WILSON POWER SOLUTIONS
Responsible Power Engineering

NHS
UNIVERSITY HOSPITAL
OF SOUTH MANCHESTER [UHSM]
ACUTE SUBSTATION TX1 & TX2

SUPER LOW LOSS AMORPHOUS TRANSFORMER REPLACEMENT

£31,000
ANNUAL SAVINGS

3 YEARS
PAYBACK

Based on electricity costs of £0.09 /kWh

THE CHALLENGE

The NHS is the largest Public Sector contributor to climate change in Europe. Each year it emits 21 million tonnes of CO_2e and spends in excess of £400 million per year on energy. With ambitious carbon reduction targets in place (80% by 2050; 26% by 2020) reducing energy consumption across its estate is a major concern.

> An extremely cost effective infrastructure upgrade that not only provides guaranteed energy savings through reduced transformer losses but delivers substantial additional savings through inbuilt voltage management capabilities.
>
> NHS ESTATES MANAGER

INSTALLATION BENEFITS AT A GLANCE

1. OVERALL 6% REDUCTION IN ELECTRICITY CONSUMPTION
2. ANNUAL SAVINGS OF £31,000
3. MINIMUM OF 25 YEARS LIFE EXPECTANCY
4. 3 YEARS PAYBACK
5. NSTALL & FORGET SOLUTION

THE PROJECT

The University Hospital of South Manchester is recognised as the "greenest" hospital in the UK and has recently been acknowledged as the most environmentally friendly in Europe. With on-site generation, modern LED lighting systems and efficient controls already in place, the energy and environmental manager was looking for additional areas that could drive energy savings.

Having identified super low loss amorphous transformers as an extremely cost effective infrastructure upgrade that would not only provide guaranteed energy savings through reduced transformer losses but deliver substantial additional savings through inbuilt voltage management capabilities, the trust sourced seven replacement supply transformers.

This case study provides power quality data for TX1 and TX2 replacement at the acute substation (pre and post install) as well as energy savings projections.

THE FINDINGS

(FROM A REPORT BY AN INDEPENDENT POWER QUALITY MANAGEMENT COMPANY)

The measurements show that the installation of the Super Low loss Amorphous Transformer, combined with a 6.3% (TX1) and 6.6% (TX2) voltage reduction, has reduced the kWh used.

The measurements taken before installation and those with the super low loss transformer on Tap 3 shows a 5.9% (TX1) and 6.0% (TX2) reduction in kWh. The savings are estimated to be £31,010 p.a. total (based on 9p/kWh).

The kWh reduction can be trended long term using the electricity supplier's half hourly averaged value data.

The reduction in voltage has also improved the site power factor.

ENERGY SURVEY SCOPE

With the installation of two Wilson e2 Super Low Loss Amorphous Transformers at site, a Load Survey was conducted to quantify the energy savings. This case study presents the recorded Power before and after the new transformer was installed.

Power analysing monitoring equipment was connected at each main incoming LV supply and left in situ for 17 days. The data shows the before and after installation readings.

GENERAL INFORMATION

VOLTAGE

The voltage supplied to many sites is higher than it needs to be. The network operator often keeps the Primary Voltage high to reduce transmission losses while keeping the voltage within statutory limits for all customers on the network.. In 2008 the final stage of the European Voltage Harmonisation came into place setting the voltage levels to 230V ± 10% (see Appendix A); the statutory limits for voltage are now from 207 to 253V phase-neutral.

Most sites have a L-N voltage of 240V or higher giving rise to equipment running at inappropriate levels resulting in additional costs. Reducing and maintaining the voltage at the most favourable level is an established way to significantly reduce energy consumption and costs whilst having the additional benefits of reduced maintenance and increased equipment life.

POWER EFFICIENCY

The efficiency of a supply is expressed as a 'power factor' (pf) where 1.0 (unity) is ideal and anything below 0.95 is highly likely to attract significant penalty charges. Power Factor Correction (PFC) equipment is installed to ensure that the pf is automatically maintained above the charging threshold of 0.95. The correct type and rating of this equipment is based upon the total power, the uncorrected pf, and levels of harmonic currents.

LOAD SUMMARY - TX1

In order to remove the load changes as a result of weekend loading, the before data is taken from 11/05/2014 06:30 to 17/05/2014 05:30 and the after date from 18/05/2014 06:30 to 24/05/2014 06:30.

PRE WORKS SURVEY WITH PREVIOUS STANDARD TRANSFORMER - TX1

	Amps				kVA	kW	kvar	PF
	L1	L2	L3	N				
Max	843.6	725.2	779.3	248.0	556.4	541.4	129.0	0.99
Min	521.3	478.3	471.1	124.6	364.4	348.0	98.9	0.97
Average	666.2	595.1	608.0	176.3	453.5	438.4	115.4	0.98

* Power Factor given at stated kVA value

	Volts		
	L1-N	L2-N	L3-N
Max	245.3	245.7	247.3
Min	238.1	238.4	239.8
Average	242.0	242.2	243.8

Recorded Energy	7 Day	Year
kWh	73,646	3,840,113
kvarh	19,394	1,011,259

AFTER NEW TRANSFORMER INSTALLATION TX1

	Amps				kVA	kW	kvar	PF
	L1	L2	L3	N				
Max	822.5	740.3	769.3	235.2	515.6	504.2	112.7	0.99
Min	525.5	489.4	485.5	112.2	346.5	334.2	87.5	0.98
Average	661.7	600.8	610.7	159.3	425.7	413.6	102.4	0.99

* Power Factor given at stated kVA value

	Volts		
	L1-N	L2-N	L3-N
Max	230.0	230.2	231.3
Min	222.8	223.4	224.4
Average	226.8	226.8	228.2

Recorded Energy	7 Day	Year
kWh	69,482	3,622,990
kvarh	17,202	896,961

VOLTAGE OPTIMISATION SAVINGS – TX1

The voltage reduction of 6.3% (11000/415V Transformer) shows a saving of 5.7% which equates to 217,123kWh (£19,541 gross), based on the yearly kWh estimated in 2.1 above.

FINANCIAL SAVINGS – TX1

Substation Details	Tap Settings	Transformer Size	Transformer Load Factor
TX1	3	1000kVA	41.8%

No Load Loss Annual Saving (per annum)*	Load Loss Annual Saving (per annum)#	Voltage optimisation Annual Saving	CRC Saving	Total Annual Saving
£670	£1,968	£19,541	£1,367	£23,546

* Using a super low loss transformer
#All monetary values are based on 9p/kWh

LOAD SUMMARY - TX2

In order to remove the load changes as a result of weekend loading, the before data is taken from 11/05/2014 06:30 to 17/05/2014 05:30 and the after date from 18/05/2014 06:30 to 24/05/2014 06:30.

PRE WORKS SURVEY WITH PREVIOUS STANDARD TRANSFORMER - TX2

	Amps				kVA	kW	kvar	PF
	L1	L2	L3	N				
Max	314.3	256.1	283.2	105.2	205.2	197.6	59.0	0.98
Min	100.5	99.2	103.3	0.3	75.3	73.1	16.0	0.93
Average	184.7	165.4	175.6	25.2	128.4	123.7	32.8	0.97

* Power Factor given at stated kVA value

	Volts		
	L1-N	L2-N	L3-N
Max	247.3	247.6	249.3
Min	239.9	239.9	241.7
Average	243.8	243.9	245.6

Recorded Energy	7 Day	Year
kWh	20,784	1,083,737
kvarh	5,517	287,672

AFTER NEW TRANSFORMER INSTALLATION TX2

	Amps				kVA	kW	kvar	PF
	L1	L2	L3	N				
Max	315.3	250.0	280.2	113.3	190.6	185.6	47.3	0.98
Min	104.8	97.7	103.0	0.0	70.6	68.4	4.2	0.94
Average	186.3	163.1	175.2	29.3	119.8	116.3	27.0	0.98

* Power Factor given at stated kVA value

	Volts		
	L1-N	L2-N	L3-N
Max	231.0	231.5	232.4
Min	224.1	224.4	225.6
Average	227.8	228.0	229.2

Recorded Energy	7 Day	Year
kWh	19,542	1,018,976
kvarh	4,531	236,259

VOLTAGE OPTIMISATION SAVINGS – TX2

The voltage reduction of 6.6% (11000/417V Transformer) shows a saving of 6.0% which equates to 64,761kWh (£5,828 gross), based on the yearly kWh estimated in 3.1 above.

FINANCIAL SAVINGS – TX2

Substation Details	Tap Settings	Transformer Size	Transformer Load Factor
TX12	3	1000kVA	11.9%

No Load Loss Annual Saving (per annum)*	Load Loss Annual Saving (per annum)#	Voltage optimisation Annual Saving	CRC Saving	Total Annual Saving
£670	£558	£5,838	£408	£7,464

* Using a super low loss transformer
#All monetary values are based on 9p/kWh

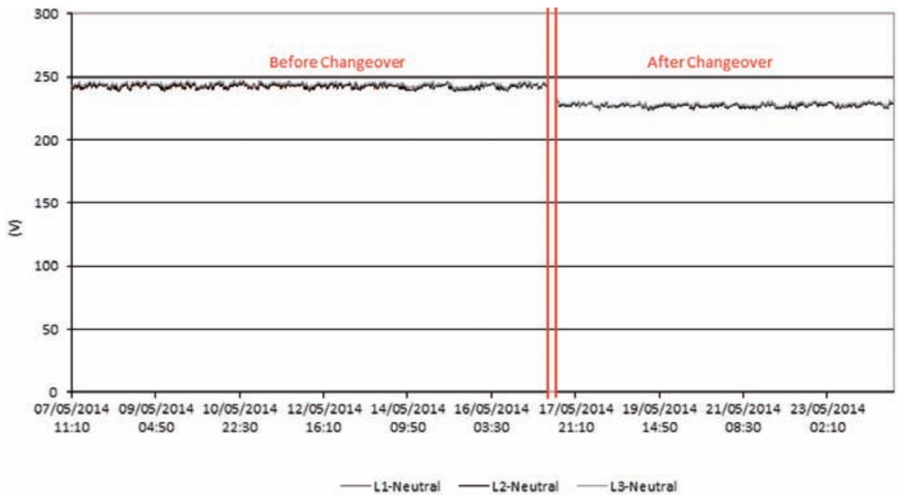
GRAPHICAL RECORDED POWER DATA

The following results show the electrical characteristics present for the before/ after period.

V

VOLTAGE DATA - TX1

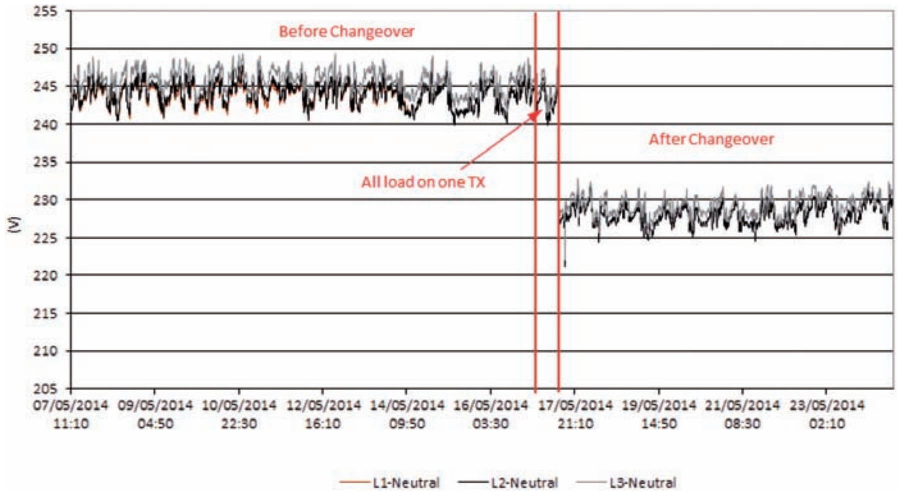
The following graph details the recorded RMS voltage for the supply.



V

VOLTAGE DATA - TX2

The following graph details the recorded RMS voltage for the supply.



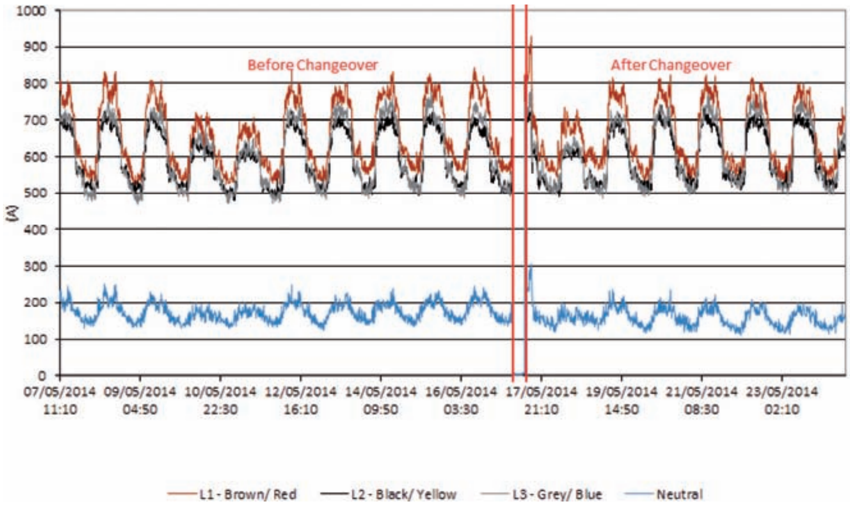
GRAPHICAL RECORDED POWER DATA CONTINUED

The following results show the electrical characteristics present for the before/ after period.

V

CURRENT DATA - TX1

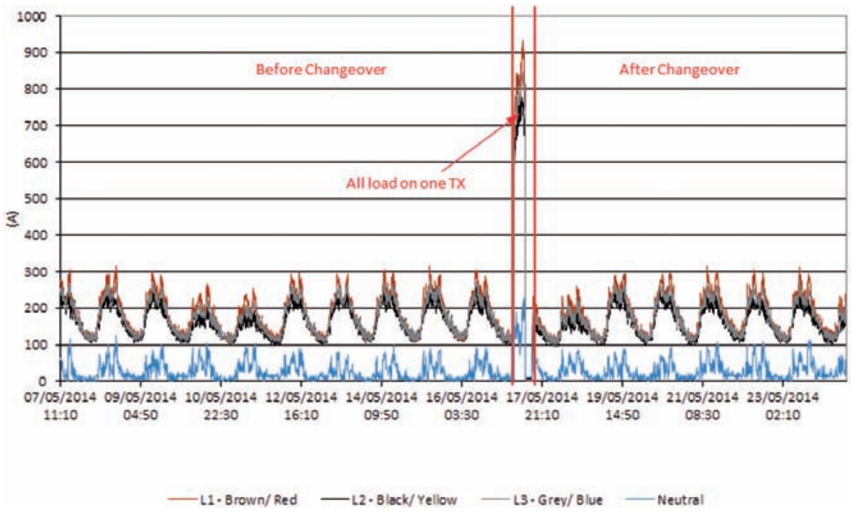
The following graph details the recorded RMS voltage for the supply.



V

CURRENT DATA - TX2

The following graph details the recorded RMS voltage for the supply.



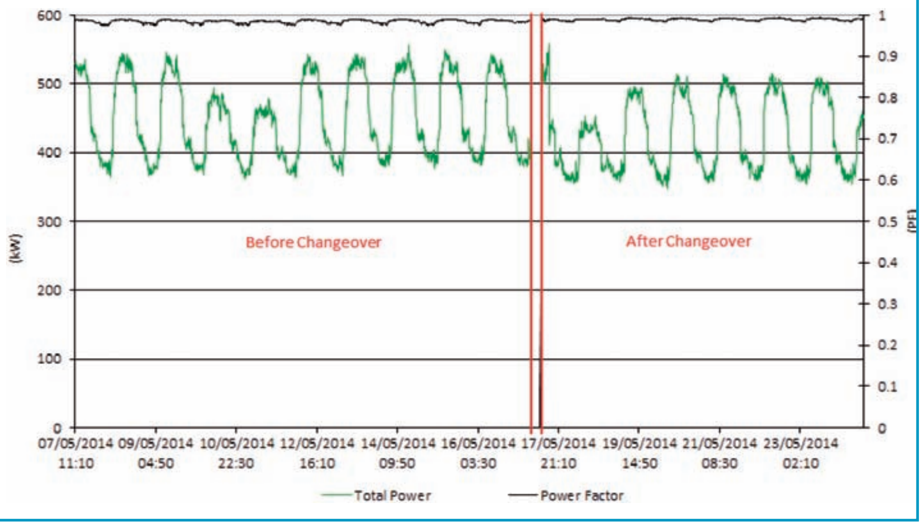
GRAPHICAL RECORDED POWER DATA CONTINUED

The following results show the electrical characteristics present for the before/ after period.

kW

POWER DATA - TX1

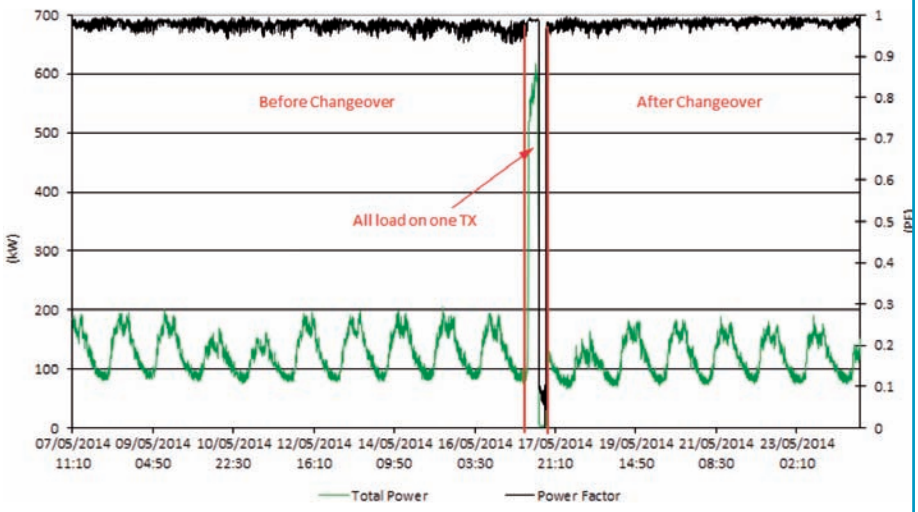
The following graph details the recorded RMS voltage for the supply.



kW

POWER DATA - TX2

The following graph details the recorded RMS voltage for the supply.



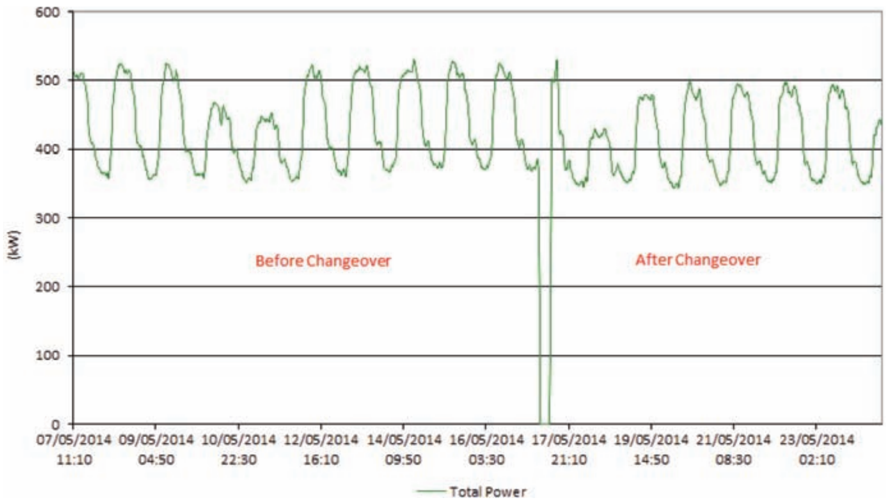
GRAPHICAL RECORDED POWER DATA CONTINUED

The following results show the electrical characteristics present for the before/ after period.

kW

AVERAGE POWER DATA – TX1

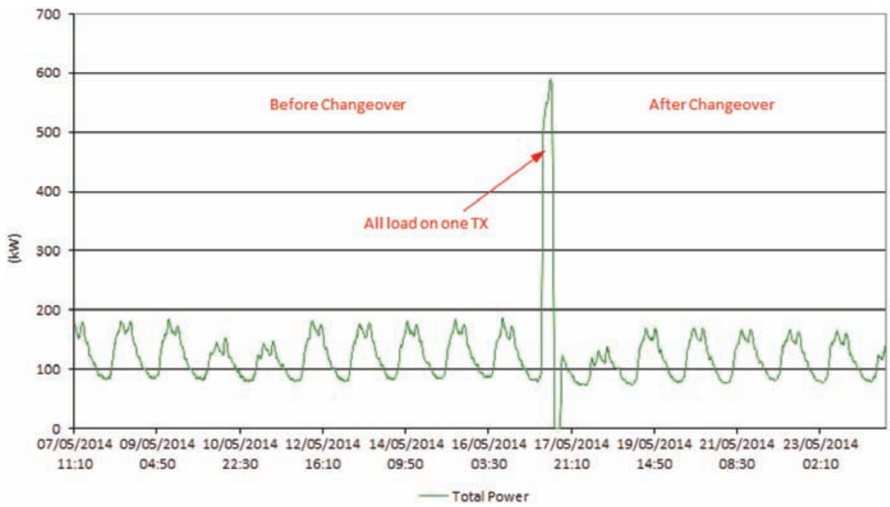
The following graph details the recorded RMS voltage for the supply.



kW

AVERAGE POWER DATA – TX2

The following graph details the recorded RMS voltage for the supply.



APPENDIX A - EUROPEAN VOLTAGE HARMONISATION

Up until January 1995 the nominal supply voltage in the UK was 240/415V +/- 6%. In Europe the nominal standard was 220/380V +/- 6%.

Following European harmonisation standards coordinated by The European Committee for Electro-technical Standardisation (CENELEC)1, all electricity supplies within the EU are now nominally 230V +/-10%2. The statutory band that electricity network operators have to supply within is therefore between 216.2 and 253V for single phase and 380V to 440V for three phase. Customers can expect to remain within these limits except in abnormal circumstances, which are described in the Grid Code.

These limits enable countries such as the UK who previously supplied at 240V nominal to continue, thus reducing the need for considerable investment in distribution infrastructure to accommodate the new nominal voltage. The continued deviation in the UK from harmonised European voltage has been criticised in particular by light bulb manufacturers. The higher voltage reduces significantly the lifetime of their product.

The next stage in the European harmonisation process was scheduled to take place in the UK in 2010 with voltage supply range in the UK broadened to 207 and 253V (+/-10%)3. Most equipment manufactured for use in Europe is typically rated at 230V (or even 220V) meaning that it could be running as much as 33V above the rated voltage.

Effective Date	Nominal voltage (Ph-N)	Permitted tolerance	Permitted voltage range
Pre-1995	240V	+6% / -6%	225.6 - 254.4V
01 January 1995	230V	+10% / -6%	216.2 - 253.0V
April 2010 (proposed)	230V	+10% / -10%	207.0 - 253.0V

[1] CENELEC Document HD 472 S1:1988

[2] Harmonised standard BSEN50160: 2000

[3] BS 7697

APPENDIX B - CONNECTED LOAD/ SAVINGS

Electrical Load Type	Effect of VO	Comments
General lighting Scheme (GLS) Incandescent lighting.	Energy savings achievable	Life of lamps will increase. Tungsten filament lamps will have reduced illumination. GLS phased out by 2011.
Compact Fluorescent Lamps	No energy saving as constant power control	If voltage drops below statutory levels lamp may extinguish
High Frequency (HF) electronic ballast lighting	Energy savings achievable	If voltage drops below statutory levels lamp may extinguish
Magnetic ballasts fluorescent lighting	Energy savings achievable	Specialist lighting voltage optimisation may provide greater savings
Industrial discharge lighting	Energy savings achievable	High Pressure Sodium (SON, SONT), High Pressure Mercury (MBF), Metal Halide & other high bay installation. Specialist lighting voltage optimisation may provide greater savings.
Fixed Speed Linear motors (DOL)	Energy savings achievable on oversized and lightly loaded motors	Reduced torque capability so may not be suitable for high torque applications (lifts etc).
Motors controlled by Variable Speed Drives (VSD)	No energy savings achievable	
Electrical heating (with temperature control)	No energy savings achievable	
Switch Mode Power Supplies (SMPS) – IT/ Electronic equipment	Possible energy saving	Equipment should operate satisfactorily if voltage is kept within statutory levels. Although the output is regulated regardless of input, losses are reduced proportional to voltage.

APPENDIX C - GLOSSARY OF TERMS

Term/ Abbreviation	Comments
Harmonic	Some electrical equipment such as variable speed drives and regulated power supplies (see Non-linear Load) can impose electrical interference or 'harmonics' onto the electricity supply. This can increase the energy consumption of some items e.g. transformer losses, and can cause interference with other equipment. Site operators are obliged to keep harmonics within specified limits. See G5/4-1 (2005) below.
G5/4-1 (2005)	Planning levels for Harmonic Voltage Distortion and Connection of Non Linear Equipment to Transmission Systems and Distribution Networks in the UK.
Fault Level	Fault level provides an indication of current flow under fault conditions and reflects the strength of an electrical network; the higher the fault current level the stronger the network. Harmonic current and voltage distortion impact is heavily influenced by system Fault Level.
Non-Linear Load	Any load or connected equipment which has a waveform that is non sinusoidal when powered by a sinusoidal voltage. These include and load which controls to supply current to given energy efficiency or control. Typical loads are Variable Speed droves, UPS, Generators, and lighting
High Voltage (HV)	Above 1000Vac
Low Voltage (LV)	Below 1000Vac
Network Operating Company (NOC)	The electricity supplier who owns the network where the site is located. This is normally not the company who provides the electricity billing.
Point of Common Coupling (PCC)	This is the point where the user and other network customers are on the same voltage/ supply point. In may cases this is where the metering Current Transformers are located. In the UK this can be 400V, 11kV, 11kV, 33kV, 132kV, and 400kV
Power Factor	The ratio of useful power to total power as drawn from an AC supply by an electrical device or installation. In most instances a poor power factor is caused by the magnetising power required by equipment such as electric motors. The cables within electricity supply networks and on sites need to deliver the total power (useful and magnetising power) and one implication of poor power factor is that it can reduce the capacity of cables etc to deliver useful power.

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