

# TECHNICAL OVERVIEW

  
**powerstar**  
100% British Engineered. 100% Guaranteed Results.

A UNIQUE VOLTAGE OPTIMISATION SYSTEM

INNOVATOR 10

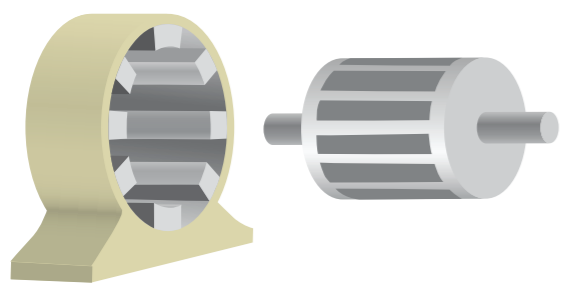


# WHAT IS VOLTAGE OPTIMISATION?

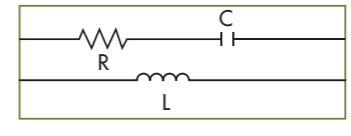
Voltage optimisation is beneficial when the electricity supply to your site is at a higher voltage level than needed, resulting in excessive energy consumption and high electricity bills. Voltage optimisation systems work to optimise the outgoing voltage without compromising the supply.

One of the reasons why voltage optimisation is so effective is that the average voltage supplied from the National Grid is 242V (although it can be as high as 253V), whereas the nominal UK voltage is 230V.

### SIMPLIFIED MOTOR SCHEMATIC CIRCUITRY



### SIMPLIFIED MOTOR ELECTRICAL



There are three types of load within a motor.

- INDUCTIVE**
- RESISTIVE**
- CAPACITIVE**

**Resistive element of Load**  
**Determined by  $V = I R$  (Voltage = Current x Load)**

Where load remains constant, a reduction in voltage will see a corresponding reduction in current. For example a 5% reduction in the voltage at the motor will result in a 5%

reduction in current (at all times except when the motor is on full capacity. When a motor is required to produce its full power capacity it will do so regardless of the input voltage).

**$0.95 V = 0.95 I * R$**   
 To calculate the effect on motor input power:  
 **$P_o = V * I * \sqrt{3} * \cos \phi$**       **Where  $P_o$  = original Power**  
 Therefore  
 **$P_n = 0.95 V * 0.95 I * \sqrt{3} * \cos \phi$**       **Where  $P_n$  = new Power**

Reducing the input voltage by 5% will **reduce consumed power by 10%**.

**Inductive element of Load**  
**Determined by  $X_L = 2 \pi f L$**       **The magnetic flux is proportioned to current flow**

The reduction in the current flow will affect the inductance and therefore reduce the magnetisation losses within the motor.

Theoretically, for a 5% reduction in the voltage, the total savings would be up to 15% (10% from resistive and 5% from inductive components).

$X_L$  is impedance, therefore the bigger the impedance the bigger the losses. Hence, for a 5% reduction in the current flow, there would be a 5% reduction in the motor impedance and a 5% reduction in the power consumption.

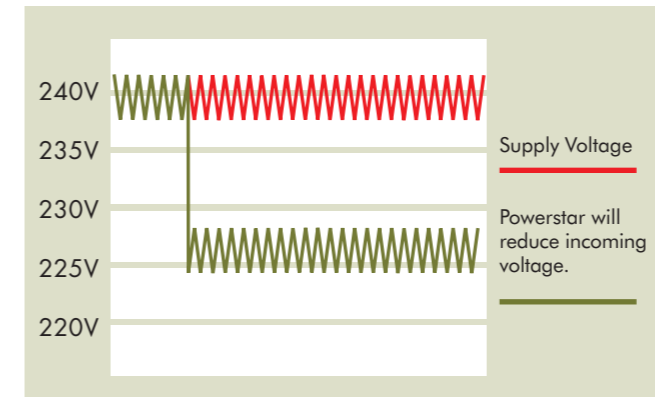
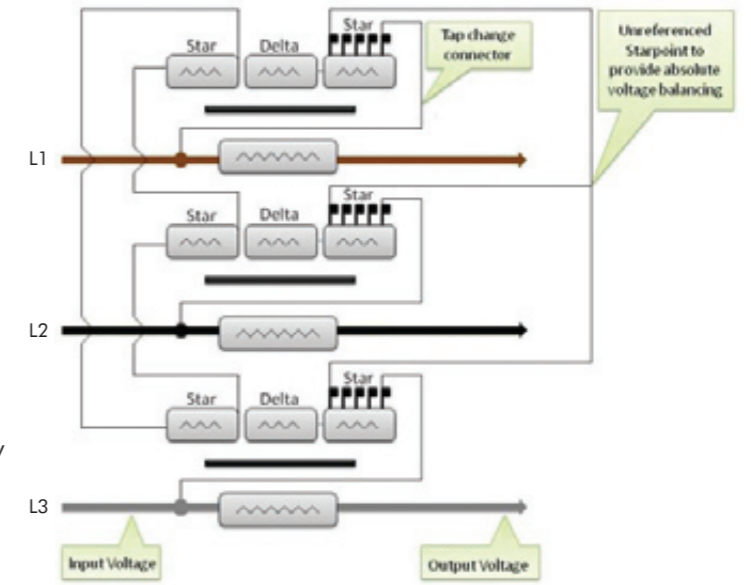
Practically, savings will be dependent on individual site conditions. That underlines the importance of a site survey.

# THE POWERSTAR TECHNOLOGY

The Powerstar system is a uniquely designed and patented triple-wound transformer with an efficiency of 99.91%. By accurately controlling the incoming voltage it ensures that energy savings are maximised without compromising the supply.

The diagram (right) shows the patented Powerstar basic schematic.

- 1. Star Configuration** - To eliminate harmonics. The two windings for each phase (outer and inner windings) are wound on the same core but in opposite directions. The windings are connected in a cross-connected fashion. For instance, the primary winding of Brown (L1) phase may be connected to the secondary of Black (L2) phase; the primary of Black phase would be connected to the secondary of Grey (L3) phase.
- 2. Delta Configuration** - To further suppress any remaining harmonics.
- 3. Star Configuration** - To control voltage.



The Powerstar design ensures that it provides an efficient and effective voltage optimisation system. For example: 1,000kVA has an impedance of 0.000178Ω and therefore consumes extremely low power.

Powerstar provides savings in the inductive electrical loads within buildings. Inductive loads being motors, pumps, fans, IT equipment (switch mode power supplies) and lighting (non high frequency).

The actual energy savings that can be achieved by the Powerstar system completely depend on the electrical loading characteristics of a particular building.

Electricity supplied at this voltage

UK average supply voltage

Historic UK voltage

UK nominal voltage

Most equipment is designed to operate at this level of voltage

250V

240V

230V

220V

Your business could be paying for this level of voltage

**POWERSTAR** will reduce your incoming voltage leading to lower electricity usage and reduced bills

For example: a building which has fixed speed devices such as air-handling units (AHUs), multi stage compressors (i.e. chillers), pumps and standard switch-start fluorescent fittings, will achieve high savings. Variable speed equipment will also see savings but at reduced levels.

It is not only unnecessary electricity that gets saved. Operating equipment at a higher voltage than it is designed for reduces its lifespan and there is no improvement in performance to offset this. Reducing the voltage to that required for optimum performance (eg. 220V) increases equipment efficiency and could reduce maintenance costs.



# THE BENEFITS OF POWERSTAR

The Powerstar unit has been proven in independent tests to be the most effective voltage optimisation system on the market, with benefits including:

- Savings of up to 26.1% on energy consumption and related CO<sub>2</sub> emissions
- Reduction of maximum load demand (kVA) and in turn a reduction of electricity bills
- 5 voltage settings to ensure optimum voltage output achieved
- Improved life expectancy of site equipment, therefore reducing site maintenance costs
- Provides voltage phase balancing
- No moving parts, therefore zero maintenance
- Helps protect against damaging transients (power spikes) of up to 25,000V

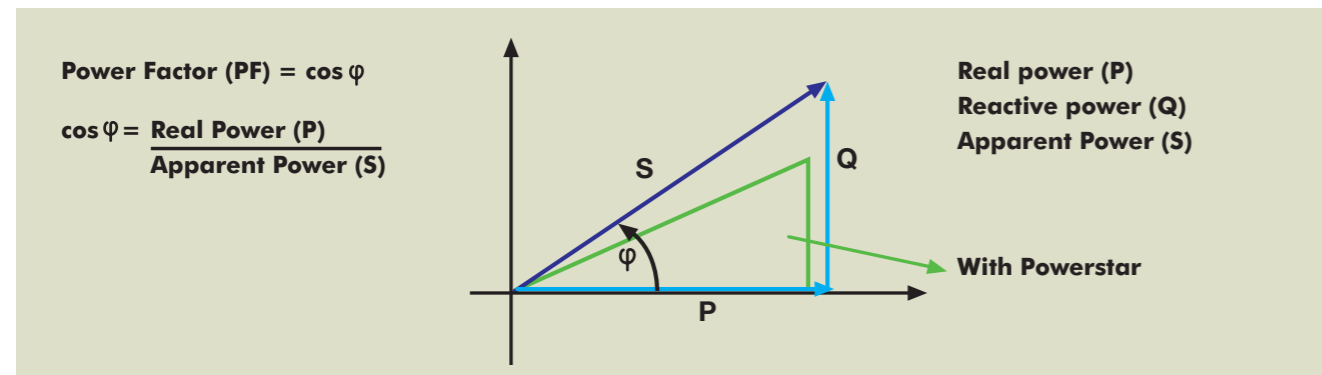
## IMPROVES POWER FACTOR

Power factor is a way of describing how efficiently electrical power is consumed. It is the ratio of delivered useful power to the total power taken from the supply. An ideal ratio is 1.0.

Poor power factor has a negative impact on a site including drawing more power from the network, causing losses at transformers, reducing effective capacity and incurring 'poor power factor' or 'reactive power' charges from the supplier.

Powerstar will reduce the resistive and inductive losses (the inductive is a combination of reactance and resistance), reducing the apparent and reactive power vectors, resulting in smaller phase angle ( $\phi$ ) and therefore improving power factor.

Advantages of improved power factor include reducing power demand from the network (which will result in lower electricity bills), prolonging lifespan of equipment, reducing losses in supply transformers and increasing the effective capacity of your electrical network.

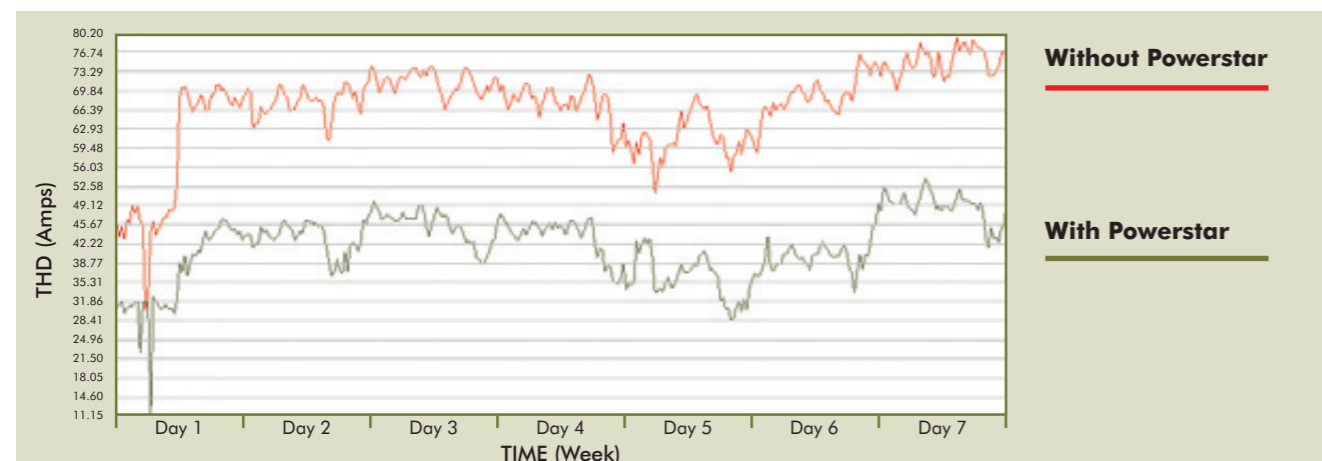


## REDUCES HARMONICS

Harmonics can create a large load current, overheating of electrical supply transformers, high voltage and current distortions and false tripping of branch circuit breakers.

measured concurrently either side of the Powerstar unit. Total current harmonic distortions were significantly reduced by nearly 50%.

The effect of reduced harmonic distortion is shown below at a printing machine electrical supply, where the two traces are



# WHERE VOLTAGE OPTIMISATION WORKS AND EFFICIENCY UNDER VARIOUS LOADS

Voltage optimisation works best on inductive loads – motors and lighting for example – and significant savings can be achieved on motors in particular, especially if these are not loaded at 100% of their capacity for 100% of the time.

All Powerstar systems are fully tested under BS171 and these tests include;

- 25,000V surge/transient protection
- 50,000A fault level tests
- Efficiency tests at 25%, 50%, 75% and 100% loading
- Impedance testing
- Overloading test at 110% of the Powerstar capacity for 4 hours

## POWERSTAR TYPICAL OPERATING EFFICIENCIES TABLE

| Load rating | Efficiency |
|-------------|------------|
| 0%          | 99.97%     |
| 25%         | 99.95%     |
| 50%         | 99.94%     |
| 75%         | 99.93%     |
| 100%        | 99.91%     |

# TECHNICAL SPECIFICATION

## MANUFACTURING OVERVIEW

The Powerstar systems are designed and manufactured by EMSc (UK) Ltd in the UK using locally sourced components wherever feasible.

They are manufactured to BS171-IEC60076-IEC60726, using low loss core steel, close coupled copper, and high quality components.

Powerstar operates at ambient temperature plus a maximum 5°C (i.e. if ambient is 20°C the Powerstar temperature will be between 20°C and 25°C).

The Powerstar unit has a design life in excess of 50 years for the wound components; also it has been designed so that over 98% is recyclable.

## WEIGHTS & DIMENSIONS

The weights and dimensions provided in this table are for guideline only.

| kVA  | Amps | Dimensions                  |     |      | Weight |
|------|------|-----------------------------|-----|------|--------|
|      |      | L                           | D   | H    | Kg     |
| 50   | 70   | 500                         | 350 | 500  | 75     |
| 72   | 100  | 500                         | 350 | 500  | 100    |
| 90   | 125  | 600                         | 400 | 600  | 231    |
| 100  | 140  | 600                         | 400 | 600  | 242    |
| 144  | 200  | 600                         | 400 | 600  | 286    |
| 144  | 200  | 770                         | 485 | 760  | 330    |
| 150  | 210  | 770                         | 485 | 760  | 341    |
| 200  | 280  | 770                         | 485 | 760  | 374    |
| 226  | 315  | 770                         | 485 | 760  | 402    |
| 250  | 348  | 770                         | 485 | 760  | 413    |
| 288  | 400  | 770                         | 485 | 760  | 429    |
| 288  | 400  | 850                         | 510 | 1030 | 451    |
| 300  | 420  | 850                         | 510 | 1030 | 473    |
| 350  | 490  | 850                         | 510 | 1030 | 550    |
| 359  | 500  | 850                         | 510 | 1030 | 561    |
| 400  | 560  | 850                         | 510 | 1030 | 583    |
| 453  | 630  | 850                         | 510 | 1030 | 627    |
| 453  | 630  | 1000                        | 630 | 1210 | 627    |
| 500  | 700  | 1000                        | 630 | 1210 | 671    |
| 500  | 700  | 1400                        | 730 | 1610 | 748    |
| 575  | 800  | 1000                        | 630 | 1210 | 726    |
| 575  | 800  | 1400                        | 730 | 1610 | 781    |
| 719  | 1000 | 1000                        | 630 | 1210 | 913    |
| 719  | 1000 | 1400                        | 730 | 1610 | 913    |
| 750  | 1048 | 1400                        | 730 | 1610 | 957    |
| 800  | 1120 | 1400                        | 730 | 1610 | 979    |
| 898  | 1250 | 1400                        | 730 | 1610 | 1012   |
| 1000 | 1400 | 1400                        | 730 | 1610 | 1078   |
| 1150 | 1600 | 1400                        | 730 | 1610 | 1243   |
| 1250 | 1740 | 1400                        | 730 | 1610 | 1408   |
| 1250 | 1740 | 1650                        | 830 | 1610 | 1551   |
| 1438 | 2000 | 1400                        | 730 | 1610 | 1452   |
| 1438 | 2000 | 1650                        | 830 | 1610 | 1606   |
| 1500 | 2088 | 1400                        | 730 | 1610 | 1518   |
| 1500 | 2088 | 1650                        | 830 | 1610 | 1639   |
| 1797 | 2500 | 1400                        | 730 | 1610 | 1672   |
| 1797 | 2500 | 1650                        | 830 | 1610 | 1760   |
| 2000 | 2784 | 1400                        | 730 | 1610 | 1815   |
| 2000 | 2784 | 1650                        | 830 | 1610 | 1969   |
| 2200 | 3080 | 1400                        | 730 | 1610 | 1881   |
| 2200 | 3080 | 1650                        | 830 | 1610 | 2035   |
| 2500 | 3480 | 1650                        | 830 | 1610 | 2200   |
| 3000 | 4200 | Designed to site conditions |     |      |        |

# HOW WE CALCULATE SAVINGS

## CALCULATING ESTIMATED SAVINGS

When calculating the savings, voltage data logging and site surveys are carried out to identify any energy consumption where voltage optimisation will achieve zero or reduced savings (i.e. high frequency lighting, inverter drives, etc). By analysing the data logging information the optimum voltage for the site can be determined.

The site survey determines how much of the total site electricity load (as a percentage) will benefit from the full, reduced or zero percentage saving. When specifying the percentages the engineer takes into consideration the operating load and operational period of the equipment.

Dividing the voltage drop into the original voltage figure gives the voltage percentage saving. This figure is doubled because according to the IET (The Institution of Engineering and Technology) on average a 1% reduction in voltage will produce a 2.1% reduction in electricity consumption. We then take into consideration the site loads that will yield less than optimum savings and we calculate a guaranteed saving as a percentage of kWh.

Using the guaranteed savings, a payback period for the customer is calculated. Our savings are 100% guaranteed.

## CALCULATING ACTUAL SAVINGS

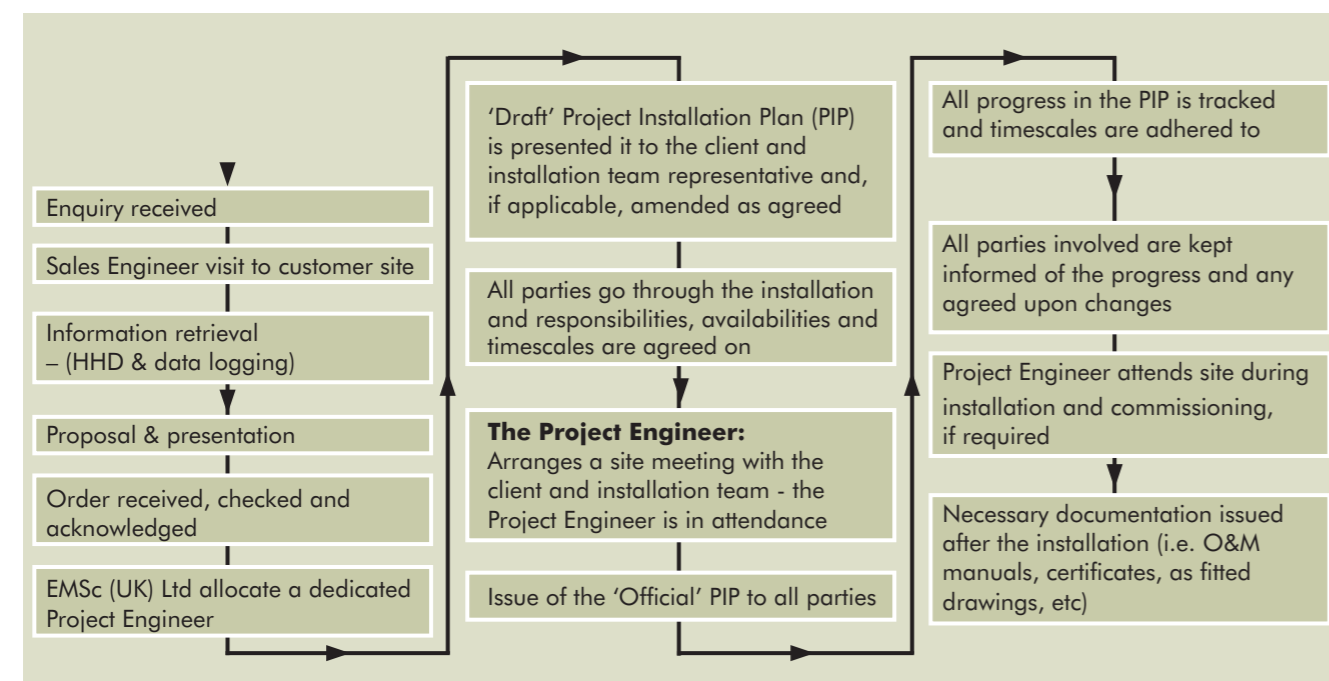
When calculating the actual savings we provide three options:

1. **HHD** – A comparison of half hour data over a 3 month period from before and after the installation. We also take into consideration if the site loading has changed (e.g. installing or removing equipment, changing occupancy levels, etc), any weather affected loads (using the relevant degree days) and how they would affect electricity consumption. HHD is the option recommended by EMSc (UK) Ltd due to the accuracy of the results received from this calculation method.

2. **Independent verification** – Saving results independently verified by The University of Sheffield's Department of Probability and Statistics. An accuracy of +/- 1% is guaranteed. For more information see FAQs.

3. **IPMVP** - An independent company verifies the savings using the International Performance Measurement and Verification Protocol (IPMVP) method. IPMVP uses variables which can also be assigned to the user. Accuracy could significantly vary dependant upon the number of variables.

# HOW WE WORK



The above chart illustrates how EMSc UK Ltd work with our clients from enquiry through to completion. Our installations range from one-off installations to roll-out programmes. We always work with you throughout the project and installations occur at your convenience.

## QUALITY SYSTEM

The Quality Assurance System applies to all activities, and has been developed based on principles defined within BS EN ISO 9002: 1994. The Quality Assurance System is fully documented and structured in three levels:

### Level 1: Quality Manual

This document details the corporate quality policy and structure of the company and references appropriate operating procedures.

### Level 2: Supporting/Operating Procedures

These documents describe the actual process, and controls applied, to all activities concerned with the attainment of a quality assured contracting service.

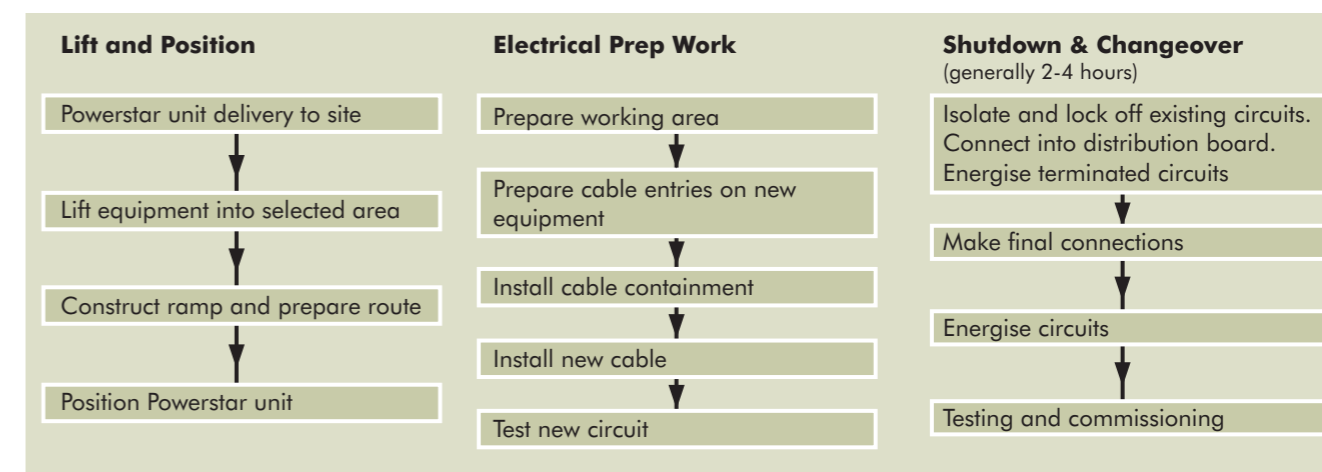
### Level 3: Quality Planning

As the company operates a standard type and range of services, customer satisfaction and quality are achieved by

operation in accordance with the documented quality system. Specific customer requirements are identified and documented during the contract/tendering review process, allowing these requirements to be communicated and achieved, ensuring satisfaction of all customer declared needs.

The Quality Assurance Manual, Procedures and Quality Plans are maintained by the Quality Manager who ensures that the appropriate items, at the correct revision levels, are issued to all who need them within the company.

## POWERSTAR INSTALLATION



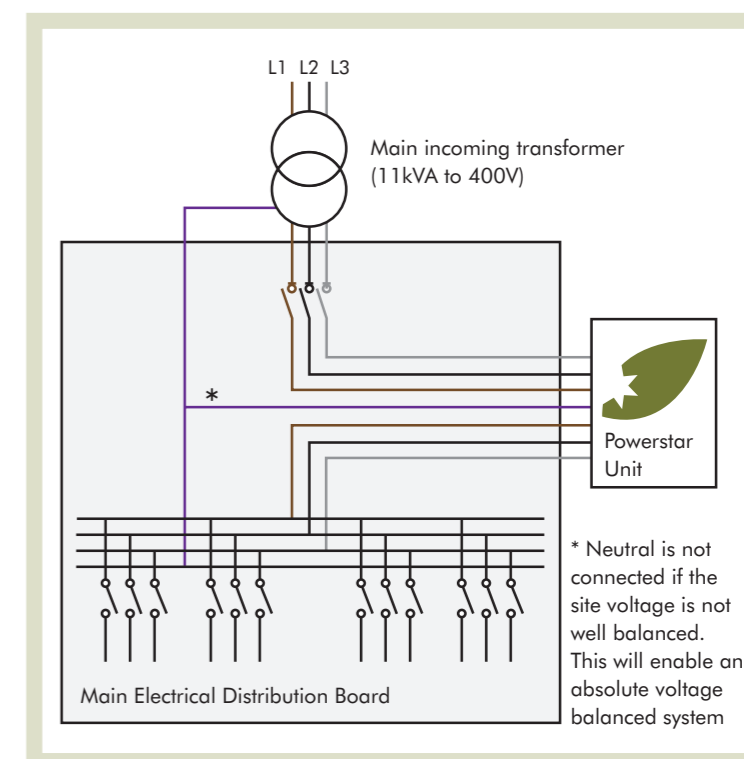
After discussions with you a delivery date and time is arranged. Appropriate transportation is arranged and the installation team will be on site to receive the delivery of the Powerstar unit and transport this to the install location.

The installation team will remove the packaging from the Powerstar unit and remove from site, recycling material where appropriate.

EMSc (UK) Ltd will use either our own installation teams or an approved subcontractor (all are NICEIC registered) who has undergone a competency verification procedure.

A list of current approved subcontractors is available on request and we may use any one of them to install Powerstar on your site.

All of our installation sub-contractors are subjected to regular competency criteria checks where they have to meet our high standards.



## HEALTH & SAFETY

EMSc (UK) Ltd operates within the guidelines of health and safety risk assessments and method statements and within the clients site-specific requirements.

In most cases the connection is done outside normal working hours, therefore any risks to employees and the general public are minimised. For any work done during normal working hours, these will occur within authorised personnel areas where site-specific safe working conditions apply and will be followed.

All installation subcontractors have gone through a competency procedure that ensures they are capable of installing Powerstar, that they do so safely and they will always comply to local and other authorities regulations and by-laws. They also conform to the provisions of every act of parliament applicable to the work, as well as with the clients health and safety rules.

EMSc (UK) Ltd has never had any Health and Safety Executive enforcement action or reported incidents.

## FAQ's

### What level of savings are guaranteed?

Savings are 100% guaranteed.

We guarantee the savings as per our proposal. If the minimum savings are not achieved, we will provide payment to compensate for the difference between your actual savings and our guaranteed savings.

### What warranty is offered?

Our warranty includes parts and labour for a 15 year period. It excludes damage due to overloading the Powerstar system (i.e. if your company purchases and installs a 250kVA Powerstar system and loads it to 300kVA, this will damage the system).

### How are the savings calculated by the University of Sheffield?

A regression line is fitted to the daily consumption (that is summed interval data, 48 half hours for 24hrs) prior to the project (device) being commissioned. This regression (formula) takes a baseline figure and six factors into account to calculate a forecasted consumption figure. Therefore, the methodology predicts what the consumption would have been without any energy saving devices.

The base line and coefficients are calculated by multivariate regression analysis using the historic consumption.

With the energy saving device in place, the actual consumption would be less than the predicted consumption and this difference is the device savings. Using this methodology, an accuracy of +/- 1% is guaranteed.

### Does the unit have incoming circuit protection as standard?

Powerstar will always have incoming protection as standard. If possible, we will utilise existing protection or install new protection. In either instance the protection will be rated to the installed Powerstar system. As part of the installation process we will always ensure that discrimination is never compromised therefore incoming circuit protection is always essential.

### What is different about the way the Powerstar system deals with harmonics?

The Powerstar system uses a star-wound cross-connected winding followed by a delta winding as opposed to a single delta wound 'tertiary or harmonic trap'.

A tertiary trap captures the triplens and then seeks to get rid of them, which generates a lot of heat and wasted kWh. The Powerstar system eliminates (rather than traps) triplens before moving on to the others.

### Does Powerstar have an automatic by-pass?

Yes, as an optional extra the automatic under voltage by-pass system is designed to remove the voltage reduction applied by the Powerstar system if the mains incoming voltage falls below a pre defined level for a period of time (e.g. mains sag or fluctuation).

In the by-passed state, the output voltage from the Powerstar is equal to that of the mains voltage being supplied from the Grid. Once the mains supply voltage returns to its normal level, the reduction can be reapplied to the Powerstar either via a manual (push button) reset or through an automatic timer based reset.

### What are the maintenance requirements of the Powerstar (fixed) system?

The Powerstar unit has 100% reliability, no moving parts and is maintenance free.

### Is there a need for cooling?

No, the unit is naturally ventilated within its enclosure and emits minimal sound and vibration while operating with a maximum heat output of 5°C above ambient.

### What is the procedure if the optimisation levels need to be adjusted at a site following installation?

Powerstar has 5 tappings, 2.5V between. It is a very simple procedure to adjust (off-line) should a change be required. A visit from an engineer will be arranged, free of charge, to carry this out and train site electricians.

## SUMMARY

- ✓ **Patented design**
- ✓ **UK manufactured**
- ✓ **Project & installation management**
- ✓ **Verified savings, 100% guaranteed as per proposal**
- ✓ **Results proven via independent tests**
- ✓ **Turnkey solution**