Waste heat:
improving comfort, saving money

Findings from the study: Comfort and electricity use in remote Australian buildings

Energy efficiency recommendations for buildings aim to reduce the amount of gas or electricity consumed by appliances. The benefits are reduced electricity bills and reduced greenhouse gas production and are usually estimated from the electricity used in the appliance. Every appliance that consumes energy produces waste heat, and removing that heat also costs money. Every $3 of electricity an appliance uses needs around $1 to run an air conditioner to remove the heat, or else the building is very likely to become too warm.

Where does waste heat come from and how is it removed?

The energy we consume, whether it's from food, electricity or any other form of energy, eventually becomes heat. The light from our lamps heats up floors and walls, the mechanical movement turning our clothes in a washing machine heats the machine, and the food we eat will be used by our bodies and keep us warm. The heat left over after we have used energy is called waste heat. Inside buildings, it can cost hundreds of dollars a year to remove. Fortunately, the air conditioners that remove heat generated from other appliances in our buildings get rid of their own heat outside a building, otherwise the building would never be cooled!

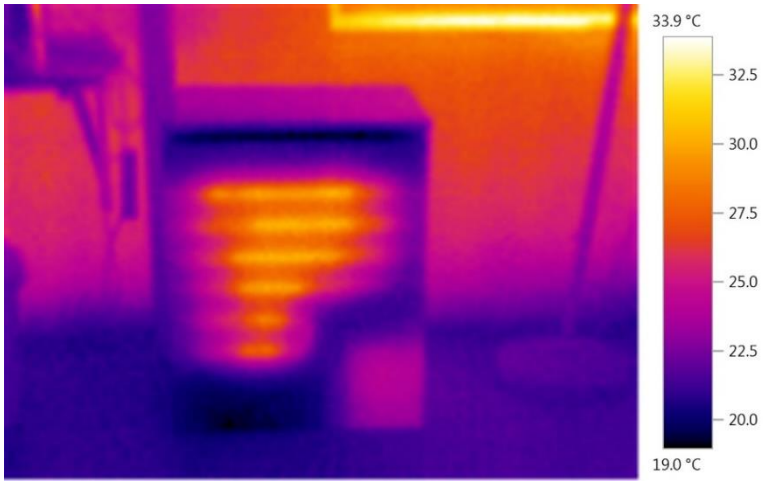
Is waste heat useful?

Waste heat is an additional burden on an air conditioner in summer, while in winter it could contribute to keeping a building warm. But waste heat is an expensive way to keep a building warm. It costs three times as much to warm a house in winter relying on waste heat as it does to use a reverse cycle air conditioner.

How to prevent waste heat from wasting money

Given that waste heat inside a building costs money to remove, it makes sense to only use electricity when it's necessary and not to leave appliances running when they are not needed. It also makes sense to remove appliances that produce heat away from rooms you are trying to keep cool. For example:

Kitchen equipment: Many kitchen appliances produce significant waste heat. For example, the figure below shows the heat from a refrigerator. Close off kitchens from office and work areas, and make sure they are well ventilated to remove steam and heat.
Air conditioners in the kitchen should be switched off when the ventilator or exhaust fan are running.

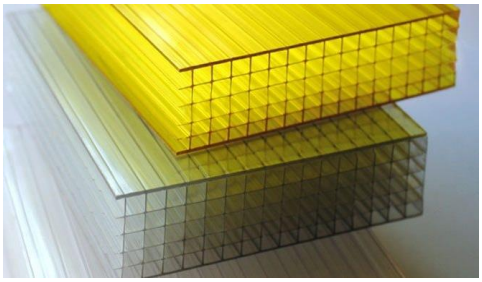


Computer and telephone equipment: Computing or telephone equipment in air conditioned offices can easily produce as much heat as a kitchen if they are switched on all the time. The waste heat from office equipment can spread through the building and place an unnecessary load on office air conditioners. It's worth asking:

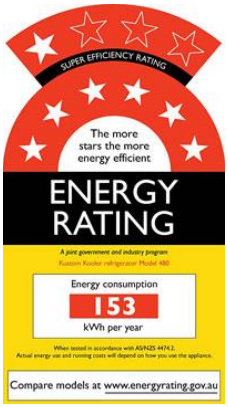
- Does the equipment have to be kept as cool as an office?
- Does it need to run 24 hours a day?
- Would it be cheaper to install some computer and telecommunications equipment in a dust free cupboard, room or outside shed, with its own small cooling system or ventilator fan?
- Is it cheaper and cooler to hire a company to provide the services instead of using your own equipment? For example, it might pay to hire an internet service provider to run your web site from their offices rather than have a computer server in your office running 24 hours a day.

Lighting – downlights: Downlights or spotlights are often used in art centre offices and display areas. Halogen down lights use about 50 watts, so 10 of them is like using a small electric heater. LED downlights use about 1/10 the power that a halogen downlight uses, so that's 1/10 the heating. For each downlight, this could save up to $40 for the electricity to run the light and even more if you count the cost of removing the waste heat.

Lighting – skylights: Skylights and natural light are an excellent way to reduce electricity bills for lighting. However, they often let heat into the building as well as light. It's worth making sure that skylights are designed to protect a building from the sun's heat, for example, they can be made from plastic (polycarbonate) with air pockets for insulation. This may be called cellular, honeycomb, multiple wall or double glazing (see figure). The air pockets reduce the amount of heat being conducted into or out of the building, which is particularly useful for air conditioned spaces.



Translucent roofing materials made with air pockets to reduce conducted heat. Image source http://danpal.com.au/products/danpavault/



Appliances and equipment: Energy star rated products use less electricity and consequently generate less waste heat. For example, replacing a 1-star rated fridge-freezer with a 7-star unit could save $180 a year, including the cost of the electricity to both run the appliance and to remove its waste heat. The Australian Equipment Energy Efficiency (E3) web page http://www.energyrating.gov.au/products/ describes how much electricity can be saved for a range of products with different star ratings. The website includes a calculator at http://www.energyrating.gov.au/calculator that quickly estimates savings for individual products and star ratings.

Image source http://www.energyrating.gov.au/
© Commonwealth of Australia (E3 Program)

Installing equipment: If possible, install equipment – such as printers, modems and servers, telecommunications equipment and other appliances that run continuously for long periods – in a room with air conditioning or ventilation specifically designed for the equipment and away from where people are constantly working.

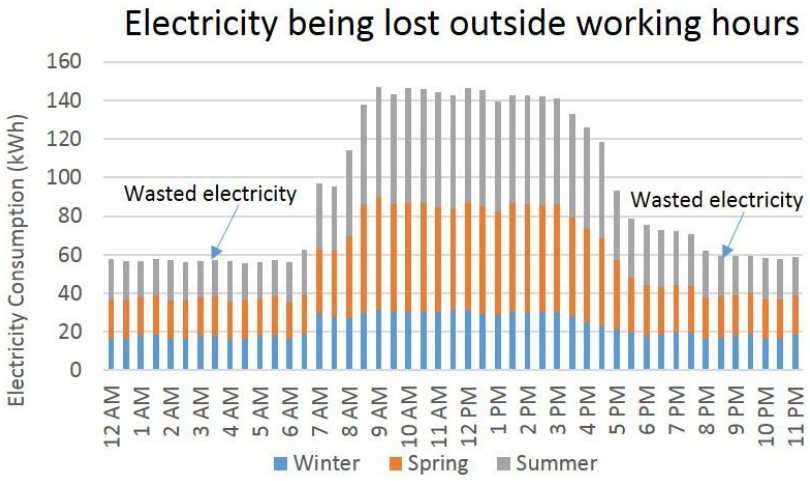
Turning off computers and other appliances

Some appliances – such as security lights, fire alarms, clocks or telephone equipment – may need to run all the time, but many are switched on 24 hours a day using electricity unnecessarily. Small appliances may not use much electricity or generate much heat individually, but if they are left running constantly and taken as a group they can use $100–$200 worth of electricity each year. Switching off at the appliance is not always enough to ensure that it's completely switched off.

For example, items such as computers or microwave ovens that are switched off at the appliance but not at the wall still use electricity, even though they seem to be doing nothing. The figure below shows the electricity that can be consumed by a set of computers and other equipment over 24 hours. It can be seen that there is as much electricity being consumed outside working hours as during the day!

Others include:

- Battery chargers, phone chargers and appliance chargers
- Computers, displays, printers, copiers, modems left running or on standby overnight
- Lights in toilets, storage areas and unused rooms or rooms with good natural light
- Clocks such as those found on cookers or microwave ovens
- Dishwashers.



When appliances are not being used, turn them off at the wall or switch them to sleep or standby mode. To avoid power surges damaging your equipment when switching off, switch off the equipment at the appliance and then at the wall. When switching on do the reverse – switch on at the wall and then on at the appliance.

When there are a lot of appliances to switch off, it can make sense to run them as a group off a power board so that multiple units can be switched off together, taking care of course not to overload the wall power outlet. For example, computer equipment might be run off one power board per computer desk plus another board for the printers, copiers and modems. Likewise, battery and appliance chargers could be run off one or two power boards with charging carried out overnight using a timer to switch the board on for sufficiently long to charge the appliance and then off.

Reducing waste heat generated by appliances

An example of how waste heat can be generated from the equipment inside an office building is given in the table below. The avoidable waste heat energy generated over a year is about 6,461 kWh, equivalent to an electric bar heater running every day for a year. The extra running costs for an air conditioner to cope with this heat would be $581. As well as the savings in waste heat, there is also a direct saving of $1,744 from using more efficient appliances and from switching appliances off outside working hours, so the total savings could be $2,326. The following table provides a tool for calculating possible savings: note that these are a very approximate estimate of the savings that could be made in a building where no energy savings measures have already been made. They also do not take into account the cost of replacing appliances which are assumed to be replaced at the end of their useful life.

Summary

If possible:

- Switch appliances off at the wall power outlets after hours.
- When planning to purchase equipment replace inefficient units with more efficient ones and check that their ‘standby power’ is not excessive. The standby power should be no more than a few watts. If it’s as much as 100 watts then it may be worth looking for an alternative as that could easily add about $200 to your bill each year.
- Relocate equipment that generates a lot of heat away from where people are working to a room or cupboard that has purpose-built cooling for the equipment.

Example of waste heat generated by appliances in a typical enterprise building art centre and the savings that can be made

Appliance	Number	Waste heat kWh	$ saving per year	Savings action
Web server/telecomm. system (PABX, VOIP)	1 system	3,061	$826	Upgrade to energy-saving equipment, use energy-saving mode after hours, or use alternative facilities from a telephone or internet service provider
Tea urn uninsulated continuous running	1	1,753	$473	Switch to insulated timed tea urn
1-star refrigerator, 2-door, 200 L fridge-freezer	1	500	$135	Replace with 6-star energy rated fridge-freezer
Halogen downlights	10	510	$138	Replace with LED lights
Computer, desktop switched to standby mode	2	319	$86	Switch off at wall when not in use for an hour or more
Computer, desktop switched to sleep mode	2	42	$11	Switch off at wall when not in use for an hour or more
Fax, laser	1	47	$13	Change appliance to fax free or high efficiency
Multifunction device, laser	1	23	$6	Switch off at wall outside working hours
Modem, cable	1	22	$6	Switch off at wall outside working hours
Modem, DSL	1	8	$2	Switch off at wall outside working hours
Speakers, computer	2	21	$6	Switch off at wall outside working hours
Computer display, LCD	2	14	$4	If possible, switch off when not in use for an hour or more
Scanner, flatbed	1	14	$4	Switch off at wall outside working hours
Printer, laser	1	9	$2	Switch off at wall outside working hours
Copier	1	9	$2	Switch off at wall outside working hours
Power tool, cordless	3	69	$19	Switch off charger when fully charged or not in use
Microwave ovens	1	18	$5	Switch off at wall outside working hours
Phone, cordless	1	6	$2	Switch off outside working hours
Charger, mobile phone	2	9	$2	Switch off charger at wall when not in use
Coffee maker	1	7	$2	Switch off at wall outside working hours

Direct saving	$1,744 per year
Waste heat	6,461 kWh per year
Air conditioning cost saving	$581 per year
Total saving	$2,326 per year

FOR MORE INFORMATION ABOUT THIS RESEARCH, CONTACT:

Dr Peter Osman

P: +(61) 2 9490 5526 M: +(61) 411 440 339 E: peter.osman@csiro.au

Visit: http://crc-rep.com/research/regional-economies/climate-change-adaptation-and-energy-futures

This pamphlet is one of a set of four that aims to reduce electricity bills and improve thermal comfort in community and enterprise buildings in remote regions of Australia. The findings are based on applying CSIRO's knowledge base and research capacity in designing thermally efficient buildings to address enterprise needs in the hot arid and hot humid climate zones of remote Australia. CSIRO partnered with Charles Darwin University and the University of South Australia as part of the Cooperative Research Centre for Remote Economic Participation to conduct a research project in which the physical properties of eight community buildings (art centres) were studied to provide a realistic assessment of where design improvements could be made and operating practices enhanced. It was clear from the study that managers were already very careful in their use of electricity. However, we found substantial technical changes could be made in the building design and appliance selection and operation that could lead to substantial reductions in cost and improvements in thermal comfort. This pamphlet focuses on ways to reduce or remove waste heat and by doing this reduce the load on air conditioners and/or maintain reduced temperatures in the working environment. The recommendations should be of particular interest to architects, builders and building managers. The full report of the research can be found at Osman P, Havas L, Ambrose M and Clark G. 2017. *Comfort and electricity use in remote Australian buildings*. CRC-REP Research Report CR018. Ninti One Limited. Alice Springs. http://www.crc-rep.com.au/resource/CR018_ComfortElectricityUseRemoteAustralianBuildings.pdf.