and the optimisation of the units differing, the data from

20th March to 25th May 2011 is shown in light brown; this will not be included in the calculation of the savings. The post installation consumption data is shown in green.



The previous chart shows that, having taken into account the external temperature, the energy consumption at North Norfolk District Council – Council Offices has been, on average, 11.3% lower than would have been predicted had the powerPerfector not been installed.

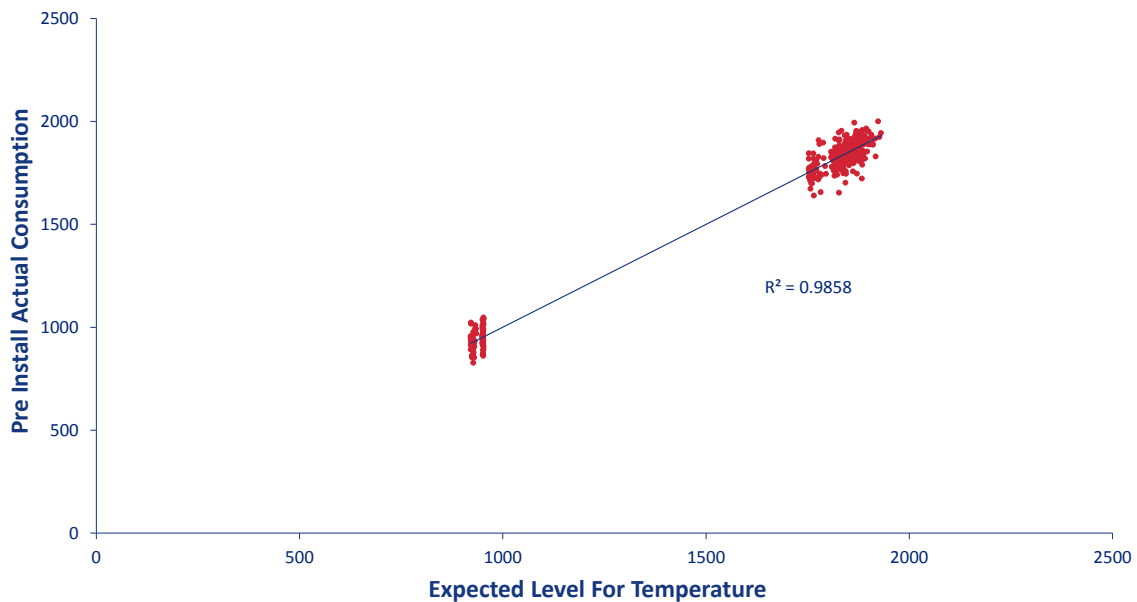
Conclusions

In conclusion, the electricity consumption at North Norfolk District Council – Council Offices has been **11.3%** lower than the expected levels for temperature since the installation of the powerPerfector. This level of kWh reduction equates to a projected annual carbon dioxide emissions saving of approximately **37 tonnes** and an annual financial saving of **£6,600**.

Appendix 1: Accuracy and Calculations

The daily Degree Days model shows a good correlation with the actual energy consumption with an R^2 value of 0.99 as shown below. The R^2 value, also known as the coefficient of determination, can be interpreted as the proportion of the variation in the energy consumption explained by variation in the model (1.0 indicating perfect correlation and 0 indicating no correlation). In this case it should be noted that the R^2 is particularly high because there is a large difference between weekend and weekday consumption.

North Norfolk District Council - Council Offices - Accuracy of Model



Appendix 2:

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. **Common transients** – which are very brief surges in voltage from the grid – are eliminated by the powerPerfector.
- In some cases this can prevent catastrophic damage to equipment, but it also prevents smaller transient events that act to degrade equipment over time. This prolongs the expected life of electronic equipment.



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