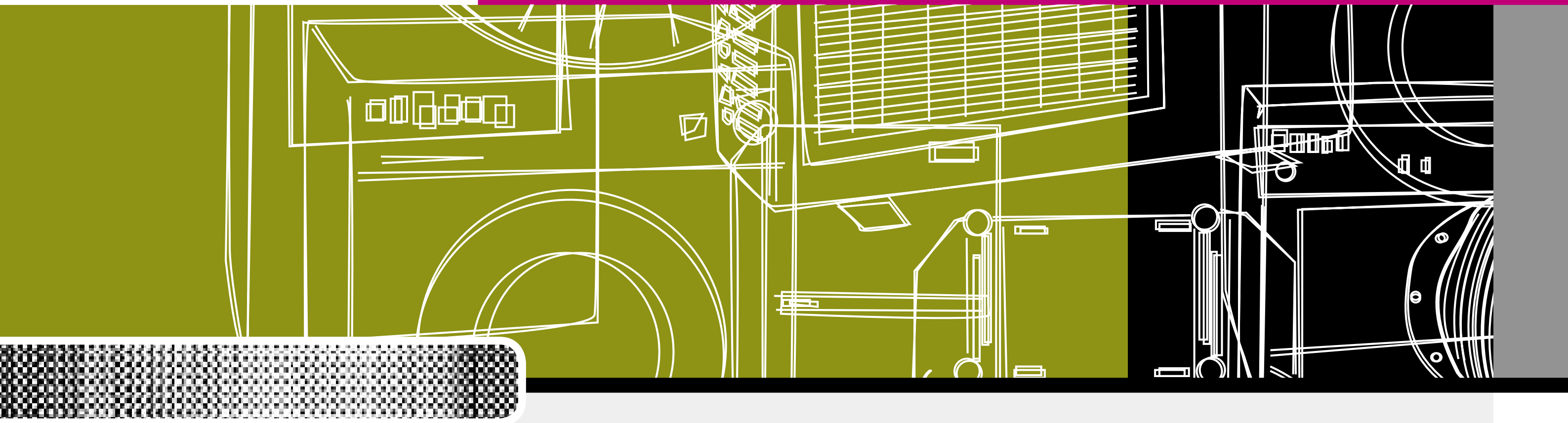
Report No: 2003/07

NATIONAL APPLIANCE AND EQUIPMENT
ENERGY EFFICIENCY PROGRAM

A STUDY OF OFFICE EQUIPMENT OPERATIONAL ENERGY USE ISSUES



February 2003

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A Study of Office Equipment Operational Energy Use Issues

Final Report

Prepared for

THE AUSTRALIAN GREENHOUSE OFFICE

February 2003

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1. Background

This is the first of a pair of reports prepared for the Australian Greenhouse Office, (AGO) acting on behalf of the National Appliance and Equipment Energy Efficiency Committee (NAEEEC), that examine issues associated with the operational energy use of office equipment and of home entertainment equipment. The second report deals with home entertainment equipment.

Programs such as *Energy Star*, initiated by the US Environmental Protection Agency, and NAEEEC's *One Watt Target* (NAEEEC, 2002) focus on limiting the standby energy use of equipment and, secondarily, cutting the operating energy use by facilitating switching to low power mode when equipment is not carrying out its core functions. Given that standby power consumption has been estimated to be approximately 12% of all household electricity and growing at 8% per annum, reduction of standby power is certainly a major issue **(**Harrington and Kleverlaan, 2001**)**. Similarly, studies in the early 1990s (for example, Sustainable Solutions, 1993) showed that standby power use of office equipment was very substantial – often 40 to 90% of total energy use for particular items of equipment.

However, as standby power consumption is being brought under control, and barriers to users actually switching to low power modes have proved difficult to overcome, it is becoming increasingly clear that the operational energy of office equipment is also a major issue. There is scope for substantial improvement in operational energy efficiency for many items of office equipment. This report highlights that the potential gains from such improvements are significantly greater than those from the remaining opportunities from the important standby energy efficiency programs.

For equipment that operates for long periods – such as many office computers, the potential significance of operational energy efficiency is large.

There are significant variations in operating energy consumption of computer monitors of the same size, not linked to cost or quality of product. Measurements by *Lincolne Scott* (2002) indicated a range of power consumption from 120 to 175 watts for personal computers with 17 inch monitors: The annual difference was of the order of 150 kWh for a computer used regularly for business. This is equivalent to the amount of energy saved by improving the energy rating of a refrigerator, clothes dryer or dishwasher by almost 2 stars. Therefore, the reported range of variation in energy use of a small sample of computers could be as significant as major improvements in efficiency of household products that already carry appliance energy labels.

Sustainable Solutions recently measured the energy consumption of two models of laptop computer released by a major manufacturer and purchased on the same day for the same price. Their respective operating/active standby power consumptions were 20 watts and 45 watts. It appears that much of this difference may be due to the processors – one having a 1.2 GHz Celeron Processor and the other having a 1.6 GHz Pentium 4 Processor. The fan of the Pentium 4 machine operates semi-continuously when the machine is in operation and ejects very warm air, in marked contrast to the Celeron machine. Laptops have traditionally operated at 15-25 watts but far higher power-consuming machines could predominate in future unless this issue is addressed.

These two examples highlight the importance of identifying the scale of variation in operating energy efficiency for a range of office equipment items when exploring options such as information programs and development of standards, for government action to provide impetus to improvements in energy efficiency and reductions in greenhouse gas emissions. In developing such programs it is also important to recognise the potential for further improvement beyond today's best practice.

There is very little information on the Power Factors of office equipment, and their significance for overall energy efficiency of the electricity supply system. This project provides an opportunity to collect preliminary data and consider options for policy response.

This Report examines the following items of office equipment:

- Computers
- Monitors:
    - Cathode Ray Tube (CRT)

  - Liquid Crystal Display (LCD) – flat panel
- Packaged Uninterruptible Power Supplies
- Servers for small systems
- Photocopiers
- Facsimile machines
- Printers (inkjet and laser)
- Multifunction Devices (MFDs)
- Scanners
- Computer projectors
- Hubs for wireless networks

2. Introduction

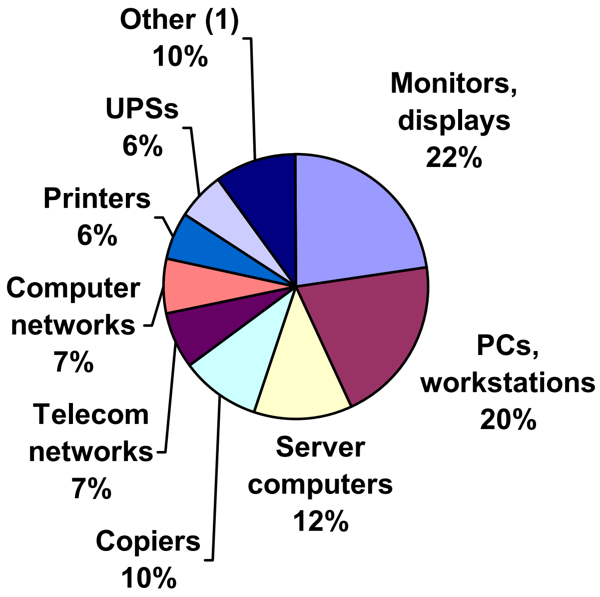
The energy used by office equipment is a significant and growing source of Australia's greenhouse gas emissions.

The means by which it contributes to greenhouse gas emissions include:

- direct use of electricity to operate equipment;
- increased use of electricity for cooling: it is obvious that the heat generated by office equipment is an additional heat load that adds to cooling energy requirements. This heat somewhat reduces heating energy requirements in winter, but this is a comparatively minor effect, as offices need little heating in virtually all Australian climates because of the heat output from lights, equipment and people
- energy use for manufacture of paper associated with office equipment, as well as for the manufacture of office equipment and other consumables. Roth *et al* (2002) refer to a study by the Carnegie Mellon University Green Design Initiative, which estimated that in 1997 energy use associated with the manufacture and supply of office equipment (including both direct and indirect energy usage due to inputs from all sectors) was similar in magnitude to that used by the equipment in that year. From this it could be inferred that operating energy in 1997 was around half of full lifecycle energy for office equipment. Such a conclusion should be treated carefully, as both operating energy and manufacturing energy efficiencies have changed, and the study included all office equipment and computers (including equipment sold into homes and industry) but not some of the equipment types discussed in this report. Energy used for manufacture of paper for office printing and photocopying is larger than the direct energy use of all printers and copiers, but less than a fifth of the direct energy used by all equipment. (should we ref this – either to Pickin or us?)

Figure 2.1 shows an estimated breakdown of office equipment energy use in the US by equipment type (Roth *et al*, 2002). Approximately 60% of the total energy used is directly associated with computer use, including communications and information transfer, while about one-sixth of the total is associated with energy used by paper-imaging equipment. Australian data are not sufficiently detailed to prepare such a breakdown of office equipment energy use, but it is likely to be similar to the US situation.

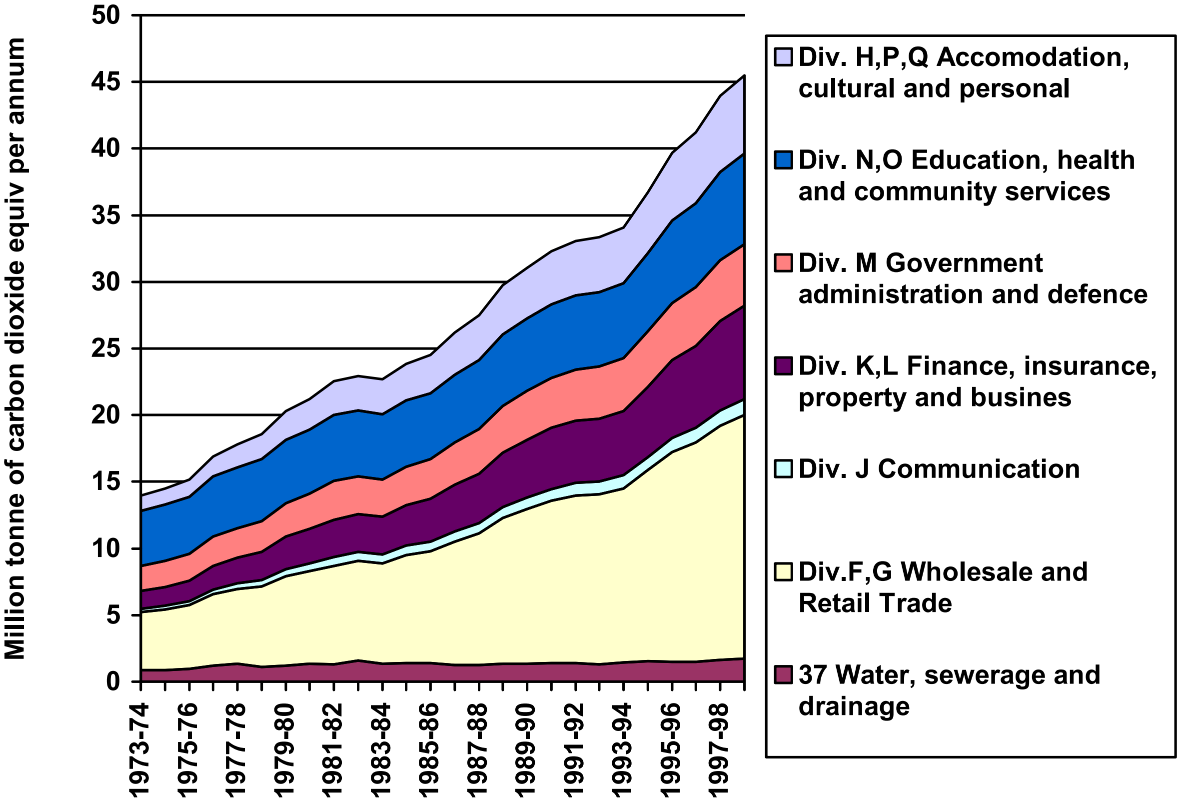
Figure 2.1
Breakdown of Office Equipment Energy Use by Equipment Class



(1) 'Other' includes fax machines, desktop and hand-held calculators, point of sale (POS) terminals, electric typewriters, automated teller machines (ATMs), scanners, very small aperture terminals (VSATs), supercomputers, voicemail systems, smart hand held devices and dictation equipment.

Figure 2.2 shows the growth in greenhouse gas emissions from the Australian commercial sector from 1973/74 to 1997/98. The *Baseline Study of Greenhouse Gas Emissions from the Commercial Sector* (EMET and Solarch, 1999) prepared for the Australian Greenhouse Office indicates that in 1990, direct energy use by "Office Equipment and Other" comprised 12% of commercial sector greenhouse gas emissions, 3.9 million tonnes (Mt) of a total of 32.2 Mt of carbon dioxide. This was projected to rise to 7.1 Mt out of a total of 62.8 Mt in 2010 - a slightly lower proportion, at 11%. The impacts of this load on heating, ventilation and cooling (HVAC) add around 25% (of 11%), so the direct and indirect contribution from operating energy use is around 14% of commercial sector emissions. Total emissions from the commercial sector grew by 45% between 1990 and 1999 and it is likely that office equipment energy use grew at a faster rate.

Figure 2.2
Trends in Greenhouse Gas Emissions from the Australian Commercial Sector



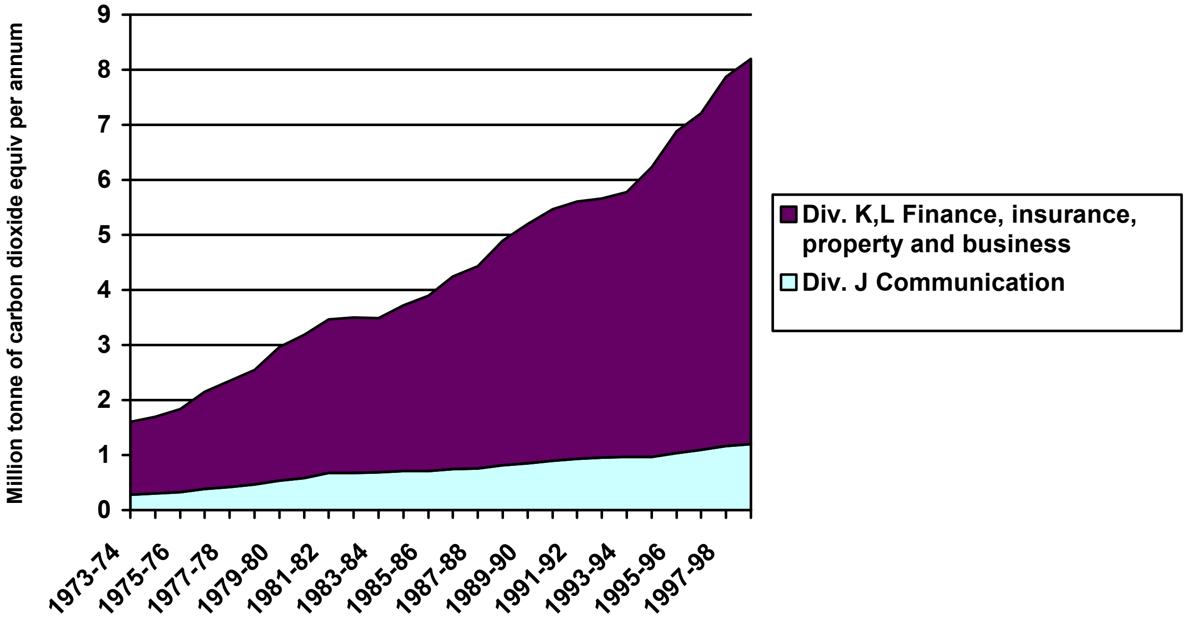
So, based on the EMET/Solarch study, greenhouse gas emissions from direct energy use and HVAC impacts of commercial sector office equipment in 1999 were probably about 7 Mt CO_2, around 4% of emissions from all Australian electricity supply and use (approximately 172 Mt in 1999 (AGO, 2001)). Use of equipment in homes and industry adds to this. According to Kawamoto *et al* (2000), the commercial sector uses 71% of office equipment energy in the US, so total greenhouse gas emissions from all office equipment in Australia in 1999 were likely to be at least 9 Mt CO_2 per annum, around 5% of total emissions from electricity supply and use.

Based on the explosive growth in the number of computers and equipment associated with the internet, it could be expected that energy use by office equipment would have grown more rapidly than other aspects of commercial sector energy use, making the above estimate conservative. This seems to have been the case in the USA, although historical data quality is poor.

Figure 2.3 looks at the sub sectors that could be expected to make heavy use of office equipment and, indeed their greenhouse gas emissions increased by 58% between 1990 and 1999, significantly faster than for the commercial sector as a whole (45%).

Data quoted by Roth *et al* (2002) suggest that direct electricity use of office equipment in 1990 in the US was in the range of 30-58 terawatt-hours (TWh), compared with their estimated 97 TWh for the year 2000. They hypothesise three very different scenarios leading to a possible range of 85-135 TWh in 2010. On this basis, it seems that US office equipment energy use over the past decade has grown at least 70%. However, it seems that (at least under Roth *et al*'s scenarios) growth is expected to moderate due to a combination of market saturation and technology improvement. If Australian office equipment energy use has risen by 70% over the past decade, total office equipment greenhouse gas emissions would be around 11 Mt CO_2 and more than 6% of emissions from all Australian electricity

Figure 2.3:
Growth Trends in Greenhouse Gas Emissions from Commercial Subsectors with High Usage of Office Equipment



As can be seen from the above discussion, future trends in office equipment energy use and associated greenhouse gas emissions in the commercial sector are highly uncertain. Further, office equipment use is increasing in industry and households, where it is extremely difficult to identify its contribution, given widely varying usage patterns and lack of end use metering.

The purpose of this paper is to assess whether there is a case for pursuing energy efficiency programs for the operating energy of office equipment. Despite uncertainties in the data it is clear that office equipment energy use is a substantial and growing component of Australia's greenhouse gas emissions; and, as this paper will show, we can do something about this.

3 Existing Energy Efficiency Programs

3.1 Defining Office Equipment Power Modes

There is a somewhat confusing range of terms and definitions used in the literature for the various office equipment power modes. For the purposes of this report:

- **Operating Mode** will be taken to mean when the equipment is performing any of its intended functions, ie, when it is 'in use', and it will also include what is often referred to as 'active standby mode', where the equipment is in a state of instant readiness to perform an intended function. If, for example, a computer has been programmed to enter a lower power mode after 15 minutes of keyboard inactivity it would be using active standby energy for those 15 minutes and for the purposes of this report this energy will be regarded as a component of the operating energy;
- **Standby Mode(s)** is a lower power mode which may be activated by programming (eg, the sleep mode of an *Energy Star* computer) or by physical intervention (eg, pressing the energy save button on some photocopiers). Where equipment consumes energy in 'off mode' (ie, where the equipment has been turned off, remotely or otherwise, and is still connected to the power supply), for the purposes of this report this energy will be regarded as a component of standby energy.

3.2 Existing Office Equipment Energy Efficiency Programs

For the past decade, the predominance of government effort to improve the energy efficiency of office equipment and to reduce associated greenhouse gas emissions has been directed towards reducing standby energy and facilitating switching to lower energy standby when the equipment is in operating mode but not actually in use (active standby). The flagship program for this effort has been the US EPA-initiated ENERGY STAR (US EPA, 2002b; AGO, 2002). This has been buttressed in recent times with the initiation of the *One Watt Standby* program (NAEEEC, 2002; Bush 2001).

3.2.1 Energy Star

ENERGY STAR is a voluntary program originally negotiated in 1992 between equipment manufacturers and the United States Environmental Protection Agency (USEPA). For the right to display the ENERGY STAR logo, manufacturers agree to make and promote office equipment satisfying established, and progressively-tightening, standby energy efficiency standards and time limits in which equipment not in use will switch to a lower power mode.

The first standards, for computers and monitors, were promulgated in 1993. The program has expanded progressively since then to cover most of the equipment items being investigated in this report, with the exception of UPSs, wireless network hubs and servers. In the US, ENERGY STAR has expanded far beyond the initial emphasis on office equipment and now covers consumer electronics, appliances, residential heating and cooling equipment, lighting, housing, home envelope products, traffic signals, transformers and more.

In Australia, the National ENERGY STAR Program is a co-operative energy efficiency program between Commonwealth, State and Territory governments agencies to promote the use and purchase of ENERGY STAR office equipment. It is funded by the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) and managed by the Sustainable Energy Development Authority (SEDA) in NSW on behalf of all participating jurisdictions. In this country the program currently applies to office equipment and home electronic equipment only.

Most commonly, ENERGY STAR requirements include office equipment:

- powering down (or entering sleep mode) to below a set level after a set period of inactivity. This may occur in one or two stages; and
- waking up when needed.

The features covered by ENERGY STAR specifications for various types of office equipment are summarised in Table 3.1.

Table 3.1
Features Specified by Energy Star for Various Types of Office Equipment

EQUIPMENT	Low Power Mode (1)	Low Power (Sleep) Mode (2)	Low Power Default Time	Off Mode Power	Off Mode Default Time	Recovery Time From (1)	Automatic Duplexing Mode	Standby Power	Notes
Computers	Yes		Yes						If shipped with network capability, shall sleep on network and respond to wake events
Monitors	Yes	Yes							
Copiers ≤ 20cpm				Yes	Yes				cpm = copies per minute
Copiers > 20cpm	Yes		Yes	Yes	Yes	Yes*			* For 20<cpm≤44 a recovery time of 30 seconds is obligatory, for higher speeds it is recommended
Upgradeable Digital Copiers ≤ 20cpm		Yes	Yes						
Upgradeable Digital Copiers > 20cpm	Yes	Yes	Yes (for 2)			Yes*			
Printers, Faxes		Yes	Yes						
Scanners	Yes		Yes						
MFDs, ipm ≤ 20		Yes	Yes						ipm = images per minute
MFDs, ipm >20	Yes	Yes	Yes (for 2)			Yes*	Yes†		† Automatic duplex is default for machines >44 ipm

Table 3.2 lists the ENERGY STAR criteria for various equipment types and modes and provides data from the US EPA database for the most efficient equipment for these criteria. It is clear that equipment is available that beats the criteria by a very wide margin, although there is great variation in performance (often unrelated to price) in the market place. There is a lot of equipment that narrowly qualifies for ENERGY STAR and there is some equipment on the database that appears not to conform to the criteria

Table 3.2

Energy Star Criteria for Various Equipment Types Compared to Most Efficient Equipment Under the Criteria[1]

Equipment Type	Operating Mode	Energy Star Criteria (watts)	Best of Type (watts)
Computers			
≤200W	Sleep	≤15	0.1
Monitors	Sleep	≤15	0.22
	Deep Sleep	≤8	0.08
Copiers			
≤20 cpm	Off	≤5	0.04
20<cpm≤44	Low Power	≤3.85×cpm+5	7
20<cpm≤44	Off	≤15	0.04
44<cpm	Low Power	≤3.85×cpm+5	6
44<cpm	Off	≤20	1
Faxes			
≤10ppm	Sleep	≤10	1
>10ppm	Sleep	≤15	1
Printers			
≤10ppm	Sleep	≤10	1
10<ppm≤20	Sleep	≤20	0.7
20<ppm≤30	Sleep	≤30	0.7
30<ppm≤44	Sleep	≤40	6.9
44<ppm	Sleep	≤75	7.1
MFDs			
≤10ipm	Sleep	≤25	6
10<ipm≤20	Sleep	≤70	0.1
20<ipm≤44	Low Power	≤3.85×ipm+50	6
20<ipm≤44	Sleep	≤80	0.13
44<ipm≤100	Low Power	≤3.85×ipm+50	101
44<ipm≤100	Sleep	≤95	0.02
100<ppm	Low Power	≤3.85×ipm+50	339
100<ppm	Sleep	≤105	30
Scanners	Low Power	≤12	2.5

Table 3.2 reveals that across the range of ENERGY STAR criteria, the best performing office equipment will beat the criterion by at least 10-fold and sometimes by 100-fold or more. The current exceptions appear to be scanners and very high speed copiers, printers and MFDs. Outside these equipment types the lowest power equipment almost invariably achieves standby power ratings of 1W or less.

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[1] Upgradeable digital copiers are listed as a subset of Multi-Function Devices (MFDs). Data for cordless telephones and answering machines is not currently available on the US EPA web site.

3.2.2 One Watt Standby

The significant gap between most of the current ENERGY STAR criteria and the best performing equipment for standby power demand has highlighted that there are still large available gains in energy efficiency and greenhouse gas reductions through reductions in standby power.

The International Energy Agency has called upon member countries to develop programs to reduce waste standby power (Lebot, 2001).

In August 2000, Australian governments agreed to a one watt standby target as policy for all electrical products. Following consultation a *Standby Power Response Strategy* was released in late 2002; this will result in specific product plans being published progressively over the next 10 years on the following timetable (NAEEEC, 2002a):

- high priority (2003-2004)
- medium priority (2005-2007)
- low priority (2008-2012)

Of the equipment types being considered in this report, personal computers, monitors, copiers, printers, scanners, and MFDs have been assessed high priority and are will be subject to profiling for development of specific implementation plans from early 2003. Faxes and laptop computers have been assessed as medium priority and will be subject to profiling from mid-2004(NAEEEC, 2002b). Cordless telephones and answering machines, which had been initially assessed as high priority (NAEEEC, 2002a), do not appear to be mentioned in the action plan in the final strategy (NAEEEC, 2002b)

On 31 July last year, US President Bush (2001) issued an Executive Order requiring Federal Agencies to purchase "products that use no more than one watt in their standby power consuming mode. If such products are not available, agencies shall purchase products with the lowest standby power wattage while in their standby power consuming mode". The order is subject to life-cycle cost-effectiveness and practicability considerations. The President's enthusiasm for vampire slaying (vampires being machines that suck electricity) has led to opposition from some sections of the US electronics industry (Landers, 2001).

The European Union, Japan and others are also vigorously engaged in one watt programs. The benchmarks established by ENERGY STAR to date have only been modestly challenging, as revealed by the wide gap between best performance and mere qualification for ENERGY STAR. However, ENERGY STAR has provided enormous impetus for better, more energy-efficient product design and consumer awareness of the importance of, at least, those elements of energy efficiency covered by the program. A *One Watt* program would have been almost unthinkable in 1992, when ENERGY STAR was launched with benchmarks clearly designed to raise awareness of energy wastage in standby mode and promote cooperative action with industry rather than setting tough targets and risking upsetting sections of industry. Now industry innovators have much more efficient products and are thinking of ways of improving them further, so that *One Watt* programs are a logical progression that are far more widely supported by industry than they are opposed.

The focus on standby energy over the past decade has led to very significant gains in efficiency with the promise of more to come. It could be argued that attention on operating energy has languished in comparison. As deeper cuts are made to standby energy, operating energy performance is likely to be thrown into stark relief with a corresponding appreciation of the opportunities it presents for increasing energy efficiency and reducing greenhouse gas emissions.

3.3 Other Energy Efficiency Programs for Appliances and Equipment

3.3.1 Australia

In Australia, well-developed mandatory appliance energy labelling and Minimum Energy Performance Standards (MEPS) programs are being pursued for a small range of household appliances and equipment, and for some commercial equipment. These are described in detail in a range of Australian Greenhouse Office publications available at www.greenhouse.gov.au.

Appliance energy labelling was introduced in the mid 1980s, initially in Victoria and New South Wales for household refrigerators and freezers, and was extended progressively to national coverage and to cover other major whitegoods – clothes washers and driers, and dishwashers – and single phase air-conditioners. Key criteria for application of energy labelling were that the products were significant energy consumers, and that individual households were a significant proportion of the market.

Australia's appliance energy label is well-regarded internationally, and market research has demonstrated that it works well (Colombier and Menanteau, 1997). The graduated scale means that users can easily compare products' relative performance, and the label also offers recognition of ongoing improvement of market leaders – at least within the boundaries of the scale used. Because of significant improvements in products, the scales used on Australia's energy labels were updated in 2000, so that products that previously rated 5 stars now score around 3 stars.

The original appliance energy labelling scheme addressed only operating energy. Where this involves continuous consumption (for example, refrigerators), this necessarily included standby power usage but, for appliances used for specific tasks such as dishwashers and clothes dryers, only the energy used during a program or cycle was measured, and standby power was ignored. In recent years, it has been recognised that standby power can be quite a significant issue for energy labelled appliances. It has therefore been agreed as part of the national standby strategy that by 2006 the energy labelling test procedures will be modified to include measurement of standby power, and this energy use will be included in the consumption data presented on the label (NAEEEC, 2002a). The Australian energy label is therefore adapting into a form of label that takes into account all aspects of energy use.

MEPS have been applied to products - electric storage water heaters, three phase airconditioners and three phase electric motors - where end-user/owners may have little influence on the purchasing decision (for example, plumbers and builders often specify hot water services), and/or where there is little variation in performance across the product range (again, pre-MEPS most resistive electric HWS units consumed similar amounts of energy because space constraints and capital cost led to manufacturers using limited insulation). For refrigerators and freezers, MEPS have been introduced to complement appliance energy labelling. Here it was found that while appliance energy labelling was driving improvement in the efficiency of many products, significant numbers of poor performers were still being sold to purchasers who, for a variety of reasons, were not responding to the energy label. MEPS remove such products from the market. MEPS rely upon the same tests as are used for appliance energy labelling where this is appropriate.

3.3.2 Other Countries

A variety of other labelling, standards and efficiency improvement programs have been pursued around the world. Harrington and Damnics (2001) provide a comprehensive review of these.

Most of the approaches used for labels involve either endorsement or comparative labels. ENERGY STAR is an endorsement label, while the Australian appliance energy label is a comparative label.

For office equipment, the voluntary ENERGY STAR label dominates globally. However, US market research on this label (Brown *et al* 2002) showed a low level of consumer understanding of what the label means, and low media awareness of the label. While there was a 30% unprompted recognition of the label itself, ie it was a gold star that appears on office equipment, few people knew what the gold star really meant.

Korea is the only country with mandatory MEPS for computers and some other types of office equipment (Harrington and Damnics, 2001). Japan is applying its *Top Runner* approach to computers. In this program, the best performer in a category in a specific year is identified and all other products are expected to improve to match its performance within a specified period.

3.4 Conclusions

In reality, energy efficiency programs in the office equipment area are not very advanced. The major international program is ENERGY STAR, which is voluntary and seems to be poorly understood by consumers in the USA - where it is best established and applies to a very wide range of products. Further, because it is an endorsement type label, the basis of the label not only requires updating to reflect improvements in performance but the criteria often lag significantly behind the performance of the best equipment. Lastly, it sets requirements only for standby energy consumption and the time before equipment switches to low power standby modes: technicians or users can (and often do)disable or delay switching to low power standby, thereby substantially reducing energy savings ENERGY STAR therefore does not relate directly to actual energy use.

The *One Watt Standby* program will achieve a reduction in standby power consumption, but it will also only partly address overall energy use of office equipment.

The Australian Energy labelling scheme applies to some household appliances rather than office equipment. In focusing on operating energy it has approached the issue from the reverse direction from that taken for the two standby programs. It is also beginning to incorporate standby energy in its considerations.

MEPS also do not apply to office equipment in Australia, but where they do apply they have the advantage of driving energy wasteful models out of the market. Under the standby programs, it is still possible for products that are very wasteful in terms of their operating energy to qualify on the basis of their standby performance.

It could be argued that a comprehensive approach for driving energy efficiency would include labelling based upon total energy use, with MEPS to drive very inefficient equipment out of the market place.

Harrington and Damnics (2001) point out that it is important for energy labelling schemes to fit the cultural context in which they operate, and that this varies from country to country. They suggest that this implies poor prospects for harmonised labels, but that it is not a barrier to international standard test procedures.

The office equipment market is very much an international one. There are concerns that if one country introduces programs that differ from those used elsewhere, it could limit the range of product available, increase prices of equipment in that country, or reduce the range of choice available in that country.

4 Operating and Standby Energy: Relative Significance

To date, the focus of energy-saving action for office equipment has been on standby power consumption. This reflects the realisation in the early 1990s that a surprisingly high proportion of the energy used by office equipment came from equipment being left on when it was not being used, or from equipment consuming significant amounts of energy when users thought it was in low power mode or even consuming no energy because it was turned off.

The major programs that have targeted standby energy use are ENRGY STAR and, more recently, the *One Watt Standby* program. These have been discussed in Sections 3.2.1 and 3.2.2. Regardless of the effectiveness of these programs at reducing standby power usage, there are several good reasons for considering operating energy:

- when equipment is operating, its power usage is much higher than when it is on standby – indeed, with the increasing impact of efforts to reduce standby power usage, this gap is widening rapidly;
- a lot of office equipment runs in operating mode for quite long periods. For example, servers run continuously, and some computers (eg in student computer laboratories) are heavily used. Other equipment has its power management features disabled and is left on unnecessarily. Figure 4.1 shows classical Canadian data regarding computer use from Natural Resources Canada (1992), the year the ENERGY STAR program was initiated. It shows that during working hours office desktop computers were, on average, in effective use for less than 10 minutes per hour; even though most were switched on continuously;
- even when power management modes are enabled, equipment typically remains on active standby (at power levels close to ‘in use’ mode) for periods ranging from a few minutes to an hour (for example, a computer qualifies for ENERGY STAR provided it is able to enter a sleep mode within 30 minutes of inactivity). In many offices, this effectively means that much equipment is in or close to its highest power mode for a large proportion of office hours;
- Power Factors of office equipment in operating mode are generally relatively poor, at 0.6 or less (Roth *et al*, 2002), adding to electricity supply losses[2];
- operating energy generally occurs during times of peak and intermediate electricity demand, when electricity prices are at their highest, the risk of power failure is greatest and loads on cooling equipment are greatest. In turn, this drives pressure for growth in overall electricity consumption as electricity suppliers attempt to increase load factors to improve their economics of operation. Roth *et al* (2002) estimate that office equipment is responsible for 3-4% of total peak electricity demand in the USA;
- operating energy therefore contributes directly to capital costs of cooling plant and electricity supply infrastructure. For a 100 watt computer contributing up to 50 watts to peak cooling electricity demand, this could equate to around $150 investment in electricity supply infrastructure (at around $1000/ kW and assuming an overall Coefficient of Performance of 2 during periods of extreme heat, when peak electricity demand generally occurs) and $13 for HVAC plant (at around $250/kW(thermal
- there is substantial scope to reduce operating energy through technological improvement, as will be discussed in Section 5.

Kawamoto *et al* (2000) estimated that 86% of the energy consumed by all US office equipment occurred while it was in operating mode, including active standby. This is partly due to the relatively low utilisation of power management features, but it provides a compelling rationale for finding mechanisms for reducing operating mode energy as a complementary strategy to standby power management.

4.1 Modelling Equipment Operation

Models of computer/monitor and photocopier operation were developed for this Report to gain an appreciation of the interaction between the efficiency of various power modes and operator behaviour and to act as a basis for identifying, and potentially prioritising options for energy efficiency.

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[2] This issue is dealt with in more detail in our second Report on Home Entertainment Equipment.

4.1.1 Computers/Monitors

Models were developed for desktop computers with conventional CRT and flat screen LCD monitors, for cases where they just met ENERGY STAR specifications and where the 1W standby criterion was met. Models were also developed for the laptops with very different operating energies, mentioned in Section 1. The power levels used are shown in Table 4.1.

Figure 4.1
PC Usage Patterns and Operation
(for 36 computers over an 8 week period. "One in six left on overnight – used for only a small fraction of the time they were switched on")

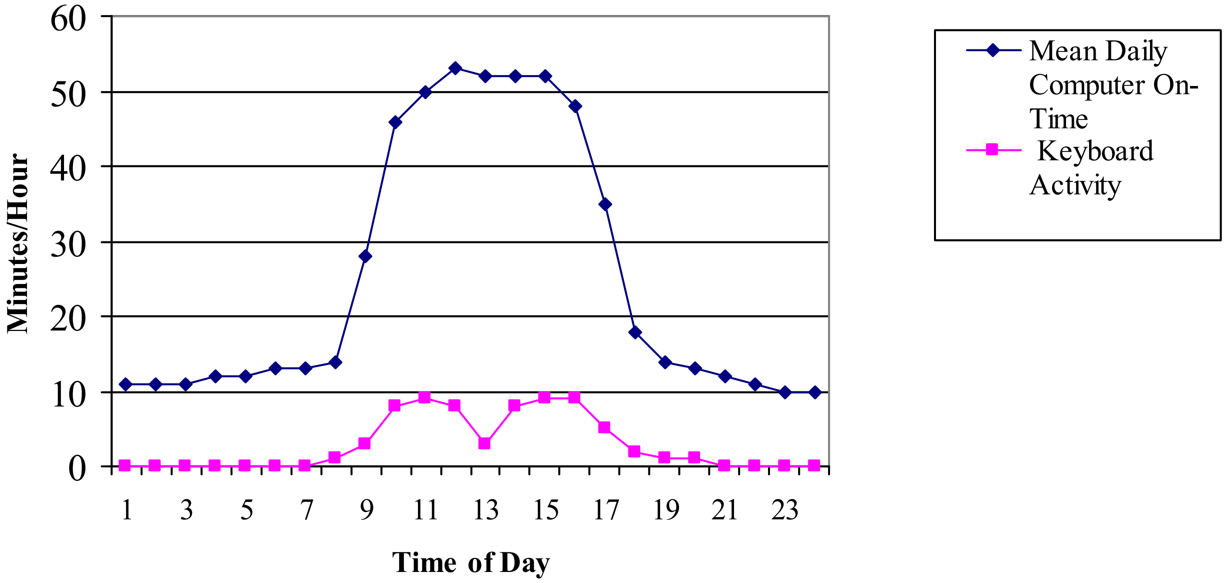

Table 4.1
Power Levels (Watts) of Modelled Computers/Monitors

Mode	CRT(ES)	LCD(ES)	CRT(1W)	LCD(1W)	Laptop 1	Laptop 2
In Use	120	85	120	85	20	45
Active Standby	114	80	114	80	18	42
Sleep[3]	30	30	2	2	4	4
Deep Sleep[2]	23	23	2	2	2	2
Off	4	3	2	2	1	1

For each of these equipment items the following power management scenarios were modelled:

1. power management features disabled, equipment on all of the time;
2. power management features disabled, equipment off outside office hours;
3. power management enabled, equipment on all of the time;
4. power management enabled, equipment off outside office hours; and
5. aggressive power management (effective after 5 minutes of inactivity)

The results of the modelling are shown in Figure 4.2.

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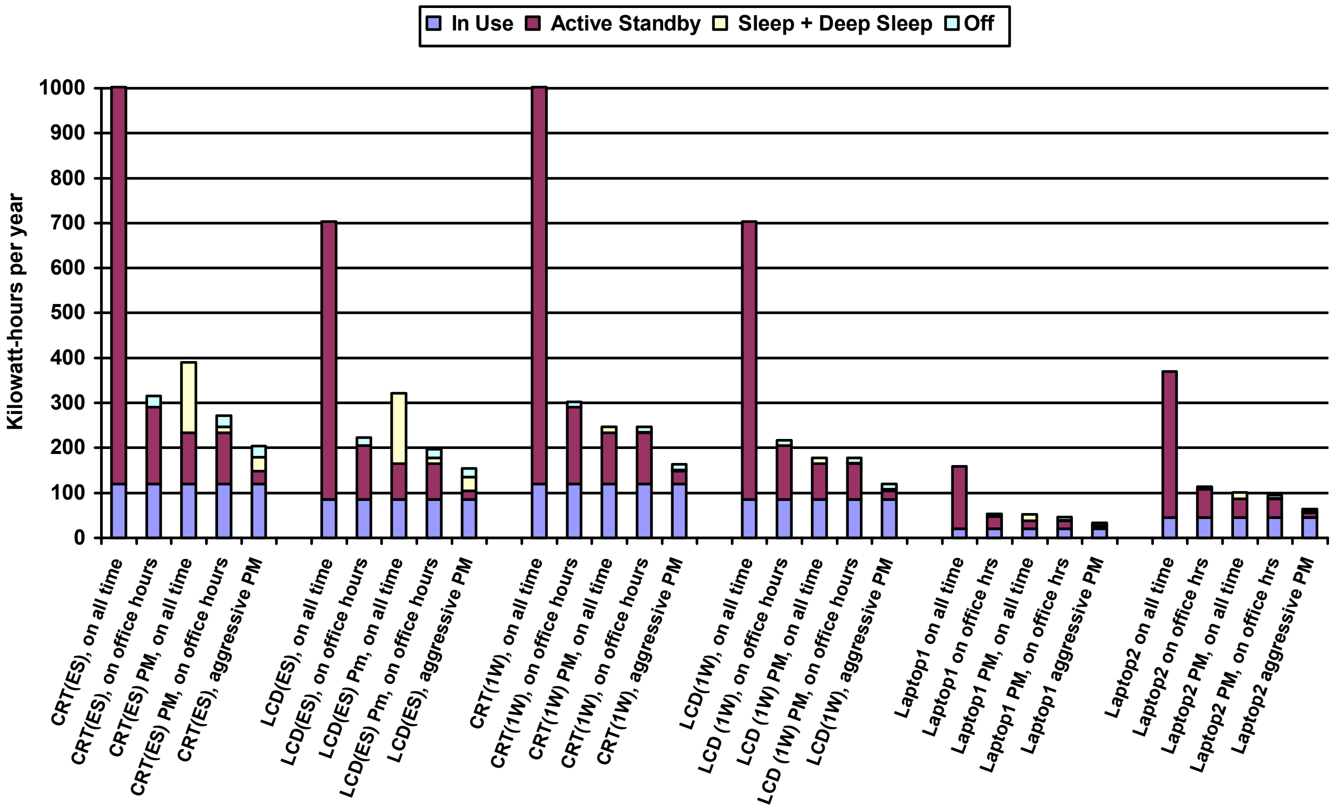
[3] For some equipment types, ENERGY STAR requires two low power modes.

Figure 4.2
Annual Energy Consumption of Various Computers/Monitors Under Different Power Management Regimes



Key conclusions that can be drawn from the modelling include:

- In all circumstances, operating energy (in use + active standby, ie with the screen active and ready to respond to the keyboard) dominates energy consumption – varying from 100% of consumption in circumstances with no power management down to 51% for the LCD equipment that just meets ENERGY STAR requirements and is left on all the time. The latter is clearly a limit case for maximising standby energy consumption;
- For the 1W standby equipment, operating energy accounts for at least 87% of consumption in all scenarios. The lower bound applies to the case of the LCD equipment with aggressive power management. For all scenarios other than aggressive power management (which is quite rare in current practice), operating energy accounted for at least 95% of consumption;
- For all equipment types with conventional power management, energy consumption in the ‘in use’ and ‘active standby’ modes are fairly similar, but with aggressive power management active standby consumption falls to about one-quarter of the in use values;
- For the 1W standby equipment, allowing power management of the unit outside working hours gives similar energy use to switching off manually at the end of the day or during significant breaks in computer use, due to the energy used in ‘off’ mode being comparable to the standby energy. Further savings can be made, however, by disconnecting the equipment from the power supply.

4.1.2 Digital Copiers

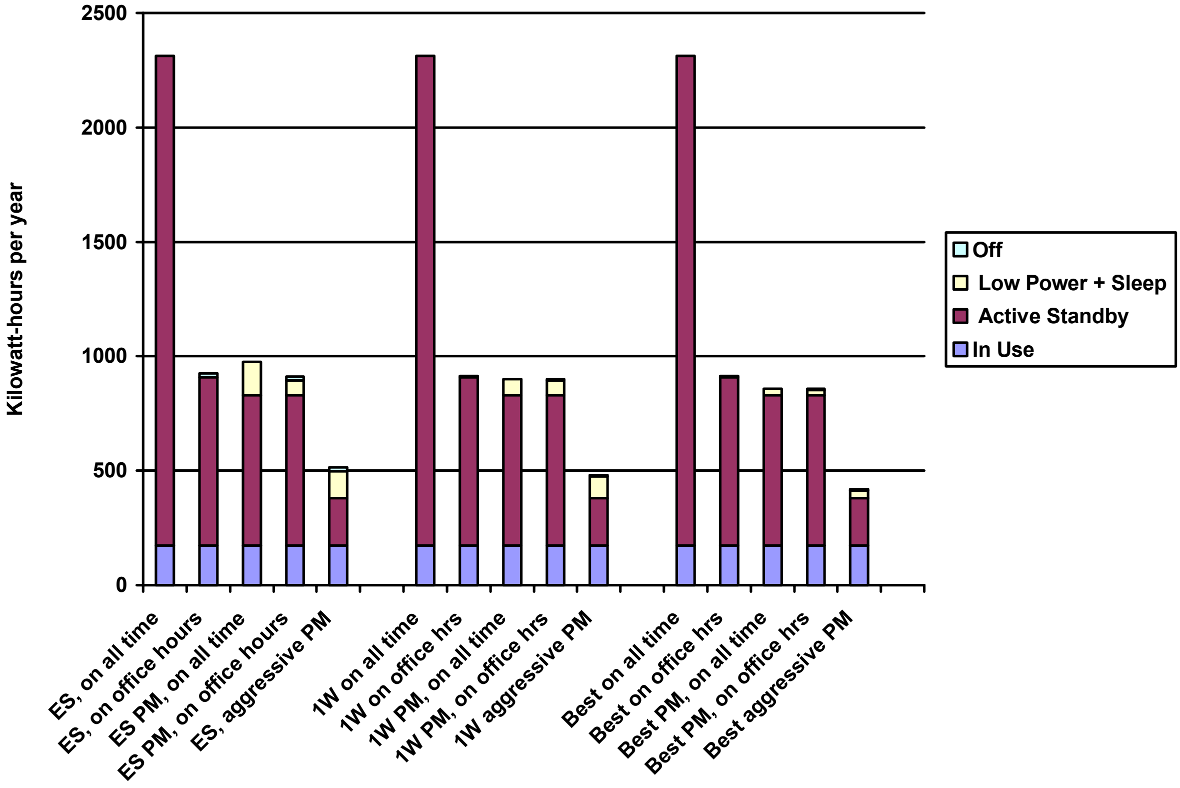
Models were developed for a 30 copy per minute (cpm) digital copier that just meets ENERGY STAR specifications and one that meets the 1W standby criterion in sleep mode. Additionally the model was applied to a hypothetical machine generically based on a new Canon IR5000 digital copier measured by Sustainable Solutions that achieves 40W in low power mode and also complies with a 1 Watt power standard for standby and off modes. This was defined as best practice as it appears to beat the performance of any machine listed on the US EPA’s database. The power levels used are shown in Table 4.2.

Table 4.2
Power Levels (Watts) of Modelled Digital Copiers

Mode	**Energy Star**	**1W**	**Best Practice**
In Use	1000	1000	1000
Active Standby	250	250	250
Low Power	120	120	40
Sleep	15	1	1
Off	3	1	1

It was further assumed that 1000 copies were produced per day, with a 10 second start up to produce the first copy. The results of the modeling are shown in Figure 4.3.

Figure 4.3
Annual Energy Consumption of Various Digital Copiers Under Different Power Management Regimes



Key conclusions that can be drawn from the modelling include:

- In all circumstances, operating energy (in use + active standby) dominates energy consumption – varying from 100% of consumption in circumstances with no power management down to 74% for the copier that just meets ENERGY STAR requirements and is left on all the time;
- For the 1W standby copier, operating energy accounts for 79% of energy use in the aggressive power management scenario. Very few copiers are power managed as aggressively as assumed in this scenario. For all other scenarios, operating energy accounts for at least 92% of all energy use;
- For the best copier, operating energy accounts for 91% of energy use in the aggressive power management scenario. Very few copiers are power managed as aggressively as assumed in this scenario. For all other scenarios, operating energy accounts for at least 97% of all energy use;

- In all scenarios, active standby mode accounts for a majority of operating energy use, varying from 55% for the aggressive power management scenarios to 93% where equipment is left on all the time. Only very high volume use copiers (eg, a workhorse machine in a print shop) are likely to consume more energy in use than in active standby; and
- For the 1W standby and best equipment, allowing power management of the unit outside working hours gives similar energy use to switching off manually at the end of the day or during significant breaks in computer use, due to the energy used in 'off' mode being comparable to the standby energy. Further small savings (of around 1%) can be made, however, by disconnecting the equipment from the power supply.

4.2 Conclusions

ENERGY STAR and the *One Watt Standby* program are leading to dramatic reductions in energy use from equipment standby modes. They are also leading to reductions in active standby energy use by reducing the amount of time that equipment spends in that mode.

However, the results of the modelling are broadly consistent with the Kawamoto *et al* (2000) estimate of 86% of US office equipment energy consumption occurring while the equipment is operating, including while in active standby mode. Vigorous pursuit of the *One Watt Standby* program can realise further important reductions in energy use and greenhouse gas emissions, particularly when allied with effective education and training programs.

That said, it is clear that the major further opportunities for energy efficiency and greenhouse gas emissions reductions are in the area of operating energy. Over the last decade, ENERGY STAR has encouraged industry and government to examine the assumptions underlying equipment design and use as they impact upon unnecessary energy use in standby. A similar focus on the equipment energy use in operating mode and its relationship to effective delivery of the services sought from particular items of equipment should reap handsome dividends.

5 Factors Influencing Future Energy Consumption of Office Equipment

The office equipment arena is dominated by high rates of innovation and unexpected developments. The three scenarios developed by Roth *et al* (2002), where total US office equipment energy consumption could increase by as much as 40% or decline by as much as 15% over the next decade, illustrate the breadth of possibilities. They also highlight the importance of effective policy development and delivery in a volatile situation.

In this Section, we consider some of the possible drivers of future energy use of office equipment, including technological developments, to show that there is potential for large savings, and that public policy should facilitate their capture.

Broad drivers that may influence the energy consumption and greenhouse gas emissions from demand for office equipment services include:

- increasing portability: more and more people want to access and send information and carry out traditional office-based tasks as they move around. This will drive demand for higher rates of information transfer, and lightweighting and miniaturisation of equipment. Importantly, it should drive energy efficiency, as battery life is a critical factor for portable equipment. However, a breakthrough in battery technology (eg small fuel cells) could potentially reduce pressure to maximise energy efficiency and change the direction of development;
- new devices are being developed all the time, and some may be energy intensive. For example, virtual reality systems may allow people to conduct meetings from remote locations, and these systems may use significant amounts of electricity. On the other hand, transport energy savings could far outweigh any such increase;
- technological development is leading to dramatic improvements in energy efficiency, often as a by-product of efforts to cut heat build-up or reduce weight and size;
- evolution of energy sources may reduce reliance on conventional mains power for office equipment. Already it is possible to buy solar-powered battery chargers for laptop computers, and work is being conducted on generating small quantities of electricity from walking, via special shoes (Kymissis *et al*, 1998). In buildings, such as 120 Edwards Street in Brisbane, office equipment may be run from dedicated high reliability circuits powered by solar electricity or other distributed generation options.

These trends reinforce the need for policies that drive development activity towards energy efficiency improvement, and for information and education of users so that the potential savings are adopted quickly.

5.1 Trends for Specific Types of Equipment

5.1.1 Personal Computers

In the short term, many people who now have two desktop computers (one at work and one at home) may switch to a single laptop computer as the technology improves. Increasing sales of laptops may partly reflect this trend. Rapid improvement in the capability of palmtop computers, including 'fold-up' keyboards and improving screens means that they may replace conventional computers in an increasing variety of activities – after all, it really does not require enormous computing power to do word processing at the level most people operate. Existing palmtop computers consume around 0.1 watts – losses from their battery chargers (at 1-2 watts) exceed actual energy usage. With improved larger high efficiency screens (that may use a few watts more), such products could potentially offer satisfactory portable computing capacity using less than 5 watts, a quarter of that used by a typical laptop.

According to Intel (2002), losses from power supplies comprise around a third of the power consumption of a typical desktop computer (excluding monitor). Much of this waste of around 15 watts per computer could be saved by utilising more efficient power supplies that are already widely available. One small computer assembler in Melbourne uses high efficiency switched mode power supplies because of their superior performance, lower weight and lower heat generation: this adds only $10 to his costs (King, 2003)

Growth in energy use by computers will be driven by ongoing increases in the numbers of computers. Businesses may utilise under-used computing capacity by renting it out outside business hours for large scale data processing via distributed systems: this would increase operating energy use of those computers but possibly avoid the energy use by additional supercomputers (Roth *et al*, 2002).

Ongoing technological development is creating a race between increasing computer power and improving energy efficiency. The outcome may depend as much on policy directions as on science and engineering. However, with companies such as Intel and IBM taking increasing interest in energy efficiency as a research field (for example, IBM has established a 'low power' research team in Austin, Texas), we can be optimistic that ongoing efficiency improvements will occur. For example, IBM (2001) has announced its view that devices requiring a tenth as much power as existing products can be produced.

When considering possible programs to drive efficiency improvement in desktop computers, it will be important to recognise that there is a very wide range of buyers, from individuals visiting appliance stores, to large business buyers. Further, there is wide variation in specifications of computers, as many are tailored to customer requirements. Indeed, many small suppliers 'build to order'. From one perspective, it may be difficult to include all small suppliers and options in a comprehensive information scheme but, on the other hand, an effectively promoted and managed program may help improve accountability if, for example, energy labels can only be attached to products supplied by businesses that have formally committed to meet a code of practice or similar conditions. Measurement of energy use of desktop computers is not difficult, and fairly simple meters can be used, even by small suppliers, although the importance of effective enforcement would be great if many small suppliers were allowed to measure and label their own equipment. Alternatively, if labelling were concentrated on large volume production standard products sold through major dealers, the presence of the energy label may create a marketing advantage that smaller suppliers might seek to capture through compliance with a reporting scheme.

5.1.2 Monitors

There appears to be a clear trend away from traditional cathode ray tube (CRT) monitors towards flat screen technology which, in principle, uses less than a third as much energy. However, it appears that some of this equipment squanders part of the savings by using low-efficiency power supplies or through other inefficiencies. For example, some 17 inch flat screens have been measured at 30-34 watts by *Sustainable Solutions*, yet Roth *et al* (2002) estimate power consumption for that size screen at just 16.7 watts. This estimate is consistent with scaling up power consumption linearly with area from the power consumption of a smaller laptop screen. The difference between this estimate and measured results seems to reflect a combination of power supply inefficiency and technical difficulties in maintaining efficiency as screen size increases, such as providing backlighting. The power supplies of some flat screens have been observed to run quite hot, so this may indicate that they are relatively inefficient. Modern high quality power supplies are now operating at 85% or better efficiency, so this issue should be able to be addressed easily. Other technologies such as organic light-emitting diode (OLED) screens are under development that should cost much less to manufacture and are expected to use a third as much energy as today's liquid crystal display (LCD) flat screens, offering potential for almost a Factor 10 saving relative to today's CRT monitors (Roth *et al*, 2002, TIAX, 2002).

However, there are also pressures towards an increase in energy use. Some users may use the lower space requirements of flat screens as an opportunity to upgrade to a larger screen, or even to multiple screens. The declining cost of flat screens may see their proliferation in merchandising, where they could increase energy use. Already at least one new supermarket in Sydney has multiple LCD screens at checkouts providing consumer information and advertising. However, the wider use of flat screens in retail environments may lead to a reduction in background light levels (so customers can read the screens easily), so there may be offsetting energy reductions.

At present, very large plasma flat screens use large amounts of power – up to 400 watts for the biggest models. While these are generally used as televisions, it is possible that they may be applied to some computing activities, thereby adding to consumption.

Monitors are manufactured by large companies, and there is virtually no scope for customising in the supply chain. Given this, it should be relatively simple to establish and operate information programs, MEPS etc. However, while many monitors are sold packaged with computers, others are sold separately, so it will be important for purchasers to be able to assess the performance of both individual monitors and monitors packaged with computers easily.

5.1.3 Uninterruptible Power Supplies (UPSs)

With increasing sensitivity of electronic equipment to electricity supply quality and reliability there has been strong growth in UPS use, which may continue.

There are two fundamentally different UPS technologies. The older type converts all incoming power into DC power, then converts it back to 240V AC. If there is a power failure, the battery (a DC supply) replaces the mains supply. This approach is inherently inefficient, and may operate at 85-90% efficiency at high load, but at much lower efficiency at under 50% load. Where the UPS is oversized, to handle peak power usage of computers or with a view to expansion, it may therefore run at poor efficiency. The newer technology has two separate systems so that, under normal conditions, mains power simply flows through the unit (via a surge protector). If there is a power failure, the unit switches rapidly across to a battery supply. These units are very high in efficiency with less than 3% losses claimed.

UPSs are usually located in airconditioned environments. However, this is not necessary, as demonstrated by the ability of similar renewable energy technology (inverters, regulators, batteries and other equipment typical of that included in UPSs) to operate in unconditioned cupboards throughout rural Australia.

It seems that the future trend in UPS energy use will depend critically on which technology is preferred by the marketplace – or whether policy intervention supports the more energy efficient solution.

Laptop computers do not need separate UPS support, as they have their own internal batteries.

A further development is the emergence of renewable energy-sourced circuits in buildings. In this case, a combination of renewable energy sources with energy storage and possibly mains back-up can provide very high quality reliable power supply throughout a building. Such an approach is likely to be attractive in developing countries, where power supply reliability is often poor, and may even become a solution of choice in developed countries because of a combination of power quality, public relations and (possibly) financial factors. Energy efficiency of office equipment is very important in this situation as a means of limiting the capital cost of the on-site energy supply infrastructure.

The Swiss Office of Energy (2002) has developed a proposal for an energy label for UPSs, intended to encourage adoption of more efficient options.

The key issues with regard to efficiency of UPSs seem to be to ensure selection of the superior energy-efficient technology, and to maintain high efficiency at the loads commonly driven rather than just at peak load. A MEPS program might easily deal with these issues.

5.1.4 Servers

Computer servers are used to run internal networks, internet services and an increasing range of networks between these extremes. Huser (2002) estimates that typical ‘low-end’ servers use between 80 and 150 Watts. Most smaller servers are effectively desktop computers, and are often located in general office areas.

As interconnection and internet services expand, the number and possibly capacity of servers will increase, potentially driving energy consumption upwards.

Scope for improving efficiency has been identified through development of more efficient equipment, and through improved power management strategies. Both IBM (2001) and Intel (2001) have flagged progress on making significant reductions in energy consumption, and IBM has released the Z900 server, which can apparently replace hundreds of smaller server units and their energy use. Gubler and Peters (2000) studied server use in Switzerland, and found that 94% of servers were left on overnight and 90% on weekends, but a quarter of them did nothing overnight, a half did nothing on weekends, and two-thirds carried out useful work for less than 3 hours overnight. This demonstrates that potential exists for substantial energy savings through power management of servers: Huser (2002) estimated potential for 43% savings through power management for Switzerland. If Australian usage of servers were the same per capita as in Switzerland, this would equate to a savings potential of around 240 GWh per annum or 240,000 tonnes of carbon dioxide per annum.

The Swiss Office of Energy (2002) notes that power supply efficiency in servers is often only 60-70% and can fall to as low as 20%, presumably because they use power supplies similar to those used in ordinary desktop computers, rather than high efficiency options. Given the long operating hours of servers, there is a case to apply more stringent efficiency standards to them than to standard desktop computers.

Larger servers not only use electricity for their own operation, but are also often located in special computer rooms with specialised airconditioning systems. These airconditioning systems may use from a half to as much electricity as the equipment in the conditioned space (Huser, 2001). The high energy, maintenance and capital costs of specialised airconditioning systems for computer rooms may create pressure for higher energy efficiency and greater tolerance of temperature variations: already most Cisco servers can operate in a range of temperatures from 5 to 40C, and humidity ranging from 5 to 95% - and one product range is designed to operate in unconditioned facilities on microwave towers (Cisco, 2002)! On this basis, it should be possible to use outdoor air, or even exhaust air from the conditioned spaces, to cool computer rooms. Retrofitting such solutions to existing computer rooms could deliver large energy and financial savings. Huser (2002) recommends that computer rooms be allowed to operate at 26C instead of around 20C, to allow the airconditioning equipment to run more efficiently, as the chilled water loop can run warmer and airconditioner efficiency is very sensitive to the temperature differential across the system. Allowing humidity levels to float over a wider range in computer rooms would also save energy.

Servers are usually purchased by informed buyers or people with access to technical advice. However, since the specifier or adviser may not have a responsibility for ongoing energy costs, it may be necessary to use MEPS and/or financial incentives to influence their behaviour. There are clear opportunities for financial and energy savings where servers are located in dedicated computer rooms, but the design of these facilities and the installation of the airconditioning equipment is the responsibility of a different group of people, who may be financial losers if the expensive and complex systems they sell and maintain are no longer used. Further, there seem to be some strongly held beliefs about the ambient conditions required by servers and other centralised computers. There may be a need for demonstration projects and information strategies to drive change in this area.

5.1.5 Copiers, Printers, Fax Machines and Multifunction Devices (MFDs)

All of these items of equipment use energy to create images on paper from local or remote inputs. As standby power requirements are reduced by programs such as the *One Watt Standby* campaign, the major source of energy use becomes the delivery of ink or toner onto paper, and the requirement to maintain parts of the equipment at a temperature high enough to perform this task with minimal delay when a user operates the equipment.

Of course, this energy use should be kept in context. The amount of energy used to manufacture and supply paper is estimated at 10-20 Watt-hours per sheet (Roth *et al*, 2002), which is an order of magnitude larger than that required for conventional copying (see below). However, for a non-power managed copier left on continuously while being used to print 250,000 images per year, energy use- 90% of which is standby losses - is comparable to that used to make the paper, at close to 10 Watt-hours per copy.

Inkjet technology is fundamentally much more efficient than laser or conventional copier technologies. Inkjet printers typically use less than 30 watts when printing, as the main energy requirement is delivering small droplets of ink onto the paper. This translates to an energy requirement of less than 0.1 Watt-hours per page.

Laser printers and copiers use variations on the principle of melting or fusing toner onto paper. Normally this requires substantial heating energy. This has two implications for energy use. First, it is estimated that the average amount of energy required per image is around 1 Watt-hour (Roth *et al*, 2002): so a 30 copy per minute machine requires around 1,800 Watts average power when printing or copying Second, in order to limit the time delay between pressing the PRINT button and receiving a copy, components within the machine are kept hot while it is on standby. A common technique for reducing energy use while in low power modes is to lower the temperature of these components: this leads to longer delays before printing, which can provoke user dissatisfaction. This issue has been addressed to some degree both by the ENERGY STAR program, which requires medium-sized copiers to print within 30 seconds of activation, and the IEA *Copier of the Future* program (US EPA, 2002a), which requires less than a 10 second delay.

Improvements in efficiency are being pursued through:

- new toners that require lower temperatures to fuse; (TIAX, 2002)
- copiers that use pressure instead of heat to fuse the toner;
- lightweighting and changes in materials of heated components; and
- reduction of heat loss from hot components.

Measurement of copying energy on a new digital copier by *Sustainable Solutions* indicated that, when copying batches of 20 or more copies, printing energy was as low as 0.6 watt-hours per copy, significantly better than the 1 watt-hour estimate used by Roth. However, it was found that copying energy for single copies was much higher, with an average of 0.9 Wh per copy. The actual amount of energy required to make a single copy was found to vary markedly, from 0.4 Wh to 2.8 Wh. This seems to reflect a cycling of the heating element in active standby mode – so the temperature of the fuser elements seems to vary over time. Depending on the initial temperature of the fuser when the *Copy* button is pressed, it will take more or less time and more or less energy to bring the system to operating temperature: hence the variation in energy use for making a single copy. If these measurements are representative of recent trends, energy consumption per copy is probably declining from the 1 Wh value in the late 1990s, possibly towards 0.7-0.8 Wh per copy for the best new machines.

It was noted that the digital copier tested (a Canon IR5000) had a useful energy saving feature for making single copies of a number of images, such as copying the pages of a book or report. It is possible to scan the images and store them in memory (using very little energy), then print them all as a batch at the end: this also facilitates duplex copying. So, instead of making a number of copies at, say 20 second intervals, with a high rate of energy use, a batch of copies can be made energy efficiently after all of the images have been scanned in. Some people may not use this function if they wish to confirm the quality of the image before making further copies, but with familiarity, this tendency could be contained – and a LCD screen could be added to allow users to confirm copy quality, as well as to facilitate other functions of the machine. And the problem already exists to some extent where users are duplex copying anyway, as the user can only see the copy quality after two images have been made. As office equipment becomes increasingly interconnected, a LCD screen on a digital copier could facilitate sending images to a user's computer instead of making hard copies, saving printing energy.

A preliminary analysis by *Sustainable Solutions* of the energy flows during copying indicate that between 1-7% of the energy is actually used to fuse toner onto paper. The rest is wasted in heating up the paper and balancing heat losses from the hot components of the copier. It seems likely that the (theoretically largely unnecessary) heating of the sheets of paper is actually the dominant mode of energy waste. On this basis, measures that could save energy include:

- lowering the temperature at which fusing of toner occurs
- optimising the heating systems, such as tailoring the frequency of radiant heating to that absorbed by the toner, to reduce the wasteful heating of the paper
- avoiding or minimising use of rollers
- reducing heat loss from the hot components through insulation and improved design
- heat recovery from outgoing paper to pre-heat incoming paper
- lightweighting and reducing the size of components..

The competition between inkjet and laser technology for producing images will be a significant driver of future energy use (as inkjets are much more energy efficient when in use, but slower – although their speed is increasing over time). Growing demand for colour reproduction may influence the outcome of this battle – and drive future energy trends. It is also difficult to predict whether the future will emphasise large numbers of small, cheap decentralised machines or fewer, more sophisticated centralised machines, or both.

A fundamental question regarding printing and copying is the extent to which electronic and non-paper media may replace them (*cf* the impact of E-mail on facsimiles in recent years). For example, many organisations are issuing CDs of material that used to be printed, although many users then print out much of this material. In this case, the overall energy outcome is difficult to assess, as printing may decline, but it may be done on smaller, less efficient printers instead of on commercial printing equipment. In the longer term, e-paper and various devices that replace paper may reduce the amount of paper, and the energy and resources used for its production. On the other hand, growth in demand for paper has been very resistant to change so far.

Many larger copiers and printers are leased, so limited numbers of informed people are involved on the supply side, while procurement is usually carried out by a small number of people in the user organisation. Model purchasing policies and guidelines, labels and/or MEPS should therefore be relatively easy to apply to larger equipment.

For smaller units, energy labels and MEPS are also applicable. Even though usage patterns can vary significantly, the model of appliance energy labelling demonstrates that information based on a representative usage pattern can still be very effective: and more comprehensive data could be provided to those with a higher level of interest.

Information programs or MEPS should focus on ensuring that highly rated equipment has quick start-up from energy saving modes. Otherwise, user impatience may undermine the value of efficiency improvement programs.

Energy use of small inkjet printers tends to be dominated by standby power use, so there can be significant gains from focusing on their standby power. However, manufacturers of inkjet printers may wish to be compared to lasers on an overall operational energy basis, as they should look very good! There would also be benefits in treating all forms of printers in the same way for purposes of information in the market place, as consumers may increasingly be comparing inkjet and laser technologies against each other.

It should be noted that the ENERGY STAR program does not always measure performance of copiers and printers with peripheral equipment such as duplex and collating features attached. It is desirable that any information program includes energy use with all features attached, to provide an incentive to minimise energy use of all elements, not just the core equipment. Measurements have shown that peripheral equipment may not default to low power and sleep modes, although there is no reason why it should not. One copier marketed on the basis of having a sleep mode of 4 watts was measured by *Sustainable Solutions* at over 90 watts, the discrepancy being due to power consumption by peripheral equipment. Including peripheral equipment in energy rating will drive sensible management of its power usage.

Similarly at present many MFDs (multi-function devices) have higher energy consumption than might be expected from summing the energy consumption of devices performing individual functions.

The American Society for Testing and Materials has published a number of Standards for testing energy consumption of office equipment. These include:

- ASTM F757-01, *Standard Test Method for Determining Energy Consumption of Copier and Copier-Duplicating Equipment*
- ASTM F1706-96, *Standard Practice for Determining Energy Consumption of Nonimpact personal Computer Printers*
- ASTM F1707-96, *Standard Practice for Determining Energy Consumption of Facsimile Machines*

These Standards provide a useful basis for development of information and standards programs although, as discussed earlier, there is rapid change in the functionality of much of this equipment, so further development of the methodologies may be required.

5.1.6 Scanners

Energy use of scanners tends to be dominated by standby energy use and as a class they appear to be relatively inefficient in this mode. However, there seems to be no reason for high standby energy use. On this basis, a simple MEPS linked to the *One Watt Standby* program may be sufficient to address energy efficiency.

5.1.7 Computer Projectors

Computer data projectors are gaining in popularity as they have become more affordable and more compact. Energy use of a sample of portable models was measured for this Report. Consumption ranged from 150 watts to 270 watts, with units capable of projecting brighter images being at the higher end. A four year old EIKI

LCXGA970 unit was measured at 180 watts, of which 150 watts was for the lamp while a new Mitsubishi XD 200U used 270 watts, of which 17 watts was for the fan and 210 watts for the lamp. However, manufacturers' data does not always provide consistent and comparable data on brightness/light output.

It can be seen that around 80% of the energy used by this equipment is for the lamp, although there is some variation in energy use by fans and electronics. Energy use by lamps is, on one hand, reducing due to pressure for higher efficiency and less weight while, on the other hand, there is consumer support for higher brightness, which requires higher energy use for a given efficiency.

Modern units have low power standby modes in which the lamp shuts off: this feature is usually needed for cool-down cycles. There seems to be scope for improving the efficiency of the electronics and fan, as well as ongoing improvement in lamp efficiency and potential for more advanced power management to dim the lamp when appropriate, or to vary brightness in response to ambient light levels.

For comparison, overhead projectors use 250 to 400 watts, so it seems that a transition from overhead projector to computer projector plus laptop computer is likely to be fairly energy neutral for a given presentation, although users may be more likely to switch off an overhead projector when it is not needed.

The efficiency of computer projectors could be rated on the basis of energy use per unit of light output for a representative cycle of usage. Since they are likely to be purchased by an ever-widening range of users, a labelling scheme may be most appropriate.

5.1.8 Wireless Network Hubs

A network hub is a multi-port amplifier that allows a number of users to be linked to a computer or server. In principle, these are relatively low energy devices whose power usage can be managed in the same way as for servers.

6 Options for Action

6.1 Objectives for an Office Equipment Energy Efficiency Program

The key objectives of an office equipment energy efficiency program should include:

- Encouraging (or requiring) manufacturers to improve energy efficiency of their equipment;
- Encouraging (or requiring) distributors to select and promote more energy efficient models and features over less efficient ones;
- Providing a mechanism for buyers and specifiers to specify and select more energy efficient models
- Encouraging users to utilise their equipment in the most energy efficient ways, consistent with user requirements
- Recognising the varying characteristics of suppliers, markets and customers involved in each type of equipment.

To achieve these objectives, a means of measuring/estimating and communicating the energy use of equipment in each mode of operation and, preferably, overall is required. Such a methodology must address both operating and standby energy use: particularly as the *One Watt Standby* program rolls out, failure to consider operating energy will mean that the major opportunity to reduce energy consumption and greenhouse gas emissions is not being grasped.

As Harrington and Damnics (2001) have pointed out, while it is important for test procedures to be internationally standardised or compatible, it is also important that each country's programs respond to their cultural context. Australia has an excellent and well-recognised star rating approach for household appliances that could certainly be extended to office equipment. Such a program would benefit from the high level of existing awareness and understanding. An alternative approach would involve much higher promotional costs and take much longer to establish within the Australian context. Indeed, we have already seen attempts to establish the ENERGY STAR label in Australia struggle to gain the effective traction achieved by the appliance energy label.

Australian experience has also demonstrated that MEPS can play an important role in removing poorly performing equipment from the market, both in situations where the users of equipment play a minor role in its selection, and as a complement to information and labelling programs that promote best practice.

The ENERGY STAR program, which focuses on standby power usage and reduction of the time unnecessarily spent in active mode deals with the problem of operating energy indirectly and partially. Moreover, it provides no incentive to reduce operating/active standby power consumption. It must also be remembered that the ENERGY STAR program is voluntary, and that, as an international program originating in the USA, Australia would have very limited leverage to influence modification of the scheme to include operating energy. In any case, the fact that the scheme is an endorsement or 'threshold' approach makes it difficult to use it to drive progressive improvement. Development of local programs based on international standard test procedures would not preclude ongoing support of international programs such as ENERGY STAR, but would offer Australia the flexibility to move faster and to respond to our own circumstances.

It is not necessarily easy, at first glance, to develop standard label algorithms for office equipment, which may have a wide variety of patterns of use. For each different pattern of use, the proportions of energy consumption in 'in use', active standby and low power modes will vary, as will the total energy used. However, Australian experience with appliance energy labelling has shown that information provision based on a representative usage pattern can meet the needs of many consumers. Further, a number of existing ASTM Standards provide methodologies for testing of copiers, printers and fax machines. It would also be possible to make more detailed information on energy use in each operating mode available to those with a higher level of interest or unusual circumstances. *Sustainable Solutions* has previously developed simple models that estimate total equipment energy use when data on energy use in the main operational modes and the levels of usage are specified, and such an approach seems well-suited to provision of supplementary information.

6.2 Key Conclusions

Key conclusions that can be drawn from this report and which form a basis for action to reduce operating energy of office equipment include:

- Office equipment directly and indirectly generates between 9 and 11 million tonnes of CO_2 each year in Australia, and uses at least 5% of all electricity. Around 85% of this energy consumption occurs when equipment is being used (ie, operating) or is in active standby mode;
- Future trends in office equipment energy use are very uncertain, although growth seems likely under most scenarios due to the increase in numbers of items of equipment. Future energy use can be strongly influenced by public policies and programs, as the rate and direction of technological innovation will be critical;
- The ENERGY STAR program has led to substantial reductions in office equipment power usage where equipment has this feature enabled. However, in many cases the feature is disabled by technicians or users. ENERGY STAR does not address power usage in operating and active standby modes, although effective use of power management features can reduce the time spent on active standby;
- The best-performing products use far less energy in standby mode than is needed to qualify under ENERGY STAR criteria;
- Further energy savings will come mostly from improvements in operating energy efficiency and more effective and reliable methods of switching to low power modes, as well as efforts to achieve *One Watt Standby* or better. Modelling carried out for this study suggests that further savings of 50-80% are possible with existing technologies, with larger savings feasible as technology evolves. Savings due to reduced capital investment in electricity supply infrastructure and space cooling equipment add to the financial benefits of saved energy;
- American Society for Testing and Materials (ASTM) standard test methods exist for measuring energy consumption of copiers, printers and fax machines; and
- There seem to be feasible options for public policy responses to reduce energy consumption by all the types of office equipment considered in this report.

6.3 Options for Action

Table 6.1 lists energy-saving opportunities and suggests priorities for action for various types of office equipment.

Table 6.1
Energy-Saving Opportunities and Priorities for Action for Various Types of Office Equipment

Type of Equipment	Significance	Priority for Action	Energy-Saving Opportunities	Options for Action
Personal computers	High: around 20% of Office Equipment (OE) energy	1	Wide range of energy use from 10-90W Energy saving strategies: - high efficiency power supply - improved power management - efficient devices (eg processors) - laptops	MEPS for power supplies, power management and device efficiency; mandatory energy consumption disclosure or energy labels; government procurement programs
Monitors	High – over 20% of OE energy	1	LCDs with efficient power supplies offer up to 70% savings and further improvements are likely	Mandatory energy consumption disclosure; energy labels; MEPS; government procurement

Type of Equipment	Significance	Priority for Action	Energy-Saving Opportunities	Options for Action
Servers	Moderate – high; over 10% of OE energy + inefficient a/c systems	1	Energy saving strategies: - high efficiency power supplies - power management - efficient devices - airconditioning efficiency	MEPS; mandatory energy consumption disclosure; government procurement; demonstrations and info programs for airconditioning efficiency
Uninterruptible Power Supplies	Moderate: about 6% of OE energy	1	Key issue is to ensure the superior technology option is used, and that appropriate sizing (or high efficiency at low load) is achieved	MEPS; government procurement programs
Copiers and MFDs	Moderate-high: about 10% of OE energy	1	Likely that manufacturers will include various low power modes, and peripherals can use significant energy. Power management and reduction in copying/fusing energy are key issues. IEA *Copier of the Future* program shows substantial scope for improvement.	MEPS; mandatory energy consumption disclosure; government procurement; maybe energy labels
Printers	Moderate: about 6% of OE energy	2	Wide variation in energy use, especially between laser and inkjet, where up to 10-fold differences can exist. For laser printers savings options are similar to those for copiers.	As for copiers, with energy labels for smaller equipment
Faxes, scanners	Moderate: probably <5% of OE energy	1	For inkjet models of faxes, standby is the major issue, but for laser faxes total energy use should be considered. For scanners, automatic low power standby mode is critical	*One Watt* programs, MEPS
Computer projectors	Small	2	Ongoing potential for improvement in efficiencies of lamp, fan, electronics and power supplies. Could rate on basis of energy use/light output plus performance of 'smart' energy saving features (see text)	Mandatory standardised energy use and light output disclosure; maybe energy labels
Hubs	small	2	Power management and standby energy use probably the major issues. Could be rated by class based on capability	MEPS

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NAEEEC MEMBER ORGANISATIONS

The Commonwealth, New Zealand, each State and each Territory are represented on NAEEEC and participate in its deliberations. Representatives are drawn from officials within Government departments, agencies and statutory authorities or from persons appointed to represent those bodies. Representatives are usually a senior officer directly responsible for energy efficiency. The membership is currently under review and may expand to include other agencies working in these fields.

The *Australian Greenhouse Office* is the lead Commonwealth agency for greenhouse matters. The Australian Greenhouse Office (AGO) is responsible for monitoring the National Greenhouse Strategy in a cooperative effort with States and Territories and with the input of local Government, industry and the community. An AGO officer is the chair of NAEEEC and others provide support for its activities.

The NSW *Ministry of Energy and Utilities* provides policy advice to the NSW Government and operates a regulatory framework aimed at facilitating environmentally responsible appliance and equipment energy use. The Ministry is represented on the Energy Efficiency and Greenhouse Gas working group through which the appliance and equipment related elements of the National Greenhouse Strategy will be progressed.

The NSW *Sustainable Energy Development Authority* was established in February 1996 with a mission to reduce the level of greenhouse emissions in New South Wales by investing in the commercialisation and use of sustainable energy technologies.

The *Office of the Chief Electrical Inspector* is the Victorian technical regulator responsible for electrical safety and equipment efficiency. Its mission is to ensure the safety of electricity supply and use throughout the State. The corporate vision of the Office is to demonstrate national leadership in electrical safety matters and to improve the superior electrical safety record in Victoria. The Office's strategic focus is to ensure a high level of compliance is sustained by industry with equipment efficiency labelling and associated regulations.

The *Sustainable Energy Authority* was established in 2000 by the Victorian Government to provide a focus for sustainable energy in Victoria. The Authority's objective is to accelerate progress towards a sustainable energy future by bringing together the best available knowledge and expertise to stimulate innovation and provide Victorians with greater choice in how they can take action to significantly improve energy sustainability.

The *Electrical Safety Office, Department of Industrial Relations*, is the Queensland technical regulator responsible for electrical safety and appliance and equipment energy efficiency. The office ensures compliance with electrical safety and efficiency regulations throughout Queensland.

The *Environmental Protection Agency*, a Division of Sustainable Industries, is Queensland's lead agency in the promotion of energy efficiency, renewable power, and other initiatives that reduce greenhouse gas emissions throughout the State. The key aim of the unit is to achieve increased investment in sustainable energy systems, technology and practice.

Energy Safety WA seeks to promote conditions that enable the energy needs of the Western Australian Community to be met safely, efficiently and economically.

The Western Australian *Sustainable Energy Development Office* promotes more efficient energy use and increased use of renewable energy to reduce greenhouse gas emissions while increasing jobs in related industries.

The *Office of the Technical Regulator* seeks to ensure the coordinated development and implementation of policies and regulatory responsibilities for the safe, efficient and responsible provision and use of energy for the benefit of the South Australian community.

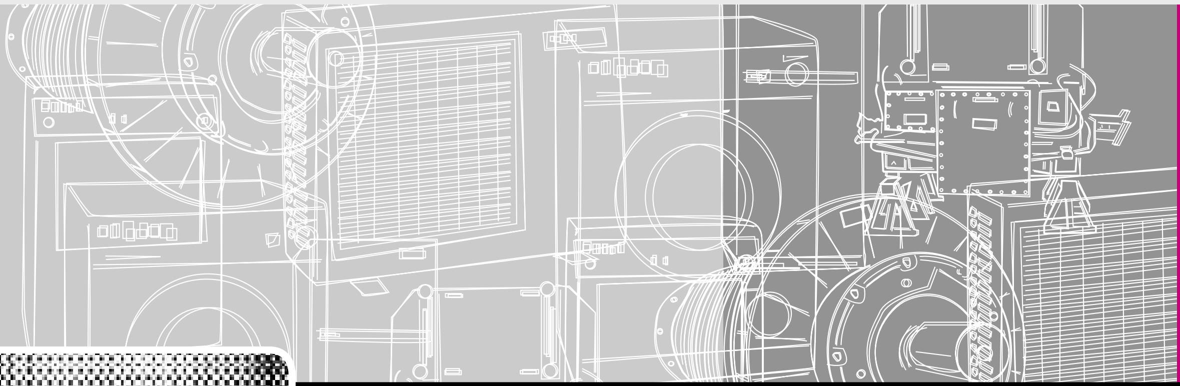
The Tasmanian Government's interest is managed by the *Office of Energy, Planning and Conservation.*

The Australian Capital Territory's interest is managed by the *Energy Policy Unit, Economic Management Branch, ACT Department of Treasury.*
(http://www.treasury.act.gov.au/energypolicy)

The *Department of Employment, Education and Training* is responsible for the administration of regulations in the Northern Territory regarding various aspects of safety, performance and licensing for goods and services including electrical appliances.

The *Energy Efficiency and Conservation Authority (EECA)* is the principal body responsible for helping to deliver the New Zealand Government's extensive sustainable energy future. EECA's function is to encourage, promote and support energy efficiency, energy conservation and the use of renewable energy sources.

The *Ministry for the Environment* (MfE) is the lead environmental policy agency in New Zealand and is the government policy agency which advises the Minister of Energy on energy efficiency and renewables policy. MfE administers the Energy Efficiency and Conservation Act 2000, and energy efficiency regulations made under the Act.



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Energy Efficiency Program.