CASE STUDY OO6

Power Factor Improvement Reduces Electricity Cost at the University of Ghana, Legon

Automatic Capacitor Banks in a Metal Case

What is power factor?

An electrical system may comprise different types of load: - resistive, inductive, and capacitive elements.

The significance of these different types of load is that true or useful power can only be consumed in the resistive part of the load, where the current is in phase with the voltage.

However, the total (apparent) power used includes non-productive power consumed in the inductive and capacitive elements. The ratio of true power to apparent power is known as the power factor. For an ideal, pure resistor, the power factor would be 1. When the actual ratio is less than 1, it means that some of the current drawn from the electricity supplier is non-productive.

Why improve power factor?

Owing to the nature of the machinery that generates alternating current (AC) voltage, the power factor of the connected circuits has a direct bearing on the cost of such generation.

The lower the Power Factor of an electrical system, the greater will be the non-productive current drawn from the supply, and the power utilities will have to generate much more current than is theoretically required to meet the demand. The power supply system becomes inefficient, and the cost of electricity is correspondingly increased. Low power factor also means that the size of cabling, switchgear, fuse gear and transformers will all have to be greater than necessary and therefore more costly. In such cases, an improvement in power factor is necessary to reduce waste.

To ensure that the generators and cables are not overloaded with reactive current, power utilities often impose penalties for low power factor.

What elements constitute Industrial electricity bills?

Industrial electricity bills in Ghana comprise several billing elements, namely:-

Maximum demand in **kVA,**
Electrical Energy Consumption in **kWh**,
Power Factor surcharge,
National Electrification Scheme (NES) Levy per kWh,
Street Lighting Levy per kWh, and a Service Charge.

How can electricity costs be controlled?

The industrial/commercial electricity user in Ghana can reduce costs by:-

a) Reducing the maximum demand.
b) Reducing the electrical energy consumption.
c) Improving power factor to avoid paying Power Factor Surcharges.

***What is maximum demand*?**

The kVA maximum demand charge is levied against the ***highest*** *kVA* demand a consumer makes on the electricity supply system over a period of ***30 minutes***, during the month.

kVA = kW/pf, **(1)**
where,
kW is actual power consumed;
pf is the power factor of the consumer's system.

How is power factor surcharge applied?

Power Factor surcharges were introduced in January 1995 and consumers whose plant power factors are below a threshold value of 0.90 are levied with a surcharge according to the following formula:-

$$PFS = \frac{(0.90 - Pf_{actual})}{0.90} \times MD \times MD_{charge}, \qquad (2)$$

where,

MD is the Maximum Demand for the month in kVA,

MD_{charge} is the maximum demand charge per kVA, set by the PURC in the tariffs.

Pf_{actual} is the actual power factor of the consumer's system, measured by the demand meters installed by the utilities.

Unlike taxes or levies, the Power Factor Surcharge is avoidable. It is therefore highly recommended for industrial (including mining) and commercial consumers to avoid this surcharge by improving plant power factor to 0.90 or above.

HOW TO IMPROVE POWER FACTOR

1. USE OF CAPACITOR BANKS.

For inductive loads, which are much more common, the simplest method to improve power factor is to install capacitors across the input lines feeding the affected equipment. This is done by energy service engineers who use special equipment to determine the size of capacitor necessary.

Metal Case containing Automatic Capacitor Banks

2. USE OF SYNCHRONOUS MOTORS.

Where synchronous motors are used, an improved power factor may be obtained by adjusting the field excitation of the motors. Synchronous motors used in this way are termed synchronous condensers.

The use of this method is however limited to cases where the synchronous motors are in constant use to provide the required field excitation at all times. The high cost of such motors is also a limiting factor to its widespread use.

Whichever method is used, Power Factor Correction should always be regarded as an investment with two main objectives:

• Reducing electricity costs
• Freeing transformer, cable, and switchgear capacity.

Other benefits of power factor improvement

Some of the other benefits that can be derived from power factor improvement are:-

1. Voltage improvement. The capacitors reduce the reactive current being drawn, thus the total current drawn is reduced therefore the voltage drop on the load is reduced.

2. Increased system capacity. The improved power factor will result in a reduced line current; thus it is possible to release extra capacity from an existing supply by improving the power factor.

3. Reduction in cable rating. The installation of capacitors reduces the nominal line current, thus lower-rated cables, which are cheaper, can be utilised when supplying a given load in conjunction with capacitors.

Power Factor Improvement at the University of Ghana, Legon

As part of measures adopted by government to reduce recurrent expenditure, the Ministry of Energy is installing Power Factor Correction equipment in five tertiary institutions. The first of the five to benefit is the University of Ghana, Legon where 26 capacitor banks were installed on transformers that serve the various halls and academic facilities of the University.

The activity was implemented by the Energy Foundation on behalf of the Ministry of Energy. The contract for the supply and installation of equipment which was specified by the Energy Foundation was executed by AB Management & Agency Ltd, a local energy management firm and one of the few contract energy managers in the country. Equipment installation was completed in November 2005.

Results

The first results of the effect of the installation on the electricity bills of the University appeared in December when the bill for the first full month after the installation was presented. Since then energy consumption for January and February 2006 have been collected for analysis.
From the preliminary analysis the following conclusions can be drawn.

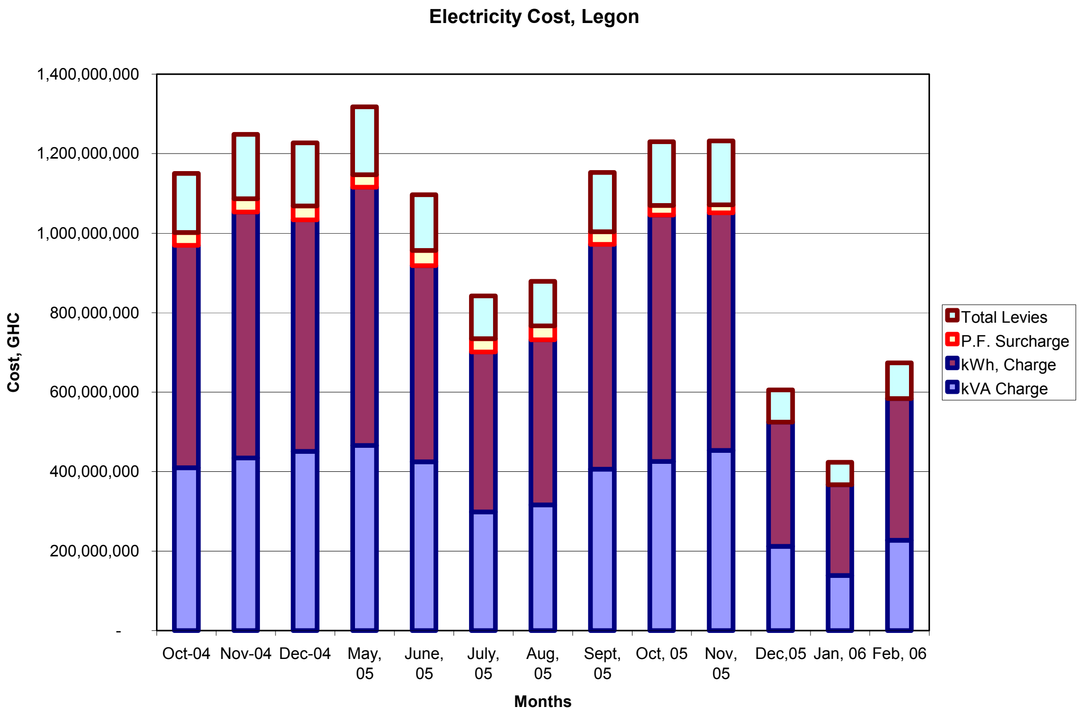

Fig. 1. Electricity Cost components over time.

The total cost of electricity to the University has reduced from an average of ¢1.28 billion a month between October 2004 and November 2005, to a three-month average of ¢643million in December 2005 and January 2006. In December 2004 the University paid a total of ¢1.38billion on electricity.

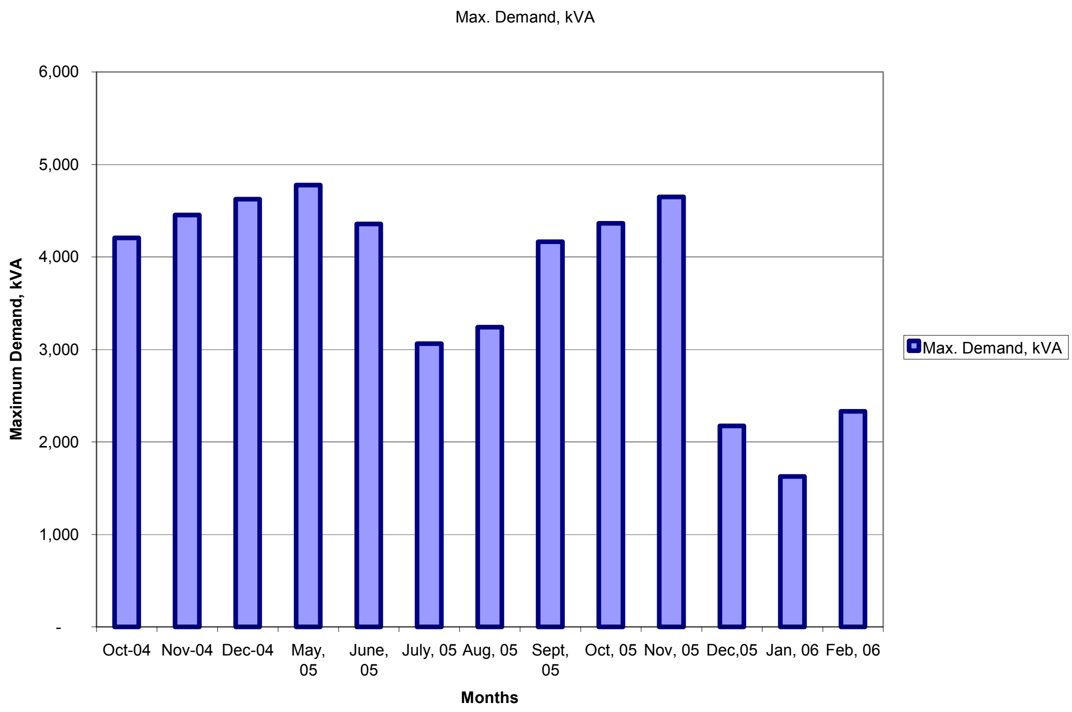

Fig. 2. Reduction in Maximum Demand as a result of capacitor installations

The reduction has been mainly due to a reduction in Maximum Demand from 4,659kVA in November 2005 to 2,175kVA in December and further to 1,627kVA in January 2006. As a result of the installation Power Factor has improved from an average of 0.83 to 1. Power Factor Surcharge which averaged ¢28.5million per month has been totally eliminated.

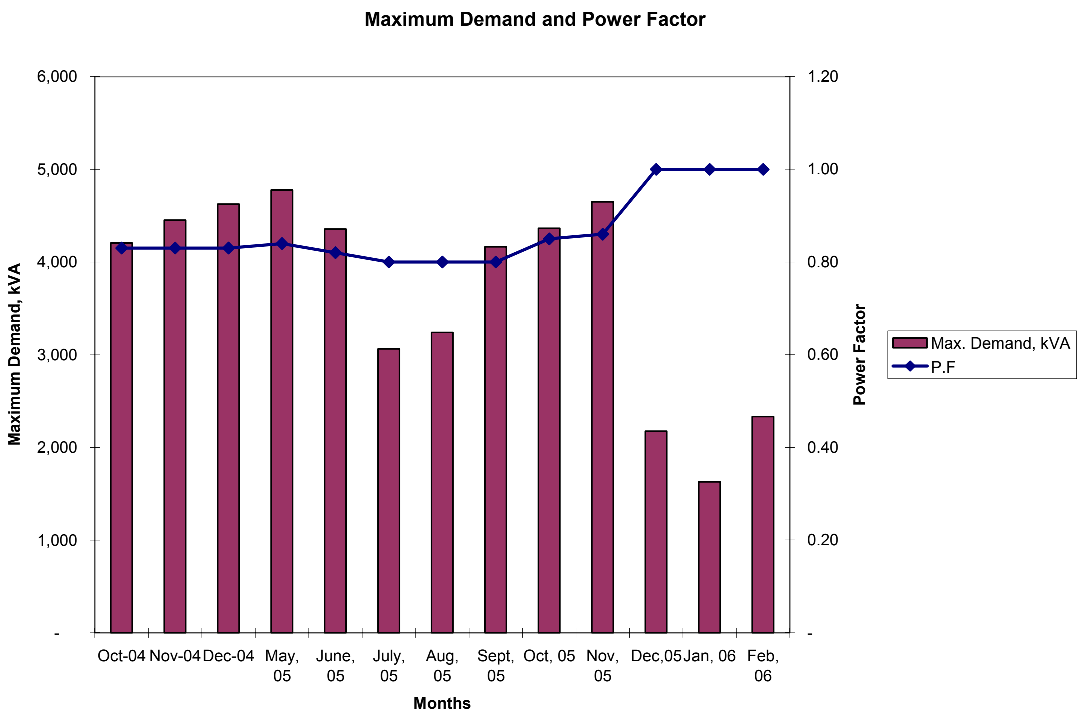

Fig. 3. Improvement in Power Factor is always associated with Demand Reductions

A remarkable achievement is the reduction in energy use and consequent cost. It is important to note that the University is supplied power at 11kV and is metered at a bulk meter point before power is distributed to the various transformers scattered throughout the campus. The installation of the capacitors has reduced cable losses, (I^2R) losses to such an extent that actual electricity consumption has reduced. It is important also to note that in December 2004, the University consumed 1,525,130kWh of electricity as against 819,131kWh in December 2005.

Cost Savings

Compared to the electricity cost profile before the installation, the University of Ghana is saving an average of ¢641.49million a month. This means that the cost reduction for the University of Ghana alone is enough to pay for the installations in all the five tertiary institutions in less than 4 months. The total cost of the installations in all the five institutions namely University of Ghana, Legon, University College of Education, Winneba, GIMPA, University of Cape Coast and KNUST was ¢1.9billion.

ENERGY FOUNDATION

For further details on how you can improve power factor including financing options, contact the Energy Foundation at 5 East Legon, Tetteh Quarshie Interchange – Legon Road, East Legon. P.O. Box CT 1671, Accra Tel: +233-21-515610 - 12
e-mail: info@ghanaef.org
URL: www.ghanaef.org