Motors, drives, pumps and fans

Operating electric motors—in fans, pumps, chillers, lifts and other machines—can account for a significant proportion of greenhouse emissions from Council activities. The energy consumption of electric motors translates to some 37 megatonnes of CO_2 emissions annually, which is 6.6 per cent of total greenhouse gas emissions.

Opportunities for savings

The potential for savings in this area is great. Reductions in energy use and greenhouse emissions of about 40 per cent can be achieved, with a return on investment of about 40 per cent per year.

Consider the system

The greatest savings can be achieved by seeing the motor as part of a system. Although the difference in efficiency between a standard and efficient motor may not be great by itself, the cumulative effect of all parts of the operating system can create a significant difference in overall efficiency.

For example:

INEFFICIENT SYSTEM	Loss of efficiency ↓		Less loss of efficiency ↓	**EFFICIENT SYSTEM**
Standard motor, e.g. **90%** efficiency		**Motor**		Efficient motor, e.g. **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%**

Do you need the motor?

The first thing to think about is whether you actually need the motor at all; reassessing the motor's function sometimes means you can do without it. This is a very cheap energy-saving measure.

Reduce operating time

There are many ways to reduce the operating time of motors and these are usually cheap to implement. Examples include:

- a simple time-switch to restrict the hours of the day or week that the motor runs;
- a calendar time-switch will prevent a motor (in an airconditioning system, for example) from running on public holidays;
- an ambient air temperature sensor can be used to prevent cooling equipment from running in cold weather.

Select the right motor for the job

Consider all the costs

The cost of an electric motor will usually be overtaken by electricity costs in the first one to four months of operation. Even without considering maintenance costs, **the operating cost of a motor over a life of just 20 years can be up to 200 times the original purchase price.**

Factoring in all the costs and selecting the motor with the lowest cost over its full operating life will be better for the environment and for your organisation.

⇒ *Refer to Strategy sheet S3* Financial evaluation of projects

Size

Size does matter. Usually, motors are oversized. This is understandable, as erring on the small side would be more obvious than selecting a motor that is too large. But there is a hidden cost in this conservative approach, because the efficiency of an electric motor is reduced as load is reduced. For example:

- while a 10 kW motor driving a 10 kW load may be 90 per cent efficient, when driving a 4 kW load it will have an efficiency of about 75 per cent, so the electrical load will be 5.3 kW;
- a 5 kW motor driving the same 4 kW load will have an efficiency of 90 per cent, so the electrical load would be 4.4 kW—a saving of 0.9 kW or 17 per cent.

For a motor which is part of the air-conditioning system in a typical office building, the second option would save 2,250 kg of CO_2 equivalent every year.

An oversized motor is sometimes specified to allow for high load during motor start, but a variable-speed drive (see next page) or a 'soft starter' device is a more appropriate way of handling this situation.

Efficiency

Not all electric motors are created equal. Like most other products, quality and efficiency vary within and between brands, and some motors are designed and built to be more efficient. For example, a 10 kW high-efficiency motor (HEM) will have an efficiency of 93 per cent, compared with the standard electric motor's 88 per cent—a saving of 4.3 per cent in both energy and greenhouse gas emissions. The reduction in electricity costs will usually recoup the premium paid for a HEM in under two years.

The gap between standard and high-efficiency motors becomes increasingly wide as motor size decreases. Many small motors, such as those used in exhaust fans, may have efficiencies as low as 50 per cent.

Replace rather than rewind

A burnt-out motor can be rewound, at least to its design efficiency, as long as energy efficiency best practice is observed by the rewinder.

A poorly rewound motor can result in a loss of efficiency of up to 3 per cent, which for a 30 kW motor would add 2,500 kg CO_2 equivalent to greenhouse emissions and $1,500 to the operating cost in just 10 years (based on 80 per cent load, 3,000 operating hours per year, 10 cents per kWh).

If the burnt-out motor cannot be rewound to its design efficiency then a preferred option is to replace it with a new motor. The new motors available now are more efficient than, say, 20 years ago.

Use variable speed

Most fans and pumps tend to run at constant speed, even though the flow they're required to deliver may vary. This means they are running too fast and using too much electricity *most* of the time. Big savings are possible because reducing the flow by 50 per cent will reduce the power required by around 85 per cent.

Variable speed can be achieved with a so-called *variable-speed drive* (VSD), an electrical device which controls power to the motor. Other advantages of a VSD include:

- it acts as a 'soft starter' which prevents the electrical system overloading (which can drop the voltage and affect other equipment) and avoids the cost of other starter controllers;
- the ability to control the speed often results in a higher quality of service (for example,. better comfort or process control);
- the ability to control speed allows the motor size to be matched more closely to the actual load, as the VSD can operate the motor at full or higher speed for short periods (see *Size* above).

Where a variable-speed drive is considered too expensive, it may be possible to use a multi-speed motor, or to install several smaller motors, with controls that switch on only enough motors for the required performance.

Avoid undersized piping or ductwork

Money saved by installing undersized piping or ductwork can be a very costly false saving, as it puts additional loads on the fans, pumps and motors. Ensure that the full effect of such additional loads is evaluated and included in the process of selecting system components.

Don't forget the transmission

Getting the motor to turn is only the first step. The efficiency of belt drives can drop from 90 to 60 per cent if poorly designed or maintained. And all types of drives require regular maintenance to perform at optimum efficiency.

Maintenance

Check that drive belts, chains and coupling are in good condition and adjusted in accordance with the equipment supplier's recommendations.

Check for motors which are running hot, as this is a sign that energy is being lost. Use an infrared non-contact thermometer in preference to touching the casing. A motor casing temperature of 60°C or higher should be investigated. *Do not put hands near moving parts, couplings etc. even if the motor is stopped.*

Checking out your motors

An energy audit should identify significant electric motors and reveal opportunities to reduce electricity consumption and greenhouse gas emissions (see Energy sheet E1 *Developing an energy efficiency program*).

If an energy audit is not being conducted, a survey of the following data will often reveal motors which are running unnecessarily. For each motor, record:

- the motor's application or location—for example, main fan, air handling unit in pool hall;
- the purpose of the motor;
- the nominal power (in kW or horsepower) from the motor identification plate;
- how the motor is controlled (float switch, time switch, etc.);
- the motor's operating times;
- the actual power (preferably) or motor current. An electrician or other suitably qualified person can measure this by using a clamp-on meter. In some facilities, you may be able to determine the motor power by running only this motor (possibly after hours), and timing the electricity meter (see Energy sheet E4 *Using an electricity meter*).

Such a survey will often reveal clear opportunities to reduce motor energy use—for example, motors running when not required, or motors running at very light load (when the measured actual power is much lower than the nominal power), indicating that a smaller or slower motor, or a variable-speed drive, should be investigated.

See also sheet E18 *Water supply and sewage treatment*, for a method of calculating pump efficiency.

Estimating energy use and greenhouse emissions

For each motor:

1. Calculate the annual electricity use in kilowatt hours (kWh) by multiplying the average power of the motor by the number of hours of operation; the table below gives sample values for a range of different motors and applications.
2. Use the greenhouse coefficients in your CCP™ software to convert the annual electricity use (kWh) to greenhouse gas emissions (tonnes of CO_2 equivalent)

Application	Operating hrs/year	Annual energy use (MWh/year[1]) by average power of motor					
		1 kW	2 kW	5 kW	7.5 kW	15 kW	25 kW
Office cooling	1,000	1.0	2.0	5.0	7.5	15	25
Office heating pump	1,500	1.5	3.0	7.5	11.3	23	38
Office airconditioning fan	2,500	2.5	5.0	12.5	18.8	38	63
Depot (2 shifts)	4,000	4	8	20	30	60	100
Gymnasium fan	5,000	5	10	25	38	75	125
Continuous running	8,760	9	18	44	66	131	219

[1] 1 MWh (megawatt hour) = 1000 kWh (kilowatt hours)

Example

For example, a 20 kW airconditioning fan in the municipal offices operates for 2500 hours per year. The electricity supply contract includes a 25 per cent Green Power component, with the remainder of the electricity generated in Queensland. What is the amount of CO_2 emitted as a result of supplying the motor with electricity?

In this case, the table doesn't give values for a 20 kW motor, so you could use the figure for a 1 kW motor operating for 2500 hours and multiply it by 20.

1. Annual electricity use for a 1 kW motor	From table above	= 2.5 MWh/yr
2. Annual electricity use for 20 kW motor	2.5 MWh/yr x 20	= 50 MWh/yr
3. Deduct proportion of Green Power	50 – (0.25 x 50)	= 37.5 MWh/yr
4. Greenhouse emissions from lighting	From CCP™ software[1]	= 38.3 tonnes CO_2/yr

[1] Factor for Qld electricity is 1.02, so emissions are 37.5 MWh x 1.02 = 38.25 tonnes CO_2 per year