

# **RPICT02/07:**

## **Overview of MTP Desktop Computer Testing Activities and Results**

# Executive summary

This report gives an overview of MTP testing<sup>1</sup> results on desktop computers and provides analysis of results against the ENERGY STAR<sup>®</sup> criteria for computers.

The results were submitted to the US Environmental Protection Agency (EPA) to assist it with setting criteria for the ENERGY STAR label.

In total, 39 desktop computers were tested between April 2006 and March 2007. These desktop computers were categorised by the sample provided for magazine publication purposes. The five categories were Windows Vista™ capable PCs, Photo-editing PCs, £999 PCs, £600 Business PCs and Quad-core PCs.

In standby (off mode), all desktop computers consumed fewer than 10 W. The ENERGY STAR criterion of 2 W is slightly under the lowest consuming 25% of models (2.4 W). Standby for some products was as low as 1.6 W. It is worth noting that with current configurations, none of the PCs tested would be able to meet a maximum 1 W standby/off requirement.

In sleep mode, most desktop computers sat below the 10 W level, but others consuming high amounts of power (because of a failure to enter a proper sleep mode under test conditions) would have brought the sleep mode average consumption up to a higher level. These were clearly incorrectly configured as they only decreased by a maximum of 21% from the idle-mode consumption measurements and were removed from the sleep-mode results to preserve the integrity of the test. The ENERGY STAR criterion for sleep mode of 4 W, is set at a level close to the lowest consuming 25% threshold (4.4 W) of products tested. Some products could consume as low as 1.5 W, while the maximum value measured was 10.1 W, measured on a Photo-editing PC.

The most power-hungry desktop computers in idle mode used between 211.92 W and 221.02 W. These were all in the Quad-core category tested in February 2007, which featured the latest Quad-core processors.

The least power-hungry desktop computers in idle mode were all from the £600 Business PCs category tested in January 2007 and used between 56.52 W and 69.60 W.

Desktop computers compare unfavourably with laptops in terms of energy consumption. In fact, even the desktop computers that consumed the least amount of power in idle mode consumed much more power than the highest consuming laptop computers that were tested in the same year<sup>2</sup>

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<sup>1</sup> As part of ongoing computer testing (at MTP consortium partner Intertek) there has been the opportunity to run power measurements on samples as they come into the laboratory. This greatly reduced the cost of compliance testing as the purchase of samples was not required.

<sup>2</sup> RPIC03/07 Overview of MTP Laptop Computer Testing Activities and Results

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# 1 Background

As part of a programme of on-going computer testing<sup>3</sup>, MTP has had the opportunity to carry out compliance testing on batches of samples, available for only a limited period in the testing lab, during which time power measurements and other commissioned tests had to be performed.

## 2 Breakdown of quantity by category

These desktop computers were normally tested in batches, categorised as 'Windows Vista™<sup>4</sup> capable PCs', 'Photo editing PCs', '£999 PCs', '£600 Business PCs' and 'Quad-core PCs'. They were new to the market and, as such, reflected as near as possible, up-to-date consumer configurations. One batch (£600 Business PCs) tested was configured for the enterprise market. In total, 39 desktop computers underwent power measurements between April 2006 and March 2007. One sample in the Windows Vista™ capable PCs category was removed from the following results and analysis as it was discovered that it was a pre-production model that would eventually ship with a different power supply to the one tested.

**Table 2.1 Breakdown of quantity by category**

Desktop computer category	Date tested	Number of samples
Windows Vista™ capable PCs	31/05/2006	7
Photo-editing PCs	27/07/2006	9
£999 PCs	05/10/2006	9
£600 Business PCs	03/01/2007	7
Quad-core PCs	28/02/2007	6
<b>TOTAL</b>		<b>38</b>

### 2.1 Description of categories

The categories were constructed by the sample provider for purposes of group testing for magazine reviews. The price of the PCs falling into the £600 and £999 price categories excluded VAT and delivery. The categories in Table 2.1 are in the sequence in which they were tested. Due to the rapid increase in performance of available computer hardware over time, a highly specified computer could, in a few months time be considered a typically specified computer. It is worth noting that in testing year 2006/07, all the PCs had a minimum of a dual-core processor, whereas in testing year 2005/06 only 30% of products tested had a dual-core processor.

<sup>3</sup> As part of ongoing computer testing (at MTP consortium partner Intertek) there has been the opportunity to run power measurements on samples as they come into the laboratory. This greatly reduced the cost of compliance testing as the purchase of samples was not required.

<sup>4</sup> Windows Vista™ is an operating system. Windows Vista™ is either a registered trademark or trademark of Microsoft Corporation in the United States and/or other countries.

### 2.1.1 Windows Vista™ capable PCs

These were computers that met the minimum requirements of the most basic version of the Windows Vista™ operating system. They featured fast processors (2 GHz to 3 GHz) with random access memory (RAM) of between 512 MB and 1 GB and hard disc drives HDDs of between 160 GB and 300 GB. As they were brought to market prior to the launch of Windows Vista™, they were all supplied with Microsoft® Windows® XP Home or Microsoft® Windows® XP Media Center, but they claimed to be future-proofed by being upgradeable to Windows Vista™.

### 2.1.2 Photo-editing PCs

Computers in this category were designed for editing digital images and, as such, were configured with fast, dual-core processors (2.4 GHz to 3.2 GHz) with RAM of between 1GB and 4GB, and HDDs of between 400 GB and 1,000 GB and dedicated graphics processing units (GPUs).

### 2.1.3 £999 PCs

These computers were priced at around £999 (excluding VAT and delivery). This category aimed to illustrate how advanced a specification a consumer could get for £999. They all featured the new dual-core processors with RAM of between 1GB and 2GB and HDDs of between 200 GB and 320 GB.

### 2.1.4 £600 business PCs

These computers were all priced at under £600 (excluding VAT and delivery) for the enterprise market. These PCs were not designed for gaming or multimedia, but were fully capable of running office applications. They all featured the dual-core processors with a RAM of between 512 MB and 1 GB, and HDDs of between 80 GB and 250 GB.

### 2.1.5 Quad-core PCs

All the computers in this category were very highly specified (in comparison to the market at the time of testing) with quad-core processors (i.e. processors with four cores), RAM of 2GB, HDDs of between 500 GB and 1,000 GB and graphics cards with video RAM of between 320 MB and 768 MB. All the PCs in the other categories had dual-core processors.

## 3 Power modes

Laptop and desktop computers consume different amounts of energy depending on their modes of operation. In general, they consume most energy when they are in the on mode, actively performing tasks such as writing to a DVD recordable disc. They consume the least energy when they are in standby (off mode) or in sleep mode.

### 3.1 On Mode

This is the state in which the computer is connected to the mains power supply and has fully loaded the operating system. Testing has shown that idle mode is broadly representative of the consumption levels that would occur when the computer is being used for non processing-intensive tasks, such as email, word processing and internet browsing.

### 3.2 Sleep Modes

There are several low power mode states that a computer can be in. For example, sleep mode is a low power mode from which the computer can quickly be returned to its on mode, without having to reboot the operating system. Sleep mode can further be divided into four types of ACPI modes as described below.

#### 3.2.1 S1 and S2

S1 halts the processor and S2 powers down the processor. Due to development of more sophisticated power management these tend to be found mainly on older computers.

#### 3.2.2 S3

S3 is the most common sleep mode and is often referred to as suspend to RAM (STR). In this state, information about the computer's state is stored and retained in RAM and can quickly be read back when the computer returns to the on mode. The RAM must be powered to retain this information. It is important to note that in Microsoft® Windows®, this is referred to as the standby mode.

### 3.3 Standby (Off Modes)

#### 3.3.1 S4

S4 is also referred to as hibernate mode and is an extension of the S3 (sleep mode) and has similarities to S5 mode below. Instead of storing the computer's state in RAM (as happens in S3 mode) which allows for fast wake-up from sleep mode, but requires additional power to retain the information, it is stored on the computer's HDD. This can require less power, but takes slightly longer for the information to be read back from the HDD when the computer returns to its on mode. In some instances, S4 can even consume the same or less power than in standby (off) mode, due to some components,

such as the network interface card being in a low power state in sleep mode, but having no power management in standby mode.

### 3.3.2 S5

This mode, often referred to as advanced configuration and power interface (ACPI<sup>5</sup>) mode S5, is *generally* the lowest power mode. However, these tests indicate that this is not always the case. The computer is connected to the mains power supply, but has undergone an operating system shut down procedure. The S5 mode, unlike S4 or S3 does not save any data relating to the computer's state. In Microsoft® Windows®, this is the state when 'shut down' is selected. To return to the on mode, the computer has to boot the operating system. See Table 3.1 for a full explanation of the different power modes.

Desktop power measurements were taken in the following power modes:

- Hard off.
- Standby (off mode).
- Sleep mode.
- Idle mode.

**Table 3.1 General ENERGY STAR® Definitions**

Power mode	Description
Hard off	In the case of desktop computers, this is when the desktop PC is connected to a mains supply, but the power supply switch is in the OFF position. In the case of laptop computers, this is when the external power supply is connected to the mains supply, but is not connected to the laptop.
Standby (off mode)	The power consumption level in the lowest power mode that 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, the standby (off) mode correlates to ACPI System Level S4 or S5 states, where applicable. (This is NOT the same as putting Microsoft® Windows® into standby – this power mode would occur when the user has shut down their PC)
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 mode 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. (This is the same as putting Microsoft® Windows® into standby).
Idle mode	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. A period of 15 minutes must elapse from the time the computer is switched on and the measurement is integrated over the following five minutes. An arithmetic mean value is quoted as the result.

<sup>5</sup> For an explanation of ACPI please refer to <http://www.acpi.info/>

## 4 Power measurements

Power measurements were taken using a calibrated power analyser. A voltage stabiliser was also used to regulate the mains supply voltage to 230V during testing.

Measurements were recorded in watts, rounded to two decimal places and were integrated<sup>6</sup> over five minutes.

### 4.1 Test methodology followed

Each sample was connected to a 230V mains supply via the voltage stabiliser, with the power analyser set to take measurements.

For tests carried out before 1 January 2007, the samples were left for five minutes as per the ENERGY STAR DRAFT Version 2.0 test methodology before integrating a power measurement over five minutes.

For tests carried out after 1 January 2007, the samples were left for 15 minutes as per the Final Version 4.0 of the ENERGY STAR ENERGY STAR test methodology before integrating a power measurement over five minutes.

#### 4.1.1 Hard off

In the case of desktop computers, this was measured with the computer connected to the mains supply, with the power switch on the computer's internal power supply unit (PSU) in the off position. This was only relevant to computers with PSUs that had an on/off switch. This meant that only the energy consumption of the PSU was measured.

#### 4.1.2 Standby (off mode)

This was measured by turning the sample on, allowing it to fully boot into Microsoft® Windows® and then powering it off via the start menu (start/shutdown). A measurement was then taken. In this mode, the computer's motherboard and internal components consume a small amount of energy.

#### 4.1.3 Sleep mode

This was measured by turning the sample on, allowing it to fully boot into Microsoft® Windows® and then putting it into stand by mode (sleep mode) via the start menu (start/shutdown). A measurement was then taken. This is mainly a measure of the energy consumed by the computer's motherboard, RAM and any other components that are in a low power state (e.g. a network interface card (NIC)).

#### 4.1.4 Idle mode

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<sup>6</sup> Integrated values are the average energy consumption over a user selected time interval.

This was measured by turning the sample on and allowing it to fully boot into Microsoft® Windows®. Idle mode is indicative of the energy consumed by the computer's motherboard and other internal devices when the computer is switched on. This value will be higher for computers with a larger number of high-power-consuming internal devices. The more RAM, video RAM<sup>7</sup>, and HDDs, the greater the computer is likely to consume in idle mode.

## **4.2 Test methodology observations**

As all the samples had undergone previous tests and are not in 'out-of-the-box' configurations, it was not possible to confirm that the basic input/output system (BIOS)<sup>8</sup> settings had not been altered. This could be the cause of some of the unusually high sleep-mode consumption results that had to be discounted in the main analysis. Future testing could involve the purchase of some off-the-shelf samples to clarify consumption results for those products where these measurement anomalies were experienced.

The network interface speed is sometimes reduced in sleep mode, but not in standby mode, resulting in higher power consumption in the lowest power mode (standby mode) than in sleep mode.

The Final Version 4.0 of the ENERGY STAR test methodology requires turning off the wireless network hardware (where available) during testing. Current market trends may warrant the opposite approach for a truer measurement, in the same way that the wired network hardware must be configured with a similarly capable network switch during measurements.

Further testing specific to modern graphics cards may prove useful in determining the cause of high power consumption. The most recent generation of graphics cards have been reported as consuming between 130 W to 500 W depending on load<sup>9</sup>, but these figures have not yet been verified by MTP.

MTP will continue to submit results to the US Environmental Protection Agency (EPA) to assist it in its assessment of the ENERGY STAR label criteria and to the European Computer Manufacturer's Association (ECMA) to assist it in developing benchmark-based approaches for subsequent ENERGY STAR Tiers.

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<sup>7</sup> Also a discrete rather than integrated GPU has an impact.

<sup>8</sup> The BIOS is the firmware code run by IBM®-compatible computers when first switched on and controls the behaviour of various hardware devices that make up the computer.

<sup>9</sup> [http://www.bit-tech.net/hardware/2007/05/16/r600\\_ati\\_radeon\\_hd\\_2900\\_xt/21](http://www.bit-tech.net/hardware/2007/05/16/r600_ati_radeon_hd_2900_xt/21)

## 5 Results summary

An analysis was carried out on the best and worst-performing desktop computers in each power mode where there were data available to perform the analysis. The figures below apply to the five lowest recorded measurements, the five highest recorded measurements and an overall average of all measurements. See Table 5.7 for the full table of results.

### 5.1 Hard off

Many PSUs did not have switches, so these results only applied to samples with PSUs which had on/off switches. Standby/off state would be the lowest power state achievable by computers with switchless PSUs. This measurement does not form part of the ENERGY STAR criteria, but could be regarded as useful data as this is possibly a more convenient way, compared with switching off at the wall outlet, for a consumer to reduce the standby (off mode) power consumption to zero or near-zero. Unusually, one sample tested had an external PSU, the type normally used with laptops. This had no on/off switch and was not included in the hard off results below. It was a 135 W supply and consumed 0.62 W in the no-load condition.

**Table 5.1 Hard-off results summary**

Hard off		
	Measurement	Observations
Lowest power consumption	0.02 W	These desktop computers, tested in July and October 2006, had 350 W PSUs.
Average power consumption	0.13 W	
Highest power consumption	0.20 W	This desktop computer, tested in February 2007 from the £600 Business PCs category, had a 430 W PSU.

### 5.2 Standby (off mode)

**Table 5.2 Standby (off mode) results summary**

Standby (off mode)		
	Measurement	Observations
Lowest power consumption	1.61 W to 2.20 W.	The sample that measured 1.61 W had a 550 W power supply and was from the £999 PCs category, as was the sample that had the third lowest measurement. The other three of the five desktop computers with the lowest standby (off mode) power consumption were from the £600 Business PCs category tested in January 2007.
Average power consumption	4.55 W	
Highest power consumption	7.17 W to 9.77 W	Surprisingly, the desktop computer with the highest measured standby (off mode) level was not a very highly specified computer, it was from the Windows Vista™ capable PCs category tested in May 2006 and had a 450 W power supply.

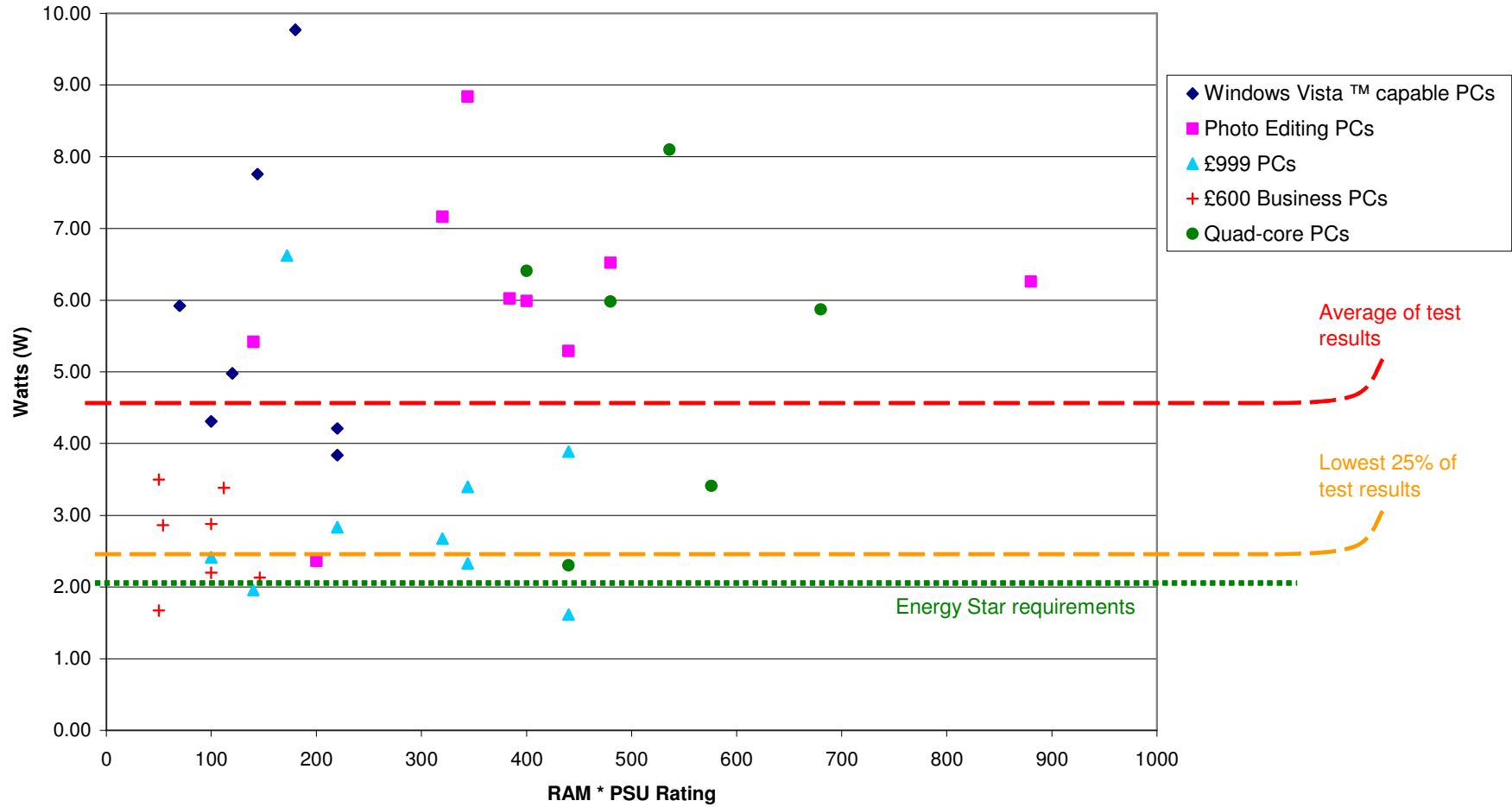
The results below show that there is little evidence to suggest a link between specification level and standby power consumption in desktop computers. In this mode, power is predominantly consumed by the PSU, motherboard and network card.

**Table 5.3 Standby (off mode) average results summary**

<b>Desktop computer category</b>	<b>Date tested</b>	<b>Average standby (off mode) power consumption (W)</b>
<b>Windows Vista™ capable PCs</b>	31/05/2006	5.83
<b>Photo-editing PCs</b>	27/07/2006	5.99
<b>£999 PCs</b>	05/10/2006	3.08
<b>£600 Business PCs</b>	03/01/2007	2.66
<b>Quad-core PCs</b>	28/02/2007	5.35

The following scatter graph shows that all standby (off mode) levels were fewer than 10 W. The wide scatter shows there is little correlation between specification levels and standby power consumption, and that many of the products tested consumed higher than ENERGY STAR consumption threshold in this mode, suggesting that ENERGY STAR requirements for this mode are sufficiently stringent.

Figure 5.1 Standby (off mode) of all samples



### 5.3 Sleep mode

**Table 5.4 Sleep mode results summary**

<b>Sleep mode</b>		
	<b>Measurement</b>	<b>Observations</b>
Lowest power consumption	1.47 W to 2.97 W.	Two out of five desktop computers with the lowest sleep mode power measurements were from the £600 Business PCs category tested in January 2007 and two were from the £999 PCs category tested in October 2006. The sample measuring 1.47 W was from the £600 Business PCs category and had 512 MB of RAM. The network interface was powered off in sleep mode.
Average power consumption	6.12 W	Some samples seemed to be incorrectly configured. This would have had the effect of raising the average power consumption to 31 W had they not been removed from these results.
Highest power consumption	9.61 W to 10.07 W	Some of the samples appeared to be incorrectly configured. Some appeared to merely turn off the video when in sleep mode leaving all fans running. This would seem in line with the respective idle mode results. There could be many reasons why a computer will not go into sleep mode. The BIOS may not be configured correctly (see section 4.2). Some components (e.g. the sound card or graphics card) may not support this mode, or some software drivers may not support this mode. Those ten samples (the highest of which measured 150 W in sleep mode) were removed from these results. Of the remaining 28 samples, three of the five desktop computers with the highest sleep mode power consumption were from the Photo-editing PCs category, tested in July 2006

**Table 5.5 Sleep mode average results summary**

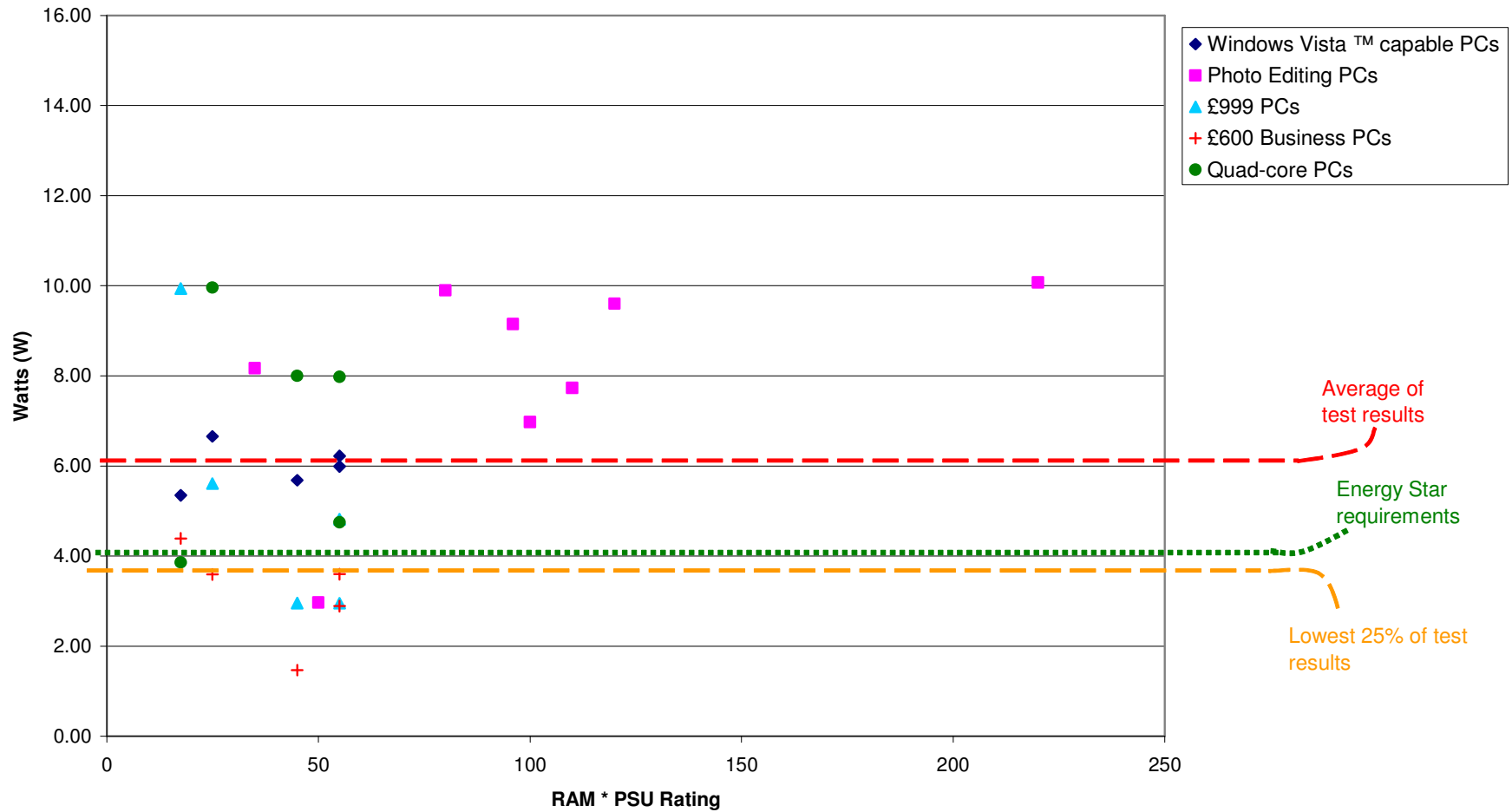
<b>Desktop computer category</b>	<b>Date tested</b>	<b>Average sleep mode power consumption (W)</b>
<b>Windows Vista™ capable PCs</b>	31/05/2006	5.98
<b>Photo-editing PCs</b>	27/07/2006	8.07
<b>£999 PCs</b>	05/10/2006	5.26
<b>£600 Business PCs</b>	03/01/2007	3.19
<b>Quad-core PCs</b>	28/02/2007	6.91

The following scatter graph shows that majority of samples tested have sleep mode levels below 10 W. Some samples did not have sleep modes configured correctly (i.e. the device did not enter a true sleep mode automatically). Due to the nature of the samples, it is difficult to determine if this is a common trend in the market.

Trends can be seen in some categories (e.g. the £600 Business PCs) that are mostly within the ENERGY STAR requirements, but not in others (e.g. the Quad-core PCs and Photo-editing PCs).

ENERGY STAR requirements for sleep mode (aiming at qualifying the best-performing 25% of the market) appear to be more or less in line with the data set results, suggesting the Tier 1 specification as it stands is adequately stringent for this mode.

Figure 5.2 Sleep mode of all samples



## 5.4 Idle mode

**Table 5.6 Idle mode results summary**

Idle mode		
	Measurement	Observations
Lowest power consumption	56.52 W to 69.60 W.	All five samples with the lowest idle mode results were from the £600 Business PCs category tested in January 2007, with between 512 MB and 1,024 MB of RAM and 135 W to 280 W power supplies.
Average power consumption	124.89 W	
Highest power consumption	211.92 W to 221.02 W	The desktop computers with the five highest measured idle mode measurements were all from the highly specified Quad-core PCs category tested in February 2007.

As shown in the table above, there is considerable variation in power consumption in idle mode between different PC types. To handle this wide range in consumption, ENERGY STAR defined three desktop computer categories for idle mode power consumption:

**Table 5.7 ENERGY STAR categories**

Category	Criteria	Notes
A	These are computers that do not meet the definitions of either categories B or C.	Very basic desktop computers. Only two samples fell into this category (both £600 Business PCs)
B	<ol style="list-style-type: none"> <li>1. A multi-core processor and</li> <li>2. A minimum of 1 GB of RAM.</li> </ol>	Medium specifications. Most of the samples tested fell into this category
C	<ol style="list-style-type: none"> <li>1. A multi-core processor</li> <li>2. A GPU with at least 128 MB of dedicated video RAM</li> </ol> <p>Plus 2 of the following:</p> <ol style="list-style-type: none"> <li>1. A minimum of 2 GB RAM</li> <li>2. Television tuner and/or video capture capability with high-definition support</li> <li>3. A minimum of two HDDs</li> </ol>	High specifications. Three of the six Quad-core PCs fell into this category

**Table 5.8 Idle-mode average results summary**

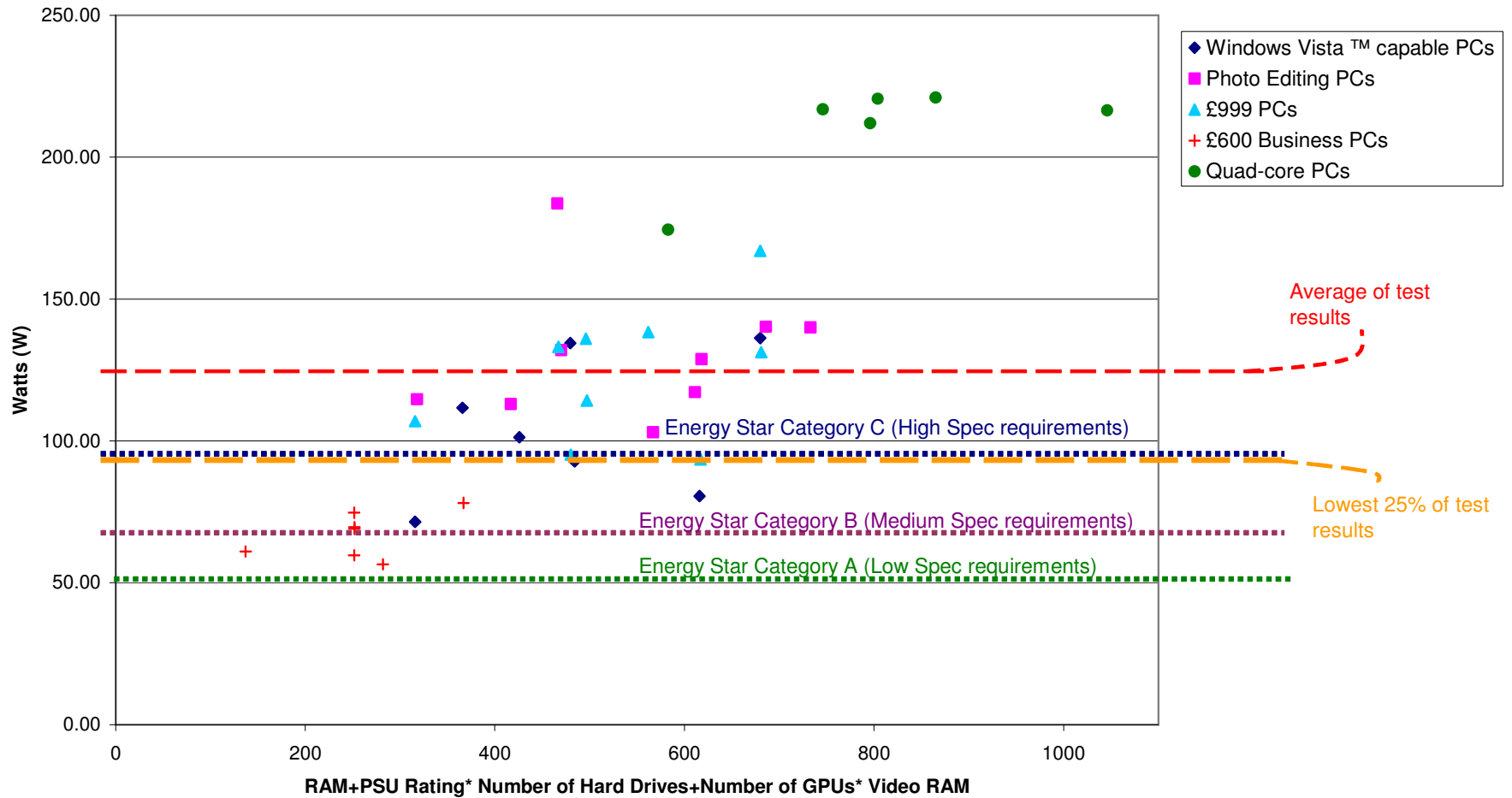
Desktop computer category	Date tested	Average idle mode power consumption (W)
Windows Vista™ capable PCs	31/05/2006	104.03
Photo-editing PCs	27/07/2006	130.27
£999 PCs	05/10/2006	123.94
£600 Business PCs	03/01/2007	66.94
Quad-core PCs	28/02/2007	210.20

It is worth noting that these idle-mode figures are substantially higher than the idle-mode results obtained from laptop testing in the same year, even though, on some models, there was little difference in core functionality. The lowest consuming desktop computers still consumed considerably more power than the highest consuming laptop computers. The highest idle-mode consumption was measured at 35.63 W on a dual-core notebook tested

in September 2006<sup>2</sup>, compared with a minimum of 56.52 W for the lowest consuming desktop PC.

The following scatter graph shows that the majority of samples tested have idle-mode levels between 50 W and 150 W. A trend can be seen here as the £600 Business PCs are all grouped around the 60 W to 80 W level and the Quad-core PCs are almost all above the 200 W level. Note that none of the samples tested measured below the ENERGY STAR Category A requirement. This suggests that the ENERGY STAR categories and thresholds may need to be revised to adequately address the market. This revision work will be underway in 2007/08 to arrive at a potentially new approach for evaluating computer consumption based on a benchmarking tool.

**Figure 5.3 Idle mode of all samples**



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**Table 5.9 Table of results**

	Standby Mode (W)	Sleep Mode (W)	Idle Mode (W)	Sample Category
Windows Vista™ capable PCs	4.21	6.22	136.18	Windows Vista™ capable PCs
	4.31	6.66	71.48	Windows Vista™ capable PCs
	9.77	Result removed <sup>10</sup>	92.72	Windows Vista™ capable PCs
	3.84	5.68	80.52	Windows Vista™ capable PCs
	5.92	5.99	134.42	Windows Vista™ capable PCs
	4.98	5.35	111.67	Windows Vista™ capable PCs
	7.76	Result removed <sup>10</sup>	101.24	Windows Vista™ capable PCs
	5.83	5.98	104.03	<b>Windows Vista™ capable PCs Average</b>
Photo-editing PCs	6.52	9.61	139.96	Photo-editing PCs
	6.26	10.07	140.23	Photo-editing PCs
	5.42	8.17	112.98	Photo-editing PCs
	7.17	9.90	131.98	Photo-editing PCs
	5.29	7.73	128.81	Photo-editing PCs
	2.36	2.97	114.62	Photo-editing PCs
	5.99	Result removed <sup>10</sup>	103.04	Photo-editing PCs
	6.02	6.97	117.11	Photo-editing PCs
	8.84	9.15	183.71	Photo-editing PCs
	5.99	8.07	130.27	<b>Photo-editing PCs Average</b>
£999 PCs	2.67	Result removed <sup>10</sup>	133.13	£999 PCs
	1.61	Result removed <sup>10</sup>	131.21	£999 PCs
	1.96	2.95	95.14	£999 PCs
	3.40	5.61	138.34	£999 PCs
	2.83	Result removed <sup>10</sup>	166.97	£999 PCs
	2.42	2.96	106.94	£999 PCs
	3.89	4.82	93.49	£999 PCs
	6.62	9.94	136.03	£999 PCs
	2.33	Result removed <sup>10</sup>	114.22	£999 PCs
	3.08	5.26	123.94	<b>£999 PCs Average</b>
£600 Business PCs	2.86	Result removed <sup>10</sup>	61.03	£600 Business PCs
	3.38	3.60	56.52	£600 Business PCs
	2.20	3.59	69.60	£600 Business PCs
	1.67	1.47	74.71	£600 Business PCs
	2.13	2.89	78.10	£600 Business PCs
	3.50	Result removed <sup>10</sup>	59.68	£600 Business PCs
	2.88	4.39	68.96	£600 Business PCs
		2.66	3.19	66.94
Quad Core PCs	5.98	7.98	211.92	Quad-core PCs
	8.10	9.96	221.02	Quad-core PCs
	5.87	8.00	216.49	Quad-core PCs
	3.41	4.75	220.55	Quad-core PCs
	2.30	3.86	216.79	Quad-core PCs
	6.41	Result removed <sup>10</sup>	174.42	Quad-core PCs
	5.35	6.91	210.20	<b>Quad-core PCs Average</b>
	4.55	6.12	124.89	<b>OVERALL AVERAGE</b>

<sup>10</sup> Sleep-mode results removed because of a failure to enter a proper sleep mode under test conditions

## 6 Conclusions

This study has not aimed to cover the full range of the desktop-PC market. However, these tests cover desktop computers over a wide range of prices and specifications, and some valuable conclusions can be drawn from the test result data.

### 6.1 Move to quad-core PCs resulting in trend towards increased consumption:

The test results illustrate that Quad-core PCs are the highest consuming desktop computers, although for modes such as sleep mode and standby (off mode) there can be widely ranging consumption regardless of PC specification (suggesting that consumption in these modes is not dependant on specification).

### 6.2 Adequacy of the current Tier 1 ENERGY STAR specification

The spread in consumption observed in many cases, highlights the need for a label that can push product manufacturers to move towards more efficient designs. The ENERGY STAR approach for the computer specification appears to meet this requirement in the new proposal, with criteria that appear to be matching the level of the lowest consuming 25% of the market:

- For standby (off mode), the ENERGY STAR proposal appears to be quite ambitious (2 W), aiming at a level that is less than the lowest consuming 25% of models tested (2.4 W).
- For sleep mode the ENERGY STAR level (4 W) is set at a level close to the lowest consuming 25% threshold (4.4 W)
- For idle mode, the ENERGY STAR requirement (50 W to 95 W depending on specification) for a high-specification C category computer appears to align with the lowest consuming 25% of products tested. However, the ENERGY STAR categories and thresholds may need to be revised to adequately address the spread in the market, as there is a move to increasingly high specification products that will need to be addressed on an ongoing basis.

### 6.3 Correlation of increased specification/performance with increased power consumption:

The following relationships between the level of specification of a PC and its consumption could be observed:

- For standby (off) mode: the £999 PCs and the £600 Business PCs consumed less than the majority of other PCs, while the Photo-editing PCs, Windows Vista™ capable PCs, and Quad-core PCs consumed more power. Two of the Quad-core PCs consumed similar power to the £900 PCs and £600 Business PCs. These had similar specifications to the other Quad-core PCs, so it would seem that this level of standby

(off mode) power consumption is achievable with this level of hardware and, therefore, does not necessarily correlate to specification level.

- For sleep mode: in sleep mode, most desktop computers were below the 10 W level. There appeared to be a slight correlation between power consumption and specification level with some of the categories (eg the £600 Business PCs), but not with others (eg the Quad-core PCs and the Photo-editing PCs).
- For idle mode: most of the desktop computers were grouped in the 100 W to 150 W range, except for the lower specification £600 Business PCs consuming between 56 W to 80 W and the higher specification Quad-core PCs, which in most cases consumed in excess of 200 W. It appeared that there may be some kind of correlation between idle mode consumption and capability, which would back the EPA's approach to divide the criteria into low and high specification models.

## **6.4 Potential sleep-mode issues**

Some samples may have not been configured correctly as they had unreasonably high sleep mode levels and were, therefore, removed from the results to preserve the integrity of the test (as it could not be clarified if these results were due to specific product/test configurations). This does suggest that there is a possibility that some PCs are failing to enter sleep mode, which could result in considerable unnecessary consumption. Future testing could involve the purchase of off-the-shelf samples of those products where these measurement anomalies have been experienced to investigate this issue further.

## **6.5 Disparities in power-consumption modes**

Surprisingly, some desktop computers consumed more power in standby (off mode) than in sleep mode. On closer inspection, it would appear that this may be due to there being a level of power management in sleep mode that is not present in standby (off mode). This would result in the computer putting devices into low power states in sleep mode and not managing their power at all in standby (off mode). This was evident with some samples where the network interface's speed was reduced in sleep mode, but ran at full speed in standby mode.

## 7 Glossary

<b>CPU</b>	Central processing unit
<b>GPU</b>	Graphics processing unit (processor dedicated to performing calculations related to displaying computer graphics – sometimes integrated onto motherboard)
<b>HDD</b>	Hard disk drive (non-volatile storage device that stores data magnetically on rotating platters)
<b>Motherboard</b>	The main printed circuit board that holds the CPU, RAM and other essential components. Other components such as the HDD, GPU and PSU also connect to the motherboard
<b>Multi-core processor</b>	CPU containing two or more processors as in 'dual-core' or 'quad-core'
<b>PSU</b>	Power supply unit (converts mains voltage to low voltages used by the computer components)
<b>RAM</b>	Random access memory (volatile memory used for loading, displaying and manipulating applications and data)

Market Transformation Programme  
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