# Analysis of the Potential for Minimum Energy Performance Standards for Computers and Monitors

Prepared for

## Equipment Energy Efficiency Programme

By

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**Draft Report**

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# Executive Summary

## Scope

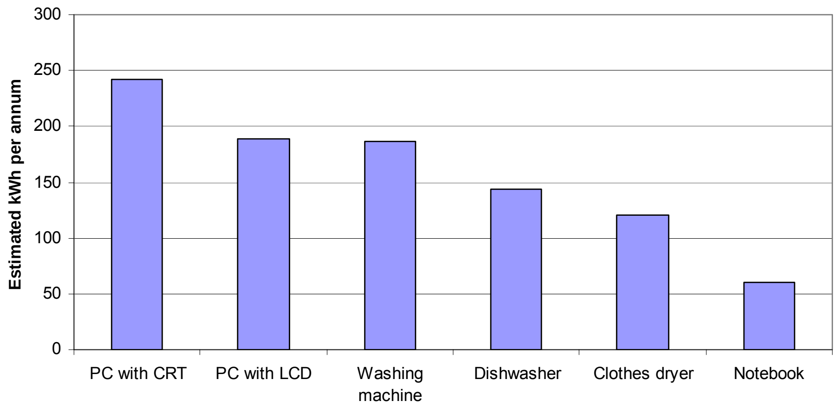
This report was commissioned, within the scope of the Equipment Energy Efficiency Program (E3), to explore the potential for energy and greenhouse savings through improvements to desktop and notebook/tablet computers and cathode ray tube (CRT) and liquid crystal display (LCD) monitors in Australia and New Zealand.

## Current Energy Consumption

Computers and monitors consume significant amounts of energy in the Australia and New Zealand markets and this is forecast to increase. It is estimated that, in 2006, computers and monitors consumed more than 6,800 GWh in Australia and 1,300 GWh in New Zealand, resulting in greenhouse gas emissions of 7Mt $CO_2$-e and 0.8Mt $CO_2$-e respectively.

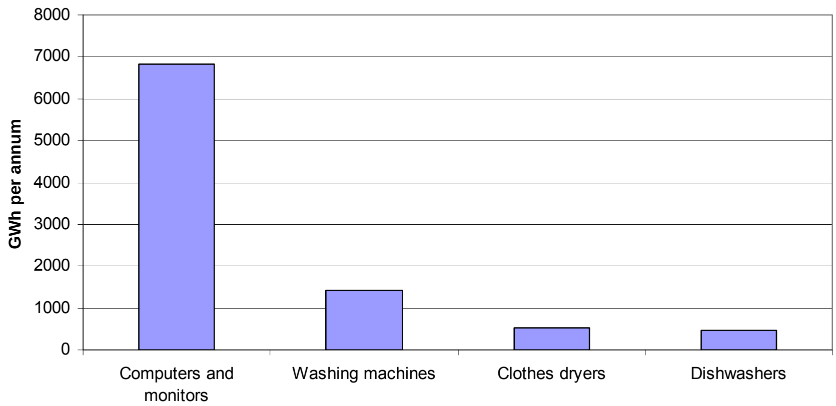
Typical home computer system energy consumption exceeds that of some products already subject to mandatory energy performance labelling.

**Comparative Annual Energy Consumption – Home Computer Systems and Energy Rated Products**




From an Australia wide perspective, office and home computer system energy consumption dwarfs that of some products already subject to energy performance labelling.

**Australian Annual Energy Consumption – Computer Systems and Energy Rated Products**



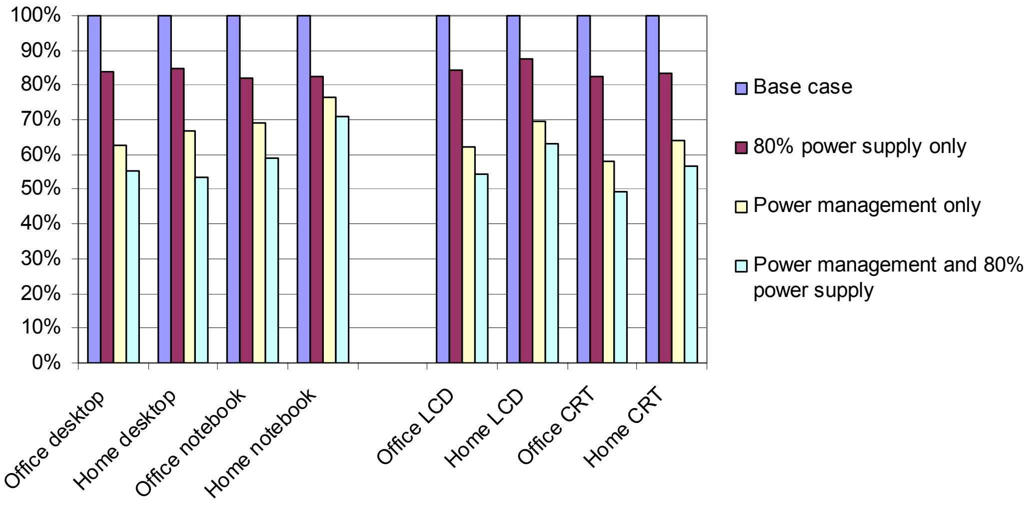

## Energy Consumption Issues

This report demonstrates, using international and local data, that it is clear that in the supply sector (hardware), many computers and monitors consume much more power than many equivalent products already in the market place. With the exception of government directives and corporate requirements, consumers generally have little market influence on hardware power consumption.

At the operational level, it is evident that utilisation of ‘built in’ power saving features for computers is less than a quarter. Power saving settings for monitors is much higher, circa 80% enabled.

US Environmental Protection Agency tests demonstrate that lower energy computers and monitors are available in the market place, but there are also many other models that consume significantly higher amounts of energy. Similarly, analysis of European ENERGY STAR data show that low energy monitors are available as are many more that consume significantly more energy.

The following chart, based upon European studies, shows the step reductions that can be achieved by increasing power supply efficiency to 80%, enabling power management only and finally implementing both. These are relatively simple, but significant reductions.




## Forecast Energy Consumption and Greenhouse Gas Emissions

This is influenced by two parameters.

- Hardware trends and market growth.
- What is technically achievable, compared to business as usual. As above, analysis of the international studies indicates that by using more efficient hardware and enabling power management, (addressing market failure/business as usual) energy consumption could be reduced by as much as 45% for some products. The overall impact of improvements in the market place would increase over time, as inferior products are retired and replaced with energy efficient products.

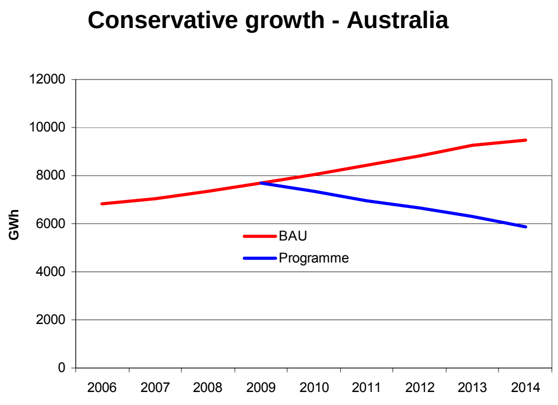
Two growth forecasts have been analysed using business as usual (BAU) data and the introduction of mandatory measures, from October 2009, thus reducing energy consumption from 2010 onwards after current stock is sold.

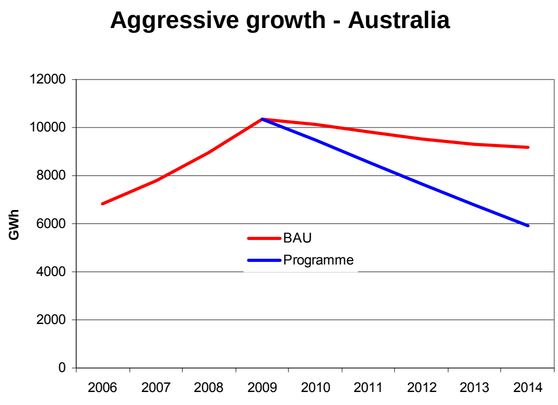
- A conservative forecast uses growth rates returning to levels experienced prior to the high growth that was experienced from 2003 - circa 8% per annum with market saturation being reached in 2014.
- An aggressive forecast that continues the high growth from 2003 – circa 20% to 2009, with the growth tapering off after market saturation in 2010.

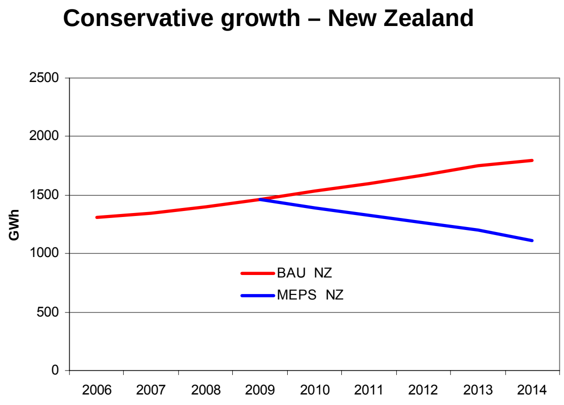
The following charts show forecast Australian and New Zealand energy consumption for the two growth scenarios for the BAU and mandatory measures. In the aggressive growth chart, energy is forecast to reduce after 2009 due increased penetration of lower energy consuming notebook computers and LCD monitors.

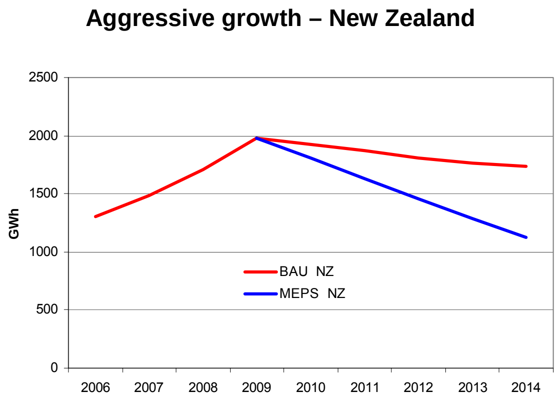
Australian greenhouse gas emission savings in 2014 are estimated to be 3.52 Mt $CO_2$-e and 3.18 Mt $CO_2$-e for the conservative and aggressive growths respectively.

New Zealand greenhouse gas emission savings in 2014 are estimated to be 0.41 Mt $CO_2$-e and 0.37 Mt $CO_2$-e for the conservative and aggressive growths respectively.




## Recommendations

As opposed to voluntary schemes, minimum energy performance standards and energy rating labels have a good track record in reducing energy consumption of a range of domestic appliances and commercial/industrial products.

To address hardware market failure, information failure and power management enablement failure, it is recommended that the following actions be taken.

- Australian and New Zealand Standards are developed, based upon ENERGY STAR V4.0 for computer test methods. Computers to be included are both stationary and portable units, including desktop computers, integrated computers, notebook computers, tablet computers and desktop-derived servers
- An Australian and New Zealand Standard is developed, based upon ENERGY STAR V4.1 for computer monitor test methods.
- An Australian and New Zealand Standard is developed, based upon the Generalised Internal Power Supply Test Protocol Rev 6.1, for internal power supply test methods and computer internal power supply efficiency is no less than 80% when tested to this standard.
- That E3 plans to introduce MEPS, including mandatory power management enablement prior to supply, for computers, based upon ENERGY STAR computer specifications V4.0 as follows:

| Computer type | Sleep mode power consumption | Standby (off) mode | On/idle power consumption |
|---|---|---|---|
| Desktops<br>Integrated<br>Desktop-derived servers | < 4W | < 2W | Category A: < 50 W<br>Category B: < 65 W<br>Category C: < 95 W |
| Notebooks/tablets | < 1.7W | < 1.0W | Category A < 14W |

| | | | |
|---|---|---|---|
| | | | Category B < 22W |
| Wake on LAN adder | + 0.7W | + 0.7W | |

- That E3 plans to introduce MEPS for monitors, based upon ENERGY STAR specification version 4.1 Tier 1 as follows:

| Off | Sleep | Active |
|---|---|---|
| < 2W | < 4W | 30 + (Megapixels x 38) W |

- That E3 plans to introduce a voluntary 'high efficiency' energy performance level for monitors, based upon ENERGY STAR specification version 4.1 Tier 2 as follows:

| Off | Sleep | Active |
|---|---|---|
| < 1W | < 2W | If Megapixels (MP) less than 1, then 23 W<br>If Megapixels (MP) greater than 1, then 28 x MP W |

- That the Australian and New Zealand standard includes mandatory energy performance labels for computers and monitors.

- To address energy performance of smaller 'one off' manufacturers, 'deem to comply' conditions are included in the computer and monitor standards. Mandatory labelling would also apply.

**Proposed Timetable**

| Item | Date |
|---|---|
| AIIA meeting to flag intentions | May 2007 |
| Publication of computer and monitor profile fact sheet | August 2007 |
| Australian proposal to AP6 to develop harmonised standards | August 2007 |
| Draft technical report for industry comment | October 2007 |
| Release of E3 Plan | October 2007 |
| Consultation with Industry | August – October 2007 |
| Draft standards for Standards working group | October 2007 |
| Consideration of draft Standard by Working Group of Standards Committee (TE-01) | November 2007 |
| Publication of Draft Standards | |
| Publication of draft cost benefit analysis | January 2008 |
| Publication of Standards | |
| Draft Regulatory Impact Statement (RIS) | May 2008 |
| Stakeholder forum to discuss draft RIS | July 2008 |
| Final (decision) RIS clearance | September 2008 |
| Approval of decision RIS by MCE | October 2008 |
| Implementation of MEPS | October 2009 |

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**Glossary of abbreviations**

| Abbreviation | Expanded meaning |
|---|---|
| ABS | Australian Bureau of Statistics |
| AC | Alternating Current |
| ACPI | Advanced Configuration and Power Interface |
| AGO | Australian Greenhouse Office |
| AS/NZS | Australian Standard/New Zealand Standard |
| COAG | Council of Australian Governments |
| CPU | Central Processing Unit |
| CRT | Cathode Ray Tube |
| DVI | Digital Visual Interface |
| E3 | Equipment Energy Efficiency Program |
| EECA | Energy Efficiency and Conservation Authority - NZ |
| EMC | EMC Directive 89/336/EEC |
| EPA | Environmental Protection Agency – USA |
| EPEAT | Electronic Product Environmental Assessment Tool |
| EPS | External Power Supply |
| EU | European Union |
| EuP | Energy using Products |
| FEMP | Federal Energy Management Program (US) |
| FPDM | Flat Panel Display Monitor |
| Gb | Gigabyte |
| GWh | Giga Watt hour |
| HDD | Hard Disk Drive |
| ICT | Information and Communication Technology |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| IEEE 1394 | IEEE computer bus standard |
| IPS | Internal Power Supply |
| ITU | International Telecommunications Union |
| KEMCO | Korea Energy Management Corporation |
| kWh | Kilo Watt hour |
| LAN | Local Area Network |

| | |
|---|---|
| LBL | Lawrence Berkley National Laboratory |
| LCD | Liquid Crystal Display |
| MEPS | Minimum Energy Performance Standards |
| MP | Mega pixels |
| Mt | Mega tonne |
| Mt $CO^2$-e | Mega tonne carbon dioxide equivalent |
| MTBF | Mean Time Between Failures |
| NGS | National Greenhouse Strategy |
| PC | Personal Computer |
| $P_{max}$ | Maximum Power |
| RIS | Regulatory Impact Statement |
| TEC | Total Energy Consumption |
| USB | Universal Serial Bus |
| UUT | Unit Under Test |
| VESA | Video Electronics Standards Association |
| VGA | Video Graphics Array |
| WOL | Wake on LAN |

# 1 Introduction

This report was commissioned, within the scope of the Equipment Energy Efficiency Program (E3), to explore the potential for energy and greenhouse savings through improvements to desktop and notebook/tablet computers and computer monitors in Australia and New Zealand.

The implementation of E3 is overseen by the Equipment Energy Efficiency Committee (E3 Committee), which comprises officials from Commonwealth, State and Territory Government agencies and the New Zealand Government. The E3 Committee is ultimately responsible to the Ministerial Council on Energy (MCE) comprising ministers responsible for energy from all jurisdictions.

The activities flow from the requirement in the National Greenhouse Strategy (NGS 1998) to improve the energy efficiency of energy-consuming household appliances, and industrial and commercial equipment.

In October 2004 the Australian Greenhouse Office flagged its intentions to introduce MEPS for personal computers and computer monitors, with the publication of the report *Minimum Energy Performance Standards for Computers and Computer Monitors*.[1]

This was reiterated at the National Standby Conference in Canberra - November 2006[2].

The objective of this document is to advance the process and to facilitate informed decision-making by providing updated information about these products in Australia and New Zealand.

From this initial assessment it is concluded that, in 2006, computers and computer monitors are estimated to have consumed 6,800GWh of electricity in Australia and 1,308 GWh in New Zealand, based upon households in New Zealand. The detailed assessment focuses on desktop computers, notebook computers, cathode ray tube (CRT) monitors and liquid crystal display (LCD) monitors with respect to the introduction of energy efficiency measures for these products to manage greenhouse emissions.

Key information presented herein includes:

- current computer and computer monitor types (computer monitors will hereinafter be referred to as monitors);
- current market and stock estimates for computers and monitors, as well as an assessment of market trends;
- international standards applicable to computers and monitors;
- energy consumption data for computers and monitors;
- analysis of the potential to reduce energy consumption and greenhouse emissions from these products;
- recommendations for setting efficiency levels and test methods.

# 2 Product Description – Computers and monitors

## 2.1 Computers

A computer is defined as a device which performs logical operations and processes data. Computers are composed of, at a minimum:

- a central processing unit (CPU) to perform operations;
- user input devices such as a keyboard and mouse;

and

- a monitor to display output information.

Although computers must be capable of using input devices and displays, as noted above, computer systems do not need to include these devices on shipment to meet this definition.

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[1] http://energyrating.gov.au/library/details200406-mepscomputers.html

[2] http://www.energyrating.gov.au/pubs/2006-sb-ausnz-edlington-ryan-collins.pdf

Within the context of this report, computers addresses are of three types.

**Desktop computers**

Desktops are designed for a broad range of home and office applications including, email, web browsing, word processing, standard graphics applications, gaming, etc.

**Integrated computers**

Integrated computers come in one of two possible forms:

1. a system where the display and computer are physically combined into a single unit;

 or

2. a system packaged as a single system where the display is separate but is connected to the main chassis by a dc power cord and both the computer and display are powered from a single power supply. As a subset of desktop computers, integrated computers are typically designed to provide similar functionality as desktop systems.

**Notebook/tablet computers**

A computer designed specifically for portability and to be operated for extended periods of time without a direct connection to an ac power source. Notebooks and tablets utilize an integrated monitor and be capable of operation off an integrated battery or other portable power source. In addition, most notebooks and tablets use an external power supply and have an integrated keyboard and pointing device, though tablets use touch-sensitive screens. Notebook and tablet computers are typically designed to provide similar functionality to desktops except within a portable device. For the purposes of this report, docking stations are considered accessories and therefore, the performance levels associated with notebooks do not include them.

### 2.2 Monitors

A commercially-available, electronic product with a display screen and its associated electronics encased in a single housing that is capable of displaying output information from a computer via one or more inputs, such as VGA, DVI, and/or IEEE 1394. The monitor usually relies upon a cathode-ray tube (CRT), liquid crystal display (LCD), or other display device. This definition is intended primarily to cover standard monitors designed for use with computers. To qualify, the computer monitor must have a viewable diagonal screen size greater than 30.5 cm (12 inches) and must be capable of being powered by a separate AC wall outlet or a battery unit that is sold with an AC adapter. Computer monitors with a tuner/receiver may be included as long as they are marketed and sold to consumers as computer monitors (i.e., focusing on computer monitor as the primary function) or as dual function computer monitors and televisions. However, products with a tuner/receiver and computer capability that are marketed and sold as televisions are not included.

### 2.3 Definitions

The definitions and terminology utilised in this report are those employed in the most widespread, almost universal, programmes and initiatives for computers and monitors. As expanded upon in later sections of this report, these definitions are those utilised in the US and European ENERGY STAR specifications, which will utilised in the Australian and New Zealand standards. This is in keeping with the goal of internationally harmonised specifications and will simplify the processes for these globally traded products.

# 3 Market Profile

## 3.1 Industry Profile - Computers

Computer supply in Australia and New Zealand is currently dominated by a relatively small number of international brand names. There are also many, possibly hundreds of smaller importers and local ‘white box’ assemblers computers utilising imported components. ’White box’ computers are mostly limited to the desktop market and not the notebook market due to the simplicity of assembly into an enclosure – ‘box’.

Table 1 provides a summary of some historical sales data to show trends.

Table 1: Australian computer market share

| Brand | Q1 2005[3] | Q1 2006[4] | Q1 2007[5] |
|---|---|---|---|
| HP | 16.3% | 18.6% | 20.5% |
| Dell | 13.3% | 15.3% | 15.4% |
| Acer | 10.4% | 12.3% | 11.8% |
| Toshiba | 5.2% | 7.8% | 8.6% |
| IBM/Lenovo | 8.1% | 6.0% | 6.9% |
| Apple | 3.5% | 3.2% | 5.0% |
| Asus | | | 3.7% |
| Optima | 3.0% | 2.3% | |
| Others | 40.2% | 34.5% | 28.1% |

## 3.2 Industry Profile - Monitors

Similarly to computers, major brand names dominate the market. This market is quite variable, as can be seen in Table 2, which provides a summary of some historical sales data to show trends. It is also influenced by availability of product, particularly in the LCD sector, with trends to larger monitors, partly due availability of smaller sized screens.

Table 2: Australian monitor market share

| Brand | Q1 2005[6] | Q2 2006[7] | Q1 2007[8] |
|---|---|---|---|
| Samsung | 15.5% | 20.0% | 18.7% |
| BenQ | 14.5% | 15.7% | 8.6% |
| LG Electronics | 18.0% | 14.8% | 16.6% |
| Viewsonic | | 12.4% | 17.4% |
| Acer | 11.1% | 11.9% | 9.8% |
| Philips | 10.2% | | |
| Others | 30.7% | 25.2% | 28.9% |

## 3.3 Stock

Whilst there have been a number of studies, addressing information and communication technology (ICT) waste, in use computer and monitor stock is difficult to assess. Various sources of data, including ABS and market research sales data, have been assessed, however the bottom line issue is how many computers and monitors are actually in use, not just historical sales data, with no regard for retirements or 'second life' use. An authoritative industry source[9] estimates that there were some 24 million computers in use in Australia in 2006, equally divided between the home, office and government sectors. Table 3 shows the estimated market use by computer and monitor type and application. Government and office are combined under the 'Office' heading.

Table 3: Estimated in use stock of computers and monitors - Australia

| | PC | Notebook | CRT | LCD |
|---|---|---|---|---|
| Office | 12.8 | 3.2 | 10.2 | 2.6 |
| Home | 7.6 | 0.4 | 7.2 | 0.4 |
| Total | 20.4 | 3.6 | 17.5 | 2.95 |

3 http://www.idc.com.au/press/release.asp?release_id=159
4 http://www.idc.com.au/press/release.asp?release_id=230
5 http://www.gamepro.com.au/index.php/id;1150810906
6 http://www.idc.com.au/press/release.asp?release_id=164
7 http://www.idc.com.au/press/release.asp?release_id=253
8 http://www.gamepro.com.au/index.php/id;263831746
9 AIIA – telephone conversation.

At first glance this indicates a significant increase from the 9.2 Million computers estimated to be deployed as recently as in 2002.[10] Simply extrapolating from the 9.2 Million in 2002, using the historical market data, suggests there are at least 19 million in 2006 as the stock of computers in Australia. The International Telecommunication Union also published country estimates of quantities of computers per capita[11] from 2000 to 2004. The ITU estimate is some 11 Million in 2002 and there is close agreement for 2004. The stock of computers can now confidently be estimated as at least one computer for every person living in Australia.

Assuming the same penetration of computers and monitors in New Zealand, Table 4 shows the estimated New Zealand stock for 2006.

Table 4: Estimated in use stock of computers and monitors – New Zealand

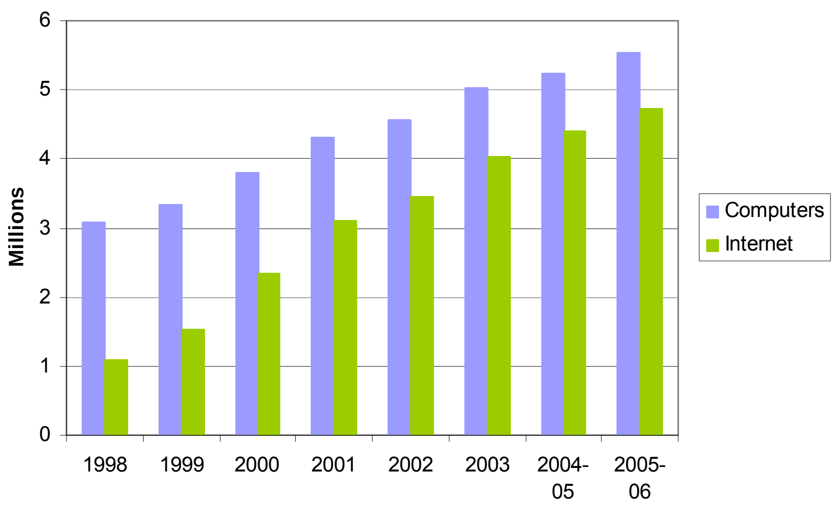
| | PC | Notebook | CRT | LCD |
|---|---|---|---|---|
| Office | 2.45 | 0.61 | 1.96 | 0.49 |
| Home | 1.46 | 0.08 | 1.38 | 0.07 |
| Total | 3.91 | 0.69 | 3.35 | 0.56 |

## 3.4 Market Trends

The duration of usage of computers and the internet in the business sector is increasing according to many sources. With access to broadband internet, the growth in e-commerce and computers offering additional services, overall computer stock must be rising dramatically although little Australian data exists to verify this conclusion.

Australian Bureau of Statistics (ABS) data, as shown in Figure 1 indicates continued growth in household access to computers and the internet. This data only addresses households with computer access, not the total number of computers. I.e. some households have more than one computer. ABS data from 2005 indicates there were some 6.45 million computers in Australian households.

Figure 1 ABS household data for computers and internet access - Australia




Data from Statistics New Zealand[12] is limited to 2001 and 2006, however the 2006 penetration is similar to Australia as shown in

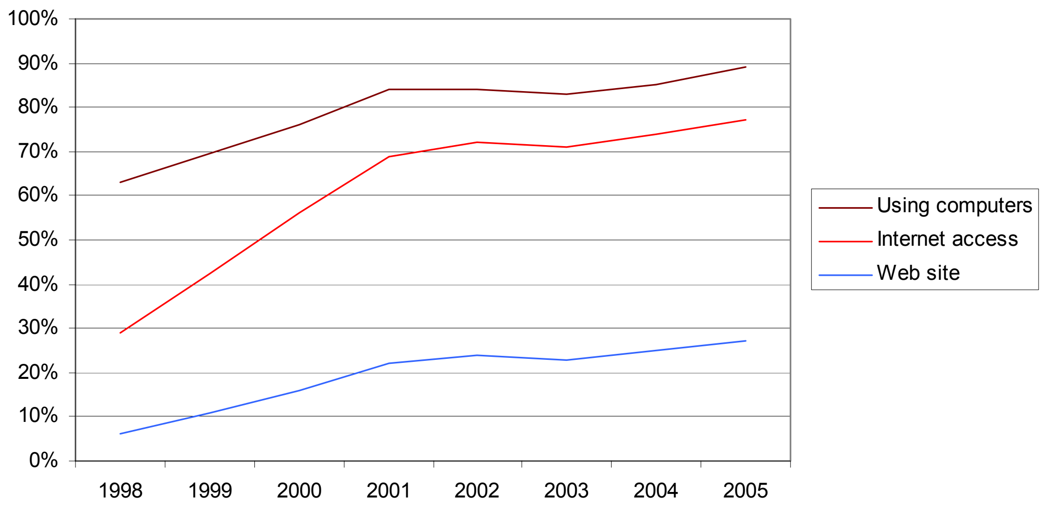
[10] Recycle IT! Summary report – NSW Dept. of Environment and Conservation 2004
[11] http://www.itu.int/ITU-D/ict/statistics/at_glance/Internet00.pdf series to 04
[12] http://www.stats.govt.nz/NR/rdonlyres/BA872497-4B85-4386-8395-3ACBEBDA7C4A/0/householduseofict2006hotp.pdf

Table 5.

Table 5 Household computer and internet penetration, Australia and New Zealand

| Country | Internet 2001 | Computers 2001 | Internet 2006 | Computers 2006 |
|---|---|---|---|---|
| New Zealand | 37% | 45% | 64.5% | 71.6% |
| Australia | 31% | 51% | 59% | 68% |

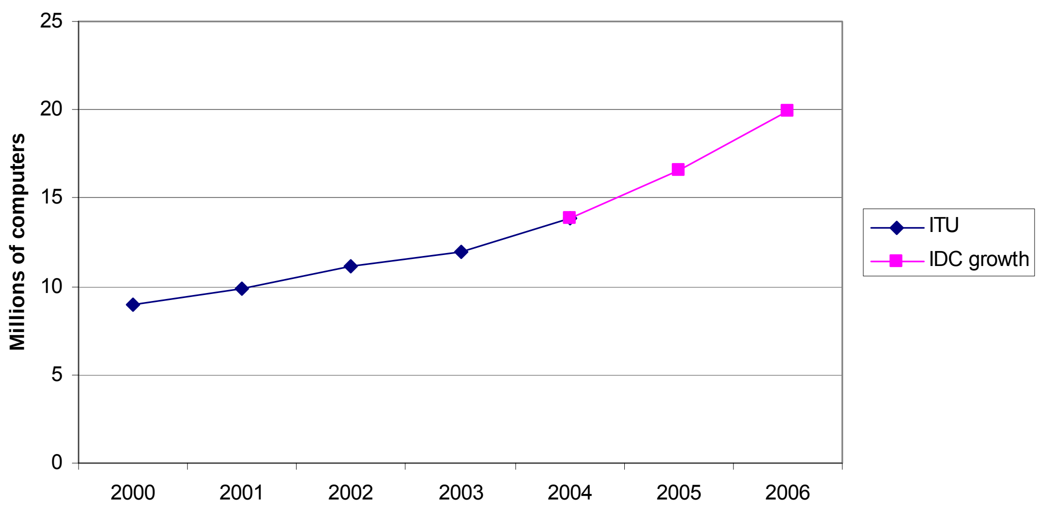
Figure 2 Business use of computers and the internet




Recent data[13] indicates strong and steady growth for computers and monitors, however notebook penetration is increasing at the expense of desktop computers, particularly in the office sector. The LCD monitor market share is increasing rapidly at the expense of CRT monitors. The trend to LCDs is driven by rapidly decreasing prices and the desire for more space on the desktop/workspace than afforded by CRT monitors.

Figure 3 shows a combination of stock data from the ITU annual estimates per capita and projections from this data based upon recent market data.

Figure 3 Computer stock growth




[13] http://www.itfacts.biz/index.php?id=P3591, IDC Australia

Within this report, two stock forecasts are considered.

The first forecast, Forecast 8%, acknowledges a range of downward pressures on computers and monitors, as the market moves towards LCD from CRT, and as more laptops and notebooks are sold instead of personal computers. Forecast 8% is aligned to the International Telecommunications Union (ITU) annual growth prior to 2003 of 8% and utilises stock growths of 5% and 10% for the home and office sectors respectively.

The second forecast, Forecast 20%, adopts continued aggressive growth rates in both sales and stock, based upon recent IDC sales growth data of 20% and the entry of more affordable computers in market (encouraging more sales growth).

In Figure 4 and Figure 5, the left hand columns represent growth Forecast 8% increasing linearly to market saturation in 2014, whilst the right hand columns represent the aggressive growth Forecast 20%, reaching saturation earlier, then increasing in line with population growth.

Figure 4 Australian computer stock projections – Forecast 8% and Forecast 20%

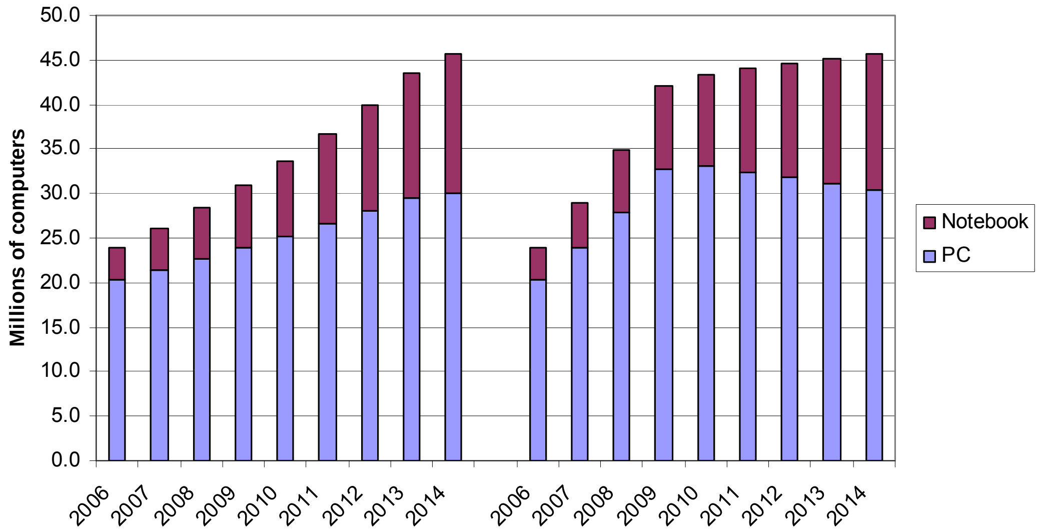



Figure 5 New Zealand computer stock projections - Forecast 8% and Forecast 20%

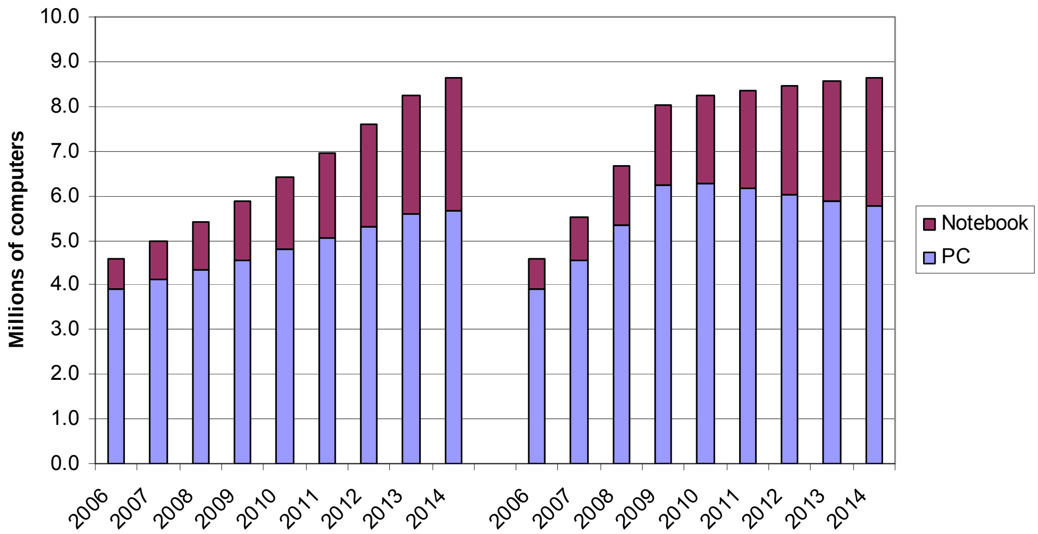


Figure 6 shows projections by monitor type and sizes. In the left hand columns, Forecast 8%, CRTs reduce more rapidly as growth in the office sector is higher as there is a greater trend to LCDs and notebooks in that sector. In the right hand columns, Forecast 20%, CRTs remain relatively high as the growth in the home and office sectors is 20% and the adoption rate of LCD monitors in the home sector instead of CRTs is lower than the office sector. The total monitor stock for each forecast tracks PC stock forecast and would be higher due to the use of docking stations and separate monitors for notebook computers.

Figure 6: Australian monitor stock projections - Forecast 8% and Forecast 20%

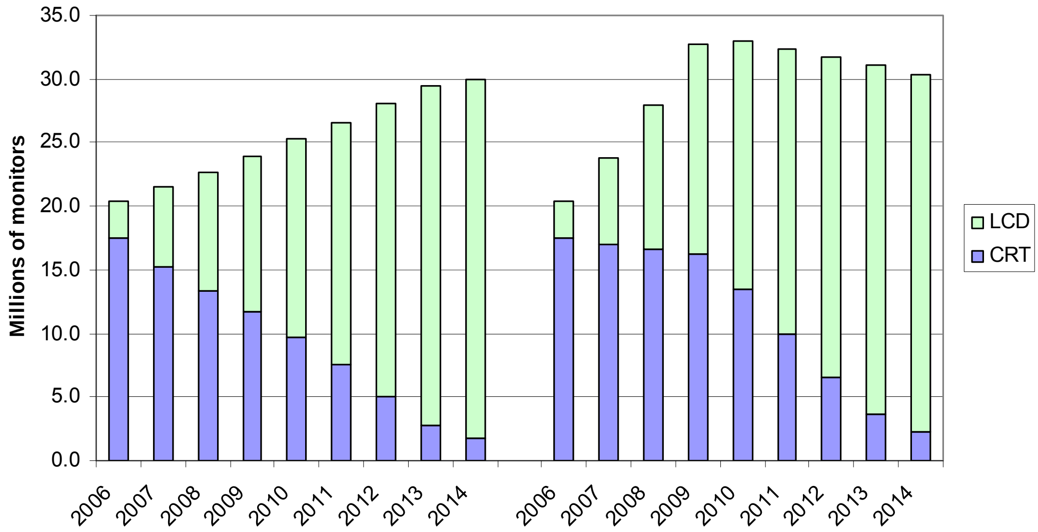
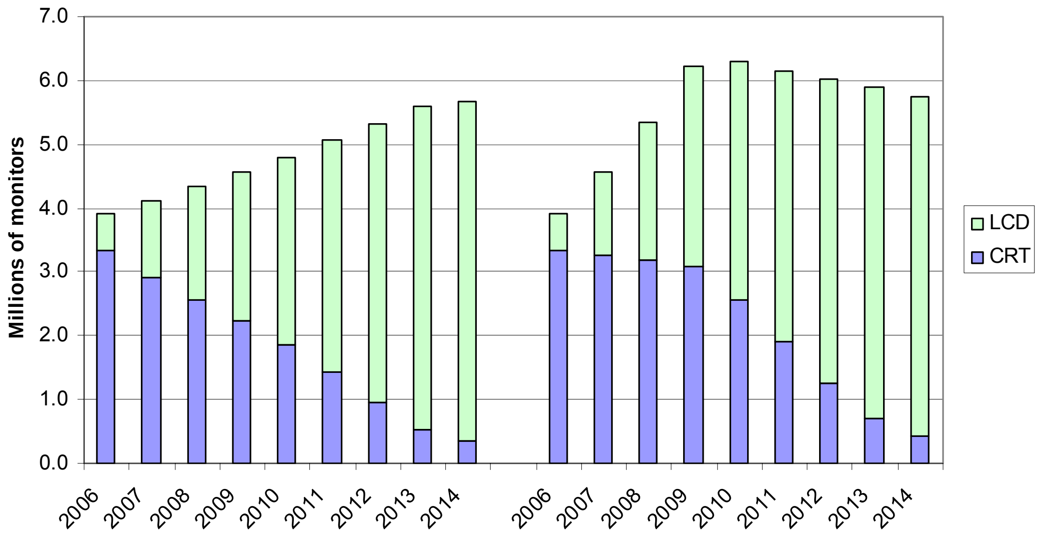



Figure 7: New Zealand monitor stock projections - Forecast 8% and Forecast 20%




# 4 Operation

## 4.1 Computers

Computers typically operate in four modes.

Standby Level (Off Mode): The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

Sleep Mode: A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly 'wake' in response to network connections or user interface devices. For the purposes of this specification, Sleep mode correlates to ACPI System Level S3 (suspend to RAM) state, where applicable. The industry standard power management technology is known as the Advanced Configuration and Power Interface (ACPI), which enables the operating system to control power to your computer and peripheral devices. Sleep mode reduces the power consumption of the computer by cutting power to hardware components. Sleep can cut power to peripheral devices, such as the monitor, even hard drives, but maintains power to the computer memory so work is retained.

Idle State: For purposes of testing and qualifying computers under this specification, this is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default.

Active Mode: The operator is using the computer. E.g. typing or a program is carrying out instructions.

Other options

Other options are available to reduce power consumption, such as hibernate and hard disk(s) off.

Hibernate is an additional low power option and typically must be activated by the operator or system administrator. This is more likely to be implemented on notebook computers, activated when the notebook is using its internal battery and the operator wishes to achieve maximum computer usage time.

Hibernate saves an image of all open files and documents, then powers down the computer. When the power is turned on, all the files and documents saved are opened exactly as they were prior to hibernation.

Hard disk(s) off switches off the power to spinning the hard disk after an operator set time. Again this is more likely to be activated for notebooks using the internal battery.

Table 6 shows the power of the author's notebook when operated with various standard options enabled. This demonstrates significant step reductions in power levels.

Table 6 Power levels by state of a 2005 notebook

| Laptop Mode | AC Power |
|---|---|
| Idle | 47 – 55 W |
| Monitor off | 20.2 W |
| Hard drive Off | 11.6 W |
| Standby | 1.6 W |
| Off and hibernate | 0.8 W |

### 4.2 Monitors

Monitors typically operate in three modes

On Mode/Active Power: The monitor is connected to a power source and produces an image. The power requirement in this mode is typically greater than the power requirement in Sleep and Off Modes described below.

Sleep Mode/Low Power: The reduced power state that the monitor enters after receiving instructions from a computer or via other functions. A blank screen and reduction in power consumption characterize this mode. The computer monitor returns to On Mode with full operational capability upon sensing a request from a user/computer (e.g., user moves the mouse or presses a key on the keyboard).

Off Mode/Standby Power: The lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when a computer monitor is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Off Mode is defined as the power state when the product is connected to a power source, produces no images, and is waiting to be switched to On Mode by a direct signal from a user/computer (e.g. the operator pushes a power switch).

# 5 Energy Consumption and Greenhouse Gas Emissions

## 5.1 Survey Information

In the US, EU and UK, studies have been carried out to provide information on the power and energy performance of computers and monitors. Within Australia, there are two reports that, whilst not focusing on computers and monitors alone, provide sufficient information to indicate that computers and monitors in the Australian market exhibit similar energy performance to those from the international surveys. This data is summarised in the following tables.

Table 7 Comparison of Desktop Computer Power Studies

| | IVF Office | IVF Home | ENERGY STAR | MTP lowest[14] | MTP Highest | NAEEEC Home[15] | NAEEEC Council[16] |
|---|---|---|---|---|---|---|---|
| On/idle | 70.5 - 78 | 50 – 79.7 | 23 – 221 | 39.4 – 55 | 192 – 218 | 65 – 140 | 28.1 - 90 |
| Sleep | 1.2 – 4.2 | 2.61 - 5 | 1.4 – 10.1 | 1.8 – 2.34 | 72.2 – 125.3 | | 1.5 – 6.8 |
| Off | 1 – 2.3 | 0.7 - 3 | 0.4 – 10.1 | 0.9 – 1.31 | 9.64 – 13.04 | 0.7 - 7 | 0.7 – 2.3 |

Table 8 Comparison of Notebook Computer Power Studies

| | IVF Office[17] | IVF Home | ENERGY STAR | NAEEEC Home | NAEEEC Council |
|---|---|---|---|---|---|
| On/idle | 18 – 34.6 | 17 – 34.2 | 6.8 – 38.1 | Note 1 | 15.4 – 44.6 |
| Sleep | 1.7 – 7.7 | 0.5 – 5 | 0.3 – 3.5 | Note 1 | Note 1 |
| Off | 0.3 – 3 | 0.28 – 3 | 0.1 – 2.4 | Note 1 | Note 1 |

Note 1 – data is available, but not included as power may be influenced by condition of batteries.

Table 9 Comparison of CRT Monitor Power Studies

| | IVF | TCO 2005 | NAEEEC Home[18] |
|---|---|---|---|
| On/idle | 75 | 60.4 | 60 |
| Sleep | 9 | 2.6 | 4 (est) |
| Off | 1 | 2.2 | 2.2 (est) |

14 PICT02-MTP-Desktop-PC-Testing-Activities-Results-v2.1.pdf
15 http://energyrating.gov.au/library/pubs/200602-intrusive-survey.pdf 2005 data only
16 http://energyrating.gov.au/library/pubs/200522-standby-local-gov.pdf
17 European Union Energy using Products EuP Lot 3 study www.ecocomputer.org
18 http://energyrating.gov.au/library/pubs/200602-intrusive-survey.pdf 2005 data only

Table 10 Comparison of LCD Monitor Power Studies

| | IVF | TCO 2005 |
|---|---|---|
| On/idle | 30 - 70 | 17.1 - 47 |
| Sleep | 0.65 – 2 | 0.5 – 4 |
| Off | 0.65 - 2 | 0.5 - 3 |

Table 11 Comparison Power Management Data

| | Computers | Monitors |
|---|---|---|
| TIAX[19] USA Office | 6 – 25% | |
| MTP[20] Home | 22% | 73% |
| NAEEEC Council | 15% | 86% |
| NAEEC Home | 23% | |

## 5.2 Energy Consumption Issues

The European study[21] analysed and compared energy consumption data from a range of European and US reports and sources. This study estimated average annual energy consumption, by operational mode, for computers and monitors used in the office and home environments. These estimates are presented in Figure 8 showing annual energy consumption by computer and monitor type, market sector and operational mode. This data is used within this report to estimate current Australian and New Zealand energy consumption.

Figure 8 European estimates of annual energy

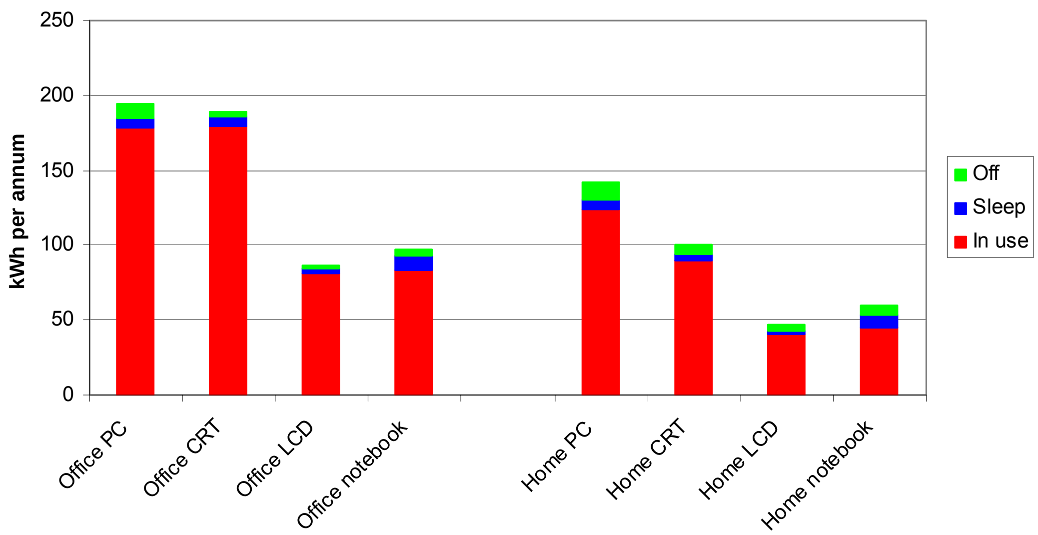



Figure 9, is an alternate view of these estimates showing energy by mode as a percentage.

Figure 9 Percentage annual energy by mode

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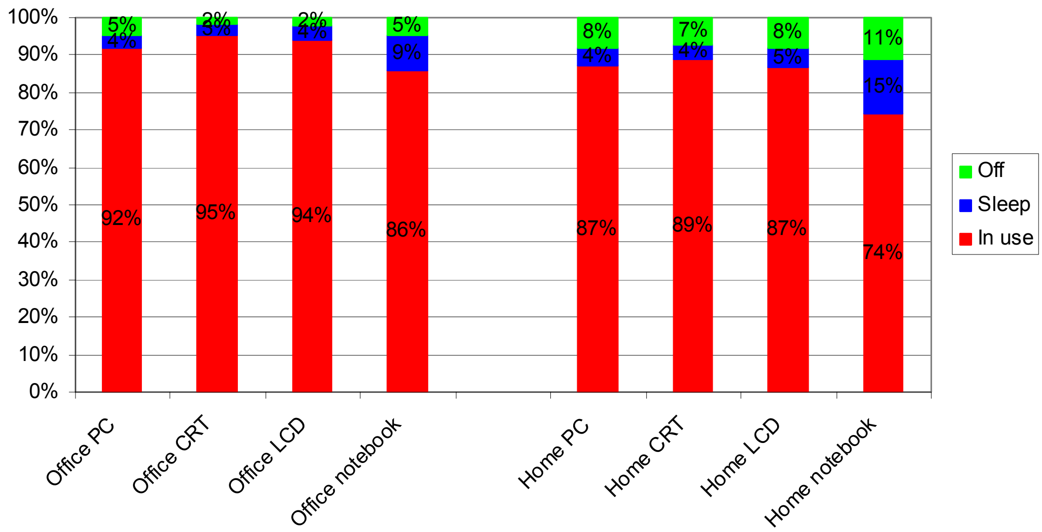
[19] Quoted from EuP Lot 3 study
[20] UK Market Transformation Programme – Monitoring Home Computers
[21] European Union Energy using Products EuP Lot 3 study www.ecocomputer.org




Notable points are from the two figures are;

- 'In use' energy is the most significant energy consuming mode, irrespective of the product or market sector.
- LCD monitors consume significantly less energy than CRT monitors.
- Notebooks consume significantly less overall energy and spend less time in use mode than PCs. I.e. it the probability is higher that even basic power management is enabled for notebooks than PCs, due to user requirements to maximise battery use time.

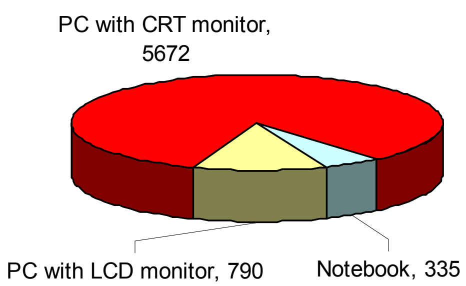
## 5.3 Estimated Total Energy Consumption

The duration of usage of computers and the internet in the business sector is increasing according to many sources. With access to broadband internet, the growth in e-commerce and computers offering additional services, overall computer energy consumption must be rising dramatically though little Australian data exists to verify this conclusion. Computers are also penetrating the home entertainment sector and it is likely that a dedicated computer will be used in addition to computer(s) for 'conventional' use.

Applying the European annual energy data to Australian and New Zealand stock estimates, it is estimated that computer and monitor energy consumption approached 6,800 GWh and 1,308 GWh in Australia and New Zealand respectively in 2006.

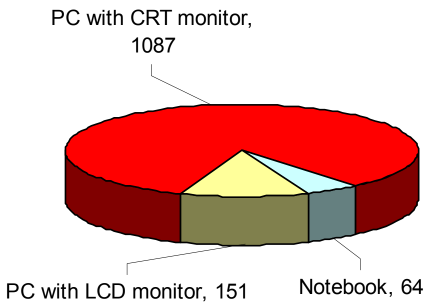
Figure 10 and Figure 11 show the estimated breakdown of energy consumption by type for Australia and New Zealand respectively in 2006. The accompanying tables show the estimated energy attributed to the home and office sectors.

Figure 10 Estimated energy consumption by type – Australia 2006




| 2006 | GWh | Office % | Home % |
|---|---|---|---|
| PC with CRT monitor | 5,672 | 69% | 31% |
| PC with LCD monitor | 790 | 91% | 9% |
| Notebook | 335 | 93% | 7% |

Figure 11 Estimated energy consumption by type – New Zealand 2006




| 2006 | GWh | Office % | Home % |
|---|---|---|---|
| PC with CRT monitor | 1,087 | 69% | 31% |
| PC with LCD monitor | 151 | 91% | 9% |
| Notebook | 64 | 93% | 7% |

## 5.4 Forecast Energy Consumption – Business as Usual

Utilising the stock forecasts from section 3.4 for computers and monitors, combined with annual energy consumption from Figure 8, total energy consumption is forecast to grow as shown in Figure 12 for the 8% and 20% growth forecasts for Australia and in Figure 13 for New Zealand. For the 8% forecast, energy consumption increases gradually as stock levels increase towards later market saturation. With the 20% forecast, saturation and high energy consumption is reached much earlier, after which energy consumption reduces due to earlier increased use of LCDs and notebooks. Due to US ENERGY STAR specifications lower energy consuming computers are appearing in the market, however, analysis of US registration data indicates relatively low numbers for both the US and Australian markets at the moment.

Figure 12 BAU energy consumption – Australia - Forecast 8% and Forecast 20%

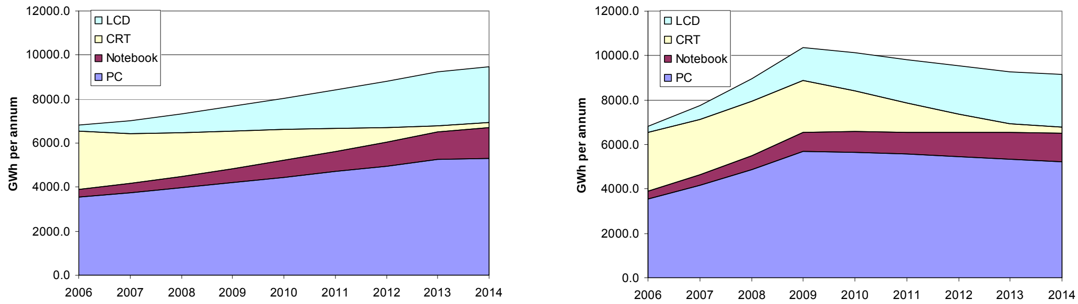
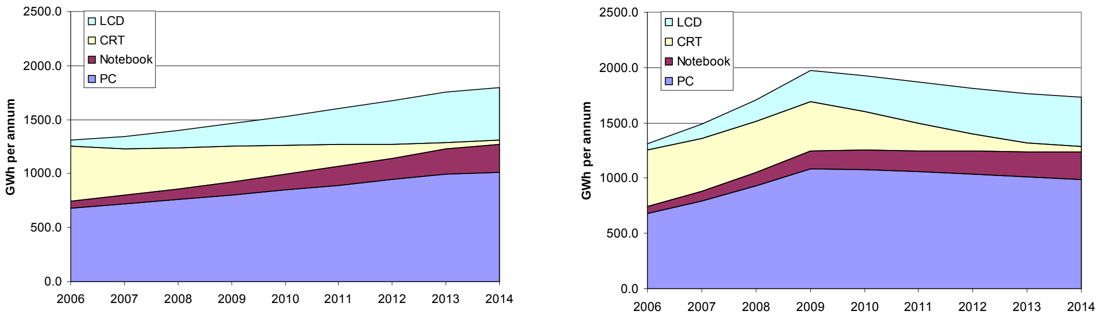



Figure 13 BAU energy consumption – New Zealand - Forecast 8% and Forecast 20%




## 5.5 Greenhouse Emissions

### 5.5.1 Forecast Business as Usual Emissions

Figure 14 shows the forecast greenhouse gas emissions for the two stock growth forecasts. The chart is based upon forecast emissions intensity by State and the energy consumption by State on the assumption that computers and monitors are deployed in proportion to forecast households in each State.

Figure 14 Forecast BAU Greenhouse Gas Emissions - Australia

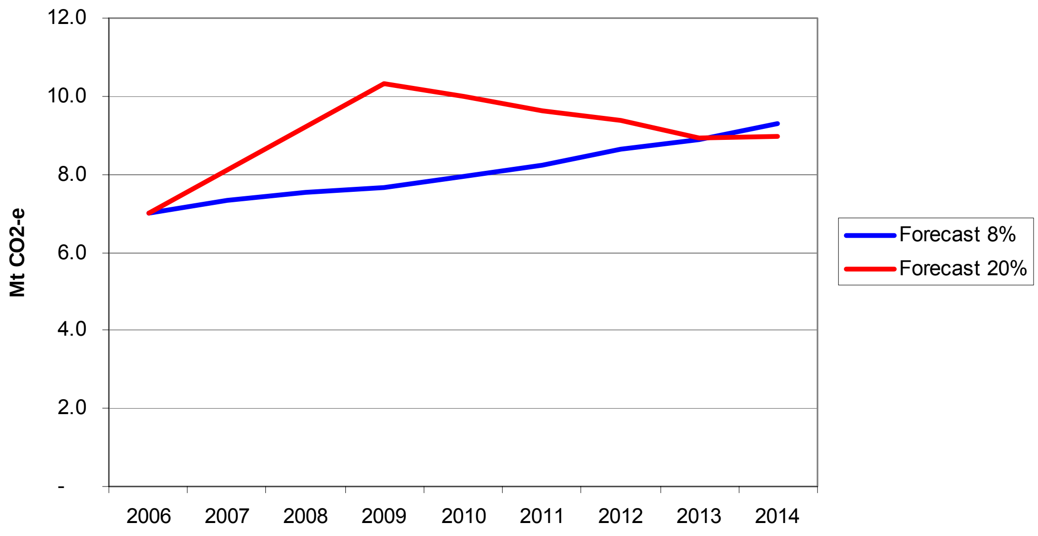
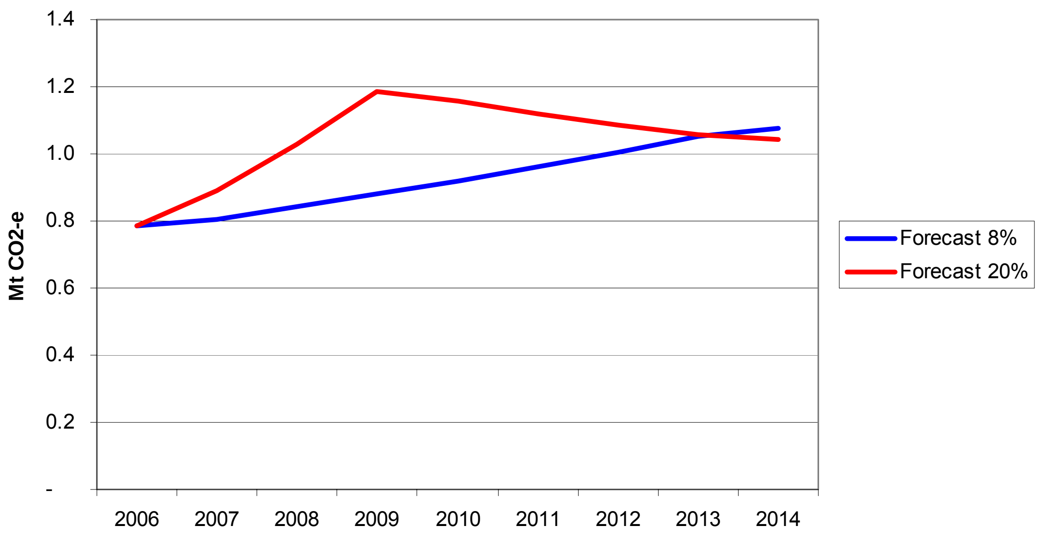



Figure 15 Forecast BAU Greenhouse Gas Emissions – New Zealand




## 5.6 Improving the Performance of Computers and Monitors

As identified in section 5.1, in use energy accounts for a significant proportion of annual energy as shown Table 12.

Table 12 Percentage of energy use by mode

| Product | In use | Sleep | Off |
|---|---|---|---|
| Office PC | 92% | 4% | 5% |
| Office CRT | 95% | 3% | 2% |
| Office LCD | 94% | 4% | 2% |
| Office notebook | 86% | 9% | 5% |

| | | | |
|---|---|---|---|
| Home PC | 87% | 4% | 8% |
| Home CRT | 89% | 4% | 7% |
| Home LCD | 87% | 5% | 8% |
| Home notebook | 74% | 15% | 11% |

### Computers

In August 2006, the US EPA published energy performance of data from tests on 141 PCs from six manufacturers and 89 notebooks from six manufacturers in three operational modes to gauge compliance levels with their power specifications by operational mode. [22] The EPA results of the analysis are shown in Table 13 which indicates high compliance for sleep and off modes, whilst also showing that idle mode compliance was achievable.

Table 13 US EPA Computer Compliance Data

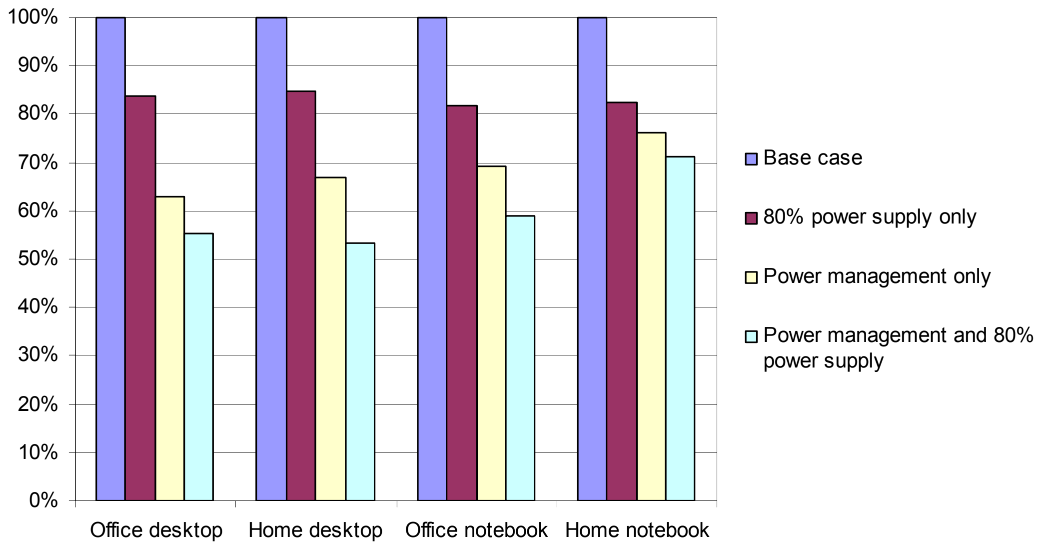
| | Desktops | Notebooks |
|---|---|---|
| Idle State | 28% | 30% |
| Sleep Mode | 90% | 72% |
| Standby (Off Mode) | 79% | 81% |
| All Requirements | 21% | 25% |
| Overall Specification - all Desktops and Notebooks | 22% | |

Energy consumption is highly dependant upon computer type and time in the various operational modes (use profile). The EPA analysis of current computers reports that compliance rate for idle mode (on, but being used) could double just through the use of a more efficient internal power supplies. Current power supplies are typically 65 to 70% efficient at idle power levels, although more efficient and comparably priced 80% power supplies are already available and used by some manufacturers. [23] The EPA analysis also reported that 39% of the computer dataset utilised 80% plus efficient power supplies and that this could be virtually the determining factor influencing power level compliance.

The European Union's EuP Lot 3[24] (energy using products) analysis of computers and monitors reported that significant energy savings can be made by the implementation of power management and, as per the US data, via the use of efficient power supplies. They compared their estimates to a base case annual energy consumption (includes **all** energy from production, distribution, use and disposal).

Figure 16 Computer Energy Consumption, Base Case Compared To Improvements

[22] ENERGY STAR Computer Levels Update 082606
[23] http://www.powerpulse.net:80/story.php?storyID=17523&source=1
[24] European Union Energy using Products EuP Lot 3 study www.ecocomputer.org




With respect to power management, it is typically 'built in' to operating system software and simply enabling it delivers energy savings between 20% to 35% for computers and 30% to 40% for monitors without additional expense.

In response to the need for 'higher end' computing, which is now increasingly available at the consumer end of the market, computer manufacturers have introduced multi-core processors (CPU) to deliver higher performance at lower cost. Traditionally manufacturers have increased the performance of computers by increasing the speed of the single processor. Multi-core processors allow manufacturers to increase performance, by utilising two or more processors on the same motherboard, rather than a single, faster CPU. A reported side benefit is lower processor energy consumption than the single processor approach and lower heat and hence lower cooling requirements. Of note, however, is that overall performance and energy consumption is influenced by other factors, such as bus speed, within the computer. I.e. the use of a multi-core processor may not ultimately improve computing and energy performance.

**Monitors**

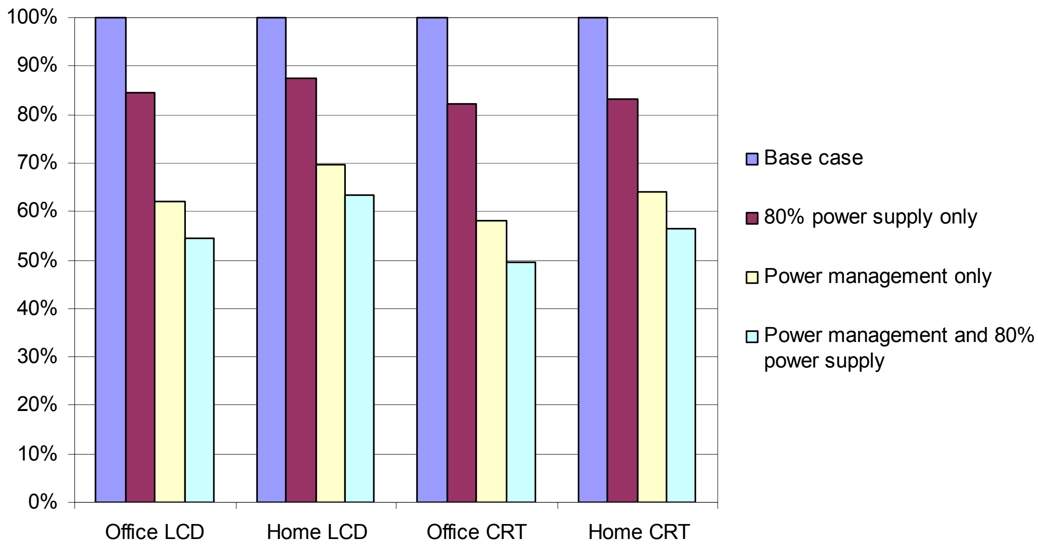
LCDs require some form of illumination behind the screen to allow the display to be seen, unlike applications such as digital watches that rely upon ambient (external) light to be seen. Current LCD technology utilises fluorescent lamps technologies to provide the 'backlit' illumination. Development of alternative technologies are under way, such as light emitting diodes, which have the potential tor educe energy consumption. However, at this time, the technology is relatively immature and expensive. As with computers, power supply efficiency is an important approach to reducing energy consumption, particularly in active mode. Internal power supplies for LCDs with very high efficiencies (93%) are already in the Australian market place. [25] Similarly, high efficiency external power supplies are also widely available in the international supply chain.

For CRT monitors, the principal mechanism is improving power supply efficiency.

As per Figure 16, significant energy savings can be achieved, compared to the BAU case, by improving power supply unit (PSU) efficiency only, power management (PM) only and PSU and PM combined.

Figure 17 Monitor Energy Consumption, Base Case Compared To Improvements

[25] http://203.6.199.77/articles/6b/0c01686b.asp




# 6 Australian and New Zealand Standards for Computers and Monitors

Currently there are no standards addressing the energy performance of computers and monitors.

In 2002, computers and monitors were identified as candidates for further energy performance analysis, beyond the prevailing voluntary power and power management specifications of the ENERGY STAR programme[26]. A subsequent assessment in 2004[27] provided estimates of Australian total computer and monitor energy consumption and concluded that energy consumption had grown in sufficient magnitude to warrant investigating intervention.

As identified in Section 3.3 computer stock is estimated to have been some 24 million, which is a significant increase from the 9.2 million and 14 million estimate in 2002 and 2004 respectively, thus increasing the energy consumption and hence need to consider a range of intervention measures. Australia's and New Zealand's efforts are in harmony with international efforts as summarised in Section 7.

# 7 Overseas programmes for computers and monitors

As summarised in this section, many countries, accounting for the majority of the world's population, have introduced programmes to address market failure in reducing or limiting the energy consumption of computers and monitors. Whilst these are mostly voluntary in nature, additional directives by some governments require that their agencies purchase compliant computers and monitors.

A number of governments and organizations are interceding to address market failures in the energy performance of computers and monitors. Significant worldwide activities are in place to analyse current and achievable power and energy performance, particularly in the European Union, the USA, the UK, Japan, China and Korea.

From the following summary tables it is evident that there are a number of measures, however the variety which strengthens the case to take an internationally harmonised approach to avoid further proliferation to the detriment of suppliers and consumers.

Within the international measures, the US ENERGY STAR programme, is the most tested and practiced specification and will be later proposed as the best available model for standards and specifications in Australia and New Zealand.

[26] http://www.energyrating.gov.au/library/pubs/200307-officeequipment.pdf
[27] http://www.energyrating.gov.au/library/pubs/200406-mepscomputers.pdf

## 7.1 Computers – ENERGY STAR

By far the most comprehensive and influential programme is the US ENERGY STAR programme. Implemented initially in 1999, the programme has expanded its energy efficiency parameters to the release of the most recent version in October 2006. The current version expanded the scope of the specification to target not only desktop and notebook/tablet computers, but also desktop derived servers, games consoles, workstations and integrated computers. With respect to computers, Australia's initial focus will be on desktop and notebook/tablet models.

The energy specification encompasses off (standby), sleep modes and the additional idle mode, which is the state after the computer operating software has loaded and the computer is ready for use. ENERGY STAR Version 4.0 also specifies that display and computer power management must be enabled, with some exceptions, at shipment and that conversion efficiency of the internal power supply be a minimum of 80% for desktop computers and for notebook computers compliant with the ENERGY STAR specification for external power supplies (AS/NZS4665). Internal power supplies are also required to have a power factor greater the 0.9 at 100% of rated output.

Table 14 provides a summary of the ENERGY STAR V4.0 computer specification, which came into effect in July 2007. Full details, including definitions of computer categories, are in Appendix 1

Table 14 Basic Summary of ENERGY STAR Computer Specification V4.0 Tier 1

| Computer type | Sleep mode power consumption | Standby (off) mode | On/idle power consumption |
|---|---|---|---|
| Desktops<br>Integrated<br>Desktop derived servers [1]<br>Games consoles [2] | < 4W | < 2W | Category A: < 50 W<br>Category B: < 65 W<br>Category C: < 95 W |
| Notebooks/tablets | < 1.7W | < 1.0W | Category A < 14W<br>Category B < 22W |
| Wake on LAN adder | + 0.7W | + 0.7W | |
| Workstations | Total energy consumption.(TEC) [3] | | |

1 Desktop derived servers are exempt from the sleep requirement

2 Games consoles are only included in the specification if they meet the physical definition of a high-performance desktop PC.

3 A TEC approach is considered, based on time spent in each mode to calculate annual consumption. The formula is: TEC Power ($P_{TEC}$): ≤ 0.35 * [$P_{Max}$ + (# HDDs * 5)] W where $P_{Max}$ is the maximum power drawn by the system as tested per the test procedure in Section 4 of Appendix A in Appendix 1, and # HDDs is the number of installed hard drives in the system.

## 7.2 Monitors – ENERGY STAR

The US ENERGY STAR programme for monitors is also the most comprehensive and influential programme on global suppliers. The most recent version commenced in July 2006 and set two tiers for maximum power levels for two automatic sleep modes and specified the modes of off, sleep and active. The computer's power management is required to enter sleep mode within 30 minutes of inactivity. If a monitor is capable of entering off mode directly, then the sleep power requirement is not required, however the power may not exceed 2 Watts for Tier 1 and 1 Watt for Tier 2.

Table 15 ENERGY STAR Monitor Specification V4.1

| Tier | Date | Off | Sleep | Active |
|---|---|---|---|---|
| 1 | January 2005 | < 2W | < 4W | (38 x MP) + 30 W |
| 2 | January 2006 | < 1W | < 2W | If Megapixels (MP) < 1, then 23W<br>If Megapixels (MP) ≥1, then (28 x MP) W |

Appendix 2 provides full details of the specification.

## 7.3 Comparison of Computer and Monitor Programmes

Other programmes exist around the world but they are often based upon ENERGY STAR or parts thereof.

Table 16 Computers - Summary of Programs and Initiatives

| Country | Programme | Date | Type | Notes |
|---|---|---|---|---|
| European Union | Eco-label – the Flower | 2005 | Voluntary | PCs and notebooks – sleep 5W, Off 2W |
| EU | ENERGY STAR | July 2007 | Voluntary | Replica of US ENERGY STAR 4.0 |
| Global | TCO Label | 2005 | Voluntary | PCs – sleep 5W, off 2W<br>Notebooks – sleep 4W, off 2W |
| The five Nordic countries | Nordic Eco-labelling. The swan | 2005 | Voluntary | PCs and notebooks – sleep 5W, Off 2W |
| Germany | Blue Angel | 2006 | Voluntary | PCs On (ACPI S3) 4.5W Off 2.5 – 3.5W depending upon wake up.<br>Notebooks On (ACPI S3) 3.5W Off 2W |
| 6 EU countries | Group for energy efficient appliances | 2006 | Voluntary | PC, notebook, desktop computers Sleep 5W Off 2W Idle 70W |
| China | CECP | 2003 | Voluntary | Sleep 10W, off 3W. Time to sleep = 30 minutes |
| Korea | KEMCO | 2003 | Voluntary | Default sleep time and maximum power [28] |
| Korea | KEMCO | 2005-7 | Voluntary | Energy Boy label if <1W sleep.<br>External power supplies 0.5 – 0.75W |
| Korea | KEMCO | 2009 | Mandatory | External power supplies – Energy Star tier 1 |
| Korea | KEMCO | 2010 | Mandatory | 1 W warning or compliance label |
| Australia | Energy Allstars | 2005 | Voluntary | Notebook, desktop computers and workstations Sleep 1 5W<br>Integrated computers Sleep 1 7W<br>Desktops and workstations Sleep 2 2W<br>Notebooks Sleep 2 0.5 (AS/NZS4665)<br>Integrated computers Sleep 2 3W |
| USA | Executive Order 13221/FEMP | 2001 | Recommended for Federal purchases | Standby/off only. Desktop ≤ 2W, Integrated computer ≤ 3W, Notebook ≤ 1W, Workstation ≤ 2W |
| USA | Energy Policy Act 2005 | Sept. 2005 | Requires federal agencies to buy either ENERGY STAR products or products designated as energy efficient by the Federal Energy Management Program (FEMP). | |
| USA | Executive Order13423/FEMP | 2007 | Requires federal agencies to activate ENERGY STAR 'sleep' features on computers and monitors and mandates that federal agencies buy EPEAT registered (ENERGY STAR) products. | |
| Japan | Top Runner | 2007 | The Top Runner program aims to raise energy | |

[28] http://www.clasponline.org/programinfo.php?no=786

| | | | |
|---|---|---|---|
| | | | performance of future products above that of the most energy efficient product in the current market.<br>2007 targets have been set for a range of computer classifications and performance is measured by the average of standby and idle power per million calculations. Compliance is measured weighted average efficiency of shipments in each classification. I.e. a manufacturer can supply compliant and non compliant product as long as the weighted average meets the target for the classification. Top Runner also includes specifications for hard disk drives. |

Table 17 Monitors - Summary of Programs and Initiatives

<table>
<tr><th>Country</th><th>Programme</th><th>Date</th><th>Type</th><th>Off</th><th>Sleep</th><th>Active</th></tr>
<tr><td>USA</td><td>ENERGY STAR</td><td>2005</td><td>Voluntary</td><td>2W</td><td>4W</td><td>30 + (38 x MP) W</td></tr>
<tr><td>USA</td><td>ENERGY STAR</td><td>2006</td><td>Voluntary</td><td>1W</td><td>2W</td><td rowspan="8">If Megapixels (MP) < 1, then 23W<br><br>If MP ≥ 1, then 28 x MP</td></tr>
<tr><td>EU</td><td>ENERGY STAR</td><td>July 2007</td><td>Voluntary</td><td>1W</td><td>2W</td></tr>
<tr><td>Global</td><td>TCO Label</td><td>2006</td><td>Voluntary</td><td>1W</td><td>2W</td></tr>
<tr><td>EU</td><td>Eco label the Flower</td><td>2005</td><td>Voluntary</td><td>1W</td><td>2W</td></tr>
<tr><td>Germany</td><td>Blue Angel</td><td>2006</td><td>Voluntary</td><td>1W</td><td>2W</td></tr>
<tr><td>6 EU countries</td><td>Group for energy efficient appliances</td><td>2006</td><td>Voluntary</td><td>1W</td><td>2W or 2.3W with USB</td></tr>
<tr><td>Australia</td><td>Energy Allstars</td><td>2005</td><td>Voluntary</td><td>1W</td><td>2W</td></tr>
<tr><td>China</td><td>CECP</td><td>2003</td><td>Voluntary</td><td>2W</td><td>4W</td><td>NA Default sleep time = 15 minutes</td></tr>
<tr><td>Korea</td><td>KEMCO</td><td>2004</td><td>Voluntary</td><td>2W</td><td>4W</td><td>NA</td></tr>
<tr><td>USA</td><td>Executive Order 13221/FEMP</td><td>2001</td><td>Recommended for Federal purchases</td><td>1W</td><td>NA</td><td>NA</td></tr>
<tr><td>USA</td><td>Energy Policy Act 2005</td><td>2005</td><td colspan="4">Requires federal agencies to buy either ENERGY STAR products or products designated as energy efficient by the Federal Energy Management Program (FEMP).</td></tr>
<tr><td>USA</td><td>Executive Order13423/FEMP</td><td>2007</td><td colspan="4">Requires federal agencies to activate ENERGY STAR ‘sleep’ features on computers and monitors and mandates that federal agencies buy EPEAT registered (ENERGY STAR) products.</td></tr>
</table>

Other broader environmental programmes exist, such as the Climate Savers Computing Initiative and Electronic Product Environmental Assessment Tool (EPEAT), which include compliance with the ENERGY STAR V4.0 computer specifications as a minimum.

# 8 Analysis

## 8.1 General Discussion

There are compelling reasons to introduce mandatory labelling and MEPS for computers and monitors. The evidence is that the industry at large has not embraced more efficient products and that there is significant scope to improve the energy performance of computers and monitors. There is also evidence that most consumers are not minimising their energy consumption through existing power management options built into computers.

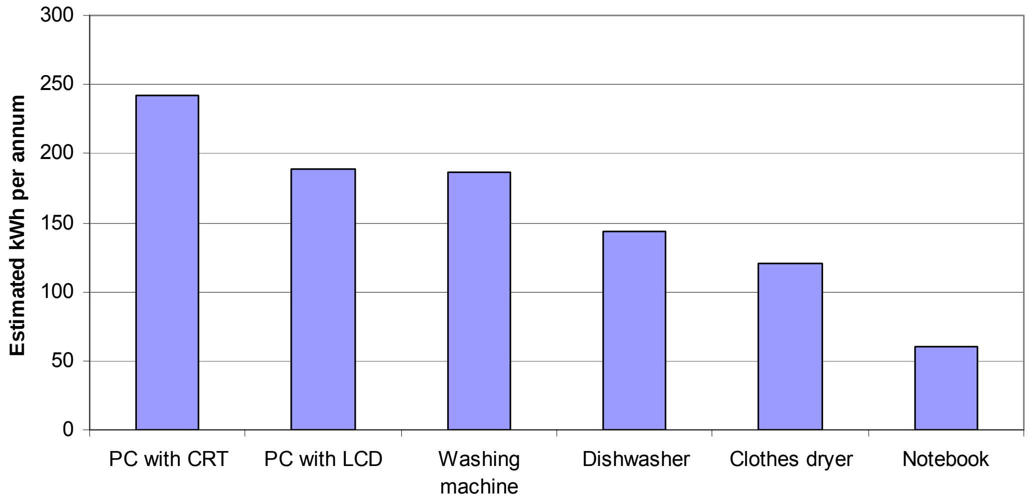
In summary, market failure exists and some form or forms of intervention is are required to influence the supply and demand sides of the market.

Voluntary programmes have influenced low power modes for many computers, however on/idle mode performance of computers has not been driven by market forces, with the exception of purchasing policies and directives of governments. Whilst government markets are large, the balance of the market (estimated at 66%) is disparate and does not have the purchasing power to demand better energy performance.

The energy performance of monitors in off, sleep and on modes appears to be more in accord with the specifications of voluntary measures, however the evidence is that energy consumption for many monitors in all modes is still much greater than it can be.

At the household level, computers and monitors consume significant amounts of energy and, as shown in Figure 18, this exceeds the typical annual energy consumption of products subject to mandatory energy rating labelling in Australia and New Zealand.

Figure 18 Estimated Annual Energy Consumption of Computer Systems and Regulated White Goods




The market has experienced high growth and is forecast to continue due to increasing use of the internet in the home and office sectors combined with cheaper, higher performance computers and reducing prices of LCD monitors. The 'in use' stock of computers and monitors is estimated to have more than doubled in the last four years and is forecast to continue to for the foreseeable future. Indeed, the latest Australian Bureau of Statistics data[29] on household goods, published in 2005, shows the penetration of home computers exceeds that of some products subject to mandatory energy performance labelling.

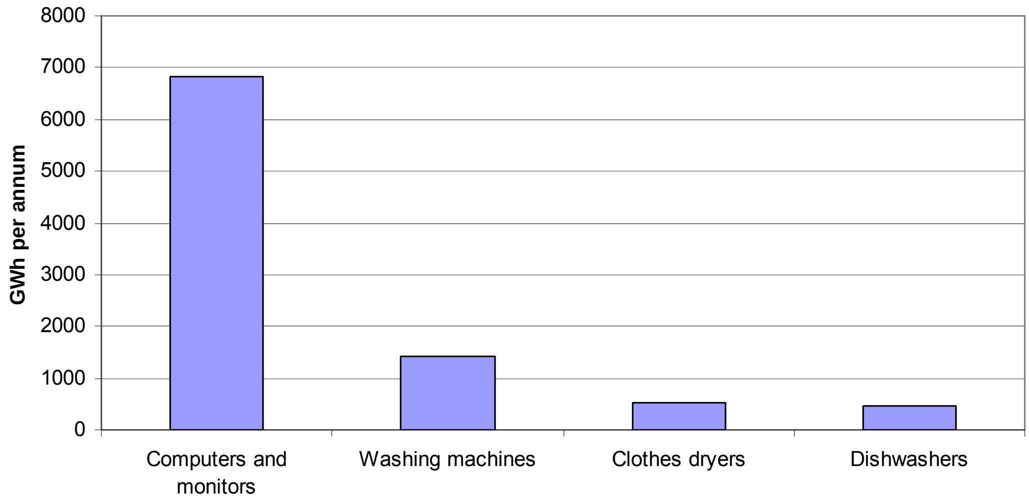
| Product | ABS estimates 2005 |
|---|---|
| Clothes Dryers | 4.32 million |

29 4602.0 - Environmental Issues: People's Views and Practices, Mar 2005

| | |
|---|---|
| Dishwashers | 3.26 million |
| Washing machines | 7.56 million |
| Computer systems | 6.75 million |

Combining the ABS stock estimates for with estimated annual energy consumption, Figure 19 shows that office and home computer systems consume significantly more energy than products already subject to mandatory energy performance labelling.

Figure 19 Australian Estimated Energy Consumption – Regulated White Goods and Computer Systems




Technical evidence from recent tests shows that low energy computers are available now and that many models have consumption levels well in excess of the low energy computers with the same or similar specifications.

Technical evidence for monitors shows that many low energy monitors models are available now and that many models have consumption levels well in excess of the low energy models with the same or similar resolution.

The European analysis indicates energy savings of the order of 45% are achievable through the use of more efficient components and enabling power management software.

There is high consumer interest in labels to show the energy performance of computers and monitors.

The following sections provide further information on market failure and proposals for energy labelling and MEPS.

## 8.2 Computer Market Failure

There is clear evidence that there is failure on the supply side of the market for computers. Hardware design/selection is in the domain of designers and suppliers, however energy performance to a degree is be influenced by government directives, purchasing policies and programmes. Analysis of the US ENERGY STAR computer data, that was used to gauge compliance levels with their specification, shows not only that low energy computers are in the market, but also that many models consumed much more energy. This shown in the following figures utilising the ENERGY STAR computer categories A, B and C.[30] The pale green column shows the quantity of computers that comply with the idle power specification.

[30] Further details in Appendix 1 – ENERGY STAR Program Requirement for computers, pp. 36 – 37.

Figure 20 Category A Computer Idle Power

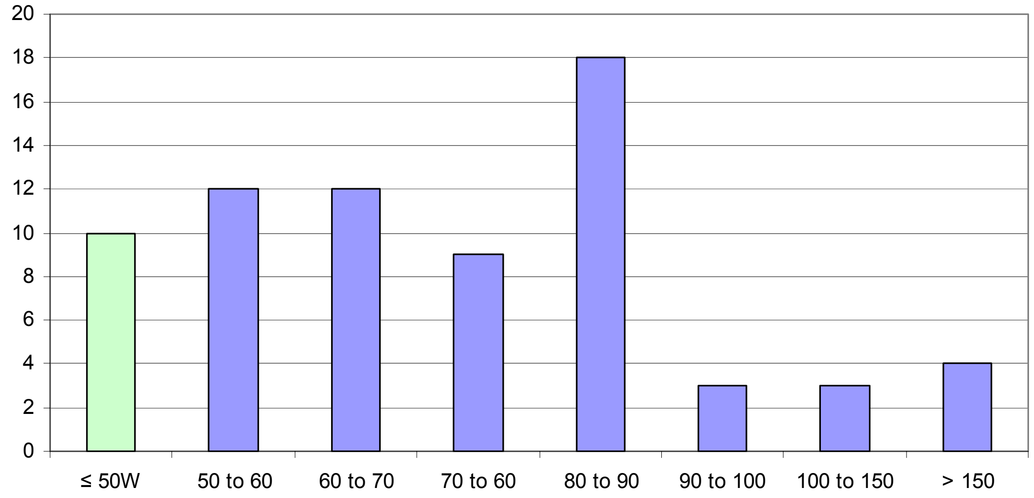



Figure 21 Category B Computer Idle Power

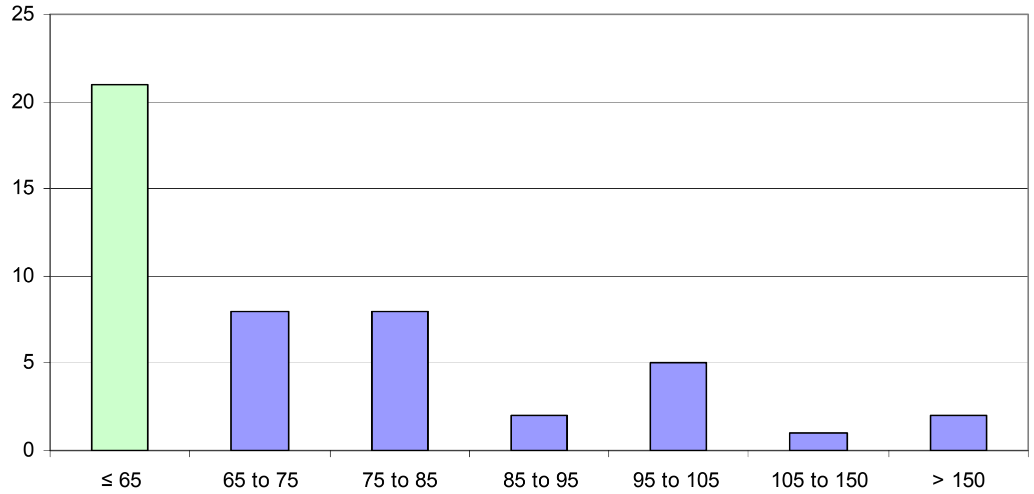
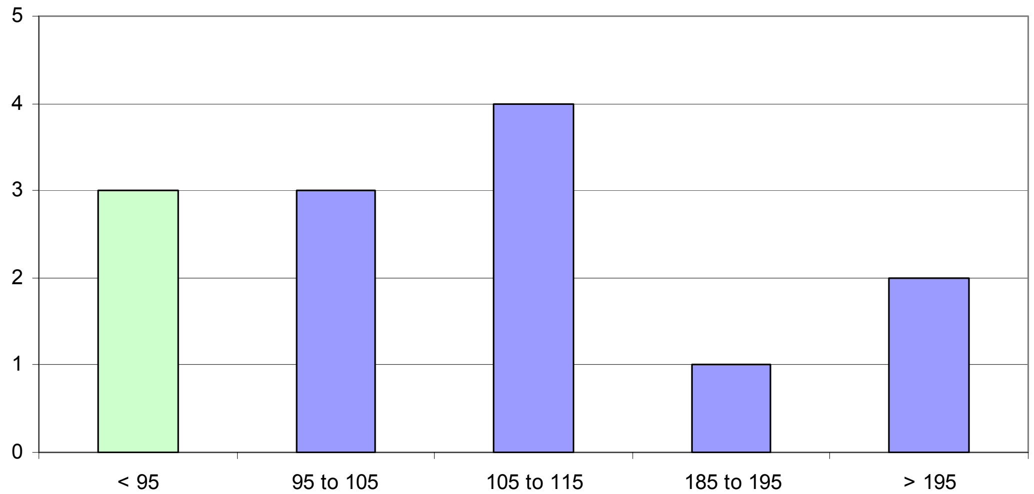



Figure 22 Category C Computer Idle Power



## 8.3 Monitor Market Failure

Comparable computer monitor data is not readily available, however analysis of data registered on the European Union's list of ENERGY STAR qualified monitors indicates that there is a wide range of idle mode power levels for monitors with the same display resolution. Some of this data was incomplete or appeared spurious in nature and has been omitted. Off and sleep mode compliance was virtually 100%, however this is to be expected in a list of qualified monitors.

For CRT monitors, Table 18 shows the display megapixels, quantity of CRTs used for data, power range and the percentage difference between minimum and maximum power (for CRT monitors where reasonable amounts of data is available). This shows that there are significant differences in idle power, just amongst products registered as ENERGY STAR compliant and hence scope to reduce energy consumption. The table also shows the percentage of monitors complying with ENERGY STAR Tier 1 and Tier 2 idle power levels. Tier 1 allowance is 30W + 38 x Megapixels. Tier 2 is also based upon megapixels as follows. If MP < 1, the maximum power allowed is 23 W. If MP ≥ 1, then maximum power is 28 x MP.

Table 18 EU ENERGY STAR CRT Idle Power

| Megapixels | Quantity | Minimum Watts | Maximum Watts | Increase Min to Max Watts | Tier 1 compliance | Tier 2 compliance |
|---|---|---|---|---|---|---|
| 0.8 | 9 | 52 | 72.7 | 40% | 33% | |
| 1 | 4 | 62 | 64.5 | | 100% | |
| 1.3 | 16 | 53.8 | 90 | 67% | 88% | |
| 1.9 | 15 | 61.9 | 123.9 | 100% | 87% | |
| 2.3 | 2 | 113.3 | 113.9 | | 100% | |
| 2.4 | 1 | 99.2 | 99.2 | | 100% | |
| 2.6 | 2 | 72.6 | 72.6 | | 100% | |
| 3.1 | 10 | 104.9 | 142 | 35% | 100% | |

Table 19 shows the display Megapixels, quantity of LCDs used for data, power range and the percentage difference between minimum and maximum power. This shows that there are very significant differences in idle power, amongst LCD products registered as ENERGY STAR compliant. The table also shows the percentage of monitors complying with ENERGY STAR Tier 1 and Tier 2 idle power levels.

Table 19 EU ENERGY STAR LCD Idle Power

| Megapixels | Quantity | Minimum Watts | Maximum Watts | Increase Min to Max Watts | Tier 1 compliance | Tier 2 compliance |
|---|---|---|---|---|---|---|
| 0.8 | 63 | 12.8 | 41 | 220% | 27% | 73% |
| 1 | 4 | 11.4 | 33.7 | 196% | 50% | 50% |
| 1.3 | 624 | 13.8 | 76 | 451% | 8% | 92% |
| 1.5 | 8 | 24.4 | 38.4 | 57% | 0% | 100% |
| 1.76 | 111 | 24.7 | 62.4 | 153% | 4% | 96% |
| 1.92 | 50 | 35.1 | 82 | 134% | 14% | 86% |
| 2.3 | 37 | 26.4 | 67.6 | 156% | 11% | 89% |
| 4.1 | 5 | 65.1 | 115 | 77% | 20% | 80% |

## 8.4 Information and Power Management

### Energy information

The most obvious barrier to the uptake of lower energy consuming computers and monitors is lack of information and awareness of the magnitude of energy consumption. Typically power specifications available to consumers is limited to the maximum AC power requirement, however there are products promoted as meeting ENERGY STAR criteria. The principal requirement for consumers is that the computer and monitor meet their performance and/or visual requirements. If energy data is not available, then it cannot be part of the decision making process.

With respect to lack of information on energy performance of products in general, Australia's Productivity Commission's report, 'The Private Cost Effectiveness of Improving Energy Efficiency' identified the following relevant points:

*"The most important barriers to the adoption of privately cost-effective energy efficiency improvements appear to be:*

- *A failure in the provision of information…*

  *Some government intervention to address these problems is appropriate. The Commission favours light-handed regulatory responses and information provision, rather than more prescriptive and intrusive approaches:*

- *Mandatory labelling can be an appropriate way of providing information"*

**Power management**

Power management capability is built into computers. Many energy reports refer to power management not being enabled, it is rarely quantified. Some data is available, as per Table 20, which shows that implementation rates are very low for computers and generally much higher for monitors.

Table 20 Power Management Data

| | Computers | Monitors |
|---|---|---|
| USA Office - TIAX[31] | 6 – 25% | |
| UK - MTP[32] Home | 22% | 73% |
| Australian Councils[33] | 15% | 86% |
| Australian Homes[34] | 23% | |

As a rule, unless specified in a procurement programme or by an IT policy, power management is not enabled for computers at time of supply of bundled packages nor in operating system software sold for subsequent installation.

A number of factors are likely to account for not enabling power management.

- Lack of information, knowledge or interest in energy consumption.
- Lack of knowledge that power management options are available.
- Reluctance by consumers to modify default software/hardware settings on a product performs it's intended function.
- In some environments it may impossible for users to enable it due to default settings set by IT administrators.

In summary, if consumers do not have information or knowledge there will be failure in their ability to influence the market.

## 8.5 Mandatory Labeling and Minimum Energy Performance Standards

Regulatory intervention measures have been an effective means to address market failure in both supply and consumer sides of markets. Australia and New Zealand have an excellent track record using these measures to reduce energy consumption of white goods and some industrial and commercial products. For example, refrigerator and freezer energy consumption has fallen by some 37% between the announcement of MEPS in 1996 and the introduction of more stringent MEPS in 2005.

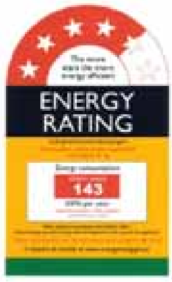
Within the Australian and New Zealand there are markets catered for by manufacturers of 'white box' and bespoke models. Within this sector, there may well be many 'one off' builds, rather than having

[31] Quoted from EuP Lot 3 study
[32] UK Market Transformation Programme – Monitoring Home Computers
[33] http://energyrating.gov.au/library/details200522-standby-local-gov.html
[34] http://energyrating.gov.au/library/details200602-intrusive-survey.html

specific models as per the larger brand name suppliers. Testing for compliance of 'one off' white boxes or bespoke products would place an unreasonable burden on these manufacturers. The recommended approach is to include a 'deem to comply' section in the standard to cover the major components that influence energy consumption. For example, manufacturers would be required to use internal power supplies certified to comply with the proposed standard, use motherboards, video cards, displays etc. that are used in compliant computers. It is recognised that simply using 'deem to comply' components may not produce a compliant computer, however it is a mechanism to improve the energy performance in this broad, difficult to control sector. Consideration will also need to be given as to a threshold of products manufactured each year, above which a manufacturer will be required to test for compliance. This issue needs to be explored further in stakeholder discussion groups and at the working group level of the Australian/New Zealand standards committee.

### 8.5.1 Mandatory labelling - Energy Rating Labels

Energy rating labels were introduced in 1986 for refrigerators and freezers in Victoria and New South Wales. Subsequently the rating label programme expanded to all states and territories and now covers a range of whitegoods and air-conditioners. It been highly effective in raising energy awareness for both consumers and suppliers/manufacturers and combined with the introduction of MEPS in 1999 at a national level and subsequent more stringent MEPS in 2005. For example, consumers can now purchase refrigerators consuming 37% less energy than in 1996 and with additional features such as automatic defrosting.




The label has two main features to allow comparison of competing products.

1. A star rating, from one to six, to allow rapid visual comparison of energy performance.
2. A numerical value providing typical annual energy consumption.

From a supplier/manufacturer perspective, it provides a fair and equitable means of displaying product energy performance.

Ultimately the success of these labels relies upon purchaser selection of more efficient appliances in conjunction with their personal requirements. The labels also encourage some manufacturers and suppliers to further improve the energy performance of their products as another benefit of purchasing their product in favour of another.

In March 2007 a survey of 1500 on-line internet users was conducted by AC Nielsen to investigate consumer attitudes towards computers and energy labelling. 95% of computer/internet users were in favour of mandatory labelling of computers and monitors. In the same study, 1400 people were contacted by telephone and more than four out of five participants were in favour of mandatory labelling of computers and monitors. This statistically relevant sample clearly indicates consumers will value accurate energy performance information.

Given the positive consumer response, some form of endorsement labelling is required and it is recommended that government engage with industry to review suitable mechanisms for computers and monitors.

Given the familiarity and success of the star rating label, it is recommended that this be utilised for computers and monitors. The ENERGY STAR logo label was also considered, however it was determined that it did not provide the comparative information. Also ENERGY STAR specifications can and have changed over time as energy performance targets are raised or expanded. In summary, the logo alone does not provide comparative information nor does the logo indicate which specification was used to allow use of the label.

In the case of computers and monitors, there are a myriad of models/types with an array of performance and functionality options. For any given computer or monitor, annual energy consumption is highly influenced by how much time the computer is actually in use, thus making a standard annual energy algorithm difficult to establish and not necessarily providing meaningful energy information.

**Computer label recommendations**

<u>Visual marking</u>

It is recommended to utilise the standard energy rating label arch with six whole stars available. Computers compliant with the recommended MEPS would be marked with two stars. Some computers, due to the deem to comply option, will not tested for compliance and to differentiate these from tested, compliant computers, it is recommended that these be marked with one star. The remaining stars will be reserved for future voluntary high efficiency specifications and/or MEPS, thus providing a 'long life' for the label.

Within the ENERGY STAR specifications, desktop computers are categorised by types A, B and C, each with different idle power specifications. Notebook computers are categorised by types A and B, each with different idle power specifications. To differentiate between types to avoid consumer energy performance comparison between, for example type A and type B computers, it is recommended that the label is also marked with the computer category.

<u>Performance information</u>

Power management and maximum power for off and sleep modes have been specified for desktop computers and notebooks. Even with the mandatory power management enabled, on/idle mode remains the most energy consuming mode and therefore this is the most important comparison information for consumers. Therefore it is recommended that the label is marked with the measured idle power only.

For deem to comply computers, this section of the label cannot have a power level and it is recommended that the label be marked with one star and text advising that the computer has not been tested in accordance with the standard.

The label could also be used to stimulate consumer awareness of power management for other computers they may own. For example additional information could be added to the label 'Power management is enabled for automatic energy savings'.

Figure 23 Examples of Computer Labels


**Monitor label options**

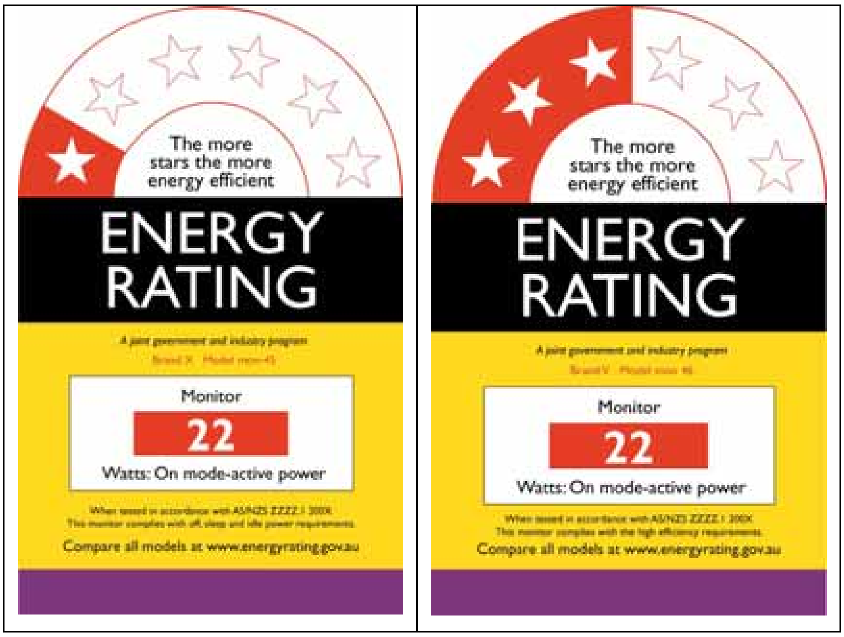
<u>Visual marking</u>

As with computers, it is recommended to utilise the standard arch with six stars available. Monitors compliant with the recommended MEPS (ENERGY STAR Tier 1) would be marked with one star. Monitors compliant with the voluntary high efficiency specifications (ENERGY STAR Tier 2) would be marked with three stars. The remaining stars are reserved for future voluntary high efficiency specifications and MEPS, thus again providing a 'long life' for the label.

<u>Performance information</u>

Maximum power for off and sleep modes have been specified for monitors as per the recommended MEPS and voluntary high efficiency levels for sleep and off modes. Even with the mandatory power management enabled on the monitor, on/idle mode remains the most energy consuming mode and therefore this is the most important comparative information for consumers. Therefore it is recommended that the label is marked with the measured idle power only.

Figure 24 Examples of Monitor Labels




### 8.5.2 Minimum Energy Performance Standards

MEPS aims to remove the worst performing products from the marketplace rather than promoting the best products, as with most voluntary programmes. MEPS are implemented by including energy performance criteria within an Australian/New Zealand Standard, which is mandated through State, Territory and New Zealand legislation. These requirements apply to products covered by the standard which are sold in Australia (and usually New Zealand as well).

It is proposed that mandatory MEPS apply to computers and monitors within the scope of the proposed Australian/New Zealand Standard and include the consumer information energy rating label.

In the main, computers, monitors and their major components are globally traded products. Within the review of international programmes, the US ENERGY STAR test methods and specifications have been identified as the most influential in the global market. In the case of computer and monitor energy performance, MEPS, in accordance with ENERGY STAR specifications, are likely to achieve the best outcome for the Australian and New Zealand markets.

Utilising the ENERGY STAR specifications will provide surety to suppliers and manufacturers that there will not be a special case requirement in our relatively small, in global terms, market. At the recent Asia Pacific Partnership (APP) standards harmonisation workshop in the US, Australia presented its case for the establishment of an international working group to initiate an international test standard for computers and monitors. In the electronics sector from the APP workshop, computers and monitors have been given the highest priority for harmonisation of test specifications. A major benefit of harmonised test specifications is that manufacturers, importers etc. and regulatory bodies minimise the cost of testing and compliance as there is a uniform test method and the tests can be carried out at source for the global market.

Seven brand name suppliers currently account for circa 72% of computer sales and as MEPS apply to all, there must be a mechanism in place to ensure compliance in the remaining 28%. Much of this market is supplied by 'white box' assemblers using mostly imported components. Within this sector, there may well be many 'one off' builds, rather than having specific models as per the larger brand name suppliers. Testing for compliance of 'one off' white boxes would place an unreasonable burden on these manufacturers. The recommended solution is to include a 'deem to comply' section in the standard to cover the major components that influence energy consumption. For example, manufacturers would be required to use internal power supplies certified to comply with the proposed standard, use motherboards, video cards etc. that are used in compliant computers. It is recognised that simply using 'deem to comply' components may not produce a MEPS compliant computer, however it is a mechanism to improve the energy performance in this broad, difficult to monitor sector. This will be explored further in stakeholder discussion groups and at the working group level of the Australian/New Zealand standards committee.

# 9 Recommendations

In conclusion, the following recommendations are made:

- Australian and New Zealand Standards are developed, based upon ENERGY STAR V4.0 for computer test methods. Computers to be included are both stationary and portable units, including desktop computers, integrated computers, notebook computers, tablet computers and desktop-derived servers
- An Australian and New Zealand Standard is developed, based upon ENERGY STAR V4.1 for computer monitor test methods.
- An Australian and New Zealand Standard is developed, based upon the Generalised Internal Power Supply Test Protocol Rev 6.1, for internal power supply test methods and computer internal power efficiency is no less than 80% when tested with this standard.
- That E3 plans to introduce MEPS for computers, including mandatory power management enablement prior to supply, based upon ENERGY STAR computer specifications V4.0 as follows:

| Computer type | Sleep mode power consumption | Standby (off) mode | On/idle power consumption |
|---|---|---|---|
| Desktops<br>Integrated<br>Desktop-derived servers | < 4W | < 2W | Category A: < 50 W<br>Category B: < 65 W<br>Category C: < 95 W |
| Notebooks/tablets | < 1.7W | < 1.0W | Category A < 14W<br>Category B < 22W |
| Wake on LAN adder | + 0.7W | + 0.7W | |

  Computer internal power efficiency is no less than 80%

  Power management is enabled prior to supply.

- That E3 plans to introduce MEPS for monitors, based upon ENERGY STAR specification version 4.1 Tier 1 as follows:

| Off | Sleep | Active |
|---|---|---|
| < 2W | < 4W | 30 + (Megapixels x 38) W |

- That E3 plans to introduce a voluntary ‘high efficiency’ energy performance level for monitors, based upon ENERGY STAR specification version 4.1 Tier 2 as follows:

| Off | Sleep | Active |
|---|---|---|
| < 1W | < 2W | If Megapixels (MP) less than 1, then 23 W<br>If Megapixels (MP) greater than 1, then 28 x MP W |

- That the Australian and New Zealand standard includes mandatory energy performance labels for computers and monitors.
- ‘Deem to comply’ is included in the computer and monitor standards. Mandatory labelling would also apply.

## 9.1 Timetable

The recommended timetable for the implementation of MEPS and labelling for computers and monitors, as outlined above, is shown in Table 21. It is important that sufficient time is allowed for assemblers, importers and customers to adjust to these proposals. The recommendation for MEPS to be introduced no earlier than October 2009 is based upon the fact that computers and monitors are globally traded products or assembled from globally traded products. By October 2009, the ‘de-facto’ specification, ENERGY STAR Tier 1 (this MEPS proposal), will have been in place for in excess of 2 years and therefore those who would voluntarily comply with international forces would have done so by then. I.e. the technology should be mature and applied by those willing to participate.

This allows for a period a consultation regarding the proposals, and for Government to consider representations from industry and other stakeholders. It will also allow adequate time for the proposal to address the 'white box' suppliers who may not participate in industry associations, but still keep abreast of news via computing magazines and web sites/broadcasts. A working group under the Standards Australia committee TE-01 will be formed to consider new draft Standards. Initial drafts accompany this report.

In concert with the draft standards, a regulatory impact statement will be developed, including the mandatory consultation and alternative option analysis associated with this task. It should be noted that it is a requirement that a regulatory impact assessment is undertaken before any new legislation is passed, ensuring that national cost-benefit of the proposal is positive. Additional information follows this section.

This period timetable also allows for the AGO to advertise the impending requirements to industry and consumers.

Table 21 Proposed timetable for implementation of MEPS for computers and monitors

| Item | Date |
|---|---|
| AIIA meeting to flag intentions | May 2007 |
| Publication of computer and monitor profile fact sheet | August 2007 |
| Australian proposal to AP6 to develop harmonised standards | August 2007 |
| Draft technical report for industry comment | October 2007 |
| Release of E3 Plan | October 2007 |
| Consultation with Industry | August – October 2007 |
| Draft standards for Standards working group | October 2007 |
| Consideration of draft Standard by Working Group of Standards Committee (ME-01) | November 2007 |
| Publication of Draft Standards | |
| Publication of draft cost benefit analysis | January 2008 |
| Publication of Standards | |
| Draft Regulatory Impact Statement | May 2008 |
| Stakeholder forum to discuss draft RIS | July 2008 |
| Final (decision) RIS clearance | September 2008 |
| Approval of decision RIS by MCE | October 2008 |
| Implementation of MEPS | October 2009 |

**Additional process notes**

The Council of Australian Governments (COAG) requires that all proposed Australian regulations undergo a Regulatory Impact Statement (RIS) process. This includes detailed analysis of the costs and benefits of the proposal, together with examination of any associated economic and trade implications. The resultant report must be published for comment, and any adverse reaction must be addressed.

A Regulatory Impact Statement shall therefore be prepared after publication of a draft Australian Standard for computers, monitors and internal power supplies, and before the implementation of MEPS.

However, some points are worth making at this stage.

- With respect to the impact on trade, some the bulk of computers and monitors are imported or assembled from mostly imported components. Importers and product specifiers will need to ensure that computers and monitors or the components imported will, after assembly, comply with the new MEPS or ‘deem to comply’ requirements as appropriate. Given that the US ENERGY STAR specification for computers will have been in place for over two years, it is anticipated that there will be sufficient numbers of compliant models and components available in the Australian and New Zealand markets. Similarly the US ENERGY STAR monitor Tier 1 specification will have been in place for four years, it is anticipated that there will be sufficient numbers of compliant models in the Australian and New Zealand Markets.

- By allowing at least 12 months between the publication of the new Australian Standard and implementation of MEPS in 2009, there should be adequate time for the Australian industry to make any necessary adjustments to purchasing policies.

# 10 Energy and Greenhouse Reduction Potential

This analysis of the potential for reducing energy consumption and greenhouse emissions from computers and monitors machines is based upon the following assumptions:

- The 2006 estimated Australian stock is 20.4 Million desktop computers, 3.6 Million notebooks, 17.5 Million CRTs and 2.95 Million LCDs as per Table 3;
- The 2006 estimated New Zealand stock is 3.91 Million desktop computers, 0.69 Million notebooks, 3.35 Million CRTs and 0.56 Million LCDs as per Table 4.
- Current stock of computers and monitors in Australia and New Zealand, as above, consumed average annual energy as detailed in Figure 8;
- Forecast 8% 5% and 10% annual growth in the home and office sectors respectively, averaging 8%;
- Forecast 20% 20 % annual growth in both home and office sectors;
- MEPS are introduced October 2009. The analysis is from January 2010 to allow for 3 months of existing stock to be sold.

Figure 25 shows the Australian energy consumption by year for the two forecasts and compares BAU with MEPS.

Figure 25 Forecast Energy Consumption – BAU and MEPS – Australia

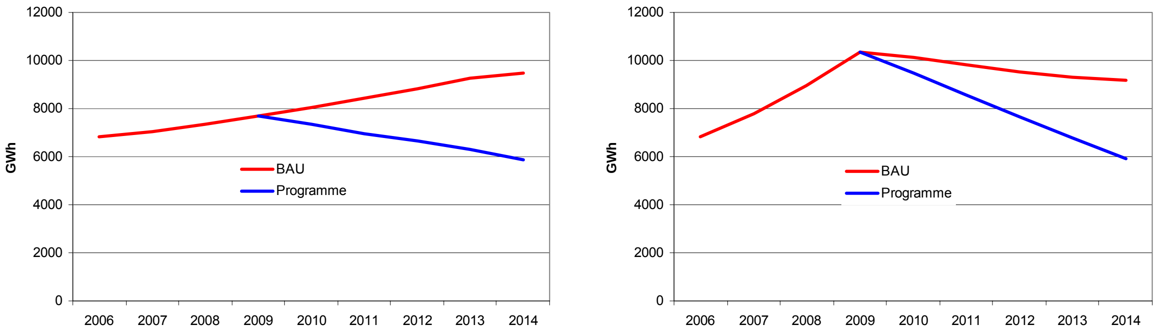
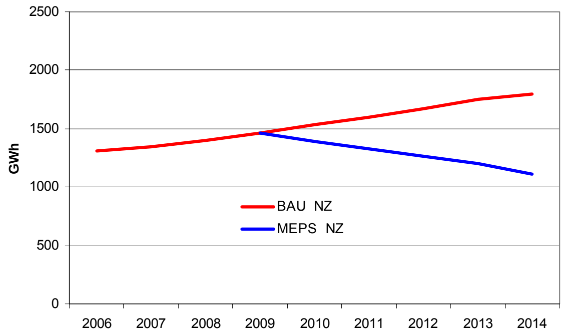



Figure 26 shows the Australian energy consumption by year for the two forecasts and compares BAU with MEPS.

Figure 26 Forecast Energy Consumption – BAU and MEPS – New Zealand

**Conservative growth – New Zealand** **Aggressive growth – New Zealand**



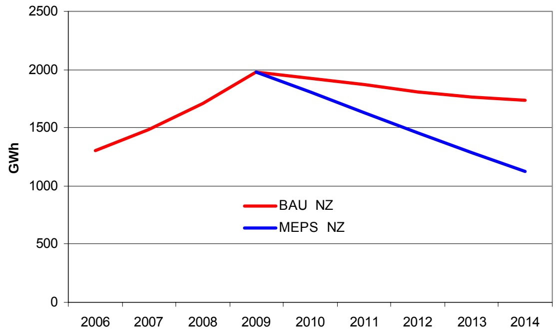




Table 22 shows the Australian and New Zealand energy and greenhouse gas savings by year for the two forecasts comparing BAU with MEPS.

Table 22 Comparison of BAU with Conservative and Annual Energy and Greenhouse Gas Reductions

| Australia | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Conservative GWh saved | 721 | 1445 | 2171 | 2921 | 3587 |
| Conservative Mt $CO_2$-e saved | 0.71 | 1.41 | 2.14 | 2.81 | 3.52 |
| Aggressive GWh saved | 639 | 1258 | 1880 | 2523 | 3235 |
| Aggressive Mt $CO_2$-e saved | 0.63 | 1.23 | 1.85 | 2.43 | 3.18 |
| **New Zealand** | **2010** | **2011** | **2012** | **2013** | **2014** |
| Conservative GWh saved | 137 | 274 | 412 | 554 | 680 |
| Conservative Mt $CO_2$-e saved | 82 | 165 | 247 | 332 | 408 |
| Aggressive GWh saved | 122 | 239 | 357 | 478 | 613 |
| Aggressive kt $CO_2$-e saved | 73 | 143 | 214 | 287 | 368 |

In addition, indirect energy savings will further increase the overall savings in energy and greenhouse gas emissions. Indirect energy can be beneficial or detrimental to energy consumption, depending upon the requirements of heating or cooling. For example, in warm climates, where air-conditioning is prevalent, waste energy adds to the load on air-conditioning systems. Conversely, waste energy may be beneficial to reducing heating requirements. This will be analysed in greater detail in the cost benefit analysis, which will further improve the benefits of the introduction of MEPS.

There will also be impacts on peak load due to reducing the in use load and the reduction from in use to sleep mode, when it is activated.

# Appendix 1 ENERGY STAR® Program Requirements for computers - Eligibility Criteria

Below is the Version 4.0 product specification for ENERGY STAR qualified computers. A product must meet all of the identified criteria to earn the ENERGY STAR.

**1) Definitions:** Below are the definitions of the relevant terms in this document.

A. Computer: A device which performs logical operations and processes data. Computers are composed of, at a minimum: (1) a central processing unit (CPU) to perform operations; (2) user input devices such as a keyboard, mouse, digitizer or game controller; and (3) a display screen to output information. For the purposes of this specification, computers include both stationary and portable units, including desktop computers, gaming consoles, integrated computers, notebook computers, tablet PCs, desktop-derived servers and workstations. Although computers must be capable of using input devices and displays, as noted in numbers 2 and 3 above, computer systems do not need to include these devices on shipment to meet this definition.

**Components**

B. Display: A commercially-available, electronic product with a display screen and its associated electronics encased in a single housing, or within the computer housing (e.g., notebook or integrated computer), that is capable of displaying output information from a computer via one or more inputs, such as a VGA, DVI, and/or IEEE 1394. Examples of display technologies are the cathode-ray tube (CRT) and liquid crystal display (LCD).

C. External Power Supply: A component contained in a separate physical enclosure external to the computer casing and designed to convert line voltage ac input from the mains to lower dc voltage(s) for the purpose of powering the computer. An external power supply must connect to the computer via a removable or hard-wired male/female electrical connection, cable, cord or other wiring.

D. Internal Power Supply: A component internal to the computer casing and designed to convert ac voltage from the mains to dc voltage(s) for the purpose of powering the computer components. For the purposes of this specification, an internal power supply must be contained within the computer casing but be separate from the main computer board. The power supply must connect to the mains through a single cable with no intermediate circuitry between the power supply and the mains power. In addition, all power connections from the power supply to the computer components must be internal to the computer casing (i.e., no external cables running from the power supply to the computer or individual components). Internal dc-to-dc converters used to convert a single dc voltage from an external power supply into multiple voltages for use by the computer are not considered internal power supplies.

**Computer Types**

E. Desktop Computer: A computer where the main unit is intended to be located in a permanent location, often on a desk or on the floor. Desktops are not designed for portability and utilize an external monitor, keyboard, and mouse. Desktops are designed for a broad range of home and office applications including, email, web browsing, word processing, standard graphics applications, gaming, etc.

F. Desktop-Derived Server: A desktop-derived server is a computer that typically uses desktop components in a tower form factor, but is designed explicitly to be a host for other computers or applications. For the purposes of this specification, a computer must be marketed as a server and have the following characteristics to be considered a desktop-derived server:

- Designed and placed on the market as a Class B product per EuroNorm EN55022:1998 under the EMC Directive 89/336/EEC and has no more than single processor capability (1 socket on board);

- Designed in a pedestal, tower, or other form factor similar to those of desktop computers such that all data processing, storage, and network interfacing is contained within one box/product;

- Designed to operate in a high-reliability, high-availability application environment where the computer must be operational 24 hours/day and 7 days/week, and unscheduled downtime is extremely low (on the order of hours/year);

- Capable of operating in a simultaneous multi-user environment serving several users through networked client units; and

- Shipped with an industry accepted operating system for standard server applications (e.g., Windows NT, Windows 2003 Server, Mac OS X Server, OS/400, OS/390, Linux, Unix and Solaris).

Desktop-derived servers are designed to perform functions such as processing information for other systems, providing network infrastructure services (e.g., archiving), data hosting and running web servers.

This specification does not cover mid-range or large servers, defined for purposes of this specification as:

- Designed and placed on the market as a Class A product per EuroNorm EN55022:1998 under the EMC Directive 89/336/EEC and designed and capable of having a single or dual processor capability (1 or greater sockets on board);

- Placed on the market as a Class B product, but hardware upgraded from a Class A product, per EuroNorm EN55022:1998 under the EMC Directive 89/336/EEC and designed capable of having a single or dual processor capability (1 or greater sockets on board); and

- Designed and placed on the market as a Class B product per EuroNorm EN55022:1998 under the EMC Directive 89/336/EEC and designed and capable of having a *minimum* dual processor capability (2 sockets on board).

G. Game Consoles: Stand alone computers whose primary use is to play video games. For the purposes of this specification, game consoles must use a hardware architecture based on typical computer components (e.g., processors, system memory, video architecture, optical and/or hard drives, etc.). The primary input for game consoles are special hand held controllers rather than the mouse and keyboard used by more conventional computer types. Game consoles are also equipped with audio visual outputs for use with televisions as the primary display, rather than an external monitor or integrated display. These devices do not typically use a conventional operating system, but often perform a variety of multimedia functions such as: DVD/CD playback, digital picture viewing, and digital music playback.

H. Integrated Computer: A desktop system in which the computer and display function as a single unit which receives its ac power through a single cable. Integrated computers come in one of two possible forms: (1) a system where the display and computer are physically combined into a single unit; or (2) a system packaged as a single system where the display is separate but is connected to the main chassis by a dc power cord and both the computer and display are powered from a single power supply. As a subset of desktop computers, integrated computers are typically designed to provide similar functionality as desktop systems.

I. Notebook and Tablet Computers: A computer designed specifically for portability and to be operated for extended periods of time without a direct connection to an ac power source. Notebooks and tablets must utilize an integrated monitor and be capable of operation off an integrated battery or other portable power source. In addition, most notebooks and tablets use an external power supply and have an integrated keyboard and pointing device, though tablets use touch-sensitive screens. Notebook and tablet computers are typically designed to provide similar functionality to desktops except within a portable device. For the purposes of this specification, docking stations are considered accessories and therefore, the performance levels associated with notebooks presented in Table 1 of Section 3, below, do not include them.

J. Workstation: For the purposes of this specification, to qualify as a workstation, a computer must:

- Be marketed as a workstation;
- Have a mean time between failures (MTBF) of at least 15,000 hours based on either Bellcore TR-NWT-000332, issue 6, 12/97 or field collected data; and
- Support error-correcting code (ECC) and/or buffered memory.

In addition, a workstation must meet three of the following six optional characteristics:

- Have supplemental power support for high-end graphics (i.e., PCI-E 6-pin 12V supplemental power feed);
- System is wired for greater than x4 PCI-E on the motherboard in addition to the graphics slot(s) and/or PCI-X support;
- Does not support Uniform Memory Access (UMA) graphics;
- Includes 5 or more PCI, PCIe or PCI-X slots;
- Capable of multi-processor support for two or more processors (must support physically separate processor packages/sockets, i.e., not met with support for a single multi core processor); and/or
- Be qualified by at least 2 Independent Software Vendor (ISV) product certifications; these certifications can be in process, but must be completed within 3 months of qualification.

**Operational Modes**

K. Idle State: For purposes of testing and qualifying computers under this specification, this is the state in which the operating system and other software have completed loading, the machine is not asleep, and activity is limited to those basic applications that the system starts by default.

L. Sleep Mode: A low power state that the computer is capable of entering automatically after a period of inactivity or by manual selection. A computer with sleep capability can quickly 'wake' in response to network connections or user interface devices. For the purposes of this specification, Sleep mode correlates to ACPI System Level S3 (suspend to RAM) state, where applicable.

M. Standby Level (Off Mode): The power consumption level in the lowest power mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Standby correlates to ACPI System Level S4 or S5 states, where applicable.

**Networking and Power Management**

N. Network Interface: The components (hardware and software) whose primary function is to make the computer capable of communicating over one or more network technologies. For purposes of testing to this specification, Network Interface refers to the IEEE 802.3 wired Ethernet interface.

O. Wake Event: A user, programmed, or external event or stimulus that causes the computer to transition from Sleep or Standby to active mode of operation. Examples of wake events include, but are not limited to: movement of the mouse, keyboard activity, or a button press on the chassis, and in the case of external events, stimulus conveyed via a remote control, network, modem, etc.

P. Wake On LAN (WOL): Functionality which allows a computer to wake from Sleep or Standby when directed by a network request.

**2)** **Qualifying Products:** Computers must meet the computer definition as well as one of the product type definitions provided in Section 1, above, to qualify as ENERGY STAR. **Please note that EPA will explore additional computer types, such as thin clients, for potential Tier 2 requirements.** The following table provides a list of the types of computers that are (and are not) eligible for ENERGY STAR.

| Products Covered by Version 4.0 Specification | Products Not Covered by Version 4.0 Specification |
|---|---|
| a. Desktop Computers<br>b. Game Consoles<br>c. Integrated Computer Systems<br>d. Notebook Computers/Tablet PCs<br>e. Desktop-Derived Servers<br>f. Workstations | g. Mid-Range and Large Servers (as defined in Section 1F)<br>h. Thin Clients/Blade PCs<br>i. Handhelds and PDAs |

**3)** **Energy Efficiency and Power Management Criteria:** Computers must meet the requirements below to qualify as ENERGY STAR. Effective dates for Tier 1 and Tier 2 are covered in Section 5 of this specification.

**A) Tier 1 Requirements - Effective July 20, 2007**

**(1) Power Supply Efficiency Requirements**

**Computers Using an Internal Power Supply:** 80% minimum efficiency at 20%, 50%, and 100% of rated output and Power Factor $\geq$ 0.9 at 100% of rated output.

**Computers Using an External Power Supply:** Must be ENERGY STAR qualified or meet the no-load and active mode efficiency levels provided in the ENERGY STAR Program Requirements for Single Voltage Ac-Ac and Ac-Dc External Power Supplies. The ENERGY STAR specification and qualified product list can be found at www.energystar.gov/powersupplies. Note: This performance requirement also applies to multiple voltage output external power supplies as tested in accordance to the Internal Power Supply test method referenced in Section 4, below.

**(2) Operational Mode Efficiency Requirements**

**Desktop Categories for Idle Criteria:** For the purposes of determining Idle state levels, desktops (including integrated computers, desktop-derived servers and game consoles) must qualify under Categories A, B, or C as defined below:

**Category A:** All desktop computers that do not meet the definition of either Category B or Category C below will be considered under Category A for ENERGY STAR qualification.

**Category B:** To qualify under Category B desktops must have:

- Multi-core processor(s) or greater than 1 discrete processor; and
- Minimum of 1 gigabyte of system memory.

**Category C:** To qualify under Category C desktops must have:

- Multi-core processor(s) or greater than 1 discrete processor; and

- A GPU with greater than 128 megabytes of dedicated, non-shared memory.

In addition to the requirements above, models qualifying under Category C must be configured with a minimum of 2 of the following 3 characteristics:

- Minimum of 2 gigabytes of system memory;
- TV tuner and/or video capture capability with high definition support; and/or
- Minimum of 2 hard disk drives.

**Notebook Categories for Idle Criteria:** For the purposes of determining Idle state levels, notebooks and tablets must qualify under Categories A or B as defined below:

**Category A:** All notebook computers that do not meet the definition of Category B below will be considered under Category A for ENERGY STAR qualification.

**Category B:** To qualify under Category B notebooks must have:

- A GPU with a minimum of 128 megabytes of dedicated, non-shared memory.

**Workstation Levels:** Workstation levels will be determined using a simplified Typical Electricity Consumption (TEC) approach to allow manufacturers energy trade offs between different operating modes, based on a given weighting factor for each mode. The final level will be based on the TEC power level ($P_{TEC}$) which will be determined by the following formula:

$$P_{TEC} = 0.1 * P_{Standby} + 0.2 * P_{Sleep} + 0.7 * P_{Idle}$$

where, $P_{Standby}$ is the power measured in Standby, $P_{Sleep}$ is the power measured in Sleep, and in $P_{Idle}$ is the power measured in Idle. This $P_{TEC}$ value will then be compared to the TEC budget which is determined by a fixed percentage of the maximum power of the system, including an adder for installed hard drives as indicated in the equation in Table 1. The test procedure for determining the maximum power of workstations can be found in Section 4 of Appendix A.

**Power Level Requirements:** The following tables indicate the required power allowances for the Tier 1 specification. Table 1 gives the baseline requirements, while Table 2 gives additional power allowances for WOL. For those products that meet the WOL enabling requirement for either Sleep or Standby, a model must meet the energy level provided in Table 1 summed with the appropriate allowances from Table 2. **Note: Products whose Sleep levels meet the Standby power requirements do not need to have a distinct Standby (Off mode), and may qualify for this specification using only Sleep mode.**

**Table 1: Tier 1 Energy Efficiency Requirements**

| Product Type | Tier 1 Requirements |
|---|---|
| Desktops, Integrated Computers, Desktop-Derived Servers and Gaming Consoles | **Standby (Off Mode):** ≤ 2.0 W<br>**Sleep Mode:** ≤ 4.0 W<br>**Idle State:**<br>**Category A:** ≤ 50.0 W<br>**Category B:** ≤ 65.0 W<br>**Category C:** ≤ 95.0 W<br>***Note: Desktop-derived servers (as defined in section 1. F) are exempt from the Sleep level above.*** |
| Notebooks and Tablets | **Standby (Off Mode):** ≤ 1.0 W<br>**Sleep Mode:** ≤ 1.7 W<br>***Idle State:***<br>**Category A:** ≤ 14.0 W<br>**Category B:** ≤ 22.0 W |
| Workstations | **TEC Power ($P_{TEC}$):**<br>≤ 0.35 * **[$P_{Max}$ + (# HDDs * 5)]** W<br>***Note: Where $P_{max}$ is the maximum power drawn by the system as tested per the test procedure in Section 4 of Appendix A, and #HDD is the number of installed hard drives in the system.*** |

**Table 2: Tier 1 Capability Adder for Sleep and Standby**

| Capability | Additional Power Allowance |
|---|---|
| Wake On LAN (WOL) | + 0.7 W for Sleep<br>+ 0.7 W for Standby |

**Qualifying Computers with Power Management Capabilities**: The following requirements should be followed when determining whether models should be qualified with or without WOL:

**Standby:** Computers should be tested and reported as shipped for Standby. Models that will be shipped with WOL enabled for Standby should be tested with WOL enabled and will qualify using the extra allowance for Standby found in Table 2 above. Likewise, products shipped with WOL disabled for Standby must be tested with WOL disabled and must meet the baseline requirement for Standby found in Table 1.

**Sleep:** Computers should be tested and reported as shipped for Sleep. Models sold through enterprise channels, as defined in the Tier 1 Power Management Requirements (Section 3.A.3), shall be tested, qualified, and shipped WOL enabled. Products going directly to consumers through normal retail channels are not required to be shipped with WOL enabled from Sleep, and may be tested, qualified, and shipped with WOL either enabled or disabled.

Those models sold both through enterprise channels and directly to consumers must test and meet both the levels with and without WOL.

Systems where any additional management services are, at the customer's request, pre-provisioned by the manufacturer, do not need to test the systems with these functions in an active state providing the function is not actually activated until there is specific action by the end user (i.e., manufacturer should test in pre-provisioned state and does not have to consider the power use after full provisioning occurs on site).

**(3) Power Management Requirements**

**Shipment Requirement:** Products must be shipped with the display's Sleep mode set to activate within 15 minutes of user inactivity. All products, except for desktop-derived servers which are exempt from this requirement, must be shipped with a Sleep mode which is set to activate within 30 minutes of user inactivity. Products may have more than one low power mode but these proposed criteria address Sleep mode as defined in this specification. Computers shall reduce the speed of any active 1 Gb/s Ethernet network links when transitioning to Sleep or Standby.

All computers, regardless of distribution channel, shall have the ability to enable and disable WOL for Sleep mode. Systems shipped through enterprise channels must have Wake On LAN (WOL) enabled from the Sleep mode when operating on ac power (i.e. notebooks may automatically disable WOL when operating on their portable power sources). For the purpose of this specification, 'enterprise channels' are defined as sales channels normally used by large and medium-sized business, government organizations, and educational institutions, with the intent of identifying machines that will be used in managed client/server environments. For all computers with WOL enabled any directed packet filters shall be enabled and set to an industry standard default configuration. Until one (or more) standards are agreed upon, partners are asked to provide their direct packet filter configurations to EPA for publication on the Website to stimulate discussion and development of standard configurations. Systems in which the Sleep mode maintains full network connectivity, providing the same fully connected network state found in Idle, can be considered to meet the WOL enabling requirement and may qualify using the corresponding WOL capability adder.

All machines shipped to enterprise customers shall be capable of both remote and scheduled wake events from Sleep mode. Manufacturers shall ensure, where the manufacturer has control (i.e., configured through hardware settings rather than software settings), that these settings can be managed centrally, as the client wishes, with tools provided by the manufacturer**.**

**User Information Requirement:** In order to ensure that purchasers/users are properly informed on the benefits of power management, the manufacturer will include with each computer, one of the following:

- Information on ENERGY STAR and the benefits of power management in either a hard copy or electronic copy of the user manual. This information should be near the front of the user guide; or

- A package or box insert on ENERGY STAR and the benefits of power management.

Either option must at least include the following information:

- Notice that the computer has been shipped enabled for power management and what the time settings are; and

- How to properly wake the computer from Sleep mode;

**(B) <u>Tier 2 Requirements - Effective January 1, 2009</u>**

**(1a) Tier 2 Energy Efficiency Performance Metric.** All computers will be required to meet the following minimum performance per unit energy metric:

Energy Efficiency Performance Software and Associated Levels: **TBD**

- OR -

**(1b) Provisional Tier 2 Idle State Requirements.** If an energy efficiency performance metric and associated performance levels are not ready to go into effect **by January 1, 2009**, a provisional Tier 2 specification will automatically go into effect and will remain in effect until such a benchmark is established. This provisional Tier 2 will include revised Idle state levels for all computer types (those included in Tier 1 as well as others as appropriate [e.g., thin clients]) with the intention of capturing the top 25% performers in energy efficiency.

Additional topics, including the following, will also be re-examined under a provisional Tier 2:

- Idle levels for notebooks and integrated computers that incorporate the energy use of the displays;
- Quantitative distinctions between desktop categories (e.g., megabytes of video memory, number of processor cores, megabytes of system memory) to ensure that these distinctions remain current;
- Sleep levels for desktop-derived servers; and
- Allowances for additional management tools, such as service processors in Sleep and Standby, which may aid in the adoption of computer power management.

In the case of the implementation of a provisional Tier 2, EPA and the European Commission will re-examine these new topics and finalize new levels at least six months prior to the effective date for Tier 2.

**(2) Power Management Requirements:** In addition to the requirements provided under Tier 1, above, ENERGY STAR qualified computers must maintain full network connectivity while in Sleep mode, according to a platform-independent industry standard. All computers shall reduce their network link speeds during times of low data traffic levels in accordance with any industry standards that provide for quick transitions among link rates.

**C) <u>Voluntary Requirements</u>**

**User Interface:** Although not mandatory, manufacturers are strongly recommended to design products in accordance with the Power Control User Interface Standard — IEEE 1621 (formally known as 'Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments'). Compliance with IEEE 1621 will make power controls more consistent and intuitive across all electronic devices. For more information on the standard see http://eetd.LBL.gov/Controls.

**4) <u>Test Procedures:</u>** Manufacturers are required to perform tests and self-certify those models that meet the ENERGY STAR guidelines.

- In performing these tests, partner agrees to use the test procedures provided in Table 3, below.
- The test results must be reported to EPA or the European Commission, as appropriate.

Additional testing and reporting requirements are provided below.

A. <u>Number of Units Required for Idle Testing:</u> Manufacturers may initially test a single unit for qualification. If the initial unit tested meets the maximum power level for Idle but falls within 10% of that level, one additional unit of the same model with an identical configuration must also be tested. Manufacturers shall report Idle values for both units. To qualify as ENERGY STAR, both units must meet the maximum Idle level for that product category. **Note:** This additional testing is only required for Idle qualification – only one unit is required to be tested for Sleep and Standby. The following example further illustrates this approach:

Category A desktops must meet an Idle level of 50 watts or less, making 45 Watts the 10% threshold for additional testing. The following scenarios could then occur when testing a model for qualification:

- If the first unit is measured at 44 watts, no more testing is needed and the model qualifies (44 watts is 12% more efficient than the specification and is therefore 'outside' the 10% threshold).
- If the first unit is measured at 45 watts, no more testing is needed and the model qualifies (45 watts is exactly 10% more efficient than the specification).
- If the first unit is measured at 47 watts, then an additional unit must be tested to determine qualification (47 Watts is only 6% more efficient than the specification and is 'within' the 10% threshold).
- If the two units are then tested at 47 and 51 watts, the model does not qualify as ENERGY STAR—even though the average is 49 watts— because one of the values (51) exceeds the ENERGY STAR specification.
- If the two units are then tested at 47 and 49 watts, the model does qualify as ENERGY STAR because both values meet the ENERGY STAR specification of 50 watts.

B. Models Capable of Operating at Multiple Voltage/Frequency Combinations: Manufacturers shall test their products based on the market(s) in which the models will be sold and promoted as ENERGY STAR qualified. EPA and its ENERGY STAR Country Partners have agreed upon a table with three voltage/frequency combinations for testing purposes. Please refer to the Test Conditions in the Test Procedure (Appendix A) for details regarding international voltage/frequency combinations for each market.

For products that are sold as ENERGY STAR in multiple international markets and, therefore, rated at multiple input voltages, the manufacturer must test at and report the required power consumption or efficiency values at all relevant voltage/frequency combinations. For example, a manufacturer that is shipping the same model to the United States and Europe must measure, meet the specification, and report test values at both 115 Volts/60 Hz and 230 Volts/50 Hz in order to qualify the model as ENERGY STAR in both markets. If a model qualifies as ENERGY STAR at only one voltage/frequency combination (e.g., 115 Volts/60 Hz), then it may only be qualified and promoted as ENERGY STAR in those regions that support the tested voltage/frequency combination (e.g., North America and Taiwan).

**Table 3: Test Procedures for Measuring Operational Modes**

| Specification Requirement | Test Protocol | Source |
|---|---|---|
| Standby (Off Mode), Sleep Mode, Idle State and Maximum Power | ENERGY STAR Computer Test Method (Version 4.0) | Appendix A |
| Power Supply Efficiency | IPS: Internal Power Supply Efficiency Protocol<br>EPS: ENERGY STAR Test Method for External Power Supplies | IPS: www.efficientpowersupplies.org<br>EPS: www.energystar.gov/powersupplies |

C. Qualifying Families of Products: Models that are unchanged or that differ only in finish from those sold in a previous year may remain qualified without the submission of new test data assuming the specification remains unchanged. If a product model is offered in the market in multiple configurations or styles, as a product 'family' or series, the partner may report and qualify the product under a single model number, as long as all of the models within that family or series meet either of the following requirements:

- Computers that are built on the same platform and are identical in every respect except for housing and colour may be qualified through submission of test data for a single, representative model.

- If a product model is offered in the market in multiple configurations, the partner may report and qualify the product under a single model number that represents the highest power configuration available in the family, rather than reporting each and every individual model in the family. In this case, the highest configuration would consist of: the highest power processor, the maximum memory configuration, the highest power GPU, etc. For desktop systems which meet the definition for multiple desktop categories (as defined in section 3.A.2) depending on the specific configuration, manufacturers will have to submit the highest power configuration for each category under which they would like the system to qualify. For example, a system that could be configured either as a Category A or a Category B desktop would require a submittal of the highest power configuration for both categories in order to qualify as ENERGY STAR. If a product could be configured to meet all three categories, it would then have to submit data for the highest power configuration in all categories. Manufacturers will be held accountable for any efficiency claims made about all other models in the family, including those not tested or for which data was not reported.

**5)** **Effective Date:** The date that manufacturers may begin to qualify products as ENERGY STAR, under this Version 4.0 specification, will be defined as the *effective date* of the agreement. Any previously executed agreement on the subject of ENERGY STAR qualified computers shall be terminated effective July 19, 2007.

1. Qualifying Products under Tier 1 of the Version 4.0 Specification: The first phase of this specification will commence on **July 20, 2007**. All products, including models originally qualified under Version 3.0, with a **date of manufacture** on or after **July 20, 2007**, must meet the new (Version 4.0) requirements in order to qualify for ENERGY STAR. The **date of manufacture** is specific to each unit and is the date (e.g., month and year) of which a unit is considered to be completely assembled.

2. Qualifying Products under Tier 2 of the Version 4.0 Specification: The second phase of this specification, Tier 2, will commence on **January 1, 2009**. All products, including models originally qualified under Tier 1, with a **date of manufacture** on or after **January 1, 2009**, must meet the Tier 2 requirements in order to qualify for ENERGY STAR.

3. Elimination of Grandfathering: EPA will not allow grandfathering under this Version 4.0 ENERGY STAR specification. **ENERGY STAR qualification under previous versions is not automatically granted for the life of the product model.** Therefore, any product sold, marketed, or identified by the manufacturing partner as ENERGY STAR must meet the current specification in effect at the time of manufacture of the product.

**6)** **Future Specification Revisions:** EPA reserves the right to revise the specification should technological and/or market changes affect its usefulness to consumers or industry or its impact on the environment. In keeping with current policy, revisions to the specification will be discussed with stakeholders. In the event of a specification revision, please note that ENERGY STAR qualification is not automatically granted for the life of a product model. To qualify as ENERGY STAR, a product model must meet the ENERGY STAR specification in effect on the model's date of manufacture.

## ENERGY STAR Specification APPENDIX A

### ENERGY STAR Test Procedure for Determining the Power Use of Computers in Standby, Sleep, Idle and Maximum Power

The following protocol should be followed when measuring power consumption levels of computers for compliance with the Standby, Sleep, and Idle levels provided in the ENERGY STAR Version 4.0 Computer Specification. Partners must measure a representative sample of the configuration as shipped to the customer. However, the Partner does not need to consider power consumption changes that may result from component additions, BIOS and/or software settings made by the computer user after sale of product. *This procedure is intended to be followed in order and the mode being tested is labelled where appropriate.*

### I. Definitions

Unless otherwise specified, all terms used in this document are consistent with the definitions contained in the Version 4.0 ENERGY STAR Eligibility Criteria for Computers.

**UUT**

UUT is an acronym for 'unit under test' which in this case refers to the computer being tested.

**UPS**

UPS is an acronym for 'Uninterruptible Power Supply,' which refers to a combination of converters, switches and energy storage means, for example batteries, constituting a power supply for maintaining continuity of load power in case of input power failure.

### II. Testing Requirements

**Approved Meter**

Approved meters will include the following attributes[35]:

- Power resolution of 1 mW or better;
- An available current crest factor of 3 or more at its rated range value; and
- Lower bound on the current range of 10mA or less.

The following attributes in addition to those above are suggested:

- Frequency response of at least 3 kHz; and
- Calibration with a standard that is traceable to the U.S. National Institute of Standards and Technology (NIST).

It is also desirable for measurement instruments to be able to average power accurately over any user selected time interval (this is usually done with an internal math's calculation dividing accumulated energy by time within the meter, which is the most accurate approach). As an alternative, the measurement instrument would have to be capable of integrating energy over any user selected time interval with an energy resolution of less than or equal to 0.1 mWh and integrating time displayed with a resolution of 1 second or less.

**Accuracy**

[35] Characteristics of approved meters taken from IEC 62301 Ed 1.0: Measurement of Standby Power

Measurements of power of 0.5 W or greater shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level. Measurements of power of less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level. The power measurement instrument shall have a resolution of:

- 0.01 W or better for power measurements of 10 W or less;
- 0.1 W or better for power measurements of greater than 10 W up to 100 W; and
- 1 W or better for power measurements of greater than 100 W.

All power figures should be in watts and rounded to the second decimal place. For loads greater than or equal to 10 W, three significant figures shall be reported.

**Test Conditions**

| | | |
|---|---|---|
| **Supply Voltage:** | North America/Taiwan:<br><br>Europe/Australia/New Zealand:<br><br>Japan: | 115 (± 1%) Volts AC, 60 Hz (± 1%)<br><br>230 (± 1%) Volts AC, 50 Hz (± 1%)<br><br>100 (± 1%) Volts AC, 50 Hz (± 1%)/60 Hz (± 1%)<br><br>*Note:* For products rated for > 1.5 kW maximum power, the voltage range is ± 4% |
| **Total Harmonic Distortion (THD) (Voltage):** | < 2% THD (< 5% for products which are rated for > 1.5 kW maximum power) | |
| **Ambient Temperature:** | 23°C ± 5°C | |
| **Relative Humidity:** | 10 – 80 % | |

(Reference IEC 62301: Household Electrical Appliances – Measurement of Standby Power, Sections 3.2, 3.3)

**Test Configuration**

Power consumption of a computer shall be measured and tested from an ac source to the UUT.

The UUT must be connected to an Ethernet network switch capable of the UUT's highest and lowest network speeds. The network connection must be live during all tests.

### III. *Test Procedure for Standby, Sleep and Idle for All Products*

Measurement of ac power consumption of a computer should be conducted as follows:

**UUT Preparation**

1. Record the manufacturer and model name of the UUT.
2. Ensure that the UUT is connected to a live Ethernet (IEEE 802.3) network switch as specified in Section II., 'Test Configuration,' above, and that the connection is live. The computer must maintain this live connection to the switch for the duration of testing, disregarding brief lapses when transitioning between link speeds.
3. Connect an approved meter capable of measuring true power to an ac line voltage source set to the appropriate voltage/frequency combination for the test.

4. Plug the UUT into the measurement power outlet on the meter. No power strips or UPS units should be connected between the meter and the UUT. For a valid test to take place the meter should remain in place until all Standby, Sleep, and Idle power data is recorded.

5. Record the ac voltage.

6. Boot computer and wait until the operating system has fully loaded.

7. If necessary, run the initial operating system setup and allow all preliminary file indexing and other one-time/periodic processes to complete.

8. Record basic information about the computer's configuration – computer type, operating system name and version, processor type and speed, and total and available physical memory, etc.[36]

9. Record basic information about the video card - video card name, resolution, amount of onboard memory, and bits per pixel.[37]

10. Ensure that the UUT is configured as shipped including all accessories, power management settings, WOL enabling and software shipped by default. UUT should also be configured using the following requirements for all tests:

    a. Desktop systems (including workstations and desktop-derived servers) shipped without accessories should be configured with a standard mouse, keyboard and external monitor.

    b. Notebooks and tablets should include all accessories shipped with the system, and need not include a separate keyboard or mouse when equipped with an integrated pointing device or digitizer.

    c. Notebooks and tablets should have the battery pack(s) removed for all tests. For systems where operation without a battery pack is not a supported configuration, the test may be performed with fully charged battery pack(s) installed, making sure to report this configuration in the test results.

    d. Power to wireless radios should be turned off for all tests. This applies to wireless network adapters (e.g., 802.11) or device-to-device wireless protocols.

11. The following guidelines should be followed to configure power settings for displays (adjusting no other power management settings):

    a. <u>For computers with external displays (most desktops):</u> use the monitor power management settings to prevent the monitor from powering down to ensure it stays on for the full length of the Idle test as described below.

    b. <u>For computers with integrated monitors (notebooks, tablets and integrated systems):</u> use the power management settings to set the monitor to power down after 1 minute.

12. Shut down the computer.

**Standby (Off Mode) Testing**

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[36] On Windows-based machines, much of this information can be found by selecting the following window: Start / Programs / Accessories / System Tools / System Information.

[37] On Windows-based machines, this can be found by selecting the following window: Start / Programs / Accessories / System Tools / Components / Display.

13. With the UUT shut down and in Standby, set the meter to begin accumulating true power values at an interval of 1 reading per second. Accumulate power values for 5 additional minutes and record the average (arithmetic mean) value observed during that 5 minute period.[38]

#### Idle Mode Testing

14. Switch on the computer and begin recording elapsed time, starting either when the computer is initially switched on, or immediately after completing any log in activity necessary to fully boot the system. Once logged in with the operating system fully loaded and ready, close any open windows so that the standard operational desktop screen or equivalent ready screen is displayed. Exactly 15 minutes after the initial boot or log in, set the meter to begin accumulating true power values at an interval of 1 reading per second. Accumulate power values for 5 additional minutes and record the average (arithmetic mean) value observed during that 5 minute period.

#### Sleep Mode Testing

15. After completing the Idle measurements, place the computer in Sleep mode. Reset the meter (if necessary) and begin accumulating true power values at an interval of 1 reading per second. Accumulate power values for 5 additional minutes and record the average (arithmetic mean) value observed during that 5 minute period.

16. If testing both WOL enabled and WOL disabled for Sleep, wake the computer and change the WOL from Sleep setting through the operating system settings or by other means. Place the computer back in Sleep mode and repeat step 14, recording Sleep power necessary for this alternate configuration.

#### Reporting Test Results

17. The test results must be reported to EPA or the European Commission, as appropriate, taking care to ensure that all required information has been included.

### IV. Maximum Power Test for Workstations

The maximum power for workstations is found by the simultaneous operation of two industry standard benchmarks: Linpack to stress the core system (e.g., processor, memory, etc.) and SPECviewperf® (version 9.x or higher) to stress the system's GPU. Additional information on these benchmarks, including free downloads, can be found at the URLs found below:

| | |
|---|---|
| **Linpack** | http://www.netlib.org/linpack/ |
| **SPECviewperf®** | http://www.spec.org/benchmarks.html#gpc |

This test must be repeated three times on the same UUT, and all three measurements must fall within a ± 2% tolerance relative to the average of the three measured maximum power values.

Measurement of the maximum ac power consumption of a workstation should be conducted as follows:

#### UUT Preparation

1. Connect an approved meter capable of measuring true power to an ac line voltage source set to the appropriate voltage/frequency combination for the test. The meter should be able to

[38] Laboratory-grade, full-function meters can integrate values over time and report the average value automatically. Other meters would require the user to capture a series of changing values every 5 seconds for a five minute period and then compute the average manually.

store and output the maximum power measurement reached during the test or be capable of another method of determining maximum power.

2. Plug the UUT into the measurement power outlet on the meter. No power strips or UPS units should be connected between the meter and the UUT.

3. Record the ac voltage.

4. Boot the computer and, if not already installed, install Linpack and SPECviewperf as indicated on the above Websites.

5. Set Linpack with all the defaults for the given architecture of the UUT and set the appropriate array size ‘n’ for maximizing power draw during the test.

6. Ensure all guidelines set by the SPEC organization for running SPECviewperf are being met.

**Maximum Power Testing**

7. Set the meter to begin accumulating true power values at an interval of 1 reading per second, and begin taking measurements. Run SPECviewperf and as many simultaneous instances of Linpack as needed to fully stress the system.

8. Accumulate power values until SPECviewperf and all instances have completed running. Record the maximum power value attained during the test.

**Reporting Test Results**

9. The test results must be reported to EPA or the European Commission, taking care to ensure that all required information has been included.

10. Upon submittal of data, manufacturers must also include the following data:

    a. Value of the n (the array size) used for Linpack,

    b. Number of simultaneous copies of Linpack run during the test,

    c. Version of SPECviewperf run for test,

    d. All compiler optimizations used in compiling Linpack and SPECviewperf, and

    e. A precompiled binary for end users to download and run of both SPECviewperf and Linpack. These can be distributed either through a centralized standards body such as SPEC, by the OEM or by a related third party.

## V. Continuing Verification

This testing procedure describes the method by which a single unit may be tested for compliance. An ongoing testing process is highly recommended to ensure that products from different production runs are in compliance with ENERGY STAR.

# Appendix 2 ENERGY STAR® Program Requirements for Computer Monitors

**Eligibility Criteria (Version 4.1)**

Below is the (Version 4.1) product specification for ENERGY STAR qualified Computer Monitors. A product must meet all of the identified criteria if it is to be labelled as ENERGY STAR by its manufacturer.

**1)** **Definitions**: Below is a brief description of a Computer Monitor and other terms as relevant to ENERGY STAR.

A. Computer Monitor (also referred to as 'Monitor'): A commercially-available, electronic product with a display screen and its associated electronics encased in a single housing that is capable of displaying output information from a computer via one or more inputs, such as VGA, DVI, and/or IEEE 1394. The monitor usually relies upon a cathode-ray tube (CRT), liquid crystal display (LCD), or other display device. This definition is intended primarily to cover standard monitors designed for use with computers. To qualify, the computer monitor must have a viewable diagonal screen size greater than 12 inches and must be capable of being powered by a separate AC wall outlet or a battery unit that is sold with an AC adapter. Computer monitors with a tuner/receiver may qualify as ENERGY STAR under this specification as long as they are marketed and sold to consumers as computer monitors (i.e., focusing on computer monitor as the primary function) or as dual function computer monitors and televisions. However, products with a tuner/receiver and computer capability that are marketed and sold as televisions are not included in this specification.

B. On Mode/Active Power: The product is connected to a power source and produces an image. The power requirement in this mode is typically greater than the power requirement in Sleep and Off Modes.

C. Sleep Mode/Low Power: The reduced power state that the computer monitor enters after receiving instructions from a computer or via other functions. A blank screen and reduction in power consumption characterize this mode. The computer monitor returns to On Mode with full operational capability upon sensing a request from a user/computer (e.g., user moves the mouse or presses a key on the keyboard).

D. Off Mode/Standby Power: The lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when a computer monitor is connected to the main electricity supply and used in accordance with the manufacturer's instructions. For purposes of this specification, Off Mode is defined as the power state when the product is connected to a power source, produces no images, and is waiting to be switched to On Mode by a direct signal from a user/computer (e.g., user pushes power switch).[39]

E. Hard Off Mode: A condition where the product is still plugged into the mains, but has been disconnected from an external power source. This mode is usually engaged by the consumer via a 'hard off switch.' While in this mode, a product will not draw any electricity and will usually measure 0 watts when metered.

F. Disconnect: The product has been unplugged from the mains and therefore is disconnected from all external power sources.

2) **Qualifying Products**: In order to qualify as ENERGY STAR, a computer monitor model must meet the definition in Section 1.A and the specification requirements provided in Section 3, below.

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[39] This definition is consistent with IEC 62301: Household Electrical Appliances – Measurement of Standby Power. IEC 62301 is still in draft form, as of the writing of this specification. While significant changes to the relevant portions of the IEC document are not envisioned by its authors, EPA will review the final version, when available, to ensure that no material changes have been made to the applicable sections of the document.

As explained in Section 1, this specification does not cover products with computer capability that are marketed and sold as televisions.

3) **Energy-Efficiency Specifications for Qualifying Products**: Only those products listed in Section 2 that meet the following criteria may qualify as ENERGY STAR. Effective dates for Tiers 1 and 2 are provided in Section 6 of this specification.

Widescreen Models: Widescreen (e.g., 16:9, 15:9, etc.) models are eligible to earn the ENERGY STAR, provided that they meet EPA's energy-efficiency requirements. There are no separate specifications for widescreen models and as such, they must comply with Sections 3.A and 3.B, below. For Tier 2, future revisions or clarifications for widescreen models will be evaluated and considered, when adequate energy consumption data is readily available to EPA.

A. On Mode/Active Power

1. Tier 1: To qualify as ENERGY STAR, computer monitor models must not exceed the following maximum active power consumption equation: Y = 38X + 30. Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form (e.g., 1,920,000 pixels = 1.92 megapixels). For example, the maximum power consumption for a computer monitor with 1800 x 1440 resolution, or 2,592,000 pixels, would be: 38(2.592) + 30 = 128.49 or 129 watts when rounded up. Under this metric, maximum allowed power consumption for computer monitors with various standard resolutions is provided below in Table 1.

2. Tier 2: To qualify as ENERGY STAR, computer monitor models must not exceed the following maximum active power consumption equation: If X < 1 megapixel, then Y = 23; if X $\geq$ 1 megapixel, then Y = 28X. Y is expressed in watts and rounded up to the nearest whole number and X is the number of megapixels in decimal form (e.g., 1,920,000 pixels = 1.92 megapixels). For example, the maximum power consumption for a computer monitor with 1024 x 768 resolution (or .78 megapixels) would be Y = 23 watts and for a computer monitor with 1600 x 1200 resolution would be 28(1.92) = 53.76 or 54 watts when rounded up.

Table 1: Sample Tier 1 On Mode Maximum Power Levels

| ***Resolution*** | ***Total Pixels*** | ***Maximum Power Use for Tier 1*** |
|---:|---:|---:|
| *640 x 480* | *307,200* | *42 watts* |
| *800 x 600* | *480,000* | *49 watts* |
| *1024 x 768* | *786,432* | *60 watts* |
| *1280 x 768* | *983,040* | *68 watts* |
| *1280 x 1024* | *1,310,720* | *80 watts* |
| *1600 x 1024* | *1,638,400* | *93 watts* |
| *1600 x 1200* | *1,920,000* | *103 watts* |
| *1920 x 1200* | *2,304,000* | *118 watts* |
| *1800 x 1440* | *2,592,000* | *129 watts* |
| *2048 x 1440* | *2,949,120* | *143 watts* |
| *2048 x 1536* | *3,145,728* | *150 watts* |

*To qualify a computer monitor as ENERGY STAR, it must be tested according to the protocol outlined in Section 4, Test Methodology.*

B. Sleep and Off Modes

1. Tiers 1 and 2: Maximum power consumption levels for Sleep and Off Modes are provided in Table 2 below. Computer monitors capable of multiple Sleep Modes (i.e., Sleep and

Deep Sleep) shall meet the Sleep Mode requirement below in all such modes. For example, under Tier 1, a computer monitor tested at 7 watts in Sleep and 3 watts in Deep Sleep would not qualify because one of the Sleep Modes exceeds 4 watts.

2. Sleep Mode Exception: Computer monitors that have the capability to proceed automatically from On Mode/Active Power to an Off Mode/Standby Power of 2 watts or less in Tier 1 and 1 watt or less in Tier 2 comply with these energy consumption requirements. The computer monitor's Off Mode/Standby Power must be activated within 30 minutes of user inactivity or as otherwise defined in future versions of the Computer Agreement (issued after current Version 3.0). Upon resumption of user activity (e.g., user moves the mouse or presses a key on the keyboard), the computer monitor must return to full operational capability. In other words, a Sleep Mode is not necessary if the computer monitor can proceed from On Mode/Active Power to Off Mode/Standby Power and meet the ENERGY STAR requirements in the Off Mode/Standby Power.

Table 2: Energy-Efficiency Criteria for Sleep and Off Modes (Tiers 1 and 2)

| | ***Tier 1*** | ***Tier 2*** |
|---|---|---|
| ***Sleep Mode*** | *≤ 4 watts* | *≤ 2 watts* |
| ***Off Mode*** | *≤ 2 watts* | *≤ 1 watt* |

3. Sleep Mode Enabling: Energy savings from the computer monitor's Sleep Mode can only be achieved if this power-saving mode is enabled. EPA recognizes that enabling and default times are driven by the computer, and as such, has outlined these requirements in the Computer Agreement. However, where feasible (e.g., where monitor manufacturer has a business relationship with specific computer manufacturers or where monitor manufacturer also sells its own computers or bundled products), monitor manufacturer should ensure that ENERGY STAR qualified computer monitors have their Sleep Modes enabled when shipped to the customer. Further, the computer shall activate the computer monitor's Sleep Mode within 30 minutes of user inactivity or as otherwise defined in future versions of the Computer Agreement (issued after current Version 3.0). **If a computer monitor has the capability to proceed automatically from On Mode/Active Power to Off Mode/Standby Power, then, consistent with the Sleep Mode requirements, the computer monitor's Off Mode/Standby Power must be activated within 30 minutes of user inactivity or as otherwise defined in future versions of the Computer Agreement (issued after current Version 3.0).**

## 4) Test Methodology

Product Testing Set-up, Methodology, and Documentation: EPA utilizes, where possible, existing, widely-accepted industry practices for measuring product performance and power use under normal or typical operating conditions. The testing and measurement methods below reference published specifications from the Video Electronics Standards Association (VESA) Display Metrology Committee and the International Electrotechnical Commission (IEC), and supplement those guidelines where necessary with methods developed in cooperation with the computer monitor industry.

Manufacturers are required to perform tests and self-certify those product models that meet the ENERGY STAR guidelines. Families of computer monitor models that are built on the same chassis and are identical in every respect but housing and colour may be qualified through submission of test data for a single, representative model. Likewise, models that are unchanged or that differ only in finish from those sold in a previous year may remain qualified without the submission of new test data, assuming the specification remains unchanged.

The power requirement shall be measured from the outlet or power source to the product under test. The average true power consumption of the computer monitor shall be measured during the On Mode/Active Power, the Sleep Mode/Low Power, and the Off Mode/Standby Power. When performing measurements to self-certify a product model, the product being tested must initially be in the same condition (e.g., configuration and settings) as when shipped to the customer, unless adjustments need to be made pursuant to instructions below.

To ensure a consistent means for measuring the power consumption of electronics products, the following protocol must be followed, which has three main components:

*Product Testing Set-up and Conditions:* Outlined below in Sections A through H are the ambient test conditions and measurement protocols that must be respected when performing power measurements.

*Product Testing Methodology:* The actual test steps for measuring power in On Mode/Active Power, Sleep Mode/Low Power, and Off Mode/Standby Power are provided in Section I, below.

*Product Testing Documentation:* Documentation requirements for submittal of qualified product data to EPA are detailed in Section J, below.

This protocol ensures that outside factors do not adversely affect the test results and that the test results can be consistently reproduced. Manufacturers may elect to use an in-house or independent laboratory to provide the test results. A sample of test facilities and recommended test equipment will be provided in the near future on the ENERGY STAR Web site at www.energystar.gov.

***Product Testing Set-up and Conditions***

A. Test Conditions:

*General Criteria*

| | | |
|---|---|---|
| **Supply Voltage*:** | North America:<br>Europe:<br>Australia/New Zealand:<br>Japan: | 115 (± 1%) Volts AC, 60 Hz (± 1%)<br>230 (± 1%) Volts AC, 50 Hz (± 1%)<br>230 (± 1%) Volts AC, 50 Hz (± 1%)<br>100 (± 1%) Volts AC, 50 Hz (± 1%)/60 Hz (± 1%) |
| **Total Harmonic Distortion (Voltage):** | < 2% THD | |
| **Ambient Temperature:** | 20°C ± 5°C | |
| **Relative Humidity:** | 30 – 80 % | |
| **Line Impedance:** | < 0.25 ohm | |

(Reference IEC 62301: Household Electrical Appliances – Measurement of Standby Power, Sections 3.2, 3.3 and VESA Flat Panel Display Measurements (FPDM) Standard 2.0, Section 301-2)

***Supply Voltage**: Manufacturers shall test their computer monitors based on the market in which the models will be sold. Manufacturers must ensure that qualifying products marketed and sold in any region as ENERGY STAR do not exceed the power levels declared on the Qualifying Product Information (QPI) form (and stored in the ENERGY STAR database) at the standard mains voltage and frequency conditions of that region. For equipment that is sold in multiple international markets and therefore rated at multiple input voltages, the manufacturer must test at and report all relevant voltages and power consumption levels if it intends to register the product as ENERGY STAR in the respective markets. For example, a manufacturer that is shipping the same computer monitor model to the United States and Europe must measure and report the On, Sleep, and Off power consumption at both 115 Volts/60 Hz and 230 Volts/50 Hz.

B. Dark Room Conditions: When performing light measurements, the computer monitor shall be located in a dark room condition. The computer monitor screen illuminance measurement (E), when in Off Mode/Standby Power, must be 1.0 Lux or less. Measurements should be made at a point perpendicular to the centre of the screen using a Light Measuring Device (LMD) with the computer monitor in Off Mode/Standby Power (Reference VESA FPDM Standard 2.0, Section 301-2F).

C. Colour Controls and Peripherals: All colour controls (hue, saturation, gamma, etc.) shall be placed at their factory default settings. No external devices shall be connected to any included Universal Serial Bus (USB) hubs or ports. Any built-in speakers, TV tuners, etc. may be placed in their minimum power configuration, as adjustable by the user, to minimize power use not associated with the display itself. Circuit removal or other actions not under user control may not be taken to minimize power use.

D. Power Measurement Test Conditions: CRT pixel format shall be set at the preferred pixel format with the highest resolution that is intended to be driven at a 75 Hz refresh rate. A VESA Discrete Monitor Timing (DMT) or newer industry standard pixel format timing must be used for the test. The CRT monitor must be capable of meeting all its manufacturer-stated quality specifications in the tested format. For LCDs and other fixed pixel technologies, pixel format shall be set to the native level. LCD refresh rate shall be set to 60 Hz, unless a different refresh rate is specifically recommended by the manufacturer, in which case that rate shall be used.

E. Power Measurement Protocols: Computer monitor power consumption shall be measured in watts with an imposed test pattern. Warm-up time shall be a minimum of a 20-minute period (Reference VESA FPDM Standard 2.0, Section 301-2D or 305-3 for warm-up test). A true RMS power meter with a crest factor of at least five shall be used to measure the power use of each randomly chosen unit at one or more, as appropriate, of the voltage/frequency combinations provided in Section 4.A (Reference VESA Standard: Display Specifications and Measurement Procedures, Version 1.0, Revision 1.0, Section 8.1.3). Measurements shall be taken after wattage values are stable over a three-minute period. Measurements are considered stable if the wattage reading does not vary more than 1% over the three-minute period (Reference IEC 4.3.1). (Manufacturers shall ignore the input sync signal check cycle when metering the model in Sleep Mode/Low Power and Off Mode/Standby Power.) Manufacturers shall use calibrated measuring equipment capable of measurements accurate to one-tenth of a watt or better.

Borrowing from European Norm 50301 (Reference BSI 03-2001, BS EN 50301:2001, Methods of Measurement for the Power Consumption of Audio, Video, and Related Equipment, Annex A), EPA has established a test procedure where the number of units required for test depends on the test results for the first unit. For the purposes of ENERGY STAR, if a tested computer monitor uses at least 15% less power (i.e., greater than or equal to 15%) than the ENERGY STAR specification in all three operating modes (On Mode/Active Power, Sleep Mode/Low Power, and Off Mode/Standby Power), then it only has to be tested once. However, if a tested

The following example further illustrates this approach:

EXAMPLE: For simplicity, assume the specification is **100 watts or less and only applies to one operational mode. 85 watts would represent the 15% threshold…**

- If the first unit is measured at **80 watts**, **no more testing** is needed and the model qualifies (80 watts is at least 15% more efficient than the specification and is 'outside' the 15% threshold).
- If the first unit is measured at **85 watts**, **no more testing** is needed and the model qualifies (85 watts is exactly 15% more efficient than the specification).
- If the first unit is measured at **90 watts**, then **two more units** must be tested to determine qualification (90 watts is only 10% more efficient than the specification and is 'within' the 15% threshold).
- If three units are tested at **90, 98, and 105 watts**, the model **does not qualify** as

computer monitor is within 15% (i.e., less than 15%) of the ENERGY STAR specification in any of the three operating modes, then two more units have to be tested. None of the test values may exceed the ENERGY STAR specification for the model to qualify as ENERGY STAR. All of the test results as well as the average values (based on the three or more data points) must be reported on an ENERGY STAR QPI form.

F. Luminance Test Patterns and Procedures: **For CRT monitors,** the technician shall initiate the AT01P (Alignment Target 01 Positive Mode) pattern (VESA FPDM Standard 2.0, A112-2F, AT01P) for screen size and use it to set the computer monitor to the manufacturer's recommended image size, which is typically slightly smaller than maximum viewable screen size. Then, test pattern (VESA FPDM Standard 2.0, A112-2F, SET01K) shall be displayed that provides eight shades of gray from full black (0 volts) to full white (0.7 volts).[40] Input signal levels shall conform to VESA Video Signal Standard (VSIS), Version 1.0, Rev. 2.0, December 2002. The technician shall adjust (where feasible) the computer monitor brightness control downward from its maximum until the lowest black bar luminance level is just slightly visible (VESA FPDM Standard 2.0, Section 301-3K). The technician shall then display a test pattern (VESA FPDM Standard 2.0, A112-2H, L80) that provides a full white (0.7 volts) box that occupies 80% of the image. The technician shall then adjust the contrast control until the white area of the screen provides at least 100 candelas per square meter of luminance, measured according to VESA FPDM Standard 2.0, Section 302-1.

**For all Fixed Pixel displays (e.g., LCDs and others),** test pattern (VESA FPDM Standard 2.0, A112-2F, SET01K) shall be displayed that provides eight shades of gray from full black (0 volts) to full white (0.7 volts).[2] Input signal levels shall conform to VESA Video Signal Standard (VSIS), Version 1.0, Rev. 2.0, December 2002. With the brightness and contrast controls at maximum, the technician shall check that, at a minimum, the white and near white gray levels can be distinguished. If white and near white gray levels cannot be distinguished, then contrast shall be adjusted until they can be distinguished. The technician shall next display a test pattern (VESA FPDM Standard 2.0, A112-2H, L80) that provides a full white (0.7 volts) box that occupies 80% of the image. The technician shall then adjust the brightness control until the white area of the screen provides at least 175 candelas per square meter of luminance, measured according to VESA FPDM Standard 2.0, Section 302-1. [If computer monitor's maximum luminance is less than 175 candelas per square meter (e.g., 150), then technician shall use the maximum luminance (e.g., 150) and report the value to EPA with other required testing documentation. Similarly, if the computer monitor's minimum luminance is greater than 175 candelas per square meter (e.g., 200), then technician shall use the minimum luminance (e.g., 200) and report the value to EPA.]

G. Light Measurement Protocols: When light measurements, such as illuminance and luminance, need to be made, a LMD shall be used with the computer monitor located in dark room conditions. The LMD shall be used to make measurements at the centre of, and perpendicular to the computer monitor screen (Reference VESA FPDM Standard 2.0, Appendix A115). The screen surface area to be measured shall cover at least 500 pixels, unless this exceeds the equivalent of a rectangular area with sides of lengths equal to 10% of the visible screen height and width (in which case this latter limit applies). However, in no case may the illuminated area be smaller than the area the LMD is measuring (Reference VESA FPDM Standard 2.0, Section 301-2H).

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[40] Corresponding voltage values for digital only interface monitors that correspond to the brightness of the image (0 to 0.7 volts) are:

0 volts (black) = a setting of 0

0.1 volts (darkest shade of gray analog) = 36 digital gray

0.7 volts (full white analog) = 255 digital gray

Please note that future digital interface specifications may widen this range, but in all cases, 0 volts shall correspond to black and the maximum value shall correspond to white, with 0.1 volts corresponding to one-seventh of the maximum value.

H. Display Set-up and Characterization: The computer monitor test sample characteristics shall be recorded prior to the test. The following information shall be recorded at a minimum:

| |
|---|
| Product Description/Category (e.g., 17-inch computer monitor with white housing) |
| Display Technology (e.g., CRT, LCD, Plasma) |
| Brand Name/Manufacturer |
| Model Number |
| Serial Number |
| Rated Voltage (VAC) and Frequency (Hz) |
| Viewable Diagonal Size (inches) |
| Aspect Ratio (e.g., 4:3) |
| Recommended Image Size (actual size tested) Width X Height |
| Viewing Angle (horizontal and vertical degrees) |
| Screen Refresh Rate (during test) (Hz) |
| Number of Pixels as Tested (horizontal) |
| Number of Pixels as Tested (vertical) |
| Maximum Claimed Resolution (horizontal) |
| Maximum Claimed Resolution (vertical) |
| Analog, Digital, or Both Interfaces |
| Instrumentation Information (e.g., type of signal generator) |

a. Product Testing Methodology

I. Test Method: Following are the test steps for measuring the true power requirements of the test unit in On Mode/Active Power, Sleep Mode/Low Power, and Off Mode/Standby Power. Manufacturers are required to test their computer monitors using the analog interface, except in those cases where one is not provided (i.e., digital interface monitors, which are defined as only having a digital interface for purposes of this test method). For digital interface monitors, please see Footnote 2 on page 9 for voltage information and then follow the test method below using a digital signal generator.

**On Mode/Active Power**

1. Connect the test sample to the outlet or power source and test equipment. For computer monitors shipped with an external power supply, the external power supply (as opposed to a reference power supply) must be used in the test.

2. Power on all test equipment and properly adjust power source voltage and frequency.

3. Check for normal operation of the test unit and leave all customer adjustments set to factory default settings.

4. Bring the test unit into On Mode/Active Power either by using the remote control device or by using the ON/OFF switch on the test unit cabinet. Allow the unit under test to reach operating temperature (approximately 20 minutes).

5. Set the proper display mode. Refer to Section D, Power Measurement Test Conditions.

6. Provide dark room conditions. See Sections G, Light Measurement Protocols, and B, Dark Room Conditions.

7. Set size and luminance. Refer to Section F, Luminance Test Patterns and Procedures for CRT or Fixed Pixel displays. Once luminance is set, dark room conditions are no longer needed.

8. Either verify that the wall outlet power is within specifications or adjust the AC power source output as described in Section A (e.g., 115V ± 1%, 60Hz ± 1%).

9. Set the power meter current range. The full-scale value selected multiplied by the crest factor rating (Ipeak/Irms) of the meter must be greater than the peak current reading from the oscilloscope.

10. Allow the readings on the power meter to stabilize and then take the true power reading in watts from the power meter. Measurements are considered stable if the wattage reading does not vary more than 1% over the three-minute period. See Section E, Power Measurement Protocols.

11. Power consumption shall be recorded, as well as total pixel format (horizontal x vertical pixels displayed), to calculate pixels/watt.

12. Record the test conditions and test data.

**Sleep Mode/Low Power (Power Switch On, No Video Signal)**

1. At the conclusion of the On Mode/Active Power test, initiate the computer monitor's Sleep Mode/Low Power. The method of adjustment shall be documented along with the sequence of events required to reach the Sleep Mode/Low Power. Power on all test equipment and properly adjust operation range.

2. Allow the computer monitor to remain in Sleep Mode/Low Power until stable power readings are measured. Measurements are considered stable if the wattage reading does not vary more than 1% over the three-minute period. Manufacturers shall ignore the input sync signal check cycle when metering the model in Sleep Mode/Low Power.

3. Record the test conditions and test data. The measurement time shall be sufficiently long to measure the correct average value (i.e., not peak or instantaneous power). If the device has different Sleep Modes that can be manually selected, the measurement should be taken with the device in the most energy consumptive of those modes. If the modes are cycled through automatically, the measurement time should be long enough to obtain a true average that includes all modes.

**Off Mode/Standby Power (Power Switch Off)**

1. At the conclusion of the Sleep Mode/Low Power test, initiate the computer monitor's Off Mode/Standby Power. If only one power switch is provided (i.e., a soft off or a hard off), press that switch; if two power switches are provided (i.e., a soft off AND a hard off), press the soft off switch. The method of adjustment shall be documented along with the sequence of events required to reach the Off Mode/Standby Power. Power on all test equipment and properly adjust operation range.

2. Allow the computer monitor to remain in Off Mode/Standby Power until stable power readings are measured. Measurements are considered stable if the wattage reading does not vary more than 1% over the three-minute period. Manufacturers shall ignore the input sync signal check cycle when metering the model in Off Mode/Standby Power.

3. Record the test conditions and test data. The measurement time shall be sufficiently long to measure the correct average value (i.e., not peak or instantaneous power).

***Product Testing Documentation***

J. Submittal of Qualified Product Data to EPA: Partners are required to self-certify those product models that meet the ENERGY STAR guidelines and report information to EPA through the Online Product Submittal tool. ENERGY STAR qualifying product data, including information about new as well as discontinued models, must be provided on an annual basis, or more frequently if desired by the manufacturer.

5) **User Interface**: Manufacturers are strongly recommended to design products in accordance with the user interface standard IEEE P1621: Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments[41]. This standard was developed by the Power Management Controls project to make power controls more consistent and intuitive across all electronic devices. For details on this project, see http://eetd.LBL.gov/Controls.

6) **Effective Date**: The date that manufacturers may begin to qualify products as ENERGY STAR, under the Version 4.1 specification, will be defined as the *effective date* of the agreement. Any previously executed agreement on the subject of ENERGY STAR qualified computer monitors shall be terminated effective December 31, 2004.

A. Qualifying Products under Tier 1 of the Version 4.1 Specification: Tier 1 of the Version 4.1 specification shall commence on **January 1, 2005**. All products, including models originally qualified under Version 3.0, with a **date of manufacture** on or after **January 1, 2005**, must meet the new (Version 4.1) requirements in order to qualify for ENERGY STAR (including additional shipments of models originally qualified under Version 3.0). The **date of manufacture** is specific to each unit and is the date (e.g., month and year) of which a unit is considered to be completely assembled.

B. Qualifying and Labeling Products under Tier 2 of the Version 4.1 Specification: The second phase of this specification, Tier 2, shall commence on **January 1, 2006**. Specifications for Tier 2 shall apply to products with a date of manufacture on or after **January 1, 2006**. For example, a unit with a date of manufacture of January 1, 2006 must meet the Tier 2 specification in order to qualify as ENERGY STAR.

C. Elimination of Grandfathering: EPA will not allow grandfathering under this Version 4.1 ENERGY STAR specification. **ENERGY STAR qualification under Version 3.0 is not automatically granted for the life of the product model.** Therefore, any product sold, marketed, or identified by the manufacturing partner as ENERGY STAR must meet the current specification in effect at the time of manufacture of the product.

7) **Future Specification Revisions**: EPA reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions.

EPA will periodically assess the market in terms of energy efficiency and new technologies. As always, stakeholders will have an opportunity to share their data, submit proposals, and voice any concerns. EPA will strive to ensure that the Tier 1 and 2 specifications recognize the most energy-efficient models in the marketplace and reward those manufacturers who have made efforts to further improve energy efficiency.

[41] Please note that IEEE officially approved standard P1621: Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments on December 9, 2004. The Version 4.1 ENERGY STAR Program Requirements for Computer Monitors have been updated to reference this standard.

# Appendix 3 Generalised Internal Power Supply Test Protocol Rev 6.1

***NOTE – this has been converted from the PDF file available from***

**http://www.efficientpowersupplies.org/pages/Latest_Protocol/Generalized_Internal_Power_Supply_Efficiency_Test_Protocol_R6.1.pdf**

## Proposed Test Protocol for Calculating

## the Energy Efficiency of Internal Ac-Dc Power Supplies

## Revision 6.1



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**Revision History**

| Version | Release Date | Notes |
|---|---|---|
| 1.0 | Feb 15, 2004 | First draft released. |
| 2.0 | June 1, 2004 | Section on ‘Product-specific loading guidelines’ added. |
| 3.0 | Aug 1, 2004 | Definitions of measurement parameters modified to match IEEE standard. |
| 4.0 | Dec 1, 2004 | Comments from Australia on proportional allocation method received. Enhanced proportional allocation method to calculate the power supply loading was included in this revision. |
| 5.0 | Aug 1, 2005 | Addition of measurement provisions to capture the effects of cyclically operating cooling fans.<br><br>Changes in the power measurement accuracy. |
| 6.0 | Mar 15, 2006 | Scope was modified to focus on internal power supplies that are detachable, have nameplate ratings, and use standard connectors.<br><br>Specifications for power measurement equipment refined.<br><br>Addition of provisions to guide measurement of power supply ac power consumption during standby mode. |
| 6.1 | May 8, 2006 | Wiring diagram was modified to reduce possibility for introduction of errors at very low load measurements. |

## 1. Scope

This document specifies a test protocol for calculating the energy efficiency of internal ac-dc power supplies. Internal power supplies are located in the same housing as the product that they power. An example of this type of power supply is a desktop computer power supply that has multiple output voltages: +12 V, +5 V, +3.3 V, and -12 V (See Appendix B). External power supplies – often referred to as ac adapters – are contained in a housing separate from the devices they power and are not included in the scope of this document. In addition, ac-ac voltage conversion equipment such as ac transformers and dc-dc voltage conversion equipment are not included in the scope of this document. The test protocol in this document applies specifically to single-phase or three-phase internal power supplies that meet the following criteria:

i. Power supplies that have detailed input and output ratings on their name plate or in available literature from their manufacturer, specifying the maximum loads that can safely be placed on each individual dc output voltage bus and, where necessary, groupings of those voltage busses

ii. Power supplies that have industry standard connectors that allow the dc output voltage busses to be connected and disconnected from the powered product non-destructively

iii. Power supplies that can be easily detached from the housing of the product they power without causing harm to other circuits and components of the product

Power supplies physically integrated within the main circuit board of the device they are powering are specifically not covered by this test procedure, as are power supplies that have a combination of ac and dc output voltage busses. Building upon the efficiency test protocol outlined in Section 4.3 of IEEE Std. 1515-2000, *IEEE Recommended Practice for Electronic Power Subsystems: Parameter Definitions, Test Conditions, and Test Methods*, this test protocol establishes consistent loading guidelines for ac-dc internal power supplies.

### 1.1 Intent

The intent of this document is to use existing industry standards that have been created for electronic test and measurement to develop a consistent and repeatable method for measuring the energy efficiency of single and multiple output ac-dc internal power supplies. Existing standards occasionally give conflicting approaches and requirements for efficiency testing, all of which this test protocol seeks to clarify.

## 2. References

The following list includes documents used in the development of this proposed test protocol. If the following publications are superseded by an approved revision, the revision shall apply:

1. IEEE Std 1515-2000, *IEEE Recommended Practice for Electronic Power Subsystems: Parameter Definitions, Test Conditions, and Test Methods*.

2. IEEE Std 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*.

3. IEC 62301 Ed 1.0, *Household Electrical Appliances – Measurement of Standby Power*

4. Draft IEC 62018 Ed. 1, *Energy Management Requirements*.

5. UL 60950, 3rd Edition, *Information Technology Equipment – Safety – Part 1: General Requirements*, April 1, 2003.

6. IEC 61000-4-7 Ed.2, *Electromagnetic Compatibility (EMC) - Part 4-7: Testing and Measurement Techniques - General Guide on Harmonics and Interharmonics. Measurements and Instrumentation, for Power Supply Systems and Equipment Connected Thereto*.

7. IEC 61000-3-2, *Electromagnetic Compatibility (EMC) – Part 3-2: Limits – Limits for Harmonic Current Emissions (Equipment Input Current ≤ 16 A per Phase)*.

8. IEC 60050, *International Electrotechnical Vocabulary - Electrical and Electronic Measurements and Measuring Instruments*.

9. IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*.

10. *Power Supply Design Guidelines* (*website: www.formfactors.org*), Intel Corporation.

## 3. Definitions

For the purpose of this document, the following definitions apply. For terms not defined here, definitions from IEC 60050, IEC 62301, and IEEE 100 are applicable.

### 3.1 Ac-Dc Power Supply

Devices designed to convert ac voltage into dc voltage for the purpose of powering electrical equipment.

### 3.2 Ac Signal

A time-varying signal whose polarity varies with a period of time *T* and whose average value is zero. (ref. IEEE Std 1515-2000)

### 3.3 Ambient Temperature

Temperature of the ambient air immediately surrounding the unit under test (UUT). (ref. IEEE Std 1515-2000)

### 3.4 Apparent Power (S)

The product of RMS voltage and current (VA). Also called the *total power*.

### 3.5 Dc Signal

A signal of which the polarity and amplitude do not vary with time. (ref. IEEE Std 1515-2000)

### 3.6 Efficiency

The ratio, expressed as a percentage, of the total real output power (produced by a conversion process) to the real power input required to produce it, using the following equation:

$$\eta = \frac{\sum_i P_{o,\,i}}{P_{in}} \times 100 \qquad \text{Eq. 3-1}$$

where $P_{o,\,i}$ is the output power of the $i^{th}$ output. The input power ($P_{in}$), unless otherwise specified, includes all housekeeping and auxiliary circuits required for the converter to operate, including any integrated cooling fans.

### 3.7 Enclosed-Frame Modular Internal Power Supply

A power supply encased in a modular enclosure, as shown in Figure B-1 (a). The enclosure is installed inside the appliance and has easily accessible inputs and outputs.

### 3.8 Multiple-Output Power Supply

A power supply designed to provide more than one dc voltage level or bus.

### 3.9 Open-Frame Modular Internal Power Supply

A power supply whose components are grouped on a single printed circuit board but are not enclosed in a case, as shown in Figure B-1 (b). Such power supplies are installed inside the appliance that they power, have easily accessible inputs and outputs, and can be separated from the appliance without causing damage to other components and circuits.

### 3.10 Output Voltage Bus

Any of the dc outputs of the power supply, to which loads can be connected and current and power supplied. These busses may supply power at different voltage levels depending on the design of power supply and the product being powered.

### 3.11 True Power Factor

True power factor is the ratio of the active, or real, power (P) consumed in watts to the apparent power (S) drawn in volt-amperes, with

$$PF = \frac{P}{S} \qquad \textit{Eq. 3-2}$$

and

$$S = \sqrt{P^2 + Q^2} \qquad \textit{Eq. 3-3}$$

Where

PF is power factor,

P is active power in watts,

Q is reactive power in volt-amperes,

S is total power in Volt-amperes.

This definition of power factor includes the effect of both displacement and distortion in the input current (and/or voltage) waveform. (ref. IEEE Std 1515-2000)

### 3.12 Crest Factor

The crest factor is defined as the ratio of peak current to rms current (or peak voltage to rms voltage). For a pure sinusoidal waveshape the crest factor is 1.414, while for a pure constant dc load the crest factor is 1.0.

### 3.13 Rated Ac Input Voltage

The supply voltage declared by the manufacturer in the specification of the power supply. For a single-phase power supply, this refers to line-to-neutral voltage, and for a three-phase power supply, this refers to the line-to-line voltage.

### 3.14 Rated Ac Input Voltage Range

The supply voltage range (minimum/maximum) as declared by the manufacturer in the specification of the power supply.

### 3.15 Rated Dc Output Current

The dc output current for each output dc bus of the power supply as declared by the manufacturer in the specification or nameplate of the power supply. If there is a discrepancy between the specification and the nameplate, the nameplate rating shall be used.

### 3.16 Rated Dc Output Current Range

The dc output current range (minimum/maximum) for each output voltage bus of the power supply as declared by the manufacturer in the specification of the power supply.

### 3.17 Rated Dc Output Power

The maximum dc output power as specified by the manufacturer. This may apply to the total power for all voltage busses, some subset thereof, or a single voltage bus.

### 3.18 Rated Dc Output Voltage

The dc output voltage for each output voltage bus of the power supply as declared by the manufacturer in the specification of the power supply.

### 3.19 Rated Input Frequency

The supply ac input frequency of the power supply as declared by the manufacturer in the specification of the power supply.

### 3.20 Rated Input Frequency Range

The supply ac input frequency range (minimum/maximum) of the power supply as declared by the manufacturer in the specification of the power supply.

### 3.21 Rated Input Current

The input current of the power supply as declared by the manufacturer in the specification of the power supply. For a three-phase supply, rated input current refers to the input current in each phase.

### 3.22 Rated Input Current Range

The input current range (minimum/maximum) for a power supply as declared by the manufacturer in the specification of the power supply. For a three-phase supply, rated input current refers to the input current in each phase.

### 3.23 Rms (Root Mean Square)

The square root of the average of the square of the value of the function taken throughout the period. For instance, the rms voltage value for a sine wave may be computed as:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T V^2(t)dt} \qquad \textbf{\textit{Eq. 3-4}}$$

where

*T* is the period of the waveform,

*V(t)* is the instantaneous voltage at time *t*,

$V_{RMS}$ is the rms voltage value.

(ref. IEEE Std 1515-2000)

### 3.24 Single-Output Power Supply

Power supplies designed to provide one dc voltage level on one output voltage bus.

**3.25 Standby Mode**

Standby represents the mode during which all dc power is delivered through the standby voltage rail of the power supply (see Section 3.26).

**3.26 Standby Voltage Rail (Vsb)**

The standby voltage rail is the output voltage bus that is present whenever ac power is applied to the ac inputs of the supply. (ref. Intel Power Supply Design Guidelines Rev. 0.5)

**3.27 Steady State**

The operating condition of a system wherein the observed variable has reached an equilibrium condition in response to an input or other stimulus in accordance with the definition of the system transfer function. In the case of a power supply, this may involve the system output being at some constant voltage or current value. (ref. IEEE Std 1515-2000)

**3.28 Test Voltage Source**

The test voltage source refers to the device supplying power (voltage and current) to the unit under test (UUT).

**3.29 Total Harmonic Distortion (THD)**

The ratio, expressed as a percent, of the rms value of an ac signal after the fundamental component is removed to the rms value of the fundamental. For example, THD of current can be defined as:

$$THD_I = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 \ldots\ldots I_n^2}}{I_1} \qquad \textbf{Eq. 3-5}$$

where $I_n$ is the rms value of *n*th harmonic of the current signal.

**3.30 UUT**

Unit under test. (ref. IEEE Std 1515-2000)

**3.31 Voltage Unbalance**

The maximum difference between rms phase to neutral or phase-to-phase voltage amplitudes at the UUT input terminals. For example, for a wye-connected, three-phase system

$$V_{UNB} = \left(\max\left[V_{AN}, V_{BN}, V_{CN}\right] - \min\left[V_{AN}, V_{BN}, V_{CN}\right]\right) \qquad \textbf{Eq. 3-6}$$

where

$V_{AN}$, $V_{BN}$, $V_{CN}$ are the phase voltage magnitudes, and

$V_{UNB}$ is the maximum phase voltage unbalance.

Percent voltage unbalance is calculated by multiplying the maximum voltage unbalance by 100 and dividing the result by the average of the three phase voltages.

$$V_{UNB\%} = \frac{V_{UNB}}{\left(\frac{V_{AN} + V_{BN} + V_{CN}}{3}\right)} \times 100$$ ***Eq. 3-7***

(ref. IEEE Std 1515-2000)

## 4. Standard Conditions for Efficiency Testing

### 4.1 General Provisions

Input voltage, frequency, output bus loading, and in some cases, the duty cycle of the fan inside the power supply are among the variables that can impact the efficiency of an internal power supply. Sections 4.2, 4.3, and 4.4 below recommend a minimum set of requirements in order to control these variables while measuring internal power supply efficiency. Beyond these minimum conditions, the manufacturer and user of the power supply may determine additional requirements, such as harmonic distortion or unbalance specification as needed.

### 4.2 Input Voltage and Frequency

An ac reference source shall be used to provide input voltage to the UUT. As is specified in IEC 62301, the input to the UUT shall be the specified voltage ± 1% and the specified frequency ± 1%. The UUT shall be tested at two voltage and frequency combinations:

115 V at 60 Hz and 230 V at 50 Hz if its nameplate input voltage and frequency indicate that it can operate safely under both conditions. If testing at both conditions is not possible, the UUT shall be tested at one of the above voltage and frequency combinations that is closest to its nameplate input voltage and frequency. If voltage and/or frequency ranges are not specified by the manufacturer (or the nameplate value is unclear), the UUT shall not be tested.

### 4.3 Power Supply Loading

The efficiency of the UUT shall be measured at 20%, 50%, and 100% of nameplate output current. Testing at a 10% loading condition is required for internal power supplies that are designed to be operated in redundant configurations and optional for non-redundant power supplies. The ac power consumption of the power supply shall also be measured under a special standby loading condition. Other loading conditions may be identified that are relevant to the manufacturer and user of the power supply. Procedures for loading internal power supplies with multiple dc voltage busses are described in detail in Section 6.1.1 below.

In some cases, the manufacturer may specify a minimum current requirement for each bus of the power supply. In these cases, it is important to ensure that the 10% or 20% loading point is not lower than the minimum current requirement. In cases where the minimum current requirement exceeds the test method's calculated load point for a given voltage bus, the value of the minimum current requirement should be used to load the bus. The percent load of the load point shall be properly recorded in any test report based on the new load values used for the busses with minimum loading requirements.

Prior to power measurements, the UUT shall be allowed to operate at each load point for at least 15 minutes in order to allow the power supply to reach a steady state of operation.

### 4.4 Duty Cycle of Power Supply Fan

In some power supply designs, the duty cycle (expression of percent on time) of a cooling fan is controlled by the temperature of the heat sink. If the heat sink inside the power supply reaches a certain set temperature value, the fan switches on. If the heat sink cools down below the set temperature value, the fan switches off. The duty cycle of the fan can then influence the efficiency of the power supply especially during the time of measurement. In order to capture the effect of the duty cycle of the fan on the efficiency of the power supply, the input and output power measurements shall be integrated over a period of 30 minutes[42] (after thermal equilibrium of the power supply is reached) or five fan cycles, whichever is reached first (one fan cycle consists of one on pulse followed by one off pulse). For power measurement procedure refer to section 4 of IEC 62301 (*Measurement of Standby Power)*.

## 5. Instrumentation and Equipment

### 5.1 General Provisions

These procedures are meant to ensure the accurate and consistent measurement of power supplies across testing laboratories. Please refer to Annex B of IEEE 1515-2000, *IEEE Recommended Practice for Electronic Power Subsystems: Parameter Definitions, Test Conditions, and Test Methods*, for guidelines for general test practices and to section 4, Annex B and D of IEC 62301, Ed. 1.0, *Measurement of Standby Power*, for a discussion on evaluating measurement uncertainty.

### 5.2 Test Voltage Source

The input voltage source shall be capable of delivering at least 10 times the nameplate input power of the UUT where practicable (as is specified in IEEE 1515-2000). The input voltage source shall be deemed inadequate and different voltage source shall be used if the input voltage varies at any point during the test by more than ± 1% of the specified source voltage for the test (115 Vac or 230 Vac).

Regardless of the ac source type, the THD of the supply voltage when supplying the UUT in the specified mode shall not exceed 2%, up to and including the $13^{th}$ harmonic (as specified in IEC 62301). The peak value of the test voltage shall be within 1.34 and 1.49 times its rms value (as specified in IEC 62301).

The voltage unbalance for a three-phase test source shall be less than 0.1%.

### 5.3 Test Dc Loads

Active dc loads such as electronic loads or passive dc loads such as rheostats used for efficiency testing of the UUT shall be able to maintain the required current loading set point for each output voltage within an accuracy of ± 0.5%. If electronic load banks are used, their settings should be adjusted such that they provide a constant current load to the UUT.

### 5.4 Test Leads and Wiring

Appropriate American Wire Gauge (AWG) wires have to be selected for different part of wiring connections depending on the maximum current carried by the conductor in order to avoid overheating of wires from excessive loading and to reduce excessive voltage drop across the wires which may lead to incorrect efficiency measurements. For detailed information and guidance on measurement and wiring, please refer to Annex B in IEEE 1515-2000. The Table B.2, 'Commonly used values for wire gages and related voltage drops' in IEEE 1515-2000 gives the relation between the voltage drop across the conductor as a function of three variables: current carried by the conductor, conductor AWG, and conductor length. The voltage drop across the conductor carrying the current must be added or subtracted to the appropriate voltage measurements (please refer to Figure 1 below) if the input and output measurements of the UUT are not taken directly at the connector pins.

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[42] Accumulated energy approach to get average power consumption (Please refer to section 4.3, IEC 62301 Ed 1.0): Where the instrument can accumulate energy over a user selected period, the period selected shall not be less than 5 minutes. The integrating period shall be such that the total recorded value for energy and time is more than 200 times the resolution of the meter for energy and time. Determine the average power by dividing the accumulated energy by the time for the monitoring period.

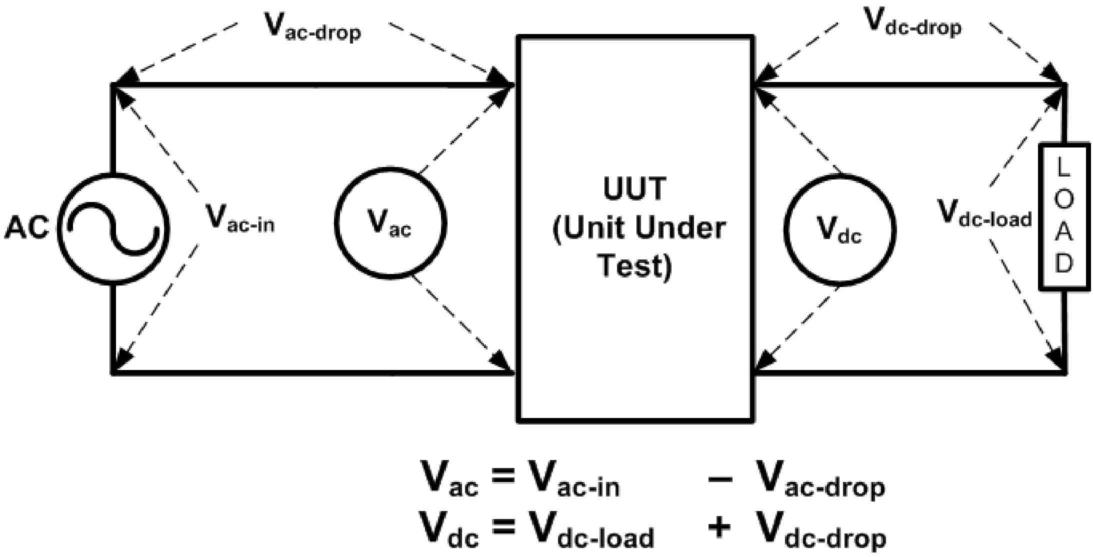



***Figure 1 Input and Output Voltage Measurements***

The generic test setup can be made as shown in Figure 2 below. The ac power meter used in the efficiency test should be capable of measuring the ac voltage, ac current, ac power, power factor, and total harmonic distortion of current. The dc power meter should be capable of measuring dc voltage, dc current, and dc power on all dc voltage outputs of the device. All power metering equipment should meet the accuracy requirements described in section 5.5 of this document. The dc load(s) shall be capable of drawing constant current during the course of the test and shall meet the tolerances specified in section 5.3 of this document.

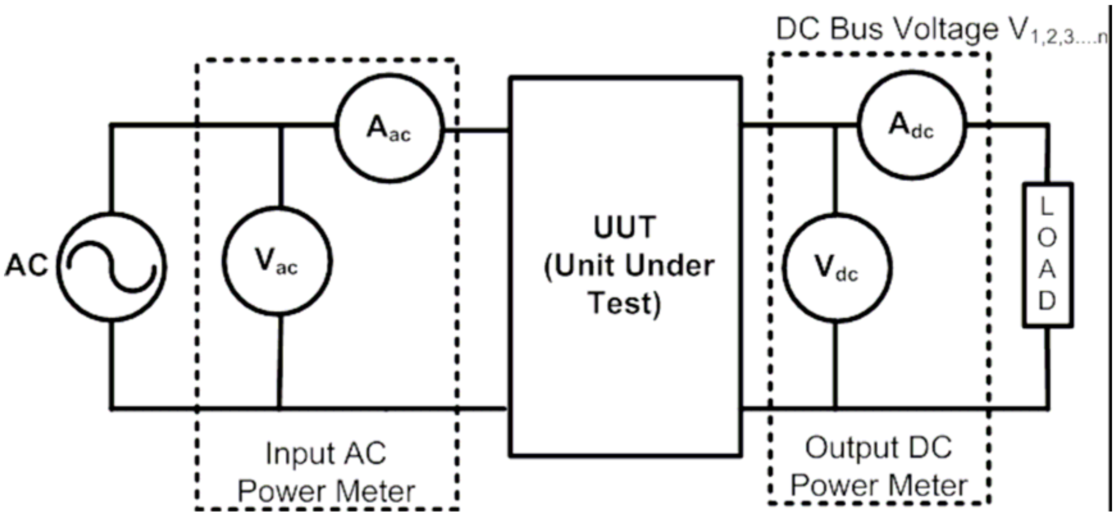



***Figure 2 Generic Efficiency Test Setup***

### 5.5 Measurement Instrumentation Accuracy

Power measurements shall be made with a suitably calibrated voltmeter and ammeter or power analyser as specified under IEC 62301. Measurements of power of 0.5 W or greater shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level. Measurements of power of less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level. The power measurement instrument shall have a resolution of:

i. 0.01 W or better for power measurements of 10 W or less.

ii. 0.1 W or better for power measurements of greater than 10 W up to 100 W

iii. 1 W or better for power measurements of greater than 100 W.

For appliances connected to more than one phase, the power measurement instrument shall be equipped to measure total power of all phases connected.

For further details please see Annex D of IEC 62301 and ISO Guide to the Expression of Uncertainty in Measurement.

### 5.6 Test Room

As is specified in IEC 62301, the tests shall be carried out in a room that has an air speed close to the UUT of ≤ 0.5 m/s, and the ambient temperature shall be maintained at 23°C ± 5°C throughout the test. There shall be no intentional cooling of the UUT by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be tested on a thermally non-conductive surface.

### 5.7 Warm-up Time

Internal temperature of the components in a power supply could impact the efficiency of the unit. As a general recommendation before testing, each UUT shall be loaded up to the test load for a period of at least 15 minutes or for a period sufficient that the total input power reading over two consecutive five-minute intervals does not change by more than ± 1%.

## 6. Loading Criteria for Efficiency Testing

### 6.1 General Provisions

Loading criteria for ac-dc power supplies shall be based on rated dc output current and not on rated dc output power. For example, consider the 50% loading condition for a 50 W, +5 V single-output power supply with a rated dc output current of 10 A. The load condition is achieved by adjusting the dc load (using a rheostat or electronic load bank) connected to the 5 V bus output so that 5 A of current is flowing on the bus. This is *not* equivalent to adjusting the load bank until the load on that bus dissipates 25 W of power, because voltage regulation may not remain constant under a range of loading conditions.

For power supplies with multiple output voltage busses, defining consistent loading criteria is much more difficult, because each bus has a rated dc output current. The sum of the power dissipated from each bus loaded to these rated currents may exceed the overall rated dc output power of the power supply. A proportional allocation method is recommended for providing consistent loading guidelines for multiple output internal ac-dc power supplies. This method is described in detail in the next section.

#### *6.1.1 Proportional allocation method for loading multiple output ac-dc power supplies*

This section shows a procedure for developing loading guidelines based on a proportional allocation method. Measurements shall be taken at loading points 20%, 50% and 100% of rated output power. A measurement at 10% is required for redundant power supplies and optional for non-redundant power supplies. The UUT’s nameplate specifies the maximum rated dc output current on each output voltage bus, and care should be taken not to exceed those values. However, loading the busses to their *individual* current maximums often will exceed the *overall* rated dc output power of the power supply. In some cases, ratings are established for a subgroup of the output voltage busses. These *subgroup* ratings can also be exceeded if the busses are loaded to their *individual* current maximums. The following sections provide procedures for loading multiple-output ac-dc power supplies by using a calculated derating factor (*D*).

6.1.1.1 Method of Proportional Allocation Based on Overall Power Supply Rated Dc Output Current with No Sub-group Ratings

The manufacturer has provided rated dc output current limits for each bus and an overall rated dc output power for the power supply. The approach for loading criteria is as follows:

Assume a power supply with four output voltage busses. A sample output specification of this power supply is shown in Table 6-1.

***Table 6-1: Labels for Output Variables***

| Rated Dc Output Voltage of Each Bus | Rated Dc Output Current of Each Bus | Rated Overall Dc Output Power |
|---|---|---|
| $V_1$ | $I_1$ | $P$ |
| $V_2$ | $I_2$ | |
| $V_3$ | $I_3$ | |
| $V_4$ | $I_4$ | |

**Step 1:** Calculate the derating factor *D* using the procedure outlined in Eq. 6-1.

$$D = \frac{P}{(V_1 \times I_1) + (V_2 \times I_2) + (V_3 \times I_3) + (V_4 \times I_4)}$$ ***Eq. 6-1***

**Step 2:** If $D \geq 1$, then it is clear that loading the power supply to the rated dc output current for every bus does not exceed the overall rated dc output power for the power supply. For this case, the required output dc current on each bus for *X*% loading can be determined by

$$I_{Bus} = I_N \times \frac{X}{100}$$ ***Eq. 6-2***

where $I_{bus}$ is the required output dc current for that bus at X percent load and $I_n$ is the rated dc output current for that bus. For example, Table 6-2 shows the guideline for 50% loading of the power supply based on $D \geq 1$.

***Table 6-2: 50% Loading Guideline for* D ≥ *1***

| Output Voltage of Each Bus | 50% Loading Guideline |
|---|---|
| $V_1$ | $0.5*I_1$ |
| $V_2$ | $0.5*I_2$ |
| $V_3$ | $0.5*I_3$ |

| | |
|---|---|
| $V_4$ | $0.5*I_4$ |

$$I_{Bus} = \frac{D \times X \times I_N}{100} \qquad \textbf{\textit{Eq. 6-3}}$$

This effectively derates the output dc current of each output voltage bus such that at 100% load, the overall load will equal the rated dc output power of the power supply. It also derates other load levels. For example, Table 6-3 shows the guideline for 50% loading of the power supply based on $D < 1$.

***Table 6-3: 50% Loading Guideline for* D *< 1***

| Output Voltage of Each Bus | 50% Loading Guideline |
|---|---|
| $V_1$ | $D*0.5*I_1$ |
| $V_2$ | $D*0.5*I_2$ |
| $V_3$ | $D*0.5*I_3$ |
| $V_4$ | $D*0.5*I_4$ |

**Step 1:** Calculate derating factors $D_{S1}$ to $D_{S6}$ for each of the subgroups as shown in Eq. 6-4.

$$D_{S1-2} = \frac{P_{S1-2}}{(V_1 \times I_1 + V_2 \times I_2)}$$

$$D_{S3-4} = \frac{P_{S3-4}}{(V_3 \times I_3 + V_4 \times I_4)}$$

***Eq. 6-4***

$$D_5 = \frac{P_{S5}}{V_5 \times I_5}$$

$$D_6 = \frac{P_{S6}}{V_6 \times I_6}$$

If the derating factor DS ≥ 1, then it is clear that when the subgroup is loaded to the rated dc output currents, the subgroup rated output powers will not be exceeded and there is no need for derating.

However, if one or more DS factors are less than 1 then the subgroup power will be exceeded if the outputs are loaded to their full output currents and there is a need for derating.

**Step 2:**

There is also a need to check whether the sum of the subgroup maximum rated powers is greater than the total maximum power rating of the power supply (PT). If the sum of the subgroup maximum rated powers is greater than the overall power rating of the power supply then a second derating factor DT must be applied. This factor is calculated as shown below:

$$D_T = \frac{P_T}{P_{S1-2} + P_{S3-4} + P_5 + P_6}$$

***Eq. 6-5***

If $D_T \geq 1$ then no derating is needed.

If $D_T < 1$ then the derating for each of the outputs has to be applied and is shown below.

For example, Table 6-5 shows the guideline for X% loading of the power supply based on $D_S < 1$ and $D_T < 1$.

***Table 6-5 Output Loading Current Calculation for Each Individual and Sub-group Bus Voltages***

| Output Voltage | Output Current Rating | Subgroup | Output Loading Current |
|---|---|---|---|
| $V_1$ | $I_1$ | 1-2 | $D_T \times D_{S1-2} \times I_1 \times \frac{X}{100}$ |
| $V_2$ | $I_2$ | | $D_T \times D_{S1-2} \times I_2 \times \frac{X}{100}$ |
| $V_3$ | $I_3$ | 3-4 | $D_T \times D_{S3-4} \times I_3 \times \frac{X}{100}$ |
| $V_4$ | $I_4$ | | $D_T \times D_{S3-4} \times I_4 \times \frac{X}{100}$ |
| $V_5$ | $I_5$ | 5 | $D_T \times D_{S5} \times I_5 \times \frac{X}{100}$ |
| $V_6$ | $I_6$ | 6 | $D_T \times D_{S6} \times I_6 \times \frac{X}{100}$ |

### *6.1.2 Method of Current Allocation for Measuring the Ac Power Consumption of a Computer Internal Power Supply in the Standby Condition*

Measurement of the ac power consumption of computer internal power supplies operated in standby mode shall be conducted by connecting the power supply to an ac voltage source through its ac input and applying the following current loads to its standby voltage rail (+5Vsb): 100 mA, 250 mA, and 1,000 mA. (ref. Intel Power Supply Design Guidelines Rev. 0.5)

For power supplies designed to power other electronic products, measurement of the ac power consumption in standby mode shall be conducted by connecting the power supply to an ac voltage source through its ac input and applying current loads to the standby voltage rail equal to 20%, 50%, and 100% of its nameplate current rating. Testers may choose to test the ac power consumption during standby mode at other load points *in addition* to the above recommended load points if these loads better characterize the real loads placed on the standby voltage rail when installed in its intended product.

## 7. Measurement Procedures

1. Record all the input and output specifications of the ac-dc power supply provided by the manufacturer in the power supply specification sheet. These may include one or more of the following specifications:

• Rated input ac voltage

• Rated input ac voltage range

• Rated input ac current

• Rated input ac current range

• Rated input frequency

• Rated input frequency range

• Rated output dc power

• Rated output dc current

• Rated output dc current range

• Rated output dc voltage

• Rated output dc voltage range

2. Record the ambient environmental conditions at the site of the test, including:

• Ambient temperature

• Elevation of test location

• Barometric pressure

3. Calculate the loading criteria for each output voltage bus for each loading level defined by the loading guidelines used for the UUT.

4. Complete the test setup with the source, UUT, load, and measurement instrumentation. Refer to IEEE 1515 Annex B, General Test Practices, for general guidelines and recommended practices for measurement and instrumentation setup for testing power supplies.

5. Set the power source input voltage and frequency (if programmable) as per the test requirement.

6. Load the output voltage busses (using either a rheostat or an electronic dc load bank) based on the loading criteria established for the UUT within the tolerance levels specified in this protocol.

7. If the fan turns on intermittently, then follow the procedure outlined in section 4.4.

8. Measure and record the following at each load condition. For dc values, record separate values for each dc output voltage bus:

• Rms ac input power

• Rms ac input voltage

• Rms ac input current

• Power factor

• Total harmonic distortion of input current

• Dc output voltage

• Dc output current

• Dc output power

9. Calculate the efficiency of the power supply for the loading condition using the equation:

$$\eta = \frac{\sum_i P_{o,\,i}}{P_{in}} \times 100 \qquad \textbf{Eq. 7-1}$$

Where, $P_{in}$ is the true rms input power and $P_{o,i}$ is the output power of the $i^{th}$ bus.

10. Repeat this procedure for other loading conditions.

11. Measure and record the ac power consumption of the UUT in standby mode at the load points specified in section 6.1.2 of this document.

### 7.1. Test Report

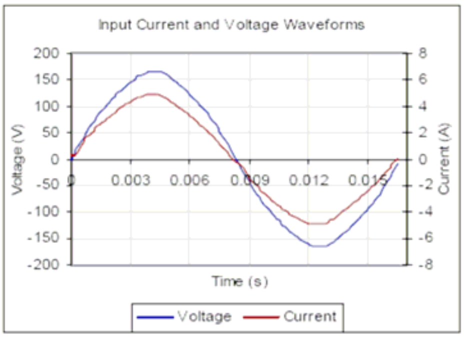
In the test report, graphically display the key data (measured and calculated) from the test along with a description of the power supply that includes the manufacturer's model name and model number, specifications, and loading criteria. Appendix A provides an example test report for an ac-dc power supply and a graphical representation of power supply efficiency under different loading conditions. For additional information on power supply test reports and other relevant information, refer to the website *www.EfficientPowerSupplies.org*.

# 8. Appendix A: Example Efficiency Report for an Internal Desktop PC Power Supply

## Computer Power Supply Efficiency Test Report

**TYPICAL EFFICIENCY (50% Load): 78.6%**
**AVERAGE EFFICIENCY : 73.7%**


| | |
|---|---|
| Specimen No. | 9 |
| Manufacturer | xxxx |
| Model | xxxx |
| Serial | xxxx |
| Year | N/A |
| Type | ATX12V |
| Test Date | 3/11/2005 |
| Tested By | BV |
| Ambient Temp | 23.5°C |

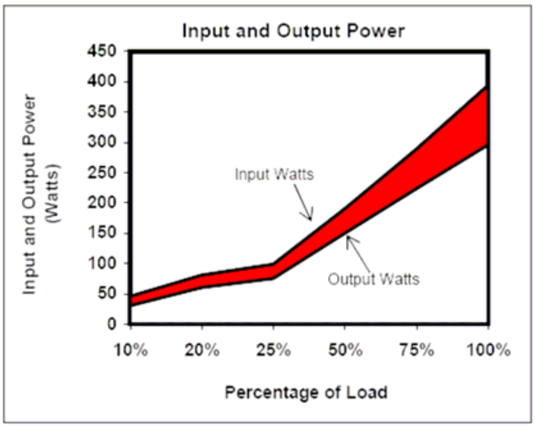


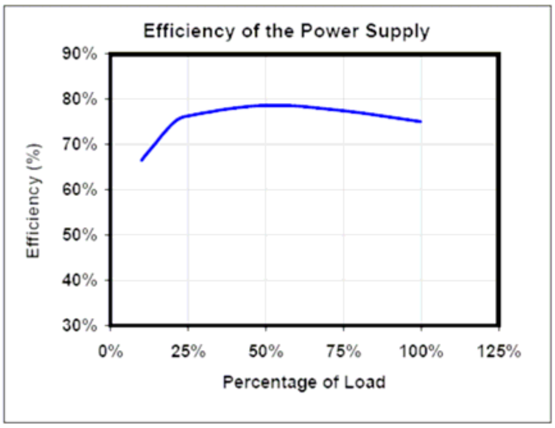

Input AC Current Waveform ($I_{THD}$ = 4.1% at 100% Load)

| Rated Specifications | Value | Units |
|---|---|---|
| Input Voltage | 100-240 | Volts |
| Input Current | 5 | Amps |
| Input Frequency | 50/60 | Hz |
| Combined Max. Output Power on 5V&3.3V | 200 | Watts |
| Combined Max. Output Power on 12V | N/A | Watts |
| Combined Max. Output Power on 5V,3.3V&12V | N/A | Watts |
| Rated Output Power | 300 | Watts |

Note: All measurements were taken with input voltage at 115 V nominal and 60 Hz.

| $I_{RMS}$ A | PF | $I_{THD}$ (%) | Load (%) | Input Watts | DC Terminal Voltage (V)/ DC Load Current (A) | | | | | | | Output Watts | Efficiency % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 12V1/18.0 | 12V2/NA | -12.0/0.8 | -5.0/NA | 5.0/30.0 | 3.3/28.0 | 5.0VSB/2.0 | | |
| 0.41 | 0.97 | 21.4% | 10% | 46 | 12.1/1.24 | N/A | -12.2/0.06 | N/A | 5.09/1.70 | 3.27/1.59 | 5.03/0.14 | 30 | 66.4% |
| 0.71 | 0.99 | 13.1% | 20% | 81 | 12.1/2.48 | N/A | -12.1/0.11 | N/A | 5.07/3.40 | 3.26/3/18 | 5.02/0.28 | 60 | 74.6% |
| 1.66 | 0.99 | 7.1% | 50% | 191 | 12.1/6.2 | N/A | -12.3/0.28 | N/A | 5.01/8.50 | 3.21/7.96 | 4.98/0.69 | 150 | 78.6% |
| 3.43 | 1.00 | 4.1% | 100% | 394 | 12.1/12.4 | N/A | -12.3/0.55 | N/A | 4.88/17.0 | 3.08/15.89 | 4.90/1.38 | 296 | 75.0% |




EPRI SOLUTIONS

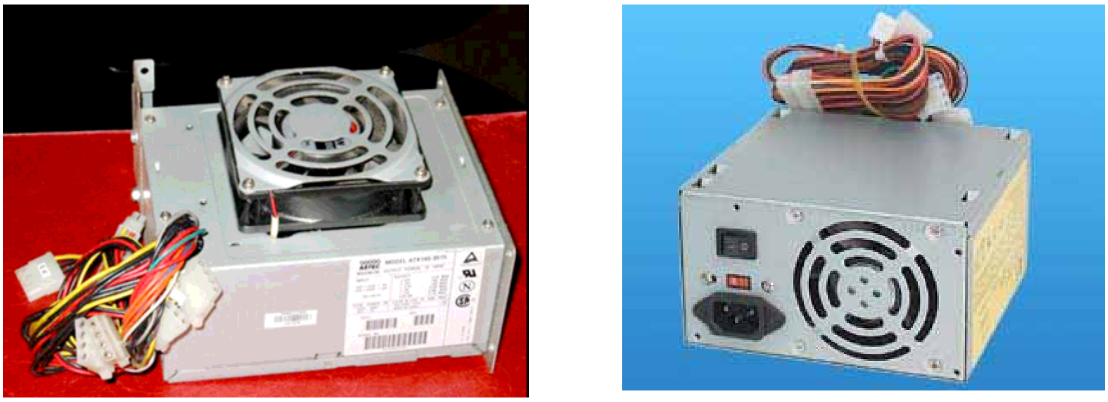
These tests were conducted as a part of California Energy Commission's intiative to improve PC power supply efficiency during active mode operation.

Test Laboratory: EPRI Solutions Inc., Knoxville, TN. USA.

Note: For more sample test reports please refer to www.EfficientPowerSupplies.org

# 9. Appendix B: Internal Power Supply Discussion

The common housing structures for internal power supplies considered in this test procedure are enclosed-frame and open-frame as shown in the Figure B-1. Internal power supplies within an enclosure could be fan-cooled.



***(a) Enclosed Frame Internal Power Supplies***

***(b) Open-frame Internal Power Supplies***

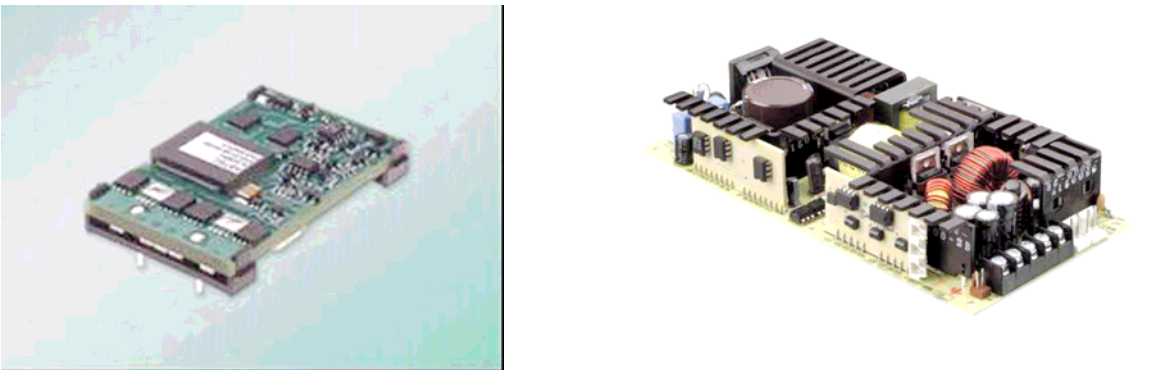


***Figure B-1. Examples of a) enclosed frame and b) open frame internal power supplies (Courtesy Astec Power, Artesyn Technologies)***

Output ratings of a cross-section of internal power supplies used in various product classes and their loading criteria are shown in the tables below.

***Table B-1: output specification of a 300 W internal power supply for an ATX 12 V form factor desktop personal computer***

| Voltage Rail Number | Output Voltage | Min. Current (A) | Max. Current (A) | Peak Current (A) |
|---|---|---|---|---|
| $V_1$ | +12 | 1.0 | 18.0 | 19.5 |
| $V_2$ | +5 | 0.5 | 26.0 | -- |
| $V_3$ | +3.3 | 0.5 | 27.0 | -- |
| $V_4$ | -12 | 0.0 | 0.8 | -- |
| $V_5$ | +5 (Standby) | 0.0 | 2.0 | 2.5 |

***Table B-2: output specification of a 220 W internal power supply for an TFX 12 V form factor desktop personal computer***

| Voltage Rail Number | Output Voltage | Min. Current (A) | Max. Current (A) | Peak Current (A) |
|---|---|---|---|---|
| **V1** | +12 | 1.0 | 15 | 17 |
| **V2** | +5 | 0.3 | 13 | -- |
| **V3** | +3.3 | 0.5 | 17 | -- |
| **V4** | -12 | 0.0 | 0.3 | -- |
| **V5** | +5 (Standby) | 0.0 | 2.0 | 2.5 |

***Table B-3: Output specification of a 200W internal power supply for a cathode Ray Tube (CRT) Display***

| Voltage Rail Number | Dc Bus Voltage (V) | Continuous Current Rating (A) | Required Voltage Regulation |
|---|---|---|---|
| $V_1$ | 135 | 0.75 | +/- 1V |
| $V_2$ | 30 | 1.2 | 5% |
| $V_3$ | 15 | 0.5 | 5% |
| $V_4$ | 7 | 1.2 | 5% |

***Table B-4: Output specification of a 55W internal power supply for a Liquid Crystal Display (LCD)***

| Voltage Rail Number | Dc Bus Voltage (V) | Continuous Current Rating (A) | Required Voltage Regulation |
|---|---|---|---|
| $V_1$ | 12 | 1.2 | 5% |
| $V_2$ | 5 | 8 | 3% |

***Table B-5: Output specification of a 360W internal power supply for a Plasma Display Panel (PDP)***

| Voltage Rail Number | Dc Bus Voltage (V) | Continuous Current Rating (A) | Required Voltage Regulation |
|---|---|---|---|
| $V_1$ | 170 | 1.3 | +/- 2V |
| $V_2$ | 65 | 0.9 | 5% |
| $V_3$ | 15 | 0.9 | 5% |
| $V_4$ | 13.5 | 0.6 | 7% |
| $V_5$ | 12 | 0.6 | 5% |
| $V_6$ | 5 | 0.7 | 5% |
| $V_7$ | 5 (standby) | 0.15 | 5% |

***Table B-6: Output specification of a 30W internal power supply for a digital set top box***

| Voltage Rail Number | Dc Bus Voltage (V) | Continuous Current Rating (A) |
|---|---|---|
| $V_1$ | 30 | 0.03 |
| $V_2$ | 18 | 0.5 |
| $V_3$ | 12 | 0.6 |
| $V_4$ | 5 | 3.2 |
| $V_5$ | 3.3 | 3.0 |

## Appendix 4  Summary of ENERGY STAR qualified computers

The following table is a manipulated version of the ENERGY STAR list of qualified computers to assess the quantity of computers stated as available for Australia.

| Type | Category | Brand | Total models listed | Listed as available 230Vac | Brand available in ANZ | Corrected total for brands available in Australia |
|---|---|---|---|---|---|---|
| Desktop | A | Apple | 2 | 2 | Yes | 2 |
| | | CTL | 7 | | | |
| | | Dell | 3 | 3 | Yes | 3 |
| | | HP | 1 | 1 | Yes | 1 |
| Desktop | B | Dell | 3 | 3 | Yes | 3 |
| | | HP | 1 | 1 | Yes | 1 |
| | | Cade | 1 | | | |
| | | Gateway | 2 | | | |
| Notebooks | A | Acer | 5 | 5 | Yes | 5 |
| | | Apple | 3 | 3 | Yes | 3 |
| | | Compaq | 1 | 1 | Yes | 1 |
| | | Fujitsu | 2 | | Yes | |
| | | Gateway | 7 | | | |
| | | HP | 4 | 4 | Yes | 4 |
| | | Lenovo | 44 | 44 | Yes | 44 |
| | | Toshiba | 5 | | Yes | |
| Notebooks | B | Acer | 7 | 7 | Yes | 7 |
| | | Apple | 3 | 3 | Yes | 3 |
| | | Gateway | 9 | | | |
| | | HP | 1 | 1 | Yes | 1 |
| | | Lenovo | 34 | 34 | Yes | 34 |
| | | Toshiba | 1 | | Yes | |
| Integrated | C | CIARA | 1 | | | |