METERING AND MONITORING—M13C

Eco-efficiency opportunities for Queensland manufacturers

Interpretation of electricity monitoring results

This fact sheet discusses some of the common occurrences in electricity monitoring data results. It should be read in conjunction with Metering and monitoring—M13A: Setting up an electricity monitoring plan *and* Metering and monitoring—M13B: Electricity metering.

Load profiles

Electricity monitoring data can be displayed as a load profile, which is useful for analysing energy consumption over a given period and helpful in identifying peak demand, base load and areas where energy might be used inefficiently. Load profiles are useful when undertaking an electricity use survey (see *Metering and monitoring—M13B: Electricity metering*).

Figures 1 and 2 show the load profiles of a factory that commences operation on Monday and shuts down on Friday for the weekend.

Figure 1 shows the factory's load profile before electricity efficiency opportunities are implemented. Figure 2 shows the profile after the opportunities are implemented. The letters on the profiles indicate startup (A), shutdown (D), base load (E), peak demand (C) and an operational delay caused by a power brownout (B). Base load consumption, peak demand and power brownouts are explained in more detail in this section.

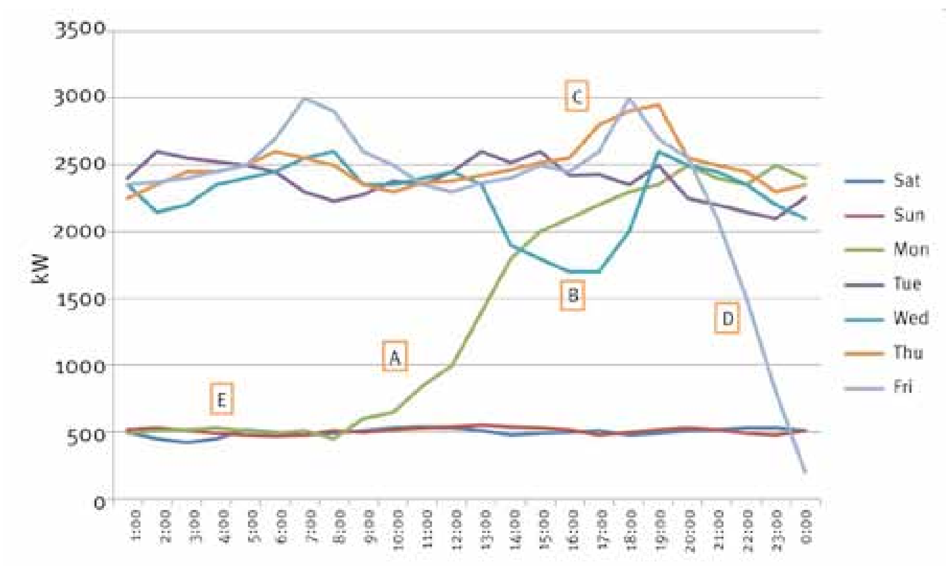

Figure 1: Load profile 'before' electricity efficiencies are implemented

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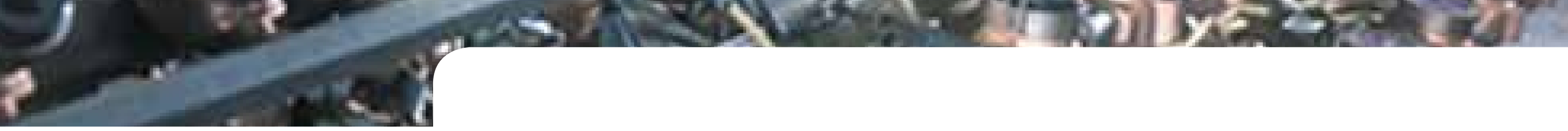


In Figure 2, a leaking compressor has been repaired. This has reduced the base load (E), the peak demand has been smoothed through better production scheduling (C) and the cause of intermittent brownouts has been identified, thus avoiding further production delays (B).

Figure 2: Load profile 'after' electricity efficiencies are implemented

Base load consumption

Base load consumption is the amount of energy consumed independent of production. See 'E' in Figures 1 and 2.

A factory will generally have some level of base load consumption due to necessary equipment operation (e.g. security lighting, refrigeration or compressed air systems). Base load consumption should be monitored to help identify wastage, including:

- **unnecessary lighting**—security lights may be required but all other lights should be switched off after hours; ensure lighting is as energy efficient as possible and consider installing timers or sensors (see *Lighting efficiency—M6: Benefits of correct lighting*)
- **unnecessary air-conditioning**—ensure air-conditioners are well maintained and are switched off in unused areas (see *Air conditioning—M1: Hot tips and cool ideas to save energy and money!*)
- **leaving equipment running**—have an effective shutdown procedure in place and ensure it is followed
- **leaks in compressed air systems**—small leaks in compressed air systems can go unnoticed and contribute to higher base load consumption—one way to detect leaks is to switch off all equipment and listen for air leaks (see *Compressed air efficiency—M3: Compress your costs*).

A leak from a compressed air system of less than 1 mm can cost $95 per year, while a leak over 5 mm can cost more than $4675 per year.[1]

1 Based on a 700 kilopascal (kPa) system, operating 2000 hours per year with electricity costs of 10 cents per kilowatt hour (kWh).

Figure 3 shows a reduction in base load consumption by about 50% after identifying an area of waste.

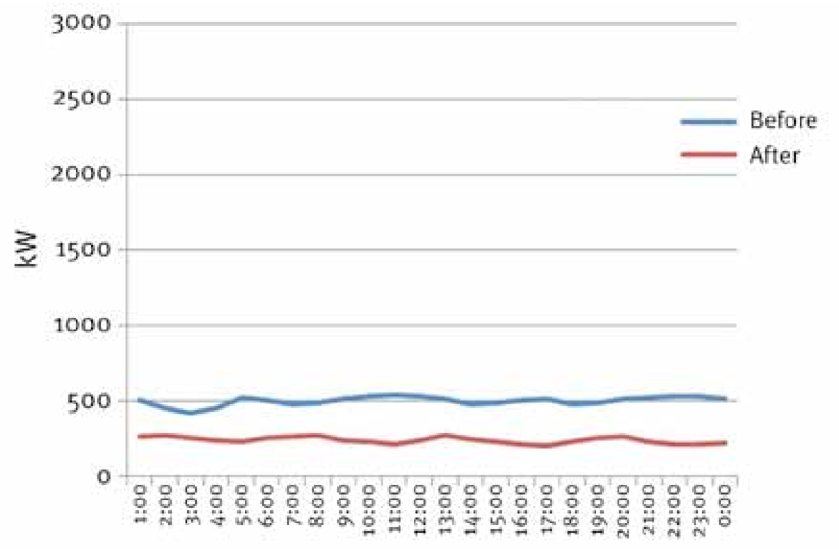


Figure 3: Reducing base load

Peak demand

Electricity bills generally include a charge based on the peak demand for the past month. Peak demand in a factory is recorded when the highest average amount of electricity is used over a set period (generally any 30 minutes during the month). For some companies, this charge can be significantly greater than the total electricity usage charge. Therefore, reducing peak demand can significantly reduce electricity bills.

Demand costs can be reduced by:

- **delaying or staggering equipment startup times**—
  - some equipment uses large amounts of electricity during startup periods, which reduces as it reaches normal operating conditions
  - operators may be in the habit of turning on equipment all at once at the start of a shift—this can cause a spike in electricity usage and lead to increased demand costs
  - staggering the startup of equipment by turning on only what is needed immediately can help to reduce or avoid spikes in consumption
- **more even scheduling of production runs to reduce peak demand**—peak demand occurs when numerous items of equipment are operated simultaneously—such spikes could potentially be reduced by rescheduling the workload (e.g. allowing for some production to occur during off-peak hours)
- **switching off non-critical items of equipment during peak periods** (e.g. cooling or heating systems).

Figure 4 shows an example of how peak demand has been reduced after turning off some equipment items and reviewing production scheduling.

Figure 4: Reducing peak demand

Power surges/spikes and brownouts

A power spike or surge generally originates from the external electricity supply due to an event such as a lightning strike (see 'B' in Figures 1 and 2). This can cause damage to equipment due to the sudden increase of voltage. Similarly, switching large electrical loads on or off can also cause surges. Surge protection equipment can be installed to protect equipment susceptible to damage from surges or spikes. It can be installed on plug-in equipment, at the power point or in the switchbox.

A brownout occurs when a phase is lost (e.g. only two out of three phases are operating). This could be due to a blown fuse within the factory suddenly switching off equipment that requires a large amount of current, or the problem could be with the supplier side. If the issue is with the supplier side, a factory circuit-breaker might cut power completely. This problem can only be corrected by fixing the fuse.

Brownouts can also occur when the power supplied to a region is insufficient for the demand. This may occur in industrial areas where there are many companies in one location with high electricity usage. Coordinated demand management for the area can reduce the impact of brownouts.

An interruption to supply could also be caused by an earth fault (e.g. a tree branch or possum touching the wire). Alternatively a circuit-breaker on the supply station might trip, with the supply returning to normal once it is reset. These interruptions are likely to be temporary (e.g. only a minute or two). The factory has little control over these issues.

Figure 5 gives an example of a production delay caused by a factory brownout, in this case due to a blown fuse.

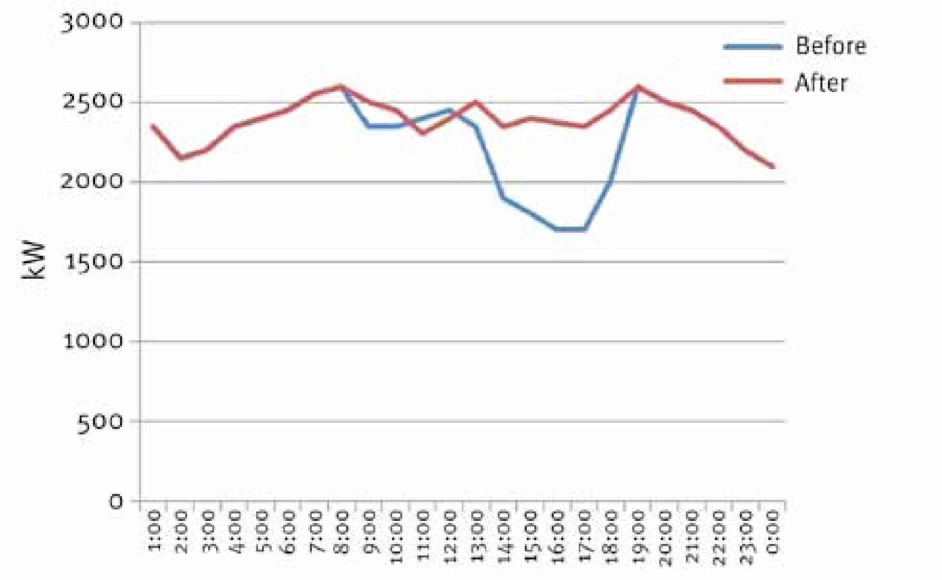


Figure 5: Production delay due to blown fuse

Power factor and harmonic distortion

Power factors and harmonic distortion both relate to the waveform of the electricity supply. Both contribute to higher electricity bills.

The correction of power factor and harmonic distortion will help to fully utilise the capacity of the electrical system, reduce the risk of outage and improve the life span of equipment. Electricity costs can be reduced by 5% to 10% through reduction in power factor and peak demand charges.[2]

Power factor

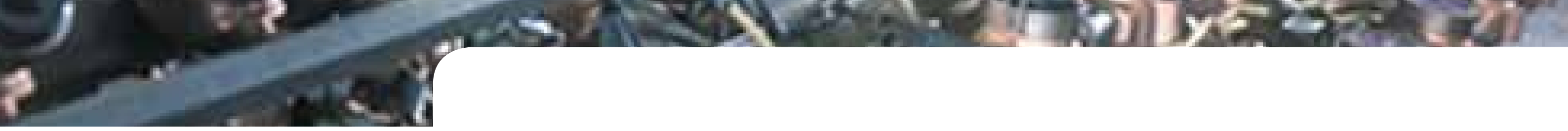
Power factor is a measure of how efficiently power supply is utilised. A low power factor is an indication of inefficient energy use. Power factor is determined using a meter and is the ratio of active power and total power where:

- active power, or kilowatt (kW)—also known as real power—is the energy required to produce work or heat
- reactive power, or kilovolt ampere reactive (kVAr), is the energy required to create a magnetic field
- total power, or kilovolt ampere (kVA)—also known as actual or apparent power–is the vector sum of active and reactive power.

Electric motors tend to have power factors of less than 0.9, whereas an electric oven will have a power factor virtually equal to 1. Poor power factors require excess current flows which:

- increase the chances of cables overheating
- reduce equipment reliability
- increase supply costs
- result in additional greenhouse gas emissions.

2 Schneider Electric, ‘Energy University’, *Energy University course transcript*, Energy efficiency—power factor and harmonics, 2010.



Plants that operate with a low power factor require suppliers to feed excess power into the distribution system to operate the plant's equipment and appliances. Many power suppliers charge an additional fee to manufacturing plants with poor power factors (e.g. 0.6 or lower) to capture costs not reflected by the electrical (kWh) meter, particularly for market contract agreements.

Power factor correction options include:

- power factor correction capacitors designed to provide reactive current
- automatic power correction equipment or banks of capacitors that are switched on and offline depending on the power factor
- replacing (or switching off) oversized motors that are lightly loaded or idling with smaller motors
- installing high power factor lighting and electronic equipment.

Harmonic distortion

Harmonic distortions occur when the current and voltage supplied to equipment is non-linear—that is, the current that the equipment draws does not match (have the same waveform as) the voltage supplied.[3]

Within a factory, this distortion can be caused by equipment such as variable speed drives, variable frequency drives, welding equipment, electronic equipment such as electronic loads, uninterruptible power supply (UPS) units and computers.[4]

Harmonic distortions can cause significant damage to equipment through overheating of electrical cables (potentially leading to fire), overheating and damage of electronics and degrading power factor correction equipment, and they can cause inefficiencies of equipment.[5]

They can also cause businesses to under-rate the current-carrying capacity of supply cables. By measuring the harmonics, businesses can install appropriately sized harmonic filtering to increase the loads they can support with the existing cabling.

Harmonic distortion correction options include:

- power factor correction capacitors designed to handle harmonic distortions
- installing filters to mitigate non-linear loads and thereby preventing distortion from occurring
- capacitor-less technology for distortions caused by centrifugal pumps, fans and heating, ventilation, and air-conditioning (HVAC) machines
- AC-line or DC-link reactors (chokes) for variable speed drives.[6]

More information

For more information (including the other fact sheets referred to in this document) visit **www.ecoefficiency.com.au**, or contact your power supplier.

This series of fact sheets provides examples and suggestions to the modern manufacturer on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website at www.ecoefficiency.com.au for more ideas and case studies. This fact sheet has been compiled by the Working Group for Cleaner Production through UniQuest at The University of Queensland.

3 Schneider Electric, *Energy University course transcript*, 2010.
4 Schneider Electric, *Energy University course transcript*, 2010.
5 Energywise, *What are the consequences of harmonic distortions?*, Energywise, Sydney, 2010, viewed 16 December 2011, ‹www.energywise.net.au/index.php?option=com_moofaq&view=category&id=54&Itemid=172›.
6 Schneider Electric, *Energy University course transcript*, 2010.