Power consumption & management: Windows Vista versus Windows XP

Overview

This white paper will show how British businesses running a fleet of Windows XP desktop PCs can reduce running costs by anything from £23 to £46 per system per year by switching to Windows Vista.

It will also show the effect Vista's improved power management can have on a business's carbon dioxide emissions.

It is important to note that the financial and carbon-dioxide savings are not due to a PC running Windows Vista consuming less power per task than a PC running Windows XP (for example, typing up a document in Microsoft Word will consume very similar amounts of power).

Instead, it is based on real-world usage of computers. In particular, the habit of computer users to leave their PCs running even when not in use.

This is more relevant to Windows Vista, as opposed to Windows XP, due to the addition of advanced power management to Group Policy, the improved reliability of Sleep mode, and, most importantly, Vista PCs being automatically put into Sleep mode after an hour of non-use.

Table of contents

This white paper was commissioned by Microsoft UK.
The testing was performed by PC Pro Labs and Intertek ETL Semko.
The report was written by PC Pro Labs.
All computers tested were supplied by Hewlett-Packard UK.

1. Testing methodology

Hewlett-Packard UK supplied PC Pro Labs with three PCs for testing, all of which were pre-loaded with Windows XP Professional. PC Pro Labs then created a new partition on each hard disk and loaded the final version (RTM) of Windows Vista onto them as a clean install.

Two of the desktop PCs are from HP's current range, the third is approximately three years old. For details of the exact specifications of the systems, see Appendix C. The below is a summary:

- HP Compaq dc7700: Intel Core 2 Duo CPU.
- HP dx5150: AMD Athlon 64 X2 CPU.
- HP Compaq D530S: Intel 2.8GHz Pentium 4 CPU.

For power testing, PC Pro Labs sent the systems to a dedicated testing facility: Intertek ETL Semko in Milton Keynes. This facility used a calibrated power meter and followed Energy Star test methodologies.

Intertek successfully tested each computer in seven different power states, three low power (sleep, hibernate and standby) and four high power (on-idle, screensaver, 3D image rendering and Microsoft Word document typing).

None of the tests include the power consumed by monitors. See Appendix A for more details.

All the results for Windows Vista are based on Aero being switched off. See Section 4, Effect of Windows Aero for more details.

The seven power states

On-idle Following the Energy Star test methodology, the computers were turned on and allowed to boot into the operating system. After exactly five minutes from switching the computers on, power consumption was measured and averaged over a further five minutes.

Screensaver The computers' screensaver settings were adjusted to come on after the on-idle test was complete. Power consumption was measured and averaged over a further five minutes.

MP3 playing An MP3 track was played with volume settings turned to zero while power consumption was measured and averaged over the following give minutes. The MP3 track chosen was over five minutes long and had a wide dynamic range.

3D image rendering Three images were consecutively rendered using Autodesk 3ds Max. On some samples with higher processing power, this task completed in less than five minutes. Power consumption was measured and averaged over the actual duration of the rendering process.

Microsoft Word document typing Approximately 1,000 characters were typed into a Microsoft Word 2003 document over five minutes. Power consumption was measured and averaged over this process.

Sleep The computers were put into Sleep mode and power consumption was measured and averaged over the following five minutes.

Hibernate The computers were put into Hibernate mode and power consumption was measured and averaged over the following five minutes.

Standby The computers were turned off using the Windows Start button and power consumption was measured and averaged over the following five minutes.

2. Sleep mode in Windows Vista

In Windows Vista, the Sleep mode refers to Hybrid Sleep (fast S4) by default on desktops and sleep (S3) on laptops.

S3 is an ACPI (Advanced Configuration and Power Interface) standard, where all the active documents, programs and settings are saved to memory. Power is then cut to almost every other component, with just enough power supplied to keep the memory active.

With desktop PCs, the data is simultaneously saved to memory and hard disk. This ensures that, if power is cut, Vista can still resume quickly using the data stored on the disk. Otherwise, it will resume more quickly using the data stored in the memory.

Windows XP included a Standby mode, which is equivalent to Sleep mode in Windows Vista. However, it wasn't widely used in a corporate environment for a number of reasons.

One key factor is that the Standby mode is not activated by default with Windows XP; with a desktop PC, the default is to keep the system idling. In Windows Vista, a desktop PC will now enter Sleep mode after being idle for 60 minutes.

Also, the process of activating the Standby mode is not easily discoverable by users, as the setting is hidden away in advanced power-management menus. Another factor is that Standby is not centrally manageable via Group Policy (see section 3) in Windows XP.

Another issue is that Standby is not reliable enough in Windows XP for a corporate-wide roll-out. For instance, Windows XP is not capable enough at detecting the PC is idle.

Finally, PCs and notebooks can take some considerable time to resume from Standby in Windows XP: around five seconds. With Windows Vista, the resume-from-standby time has been reduced to around two seconds.

In summary, these are the areas where Vista has improved its Sleep mode compared to the equivalent Standby mode in Windows XP:

- In Windows Vista, the Sleep mode is now on by default. A desktop PC will enter Sleep mode after being inactive for 60 minutes.
- In Vista, it is much easier for users to change the power management settings.
- The Sleep mode is more reliable than XP's Standby mode, both in terms of entering the mode and safely resuming back into Windows.
- Windows Vista is much quicker at resuming from Sleep, now taking 2-3 seconds compared to five seconds for Windows XP.

All this means the Sleep mode is much more likely to be used in a corporate environment, and that end users will be happier with the experience.

Further system sleep and wake performance improvements in Windows Vista include:

- Intelligent memory management of pages needed during resume from standby by ensuring these pages remain resident in system memory

- Increased efficiency of the kernel power manager during resume
- Enhancements to the USB hub driver
- Changes in the display power-on logic and timing that greatly improve user perception of system responsiveness to power state transitions

3. Group Policy in Windows Vista versus Windows XP

Windows Vista includes around 3,000 settings that can be controlled by Group Policy, approximately double the number in the initial release of Windows XP. Of particular relevance to this white paper is the fact that all power management settings have been Group Policy enabled.

This allows administrators to minutely control the settings of PCs and notebooks being managed via Active Directory, down to individual systems or groups.

Here is a sample selection of what can be specified:

- Screensaver timeout
- Monitor off timeout
- Hard disks off timeout
- Sleep timeout
- Hibernate timeout

With notebooks, all of these can be specified both for when the notebook is switched on and when running on battery power.

4. Power measurement results

Throughout our tests, it was clear that Vista is on a par with Windows XP with respect to power consumption. This is in line with our expectations: the hardware is identical, and being asked to do the same amount of work (none at all, in the cases of our Sleep, Hibernate and Standby tests).

For desktop PCs, the overall difference is too marginal to be meaningful (typically less than one per cent). The only exception to this was MP3 playback: the Windows Vista desktop PCs used anything from 3 per cent to 12.3 per cent more power.

The key difference in terms of a desktop PC's power consumption over the course of a year is therefore due to the enforced Sleep mode after 60 minutes by default.

Further savings can be made when proper power management policies are applied by companies. See Section 6.

5. Effect of enabling the Aero experience

All the following results are Watts. They are based on the measurements we took over a five-minute period in each of the states listed. Measuring over a prolonged period ensures the figures are reliable, and can therefore be converted to Watt-hours to measure power consumption in various scenarios – for example, a machine left idling for eight hours and is then switched off for the remaining 16 hours of the day.

The table does not list any results for the HP Compaq dc7700 or HP Compaq D530S because these two systems did not support the Windows Aero experience. However, it does include the results for two HP notebooks which do support Aero (details of their specifications can be found in Appendix B).

TABLE 1: Power consumption with and without Aero (in Watts)

		nx6325	nc6400	dx5150
Idle	Vista with Aero	17.1	22.86	47.7
	Vista without Aero	17.32	22.81	47.58
Screensaver	Vista with Aero	17.61	23.43	48.04
	Vista without Aero	17.71	22.98	48.43
3ds Max	Vista with Aero	54.83	40.99	100.93
	Vista without Aero	54.01	40.96	101.04
Word	Vista with Aero	17.41	23.16	47.74
	Vista without Aero	17.24	22.92	47.51

It should be immediately clear that the use of Aero has a miniscule effect on power consumption during any of the four power states in which we tested.

Effects enabled by Aero, such as live preview, are likely to increase power consumption while being used, but our tests suggest that – unless the effects are extremely heavily and consistently used – users are unlikely to see much difference to power consumption over the course of a working day.

6. Typical usage of desktop PCs

PC Pro Labs commissioned a survey of visitors to the PC Pro website to find out typical usage patterns in relation to the amount of time computers were switched on. The sample size was 800 desktop PC users.

The headline results are as follows:

Desktop PCs

- Of those people who use a computer at work, 75% use a desktop PC
- 30% leave their PC on at the end of the day
- 25% leave their PC on at the weekend

Power settings

- 29% of desktop PC users enable the standby mode
- 17% of desktop PC users enable the hibernate mode
- 67% of people enable the screensaver

Typical usage

- Light tasks, such as typing in Word or answering email, are the primary use of a computer (approximately 40% of the time)
- The second most common “task” is simply to be idle (approximately 30% of the time)
- Medium-intensity tasks, such as photo editing, account for around 15% of the working day
- Very intensive tasks, such as encoding, account for around 15% of the working day

7. Running costs

The following table details the annual cost of running a computer that is left on its default settings without direct user intervention (for example, switching it off at the end of a day).

We show three scenarios: Windows XP at its default settings; Windows Vista at its default settings; and Windows Vista with extra power-management settings enabled via Group Policy.

Based on the survey of people's genuine usage patterns at work, these scenarios are based on the computer being idle for 40% of the time during an eight-hour working day. 30% of the time the computer is performing light tasks, such as typing in Microsoft Word, 15% of the time medium-intensive tasks, such as MP3 playback, and 15% of the time intensive tasks such as video encoding.

In the XP default settings, the system will idle by default when not being used. In Vista, the system will go into Sleep mode after 60 minutes, and Hibernate mode after a further 18 hours. In the Group Policy scenario, machines were set to go into Sleep mode after 20 minutes and Hibernate after a further 60 minutes.

All figures are based on a cost of 0.09p per unit (kWh). Although costs will vary, our research suggests 0.09p is a reasonable estimate.

TABLE 2: Annual running costs and potential savings: XP default vs Vista default

	d503s	dx5150	dc7700p
XP default	£57.87	£38.54	£66.32
Vista default	£19.14	£14.73	£19.95
Annual saving	£38.73	£23.81	£46.37

These are dramatic savings, particularly for the desktop PCs (the d503s, the dx515 and the dc7700p). However, they make even more interesting reading if applied to a 200-seat business.

TABLE 3: Annual running costs and potential savings of 200 computers: XP default vs Vista default

	d503s	dx5150	dc7700p
XP default	£11,574	£7,708	£13,264
Vista default	£3,828	£2,946	£3,990
Annual saving	£7,746	£4,762	£9,274

In a company with power management set up via Group Policy, more savings can be made. However, the savings are certainly not as dramatic as the Windows XP vs Windows Vista default settings.

TABLE 4: Annual running costs and potential savings: Vista managed vs Vista default and XP default

	d503s	dx5150	dc7700p
XP default	£57.87	£38.54	£66.32
Vista default	£19.14	£14.73	£19.95

Vista managed	£16.63	£13.18	£16.93
Annual saving of Vista managed versus XP default	£41.24	£25.36	£49.39
Annual saving of Vista managed versus Vista default	£2.51	£1.55	£3.02

Larger businesses should still consider implementing a more aggressive power-management Group Policy, however. Clearly, a business with a thousand desktop PCs would save around £3,000 per year if it was running a fleet of dc7700p PCs.

The disadvantage is that PCs waking up from Windows Vista's Hibernate state could take around 30 seconds to resume compared to the 2-3 seconds of a system waking from Sleep state.

7. Carbon dioxide emissions

According to DEFRA (Department for Environment, Food and Rural Affairs), each kWh of electricity consumed via the UK mains equates to 0.43kg of carbon dioxide emissions.

Using these figures, it is very simple to translate our power-consumption results into carbon dioxide emissions.

TABLE 5: Annual carbon dioxide emissions (kg)

	d503s	dx5150	dc7700p
XP default	277	184	317
Vista default	91	70	95
Vista managed by Group Policy	79	63	81
Annual saving of Vista default versus XP default	186	114	222
Annual saving of Vista managed versus Vista default	12	7	14
Annual saving of Vista managed versus XP default	198	121	236

TABLE 6: Annual carbon dioxide emissions of 200 computers (tonnes)

	d503s	dx5150	dc7700p
XP default	55.30	36.83	63.37
Vista default	18.29	14.07	19.06
Vista managed by Group Policy	15.89	12.59	16.18
Annual saving of Vista default versus XP default	37.01	22.76	44.31
Annual saving of Vista managed versus Vista default	2.4	1.48	2.88
Annual saving of Vista managed versus XP default	39.41	24.24	47.19

It's clear from this that massive carbon dioxide savings can come simply by upgrading from Windows XP to Vista and using the default settings. In the case of 200 dc7700p systems, 44 tonnes of carbon dioxide per year.

Switching to Vista managed by Group Policy, the savings are again commendable – even if compared to the Vista default settings. Almost three tonnes per year in the dc7700p example, and still 0.54 tonnes (or 540kg) in the most energy-efficient system, the nx6325.

8. Conclusions

There are two key conclusions that can be drawn from this set of results.

1. Businesses can make savings of up to **£46 per desktop PC** simply by upgrading from Windows XP to Windows Vista.
2. The cut in power consumption translates into large reductions in carbon dioxide emissions, measuring in the tonnes per year. For a 200-seat business, this could be around **44 tonnes of carbon dioxide** per year.
3. Vista's Group Policy support for power-management settings can further reduce the cost of running computers, and carbon dioxide emissions. The financial argument (an added saving of around £3 per desktop PC) is not as strong as the carbon dioxide argument – each managed desktop PC will save around **14kg of carbon dioxide** per year.

There are a number of smaller points to also emerge.

The power consumption of computers when using screensavers is actually higher than when systems are idle. As such, any business that uses screensavers for significant amount of times is wasting huge amounts of electricity and should immediately consider switching to blank or powered-off screens. This can be configured via Group Policy.

Aero graphics have a negligible impact on overall power consumption.

Vista also addresses many of the arguments that have blocked companies from adopting a power-management strategy. The Sleep state is now much more reliable, and the user experience is not harmed – the fact computers resume from Sleep in under two seconds is almost the same amount of time that a screen takes to reactivate from Idle mode in Windows XP. Vista also has built-in management tools via Group Policy.

The final worry of some businesses, about updating machines overnight, is addressed by solutions like SC Configuration Manager (SMS 2007). Wake-on-LAN is built into SC Configuration Manager and can be used to wake computers before processing jobs.

Appendix A: monitor running costs

This white paper has entirely focused on the cost of running PCs and notebooks, cutting monitors entirely out of the equation. This is partially because all modern monitors conform to stringent standards, and will usually switch off after a few minutes of non-use via Windows' display blanking settings.

As such, the only way for a business to save money and cut carbon dioxide emissions is to cut the power supply to the monitors.

It is, of course, impractical for a company to expect its IT department or users to pull the plug out of the wall socket each night, but there are options available.

One product recommended by both PC Pro and the Energy Saving Trust is the OneClick IntelliPlug (www.oneclickpower.co.uk), a power adaptor that automatically detects if the desktop PC plugged into its main socket is switched off; if it is, it cuts power to the other two sockets.

Modern CRT monitors typically draw 80W in use and 4W in standby mode. Modern TFT monitors typically draw 35W in use and around 1W in standby mode.

If, as in the white paper above, we assume an eight-hour working day, five-day working week, then a combination of stricter power management and the use of an IntelliPlug will cut the amount of standby hours by 128 per week. Or 6,656 hours per year.

For a CRT monitor, that reduces the cost by £2.40 per year; for a TFT, £0.60 per year. As the cost of the IntelliPlug is £17, the financial argument is far more convincing for a CRT than a TFT, but the carbon dioxide cuts are also worth noting: 11.5kg for a CRT, 2.9kg for a TFT.

The drawback is that the user experience is affected: an LCD screen can take several seconds to return to full brightness from being switched off, compared to less than a second from standby.

Appendix B: specification of the tested computers

Desktop PCs

- HP Compaq dc7700: Intel Core 2 Duo CPU.
  Part code: RN132ET. 2.13GHz Intel E6400 Core 2 Duo processor; Intel Q965 Express chipset; Intel GMA 3000 graphics; 1GB RAM; 160GB hard disk.
- HP dx5150: AMD Athlon 64 X2 CPU.
  Part code: EU305ET. 2.4GHz AMD Athlon 64 3800+ processor; ATI Radeon Xpress 200 chipset; ATI Radeon X300 graphics; 512MB RAM; 160GB hard disk.
- HP Compaq D530S: Intel 2.8GHz Pentium 4 CPU.
  Part code: PB603A. 2.8GHz Intel Pentium 4 processor; Intel 865G chipset; Intel 865G graphics; 512MB RAM; 40GB hard disk.

Notebooks

- HP nc6400: Intel Core 2 Duo CPU.
  Part code: RM100ET. 1.83GHz Intel Core 2 Duo T5600 processor; Intel 945GM Express chipset; Intel GMA 950 graphics; 1GB RAM; 80GB hard disk.
- HP nx6325: AMD Turion 64 CPU.
  Part code: EY351ET. 2GHz AMD Turion 64 X2 TL-60 processor; ATI Xpress 1150 chipset; ATI Xpress 1150 graphics; 1GB RAM; 80GB hard disk.

Appendix C: Sources and further reading

Carbon dioxide emissions:

DEFRA's Guidelines for Company Reporting on Greenhouse Gas Emissions
http://www.defra.gov.uk/environment/business/envrp/gas/index.htm

Products designed to reduce power consumption:

OneClickPower intelliplug, http://www.oneclickpower.co.uk

HP Compaq dx2250 Desktop PC,
http://www.hp.com/hpinfo/newsroom/press/2006/061115a.html

General articles on reducing power consumption and costs:

Switch IT Off! campaign, by PC Pro
http://www.pcpro.co.uk/html/switch_it_off/

Cutting costs: Power down, by Computer Weekly
http://www.computerweekly.com/Articles/2004/03/01/200392

Analysis: IT power crisis – what can CIOs do?, by Silicon.com
http://www.silicon.com/research/specialreports/governance/0,3800011701,39159567,00.htm

Microsoft resources:

Measuring System Resume Performance on Windows Vista
http://www.microsoft.com/whdc/system/sysperf/resumeperf.mspx