

Power factor

Power factor can be described as the ratio of power actually used by a customer to the power supplied by SaskPower. Typically, power factor ranges from about 0.7 to more than 0.95 and is expressed as a percentage. The higher your power factor, the harder your electricity works for you and the lower your costs for power. You can often improve your power factor by adding relatively inexpensive components, such as industrial capacitors, to lower your electricity bills by as much as 20 per cent.

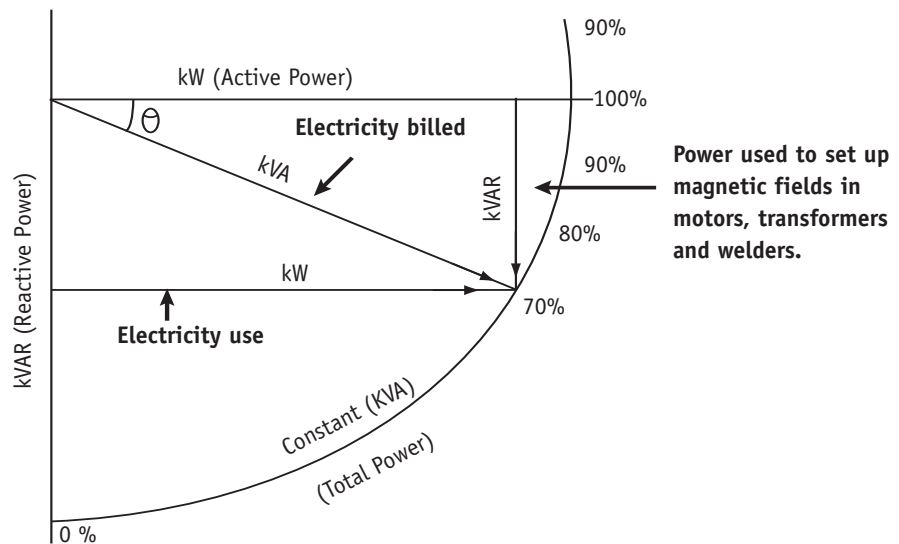
Power factor correction is of concern to commercial or industrial customers whose plant equipment includes large three-phase electric motors and is demand metered. If your plant's power factor is poor, SaskPower must supply more electrical capacity than your equipment actually requires. SaskPower recovers the cost of providing this extra capacity through demand charges that are a part of the electricity charges on your power bill. Power factor (PF) is the name given to the ratio of the real useable power measured in kilowatts (kW) to the total power (real power plus reactive or magnetizing power) measured in kilovolt-amperes (kVA).

Transformers, induction motors, lighting that uses iron core ballasts, and other electromagnetic devices must be magnetized in order to function. The current through each of these devices consists of two components – real and reactive power. The real current does the useful work and develops the power required, while the reactive current establishes magnetic fields. Magnetic current contributes nothing to the work output and actually places hardship on the supply system. The total current is the vector sum of the real current and the reactive current.

The power factor of a system may be described as either lagging or leading, depending on whether the reactive power is inductive or capacitive. Most common motors, transformers, welding machines and inductive heating coils produce lagging power factor. Resistive loads, such as heaters, ranges and incandescent lights, have a perfect power factor of 1.0 or 100 per cent. Capacitors and some synchronous motors produce leading power factor.

Lagging power factor can be corrected by connecting capacitors to the system. The current which flows in a capacitor produces a leading power factor. This current flows in the opposite direction to that in an inductive device. When the two circuits are combined, the effect of capacitance tends to cancel the effect of inductance. The problem is to select the proper amount of capacitors to produce the optimum cost-effective saving. Too few will not correct to a sufficiently high power factor and too many will cause the power factor to deteriorate in the leading mode with the same undesirable effects.

Figure iv.1 - Power factor triangle



Measuring power factor from the meter

SaskPower will, on request, provide an accurate instantaneous measure of power factor. As a first step, you can determine a rough instantaneous value from your electro-mechanical demand meter. This value will indicate the advisability of further and more accurate measurement.

Use this formula to determine your power factor from an electro-mechanical demand meter:

$$\text{Power factor} = \frac{\text{kh} \times 3,600 \times 100 \text{ per cent}}{\text{multiplier} \times \text{demand} \times \text{time}}$$

Where:

Kh = constant from meter face

multiplier = the internal multiplier of your meter

demand = present demand reading in volt amperes (VA)

time = number of seconds for one disc revolution

Example iv.1 - Power factor calculation

Kh = 1.08

multiplier = 2

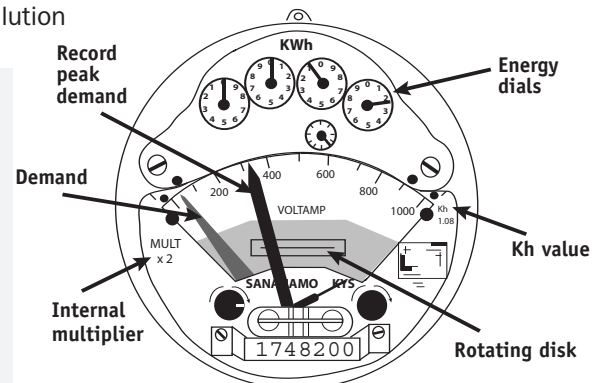
demand = 300 volt amperes (VA)

time = 80 sec. for 10 rev. (= 8 sec. per rev.)

$$\text{Power factor} = \frac{1.08 \times 3,600 \times 100 \text{ per cent}}{2 \times 300 \times 8}$$

Power factor = 0.81 (81%)

Demand meter showing the inherent multiplier (kh =1.08) and the internal multiplier (2). Time the disc for 10 revolutions to get the average time for one.



Note that an installation with this power factor requires a closer look and more accurate measurement:

- » Power factor is instantaneous
- » It is a value for the whole installation
- » It is important that the readings be made during a time of peak demand. Readings must be taken at least 15 minutes after the last major load change.

Advantages of power factor correction

- » **Reduced demand charges.** The demand portion of all SaskPower customers is billed on measured kVA (real and reactive power) based on the highest registered demand recorded on the demand meter. Increasing the power factor will decrease the measured kVA, lowering the demand and therefore your monthly bill.
- » **Increased load carrying capability of circuits.** Loads that draw reactive power also demand reactive current. Installing capacitors on the ends of circuits near the inductive loads reduces the amperage on each circuit. In addition, the diminished current flow reduces resistive losses in the circuit.
- » **Improved voltage.** Low power factor results in a higher current flow for a given load. As line current increases, there is a greater voltage drop in the conductor, which may result in poor voltage at equipment.

Disadvantages of power factor correction

- » Capacitors consume energy at the rate of 0.5-1.0 watts per kVAR
- » Slight voltage increase can be expected
- » Blown fuses due to resonance occurring with rectifier circuits in the system
- » Harmonic(s) distortion produced by variable speed drives or other equipment which alters the normal A/C wave can be magnified when capacitors are used

Savings from power factor correction

The most popular method of improving power factor is to install capacitors at the main distribution point, bus, or motor control centre for small motors or at individual large motors. Every customer will experience a different level of cost reduction due to power factor correction, depending on the situation.

Example iv.2 - Power factor (PF) correction costs, savings and payback

Maximum demand = 100 kVA

Minimum power factor = 80 per cent

Assume power factor correction to 95 per cent

Calculate kW:

$$100 \text{ kVA} \times 0.80 = 80 \text{ kW}$$

With a desired PF of 95 per cent, the kW still equals 80, but

$$\text{kVA} = 80 \text{ kW} / 0.95 \text{ PF}$$

$$\text{kVA} = 84$$

The approximate capacitance (kVAR) required is:

$$\text{kVAR} = \sqrt{(\text{kVA}_{\text{old}})^2 - (\text{kW})^2} - \sqrt{(\text{kVA}_{\text{new}})^2 - (\text{kW})^2}$$

$$\text{kVAR} = \sqrt{(100)^2 - (80)^2} - \sqrt{(84)^2 - (80)^2}$$

$$\text{kVAR} = 60 - 25.6 = 34.4$$

Capacitors cost about \$100 per kVAR installed.

$$\text{Cost (\$)} = (34 \text{ kVAR}) \times (\$100)$$

$$\text{Cost (\$)} = \$3400$$

Demand Savings:

$$100 \text{ kVA} - 84 \text{ kVA} = 16 \text{ kVA}$$

Reduced demand charges are:

$$16 \text{ kVA} \times \$10.71/\text{kVA} = \$171.36/\text{month}$$

Payback period:

$$\text{Payback} = \frac{\text{total cost of installation}}{\text{annual savings}}$$

$$\text{Payback} = \frac{\$3,400}{(\$171.36/\text{month}) \times (8 \text{ months/season})}$$

$$\text{Payback} = 2.5 \text{ seasons}$$

Section summary

- » Power factor correction means lower demand charges
- » System power factor should be maintained at or greater than 90 per cent lagging
- » Where economically feasible, install capacitors to improve the power factor to the optimum 95 per cent
- » Size motors to closely match the load they will carry
- » Capacitors, when properly applied, are the main components used for power factor correction