Improving Load Factor and Power Factor to Reduce Demand

Potential Savings for Heavy Users of Electricity

Commercial, industrial, and institutional establishments that pay demand charges, that use relatively large amounts of electricity, or that have electrically-powered systems with potential for power factor problems may be able to reduce demand charges by improving load factor and power factor.

The amount of power required to operate energy-using fixtures and equipment is measured in terms of kilowatt (kW) demand. The kW demand charge is the charge for the highest power demand recorded for any 30-minute interval during the monthly billing period.

Improving Load Factors

Load factor (expressed in terms of percentage) is a measure of the uniformity and efficiency with which electrical energy is being used. A good load factor implies a more constant rate of electrical use, because kW demand is held to a minimum relative to total overall use. In essence, the lower the established demand in relation to kilowatthour (kWh) use, the better the load factor, the lower the relative cost for electric service.

While load factor is one element in calculating the efficiency with which electricity is used, load factor ratios are not normally stated in billing information. Most billing information, however, provides sufficient information to determine load factor ratios using the following formula:

\[
\text{Load Factor (\%)} = \frac{\text{Energy Used (in kWh)}}{\text{Maximum Demand (in kW)}} \times \frac{1}{\text{Time (hours in billing period)}}
\]
For example, if 100,000 kWh are consumed over a monthly billing period (730 hours) and during that time a peak demand of 214 kW is established, the load factor would be 64 percent. Representative ranges for load factor in facilities without specific load factor improvements could be:

- Facilities with a 1-shift operation - 35 percent
- Facilities with a 2-shift operation - 60 percent
- Facilities with a 3-shift operation - 80 percent.

The load factor curve shown in Figure 1 shows how load factor improvement can lower your average energy cost. The consumer may improve his load factor in several ways. Among these are:

- Arranging work schedules to reduce peak load by shifting some electrical use to other time periods.
- Using interlocks to prevent simultaneous operation of selected equipment.
- Using heat and cool storage equipment to reduce peak load (see Figure 2).
- Staggering preheating times on process or space heating applications.
- Using demand controllers to limit kW demand in facilities where some power loads can be deferred.
- Adding off-peak energy usage.

Although cool storage may not necessarily reduce your building's overall energy consumption, it can significantly reduce your building's on-peak demand and lower your overall energy expenses as these charts illustrate.

**Improving Power Factors**

Most electrically-powered machinery and equipment requires two kinds of power -- real, usually expressed in kilowatts (kW) and reactive, usually expressed in kilovolt amperes reactive (kVAR). The real power is the work-producing power. Reactive power supplies the magnetizing field required by motors, generators, transformers, and other inductive equipment. The power being supplied is called the apparent power and is usually expressed in kilovolt amperes (kVA). The apparent power must be sufficient to supply both the total real and reactive power components of the consumer's electrical load.

Power factor (PF) is the ratio of actual power converted to work in a circuit to the apparent power being drawn from the line. It is an important measurement to utilities, because it affects the amount of utility generating capacity required to provide service to a given load. Power factor is also important to consumers, because it can restrict capacity and affect voltage regulation and service cost. The relationships between kVA, kW, kVAR, and PF are illustrated in Figure 3.
Low Power Factor Adjustments

Low power factor indicates that electricity is being used inefficiently, and low power factor adjustments are charges for the inefficiency and resulting generating capacity loss for TVA.

A facility can have a low power factor for both lagging and leading load conditions. If the net reactive power requirement (kVAR) is inductive, a lagging power factor condition will exist. If the net reactive power requirement is capacitive, a leading power factor condition will exist. The ideal condition occurs when the inductive and capacitive load components are equal, in which case the effects cancel, and the apparent power supplying the load will be equal to the real power component of the load. The power factor in this case is 100 percent (neither leading or lagging) resulting in the most efficient use of the power supplied. Since this condition is difficult to achieve in practice, TVA and distributors of TVA electric power allow certain leading and lagging power factor variations before adjustments are applied to the customer’s electric bill.

Low lagging power factor conditions can result by the use of various combinations of the following common inductive devices.

- Induction motors, including motors that are parts of compressors on air conditioners, refrigeration systems, pumps, etc. (These are the most common causes of low lagging power factor conditions because so many are in use and often run at less than full load.)
- Inductive loads of fluorescent ballasts
- Rectifiers providing a DC power supply
- Arc welders
- Solenoids
- Induction heaters
- Lifting magnets
- Small “dry-pack” transformers.

In most cases, the addition of properly sized and applied capacitors can compensate for low lagging power factor conditions.

Low leading power factor conditions usually occur as a result of too many fixed capacitors connected to the electric system during lower load (off-peak load) conditions. This condition can be corrected by installing automatic load sensing capacitors or by implementing manual procedures for disconnecting the capacitors when not needed.

Power Measurements

Real power (kW) typically is measured through demand metering. Apparent power (kVA) may also be measured. Reactive power (kVAR), not necessarily measured on demand meters, can be determined from:

1. the measured kW and kVA using the formula in Figure 3, or
2. through special metering.

Power distributors may make these special metering arrangements to determine the kVAR and the resulting power factor.
Adjustments Included in Demand Charge

For consumers on General Power rate schedules, TVA accounts for the expense of producing reactive power by including in its rates:

- Power factor provisions for customers with no contract demand or with a contract demand of 5,000 kW or less.
- Reactive demand charge provisions for customers with contract demands above 5,000 kW.

Power factor improvement can be beneficial in lowering or even eliminating cost adjustment increases on a power bill if a facility's electric use meets one or more of the following conditions:

- The electric rate has a reactive or power factor adjustment clause, and the facility's power factor is less than the specified minimum.
- There are problems with voltage regulation or chronic low voltage.
- Power factor is low and load growth is limited by capacity.
- The facility at certain load periods experiences excessive leading power factor conditions. (Applies only to customers with reactive demand charge provisions.)

For More Information

It is advisable to review the need for power factor correction with either your power distributor, equipment manufacturer, consulting engineer, or TVA.

For more information on load factor and power factor improvements, call or write your power distributor or the TVA office nearest you.