Developing an energy efficiency program

This information sheet will help you maximise the benefits of an energy efficiency program to your Council. These extend beyond the obvious benefits of lower greenhouse gas emissions and lower energy costs.

The benefits

The benefits of a well planned and managed energy efficiency program include:

- lower greenhouse gas emissions;
- lower energy consumption and costs;
- greater control over energy costs and greater confidence in estimating future energy costs;
- lower non-energy costs (for example, of consumables such as fluorescent lamps, due to their extended life);
- higher quality of energy services delivered, such as lighting and airconditioning (and hence a better working environment for staff and clients);
- higher productivity;
- reduced capital costs.

A program is more than an audit

Many people think an energy efficiency program starts and ends with an energy audit. Such a belief puts a Council at risk of:

- not capturing the potential benefits which a good energy efficiency program will deliver;
- wasting the time and money spent on the energy audit.

The main steps in establishing an energy management program are:

1. Get management support, including:
   - seed funding;
   - a commitment to reinvest all energy efficiency savings and a percentage of energy price savings in further improvements;
   - formal commitment to an energy management policy,
   - appointment of an energy manager for Council and for each site or group of facilities
2. Develop a simple and concise reporting system to keep management informed of progress.
3. Perform a desktop study to compare the energy consumption of each Council facility with similar facilities, and assign priorities for energy investigation and efficiency improvement.

4. Introduce a method of gathering energy consumption and cost data from bills as they are received.

Understand that investment will be necessary

A well designed and executed program should reduce your energy costs by around 40 per cent. To achieve these savings you may need to:

- invest around 3–5 per cent of a year's energy costs in initial energy audits (which may focus on individual facilities);
- invest between 50 and 100 per cent of a year's energy costs in implementing remedial maintenance and capital improvements to equipment (this investment does not all have to occur in a single year);
- put in place systems for ongoing monitoring and carry out more targeted audits and studies over time;
- establish an effective inhouse management system with ongoing responsibility for energy management.

Do not commit to an energy audit unless your Council is prepared to either:

- commit the funds to invest in energy-efficiency improvements; or
- enter into an agreement with a company which will finance those improvements (see table E1-1 at the end of this sheet).

In the past, some Council officers have had the authority to organise an energy audit but not the authority to find the capital funds to implement its recommendations, or have not had the line authority to organise works which had to be coordinated with Council core activities.

This is short-sighted because although the audit is a key step it is by no means the only step in an energy efficiency program. Implementing an energy audit's recommendations requires persistent management over a period of years; and this will pay dividends which will increase every year.

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

Decide on the aims of the program

Apart from the obvious goal of finding ways of cutting energy costs, what is your program trying to achieve? What are your Council's short- and medium-term goals and plans? Are there any significant concerns about the operation, maintenance or quality of service of the energy-using equipment in your Council? What will you brief an energy auditor to do? How will recommendations be implemented (this will influence the kind of contract you enter into with your energy auditor—see table E1-1 at the end of this sheet)?

⇒ *Refer to*
Strategy sheet S5 Leases and contracts
Energy sheet E2 Energy audits

Select an energy auditor

Select an energy auditor who:

- has proven experience in the areas of energy use relevant to the Council facilities to be audited;
- can demonstrate a history of energy audits where the recommendations have actually been implemented—because recommendations have been practical and the auditor has continued to work with the client organisation after submitting the report. This is important as there will often be issues which need to be resolved or misconceptions and misunderstandings clarified in order to achieve implementation. Many studies have shown that a major weakness of most energy audits is that few or none of their recommendations are implemented.

Commission the audit

The energy audit will look at the broad energy picture and formulate a coherent plan. It should identify:

- major issues which will affect subsequent opportunities to reduce consumption and costs, including such issues as choice of fuel, selection of major plant or the decision to reduce demand rather than increase supply;
- opportunities which can be implemented with little or no capital cost and time;
- other energy-efficiency opportunities which require a significant capital investment;
- potential energy-efficiency improvements which require further investigation and evaluation;
- opportunities to improve service quality or reduce costs in areas other than energy.

⇒ *Refer to Energy sheet E2* Energy audits

Implement the recommendations

Of course, this is the phase of an energy efficiency program that actually reduces greenhouse gas emissions. Table E1-1 on the next page lists some options for implementing and financing your initiatives.

Monitoring your progress using identified indicators (see Strategy sheet S2 *Monitoring and reporting*) should form an integral part of on-going management.

Examples:

Energy Efficiency Victoria is assisting Victorian Councils to establish energy management strategies, including defining and putting in place the elements of a successful strategy; collating energy consumption for Councils throughout Victoria; and calculating energy benchmarks for each type of Council facility. Further information from Mr Paul Murfitt, Manager, Local Government Energy Services, phone 03 9655 3267.

See also:
Newcastle City Council shares its successful strategies (Section 3, sheet S3)
Sutherland Shire halves energy bills for its administration centre (Section 4, title page)
Meter readings reveal saving potential for **City of Monash** (Section 4, sheet E2)

Table E1-1. Options for financing an energy efficiency program. Contractual arrangements with energy management consultants will affect the way proposed measures are implemented.

Description (see also sheet S5 *Leases and contracts*)	**Best points**	**Possible drawbacks**
Traditional Your Council contracts an energy management consultant to provide an energy audit investigation and report. You then read and understand the report, obtain finance, and organise implementation (possibly including plans and specifications, tenders etc. although the consultant often handles this)	It's a system which most managers are familiar with. The contract for each stage is fairly simple.	The process can fall over at any stage. Your Council must find the funds for implementation. Your Council must have suitably qualified staff with the time to brief service providers.
Performance contracting Also called 'shared savings'. Similar to the Traditional method except that the hired consultant is paid partly or wholly according to *achieved* energy savings. See Strategy sheet S5 *Leases and contracts* for more information about arranging performance contracts	Lower risk for your Council. Consultant will be motivated to achieve savings.	Contract may be more complicated. Some effort will be needed to calculate savings. Consultant may apply a conservative approach to maximise profitability instead of maximising cost-effective savings.
Lease Similar to the Traditional method, except that your Council leases major items of equipment or possibly even leases major modifications.	Leases are a familiar instrument. Your Council can conserve capital for core activities.	May be limited to purchasing equipment and this may not be the most cost-effective solution to your energy needs.
Energy Services Contract An Energy Services Contractor (ESCO) agrees to provide the energy services which your Council now receives (such as thermal comfort, illumination, etc.) for a fixed annual fee which is less than you now pay for energy and maintenance. The ESCO can only profit by investing in your business to improve the energy efficiency of your plant. The ESCO provides the capital required and recovers this investment by sharing in the savings for a fixed period (normally around 7 years).	Contractor is motivated to achieve savings. There is a single point of contact for energy services. The agreement, once signed, is stable. No capital needed by your Council. Demands on your time are minimised. Budgeting is easier as future energy costs are known. New technology can be incorporated during life of contract.	The concept, although common in Europe and the USA, is not known by most Australian managers. The initial contract is more involved than those in the Traditional method (but there is only one contract). Some effort will be needed to calculate savings. ESCO may apply a conservative approach to maximise profitability instead of maximising cost-effective savings.

Energy audits

An energy audit is an important step in developing an energy efficiency program. This information sheet explains what an energy audit involves and how to maximise the benefits.

An energy audit may be applied to an individual facility, a group of facilities or all facilities. Audits may also be carried out early in the development of an energy management program, or at critical times during development and operation of the program. Over time, further audits may be appropriate, as the functions of a facility may change and the range of cost-effective energy technologies available will continue to expand.

What should an energy audit include?

Whether an energy audit is conducted using in-house or external resources, it should include the following steps:

1. **Agree on the broad aims of the audit**. The auditor needs to understand the aims of the audit in the context of what you want to achieve through your energy efficiency program. Reducing energy-related greenhouse gas emissions and reducing costs are obvious aims, but there could be others, such as:

- reducing peak demand for electricity or other energy services (e.g. compressed air, steam);
- securing energy supply (especially in the case of essential community services);
- demonstrating energy efficiency or a particular energy-saving method,
- using or demonstrating renewable energy;
- reducing visible waste of energy (e.g. lights being left on when not needed), which can undermine ratepayers' and staff's confidence in the Council's commitment to energy efficiency.

2. **Understand any recent changes your Council' or facility has undergone**. This will help the auditor make sense of recent energy consumption trends.

3. **Understand any changes you expect your Council' or facility to undergo within the next 5–10 years**. This will ensure the energy auditor's recommendations are consistent with your broader plans, and the effect of planned changes is included in financial evaluations (for example, it's much more cost-effective to upgrade lighting during a planned building refurbishment than as a separate project). Relevant plans could include:

- building or plant additions or alterations;
- changes to operations (for example, operating hours, services provided, staff numbers);
- relocation, combination with other facilities, etc.

4. **Collect energy consumption data for the last two years** (electricity, gas, liquid fuels, etc.) and graph the average daily energy use for each energy source. Also collect data on

which to base **energy consumption indicators** (e.g. floor area, number of staff, pool area).

5. **Monitor and record the hourly pattern** of electricity (and other significant energy sources) for at least one week. Where a 'smart meter' is installed, your electricity retailer can supply a load profile. Other electricity meters can usually be monitored using a device that senses rotation of the spinning disc and records the number of revolutions, for example, per half hour.
6. **Survey energy-using equipment**, including:
   - power ratings and loadings including real power measurement;
   - operating times, and controls including time switches, thermostats, etc;
   - condition;
   - the benefits or services which the equipment is used to produce.
7. **Estimate the site energy consumption for each activity,** based on the total operating hours and average power of each piece of equipment.

   Temporary monitoring equipment can be installed to ascertain the load profile of the larger electrical loads, such as airconditioning plant, individual floors, or buildings on a multi-building site. Examples of temporary monitoring include:
   - clamp-on electrical current monitoring;
   - air temperature monitoring and logging (ambient air and in airconditioned buildings);
   - run-time monitors, which detect the magnetic field of a running motor without accessing the power cable.

   Where temporary metering requires access to electrical switchboards it must be installed by a licensed electrician or suitably qualified person.
8. **Reconcile the calculated energy usage** with:
   - the known total annual energy consumption;
   - seasonal variation in energy consumption and peak power;
   - energy consumption in each of the tariff periods (for example, peak, off-peak, shoulder, etc);
   - the weekly electrical demand profile (and gas profile if available).
9. **Identify opportunities** to reduce energy consumption and costs while maintaining or improving the quality of services (for example, lighting, airconditioning) and achieving your organisation's other goals. These opportunities arise from improved efficiency of procedures, equipment, controls and using the most appropriate energy source.

The audit investigation must include:

- analysis of *all* energy sources purchased by Council, including electricity, natural gas, LPG and oil;
- evaluation of real energy-saving and greenhouse gas emission-saving measures (i.e. it must not be simply a tariff or pricing check);
- sufficient initial engineering design to ensure that the estimates of savings and investment are reasonable.

The audit report must include:

- a concise, action-oriented executive summary of no more than two pages;
- a practical implementation plan which accommodates any special requirements of your Council, such as timing, cash flow, premises changes, etc.
- recommended indicators of energy efficiency, benchmarks, targets and a timetable to meet those targets, and ongoing monitoring of progress toward achieving those targets.

Costs and savings

An energy audit conducted by an energy audit consultant will require an investment of between 3 and 5 per cent of a year's energy costs.

The audit can be expected to identify economically achievable measures which can save between 20 and 40 per cent of your energy costs. You should be able to implement some (at least half) of the recommendations immediately, while others may require further investigation.

Who can help?

Standards Australia has standards which can help you prepare briefs for energy auditors.

Case study: Meter readings reveal savings potential

The City of Monash in Melbourne's east has a site with a library building and a civic offices building. There is a common electricity supply and account for the whole site, which until mid-1999 was split according to a fixed library to office ratio of 30:70. However, analysing data from an electricity sub-meter on the library supply has revealed that the ratio is actually about 15:85. The sub-meter has also made it possible to produce a load profile for the library (see Energy sheet E4 *Using an electricity meter*) giving useful clues about how energy is used and revealing savings opportunities.

The load profile was subtracted from the load profile for the site (obtained from the electricity retailer's ‘smart meter’) to produce a load profile for the office building alone, revealing further savings.

The library meter is now read monthly, and consumption data collated with data from the bill for the site. A brief report and cost summary is then sent to the library manager and the office building manager.

For further information: Ms Carly Platfuss, Environmental Manager, City of Monash, ph 03 9518 3716.

Negotiating energy contracts

Reducing emissions while minimising energy cost

The market for energy in Australia is becoming increasingly competitive, with more and more consumers able to negotiate energy supply contracts, and energy suppliers restructuring tariffs to better reflect variations in the cost of supply. This provides an opportunity to maximise the cost-effectiveness of your CCP™ action plan, as well as raise its profile within your organisation.

The key benefits from linking your action plan to energy contract negotiation are:

- management attention and support may be easier to maintain;
- savings achieved through contract negotiation can be allocated to fund strategies for improving energy efficiency, which may in turn reduce electricity contract costs even further; and
- it provides a stronger argument for establishing programs to monitor energy demand and introducing centralised systems to monitor and pay energy bills.

The introduction of ‘green’ electricity tariffs (see below) also means your Council may be able to reduce its greenhouse gas emissions by simply selecting the appropriate ‘Green Power’ option.

Opportunities in new tariff structures

Energy has traditionally been a low priority issue for management, but the ability to negotiate energy contracts has major implications for operating costs. So management now has a new level of interest in energy issues. Many strategies which reduce greenhouse gas emissions also reduce the cost of energy under new contracts, so both objectives can be met.

Electricity contract costs include:

- contestable charges for electrical energy (kWh);
- regulated charges for electrical energy (kWh) and electrical demand (kW or kVA); and
- regulated fixed charges, e.g. for metering

By managing electricity consumption and demand you will be able to control all these charges except the fixed charges, typically giving you control over more than 95 per cent of the total charge.

Examples of **new tariff structures** (which can be applied in combination) include:

- **seasonal tariffs**—for example, Western Power (WA) has introduced a tariff which is higher during the day in summer, and during the morning and evening in winter, to reflect the higher cost of supplying peak demand;

- **peak supply charges**—for example, Victorian electricity charges typically include a monthly fee of $5 per kWh of *peak annual demand*[1]; this means that peak demand for 15 minutes of the year determines a component of energy cost for the whole year;
- **'time of use' tariffs**—a higher price is charged per unit of electricity at peak periods, and lower prices during periods of low demand;
- **'Green Power' electricity tariffs**—Green Power is a national program to promote electricity generated from renewable sources. When you buy a Green Power accredited product, your electricity retailer purchases renewable energy from sources such as solar, wind, biomass, wave and hydro. Usually, a Green Power tariff involves paying a few more cents more per kWh of electricity so the supplier can finance the development of renewable energy sources. If you choose a Green Power option as well as investing in energy efficiency, you can reduce both total energy costs *and* greenhouse gas emissions, and send a 'powerful' message to energy suppliers.

Charges for 'reactive power' or poor 'power factors' may also be part of a tariff structure. This a technical issue but may be a factor in your electricity bill (see box below).

What is 'power factor'?

Mains electricity is supplied as alternating current (AC) at 50 cycles per second (and around 240 volts). In an AC supply the current and voltage vary between a maximum positive value and a maximum negative value 50 times every second (hence the term 'alternating'). Ideally, the cyclic variations of voltage and current are in phase—that is, voltage and current reach their peaks at the same time. This ideal situation is described as having a 'power factor' of 1 and zero 'reactive power'.

Because of the effects of electrical equipment, the variations of voltage and current may shift out of phase, so that they no longer peak at the same instant. The further out of phase they become, the higher the electrical current which is required to do useful work. The higher electrical current increases losses in the distribution system, increasing the electricity supplier's fuel consumption (and greenhouse gas emissions).

It can also mean the distribution company must upgrade their infrastructure, which costs them more money

So, the lower the power factor, the more some electricity suppliers now charge for the electricity used. Consumers can improve their power factor by (preferably) removing causes of low power factor such as idling motors, or by installing power factor correction devices. Some electricity supplier do not charge extra for poor power factor, but expect customers to upgrade their equipment to achieve at least a specified PF of around 0.8. Investing in some energy-saving measures (e.g. lighting with electronic ballasts) can improve PF, reducing the need to invest in PF correction equipment.

[1] The word *demand* is used by the electricity industry to mean the rate at which electricity is used, in kilowatts (kW). This figure is important because the higher the (maximum) rate of electricity use, the higher the required capacity of wires, transformers and related distribution assets. So to encourage medium and large electricity customers to control their demand, electricity companies include a demand component in their total charge. This compares with domestic tariffs which only include charges for energy (kilowatt hours) and a fixed supply charge.

Tips for getting the most out of electricity supply contracts

1. **Monitor energy consumption** to determine the factors contributing to peak demand, and develop strategies to reduce this through energy-efficiency improvement, load management and fuel switching. Strategies which reduce both peak electricity demand and greenhouse gas emissions include:
   - thoroughly checking airconditioning controls to ensure cooling equipment is not working harder than it has to (see Sheet E5 *Heating and cooling buildings*);
   - switching from electric to gas for hot water and cooking;
   - installing insulation;
   - shading windows and/or installing double glazing;
   - installing high-efficiency heating and cooling equipment;
   - improving the efficiency of any equipment that operates at times of peak demand.
2. Analyse your activities to determine **existing and possible load profiles** so you can work out the least-cost supply contract being offered. Providing good data on total electricity consumption and load profile will reduce the uncertainty and risk for potential electricity suppliers and should result in lower prices being tendered. This analysis will also help you determine how energy is being used and how to reduce consumption. Make sure your contract conditions allow you to reduce the monthly peak demand charge if you can demonstrate that the actual maximum demand has decreased, either:
   - by reference to the maximum demand figures on the electricity accounts for the last year, or by
   - by proving that more recently implemented load management measures will have reduced the maximum demand.

   As electricity suppliers are, in many cases, increasing demand charges while reducing the cost per kilowatt hour, this is important if you are to gain full financial benefit from greenhouse reduction strategies.
3. **Consolidate** the electricity consumption of all the Council's contestable sites for negotiation purposes.
4. Form **negotiating partnerships** with other consumers, to increase bargaining power.
5. Specify the provision of **billing information** which will help you manage Council's energy use. As a minimum, this should include:
   - a graph of average daily electricity use in each billing period of the past year, and
   - an hourly electricity profile for the past month (where an electricity 'smart meter' is installed).

   Make sure any contract entered into specifies that all billing data, energy profiles and greenhouse emission data will be supplied to a central point in your Council for ongoing monitoring and analysis.
6. Combine selection of a **Green Power tariff** with an effective energy efficiency program. This means total energy costs can fall at the same time as greenhouse gas emissions are reduced per unit of electricity used. Many Green Power schemes offer a range of options

which vary in price according to the proportion of Green Power purchased, so you can link your choice of tariff to the amount saved by efficiency measures to limit total energy costs.

7. Consider **a longer agreement period**, which will be more attractive to electricity retailers and result in lower energy prices. It may also reduce your administrative burden by increasing the time between tendering, while providing a stronger incentive for the electricity supplier to establish automated billing and recording systems.

8. Set aside a portion of any contract savings to be used to **reduce energy consumption and manage demand**. While negotiation of electricity contracts can result in savings on energy bills of up to 20 per cent, gains in energy efficiency will normally result in further savings of 40 per cent. It may be worth noting that the days of large cost savings through contract negotiation seem to be nearly over: according to Energymarket.com, 'customers seeking contracts today (mid 1999) in NSW and Victoria are reporting average increases of up to 20 per cent on their total bills'. In this context, strategies to manage overall energy use and peak energy demand will be critical tools in limiting the impact of possible rises in electricity costs.

Managing maximum demand for electricity will reduce the cost of the annual demand charge, which is a component in all contestable electricity accounts and many non-contestable (franchise customer) accounts. For example, a chiller which adds just 100 kW to the site maximum demand on the two hottest days of the year, will incur *energy* costs of about $125 but *demand* costs (based on $60/kW/year) of $6,000 per year.

Many NSW and ACT electricity customers are charged for maximum 'apparent power' which is shown on the bills as kVA instead of kW. The apparent power demand can be reduced by reducing the power demand (kW), or increasing the power factor (see page E4-2).

Gas supply contracts

Gas accounts will soon become contestable, starting with large consumers such as paper mills and chemical plants. The timetable in NSW and Victoria is:

Annual gas consumption (GJ/year):	> 500,000	> 100,000	> 5,000	All remaining customers
Contestable gas accounts introduced:	1 Oct 1999	1 Mar 2000	1 Sep 2000	1 Sep 2001

For most Councils, the first facilities to be able to shop around for gas will be heated swimming centres; the larger centres in cold climates will have a gas consumption over 5,000 GJ per year. However, most Council facilities will become contestable on 1 September 2001.

If market competition reduces gas prices, it will have the effect of making cogeneration more attractive (see sheet E20 *Cogeneration*).

Who can help?

On Green Power: SEDA (www.seda.nsw.gov.au) or Energy Efficiency Victoria (www.energyvic.vic.gov.au)

Market regulators: *NSW*: Independent Pricing & Regulatory Tribunal of NSW, www.ipart.nsw.gov.au *Victoria*: Office of the Regulator General, www.reggen.vic.gov.au

Quotes from energy retailers can be obtained from www.energymarket.com.au.

Using an electricity meter

This sheet describes the information which can be gleaned from an electricity meter, and how it can be used.

You can use an electricity meter to monitor electricity use by a whole building, a part of a building (e.g. the airconditioning system) or a single piece of equipment.

Each site will have an electricity meter owned by the electricity company, but there may be other meters owned by Council, installed to monitor electricity use by individual buildings on a large site, or electricity use in parts of a building (e.g. a plant room). You can also purchase or rent various types of portable electricity meter for specific monitoring tasks, and most energy management consultants should have electricity metering equipment.

Monitoring companies and electricity businesses charge between $350 and $500 to monitor an electricity billing meter for one to two weeks and between $500 and $750 to install, program and report on temporary electricity metering.

Why use electricity meters?

Electricity bills provide very limited amounts of information on the detail behind energy consumption, such as what equipment uses most electricity, when, and under what usage conditions. A variety of metering strategies can provide valuable additional information so problem areas can be pinpointed, patterns of use can be understood, and so on.

This can have financial benefits. For example, in many cases a significant component of Council's electricity bills is the peak demand charge—up to half of total costs (see sheet E3 *Negotiating energy contracts*). Meters can be used to identify the major contributors to load at this time, so that efforts can be made to reduce the load, and the cost.

Meter reading can also be done by non-technical staff, which encourages them to make suggestions on improving efficiency.

It should also be noted that energy audits often involve very limited metering. The use of additional metering will provide useful insights and more accurate data to both in-house and consultant energy managers.

Types of electricity meter and the data they provide

There are three main types of electricity meter which provide information on electricity use:

Electronic meter

An electronic meter stores numbers which can be read from the front of the meter, either as the meter automatically scrolls through them (about one each second) or in response to pushing a button on the meter. Values for up to about 20 parameters can be stored, such as peak, shoulder and off-peak energy used, maximum demand, etc, both current and for the previous month.

The parameters and the order of display will vary between meter models and electricity retailers, but the following list shows the main ones. The meters will often display a code and a value for each parameter, sometimes with an explanation of the codes printed on the meter.

The main parameters, in approximate order of display are as follows (readings may need to be multiplied by the 'meter factor'; see box opposite):

- *Date:* Month and Day, and sometimes the day of the week (e.g. Monday = 1)
- *Time*: Should show standard time, even during daylight savings period.
- *Total electricity*: Total kWh used in all periods since meter installation.
- *On-peak use*: Total kWh used in the on-peak period since meter installation. This period is normally 7 a.m. to 11 p.m. on weekdays, but more complicated tariffs exist. The pricing structure may vary according to local regulations and electricity retailer pricing methods (e.g. holiday tariffs, peak, off-peak and shoulder periods, etc.) but the same principles apply.
- *Highest demand this month*: The highest rate of electricity use (kW) any time in this metering period (month).
- *Highest demand*: The highest rate of electricity use (kW) any time since meter installation.
- *Off-peak use*: Total kWh used in the off-peak period since meter installation. This is usually the difference between the total electricity use and the on-peak use (see above), but some tariffs have more than two parts to the pricing table.

'Smart meter'

A 'smart meter' stores the same information as an electronic meter, plus the average demand every 15 minutes for at least one month. As with electronic meters, the values of parameters can be observed on the meter display, but the main distinguishing feature of a smart meter is the ability to communicate this data and the load profile using a modem (usually connected to a mobile phone network).

This meter's ability to store a month's history of the way electricity is used each 15 minutes can provide valuable clues about what is using electricity in the building. The load profile can be obtained from your electricity retailer (the account manager's contact details should be provided on your electricity invoices).

Mechanical meter

A mechanical electricity meter has a rotating disc and either:

- one register (set of digits) showing total electricity use since the meter was new; or
- two registers, showing the on-peak and off-peak electricity consumption.

(Old meters may have a series of circular dials and pointers; contact your electricity supplier for an explanation of how to read these, or see http://www.pcorp.com.au/smarthome/energyeff/reading/index.html or http://www.united.net.au/ehome/InfoCtr/How%20To/meterreading.asp)

Like an electronic meter, unless the meter has been configured to incorporate the ‘meter factor’, the numbers may need to be multiplied by this factor (see box).

The rotating disc can be used to work out the instantaneous rate of electricity use, with the formula:

Power (kW) = (3600 x K) / (revs per kWh x seconds per rev).

K is the meter factor (see overleaf). The revolutions per kWh will be stamped on the meter. The time for one revolution of the meter disc (seconds per rev) can be measured with a stop-watch.

Appliance metering

Metering and monitoring the electricity of individual appliances has the benefits of better quantifying energy use and making electricity use more tangible for the people who use the equipment. A good example is measuring the electricity use of a personal computer and the savings which can result from enabling the builtin energy saving features.

The simplest way of measuring the electricity use by a single appliance is with a plug-in appliance meter. These plug into the power outlet and the appliance plugs into the meter. Meters approved by electricity authorities are available for between $400 and $2000, depending on features. For example, one device which displays power, voltage, current, power factor and logs energy use over time is available for $585 (see www.genesisauto.com.au/elemetric.htm).

A note on ‘meter factor’

Most electricity meters in Council buildings will use current transformers (so-called ‘CT operated’ meters). Passing all the electricity used in a large building through the meter would require the meter to be very robust; instead just a small portion passes through. This is achieved by using current transformers which produce a small current (up to 5 amps) proportional to the total electrical current supplying the building. The ratio of the total current to the current actually going through the meter is the ‘meter factor’.

In most cases, the electricity meter readings (both kilowatt hours and kilowatts) will have to be multiplied by the meter factor. In other cases, the meter will have been configured to be ‘direct reading’ so that no multiplication is needed.

The meter factor will normally be stated on the meter, often prefixed by the letter ‘K’, e.g. K = 80.

Sometimes it will be expressed as the ratio of the maximum current which the current transformers will measure to their maximum output current (always 5 amps), e.g. ‘400 / 5’ means K = 80.

The meter factor will also normally be stated in the calculations on the back of the electricity bill.

Putting electricity meter data to work

Here are a few examples of how you to use an electricity meter to help you manage electricity use in Council facilities.

Load profiles

Electricity load profiles can be obtained either as 'smart meter' data from your electricity company or by attaching special monitoring equipment to a mechanical electricity meter. A load profile makes the pattern of electricity use 'visible' and so helps identify how electricity is used and how it can be saved. **Figure E4.1** shows actual load profile for a Council library.

Off-peak vs on-peak use

Use billing data to roughly compare consumption during operating hours and outside hours. This may be a crude analysis, depending on the structure of your supply tariff: for example, if your peak tariff applies 7 a.m. to 11 p.m. weekdays, comparing off-peak to peak period consumption gives a conservative indication of the proportions of energy used outside working hours versus during working hours. For a building which operates only during normal office hours, you would expect the off-peak consumption (including weekend electricity use) to be less than a fifth of the on-peak total consumption (peak plus off-peak plus shoulder), and preferably lower still. Most off-peak consumption indicates electricity use when the building is normally unoccupied, and so is wasted electricity.

After-hours use

By manually reading the electricity meter at the end of the working day and again at the start of the next working day, you can discover the amount of electricity used outside working hours. This often reveals significant and unexpected consumption, with the potential for savings.

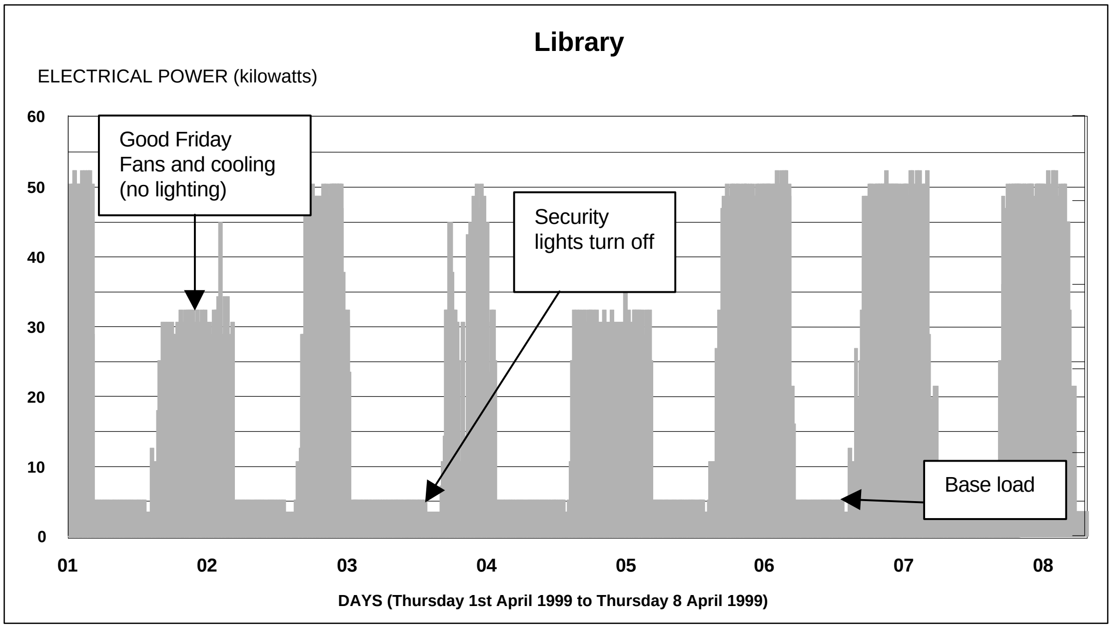
Weekly monitoring

Reading the electricity meter at the same time each week will allow you to monitor the electricity use of the main Council buildings, and to check the impact of changes as they occur (e.g. new equipment is introduced or energy-saving initiatives implemented). It also lets you monitor how energy use is affected by variations in weather conditions, which allows some evaluation of scope for improving building energy efficiency by adding shading, insulation, etc.

Instantaneous power

Calculating the instantaneous power—the rate of electricity use at a particular moment in time—can be useful in discovering the power demand of a whole building at a certain time of day, or by a particular piece of equipment (e.g. by running just the lighting or just the main fan after hours, when no other significant loads are running).

Figure E4.1. Load profile for electricity use by a Council library over one week. The building has a gas heating system (there is no electric heating). The main electricity uses are airconditioning (fan and cooling) and lighting.



The load profile reveals:

- There is a 'base-load' electricity demand of more than 5 kW, when the library is closed. This reflects equipment left on, security lighting, losses from continuously operated equipment such as boiling water units, etc.
- The library was closed on 2 April (Good Friday) and 5 April (Easter Monday) and so the lights were not on. The airconditioning, however, did operate; started by the time-switch.
- On the two public holidays, the cooling operated for most of the day, even though the outside air temperature only peaked at 17.5 °C (not shown on graph) and there was no heat generated by lighting, people, etc. This shows there are big problems with the library temperature control system.
- On the Tuesday to Thursday, the cooling also operated all day, even though the temperature rarely reached 16°C. The cooling was even operating when the plant first started, when the ambient temperature was 10°C or lower!

Heating and cooling buildings

Significant energy is required for heating, cooling and ventilating buildings, but there are also significant opportunities for saving—both costs and greenhouse gas emissions.

More than 60 per cent of greenhouse gas emissions from office buildings result from heating, cooling and ventilation. Since heating and cooling are major contributors to peak demand for energy, they also contribute disproportionately to energy bills, which increasingly include extra charges for high energy demand.

The capital investment in heating, ventilation and cooling (HVAC) equipment is enormous: equipment cost in a new high-rise building can exceed $200 per square metre of floor area—often 20 per cent of the total building cost.

Councils own and occupy a wide variety of buildings, which adds to the complexity of dealing with heating and cooling issues. The CCP™ software package allows you to enter separate data on energy use and floor area for each building. This means you can identify the buildings with the highest energy use per square metre—much of which is likely to result from heating and cooling—and target them for efficiency improvements.

Opportunities for savings

Savings of between 20 and 70 per cent can be achieved on both HVAC operating costs and greenhouse emissions, depending on the circumstances. Further, as electricity suppliers change their tariff structures in the current competitive market to charge more for peak demand (see Energy sheet E3 *Negotiating energy contracts*), operating costs could rise, as HVAC is often the major component of peak demand. So the financial benefits of reducing HVAC energy consumption are likely to increase.

Consider both the building and the system

Commercial buildings and their HVAC systems vary widely in scale and complexity. However, there are basic elements in every case and it is important to make sure each works properly. The main elements are:

Building envelope: The design of the building's envelope (walls, floors, roofs, glazing etc.) determines the rate of heat flow into or out of the building and the transfer of air between indoors and outdoors. Flows of heat are usually largest through glazing, but the other elements (walls, floors, etc.) can be important too, especially in smaller buildings. Energy-efficient building design can cut total HVAC energy requirements and peak demand, in turn reducing the capital cost of HVAC equipment (as long as the HVAC designer takes the improvements into account). For small buildings, the characteristics of the building envelope are more important than in larger buildings, because the surface area of the building (and thus heat flow through the surface) is much higher relative to the floor area than for a large multi-storey building.

⇒ *Refer to Energy sheet E6* Energy efficiency and the building envelope.

Internal heat loads: Lights, office equipment and people generate heat, and this heat must be removed by cooling equipment (although in cold weather it can reduce heating requirements). Reducing the energy consumption of lighting and equipment within buildings reduces the amount of heat generated within a building and, hence, airconditioning costs. It's important to put measures in place to minimise internal heat loads *before* addressing the heating/cooling system; otherwise, you won't achieve the full benefits of a more efficient system. In cool or moderate climates, an economy cycle (which uses cool outside air instead of refrigerative cooling; see below) can remove excess internally-generated heat when outdoor temperature is lower than the indoor temperature. This can save large amounts of energy.

⇒ *Refer to:*
Energy sheets E7 Lighting overview *and E8* Office lighting
Energy sheet E10 Office equipment

Ventilation loads: Outside air is used in airconditioning systems to control air quality (for example, to remove odours, CO_2 and contaminants such as plasticisers released by some building materials). However, ventilation often increases the amount of heating or cooling required, so outside airflow rates should match what is actually required, based on floor area and occupancy level. Modern control systems allow the ventilation rate to be varied with building occupancy, and Australian Standards now make provision for such control strategies. It also makes sense to run a start-up cycle with very low outside air supply at the beginning of each winter day, to warm-up the building at maximum efficiency.

Energy distribution systems, usually air ducts or water pipes: Pumps circulating chilled or heated water, as well as fans blowing air through ducts, often consume as much energy as is used to heat and cool the building. Further, ducts and pipes are often inadequately insulated, so much of the cooling or heating energy may be wasted during distribution. In large buildings, both heating and cooling systems often operate at the same time because of variations in temperature throughout the building. This further increases distribution energy losses.

Control systems monitor the heating and cooling requirements of the building and vary the operation of the HVAC system to maintain comfort. At its most basic, a system may have a simple thermostat. More sophisticated systems involve time controls, humidity sensors, CO_2 sensors and optimisation systems, and may be part of a complex building automation system (BAS). In large buildings, control systems may operate heating and cooling systems at the same time, in response to conditions in different parts of the building: These systems often work against each other.

⇒ *Refer to 'Optimise control systems' and 'Building management systems' later in this sheet.*

Heating or cooling equipment varies in scale and complexity from a simple wall-mounted airconditioner, through standard 'package' modular units, to large and complex systems with boilers to provide heat, and chillers and cooling towers to provide cooling. The more complex the system, the larger the energy losses from associated equipment such as fans and pumps, and from heat losses in the distribution system.

⇒ *Refer to 'Choose the right equipment' later in this sheet.*

Ensure the system is maintained properly

Even if the HVAC equipment in a building is properly commissioned after construction, performance deteriorates over time. Thorough maintenance programs can therefore bring substantial, cost-effective savings.

A sample of nine office buildings which implemented thorough maintenance programs in Sydney achieved median energy savings of 23 per cent. The ongoing annual cost of the maintenance program was typically around 15 per cent of the ongoing annual energy savings.[1]

In smaller buildings, maintenance activities might include:

- checking thermostat settings, calibration and correct operation, including sensors and controllers away from the plant room;
- checking the setting of controls including time switches and selector switches;
- checking the operation and settings of economy cooling dampers and controls;
- regular cleaning or replacement of filters in airconditioners;
- checking for leaks or deterioration in insulation of ducting;
- sealing of air leaks around doors and windows.

Where maintenance is carried out under contract, make sure the contract is sufficiently detailed and supervision is adequate to ensure that maintenance is done properly.

⇒ *See also Strategy sheet S5* Leases and contracts.

Optimise operation of pumps and fans

Large savings can be achieved by installing variable-speed motor drives, so pump and fan speeds can be matched to requirements. The savings are disproportionately large—halving the flow rate in moderate weather theoretically cuts pump or fan energy requirements to one-eighth!

Further savings can be achieved by:

- cleaning filters, fans and dampers regularly;
- checking and lubricating or replacing bearings;
- ensuring that drive belts are in good condition, evenly matched and correctly adjusted;
- installing high-efficiency, appropriately sized motors when replacement is needed, and installing variable-speed drives where loads on motors vary;
- fitting time switches or more sophisticated controls and using them to shut down cooling/heating in areas and at times when it is not needed.

⇒ *See also Energy sheet E4* Motors, drives, pumps, fans

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[1] 'Maintenance and energy management in building services', S J Hennessy, paper presented at *Cutting energy costs* conference, April 1995, Sydney; IBC Conferences, Strawberry Hills NSW

Optimise control systems

Time controls

Airconditioning systems in most commercial buildings are automatically started and stopped each day by a time switch. Operation could be optimised by ensuring that the time switch:

- is set to the correct time;
- has the latest start and earliest stop times consistent with building occupancy hours;
- cannot be permanently over-ridden by leaving a bypass switch in the wrong position.
- You could also evaluate the benefits of a time switch which:
- starts the plant later during mild weather (called 'optimal start'); this is usually able to reduce operating time by an average of 30 minutes each day, a saving of about 5 per cent in a system previously operating for 10 hours each day;
- does not start the plant on user-programmed public holidays (saving 10 days out of 250—a 4 per cent saving).

Temperature controls

You could evaluate the savings from cooling system controls which:

- prevent cooling equipment from running in cold weather in cold weather (in complex HVAC systems, controls may allow heating and cooling to operate simultaneously in different parts of a building, even if not really required);
- allow the temperature of chilled water to increase in cool weather; since only limited amounts of cooling are likely to be required in cool weather, less cold water can still provide enough cooling capability while reducing heat gain via pipe insulation (which is related to temperature differential) and improving chiller efficiency (which improves as temperature difference becomes smaller).

Similarly, savings may also be achieved with heating system controls which:

- prevent heating equipment from running in hot weather;
- allow the temperature of heating water to decrease in warm weather.

Choose the right equipment and install it properly

Small commercial buildings often use domestic airconditioners and heating equipment. These carry appliance energy labels, so it is possible to select energy-efficient models.

Where ducted or split systems are installed, it is extremely important to make sure ducts or pipes are well insulated (recently revised Australian Standard 4508-1999 now recommends minimum insulation levels of up to R1.5; see example at the end of this sheet). In general, it is more energy-efficient to distribute gas and electricity around a building than it is to pump heated or cooled air or water.

Although large chillers are much more efficient at cooling than small modular units, overall system efficiency is often much reduced when distribution losses and the additional 'parasitic' loads of cooling towers, pumps and fans are taken into account. Features such as reheat systems (which reheat cold air to optimise comfort in each zone of a building) can further reduce overall efficiency.

Trading-off efficiency of central plant against losses from distribution systems can be a challenging task. Many designers give inadequate consideration to these issues.

You could investigate the feasibility of 'economy cooling', a cooling mode which automatically uses outside air when cooling is required and the outside air is cooler than the air in the building. Note, however, that many 'economy cycles' waste energy if they are inadequately maintained; for example, if dampers controlling the supply of outdoor air jam partly open, large amounts of energy can be wasted heating or cooling excessive volumes of outside air.

Make sure HVAC designers analyse heating and cooling loads in detail and optimise operational effectiveness and efficiency under the full range of likely conditions. This may require you to specifically allocate part of the design budget to these tasks, but it will be money well spent. Structure contracts for design and commissioning so that part of the payment depends on the system performing to specified standards after the building is occupied. Designers might also be paid on the basis of system performance rather than a percentage of system cost (see performance contracting in sheet E1; table E1-1).

Also make sure your HVAC designer consults with the building designer to ensure that peak cooling and heating loads are minimised through good envelope design: this will cut the capital cost of the HVAC system, and peak energy charges.

⇒ *See also:*
Energy sheet E6 Energy efficiency and the building envelope
Strategy sheet S7 Building design and specification

Building management systems

Building management systems (also called building automation systems or simply BASs) facilitate control and monitoring of equipment (especially airconditioning and other mechanical equipment). Such systems can have the advantages of:

- improved control, comfort and security;
- reduced equipment operating times, energy consumption and greenhouse gas emissions, and reduced wear;
- improved monitoring of building and equipment, including running times, temperatures, electricity demand, running costs, etc.

A BAS will have a capital cost of about $200 per sensor or controlled point. The design of a system (working out what you want it to do now and in the future) will require a significant amount of time spent by staff and/or a consultant.

BASs are sometimes oversold—when they are credited with savings which could have been achieved more economically by fixing existing simple controls.

When considering a BAS:

- make sure existing controls are optimised and low-cost rectifications are completed first;
- consider what equipment needs controlling and what inputs will be used to decide if and how the equipment will run;

- write a technical description of the required BAS (possibly with assistance from in-house technical staff or independent consultant); this will help you clarify your requirements and communicate them to colleagues and potential suppliers.

When selecting a BAS and BAS contractor check:

- that the system permits flexibility and later expansion;
- what happens to the system if some of the remote equipment fails;
- that the system can be easily interrogated and reprogrammed by your company (without needing to refer to the installer or manufacturer);
- that any new software or equipment introduced by the manufacturer will be made compatible with all previous versions of software and equipment (preventing premature obsolescence);
- that international date formats are supported.

Estimating energy consumption and greenhouse emissions

Ideally, energy use for HVAC should be separately metered. If this is the case, this data can be easily converted to greenhouse gas emissions (see Section 5).

If separate metered data is not available, 'house power' may be separately metered. This includes HVAC, lighting of common areas, lifts, and so on. It may be possible to estimate electricity use for activities other than HVAC, and subtract this from the 'house power' to give an estimate of HVAC consumption.

If only the whole building's energy use is metered, this at least gives some indication of HVAC energy consumption.

Replacing CFCs and HCFCs in airconditioning equipment

CFCs and HCFCs are significant greenhouse gases. However, their contribution to global warming is not considered in greenhouse inventories because they are also ozone-depleting chemicals, and as such they are controlled under the Montreal Protocol. Government regulations require Councils to replace CFCs and HCFCs in their airconditioning equipment according to specified schedules. Although detailed consideration of CFCs and HCFCs is beyond the scope of this workbook, CFC replacement strategies have some important links to energy use and energy-saving strategies:

- When CFCs or HCFCs are to be removed from a building airconditioning system, HVAC equipment may have to be replaced. This provides an opportunity to consider investing in energy efficiency measures that reduce peak heating and cooling requirements.. Also, because some CFC replacements reduce the peak capacity of existing airconditioning plant, efficiency improvements to reduce cooling loads can be useful in avoiding the need for additional capacity.
- Hydrocarbon refrigerants are becoming available for use as CFC replacements. Some of these products are claimed to improve both peak cooling capacity and operational energy efficiency of existing airconditioning plant by up to 20 per cent. However, it should be noted that a number of safety measures must be applied to address concerns about the flammability of hydrocarbon refrigerants: Australian Standard 1677-1998 provides guidelines.

Possible indicators

- Total energy use or HVAC energy use (if available) in the building: trend over time
- Total energy use or HVAC energy use per square metre: monthly, seasonal and annual
- Energy use during and outside working hours (to identify scope for switching off equipment when not required)
- Energy use during peak and off-peak periods (to identify contributions to energy bills)
- Energy use in summer versus winter (to identify the extent of seasonal variation: where there is little variation, it is likely that significant energy is being wasted).

Who can help?

Seek out designers who have demonstrated expertise in achieving high levels of energy efficiency (and ask for evidence of expertise based on actual energy bills from buildings they have designed). The Property Council of Australia (PCA) carries out annual energy surveys of buildings, so they may be able to direct you to energy-efficient buildings whose designers you could engage.

Equipment manufacturers may also be helpful, but keep their advice in context as they are rewarded by bigger equipment purchases.

SEDA's building energy rating system includes an analysis tool that can be used to identify problems and opportunities for savings.

Examples:

Insulation improves airconditioning efficiency

The airconditioning system in a low-rise commercial building was expensive to run and did not provide acceptable indoor temperatures on hot days. Air was leaving the airconditioner unit at 13°C, but reached 24°C by the time it was released into the building. The temperature inside the roofspace, where the poorly insulated ducts were installed, was 62°C.

Adding extra insulation to the ducts and ventilating the roofspace reduced the problem, and air was then delivered into the building at 17°C—still a 35 per cent loss in system efficiency, but a major improvement. Installing reflective foil insulation under the roofing, as well as further upgrading duct insulation, would bring further savings. Alternatively, locating the ducting in a cooler environment (for example, within the airconditioned space) or shifting to modular airconditioners would improve efficiency.

Heat from down under

Manly Council is investigating the use of ground-source heat pumps for heating in several buildings. These heat pumps gather heat from the ground, which is warmer than the air during cold weather, and deliver it into the building. The heat is collected using a network of pipes buried about one metre below ground level, and so is well suited to buildings adjoining open space. The pipes could also be incorporated under open car parks, providing this is planned before construction of the car park. Contact Skye Addison, Manly Council, ph 02 9976 1602.

Automation system helps manage HVAC in dispersed buildings

Box Hill Institute of TAFE in Melbourne's east operates four campuses and provides classes from 9 am to 10 p.m. on weekdays and 9 am to 5 p.m. on Saturdays.

The problems

Facilities management staff had two problems: managing and monitoring the dispersed buildings was difficult and time consuming; and energy consumption was excessive because of a lack of controls on airconditioning and other equipment.

When staff received complaints (for example, about room temperature) they would have to send someone to the building (often on another campus) just to establish if there was a problem. This cost time and used vehicle fuel. If there was a problem, diagnosis took more time as plant rooms had to be accessed and equipment checked.

Time switching controls were inadequate considering the flexibility required for class scheduling. Staff often had to visit buildings including those on remote campuses to adjust or override time switches. Last-minute and un-notified changes to class times also resulted in airconditioning equipment running when it did not need to.

The BAS solution

With the help of an energy auditor, facilities management staff drew up a specification for a building automation system (BAS) which would satisfy some immediate needs and be flexible enough to have other capabilities added or programmed later.

Initially the system was used to time-switch airconditioning plant accurately according to actual needs. Boiler and cooling systems in many areas were then controlled according to the outside air temperature, which was also monitored by the BAS.

The system allows staff to respond quickly to reports of airconditioning problems; they can monitor the temperature in most rooms from the computer in the facilities management office, allowing them first to determine whether there really is a problem. If necessary, useful diagnosis can be conducted from the computer monitor, including plant status (on or off), valve positions, heating and chilled water temperatures.

The system includes a data logging facility which can produce a graph showing a history of the performance of equipment. This is a handy tool, especially when the performance is in question.

BAS controls fan speed to improves efficiency

The largest building on the main campus has six levels of classrooms, offices, a library, restaurant, a canteen and amenities. A single airconditioning fan supplies air to all areas except the library and the restaurant. This configuration required the fan to operate and warmed or cooled air to be provided to most of the building even when only a few areas were occupied.

A variable-speed drive was installed to control the speed of the fan. Initially, the speed was set by the BAS according to the need for cooling. Later, automatic dampers were installed to shut off unoccupied areas (especially at night and on weekends). A pressure sensor allows the fan to be slowed in response to the dampers closing when the building is less than fully occupied.

For further information: Mr Bruce Hird, Box Hill Institute of TAFE, 03 9286 9478.

Energy efficiency and the building envelope

Appropriate design of a building's 'envelope' (walls, floors, roofs, windows and so on) can cut greenhouse gas emissions by reducing the amount of energy required to maintain comfort.

As well as reducing greenhouse gas emissions, the benefits of an energy-efficient building envelope include:

- lower cost of airconditioning plant, as smaller quantities of heating and cooling are required at peak periods (often, the capital savings on HVAC plant can almost pay for the extra cost of insulation and other energy-efficient features—before the value of ongoing energy savings is even considered);
- lower charges for peak energy demand;
- improved occupant comfort.

The energy efficiency of an existing building envelope can be improved by a variety of measures. While this may not save on investment in heating and cooling plant, it can still cut peak energy demand charges, reduce operating costs and improve occupant comfort.

Where airconditioning equipment is being converted to eliminate the use of CFCs, the replacement refrigerants may have different properties, and this may reduce the cooling capacity of the plant. Rather than investing in extra equipment to compensate, upgrading the energy efficiency of the building envelope is a good alternative, as this option also reduces peak capacity requirements and cuts ongoing energy costs as well.

Constraints to overcome

Efforts to improve the thermal performance of a building are often treated as a low priority for a number of reasons:

- building design is the responsibility of the architect, while engineers look after HVAC design (including calculation of heating and cooling loads, which provides valuable information about which elements of the building envelope contribute most to heating and cooling energy consumption and peak demand). Often communication between the two is poor. Appropriate contractual arrangements and/or use of a project manager or coordinator can overcome this (see Strategy sheet S7 *Building design and specification*);
- HVAC designers are often paid a percentage of the cost of the HVAC system, so they have no incentive to help the architect reduce HVAC size and cost;
- many designers believe that an energy-efficient building envelope may *increase* energy consumption by trapping heat generated by lights, equipment and people inside the building (this myth is dealt with later in this sheet);

- energy-efficient building design is sometimes perceived to be expensive, but appropriate orientation, sizing and selection of glazing can actually reduce envelope costs.

Opportunities for savings

Savings on HVAC operating costs (and greenhouse emissions) through energy-efficient building design can range from 20 to 50 per cent.

Glazing

Up to a kilowatt of heat can enter a building through a square metre of clear glass exposed to direct sun—equivalent to switching on a single-bar electric heater at the hottest time of the day. Winter heat loss through each square metre of single glazing is three times that through uninsulated wall, and more than 10 times the loss through a square metre of insulated wall. This adds to peak electricity demand (often incurring extra demand charges), requires increased HVAC system capacity, and creates glare and occupant discomfort.

Ways of cutting energy flows through glass include:

- design the building with less glass (which cuts capital cost, as wall materials are usually cheaper than glazing);
- if building or renovating, advanced glazing systems (which include double glazing and heat reflective coatings) are now available which allow much less heat flow and more daylight, improving occupant comfort compared with older types of glazing; a *Window Energy Rating System* has been developed by the glazing industry, mainly for residential windows. This has been trialled in Canberra and may be launched soon throughout Australia;
- install external shading (plants or constructed shading). In hot regions, consider shading the ground around buildings, as well as windows and walls exposed to sun;
- install reflective internal blinds such as reflective pleated blinds;
- install heat-reflective window films (today’s films are much improved on those of a few years ago: they allow in more light while rejecting heat more effectively);
- paint dark-coloured metal window frames a light colour (they are disproportionately important paths for heat flow; painting them light colours reduces heat flow markedly, because light colours reflect most radiant heat. In a study at Melbourne’s Austin Hospital, it was found that dark metal window frames became dangerously hot on sunny days, and transferred so much heat they were uncomfortable to be near. Metal window frames are also available with thermal breaks, which reduce heat flow through the frame);
- for display windows in information centres, consider separating the display area from the main shop area with insulated partitions or glass panels;
- insulating panels can be fitted over part of a large window area to cut heat flow; but this should be balanced against loss of daylight and visual access.

Solar building design (which may use large areas of north-facing glazing) can often reduce energy costs and improve amenity. However, in many office buildings, which require mainly cooling and little heating, solar gains can increase energy costs and create glare problems unless carefully integrated into the building design. Ideally, computer simulation should be used to optimise building design.

Insulation of ceilings, walls and floors

Insulation reduces heat flows through ceilings, walls and floors. This can markedly improve occupant comfort and reduce the time HVAC systems take to reach comfort temperature at the start of the day.

Council buildings are generally poorly insulated for several reasons. Often, large council buildings are purchased after construction, or are designed to normal commercial building specifications, which tend to place low value on future running costs relative to up-front capital costs. This is an inappropriate approach for owner-occupied buildings with long lives. In many cases, buildings originally designed for one purpose may be converted to other uses without sufficient consideration of building energy efficiency.

Also, many HVAC consultants consider that insulation has little net energy or financial benefit because it traps heat generated within the building, thus increasing cooling loads. However, this argument is losing validity because:

- electricity tariffs are shifting emphasis to charges for *peak* demand, and insulation is particularly effective in reducing electricity consumption during peak periods; insulation also reduces the size of HVAC system required, which saves capital costs (savings on peak demand charges and offsets against capital savings are often ignored in cost–benefit analysis);
- ‘economy cycles’ are now more common, which means that, in moderate temperatures, heat generated internally can be removed using outdoor air instead of increasing cooling costs;
- improvements in office equipment and lighting energy efficiency mean internal heat loads are *declining* in many circumstances (contrary to folklore). This means there is less unwanted heat to be trapped by insulated walls, ceilings and floors, and the net economic benefit of insulation improves.

Insulation of ceilings, walls and floors is a more significant factor for smaller buildings with low internal heat loads than for large multi-storey buildings. For example, consider two buildings, one five storeys high and the other only single-storey, both with 1000 square metres of floor area per storey:

- the five-storey building has around *0.9* square metres of external surface per square metre of floor area;
- the single-storey building has *2.5* square metres of external surface area per square metre of floor area.

Energy flows through the roof, walls and floor are therefore a much larger proportion of total energy flows for the smaller building.

To summarise, under extreme conditions, an energy-efficient building envelope *always* reduces energy consumption and energy charges for peak demand. The smaller the building and/or the lower the internal heat loads, the more energy insulation will save. Since most Council buildings have long lives, relatively long occupancy hours and aim to provide a high standard of comfort, it makes sense to incorporate a high standard of insulation into all council buildings.

For existing buildings, it may be difficult to retrofit insulation into walls, but it is usually possible to insulate ceilings and under exposed floors (such as floors above carparks).

Air transfer

Air leaking at the rate of only 100 litres per second (about the rate of air removed by a domestic exhaust fan) creates a cooling or heating load of up to 2 kilowatts under extreme climatic conditions. In a building housing 250 people, entry of outside air at twice the required rate could add up to 50 kilowatts to the cooling or heating load—a substantial waste of energy, costing up to $5 per hour. Problem areas and strategies to address them include:

- ensure doors are closed where feasible; use self-closing doors, fit heavy plastic strips to limit air flow (see example below), or install windbreaks or airlocks at entrances;
- large amounts of airconditioned air may be removed by exhaust fans, particularly where a building includes a commercial kitchen (such as for Meals on Wheels). In such a situation, outside air could be ducted into the area near the exhaust fan, providing an alternative source of air for the fan and preventing it removing airconditioned air;
- gaps around doors and windows, and cracks in the building fabric can be weatherstripped or sealed. Often there are serious air leaks around doors and hatches to un-airconditioned areas; these depressurise the building and allow cold draughts to cause discomfort for staff near doors and windows;
- open fireplaces and heater flues are large sources of air leaks in some Council buildings converted from residential use. Open fireplaces can be blocked off or fitted with dampers. Not much can be done about existing heater flues, but new heaters can be chosen that isolate combustion air from the indoor air, so (warmed) indoor air is not lost;
- evaporative coolers installed for summer cooling can allow large quantities of warm air to escape in winter; they should be fitted with automatic louvres to seal them closed when not in operation.

Who can help?

⇒ *Refer to:*
Energy sheet E5 Heating and cooling buildings

Lighting overview

Energy for lighting is used in nearly every Council activity. Fortunately, it is possible to improve the quality of illumination at the same time as reducing greenhouse gas emissions and lighting costs.

Lighting accounts for about a third of all electricity used in Council buildings, while street lighting normally uses more energy than any other Council activity.

Lighting is also important to a Council because illumination affects:

- the ability of staff and citizens to see accurately, affecting their ability to read, work and move safely;
- the appearance, ambience and functionality of a building and its fittings, affecting the mood and morale.

When looking for ways to cut greenhouse gases, probably the first action most people think of is switching off lights. Of course, this is very effective, but there are many other ways to reduce lighting energy use. Some of these are described here, and opportunities particularly relevant to offices and street lighting are described in Energy sheets E8 *Office lighting* and E9 *Street lighting*.

Opportunities for savings

Use daylight

Daylight is the most abundant and easily used form of free, renewable energy.

Outside lighting and lighting in atria can be controlled by a daylight sensor. Some sensors have an adjustable light-level setting, making them suitable for areas which have access to natural lighting but which require a higher lighting level than the setting of standard sensors. Such areas could include glazed foyers, some depot buildings, indoor swimming pool halls, undercover parking, or child care centres..

In some cases, modest changes to a building will permit better use of natural lighting—for example, skylights in a depot workshop or garage. Care is needed to ensure solar heat gain is controlled, although a (pre-1994) State Electricity Commission of Victoria study showed that the heat gain from a *well-designed* roof-lighting system is less than the heat gain from electric lighting!

Painting internal surfaces light colours and trimming vegetation back so windows have greater access to the sky can improve the effectiveness of daylighting. Painting walls outside windows light colours to reflect more light into the room can also make a remarkable difference to the amount of useful daylight.

Using daylight inside a building will improve the quality of the lighting in Council buildings by improving colour rendering, eliminating flicker and giving people a link to the outside environment.

However, too much daylight, especially direct sun, can create glare problems and excessive heat. For example, a square metre of clear roof glazing in direct sun delivers as much light as up to 40 standard 36-watt fluorescent lamps.[1] Good design of daylighting systems is critical.

Use the right amount of light

People need more light to read than they do to walk down a corridor, but offices and other buildings are often lit with the same lighting intensity throughout. Over-lighting wastes energy and money without producing any benefit. Australian Standard 1680 recommends appropriate lighting levels for various tasks (see later in this sheet) and, importantly, suggests how these levels can be achieved efficiently.

Put light where you want it

You could provide a light switch for each separate work area such as an individual office, so that only those lights required are used (and ask staff to switch on only the lights they need).

You could also use fittings appropriate to the area which needs to be lit. For example, a desk-light can provide very good lighting where it is needed but consumes a small fraction of the power required by standard ceiling-mounted lights. The desk-light can also be adjusted to suit individual preferences. Moreland City Council's new offices, for example, provide a lower level of general lighting in conjunction with task lamps for desks.

Operate lights only when required

As well as the daylight sensors and manual switches already described, 'burning' time can be reduced by:

Occupancy detectors

These detect people by detecting movement, and automatically switch lighting off after no movement has been detected for a period (normally adjustable). Models are available for offices (these detect the slight movements made while reading, using a telephone or operating a computer) and for areas where movement is more obvious (for example, passageways, change rooms or car parks). Occupancy detectors are especially useful in low-occupancy areas which are not the responsibility of any one person (for example, conference rooms, tearooms or corridors).

The investment required to install occupancy detector lighting controls may be:

- about $100 for a simple detector which can be installed in less than one hour;
- about $250 for a more sensitive detector for office applications and a control relay to switch power to the lights;
- more than $300 for an installation requiring more than one sensor or a sensor to cover a large area (such as a gymnasium or hall).

[1] 'standard' means a fluorescent lamp (tube) which is not a tri-phosphor lamp. Compared with a tri-phosphor lamp, a standard fluorescent lamp has: a shorter life (i.e. 8,000 hours compared with 16,000 to 24,000 hours); a lower efficacy (lower light output for the same electrical power draw); poorer light colour; and quicker performance degradation (aging).

Selection, siting and adjustment of occupancy sensors is best done by an expert.

Note that it *is* cost-effective to switch off fluorescent lamps, even for short periods. Financial and energy analysis has shown that if a standard fluorescent lamp is switched off for more than two or three minutes, the energy and financial savings exceed the costs associated with restarting the lamp (including the cost of slightly reducing lamp life).

Time switches

Time switches are *not* appropriate for lighting in offices, stairwells and similar situations, where switching the lights off could plunge occupants into darkness. However, they can be used to switch off 'aesthetic' or display lighting at night after the time most people could benefit from it. For example, automatically switching off the lighting for a building exterior, monument or fountain at midnight will slash electricity use but still provide illumination when most people will be passing by.

Use an efficient light source

The light fitting (or 'luminaire') can be selected to provide quality lighting while minimising the total cost over the life of the unit (purchase price plus energy, maintenance and other operating costs; see Strategy sheet S3 *Financial evaluation*).

The following table gives the most appropriate lamp type for most applications (see *Don't forget the fitting* on the next page for advice about luminaires).

For many general applications:

Fluorescent	Modern fluorescent lamps, especially the more efficient 'tri-phosphor' lamps, have low cost, high efficiency, good colour (unlike the blue hues of older lamps) and very long life (8,000–16,000 hours rated life compared with 1,000–2,000 for incandescent lamps). They are readily available in lengths of 300–1500 mm.

For situations where there are size or style constraints:

Compact fluorescent:	Have characteristics similar to full-sized fluorescent lamps but are suitable for applications where the size or appearance of normal fluorescents is unacceptable or the high lighting output is unnecessary (e.g. desk lights, downlights, wall washers).

For lighting large areas (e.g. indoor pools, depot garages):

Metal halide:	Metal halide lamps produce a crisp white light. They have an efficiency about the same as the best fluorescent lamps, but more light output, and so fewer fittings are needed.

For situations of infrequent use:

Incandescent	Incandescent lamps (including standard light 'bulbs', low-voltage and linear tungsten halogen lights) should only be used in fittings which will be operated for less than 500 hours per year, such as cleaners' rooms, or outside lights controlled by movement detectors (also see box on low-voltage lights, next page).

As well as lower greenhouse gas emissions, energy-efficient light sources such as fluorescents have two significant benefits:

- increased reliability (and hence safety); and
- reduced maintenance costs (both lamps and labour).

Low-voltage lights are not energy-efficient

Low-voltage lights are not low-power or low-energy lights. They have some advantages, but energy efficiency is not one of them. Their efficacy is about 20 lumens per watt (compared with 90–110 lumens per watt for modern fluorescent lighting). The transformers supplying the low-voltage power also use energy (typically 10–20 watts per lamp), further reducing the efficiency of the lighting system. When calculating the energy use of low-voltage lighting systems, remember to include this energy loss.

Low-voltage lighting is overused in many office buildings, partly because of the misconception that it is energy-efficient.

Its real advantages are:

- the ability to highlight a small area or object (e.g. a painting); and
- small size, which can be an issue in some lighting installations.

Low-voltage lighting should not be used for lighting large areas, such as entire foyers and reception areas.

Don't forget the fitting

A light fitting should distribute the light produced by the lamp as efficiently as possible to where it is required. Some perform better than others: an efficient fitting can use half the power of an inefficient one to produce the same light output (even though they may both use the same kind of lamp). Traditional recessed fluorescent lamp fittings with acrylic plastic diffusers deliver about 50 per cent of the light produced by the lamps into the room, while the best models, which incorporate carefully shaped reflectors, deliver more than 75 per cent of the light produced.

Fluorescent fittings include a 'ballast' which controls lamp current. This unseen component consumes up to 10 watts per lamp, or more than a quarter of the power rating of the lamp itself. Modern electronic ballasts are available which:

- reduce the total power of the light fitting by about 25 per cent while maintaining light output (compared with only an 8 per cent reduction with 'low-loss' iron-core ballasts);
- eliminate flicker during start-up and normal operation; and
- extend lamp life.

You can specify electronic ballasts for fluorescent light fittings supplied in new premises or lighting refurbishments.

'Low-loss' iron-core ballasts reduce electrical power by about 3 watts per lamp (reducing ballast energy use by one third compared with a standard ballast. Although the savings are much lower than those of an electronic ballast, they are suitable for:

- the replacement of failed iron-core ballasts, and
- use in fluorescent lighting which will operate for fewer than 1500 hours per year.

Maintenance is important

Unless lighting systems are regularly maintained (cleaned and relamped), the lighting quality declines.

Fluorescent lamps dim as they age. This dimming effect, combined with the buildup of dust on lamps, diffuser panels and reflectors, reduces the amount of light reaching the area to be lit. Although you get less light, you use just as much electricity (which you pay for and which generates greenhouse gases).

There is a natural tendency to keep fluorescent lamps until they die completely, by which time they could be producing only a third of the light they produced when new. A standard 36-watt fluorescent lamp costs about $2 to buy but about 10 times this amount to operate in an office building for just *one* year.

Standard fluorescent lamps should be replaced in bulk after 8,000 hours operation (about three years in an office or one year with continuous operation) or 16,000 hours for the new long-life fluorescent lamps. The lamps and light fittings should be cleaned once a year.

The advantages of this planned maintenance include:

- the quality of the built environment is maintained;
- the tendency to add more light fittings because of falling light levels will be avoided;
- bulk lamp replacement minimises disruptions and facilitates lamp recycling through a special lamp crusher (which some Councils and electricity distributors own), whereas lamps replaced one at a time tend to end up in landfill—where the mercury they contain may contribute to environmental problems.

The amount of light entering through windows and roof lights can drop by up to 60 per cent because of dirt buildup, so these also need regular cleaning.

Lighten up

Lighter-coloured walls, ceiling and furnishings reflect more light to working areas, and so need less artificial (or natural) lighting to achieve the required illuminance. Darker colours require more light to prevent the walls and ceilings appearing gloomy.

Useful data

Lighting levels

The following recommended maintenance[2] lighting levels are extracted from AS 1680.1-1990 (Table 3.1, as amended in June 1993).

Class of task	Recommended illuminance	Characteristics and examples
Movement and orientation	40 lux	Corridors, walkways.
Rough, intermittent	80 lux	Interiors used intermittently. Change rooms, live storage areas, loading bays, stairs.
Simple	160 lux	Coarse detail. Staff canteens, entrance halls, etc.
Ordinary or moderately easy	240 lux	Continuously occupied areas with easy visual tasks, such as blackboards and charts in training rooms, food preparation, transaction counters.
Moderately difficult	320 lux	Routine office tasks of reading, writing, typing, enquiry desks, libraries.
Difficult	600 lux	Drawing boards, town planning and enquiry counters dedicated to viewing paper plans.

Lamp efficacy—light produced per unit of power

Lamps are labelled with their wattage. This tells you how much electrical power the lamp will use but not how much light it will produce. The amount of light produced by a lamp is measured in *lumens* (lm). The amount of light produced for each unit of electricity is expressed as the lamp's *lumens per watt* (lm/W). The table shows typical figures for common lamp types.

Lamp type	Lamp efficacy (lumens per watt)	Lamp life ('000 hrs)
Tungsten filament (standard incandescent light 'bulb')	10–15	1–2
Tungsten-halogen (including low-voltage lamps)[3]	15–20	1–4
Fluorescent	65–100	8–16
Compact fluorescent	50–80	8
Metal halide	70–105	6–10

[2] 'Maintenance illuminance' is the minimum illumination required for various tasks—at this level, corrective action (such as cleaning or replacing lamps) is required to maintain or improve lighting levels. The initial illuminance should be slightly higher to allow for dirt build-up in the fittings and the reduction in light output as the lamps age. Modern 'through life' tri-phosphor lamps are claimed to lose only 6 per cent of their light output over their rated life of 16,000 hours. Dirt build-up in office light fittings has reduced noticeably since the phasing out of smoking. Providing fittings will be cleaned at least once every two years, the initial illuminance need only be about 15 per cent higher than the maintenance illuminance in most offices.

[3] The transformers used for low-voltage lamps waste up to 30 per cent of the total energy used, reducing overall efficacy to little better than that of standard incandescent lamps

Calculating energy consumption and greenhouse emissions

For each group of lights:

1. Calculate the annual electricity use for one light in kilowatt hours (kWh) by multiplying the power of the lamp by the number of hours of operation; the table below gives sample values for a range of different lamp types and applications.
2. Multiply by the number of lights to give the total energy use of the group of lights,
3. Use the greenhouse coefficients in your CCP™ software (see Section 5) to convert the annual electricity use (kWh) to greenhouse gas emissions (tonnes of CO_2 equivalent)

Lighting application	Operating hrs/year	Annual energy use (kWh/year) by lamp type				
		Fluorescent		Incandescent		
		Single 1200 mm (45 W[1])	Twin 1200mm (90 W[1])	Low-voltage 50 watt (65 W[2])	Standard 'bulb' (75 W)	Tungsten (example) (250 W)
Office, individual	1,250	56	113	81	94	313
Office, open plan	2,000	90	180	130	150	500
Library	3,000	135	270	195	225	750
Depot office, two shifts	4,000	180	360	260	300	1,000
Gymnasium	5,000	225	450	325	375	1,250
Continuous running	8,760	394	788	569	657	2,190

[1] Including ballast

[2] Including transformer

Example

A Perth library has 150 fluorescent fittings, each with two 1200 mm lamps. These operate for 3,000 hours per year. The electricity supply contract includes 25 per cent Green Power. What is the amount of CO_2 emitted as a result of supplying lights with electricity?

1. Annual electricity use for one light	From table above	= 270 kWh/yr
2. Annual electricity use for all lights	270 kWh/yr x 150 lights	= 40,500 kWh/yr
3. Deduct proportion of Green Power	40,500 – (0.25 x 40,500)	= 30,375 kWh/yr
4. Greenhouse emissions from lighting	From CCP™ software[1]	= 33.4 tonnes CO_2/yr

[1] Factor for WA electricity is 1.10, so emissions are 30,375 kWh x 1.10 = 33,4125 kg CO_2 = 33.4 tonnes CO_2 per year

Possible indicators

- Total lighting energy use (if available) in the building: trend over time
- Lighting energy use per square metre: monthly, seasonal and annual
- Lighting energy use during and outside working hours (to identify scope for switching off lights when not required)

Who can help?

Illuminating Engineering Society of Australia and New Zealand has offices in most states.

Standards Australia has relevant standards and advisory publications.

Examples: Efficient lighting saves energy

Gosford Council (NSW) has reduced lighting energy use in its 10-storey administration building by replacing the three standard fluorescent lamps in its triple fittings with two high-efficiency tri-phosphor lamps ('tubes'). Despite saving of over one third on energy consumption, light output is up, and the light has a better colour.

For further Information: Mr Jim Wilson, Manager, Electrical and Mechanical Service, Gosford Council, ph 02 4325 8410

When the historic **Newcastle City Hall** was converted to a function centre in the early 1980s, 380 recessed incandescent downlights were installed. These seemed suitable at the time, but maintenance problems soon emerged—such as very short lamp life, failed lamp-holders and overheated wiring.

Also, by 1990, the electricity bill for this building had reached $105,000. This meant that 10 per cent of the Council's entire budget for this energy source was being spent on a single facility—a building which would normally be expected to have shorter operating times than most Council buildings.

Newcastle City Council converted the downlights to use an 18 watt compact fluorescent which produced light of the same colour as an incandescent lamp. The total investment was $20,000 and the action is now saving 100 tonnes of CO_2 and $15,000 per year.

The new lamps last three years, instead of 6-8 weeks, reducing maintenance costs and improving building appearance.

For more information: Mr Peter Dormand Green Energy Project contact Coordinator, Newcastle City Council, phone 02 4974 2542, email pdormand@ncc.nsw.gov.au

Office lighting

Lighting's importance and general opportunities for savings are described in Energy sheet E7 *Lighting overview*. This sheet elaborates on the opportunities for savings in offices.

Opportunities for savings

Use daylight

Daylight can often be used effectively by automatically dimming the two rows of lights adjacent to windows (daylight switching is not recommended in offices because of the distraction it can cause—although dimming can be used).

Avoid excess lighting

The building owner and lighting designer usually provide office-standard lighting before the office space has a tenant and the usage of the space is known. This results in ceiling-mounted light fittings being used to provide an illumination level suitable for reading almost everywhere, even though only about 5–10 per cent of the office space will require this lighting level (say, 1 m^2 of desk space per person).

A much better approach is to:

- use a combination of uplights and standard fittings to provide background illumination suitable for moving around the office and general tasks which do not require prolonged, detailed reading;
- use compact fluorescent task lights (desk lamps) to provide the high level of illumination required for reading and writing text, etc. Low-voltage halogen or incandescent task lights can be cheaper to buy but are much less efficient than compact fluorescent.)

The advantages of this approach are:

- the total lighting power is cut by more than half, which also reduces the load on cooling equipment;
- office staff have more control over their own lighting;
- the office will look better, and effective uplighting will remove the gloom a dark ceiling creates;
- unwanted reflections in computer screens (from light fittings and overlit objects) will be significantly reduced;
- work areas will be abundantly lit without over-lighting other areas such as walkways.

How efficient is your lighting system?

The energy efficiency of a lighting system is gauged by the 'lighting power density' (watts per square metre) for a given lighting level, and the flexibility and effectiveness of lighting controls (switches, dimmers etc).

The lighting level is expressed as the 'maintenance illuminance' (the minimum illuminance for particular tasks, below which maintenance is required—for example, cleaning or lamp replacement).

For routine office tasks, the recommended maintenance illuminance on the work surface is 320 lux (see Energy sheet E7 *Lighting overview*). This amount of light could be achieved in various ways, some obviously using more power per square metre than others. The options are described in the following table.

Lighting design and installation	Description	Power density (watts/m²)
Mediocre	Standard 'project' ceiling-mounted fluorescent fittings using standard fluorescent lamps and ballasts. Same lighting level throughout the office space.	25–35
Good	High-efficiency ceiling-mounted fluorescent fittings using tri-phosphor lamps and low-loss, iron ballasts. Same lighting level throughout the office space.	12
Excellent	High-efficiency, ceiling-mounted, fluorescent fittings and uplights with metal halide lamps used to provide background illumination of 80–160 lux. Individual task lights used to provide illuminance of at least 320 lux at each work station	4–7
State of the art	As above plus daylight integration (bringing daylight into the working areas and automatically dimming lights according to daylight).	2–5 (averaged over time)

Calculating your lighting power density

You can quickly get an idea of where your office lighting falls in the above scale of energy efficiency by estimating the lighting power density. This is simply the total lighting power divided by the floor area, and can be calculated for a small typical area. Here are some 'rules of thumb' that can help:

- Each 1200 mm fluorescent lamp uses about 45 watts (including its ballast) and most fittings have two lamps, giving a total of 90 watts. If you're not sure of the number of lamps per fitting, try switching the power off and then on; the lamps may 'strike' at different times so the number of lamps will be more obvious.
- If the floor area is difficult to measure because of obstructions, you could count the ceiling tiles. Each rectangular tile has an area of 0.74 m² and each square tile 0.37 m².

Prospecting for savings in office lighting

You could begin your search for lighting energy savings by checking for:

- **old, dirty fluorescent lamps and fittings**: cleaning the fitting will help, and using new, efficient lamps will allow you to get the same amount of light from fewer lamps (remember that fluorescent lamps dim as they age, so make sure the initial illuminance is sufficiently higher than the maintenance illuminance, although you can minimise the extra required by using modern ‘through-life’ tri-phosphor lamps (e.g. Osram Lumilux plus) which lose less than 10 per cent of their initial light output over their rated life.
- **lighting levels significantly above those required**: this is usually because the lighting has been designed assuming the space will be used for office work when it is actually a walkway or staff room;
- **incandescent downlights**: each 100 watt incandescent downlight uses more electricity than a 2 x 36 watt fluorescent fitting, although it delivers about 80 per cent less light. Also, the downlight housing causes the lamp to overheat, shortening the already short lamp life and adding further to maintenance costs. Compact fluorescent downlights will reduce the power required by 70 per cent and are available from $50 (plus installation). In a typical office, each incandescent downlight replaced will save $10 to $25 in electricity costs and $8 to $15 in lamp and labour costs every year.

Who can help?

Australian Standard 1680.1-1990 *Interior Lighting Part 1: General principles and recommendations* contains a wealth of ideas on using daylighting, avoiding glare, and other lighting principles, as well as recommended lighting levels.

Examples:

Council reduces lighting energy consumption by 76 per cent

The **City of Manningham** in the north-eastern suburbs of Melbourne has reduced lighting energy consumption by 76 per cent, while increasing lighting levels and improving the lighting colour. This has been achieved by a suite of improvements including:

- occupancy-detector switching of the lights in individual and open-plan offices, staff lunch room, and meeting rooms;
- converting incandescent downlights to use compact fluorescent lamps, by installing a ballast and lamp holder;
- using efficient high-output lamps and reducing the number of lamps;
- replacing some inefficient mercury-vapour downlights with compact fluorescent downlights which give better light colour and distribution at one quarter of the power; and
- using the security system to switch off lights automatically when an area is secured for the night.

For further details: Adam Briscomb, Environmental Planning, Manningham City Council,
ph 03 9840 9325

New lighting system will save $35,000 a year

The first stage of the **City of Adelaide's** energy-efficient buildings retrofit coincided with the Customer Centre fit-out. The newly installed lighting system, which includes display lighting, is on average 27 per cent more efficient than the previous system. When completed, the energy-efficient retrofit will result in annual emissions reduction of 315 tonnes of CO_2 equivalent and an annual 'eco-efficiency dividend' of $35,000.

For more details: Mr Jack Mazek, Program Coordinator Cities for Climate Protection, City of Adelaide, ph 08 8203 7209

Automatic controls and lighting retrofits achieve big savings

Newcastle City Council has cut lighting energy used by its administration centre by installing automatic controls and retrofitting lighting to reduce the power draw when the lights are on. Power factor has also been improved. The total investment in these works was $101,500, with savings of $67,000 to be made every year (a 40 per cent reduction—in addition to savings achieved through competitive electricity purchasing). The savings alone justified the improvements, but the resultant improved lighting, lower maintenance costs and lower greenhouse gas emissions were a significant bonus.

For more details: Mr Peter Dormand Green Energy Project contact Coordinator, Newcastle City Council, ph 02 4974 2542, email pdormand@ncc.nsw.gov.au

Street lighting

General lighting issues are described in Energy sheet E7 *Lighting overview*. This sheet describes energy use for street lighting and emerging opportunities for saving both costs and greenhouse emissions.

Electricity distribution companies normally provide street lighting (equipment, maintenance, and energy) on behalf of local government, and to a lesser extent, State departments which administer arterial roads. Of course, a Council pays for this service!

Of all Council services, street lighting is the one which uses the most energy. In greenhouse gas emissions, street lighting is second only to landfill sites. It is also an expensive activity, costing the councils and other agencies $156 million per year in energy alone and up to $900 million per year including the cost of equipment and maintenance times[1].

Good street lighting has an important role to play in the community. It contributes to people's quality of life by improving pedestrian and traffic safety, as well as making people *feel* safer; it also improves the appearance of the local environment.

Incentives for improving energy efficiency

A decade ago, the electricity industry consisted mainly of state-wide government monopolies, whose main concern was the integrity of the electricity supply system. Street lighting was a small additional task which accompanied the poles and wires asset. Street lighting was not a high priority, and the energy efficiency of the service was a small concern.

During the 1990s much of the Australian electricity supply industry has been divided into smaller parts, with generators separating from distributors and energy retailers. For distributors, street lighting is a bigger issue than it was to vertically integrated utilities.

Street lighting accounts for about 20 per cent of the greenhouse emissions attributable to a distribution company, so there is an environmental incentive to improve its energy efficiency. (And if the company is part of a program such as the Greenhouse Challenge, it will have made a formal commitment to reduce greenhouse emissions.)

There may also be a financial incentive for a distributor to improve efficiency, as long as the it is paid on the basis of the lighting service provided, rather than on a cost-plus basis (as now occurs in NSW).

Further, between 1999 and 2001, street lighting will become a contestable energy account for a Council, which means distribution companies have an incentive to provide the service which Councils ask for. And Councils can ask for a street lighting service with higher quality, lower energy use and lower ongoing costs for energy and other lifecycle items.

[1] Source: Coopers & Lybrand, "*Report to IPART on Street Lighting Review*" March 1988.

Opportunities for saving

In mid-1999, Energy Efficiency Victoria and SEDA commissioned an investigation of street lighting which found:

- present street lighting systems are inefficient, in that the quality of illumination of both minor and major roads is much lower than can be achieved, and the energy efficiency is low;
- there is a basic mismatch between the light colour produced by many street lights and the light colour which the human eye can use under typical street lighting conditions;
- The study also found that the quality of street lighting could be significantly improved, and the energy consumption at least halved, by a combination of:
- more efficient lamps (e.g. metal halide and compact or tubular fluorescent);
- more efficient luminaires (reflector design, less light loss in the diffuser, more accurate light distribution without a refractor bowl);
- efficient ballasts2; 'low loss' ballasts and especially electronic ballasts;
- more accurate control of lighting times (electronic photo-switch rather than the existing cadmium sulfide cells, to reduce burning time by at least an hour per day and give additional energy savings of 9 per cent);

The investigation report recommended field trials to demonstrate energy-efficient lighting strategies which meet the needs of local communities and road users. These trials will involve local government, electricity distributors, road authorities and lighting equipment suppliers.

What can Councils do now?

- Prepare an inventory of street lighting equipment. This can be used to minimise charges now, and help you prepare for tendering street lighting when it becomes a contestable service.
- Clarify how much you pay for power, maintenance, etc. in your existing contract.
- Inform your electricity distributor of the EEV/SEDA project, and explain that you will be expecting to work with them to achieve substantial energy and financial savings.

For further details, contact:

Energy Efficiency Victoria, Mr Paul Murfitt, Manager, Local Government Energy Services, phone 03 9655 3267

SEDA NSW, Ms Ronlyn Duncan, Project Leader Energy Efficiency, ph 02 9291 5284

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[2] A ballast is a device which controls the current in a discharge lamp (e.g. fluorescent, mercury or sodium). Without a ballast the current would increase rapidly as the lamp started and the lamp would explode. Most ballasts for fluorescent lamps use 10 watts each, and those for mercury lamps use 20 watts.

Office equipment

Energy-efficient technologies and improved management of office equipment can cut costs and greenhouse gas emissions significantly.

Each year, total energy use by office equipment in Australia generates around 7 million tonnes of greenhouse gases, of which:

- around a third is due to modular office equipment, including desktop computers, printers, copiers and fax machines;
- a third is due to mainframe computers; and
- the remaining third is due to PABXs, cash registers, EFTPOS units and other retail systems.

The electricity that powers office equipment is a direct cost to Council. There are indirect costs, too. Waste heat from office equipment increases airconditioning energy consumption, typically by 10 to 25 per cent, and increases peak energy demand. This impact is often ignored , but it adds to operational costs (see Energy sheet E5 *Heating and cooling buildings*).

The paper associated with office equipment is also a greenhouse issue. Although paper use is beyond the scope of this workbook, strategies that save office equipment energy can also cut paper consumption. Australians use around 230,000 tonnes of copy paper each year, mostly in offices, generating more than 1.2 million tonnes of greenhouse gases through paper manufacture and disposal. At an average cost of $6 per ream, office paper costs $550 million each year, so cutting paper use by office equipment can save a lot of money.

Computers, copiers, printers, fax machines

Typically, at least two-thirds (and up to 90 per cent) of the energy used by office equipment occurs when it is switched on but doing nothing useful. New equipment is generally much more energy-efficient than the equipment it replaces—although increases in screen size are outstripping efficiency improvements for computer monitors. For example, 17 inch monitors typically consume 100 to 130 watts, while 15 inch models use around 70 watts.

Use equipment efficiently

- Train staff to **switch off equipment** when it's not needed.
- **Activate energy-saving features**. Many computers, printers, faxes and copiers made in recent years comply with the *Energy Star* program originally developed by the US EPA but now promoted by energy agencies in Australia. These are fitted with 'sleep' modes (modes in which some functions are automatically shut down after set periods of inactivity). Activating these features saves energy and, in some cases, prolongs component life, but they are sometimes complicated to set up. Consult your manual or equipment supplier. Use IT staff to set up energy-saving features on all equipment in an office and train staff to work with these features—to minimise staff confusion and highlight the benefits. Check regularly to make sure energy-saving features have not been disabled. In some cases, energy-saving features can interfere with the operation of

computer networks or software. However, it is usually possible to enable at least some features. SEDA's web site (www.seda.nsw.gov.au) includes detailed advice on strategies for resolving problems.

- **Consider fitting timer switches to photocopiers,** but make sure there are instructions showing staff how to override the timer outside working hours, or the timer may be removed by frustrated staff.
- **If computers must be left on to remain connected to a network, turn off the monitor**; this uses half to three-quarters less energy without disconnecting the computer. In these circumstances, using a notebook computer instead of a desktop unit will lead to large energy savings.

It's OK to turn it off: According to major equipment manufacturers, switching off electronic office equipment does not shorten its life. In fact, since hard disk failure is linked to the total number of hours of operation, shutting computers down reduces risk of catastrophic disk failure. Monitor brightness also declines as operating hours increase—and screensavers *do not* save energy—so switching off monitors extends usable life.

There are also security reasons for shutting down computers when they are not in use. Most Council computers are linked to sensitive internal information, which may not be secure if unattended computers are left on.

Purchase energy-efficient equipment

Request information on energy use

When requesting purchasing documentation from suppliers, specifically ask for:

- power consumption in normal standby mode, in low-energy standby ('sleep') mode and while printing/copying etc.;
- time taken to change from 'sleep' and 'off' modes to full active mode (as it can be annoying if it takes three minutes for a copier to wake up and make its first copy!);
- compliance with the *Energy Star* program, which requires equipment to achieve low energy consumption in 'sleep' modes (but aim for much lower consumption than *Energy Star* requirements);
- for computers and printers, confirmation that the equipment will interact appropriately with networks (for example, some computers can't receive e-mail if in 'sleep' mode);
- evidence that controls for power management are user-friendly.
- information on the range of acceptable operating temperatures and humidity.

⇒ *See Strategy sheet S4* Purchasing policies

Assess your requirements

Regarding monitors, take into account:

- the larger the screen area, the more energy it uses (but there is up to 40 per cent variation in energy consumption for different brands of the same screen size, so the most energy-efficient large monitor may use less power than an inefficient smaller unit);
- liquid crystal display (LCD) monitors use much less energy and desk space than standard units; they are much more costly, but prices are falling rapidly;
- energy consumption among colour monitors of the same size can vary by almost 40 per cent, so check energy consumption before buying;
- while monochrome monitors are being used less often, they are still used for low-grade activities; monochrome units generally use much less power than colour ones of the same size.

One networked printer or central copier often uses much less energy than several smaller ones distributed around an office (but see the case study below).

For small offices, multipurpose printer/fax/scanner products are now available, which use less energy and can be cheaper than separate items of equipment (but adding extra features to the basic configuration can actually increase energy consumption, so beware; see 'Read the fine print' example at the end of this sheet).

Use paper efficiently

- Make sure equipment can use recycled paper without voiding the warranty.
- Purchase printers and copiers with duplex (double-sided) and reduction copying capability.
- Encourage use of paperless options such as e-mail.

Mainframe computers

Computer room airconditioning can generate a third or more of the greenhouse gas emissions associated with mainframe computers.

- **Check the power consumption** of your computing equipment and the power consumption of the computer room airconditioning (including pumps, cooling towers and fans). Often the airconditioning was designed for energy-wasteful old computers which have been replaced, and it may be inappropriate for today's demand.
- **Consider airconditioning redesign**. The amount of energy used by the dedicated computer airconditioning system is often greater than that consumed by the computers themselves, so there may be a case for the airconditioning system to be redesigned (for example, a simple domestic split-system airconditioner may replace a complex system with chillers, cooling towers and pumps).
- **Do you need a computer room?** Contact the manufacturer of your computer to find out what range of temperatures and humidity the equipment can operate in. Many modern computers can operate in a normal office environment, avoiding the need for separate airconditioning systems.

- **Minimise unnecessary power use** within an airconditioned computer room to reduce the amount of heat which has to be removed. For example, switch off lighting and monitors when they are not needed; and locate uninterruptible power supplies outside airconditioned areas.
- **Don't set temperature and humidity bandsettings too tightly** as this wastes energy. Maintaining precise temperature and humidity conditions often involves high energy use as plant may switch on and off frequently, creating high transient losses. Also, where the range of conditions is small, separate HVAC units may 'fight' each other—a heating unit running at the same time as a cooling unit, leading to energy waste—if thermostats and sensors are not constantly monitored and adjusted. Modern computers tolerate a much wider range of conditions, so this problem can be avoided.
- **Insulate the computer room from surrounding office space.** If the walls of the computer room are not insulated, running the computer room at, say, 18°C while the surrounding offices are 22°C can increase the cooling load by 1.5 kilowatts. Insulating the computer room's walls, floor and ceiling reduces cooling loads imposed by surrounding areas.

Also consider updating computers to modern ones with much reduced energy requirements. This can save space, too, as well as reducing airconditioning and computer maintenance costs.

Other equipment (PABX, cash registers etc.)

There is very little information available on energy consumption of phone systems, cash registers and so on. However, one PABX manufacturer has advertised that its system uses only 60 watts, 'much less than others'. And intelligent cash registers and EFTPOS machines can use energy-saving technology from computers and other office equipment to reduce energy consumption.

At this stage, it seems most appropriate to seek information from manufacturers when purchasing equipment, so that the most energy-efficient options can be selected. Doing this should also raise awareness among manufacturers, and should promote innovation.

Estimating energy consumption and greenhouse emissions

It is unlikely that centrally metered data will provide accurate information on the energy consumption of office equipment.

You may be able to collect metered data yourself using a plug-in meter costing about $600 (see Energy sheet E4 *Using an electricity meter*). Alternatively, you could seek information from relevant equipment suppliers; remember to ask for information on standby losses as well as consumption while operating.

You should note that the information printed on the appliance approval label is unlikely to accurately reflect actual consumption. This usually indicates the maximum possible consumption.

Once you have some information on energy use, see Section 5 for the method of converting energy consumption into greenhouse gas emissions.

Who can help?

Suppliers of equipment can usually provide information on their own products; you may have to ask them to contact head office, or talk to their technical staff.

Energy management consultants can help by measuring energy consumption of equipment.

State energy agencies are becoming increasingly active in promotion of office equipment energy efficiency.

Big savings from closing computer room

A Commonwealth Government department occupying two floors of a city office building knew that its computer centre had been superseded by the rapid growth in computing power of the desktop machines distributed around the office. The department also knew it would close the computer centre down one day.

An energy audit recommended that the closure be brought forward. Switching off the computers reduced the electricity consumption for the entire tenancy by 43 per cent (although the computers accounted for 15 per cent of the maximum power in the tenancy, they had operated 8760 hours per year compared with about 2000 hours per year for other equipment).

Monitoring of the computer room after it was converted to office and utility space showed that removing the computer room airconditioners and reinstating the normal office airconditioning ducting (which was still in the ceiling space) would reduce annual airconditioning maintenance costs by $5,400 and electricity costs by $10,100 and would require an investment of only $8,150 (a return on investment of 190 per cent per year).

Simple timer cuts photocopier energy use

The Office of Energy Policy, South Australia monitored the energy used by its central photocopier and found that most was consumed when the copier was on standby. A $40 timer was purchased, which turns the unit on between 8 a.m. and 6 p.m. weekdays. Energy savings repaid the cost of the timer within three months. The timer chosen can be easily overridden if the copier is needed outside normal operating hours. Annual greenhouse gas savings are estimated at just over a tonne of CO_2 equivalent for one copier.

Source: ‘Saving Energy in the Office’ in *Energy South Australia* Oct 1996, newsletter of the Office of Energy Policy, South Australia, Adelaide

Read the fine print

New multipurpose digital copier/scanner/fax/printers have the potential to slash office equipment energy costs by replacing several items of equipment with one. However, recent tests showed that the savings may not be as large as expected. One multipurpose unit tested by *Energy Manager* magazine was claimed to use only 4 watts on its energy-saving sleep mode. But when fitted with the extra features specified by many offices (such as collator, communication modules etc.) its standby power increased to 100 watts! This highlights the importance of asking for energy consumption information for the exact model or configuration you want, not just relying on generic information.

Adelaide computes the savings

Adelaide City Council has conducted a detailed and thorough investigation of energy use by its office equipment (especially computers, printers and photocopiers). Actual measurements of energy use of some computers before and after enabling *Energy Star* power saving features, and detailed calculations by the inhouse energy manager found:

For 370 computers	CO_2 emissions (tonnes/year)	Annual energy cost ($/year)
Before enabling Energy Star features	216.5	29,619
After enabling Energy Star features	107.383	14,694
Energy Star savings	*109.117*	*14,925*

This analysis showed that savings of approximately $15,000 and 109 tonnes of CO_2 could be achieved without any additional capital expenditure.

In addition, the Council calculated that it could save a further $9,700 and 70 tonnes of CO_2.per year by enabling the Energy Star features of its other significant energy consumers such as its 45 photocopiers and 30 printers. Some of these savings have already been achieved. Older equipment (without Energy Star features) is likely to be controlled using supplementary inexpensive timers.

To ensure the full benefits are attained, the following measures have been implemented:

- the existing electronic office equipment purchasing policy has been amended to require compliance with current relevant energy star specifications;
- Energy Star features on all new computer and other electronic hardware are being enabled by IT staff or appropriate service personnel at the time of initial installation and following repairs or regular maintenance;

Early difficulties overcome

The early difficulties with Energy Star gave it a bad reputation among some IT professionals. Occasionally, networked computers would lose their network connections when they powered down. However, this only affects older hardware or older network operating equipment; problems are rare with up-to-date hardware and robust 32-bit networking software.

Very worthwhile greenhouse gas emissions reductions can be achieved without any capital expenditure. The resultant financial savings can be reinvested in further energy efficiency initiatives.

For further information: Mr Jack Mazek, Program Coordinator Cities for Climate Protection, City of Adelaide, ph 08 8203 7209

Powersaver device cuts computer monitor power use

A simple device that senses whether the keyboard has been used shuts down the computer monitor after a specified time of inactivity, without interfering with the computer unit.

Available from Sharod International, sharod@iprolink.co.nz or ph/fax +9 478 8299 New Zealand.

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		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%**

Loss of efficiency → | Less loss of efficiency →

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

Refrigeration

Total greenhouse gas emissions from refrigeration in the commercial and public sectors are around 2.3 million tonnes (CO_2 equivalent) each year.

Australian business and public sector agencies spend at least $200 million each year running refrigeration equipment—around 5 per cent of their energy bills. Heat generated by this equipment can also increase the load on airconditioning systems, adding up to an extra $50 million to costs.

For Councils, refrigeration may be an issue:

- in community facilities and catering facilities, where commercial coldrooms and refrigeration units are installed;
- throughout offices and other facilities where domestic refrigerators and freezers may be used in kitchenettes;
- where refrigerated drink and food vending machines are installed for use by staff or visitors to facilities.

Existing refrigeration equipment may also contain large quantities of CFCs, which are powerful greenhouse gases as well as damaging the ozone layer. Issues related to CFCs are beyond the scope of this workbook, although using hydrocarbon refrigerants as replacement chemicals has the potential to improve energy efficiency (see Energy sheet E5 *Heating and cooling buildings*).

Opportunities for savings

Domestic refrigerators

Domestic refrigerators are often used in staff rooms, kitchenettes or small facilities.

Decide on the smallest size that can meet your requirements, and within that size range, use energy labelling information to choose the model with the lowest energy consumption. The energy label provides both a star rating (comparative efficiency for units of the same size) and an annual energy consumption number. Focus on the consumption number rather than the star rating, as it gives a better indication of what the actual energy consumption is likely to be. Saving 200 kWh every year can lead to savings of around $200 on running costs and two tonnes of greenhouse gas emissions over the 10-year life of the fridge.

Ensure that the refrigerator is not in direct sun or placed against an uninsulated external wall exposed to sun, and that plenty of ventilation is provided over coils and around the cabinet. Installing a bar fridge in a timber cabinet without ventilation can increase running cost by 50 per cent, impair its ability to cool its contents, and lead to premature failure. Ensure there is a 50 mm deep opening the width of the fridge under the front of the cabinet, and at least the same area of venting at the top rear of the unit.

If perishable items are not kept in a refrigerator, it can be switched off when not required (but leave the door ajar to avoid stale smells).

Modular equipment

Modular equipment includes commercial refrigerators, freezers (often fitted with glass doors), display cabinets and coldrooms with integrated compressors (often used in commercial kitchens).

Most modular equipment uses fan-ventilated evaporators and condensers and display lighting; these increase energy consumption. Fans and lights are often fitted inside the refrigerated space, adding to energy consumption directly, as well as by increasing the cooling load. In many cases, metal doorframes or structural components act as 'thermal bridges' across the insulation, increasing heat flow. This may lead to condensation problems on the outer cabinet—and extra heating elements designed to overcome this problem *further* increase energy consumption!

Tips for using your refrigeration energy as efficiently as possible include:

- use only as much refrigeration capacity as you need; in facilities that are used intermittently, shut down excess capacity when it's not needed;
- refrigerators (including softdrink vending machines) can be switched off overnight if only non-perishable goods are kept in them (but if your electricity tariff has a cheaper overnight rate, make sure the unit is switched back on at least an hour before the cheap rate period finishes). This can be achieved with a simple plug-in time-switch costing under $20;
- review freezer thermostat settings and set at the highest safe setting; for example, in a high-volume catering facility where food is turned over in less than two or three days, freezers could be set to –10°C instead of the more usual –20°C; this can cut freezer running costs by 30 per cent. But confirm the highest acceptable temperature setting with your health and safety staff;
- load non-perishable goods such as bottles or cans of drink into refrigerators when they are cool (perishables should be properly refrigerated at all times, for health reasons); cooling 20 two-litre bottles of drink from 30°C to 4°C uses 1 kWh, but cooling them from 17°C uses half as much energy;
- frozen food that is to be heated can be shifted to the refrigerator the day before (if this is consistent with the manufacturer's cooking instructions); this reduces fridge running costs, and defrosted food reheats more quickly;
- consider fitting insulating covers over glass doors and open-top cabinets outside opening hours; flexible plastic strips, doors or sliding covers can be permanently fitted to open refrigeration units or to the doorways of walk-in cold rooms;
- ensure doors close and seal properly;
- defrost evaporators regularly;
- monitor operating temperature; too low a temperature increases running costs and emissions by 2–3 per cent per degree;
- ensure airflow through condensers and evaporators is not obstructed; this is critical for efficient operation;

- avoid locating equipment against uninsulated external walls exposed to sun, in a hot area within the building, or in direct sun (this applies especially to open or glass-doored cabinets, which allow the sun to heat refrigerated contents directly);
- make sure the ceiling of the room is well insulated, particularly where open-top cabinets are installed; if the ceiling is warm, it radiates large amounts of heat into the refrigerated compartments;
- where lighting inside refrigerators or for associated displays is not needed, switch it off or disconnect it; for some equipment, such as drink vending machines, display lighting can comprise half the total energy consumption of the appliance;
- if anti-sweat heaters are fitted, use them only during operating hours or when condensation is visible; they use energy directly as well as adding to cooling loads;
- where a vending machine has relatively low use and supplies of drinks or food are available nearby, consider removing it and putting up a sign to direct users to the other source. Alternatively, instead of having large numbers of vending machines scattered around buildings, locate them centrally and run a minimum number to satisfy demand. Each refrigerated drink vending machine can consume up to 3,000 kWh per year, costing around $300, so rationalising the number in use makes financial sense.

When purchasing or leasing equipment:

- where appropriate, consider using a domestic refrigerator instead of commercial equipment—domestic units are cheaper to buy and often more energy-efficient (saving up to 80 per cent compared with commercial equipment of similar capacity), and you can use energy labels to select the most efficient model. Domestic models can also be more reliable, and have the advantage of different storage temperatures for different foods.
- request energy consumption information (preferably under standard test conditions) from potential suppliers for comparison and use it to make your choice; a two-door drinks fridge can cost $350 to $500 per year to run, so significant savings are possible. Unfortunately, few commercial suppliers will be able to provide accurate data, but if no-one starts asking, this crucial information will never be available;
- ask the supplier what energy-saving options they offer: for example, some suppliers of units with glass doors offer optional doors with improved glazing systems
- specify that switches should be installed to control lighting and anti-sweat heaters if fitted;
- particularly if premises are airconditioned, consider selecting a unit with a compressor that can be located outside (where it should be placed in a shaded, well ventilated location); then the waste heat won't increase cooling costs. But ensure that refrigerant pipes are insulated with durable insulation at least 25 mm thick (preferably thicker).
- Consider refrigeration equipment that uses hydrocarbon refrigerants (subject to compliance with AS 4677 for safety), as these have much reduced greenhouse impacts if they escape, cost less to buy than HFCs, and often allow equipment to run more efficiently. However, it should be noted that hydrocarbon refrigerants are not yet well-accepted by many in the refrigeration industry.

Estimating energy use and greenhouse gas emissions

Centrally metered data is unlikely to provide accurate information on energy consumption for refrigeration.

You may be able to collect metered data yourself (see Energy sheet E4 *Using an electricity meter*). Alternatively, you should seek information from relevant equipment suppliers. For domestic refrigerators you could refer to the energy label.

Once you have some information on energy use, see section 5 *Tools* for the method of converting energy consumption into greenhouse gas emissions.

Possible indicators

- Refrigeration energy use (if available): trend over time
- Refrigeration energy use per unit of activity (e.g. number of meals distributed by a Meals on Wheels service): monthly, seasonal and annual

Hidden costs in ‘free’ refrigerators—lessons for Council catering facilities

A general store in a tourist area had nine refrigerated display cabinets with glass doors. These had been supplied on free loan by a soft drink company. Energy monitoring established that the drink refrigerators were responsible for 26 per cent of the electricity consumption in the shop. Other refrigerators and freezers brought the total electricity use to 78 per cent of the store’s consumption. (The refrigerators operate continuously, compared with more obvious electricity loads such as lighting.)

It was also discovered that the turnover of soft drinks was very low—only half a cabinet per month was being sold. The buildup in refrigerator numbers was not justified by sales but had proceeded because there was no (obvious) cost to the shop owner.

The store removed six refrigerators and rationalised the use of a built-in freezer, resulting in savings of $4200 every year. Floor space was also made available for higher-turnover (and more profitable) stock.

Simple plug-in timer more than halves energy use

An inner city milk-bar was metered by Energy Victoria. It was discovered that the display refrigerator was responsible for 11 per cent of the shop’s total electricity use, or a total of $215 per year. The shop owner decided to store the few litres of milk which were in the refrigerator at the end of each day in a separate smaller refrigerator used for vegetables. The remaining contents of the display refrigerator were soft drinks which only needed to be kept cold during trading hours. A $40 electronic plug-in timer was purchased from a hardware shop and installed to control the refrigerator, reducing its energy use by 60 per cent or $125 every year. (Source: Energy Victoria, *Energy management in corner shops: A guide for small business owners*, 1996.)

Rationalisation means one fridge less is needed

A shop in country Victoria had three two-door drinks fridges side-by-side at the rear. The following changes were made: shelves were re-arranged with less separation, large-volume lines were placed at eye level and slow-moving lines deleted. One fridge was no longer needed, and was sold. This saved $400–$500 per year in running costs and freed up some capital, cutting finance costs by $150 per year.

Cooking and catering

For many Councils, cooking and catering can be significant energy users. Energy for cooking costs the commercial sector around $80 million each year, and generates around three-quarters of a million tonnes of greenhouse gases.

Council activities involving cooking might include:

- operating or contracting out Meals on Wheels services;
- operating or contracting out catering for community facilities (e.g. elderly citizens' centres, childcare centres or cafes at recreational centres);
- providing hospitality for Council functions (from formal dinners to coffee or tea at meetings).

Greenhouse gas emissions result from the use of gas or electricity for cooking, as well as from the breakdown of food waste if it is disposed of to landfill, and from energy embodied in materials used for packaging. Although not the focus of this workbook, emissions from waste and embodied energy may be significant. For example, many Meals on Wheels services use disposable aluminium trays for meals. These may in theory be recyclable, but few Councils promote this fact to users of the service, so many trays are not recycled.

Emissions from transport energy use can also be an issue for some catering activities, especially Meals on Wheels services.

Opportunities for savings

Ensure outsourced operations are efficient

Council cannot directly control greenhouse gas emissions from the activities of contractors, although appropriate clauses inserted into contracts can be effective. Contract terms should be long enough to allow capital costs of more efficient equipment to be recovered, and reporting of performance should be required.

⇒ *See Strategy sheet S5* Leases and Contracts *and S6* Working with contractors

Choose the right equipment

A wide variety of equipment is used for cooking and catering. The most energy-intensive is equipment used to keep things hot, or kept on hot standby, for long periods.

Cooking on conventional **electric hobs and grillplates** tends to be more expensive than cooking with gas or LPG, and generates at least twice as much greenhouse gas. However, some electric equipment—for example, microwave ovens, sandwich-type grillers, induction cooktops—can be very energy-efficient and economical to operate. There can also be significant variation between models—different rates of heat loss, for example, and use of different technologies. Ask equipment distributors for information on energy use during cooking *and* on standby.

Gas appliances vary significantly in efficiency, too. For example, when two similar gas chip fryers were compared, one used 35 per cent less gas. Ask for information on energy consumption so you can select the most efficient models.

Gas equipment usually costs more to buy and maintain than the electric equivalent, but the lower energy costs of gas often justify the initial price and greenhouse gas emissions tend to be much lower. For example, an electric chip fryer used at full capacity (35 kg per hour) can generate around 14 kg of CO_2 equivalent every hour. This compares with around 7.6 kg of CO_2 equivalent for a standard gas unit of comparable capacity, and 5 kg for a high-efficiency gas model. However, some electric units have lower standby energy consumption than gas models, so for low-usage appliances, the overall greenhouse emissions from electric appliances may be lower. Again, ask for information on energy consumption during cooking and on standby, then calculate total emissions for the likely pattern of use.

If your organisation does not want to pay higher initial costs or manage the maintenance of gas appliances, there are companies which will provide gas equipment and maintain it for you. The combined cost of this comprehensive service and the gas used is usually less than the total cost of operating electric cooking equipment. Your gas supplier should be able to provide you with information.

Electric cooking often adds to **peak electricity demand**, increasing the cost of electrical wiring. It may also attract penalty rates from electricity suppliers (see Energy sheet E3 *Negotiating energy contracts*).

Toasters (particularly the conveyor type), **urns** and **coffee percolators** can consume large amounts of electricity if they are not used efficiently. A conveyor toaster can cost $250 per year to run if operated two hours each day. A small urn left on 16 hours per day can cost more than $150 per year to run.

Portable hotplates are an example of surprising energy waste. A twin hotplate used to keep coffee hot in a meeting room can consume 250 watts—more than five fluorescent lamps. Insulated jugs are a much more energy-efficient alternative.

Turn off equipment when it isn't required

In many commercial kitchens a lot of cooking energy is wasted while equipment is kept hot in case it is required. For example, up to three-quarters of the energy used by a chip fryer can be standby energy. You could train staff and volunteers to switch off equipment when it is not needed, and select equipment capable of reaching operating temperature quickly. Choosing equipment with low rates of heat loss would also be helpful, so most of the energy is used effectively (see example at the end of this sheet).

Keeping food warm consumes large amounts of energy and can be a health risk. Aim to minimise the amount of food kept warm and, where necessary, keep it warm in closed, insulated compartments instead of open trays. Switch unneeded equipment off, or to the lowest 'standby' setting available.

Position exhaust fans carefully

If exhaust fans are used to remove cooking heat in a kitchen close to an airconditioned or heated area, ensure that an outside air supply is provided in the kitchen near the cooker. Then the exhaust fan will not extract expensively heated or cooled air from the nearby area (nor draw unwanted dust and pollution through the adjoining functions or dining area).

Investigate using waste heat

It is often difficult to use the waste heat from cooking, but two products demonstrate the possibilities:

- RMIT engineering staff have developed heat-recovery equipment to use waste heat from a bakery for proving bread;
- a Sydney company has developed a heat pump water heater which extracts heat from a kitchen area to heat domestic hot water. This also helps improve comfort in the kitchen.

Such technologies are most likely to be cost-effective in heavily-used kitchens.

Estimating energy use and greenhouse emissions

For this activity, it is unlikely that centrally metered data will provide accurate information on energy consumption, unless, for example, you use gas only for cooking, in which case you'll be able to monitor usage through your gas bills.

You may be able to meter electricity consumption yourself (see Energy sheet E4 *Using an electricity meter*). Alternatively, you could seek information from relevant equipment suppliers: remember to ask for information on standby losses as well as consumption while operating.

You should note that the information printed on appliance approval labels is unlikely to accurately reflect actual consumption: this usually indicates the maximum possible consumption.

Once you have some information on energy use, see Section 5 for the method of converting energy consumption into greenhouse gas emissions.

Possible indicators

- Cooking energy use: trend over time
- Cooking energy use per unit of activity (e.g. number of meals distributed by a Meals on Wheels service): monthly, seasonal and annual

Example: Efficient cooking technology

Griddle plates made from chrome-plated steel (e.g. the Keating Miraclean) are available for use with gas or electric elements. While a conventional black griddle plate radiates large amounts of heat to its surroundings, chrome-plated griddles radiate much less heat due to their low emissivity (in the same way as aluminium foil has low emissivity, and acts as an insulator in the roof). US energy utility tests found a 30 per cent saving.

Sandwich-type grillers cook both sides of an item at the same time, reducing heat wastage and shortening cooking time. If closed when on standby, they also waste less heat. Energy savings of at least 50 per cent are achieved; they also provide quicker service and are more compact than conventional grillers.

Hot water

Commercial hot water systems (HWS) range from large boilers delivering hot water in large buildings through pumped ring mains, to small electric units under kitchen benches and boiling water units fitted above sinks. These systems can often be very inefficient, and there is scope for large savings.

Supplying hot water in Council facilities can be an expensive process, which can also generate substantial quantities of greenhouse emissions. For example, supplying just 100 litres of hot water per day can cost $300 each year and generate 3 tonnes of greenhouse gas. In many cases, heat loss from tanks and pipes is greater than the amount of useful heat delivered.

While providing hot water is an obvious issue in healthcare and catering facilities, it is also significant in offices, when the purchase and operating costs of the many boiling water units and hot water services throughout the building are considered. Providing hot water for showers at recreational facilities is a particularly challenging and potentially greenhouse-intensive activity.

Opportunities for savings

The key issues to consider in ensuring that costs and greenhouse gas emissions from hot water are as low as possible are:

- minimising hot water consumption;
- maintaining your system;
- choosing the right equipment, based on:

  energy source—gas and solar are low in greenhouse intensity, while dayrate electricity is high cost and high in greenhouse intensity,

  consumption patterns—how much will be used (taking into account efficient water use); what will be the peak requirements,

  the performance of the equipment, taking both standby losses and hot water use into account. For example, a typical gas storage HWS generates around 0.4 tonnes of greenhouse gas each year, even if it supplies no hot water. So where only small amounts of hot water are required, a dayrate electric HWS may be comparable in emissions, and cheaper and simpler to install.

Cut hot water consumption

Water-efficient shower and tap fittings can cut hot water requirements by up to half. For new buildings and refurbishments, they also offer the opportunity to install smaller-diameter pipes, which are cheaper and hold less water (so less hot water is wasted by cooling between uses).

When purchasing water-using equipment such as dishwashers or washing machines, select the models which use the least hot water. Many household products now carry water rating labels which can help you choose the most water-efficient model.

In facilities such as swimming pools or recreation centres, where multiple showers are likely to be in use, AAA-rated water-efficient showerheads can reduce the risk of running out of hot water, as well as save hot water overall.

You could also use cold water wherever possible. In many cases, hot water may not be needed or the thermostat of the system can be set to a lower temperature to reduce heat losses. However, the storage temperature for hot water systems should normally be set above 50°C to limit the risk of legionella infection.

Carry out maintenance

Maintenance tips include:

- fix dripping taps; each litre of hot water wasted costs around half a cent and generates half a kilogram of greenhouse gas (for electric hot water systems);
- check the pressure/temperature valves fitted to mains pressure hot water units every year; these can leak large quantities of hot water without it being noticed. If more than a bucket of water is released over 24 hours, the valve should be repaired or replaced;
- drain off sediment from the bottom of HWS tanks regularly; in gas units, sediment can significantly reduce heating efficiency;
- replace sacrificial anodes in glass-lined steel HWS tanks at recommended intervals to prolong tank life.

Use low greenhouse-impact energy sources

Solar energy, gas or electric heat pumps generate much lower greenhouse gas emissions (typically around a third as much) per litre of water heated than electric storage systems. However, where only small amounts of hot water are used, a small electric HWS may be acceptable, due to its lower heat losses (especially if additional insulation is wrapped around the tank).

Choose appropriate equipment

When use is intermittent (for example, sports facilities or little-used kitchenettes), ensure the system installed loses as little heat as possible or can easily be turned off (but can also recover to operating temperature quickly, and can supply the peak demand). For example, one or more high-capacity instantaneous gas HWS units with electronic ignition may be a good option for a sports facility.

If it takes a long time for hot water to reach an outlet, there may be a case for a point-of-use HWS. Check by turning on the tap and seeing how much cold water is collected in a bucket before the water becomes hot. Calculate wastage based on likely patterns of use (see below) to see if a change is warranted.

Hot water services

The heat loss from a small electric HWS and its fittings costs around $70 each year. You could ask suppliers for data on heat loss and select units with the lowest losses. Extra insulation would also be effective—for example, foil-backed 75 mm fibreglass or polyester blanket wrapped around tanks and (at least) 10 mm thick insulation fitted to pipes within 2 m of the tank.

The pressure/temperature valve should not drip excessively: no more than 5 per cent of the volume of hot water used should be released. This may involve uncoupling the overflow pipe and placing a container under the overflow outlet. Ensure that new installations allow for easy monitoring of valve operation. Or else refer the reader to the earlier comments on p/t valves

Consider removing or switching off unnecessary HWS units. For example, if a boiling water unit is installed above a sink, an outlet with a mixing valve could be fitted to supply the modest amounts of domestic hot water needed for washing dishes much more cheaply and efficiently than a separate HWS.

In-line heating elements can be fitted to water pipes to supply warm or hot water at moderate rates, adequate for hand washing (if a water-efficient tap is fitted). These have no heat loss when not in use. They also avoid ‘dead water’ losses—heat lost when hot water cools in the pipe between the HWS and the tap.

Large central systems

Where hot water is provided by a boiler, steam is produced at much higher temperatures than required for hot water, wasting up to 30 per cent of the energy used. Replacement with a water heater will cut operating costs. If a boiler used predominantly for space heating is operated in warm weather to supply hot water, it is often economic to supply the hot water from a separate HWS all year round, to reduce boiler losses.

Where long lengths of pipe deliver hot water from a central boiler to points of use, large amounts of energy can be wasted, both through heat loss from the pipe, and through the need to flush out water remaining in the pipe that has cooled down since the previous use. For example, 4.4 metres of 19 mm OD pipe holds a litre of water. Small water heaters near points of use are often much cheaper to operate.

Ring mains (a pipe loop through which hot water is pumped continuously so it is available to any user without a long wait) often lose large amounts of heat and consume substantial electricity for pumping. For example, 100 metres of 25 mm pipe with 25 mm thick insulation loses 1.3 kW of heat, equivalent to the heat lost from about 20 small electric HWS units. Energy used to run the circulation pump adds to this energy waste.

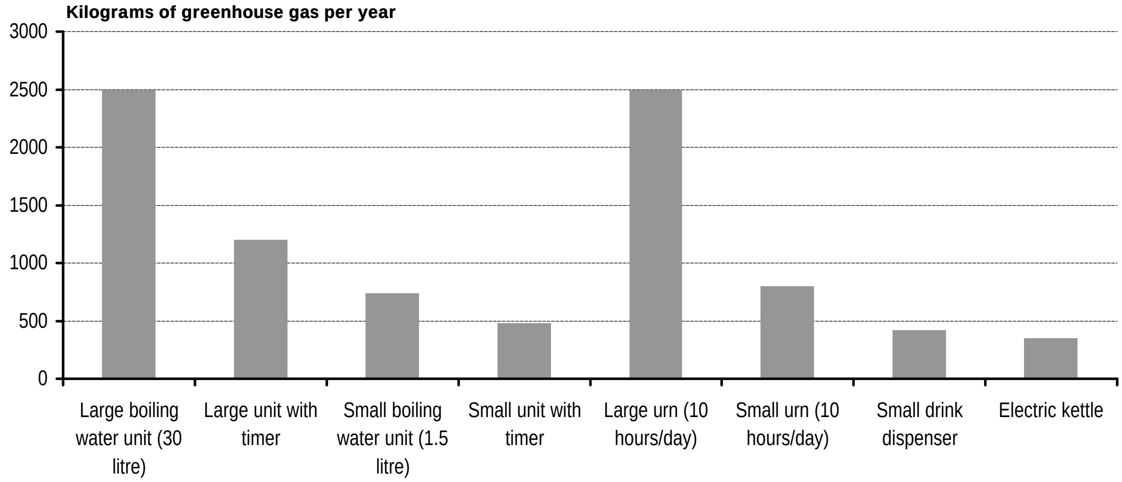
Variable-speed control of pumps and upgraded insulation on pipes can bring large savings. Again, point-of-use water heaters may be appropriate, particularly if they are well insulated. (See also Energy sheet E11 *Motors, drives, pumps and fans*.)

Boiling water units, urns etc.

A large boiling water unit can cost up to $1,000 to buy and install, and to up to $375 per year to run, while generating around 2.5 tonnes of greenhouse gas (CO_2 equivalent)—90 per cent of which is wasted through heat loss. Urns are also very inefficient.

The graph overleaf shows relative emissions from various types of boiling water dispenser.

Table E14-1. Annual greenhouse gas emissions from various types of boiling water dispensers (Energy Policy Planning Bureau, WA)



Many boiling water units are oversized, so consider a small unit. In most cases, a 5-litre model is more than adequate. It can supply around 40 cups of boiling water as quickly as people can queue, and can recover temperature in a few minutes. And it's hundreds of dollars cheaper to buy a smaller model.

Ask the manufacturer for data on standby power consumption—the major operating cost and greenhouse problem. A difference of only 50 watts in standby power consumption equates to $50–75 extra in running cost every year. Over 10 years, that's a difference of up to $700 and 4.5 tonnes of greenhouse gases. Some models have integrated timers, so they can be programmed to switch off outside working hours (but make sure there are clear instructions for users on how to override the timer; workers on overtime or participants in out-of-hours meetings may become grumpy if only lukewarm water is available!).

Few portable urns are well-insulated, so they have very large heat losses. Insulated jugs or airpots are a much more energy-efficient way of providing hot water for meetings.

Each litre of boiling water wasted costs a cent and generates a tenth of a kilogram of greenhouse gas (CO_2 equivalent). So make sure boiling water units don't drip or overflow continuously. Even a modest rate of dripping can waste thousands of litres per year

Estimating energy use and greenhouse emissions

To calculate the energy required to heat water, multiply the number of litres by the temperature rise by 0.00116 to calculate energy in kilowatt hours. For gas heating, multiply by 0.0053 for energy in megajoules (assuming 80 per cent efficient combustion).

For example, heating 100 litres of water from 15°C to 65°C (a rise of 50 degrees) consumes:

- for electricity: 100 x 50 x 0.00116 = 5.8 kWh
- for gas: 100 x 50 x 0.0053 = 26.5 MJ

Once you have some information on energy use, see section 5 *Tools* for the method of converting energy consumption into greenhouse gas emissions.

The **efficiency** of a hot water system can be calculated by comparing the energy content of the water (calculated as above) with the total energy consumption of the HWS.

For example, if an electric HWS consumes 10 kWh per day to supply the 100 litres of hot water as above (energy content 5.8 kWh), the efficiency would be:

$$\frac{5.8 \text{ kWh}}{10.0 \text{ kWh}} \times 100 = 58\%$$

Possible indicators

- Total hot water energy use in the building: trend over time
- Hot water energy use per unit of activity (e.g. number of staff, or number of customers): monthly, seasonal and annual
- Trend in efficiency over time.
- Hot water energy use during and outside working hours (to identify wastage).

Who can help?

Technical consultants can carry out appropriate tests and calculations to compare options. But make sure they use realistic demand profiles (based on water-efficient taps and showers) and consider a wide range of options.

Equipment suppliers can provide useful information: comparing data from two different suppliers may highlight each one's assumptions and allow you to ask the right questions.

Your own organisation's staff can highlight areas of hot water wastage.

Example:

Flow control system achieves substantial savings

A conference and leisure resort on Victoria's south coast installed a flow control system throughout its hot and cold water supply system. Energy savings from the system were estimated to cut 85 tonnes per year from greenhouse gas emissions while cutting LPG water heating costs by $14,000 per year. In addition total water consumption was reduced, with an estimated saving of $15,600 per year. The combined savings repaid the installation cost of the system in less than a year.

Contact: Rick Ward, Total Water Management Solutions, ph (03) 9427 1854, fax (03) 9429 3714

Depots

Council works depots offer particular opportunities for improving energy efficiency in industrial lighting, heating, motor operation and staff amenity areas.

Municipal depots (or 'works depots') may provide:

- garaging of specialist municipal vehicles and plant such as garbage and recyclable materials trucks, street sweepers, water trucks, tractors and slashers;
- maintenance workshops for specialist vehicles and plant;
- trades workshops (carpentry, plumbing, painting, welding) for the maintenance of other Council equipment and assets;
- refuelling facilities;
- a base for road repair crews;
- tipping, recycling, mulching and related services;
- offices; and
- staff facilities.

Depots often have long operating hours (typically starting at 4 a.m., finishing after 5 p.m. and often including weekends).

Opportunities for saving

Industrial lighting

The larger buildings at most municipal depots are industrial buildings which either have natural lighting (e.g. translucent roof panels) or could easily be modified to provide some daylighting. Because work normally starts before sunrise, the lights are switched on by staff when they arrive, but they are usually left on even when there is enough daylight.

Automatic controls are available which will turn the lights off when there is sufficient natural light. The control system incorporates an adjustable indoor light sensor, and can be configured to turn the lights on manually (when a button is pushed) and off automatically.

Heating

Heating large open buildings is particularly difficult, especially at 4 a.m. Warming the air is impractical and costly because of the large air volumes and because the buildings are drafty. Garage doors are often left open, making the heating task even more difficult. Some workshops have electric floor heating, which is expensive to operate and difficult to control effectively.

Heating costs can be reduced by:

- ensuring that all heating systems are controlled by thermostats and time controls and that these controls are set correctly and maintained;
- closing pedestrian and vehicular doors (you could also evaluate installing automatic closers and vehicle ‘speed doors’);
- placing covers over evaporative coolers in winter, to reduce heat losses and protect the coolers (automatic damper are now available for many evaporative coolers, which can avoid the need to get up on the roof to fit covers);
- incorporating appropriate insulation to minimise heat loss
- replacing electric resistance heaters with heat pumps where feasible (e.g. in offices and tea rooms).
- using localised heating (e.g. gas radiant panel heating in workshops, rather than warm air heaters).

The need for heating and cooling can be reduced by making the industrial-type buildings which usually house depots more efficient:

- Evaluate the benefits of wall and roof insulation, preferably 100 mm blanket plus foil in the roof, and 50 mm blanket plus foil in the walls.
- Steel framing should be insulated, so that heat from the roofing cannot bypass the insulation and enter (or, in winter, leave) the building via the metal framing. CSR Bradford manufactures foam plastic strips specifically designed for this purpose.
- Rooms within the buildings (e.g. offices) which are heated or cooled to higher comfort levels than the overall building should also be insulated from the rest of the building.
- The colours selected for the roof and walls also have a major impact on heat flows, especially if there is little or no insulation. Using white or light beige roof will be much cooler than an unpainted zincalume roof or dark-painted roof.. Also, walls exposed to afternoon sun should either be shaded, or should be the lightest acceptable colour.
- Heat flow through external pedestrian and vehicle doors can be reduced by installing automatic roller doors.
- Passive heat gains can be increased by using clear polycarbonate panels in selected north-facing walls.
- Skylight area in cold climates should be about 10 per cent of roof area, and between 5 and 10 per cent in temperate climates. Heat-stopping clear polycarbonate is available for use in hot climates.

See also Energy sheet E5 *Heating and cooling buildings,* and E6 *Energy efficiency and the building envelope*

Motors

Motors are used in equipment such as concrete crushers, chippers and mulchers, fans and pumps. Efficiency can be improved if:

- machines are controlled so that they do not operate when not required;
- material to be processed is batched where possible, rather than letting machines idle for long periods.

See also Energy sheet E11 *Motors, drives, pumps and fans*

Compressed air

When selecting a compressor:

- consider a reciprocating compressor rather than a screw compressor; the former will have a much higher efficiency considering the many hours which most depot air compressors spend running at part load or even at no load;
- select the smallest air compressor which will do the job.

Where there are several compressors:

- operate the smallest one able to supply the air required (particularly important during periods of low activity);
- use a reciprocating compressor in preference to a screw compressor.

Reduce the demand for compressed air by:

- fixing leaking unions, hoses, valves, etc.;
- isolating the compressed air supply to equipment which is not in use (e.g. using a solenoid valve).

Use the lowest air pressure which will do the job.

Staff amenity areas

Staff amenity areas can be open for long periods, but actual occupancy hours can be low. Energy savings can be made by:

- controlling lights with occupancy sensors;
- controlling comfort heating and cooling with time-switches, timer delays or occupancy sensors;
- ensuring these areas (which are maintained at higher comfort standards than the main depot buildings) are well-insulated—including the internal walls between them and the main areas of depot buildings;
- ensuring equipment left on for long periods (such as drink vending machines, boiling water units, etc.) is as efficient as possible.

See also Energy sheets E5 *Heating and* Cooling *Buildings,* E7 *Lighting overview,*
E12 *Refrigeration,* E13 *Cooking and catering,* and E14 *Hot water*

Examples:

Reservoir of potential savings

Monitoring by the **City of Darebin** (Victoria) of its Reservoir Depot found that the electric slab heating in the workshops was operating for much longer than required, because of a time-switch malfunction. The remedy for this problem—replacing the faulty switch with a more functional one—has added advantages, such as skipping public holidays, more accurate time setting, and delaying start time in milder weather. The investment was less than $1,000, and savings are estimated to be $10,000 and 175 tonnes of greenhouse emissions per year.

Darebin is now investigating alternative heating methods which will avoid the need for electric slab heating completely.

For further information: Mr Andrew Birkett, Environmental Planner, Darebin City Council,
ph 03 9230 4535

Efficiency program saves 60 per cent of energy costs

Newcastle City Council has reduced energy consumption at its Turton Road Depot with actions including: replacing the compressed air system, 'Bathhouse' water and space heating, installing new a lighting control system, and retrofitting improvements to the office lighting. The total investment over the nine years of the program has been $100,000, with annual electricity charges reduced by more than 60 per cent (approximately $60,000).

For more information: Mr Peter Dormand, Green Energy Project contact Coordinator, Newcastle City Council, ph 02 4974 2542, email pdormand@ncc.nsw.gov.au

Libraries

Libraries can save significant amounts of energy and greenhouse emissions, particularly in the areas of airconditioning, electronic equipment and lighting.

Municipal libraries provide:

- facilities for displaying, using, lending, and cataloguing books, CDs, audio and video tapes and other media;
- meeting and private study rooms;
- large numbers of computers for public and staff use; and
- offices and amenities for staff.

Libraries tend to have long opening hours (about 3,000 hours per year), so energy use is high. Further, they are often free-standing one- or two-storey buildings, creating a higher demand for heating and cooling compared with multi-storey office buildings, which tend to have a lower ratio of building surface area to floor area.

Opportunities for saving

Airconditioning

See also Energy sheets E5 *Heating and cooling buildings* and E6 *Energy efficiency and the building envelope*

The size of the airconditioning system and heating/cooling costs will depend strongly on the thermal performance characteristics of the building's envelope (walls, windows, roof, etc). This results from the long hours of operation (including evenings) associated with libraries, and the large surface area of the building.

Library airconditioning systems are often custom-built, unlike many Council buildings which use domestic-scale appliances. Energy consumption could be reduced by checking:

- the setting and operation of all controls (time-switches, thermostats, damper actuators), particularly start and stop times;
- that heating and cooling systems are not fighting each other,
- outside air flow quantities and compare these with the amount required.[1]

[1] Australian Standard 1668.2 *The use of mechanical ventilation and air-conditioning in buildings, Part 2: Mechanical ventilation for acceptable indoor air quality* calls for 10 litres per second per person, assuming one person every 5 m² if the number of occupants is not known (i.e. 2 litres per second per m² of floor area).

Electronic equipment

Increasingly, libraries are becoming resource centres, with banks of computers linked to the Internet, video recording and playing facilities, and so on. These can use surprisingly large quantities of energy. Some options worth considering include:

- Enable the *Energy Star* energy-saving features on computers, copiers and other equipment. However, since much of this equipment is for public use, you will need to provide simple explanations and instructions. When people unfamiliar with energy-saving features find the screen goes blank, they may not realise that they just need to move the mouse to re-start the screen. This is a great opportunity to educate many people about the potential for saving energy, while cutting Council's energy bills as well.
- Ensure electronic equipment is switched off when not in use. Leaving equipment on typically uses at least twice as much power as switching it to standby (that is, switching off at the appliance or by using the remote control). And switching off at the power point can save even more energy. See figures 1 and 2 below.

Figure E16-1. Annual operating costs of 68cm televisions during operation and on standby, based on 5 hours per day operation and 12 cents per kilowatt-hour (*Choice* Jan 1997)

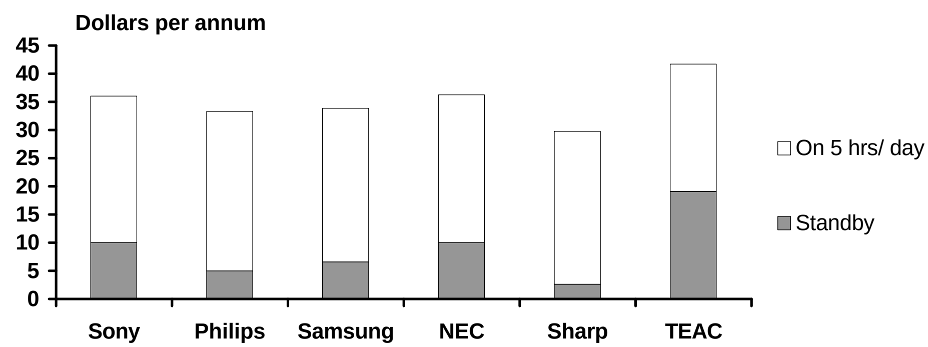
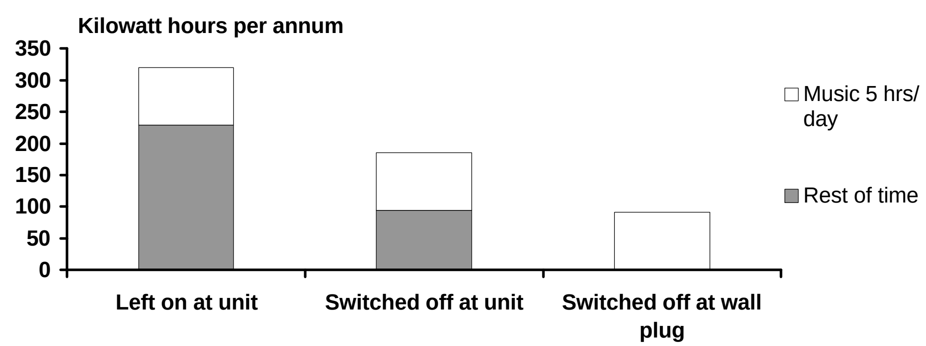


Figure E16-2. Annual electricity consumption of a $750 CD/tape/radio stereo system under various operating conditions.



Lighting

See also Energy sheets E7 *Lighting overview* and E8 *Office lighting*

- Ensure that the lighting in each area is appropriate to the function of the area. Sometimes lighting is installed to suit the arrangement of shelving racks and the shelving is subsequently moved without adjusting the lighting. Lighting could be fixed to the shelving units themselves to avoid this problem.

Provide lighting for reading in reading areas (maintenance illuminance of 320 lux) and a lower illuminance in general circulation areas and walkways. (See Energy sheet E7 *Lighting overview* for an explanation of 'maintenance illuminance'.)

- Institute a program of lighting maintenance—cleaning every two years and bulk lamp replacement every five years (based on the use of 16,000 hour life fluorescent lamps).
- Maximise the use of natural lighting and automatically switch off lighting when daylight is sufficient.
- Evaluate occupancy-sensing lighting controls in staff areas with low occupancy (e.g. tea rooms and storage areas).

⇒ *See also:*
Meter readings reveal savings potential *(City of Monash) in sheet E2, page 4*

Swimming pools and leisure centres

Many savings can be achieved with little investment or disruption to operations.

Swimming and recreation centres are a valuable community resource. They can also be big users of energy, accounting for half the energy used in Council buildings for some municipalities.

Energy is used for pool water heating and pumping. Where the pool is in a building, energy is also required to heat, dehumidify and circulate the air. The other significant energy users are airconditioning of ‘dry areas’ such as gymnasiums and aerobics rooms, creche, cafe and function rooms.

Even where a pool is leased and operated by another party, and the energy used is included in leasing fees, the Council effectively pays for these costs, even if they are not separately itemised, so this is an important area for cost-effective reduction of greenhouse gas emissions.

Opportunities for savings

While some savings opportunities occur mainly during initial design or major refurbishment, others can be achieved with little investment or disruption to operations.

Optimise control systems

Temperature controls

Select the most appropriate temperature for your intended customers. Temperatures that are too low or too high will discourage users and the community will get less benefit from the energy used in constructing and operating the pool.

The table below could be used as a guide:

Pool type and use	Recommended temperature range (°C)
Spa	32–34
Hydrotherapy	27–30
General swimming	24–27
Competition swimming	20–23

Comfort will also be influenced by swimmer age (the young require less heat), gender (males require less heat), general fitness and metabolic rate; radiant temperatures, including the effect of sunshine, also have an effect.

The temperature in each pool should be appropriate to its use. Some systems have been designed so that the temperature in several pools is the same, even though one may be used for hydrotherapy and another for lap swimming.

Air temperatures within 3°C of the water temperature will limit moisture and heat loss from the pool to the air—but increase the energy cost due to building heating and cooling.

Example:

A city hotel swimming pool, open to the general public for a fee, discovered that lunch-time lap swimmers were discouraged from using the pool because the water temperature was too high. The pool temperature had been increased for morning hydrotherapy sessions.

Time controls

Many pool heating systems maintain the same temperature 24 hours a day, every day. Consider controls which automatically:

- adjust the pool temperature for different pool uses during the day;
- allow the pool temperature to fall when the pool is unoccupied and reheat the pool to the desired temperature in time for the start of swimming.

Pumps are also designed to handle the highest water-flow requirements for both water cleaning and heating. At other times, the flow will be higher than required. The peak demand for water cleaning occurs on only a few days each year in most pools. Consider:

- automatically switching the pumps off at the end of swimming (during weekdays this will probably save on peak electricity as well as reducing CO_2 emissions) and restarting them when required to reheat the pool (see above);
- installing variable-speed drives and automatically controlling the pump speed to match the water flow rate required for water cleaning and heating. Note that halving the flow of water saves around three-quarters of the pumping energy, so large saving are possible.

⇒ *See also Energy sheet E11* Motors, drives, pumps and fans

Reduce heat losses

Consider a pool cover

Especially in outdoor heated pools, a pool blanket can reduce heat losses by about 50 per cent when the pool is not in use. A pool cover can eliminate the need to heat outside pools during summer, in all mainland locations. It will also reduce evaporation (and so water and chemical consumption) and condensation in indoor pool buildings.

By reducing pool heat loss, covers make it possible to switch pool heating systems off for much of the time the pool is closed.

Easy-to-use pool blankets are now available. It is worth specifying a foam blanket with a thermal conductivity of no more than 0.035 watts/mK, and a thickness of 3mm or more, with a protective facing of UV stabilised polyethylene woven fabric. This will have a better thermal performance and a longer life than bubble type pool covers.

Allow for a price of $16 per square metre of pool area, plus $2,000–$4,000 for a roller.

Control humidity without losing heat

Many pools control humidity by bringing in dry air and removing the moist warm air from the pool building. This is very wasteful, as the incoming air must be heated and the heat in the exhaust air is usually lost. You could evaluate the savings from recovering heat from exhaust air using a device such as a ‘heat-wheel’, heat exchanger or heat pump dehumidifier (see *Evaluate heat sources* below).

Consider the building envelope

Effective insulation and appropriate treatment of glazing are also important given the long hours and high surface area of such facilities.

⇒ *See also Energy sheet E6* Energy efficiency and the building envelope

Evaluate heat sources

Heating air and pool water is commonly achieved with a gas-fired heater. However, there are alternatives with a lower greenhouse impact and lower cost. Some of these alternatives will require specialist evaluation, although initial feasibility can be checked before bringing in outside help. Options include:

Solar heating: Active systems rely on pumping pool water through glazed (for year-round heating) or unglazed (seasonal heating) solar collectors. Outdoor pools naturally collect solar heat during the day, and using a pool cover overnight will help retain most of the solar heat gained. Solar heat gain will reduce fossil fuel consumption or provide a method of extending the swimming season without relying on fossil fuels.

Cogeneration involves generating electricity on site and using the ‘waste heat’ for pool heating.

⇒ *See Energy sheet E20* Cogeneration *and* Ringwood Aquatic Centre *example in this sheet.*

Waste heat can be harnessed from a nearby industrial site such as a cogeneration plant, landfill-gas power station, cooling system, etc.

An electric heat pump can reduce the energy required for heating pool water and for heating and dehumidifying the pool hall air. A heat pump system also reduces costs by sending water removed from the air back to the pool, reducing the consumption of water and pool chemicals. Possible heat sources for a heat pump include the outside air, pool hall exhaust air, waste heat from shower water, etc., and the sun. (Manufacturers have claimed a reduction in operating costs of around 60 per cent for heat pump dehumidifiers, which recover latent heat from the water vapour in the air as they de-humidify. [1]) Note that these systems may require a substantial upgrading of the electricity supply within or to the swimming pool facility

[1] Swimming Pool Dehumidifier’ *Energy Wise News*, Dec 1996, Energy Efficiency and Conservation Authority, Auckland, New Zealand

Other issues

Many municipal swimming pools are managed by a service provider company on behalf of the Council. Sometimes this arrangement discourages energy efficiency, for example, when:

- the Council pays the energy bills but the management company controls all aspects of swimming pool operation;
- the management company pays the energy bills but the Council discourages investment in energy efficiency by having short management contract periods and refuses to invest its own funds in energy efficiency.

The contract between the council and the service provider should ensure that both parties benefit from lower energy consumption and that investment is encouraged.

⇒ *See also Strategy sheet S5* Leases and contracts

Possible indicators and benchmarks

The following benchmarks are based on *Energy Management in Aquatic Recreation Centres*, Energy Victoria and Sport and Recreation Victoria, 1993 (based on a study of 10 Victorian centres by EMET Consultants). ‘Indoor’ refers to enclosed pools used all year; ‘outdoor’ refers to outdoor pools open four months of the year; figures are based on Victorian conditions and should be used with care in other climates.

Indicator	**Benchmark values**	
	Indoor	**Outdoor**
For total energy consumption (using natural gas for heating, electricity for pumps etc)*		
MJ/m^2 serviced floor area/year	15,200–33,700	5,200
MJ/person	9–73	3
For ventilation:		
kWh/m^2 pool area/year	1,000–3,500	
For air heating:		
MJ/m^2 pool area/year	2,300–7,700	

* Note that electricity and gas consumption have been combined into a single megajoule (MJ) value; in deriving your own values don’t forget to multiply electricity consumption in kWh by 3.6 to convert it to megajoules.

Gymnasiums and other activity areas

Recreation centres often include gymnasiums and activity rooms. These are high energy users because of the long operating hours and low cooling temperatures used to provide comfort to active people. The main opportunities to reduce energy consumption are:

- control of the airconditioning system so that it operates only when required; this sounds obvious but is often neglected in leisure centres;
- economy cooling (automatically using outside air to provide cooling when appropriate) is particularly useful in leisure centres because of the need for low indoor temperatures and the fact that the rooms are still in use during the cooler times of the day;

- occupancy-sensing lighting controls, which can also be used to control airconditioning in some rooms;
- automatic controls to switch the lights off when there is sufficient daylight—and daylighting systems.

Who can help?

Solar Energy Industry Association of Australia for suppliers of solar pool heating equipment.

Energy auditors with expertise in pools and recreation centres.

Specialist designers of recreation centres, who can demonstrate a record of energy-efficient design.

Examples: Saving energy and emissions in pools

The **Ashburton Pool and Recreation Centre** uses heat removed from the airconditioning of aerobics rooms etc. to aid in heating pool water. This is done by recovering heat from the chiller rather than dumping the heat outside the building. The system also improves the effectiveness and efficiency of the cooling system.

Contact Ms Cathy Cardwell, Technical Operations Manager, (03) 9885 0333.

The **Ringwood Aquatic Centre** has a 50-metre indoor Olympic pool, high diving boards, health and activity pool (adjustable depth), a spa and two outdoor pools. In 1992, the local Council approved the installation of a 120 kW Isuzu natural-gas-fired, reciprocating-engine cogeneration system. The unit now operates from 7 a.m. to 11 p.m. on weekdays and provides heating hot water for the swimming pool and electricity for the complex. The installation provided a 3.5 year payback.

The centre has also installed an ozone treatment plant (one of the first) and an ultra violet water sterilisation system to reduce chemical use.

For more details: Ms Viv Fraser, Environmental Planner, Maroondah City Council, 03 9879 0369

World's largest solar pool heater?

The **City of Gosnell's** Leisure World recreation centre has 1260 square metres of indoor lap and leisure pools, water slides, sauna, spa, a steam room, and an extensive gymnasium, creche and cafe. The centre has over 400,000 visitors each year.

The pool solar heating system consists of 996 square metres of roof-mounted panels made of black polypropylene tubing and is reputedly the largest such system in the world.

Pool water is pumped though the black collector pipes whenever this will increase its temperature, controlled by a sophisticated computer to optimise energy gains. The solar system has significantly reduced the amount of gas used to heat the pools. Estimated savings are 930 tonnes of CO_2 and $82,000 each year.

In addition a building management system was installed which can control the lighting, ventilation and temperatures of the facility for optimum efficiency.

For more information: Rob Horn, Available Energy Consultants, ph 08 9291 8518.

Source: *Energy Matters* No.7, October 1997

Water supply and sewage treatment

Some Councils provide water supply and sewage treatment services, and others have close links with water corporations which do.

These activities have four main energy-using components: water pumping, water treatment, sewage pumping, and sewage treatment.

Water pumping and sewage treatment tend to be the biggest energy users; their relative energy consumption depends on factors such as terrain, the height of the water supply source and standard of sewage treatment. Sewage pumping is normally a modest energy consumer, with most small pumping stations having a small duty pump of 5–10 kW, controlled by a float switch.

Opportunities for saving energy

Pumping water

To take advantage of energy-saving opportunities in pumping water:

- calculate pump efficiency (see box at the end of this sheet);
- monitor pumping system efficiency (see box) and investigate any deterioration;
- pump to the minimum pressure required;
- consider variable-speed drives for water supply; energy savings may be modest but the main advantage can be improved control of pressure regulation to customer supplies;
- where water is pumped to elevated storage tanks, evaluate pumping during the off-peak period (this will not save energy, but will result in cheaper electricity being used);
- where water is delivered to a reservoir under pressure or from a fast flow, evaluate the hydraulic power available and determine whether installation of a turbine would be justified (see box); this will only be applicable to a small percentage of water supplies;
- use high-efficiency motors;
- ensure that the pump, motor and application are matched so that the pump is operating at the best point on its performance curve;
- ensure that submersible pumps are properly seated against the O-ring and flange, to prevent fluid cycling through and around the pump.

⇒ *See also Energy sheet E11* Motors, drives, pumps and fans

Sewage treatment

Pumping is also a significant energy user in sewage treatment, and similar strategies to those outlined above can be used to enhance efficiency.

The other main contributor to energy consumption in treating sewage is the aeration process, which, for a local treatment plant, typically uses an aeration motor of 45–75 kW.

Opportunities to reduce the energy needed for aeration include:

- controlling the operation of the aeration fan according to the amount of dissolved oxygen in the sludge, using the CSIRO-developed AAA process (alternating aerobic and anaerobic). This requires the installation and maintenance of dissolved oxygen sensors. For further information, see http://www.chem.csiro.au/cpaaa.htm
- reducing the pressure drop of air pipes, so the fan requires less energy;
- using high-efficiency motors, matched to the duty and performance curve of the fan.

Other opportunities

Putting methane to work

Anaerobic breakdown of sewage sludge produces methane, a useful source of energy. If collected it can be put to work to produce electricity. If allowed to escape to the atmosphere it acts as a potent greenhouse gas. Methane can be collected either from covered treatment tanks or a covered lagoon (see case studies below).

The total electricity generation from sewage gas in Australia is now about 30 GWh per year, worth about $3M per year[1]. Most of the existing generation is in four city treatment plants (Luggage Point in Brisbane, Werribee and Carrum in Melbourne, and Bolivar in Adelaide). However, the principle and process are equally applicable to smaller sewage treatment plants.

The electricity generated can be used in-house, with any excess finding a ready market with electricity retailers who sell Green Power.

Using effluent to grow trees

Suitably treated, the effluent from sewage treatment plants can irrigate land used to grow timber. This has several advantages:

- nutrients are put to good use, rather than fouling streams and rivers;
- growing timber stores carbon dioxide from the atmosphere;
- appropriate species will create shelter for native fauna.
- For case studies, see http://www.landenergy.com.au/Case2.htm

[1] Based on 10 cents per kWh (7 cents as the value of avoided electricity purchases plus a ‘green energy’ premium which is about 3 cents in 1999; ref. http://www.affa.gov.au/netenergy/info.renew.sewage.html)

Calculating pump efficiency

This can be done simply using the following guide:

$$\text{Pump efficiency (\%)} = \frac{\text{hydraulic power (the amount of useful work being done by the pump)}}{\text{electrical power}} \times 100$$

First calculate the **hydraulic power**:

$$\text{Hydraulic power (kilowatts)} = \frac{\text{flow rate (litres per second)} \times \text{distance raised (metres)}}{100}$$

For example, 10 litres per second being raised 10 metres = hydraulic power of 1 kilowatt

To measure the flow rate, you will need to assess either:

the volume of water moved (e.g. from a collecting pit, the area multiplied by the change in depth) and the time to move that volume (time the level change with a stop-watch)

OR

the velocity of the water (metres per second) and the area of flow (square metres) in a channel or pipe.

Note: 1 cubic metre = 1,000 litres = 1 kilolitre

Then measure the **electrical power** of the pump, using either:

a clamp-on real power meter (not just a current reading meter, as that will not tell you the power factor and real power).

OR

an installed electricity meter, reading kWh (see Energy sheet E4 *Using an electricity meter*).

Now divide the hydraulic power (useful work) by the electrical power (which determines greenhouse gas emissions and electricity costs) and multiply by 100 to arrive at the percentage efficiency of the pumping system.

How efficient should the pump be?

Sewage pumps usually have open impellers to cope with the debris that finds its way into the sewerage system, so the efficiency tends to be lower than for closed-impeller pumps. The efficiency of the open-impeller pump alone (not considering the motor) can range from 10–70 per cent, depending on the head the pump is working against, and to a lesser extent on pump design and condition. The motor will have an efficiency between 80 and 90 per cent, giving a pump–motor efficiency of between 8 and 63 per cent. Clearly, with such a range there are often significant savings available.

For water supply pumping systems (enclosed impellers) expect a pump efficiency of 70–85 per cent and so a pump–motor efficiency of 55–77 per cent.

Monitoring pump efficiency

You'll need the following basic performance-monitoring instrumentation:

- for the total plant or facility—an electricity meter
- for any motor of 10 kW or more—a separate electricity sub-meter and an hours-run meter.
- for other motors—an hours-run meter.

To monitor pump efficiency:

- record the electricity meter readings and hour-run meter readings each month;
- calculate the energy use per month, and investigate any increase (there may be seasonal variations, such as increased demand for water supply in summer);
- calculate the energy use per hour run (i.e. average power) and investigate any increase, as this means a drop in pump system efficiency and could indicate a maintenance problem (e.g. pump clogged or impeller damaged).

SA wastewater treatment plants trade waste gas for electricity

All three of the South Australian Water Corporation's wastewater (sewage) treatment plants now generate electricity. Port Adelaide treatment plant is the most recent upgrade, with two 490 kW reciprocating gas engines installed in l995. The alternative to using the methane for power generation is to flare it, but this wastes energy and is also expensive as special scrubbing equipment is required to remove the hydrogen sulfide prior to flaring.

The electricity produced is used within the plant, and waste heat is used in the digesters to accelerate breakdown, resulting in a total energy efficiency of up to 75 per cent (about double that of conventional power stations).

The additional capital cost was $3 million, with a simple payback period of 3.5 years. Annual greenhouse gas emissions have been reduced by 8,600 tonnes CO_2 equivalent (compared with methane flaring) or 37,400 tonnes CO_2 equivalent (compared with venting).

For further information: Cathryn Hamilton, Manager, Environmental Management Unit, SA Water, phone: 08 8204 1953

Melbourne Water uses gas from wastewater lagoons

Sewage from all of Melbourne is treated by Melbourne Water Corporation's two treatment facilities. The older of the two, the Western Treatment Plant at Werribee, is unusual in that it consists of very large open treatment lagoons.

One of the 'smaller' lagoons (150 by 400 metres) is now covered with a 3 millimetre thick polyethylene cover (also called a membrane) in order to collect the sewage gas. Initially this was done to control odours, and the gas was flared. However, as the gas contains up to 80 per cent methane, this was a waste of energy.

In 1995, two spark-ignited piston engines with a total electricity capacity of 1.3 megawatts were installed to use the gas for electricity generation. The electricity supplies some of the plant's 3-megawatt load, mainly large motors to run thrashers for aeration of wastewater.

The lagoon produces 11,000 cubic metres of gas in warm months and 7,000 cubic metres in winter. Total gas production is 2,500 tonnes per year. Gas is collected and stored under the cover overnight, and used to operate the engines from 7 a.m. until 11 p.m.

Reduction in annual greenhouse gas emissions: 11,270 tonnes CO_2 equivalent (compared with methane flaring), 49,500 tonnes CO_2 equivalent (compared with venting).

The use of gas from this first lagoon was regarded as a pilot by Melbourne Water. Based on the success of the initial project, plans are now proceeding to capture gas for electricity generation from an additional two lagoons. The new lagoons to be tapped are considerably larger and deeper than the first lagoon used, so they may provide sufficient gas for generating up to 15 megawatts of electricity.

For further Information: Bill Welsford, Planning Manager, Western Treatment Plant, Melbourne Water Corporation, phone 03 9742 9272; Greg Nicholas, Project Manager, Sinclair Knight Merz, Consulting Engineers, phone 03 9248 3125.

Source: Greenhouse Challenge Office. *Greenhouse Challenge Case Study: Energy generation. Methane from Wastewater Treatment* (undated)

Standby electricity generation

Although an electricity generation facility can be expensive to buy and maintain, there are opportunities for savings, both in greenhouse gas emissions and costs.

Standby generators are often installed in Council facilities, particularly:

- where the facility may be used in disaster relief coordination or as an emergency shelter; or provides essential community services (e.g. water pumping or sewage treatment);
- where there are occasional high loads which do not justify the cost of upgrading the mains electrical supply (e.g. showgrounds).

A standby electricity generator normally operates only during grid power failures, during test runs or for special purposes. With such limited operating hours, the impact on greenhouse gas emissions will probably be small. However, the perceived need for a standby generator presents an opportunity to evaluate alternatives which have lower greenhouse impacts.

Opportunities for savings

An electricity generation facility can be expensive to buy and maintain. Typical project costs are $1,000 per kW of capacity (the engine generator set accounts for about half the project cost, with design, wiring, plumbing and so on accounting for the other half).

Opportunities for saving (both greenhouse emissions and energy costs) arise from:

- assessing whether you really need standby generation, or whether other strategies will fulfil the required functions just as well (but more cheaply and/or with lower greenhouse emissions);
- minimising the size of generator needed;
- choosing the most efficient method of generation (including installing a cogeneration system if possible).

Some or all of the capital earmarked for a generator which normally lies idle can be diverted to an investment which will work to reduce greenhouse gas emissions every day.

1. Do you really need standby generation?

You'll need to assess the risks of a power failure, which could range from a voltage dip of a few seconds which causes computers to reboot, to a complete loss of supply lasting for hours.

Consider the costs of alternatives, such as:

- providing a duplicate, alternative electricity feeder. Sometimes it is possible to feed electricity to a site from two different parts of the supply network (for example, from lines in separate streets adjoining the property). This can overcome the problem of a single feeder being taken out of service by a vehicle impact, a pole fire, bird, tree or animal interfering with the pole. It will not overcome the problem of a major grid failure, or if all the electricity to your area is supplied by a single feeder;

- providing facilities to enable connection to a mobile generator, taking into account the response time, standby charges, hire charges and so on;
- providing equipment which does not need a permanent electricity supply; perhaps critical computer operations could be moved to a notebook computer with battery backup;
- providing small uninterruptible power supplies for critical items of equipment.

You could also consider replacing equipment which needs electricity with equipment which does not, for example:

- using equipment driven directly by a gas engine instead of an electric motor;
- using daylight instead of electric lighting (assuming daytime operation only).

2. Reduce the size of generator needed

By reducing overall electricity demand

Your strategies for minimising the amount of electricity you use will also create savings by minimising the size of generator you need.

Each kilowatt that a generator has to supply will require an up-front payment of $1,000. This means every kilowatt you can save gives you $1000 to spend on achieving that saving—and there are many opportunities to reduce electrical demand which cost less than $1,000 per kW, for example:

- updating central computers to more modern equivalents which require less power (and less cooling, less maintenance);
- increasing the efficiency of your lighting installation;
- replacing appliances that use electric elements for heating with, for example, gas appliances, heat pumps, or radiant heaters;
- installing intelligent controls to switch off some non-essential loads (for example, heating and cooling) for short periods when demand is high.

All the above actions will have the added benefits of:

- ‘load levelling’, or reducing the ‘maximum demand’ for electricity, which will reduce your electricity costs if your business is on a ‘demand’ electricity tariff;
- reducing the amount of electricity consumed in Council facilities each year, reducing both greenhouse gas emissions and energy costs.

By reducing the demand for standby electricity

Also consider providing uninterruptible power supplies (small battery systems) for vital computers and communications equipment (for example, file servers, radio links, etc.). These will reduce the power and area of a building which a standby generator needs to serve. They also have the added benefit of protecting against power disturbances (less than a minute) and the first minute of blackouts, which a standby generator will not protect against.

Where standby power is required for only some equipment, investigate installing a separate electricity supply so that the essential loads can be fed separately, reducing the size of the generator required.

3. Choose the most efficient means of providing standby power

Where a generator is often required to meet a very small load (a few kilowatts or less) which is much smaller than the capacity of the generator, look at installing a battery inverter system.

Consider cogeneration

If you are considering investing in a diesel-powered generator which will sit idle nearly all the time, it is a relatively small step to consider a generator which can work all year, for about the same capital cost. The incremental cost will be more than justified by the greenhouse and cost savings.

'Cogeneration' involves generating electricity on Council premises all year—not just as standby—and putting the heat normally wasted in generating electricity to work.

Of course, this is only a benefit if the facility has a year-round demand for heat, but many do, including swimming pools, civic offices and some commercial buildings of which Council may be a part-owner (e.g. shopping centres).

A generator powered by a cheap fuel (biomass, waste products, or natural gas) can generate electricity more cheaply than the cost of buying the electricity from a retailer, and has the advantage of supplying heat at no added cost, as well as saving greenhouse gas emissions.

Cogeneration is explained further in Energy sheet E20.

Estimating emissions

Each litre of diesel fuel used will generate 3 kg of CO_2.

Council finds potential savings of $400,000 by reducing demand for standby electricity

A municipal office complex with an electricity demand of 500 kW was suffering increasing power blackouts. Immediately after a seven-hour blackout, the CEO directed engineering staff to provide standby power.

The first option investigated was to arrange a contract for a truck-mounted 700 kVA mobile generator to be on standby. However, they found this would cost $90,000 per year in standby charges, *plus* $1,000 for each day the generator was actually required. These charges were based on a two-hour response time, which the Council also found unacceptable. Wiring modifications to enable connection of the mobile generator would increase the project cost.

Installing a new generator to provide a complete electrical backup was estimated at $500,000 and so was rejected. The office complex had a modest demand for heating and a low electricity price, so cogeneration was also discounted.

Council staff then investigated a package of:

- installing some dedicated emergency power circuits;
- some energy-efficiency actions designed to reduce demand in strategic areas; and
- providing some uninterruptible power supplies.

With this strategy they could reduce the size of a planned emergency generator from 500 kW to 50 kW, and the capital cost from $500,000 to $85,000—a saving of more than $400,000. Ongoing energy costs would also be reduced. Response times for both systems would be comparable.

Cogeneration

If Council facilities have a year-round need for heat, cogeneration offers opportunities for major savings.

Around a quarter of Australia's electricity needs could probably be supplied by cogeneration, which generates less than half as much greenhouse gas per unit of electricity as conventional generation in a gas-fired power station.[1]

Opportunities for savings

What is cogeneration?

A typical coal-fired power station converts only a third of the energy from the coal into electricity; the remaining two-thirds is lost to the atmosphere as waste heat. A cogeneration system generates electricity (usually on the premises or site where it will be used) and uses the inevitable 'waste' heat for useful purposes such as water heating, comfort heating, pool heating or drying. A cogeneration system can reduce both energy consumption and fuel costs by utilising up to 80 per cent of the energy in a fuel instead of wasting two-thirds.

A cogeneration system is often economically justified by energy savings alone, but it also has the advantage of providing an alternative electricity supply in the event of a grid failure. (See Energy sheet E19 *Standby Generation.*)

How does it save greenhouse emissions?

Greenhouse gas emissions are reduced because of the intrinsic efficiency of getting more useful energy from the fuel used. Emissions may also be further reduced by using a less greenhouse-intensive fuel in the cogeneration system (for example, gas or biomass) than is used in the power stations which would otherwise supply the electricity.

Of course, cogeneration is only a benefit if the facility has a year-round demand for heat, but many do, including swimming pools, civic office buildings and plant hothouses.

There may also be other Council activities which could be economically converted to use heat from the generator once that cheap source of heat becomes available, including:

- absorption cooling (using hot water to produce cooling);
- desiccant dehumidification (using heat to recharge a desiccant [drying agent] used to dehumidify). Alternatively, the heat (or the above derived cooling or drying resources) could be sold to nearby business or industry.

[1] Extrapolated from figures from the Australian Cogeneration Association and other sources

Types of cogeneration

Small to medium-sized cogeneration systems are usually natural-gas-fired, spark-ignition, reciprocating engines (usually derivatives of industrial diesel engines). These convert between 30 and 40 per cent of the fuel energy to electricity and provide another 40 per cent as useful heat (usually as hot water, but some of the heat can be provided as steam).

Small gas turbines (75 kW electrical capacity) began mass production in 1999, and these may also prove suitable for a wide range of Council facilities, depending on price competitiveness. They are compact (about the size of a refrigerator) and quiet.

Large cogeneration systems (above 1 MW) usually use gas turbines. A large system is much less likely to be suitable for Council facilities unless it is installed jointly with a major industrial plant, hospital or other major energy user.

Cogeneration energy sources

Some of these fuels require conversion to gas (in a gasifier) or steam (in a boiler) as an intermediate step before electricity generation.

Landfill gas

Many Councils have active and/or disused landfill sites, producing methane which unless captured will escape to the atmosphere where it is a powerful greenhouse gas. However, it is possible to use this gas as a fuel in an engine, to generate electricity. This:

- converts a very active greenhouse gas (methane) to CO_2 which has less than 5 per cent of the greenhouse impact;
- displaces the use of fossil fuels which would otherwise be used, saving more CO_2 emissions.

One of the signs that a disused tip site is producing methane is that grass if difficult to grow; it often appears very brown and dry.

Projects converting landfill gas to energy are normally operated on Council's behalf by a specialist company which sells electricity to the grid. The waste heat may also be sold to adjacent properties, such as plant nursery hothouses. Many recently developed landfill gas projects generate electricity, but fail to utilise the waste heat from generation.

Organic waste

There may be waste products and byproducts with energy potential within the Council area, and Council may be able to facilitate a regional waste-to-energy project. Candidate materials include waste wood from Council collections and collection sites and, in some Councils, **crop residues** (cotton, bagasse, etc.) and **product waste** (tallow, sawdust, fabric, packaging).

These fuel sources can reduce greenhouse gas emissions, by:

- displacing the use of fossil fuels;
- avoiding the waste material going to landfills where the breakdown process can generate methane.
- reducing the transport energy required to remove 'waste' and to deliver fuel or electricity.

Natural gas, LPG

The use of these fuels will generate lower greenhouse gas emissions than using the same amount of electricity produced from coal.

Other processes also produce usable waste heat: Electricity generation is not the only workplace process which generates potentially usable heat. Waste heat from engines, cooking, cooling and other equipment can be used to replace the use of some fossil fuels for 'low-temperature' heating.

Who can help?

Australian Cogeneration Association

Cogeneration at Mill Park

Methane from the former landfill at the **City of Whittlesea** (Victoria) Sycamore Reserve is collected and used to heat the pool water at the Mill Park Leisure Centre, saving $86,000 in annual electricity and heating costs.

A reciprocating engine provides 104 kW of electrical power, providing most of the electricity used by the leisure centre. Heat is recovered from the engine exhaust and used for pool and air heating. The engine burns a 50:50 mix of landfill gas and natural gas, the mix used to achieve stable engine operation. Most heating for the centre is provided by water heaters ('boilers') which use only landfill gas. The system includes an innovating heat exchanger design to withstand the corrosive nature of the landfill gas.

Added advantages are that the centre can continue to operate in the event of a grid power failure—and it was very popular during the 1998 Victorian gas supply interruption!

For further information: The City of Whittlesea 03 9217 2170, or Mr Bill Ellul, Managing Director, Ecopower Consultants Pty Ltd, ph 03 9729 3559

Renewable energy

Renewable energy resources have the potential to contribute a significant proportion of the energy requirements of Council activities while generating negligible greenhouse gas emissions. In fact, the potential role of renewable energy in this sector is far greater than many would initially suspect.

This information sheet provides only a broad overview of renewable energy options. If you identify potential for applying this technology, seek expert advice from appropriate energy agencies, industry associations, consultants or equipment suppliers.

Renewable energy takes many forms, many of which do not fit into the stereotype of sun, wind or water. Most reviews of renewable energy focus on the energy supply technologies, but this brief summary outlines the technology options that could be utilised to supply energy for activities likely to be relevant to councils, including:

- electricity supply;
- lighting;
- ventilation and pumping;
- cooling;
- space and water heating;
- cooking; and
- miscellaneous tasks.

Opportunities for application

Electricity

For grid-connected facilities, the most convenient way to use renewable energy for electricity is probably by negotiating a Green Power electricity tariff, so that the electricity supplier deals with the technological details while your organisation simply uses the renewable electricity. (See Energy sheet E3 *Negotiating energy contracts*.)

Where it is considered desirable to establish a grid-connected renewable generation system, this can now be achieved relatively easily, using off-the-shelf technology. For example, Moreland Council's new Civic Centre has incorporated a photovoltaic array into a 'solar pergola' at its main entrance.

Some Councils now capture landfill gas and use it to generate electricity, which is fed into the electricity grid, or to supply heat to industry.

Off the grid, a variety of renewable energy sources can supply electricity, including photovoltaic cells, wind generators, micro-hydroelectric generators, wood, organic wastes and solar thermal plants. Detailed discussion of these systems is beyond the scope of this publication; see *Who can help?* at the end of this sheet.

It is critically important to use the most efficient technologies available, to make the most of renewable energy resources, and to minimise the overall cost of their application. For example, cutting energy waste by as little as 15 watts (continuous load) saves as much energy as that produced by a $700 solar cell panel.

Lighting

Lighting is directly responsible for more than a quarter of commercial-sector greenhouse gas emissions; and waste heat from lighting adds to airconditioning loads. Street and outdoor lighting is also a major issue for Councils.

Much activity occurs during daytime, when daylight is available, so effective use of daylight can lead to very large reductions in greenhouse gas emissions. Consider the following:

- sophisticated skylights, light tubes, light shelves and advanced glazing coatings (which exclude most heat but allow most light to pass through) are being developed rapidly, while computerised design programs are allowing these technologies to be used more effectively;
- using light colours and appropriate geometry for ceilings and walls makes the most of daylight;
- dimmable electronic ballasts are getting cheaper and improving in performance. This technology complements daylighting, as it allows artificial lighting to be modulated with variations in daylight, to maximise savings.

But beware—excessive areas of poorly designed and shaded glazing can increase cooling costs, create discomfort and cause glare problems. One square metre of clear glazing in direct sun can allow up to a kilowatt of heat to enter, while delivering as much light as up to 40 standard fluorescent lamps.

Solar-powered lighting systems are becoming more widely accepted. Even in suburban areas, they can be cost-effective where they avoid the cost of running electrical cable to toilet blocks, barbecue shelters, pathways or other points where relatively small amounts of electricity are required. Several specialist suppliers now manufacture solar lighting equipment for street and park lighting, indoor lighting, and even school crossing warning lights!

Ventilation and pumping

Pumps and fans generate more than 20 per cent of commercial-sector greenhouse gas emissions as they move air and water around for cooling and heating and water supply. As noted in sheet E11, there is great scope to reduce this consumption through strategies such as variable-speed drives, efficient fans and motors, and so on. Once the load is reduced, renewable electricity is more likely to be able to drive the motors.

Some designers use natural principles to ventilate buildings: strategies such as effective cross ventilation or rooftop systems which draw air from a building have been used in traditional buildings. These techniques can be applied to even greater effect now. Where water or other fluids must circulate, it is sometimes possible to use natural convection (warmer water, air or other fluids are less dense, so they rise) to assist or replace pumping. When mechanical systems assist natural ventilation or circulation, it is important to fit suitable controls and sensors, so that the mechanical systems do not operate unnecessarily.

Solar-powered fans and pumps can also operate very effectively. Because they supply DC (direct current) electricity, they can drive DC motors; these are far more efficient than conventional AC motors, so overall results can be very impressive.

Cooling

A number of renewable energy options can satisfy the demand for cooling.

While **renewable electricity** can be used to power conventional airconditioners, this can be an expensive solution unless the building is designed to be very energy-efficient. Rapid developments in **photovoltaic cells** mean it may be feasible in the near future to coat windows with solar-electric films which generate electricity for cooling and other purposes, but these are in the development phase at present.

Evaporative cooling provides comfort using the natural process of evaporation of water; in areas where the humidity is not too high, this can be an excellent solution. Indirect evaporative coolers can provide cooling without humidifying the indoor air. Where such coolers are installed, it is important to make sure they have automatic dampers fitted, so that they are sealed-off when not in use. Otherwise, large amounts of air may flow through the building at times when this is not wanted, such as on cold days!

Solar heat can be used to provide cooling in a number of ways. Absorption cooling (as used by the traditional kero fridge and more modern gas refrigerators) has been used widely. Desiccant cooling is also being developed. In one example of this approach, solar heat drives moisture from a moisture-absorbing substance (a desiccant), then air is dehumidified by the desiccant before being evaporatively cooled. This approach is relatively high in capital cost at present, but is useful for situations where a large amount of fresh air is required.

Solar-powered fans can also be used to improve comfort.

Space and water heating

There is a long history of use of renewable energy to satisfy this requirement. Options include:

- **passive solar** design of buildings—although, as noted in Energy sheet E6 *Energy efficiency and the building envelope*, this requires careful design if overheating and glare problems are to be avoided in office buildings; well-designed atria and conservatories can provide solar-tempered spaces which are very pleasant environments. Such spaces can be very valuable at childcare and community centres;
- **wood-fired heating**—more practicable in country areas; advanced-technology chip and pellet heaters are being developed overseas for automatic operation, and the emerging fuelwood plantation industry could provide an increasing fuel resource. Open fires are not only very wasteful of wood, but create serious air pollution problems. There is increasing concern that much of Australia's wood heating uses fuel from unsustainable sources, and that timber harvesting impacts on natural biosystems, as well as contributing disproportionately to air pollution. These issues can and are being addressed;
- **landfill gas or biogas from waste organic material**—for example, the Superdrome in Perth uses landfill gas for water heating, while landfill gas is piped 2.5 kilometres from a landfill for use at a Mill Park (Victoria) recreational centre (see case study in

sheet E20 *Cogeneration*). The landfill gas can be burned to generate heat, or waste heat from a landfill gas-fired cogeneration plant can be utilised;

- **active solar** heating systems for swimming pools and hot water are well proven, and can be very cost-effective in many parts of Australia. Active solar space heating systems are relatively uncommon, as their capital cost has been high. Ongoing improvements in technology are reducing costs and improving performance.

Cooking

The traditional renewable energy source for cooking is wood, but wood-fired cooking is usually very inefficient and polluting—although the traditional wood-fired barbecue may be a practicable solution in some parks. Biogas can be used in modified natural gas cookers. Solar thermal cookers use reflectors to concentrate the sun’s heat, but most designs lack the flexibility required for commercial operations.

Miscellaneous tasks

Photovoltaic cells and small wind generators can be used to satisfy small electrical loads. Yachts, caravans and bushwalkers are making increasing use of these technologies to charge batteries, or to run refrigerators, lights etc. Solar panels for laptop computers are also available!

Solar-powered low-speed vehicles are also becoming practicable for use at resorts, and may have application for some Councils, where local transport is required. However, it is generally more cost-effective to install the solar cells on a building, feeding into the electricity grid, then charge the vehicle batteries overnight with cheap off-peak power.

Renewable transport fuels such as alcohol and vegetable oils are now available, although they are more expensive than conventional fuels.

Applications of renewable energy can also be used for public relations purposes. Solar-powered advertising signs and hats or caps fitted with solar-powered cooling fans are just two examples of such applications. Some Councils have established display centres and demonstration renewable energy systems—for example, Newcastle (NSW) and Moreland (Vic). In these cases, the costs can be offset by publicity benefits, as well as energy savings or enhanced utility.

Emerging opportunities

Several government programs are creating opportunities for more cost-effective application of renewable energy, which may help councils in their efforts to utilise renewable energy. These include:

- Green Power schemes, which allow electricity suppliers to pay a premium to renewable electricity generators;
- the 2% Renewables Target, a Commonwealth Government program that will require all electricity suppliers to purchase an additional 2 per cent of renewable electricity by 2010;
- several programs under the renegotiated GST package, including subsidies for rooftop solar-electric cells and remote-area power systems.

Who can help?

More information can be obtained from:

Commonwealth Government Web site: www.renewable.greenhouse.gov.au. This includes links to many useful sites.

Energy Efficiency Victoria publishes a useful book titled *Remote Area Power Supplies*

The Sustainable Energy Industry Association (Australia) has many members involved in the renewable energy industry, ph (02) 6273 0271, fax (02) 6273 0273, www.seia.com.au

Showcase for renewable energy in Newcastle

Thirty historical sites in Newcastle are to be illuminated with renewable power drawn from diverse sources including wind, sun, hydro and landfill gas. All sites were photographed to produce a book currently being used by local school children and for tourism. The sites are now the subject of a night time historical bus tour.

Many partners worked with **Newcastle City Council** on this project, which was conceived by Green Energy Coordinator Peter Dormand and Newcastle University's Alan Chawner. The project has provided Newcastle with a showcase for its green energy ideals and a unique tourism opportunity.

The Council is also proud of Wallsend Rotunda Park, one of only a few solar parks in the world, with solar cells providing lighting and power. Project partners include EnergyAustralia, UNSW, DPIE. The total investment of $30,000 has cut direct electricity costs by $300 p.a. and reduced the need for infrastructure such as cables and poles.

For more information: Mr Peter Dormand Green Energy Project contact Coordinator, Newcastle City Council, phone 02 4974 2542, email pdormand@ncc.nsw.gov.au

Power from Sydney landfill gas

Gas from Lucas Heights has been used to generate electricity since 1991, and this resource is expected last for at least another 20 years. More recently, the Waste Service of NSW has commissioned a 4 MW power station at **Belrose** landfill site. The infrastructure is provided and operated by Energy Developments Limited, a publicly listed Australian company. The total investment of the infrastructure was $5 million, made up of $1 million for site works (gas collection and treatment system) and $1 million for each of the 1 MW generators. These costs are competitive with other power plants, with the added advantages of free fuel and environmental benefits. The modular power station design also allows generation capacity to be increased or decreased in response to gas flow.

Some of the advantages cited by WSNSW are odour control and improved air quality for vegetation (and so quicker remediation of the landfill site).

For further information: http://www.dpie.gov.au/netenergy/info/renew/belrose.html
Mr Walter Pahor, Managing Director, Energy Developments Ltd, ph 03 9823 9823

Wingfield won't waste

At present 65 per cent of methane produced at the Wingfield Waste Management Centre (SA) is being extracted and converted to electricity. As a result 8,000 tonnes of methane gas (which equates to at least 168,000 tonnes of CO_2 equivalent) is captured every year, and prevented from entering the atmosphere.

For further information: Mr Jack Mazek, Program Coordinator Cities for Climate Protection, City of Adelaide ph 08 8203 7209