5 Minute Guide 3.2

PACIA | energy+
Turn energy savings into business power

Upgrading your equipment and processes to improve energy efficiency

This 5 Minute Guide examines system and energy efficiencies that can be achieved when upgrading equipment commonly found in the chemicals and plastics industries. There are significant energy savings to be made by replacing ageing or inefficient equipment. However it is also important to look at the system as a whole.

Process heating, hot water and steam systems

When planning a new heating system or boiler, take stock of exactly what you use steam for, and how it helps meet your business needs.

Compile a list of all end uses of steam, the temperature, pressure and flow they require, their location and options for heat recovery. From this list, you can establish the correct temperature, pressure and the average flow required by your system. Selecting the most efficient fuel source to supply heat should be considered – refer to Figure 1 for efficiencies of different fuels.

Remember it is important to **do your homework** and ask the right questions before you begin planning any upgrades to your equipment and processes. Guidance is provided in the PACIA energy+ 5 Minute Guide 3.1: Key considerations to maximise the energy efficiency of new equipment purchases.

Figure 1: Fuel cost of various water heating systems

Energy source	Fuel cost (excluding cost of equipment)	Fuel efficiency
Gas	\$3-7/GJ	70-90%
Electricity resistance	\$25-35/GJ	Up to 100%
Steam	\$4-10/GJ	50-80%
Waste heat recovery	Low	70-90%
Solar	Free	70-90%
Heat pump	\$25-35/GJ	Up to 400%*

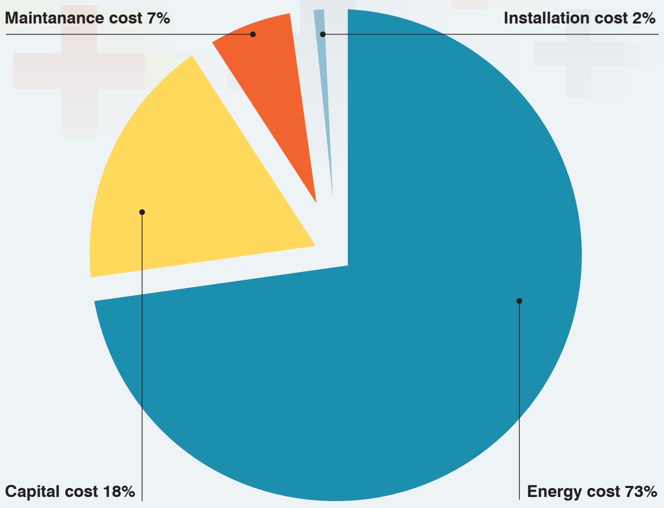
* It is difficult to represent overall system efficiency with a heat pump. The coefficient of performance (COP) of the heat pump may be as high as 4, meaning up to 4 units of heat are provided for one unit of electricity

Source: Energy Efficiency Best Practice Guide: Steam, Hot Water and Process Heating Systems; Sustainability Victoria, 2009, p22

There are two major upgrades that you can consider for your process heat and steam system:

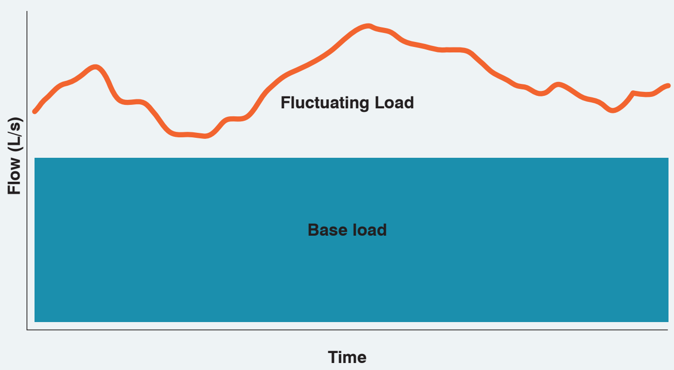
- Replacing hot water storage systems with in line hot water heaters, which only heat the water you need.
- Introducing solar hot water heating onto the roof of the building and feeding the hot water into the process heating or steam system. This will decrease the energy used by that system. If the process heating temperature requirements are quite low then adding a gas booster to the solar hot water system could be sufficient to replace an electricity or gas driven hot water heater.

Figure 2: Compressor operating cost over 10 years



Source: Energy efficient compressed air systems, p.1, Carbon Trust, UK, February 2005

Figure 3: Load profile suitable for a fixed and variable compressor configuation



Compressed air systems

Compressed air systems are often kept working beyond their useful life, becoming inefficient in mechanical operation and no longer meeting your current needs.

Upgrades you could consider:

- Introducing variable speed drives on compressors to match the speed of the compressor to the requirement of the process.
- Installing a compressed air management system to control multiple compressors efficiently.
- Adding or replacing a compressor to more efficiently service the compressed air needs or your business. Depending on your load profile it may be more efficient to purchase an additional small compressor than replace your existing compressor(s). If you have a certain amount of variability in your air demand, then a small variable screw compressor may handle the variable aspect of the load whilst an existing fixed-speed compressor runs at full speed to service your base-load air requirements. Figure 3 shows the application of a second compressor to manage the fluctuating load.

When selecting a new compressor, confirm your current and future needs. Compressor selection is not a straightforward process. Figure 4 outlines the different types of compressors and their characteristics. There are a number of simple audit tools available online that can help you to identify potential savings through energy efficiencies.

Figure 4: Advantages and disadvantages of compressor types

Compressor	Advantages	Disadvantages
Reciprocating Efficiency: 7.8 - 8.5kW/m³/min	Suitable for high pressures Can be relatively small size and weight Smaller initial cost Simple maintenance procedures Efficient multi-stage compression available	High noise levels High maintenance costs Suitable for smaller systems Requires strong foundation High oil carry over when worn
Screw Efficiency: 6.4 - 7.8kW/m³/min	Simple operation Lower temperatures Low maintenance Quiet Compact Vibration free Commercially available variable speed units with relatively good turndown	High energy use Low air quality
Vane	Simple operation Lower temperatures Quiet Low maintenance	Limited range of capacity Low air quality
Centrifugal Efficiency: 5.8 - 7kW/m³/min	Energy efficient Large capacity Quiet High air quality	High initial cost Inefficient at low capacity Specialised maintenance Only water-cooled models available

Source: Energy Efficiency Best Practice Guide: Compressed Air Systems, p14, Sustainability Victoria, 2009

Motors, pumps and fan systems

Pumps and fans make up part of a system that controls the flow of solids, fluids or gases. When thinking about the energy efficiency of equipment within the system it is critical to consider the efficiency of the system as a whole. Inefficiencies in specific equipment might not seem that important, however small individual inefficiencies can add up to a very inefficient overall system (see Figure 5).

High efficiency motors

When thinking about replacing a motor in your facility, remember the total cost of supplying electricity to a motor can overtake the motor purchase price in just two weeks[1]. The chemicals and plastics industries use more motors than any other industry in Australia, and you can purchase a high efficiency motor for only marginally more than its inefficient equivalent.

Purchasing a high efficiency motor is one of the simplest ways to make your factory more efficient and save money.

Consider the following: a 15kW motor with an efficiency of 88% operates for 8,000 hours per annum. Its purchase price was $1,200. Overall the motor will cost $13,590 each year, or $203,850 over its 15 year life. Purchasing a similar but higher efficiency motor would likely involve a purchase premium of $300. However with a superior efficiency of 92% it will save you nearly $500 in electricity costs in the first year. This equates to a saving of $7,350 over its 15 year life[2].

That is a payback of around eight months. When you apply the improved efficiency to the larger system the motor is driving (such as a pump) and take into account that you may be able to buy a slightly smaller motor if the previous one was oversized, it becomes even more attractive.

Variable speed drives

A variable speed drive (VSD) is an electronic device that controls the speed and torque of a motor. It provides a better match with the process requirements of the machine it is driving, optimises its efficiency and reduces the cost of operating the system. The application of VSDs to fans and pumps is ideal as they often have variable loads and the VSD will consume the least amount of energy to achieve the desired pressure and flow.

Selecting a VSD is not an exercise in looking for the lowest cost solution, as this will not achieve the highest efficiencies. The motor needs to be sized to satisfy the maximum load, but the motor speed can be varied in order to match the load at non-peak times.

Varying loads include:

- Pumping: the volume to be pumped may vary due to changes in production or product mix, rainfall, or a greater need for filtration or water treatment.
- Cooling: higher airflows may be required during warmer weather.
- Ventilation: airflow may need to be higher in response to higher occupancy or more vehicle movements.

Figure 5: Equipment inefficiencies compounded through a system

Inefficient system (↓ Loss of efficiency)		Efficient system (↓ Less loss of efficiency)
Standard motor eg **90%** efficiency	**Motor**	Efficient motor eg **93%** efficiency
No variable-speed drive, so motor runs too fast most of the time – wastes 50%	**Drive control**	Variable speed drive to match motor speed to task
Inefficient fan design wastes 20%	**Fan design**	Efficient fan design means as little energy as possible is wasted
Ducts undersized, so 50% of fan energy wasted due to high flow resistance	**Ducts**	Ducts optimally sized (and variable speed cuts duct losses by average of 40%)
Outcome: **Overall system efficiency 20%**	**SYSTEM**	Outcome: **Overall system efficiency 50%**

Source: Fact Sheet: Motors, drives, pumps and fans. p1, E3 Energy Equipment Efficiency website (www.energyrating.gov.au), 2013

Process operations and equipment

When considering the purchase of large process equipment, you should engage your supplier to understand its energy use for your application. For equipment that uses heat energy to perform its job, you can potentially save a significant amount of energy by reusing excess heat produced by another piece of equipment or process.

For example, creating chilled water by utilising excess heat from a boiler to drive an absorption chiller can significantly reduce the load, and therefore the energy use, on cooling water systems.

Remember to **refer back to your energy plan regularly.** Go to the PACIA energy+ portal for help in setting up your plan.

Industrial buildings

The greatest opportunity to make a step change in the energy use of an industrial building occurs when you are constructing a new building and redesigning the use of the space to support your production process. This is an ideal opportunity to set up the building's systems like heating, ventilation, air conditioning and lighting to work together efficiently and symbiotically with the building fabric. This is often achieved most effectively with a building management system. There are examples where businesses have reduced their energy use per unit production by 50% or more by taking advantage of this opportunity.

1 Based on the assumption of a 45kW motor with a purchase price of $1,750 running continuously, with an average electricity price (including network charges) of $0.12 /kWh will consume $977 of electricity every week. In this scenario, the electricity cost will overtake the purchase price in 1.8 weeks.

2 MEPS for three-phase electric motors presentation, p16, Australian Government, 2007 (www.energyrating.gov.au)

This is just one piece of the energy efficiency puzzle!

There are many other areas that you should also consider. PACIA energy+ covers the key topics and provides you with the tools and information you need to improve your energy efficiency and reduce costs. PACIA energy+ has been designed specifically for businesses in the chemicals and plastics industry.

Go to the PACIA energy+ portal for more: www.paciaenergyplus.org.au

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