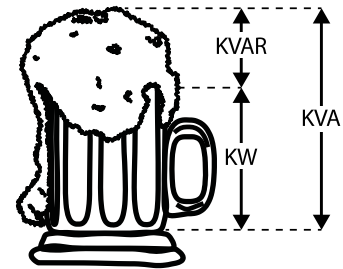




Power factor correction

Some farmers are unaware that their electricity bills can be reduced by improving the 'power factor' (PF) of their facilities. A poor power factor is analogous to a beer with too much head, when the head represents wasted energy. Networks penalise facilities with poor PFs by increasing 'demand' (or 'capacity') charges. Installing power factor correction devices can help ensure that on-farm electrical equipment uses the voltage provided by the network efficiently and that penalties are not applied as a result of the facility making unpredictable demands on the system.

The Beer Analogy



Understanding power factor

Power factor (PF) is a technical measure of how efficiently electricity is used by a customer. A farm using large amounts of electricity will sometimes be charged a penalty for having a poor PF. Their farm is presenting a poor, unpredictable load to the network, which means the network has to provide for more power than the farm actually uses.

Power factor is the ratio of real power (power that does work) to apparent power (the power delivered by the network). Power-factor correction equipment can stabilise the load, ensuring that charges apply only to power that's being used.

An ideal PF ratio is 1.00.

A poor power-factor ratio (below 0.80) can be improved with ease in a cost-effective manner to 0.95. Beyond this point, power-factor correction may not be cost-effective.

Power-factor ratio problems are caused by inductive loads such as transformers, electric motors, fluorescent lights, welding sets and induction heaters.

If a farming operation has a large number of inductive loads, the site's power factor can be affected significantly.

PF equipment is expensive but may nonetheless provide an attractive return on investment for farms with significant electricity bills – say, greater than \$100k per year – that include demand or capacity charges.

Beer analogy

Using beer on tap as an analogy, PF is the ratio of real power (the beer drunk, in kW) to apparent power (the beer plus head, expressed as kVA). Power-factor correction equipment can stabilise the load – reduce the head on the beer (kVAR) – ensuring that charges apply only to the power that's actually being used.

The brewery must charge for the beer delivered rather than the beer you drink.

Why do networks charge

Low power factor requires an increase in the generation and transmission capacity of the electric utility to handle the reactive power component caused by inductive loads.

Therefore, to avoid the expensive installation of additional capacity, utilities usually charge a penalty for poor power factor and include a demand charge component (based on kVA) in the bill to customers. A low PF means a higher kVA and consequently a higher electricity bill for the same site load (kW). Therefore, demand savings can be achieved by improving a site's PF.

A common way to increase power factor is by installing capacitors, which can supply the reactive power when installed at or near inductive electrical equipment. Capacitors can be installed in larger sets (or 'banks') at main distribution boards to control much larger loads. Capacitors are rated in reactive power units, measured as kVAR.

Quick tips

- **Check your bill for a kVA charge.** If no kVA charge is shown on the bill, then no action may be required.
- **Check your power factor rating.** The actual power factor value is sometimes shown on the bill, but you may need to analyse your metering data to determine it.
- **Get savings estimate.** If your power factor is below 0.8, ask your retailer business how much you might save if you were to increase it to 0.95 (only if kVA is charged on the bill).
- **Get a quote to install capacitors.** Typical costs start from \$2000 to \$3,000 for a small bank of capacitors. Typical low-voltage costs are \$70/kVAR to \$100/kVAR.
- **Check your maximum peak demand.** Talk to your retailer or meter data agent.

Charges	Quantity *	Rate *	TLF *	DLF =	Total
Energy Charges					
Peak	25,000 kWh	6.5 c/kWh	1.0112	1.0638	\$ 1,748.04
Off Peak	30,000 kWh	3.5 c/kWh	1.0112	1.0638	\$ 1,129.50
					\$ 2,877.54
Network Charges					
Peak	23,000 kWh	3.5 c/kWh			\$ 805.00
Off Peak	32,000 kWh	1.5 c/kWh			\$ 480.00
Demand	120 kVa	3.2 \$/kVa			\$ 384.00
					\$ 1,669.00
Market Charges					
AEMO Admin	55,000 kWh	0.04 c/kWh		1.0638	\$ 23.40
AEMO Ancillary	55,000 kWh	0.03 c/kWh		1.0638	\$ 17.55
					\$ 40.96
Other Charges					
RECs	55,000 kWh	0.25 c/kWh		1.0638	\$ 146.27
Metering	31 days	2.5 \$/Meter/day		1.0638	\$ 77.50
					\$ 223.77
Total Exc GST					\$ 4,811.27

Figure 1: This monthly bill shows a demand charge of \$3.2/kVA for a total of \$384.

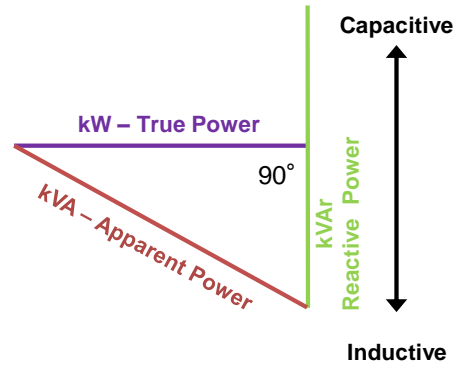


Power factor correction

Are you being charged?

Power factor correction can apply to any farm if the answer to the following questions is “Yes”.

- Is there a demand or capacity charge on your invoice? Demand charges are based on the highest monthly demand; capacity factor is similar to a demand charge but typically relates to the highest demand from the previous year. Increasing your power factor should reduce your demand or capacity charge.
- Do you have a power factor of less than 0.80?



Power factor is the ratio of the demand for True Electric Power (kW) divided by the demand for Apparent Power (kVA).

$$\text{Power Factor} = \frac{\text{True Electric Power (kW)}}{\text{Apparent Power (kVA)}}$$

Worked example

Power factor (PF) before power-factor correction = 0.78 (determined from electricity supplier at max. demand).

Apparent power (AP) – kVA (maximum demand from electricity bill) = 2,750 kVA

True power (TP) – kW demand (kVA x PF) = 2,750 * 0.78 = 2,145 kW

Desired PF after correction = 0.95

kVAR/kW factor from Table below = 0.47

Look up on 0.78 under the appropriate row and 0.95 under the appropriate column: the intersection should be 0.47.

Need to know

- Power factor can have a direct effect on the cost of your electricity bill.
- Low power factor can result in higher demand or capacity charges.
- Optimising power factor ensures that electricity demand costs are as low as possible.
- The ideal power factor is 1.00.
- Poor power factor (below 0.80) can be improved easily and in a cost-effective manner to 0.95 (beyond this point power-factor correction (PFC) may not be cost-effective).
- PFC benefits include:
 - lower electricity costs;
 - increased capacity of power cables and transformers;
 - lower power system losses; and
 - compliance with electricity distributors' connection requirements.
- If you are planning an expansion and need to increase the amount of power delivered to your farm, your network provider might demand that you improve your power factor if it is less than 0.80 before they will agree to any upgrades required to meet the extra demand.

Technical explanation

Some electrical devices, such as motors, fluorescent lighting and arc welders, use two forms of power:

- **Real or True Power:** in the case of motors, this is the useful mechanical work done, and is measured in kilowatts (kW); and
- **Reactive Power:** this does not provide any mechanical work but develops magnetic fields for motors and light ballasts and is measured in kilovolt-amp reactive (kVAR).

The total effect of these components is called the **Apparent Power**. Measured in kilovolt-amperes (kVA), Apparent Power reflects the amount of electric current demand.

	Required power factor (PF)			
Existing PF	0.80	0.90	0.95	0.98
0.70	0.27	0.54	0.69	0.82
0.72	0.21	0.48	0.64	0.76
0.74	0.16	0.42	0.58	0.71
0.76	0.11	0.37	0.53	0.65
0.78	0.05	0.32	0.47	0.60
0.80		0.27	0.42	0.55
0.82		0.21	0.37	0.49
0.84		0.16	0.32	0.44
0.86		0.11	0.26	0.39
0.88		0.06	0.21	0.34
0.90			0.16	0.28
0.92			0.10	0.22
0.94			0.03	0.16



Power factor correction

kVA_r required = kW x (kVA_r/kW) = 1,008 kVA_r

(rounding off to the nearest 50 kVA_r = 1,000 kVA_r)

Economic evaluation:

At a cost rate of \$150/kVA_r, installed cost = \$150,000

New Apparent Power = 2,145 kW/0.95 = 2,258 kVA

Demand savings = 2,750 kVA – 2,258 kVA = 492 kVA

Assuming a maximum demand charge of \$10/kVA/month:

Annual savings = 492 kVA x \$10/kVA/month x 12 months

= \$59,040 p.a.

Simple payback = \$150,000/\$59,040 p.a. = 2.5 years

Key parameters in evaluating quotes

The estimated installed cost of a basic power-factor correction system is approximately \$70/kVA_r (low voltage) and \$150/kVA_r (high voltage).

Cost estimates can be doubled for retrofitting into an existing switch room that has limited space. Costs will be also higher for additional features such as harmonic filtering and enclosure cooling.

Other considerations include:

- **PFC controllers versus static PFC capacitors.** Controllers can switch capacitors in and out of the supply automatically when required. They determine the amount of power-factor correction required by measuring the voltage and current of your power supply. Controllers are more expensive than static PFCs and they are required only when PF control is critical.
- **Standard versus de-tuned.** If a site has a large percentage of non-linear loads (such as computers, VSDs and UPSs) connected, de-tuned PFC is the preferred option even though standard PFC is approximately half the price. The rule of thumb is: if total non-linear load percentage exceeds 15 percent, de-tuned PFC must be used. Exceeding 50 percent requires a special filter.

Further information

Schneider Electric

'Electrical Installation Guide 2008'.

www.schneider-electric.com.au/documents/electrical-distribution/en/local/electrical-installation-guide/EIG-L-power-factor-harmonic.pdf

References

U.S. Department of Energy, 1996. *Reducing power factor cost*, s.l.: s.n.

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