FACT SHEET OO1

POWER FACTOR IMPROVEMENT SAVES MONEY !!!

Power Factor Improvement

Automatic Capacitor Banks in a Metal Case

The Energy Cost Situation

The cost of electricity in Ghana has increased significantly in recent times. Although electricity tariff adjustments that took effect on August 1st 2002, did not include any increases in kWh energy charges, significant changes were made to the kVA demand charges.

The implication is that industrial consumers could pay more for electricity. On the other hand, such consumers now have the opportunity to reduce their electricity bills significantly by taking steps to reduce their maximum demand and by improving the power factor of their electrical systems.

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, 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.

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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.

$$\mathbf{kVA = kW/pf,} \qquad \mathbf{(1)}$$

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:-

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

where,

MD is the Maximum Demand for the month in kVA,

$\mathbf{MD_{charge}}$ is the maximum demand charge per kVA, set by the PURC in the tariffs. Effective August 1st 2002, the Maximum Demand charge in operation are as follows:

For Low Voltage (LV) consumers i.e. consumers who take power at 415V, the MDcharge is ¢130,000,

For Medium Voltage (MV) consumers i.e. consumers who take power at 11,000V, the MDcharge is ¢82,000; and

For High Voltage (HV) consumers i.e. consumers who take power at 33,000V the MDcharge is ¢74,000.

$\mathbf{Pf_{actual}}$ 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.

Table 1. Examples of Annual Power Factor Surcharge payable by Low Voltage (LV) Special Load Tariff (SLT) Consumers with effect from 1st August 2002 for Maximum Demand Values and corresponding power factor from 0.5 to 0.90.

Maximum	*Power Factor*				
Demand(kVA)	*0.5*	*0.6*	***0.7***	*0.8*	*0.9*
100	69,333,333	52,000,000	**34,666,667**	17,333,333	0
150	104,000,000	78,000,000	**52,000,000**	26,000,000	0
200	138,666,667	104,000,000	**69,333,333**	34,666,667	0
250	173,333,333	130,000,000	**86,666,667**	43,333,333	0
300	208,000,000	156,000,000	**104,000,000**	52,000,000	0
350	242,666,667	182,000,000	**121,333,333**	60,666,667	0
400	277,333,333	208,000,000	**138,666,667**	69,333,333	0
450	312,000,000	234,000,000	**156,000,000**	78,000,000	0
500	**416,000,000**	**260,000,000**	**173,333,333**	86,666,667	0
550	381,333,333	286,000,000	190,666,667	95,333,333	0
600	416,000,000	312,000,000	208,000,000	104,000,000	0
650	450,666,667	338,000,000	225,333,333	112,666,667	0
700	485,333,333	364,000,000	242,666,667	121,333,333	0
750	520,000,000	390,000,000	260,000,000	130,000,000	0
800	554,666,667	416,000,000	277,333,333	138,666,667	0
850	589,333,333	442,000,000	294,666,667	147,333,333	0
900	624,000,000	468,000,000	312,000,000	156,000,000	0
950	658,666,667	494,000,000	329,333,333	164,666,667	0
1000	693,333,333	520,000,000	346,666,667	173,333,333	0

Note: From the table, a consumer whose maximum demand is 500kVA and is operating at a power factor of 0.70 will pay an annual power factor surcharge of ¢173,333,333. The surcharge can be avoided if the consumer improves the plant power factor to 0.90 or above. Figures are based on the August 2002 tariff structure and could change in the future if the tariff structure changes.

Apart from the avoidance of the power factor surcharge, consumers can also enjoy a reduced electricity bill as a result of improved power factor. As it is shown in equation (1) improving power factor results in reduced maximum demand and hence reduced electricity bills. The reduction in maximum demand charge is approximately equal to the avoided power factor surcharge. Power factor improvement above 0.90 does not only avoid the surcharge but also results in the reduction in maximum demand.

It is therefore recommended that consumers improve power factor to as close to unity as possible. A power factor of 0.95 is a good value. Table 2 shows the total savings that can be made if a consumer improves power factor to 0.95. The saving is made up of avoided power factor surcharges and reduced maximum demand charges.

Table 2. Examples of Annual Energy Cost Savings that can be made by an SLT, LV consumer if steps are taken to improve power factor from the corresponding power factor values to 0.95. Although the power factor surcharge is avoided once a power factor of 0.90 is achieved, further savings can be made if the power factor is further improved to 0.95. It is therefore always advisable to improve power factor beyond 0.90. A power factor of 0.95 is recommended.

Maximum	*Power Factor*				
Demand(kVA)	*0.5*	*0.6*	***0.7***	*0.8*	*0.9*
100	143,228,070	109,473,684	**75,719,298**	41,964,912	8,210,526
150	214,842,105	164,210,526	**113,578,947**	62,947,368	12,315,789
200	286,456,140	218,947,368	**151,438,596**	83,929,825	16,421,053
250	358,070,175	273,684,211	**189,298,246**	104,912,281	20,526,316
300	429,684,211	328,421,053	**227,157,895**	125,894,737	24,631,579
350	501,298,246	383,157,895	**265,017,544**	146,877,193	28,736,842
400	572,912,281	437,894,737	**302,877,193**	167,859,649	32,842,105
450	644,526,316	492,631,579	**340,736,842**	188,842,105	36,947,368
500	**716,140,351**	**547,368,421**	**378,596,491**	209,824,561	41,052,632
550	787,754,386	602,105,263	416,456,140	230,807,018	45,157,895
600	859,368,421	656,842,105	454,315,789	251,789,474	49,263,158
650	930,982,456	711,578,947	492,175,439	272,771,930	53,368,421
700	1,002,596,491	766,315,789	530,035,088	293,754,386	57,473,684
750	1,074,210,526	821,052,632	567,894,737	314,736,842	61,578,947
800	1,145,824,561	875,789,474	605,754,386	335,719,298	65,684,211
850	1,217,438,596	930,526,316	643,614,035	356,701,754	69,789,474
900	1,289,052,632	985,263,158	681,473,684	377,684,211	73,894,737
950	1,360,666,667	1,040,000,000	719,333,333	398,666,667	78,000,000
1000	1,432,280,702	1,094,736,842	757,192,982	419,649,123	82,105,263

Note: From Table 2, a consumer whose maximum demand is 500kVA and is operating at a power factor of 0.70 will save an amount of ¢378,596,491 if power factor is improved to 0.95. The cost saving is made up of avoided power factor surcharge of ¢173,333,333 (see table 1) and avoided maximum demand charge of ¢205,263,158.

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 Circle- Road, Legon. P.O. Box CT 1671, Accra
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