Power Factor:

This section consists of the following:

1. What is Power factor?
2. Why Improve Power Factor?
3. How can Power Factor be improved?
4. How does Demand Billing work?

What is Power factor?

Power Factor is a measure of the efficiency of an electrical system.

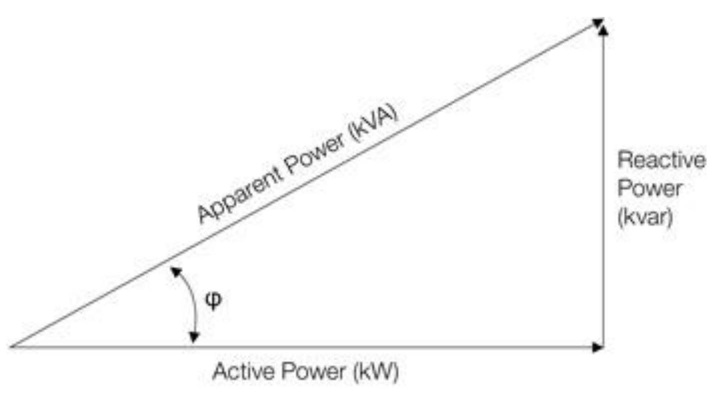
The apparent or total electrical power (Kilo Volt Amperes or kVA) used in an electrical system by an industrial or commercial facility has two components:

- Productive Power (Kilowatts or kW) which produces work.
- Reactive Power (Kilo Volt Amperes Reactive or kVAR) which generates the magnetic fields required in inductive electrical equipment (AC motors, transformers, inductive furnaces, ovens, etc.)

While the inductive electrical equipment employing magnetic fields requires this Reactive Power, it produces no productive work. Therefore , the Total Power (kVA) provided by the generating source (your utility) must always be greater than the Productive Power (kW).

The ratio of Productive Power (kW) to Total Power (kVA) is called the Power Factor (PF = kW / kVA). It is a measure of the systems electrical efficiency in an alternating current circuit and is represented as a % or a decimal.

Power Factor Triangle:



Power triangle

The relationship between kVA, kW and kVAR is non-linear and is expressed: as: $kVA^2 = kW^2 + kVAR^2$

In almost all industrial facilities where Demand charges apply, utility companies charge a penalty for poor power factor. Poor power factor is most often corrected through the use to Power Factor Correction banks.

Why Improve Power Factor?

Some of the most important reasons for improving Power Factor are:

1. To Reduce Utility Power Billing

> Electrical Utilities charge a penalty for poor power factor which can be quite substantial approximating 20-40% of the Demand Charges plus high I^2R Losses. Therefore a key reason is to eliminate needless financial losses.

2. To Increase System Capacity

> Improving Power Factor releases system capacity and permits additional loads (motor, lighting, etc...) to be added without overloading the system. In a typical system with a PF=0.80, only 800kW of productive power is able to be used out of a 1000kVA installed. By correcting the system to unity (Pf=1.00) the kW will equal the kVA. Now the corrected system will support 1000kW. Resulting in an increase of 200 KW over the uncorrected condition.

3. Improved System Operating Characteristics

A good power factor (PF=0.95) provides a "stiffer" voltage. Typically a 1-2% voltage rise can be expected when PF >= 0.95.

Improving Power Factor will also lower losses in the distribution system of the facility since losses are proportional to the square of the current.

Regardless of why you improve the electrical systems Power Factor it will provide a combination of all the things listed above.

How can Power Factor be improved?

Power Factor can be improved by one or more o the following methods:

1. the replacement of existing motors with more energy efficient ones
2. ensuring motors are properly sized for their application and duty cycle
3. the use of high power factor lighting ballasts
4. the Installation of Power Capacitors.

In general, the installation of Power Capacitors the most cost-effective method of improving Power Factor.

Ideally, to derive the maximum benefit, properly sized static capacitor banks should be located as close as possible to the offending loads. However, this may not be the most cost effective method of correction due to the sheer number of static capacitor banks that are required in a large electrical environment.

A more economical method is the installation of a centrally located Automatic switching Power Factor Correction bank (APFC). This capacitor bank is controlled by a microprocessor-based relay, which continually monitors the reactive power requirements. The relay then connects or disconnects capacitors to supply capacitance as needed.

Hybrid solutions are often the most cost-effective, wherein static capacitor banks are placed at strategic locations throughout the facility, while an APFC is used to handle the remaining requirements for capacitance at a central location. Generally, APFCs are placed centrally at the main electrical panel.

Regardless of which strategy is implemented careful planning should be undertaken to ensure maximum benefit is derived from the correction. Other factors that need to be taken into consideration during this planning phase are

1. Harmonics on the electrical system
2. future expansions to the facility.

How does Demand Billing work?

To best explain how Demand Billing works lets start with some real world readings and examine them as they are used by a utility when billing. Then we will look at ways to possibly decrease the amount we have to pay for our power through the use of Power Factor Correction equipment.

If you do not understand the components that make up your electrical systems Demand (kW, kVA, kVAR) , please read the short article "What is Power Factor?" for an overview before proceeding.

Example: At the end of the billing period the utility records the following Peak reading numbers at your facility:

- kW = 100
- kVA = 150
- Power Factor = kW / kVA = 100 / 150 - 0.67 or 67%

These are the readings that the utility will use to determine your Demand Billing. You will have to check with your local utility to determine their rate schedule, but for our example we will use $9.00 per billed kW. The general billing practice (with few exceptions) are to apply their Demand rates to the GREATER of:

- 100% of the kW reading
- Or 90% of the kVA reading

Do not be misled by the term "Billed kW" as may be listed on your utility bill. This term is generically used only to indicate the reading value that rates are being applied to, not whether its kW or kVA as they would have you believe. Although "Billed kW" seems to infer that the demand is based on kW, this number may in fact be either the kW reading or 90% of the kVA reading depending on which is the largest and being used for billing purposes.

Example: Hydro One - Conditions of Service (2011 Brochure)

2.4.1.2 Components of Distribution Rates)

Hydro one Distribution Service Rates include a monthly service charge component and a volume-based component. For Demand Billed Customers, the volume Rate is a per kW charge. The billing demand shall be taken as 90% of the kVA or 100% of the measured demand in kW, whichever is greater. For Energy Only Customers, the volume Rate is a per kWh charge. The monthly service charge component is designed to recover some common costs of Distribution Services that are independent of electricity use. All other Distribution Service costs are recovered through the Volume Rate.

To determine what reading numbers the rates will be applied to in our example lets have a look:

- 100% of kW = 100
- 90% of kVA = 150 x 0.9 = 135
- As we can see, 135kVA is the greater number, thus rates will be applied to this reading.
- So, our Demand Billing (or Billed kW as it may be called) for this period would be 135 x $9.00 = $1,215.00.

Reducing Costs

Now that we know how much we are billed and on what readings we are billed lets look to see if we can reduce this cost.

In our example, rates were applied to 90% of the kVA reading because it was larger. Ideally, we would like to have rates applied to our kW because it is the smaller reading number. If we could do that then we could realize a reduction in our utility billing. Just how much:

Cost if rates were applied to the kW reading: kW x $9.00/kW = 100 x $9.00/kW = $900.00
The potential reduction to the Demand portion of our monthly electrical bill if rates were applied to the kW reading: $1,250.00 - $900.00 = $315.00 (that's a 28% reduction in demand costs)

So, what can we do to our electrical system so that rates are applied to the kW reading? The most economical way of doing this is through the installation of Power Factor Correction Capacitor Banks. Power Factor correction has been around as long as electricity has. It is the means through which we can tweak our electrical system to make it more energy efficient, and by doing so we can ensure that we are paying the least possible cost for our power.

By correcting the Power Factor in this example to above 90% ensures that no additional expenses are being incurred.

There are additional savings to be derived through correcting the power factor and power quality in your facility. Poor power factor and power quality also play a role in premature motor failures, shortened equipment life, electrical system downtime etc. Resolving these issues while ensuring maximum life expectancy and operation of motors and optimization of your electrical system can and often far exceed just the measurable saving derived through eliminating avoidable and measurable demand penalties that are paid to your utility on an ongoing basis. Typical payback periods are often 18 months or less depending on the requirements