



# Energy Efficiency Setup Guide



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## Introduction

HP Compaq Business PCs provide broad options to achieve maximum energy savings that result in indirect benefits beyond cost savings alone. This guide provides a step-by-step approach to understanding how to achieve these benefits that can not only lower energy consumption, but also reduce noise given a system may see less fan use or slower fan speeds and increased reliability given less heat could be generated keeping the system cooler and potentially increasing the units lifecycle.

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## Steps to achieve maximum energy efficiency

- Step 1:** Choose a system that has power management technology and enable the technology on your systems. HP ships all systems out of the factory with AMD's Cool 'n' Quiet and Intel's EIST enabled.
- Step 2:** Choose a system that has a BIOS that offers a wide range of configurable power management options. The HP BIOS available in all dc5000 and dc7000 products provides five system states that can be configured to provide increased levels of power efficiency. All HP dc7000 and dc5000 products ship out of the factory with all system states enabled to achieve maximum power efficiency.
- Step 3:** Choose a system processor that provides the maximum level of power efficiency.
- Step 4:** Choose a system configuration with an 80% efficient power supply. 80% power supplies reduce energy consumption, provide peak reduction and provide improved power quality.
- Step 5:** Replace CRT monitor with LCD technology. LCD technology provides up to 70% power savings and provides up to twice the lifespan of CRT monitors.

# Power Management Technology

*Step 1: Choose a system that has power management technology and enable the technology on your systems. HP ships all systems out of the factory with AMD's Cool 'n' Quiet and Intel's EIST enabled.*

Computer processor manufacturers are incorporating the ability to manage power use directly into their newer processors. Processors recently released by both Intel and AMD include features that work with the BIOS and operating system to lower power consumption. Along with being more environmentally friendly, reduced power consumption results in reduced heat production. Less heat means lower fan speed requirements, thereby providing quieter, more efficient computers.

## What is EIST?

Enhanced Intel SpeedStep Technology (EIST) is the term Intel uses for its processor power management technology. This processor feature allows the system to dynamically adjust processor voltage and core frequency as often as is required to decrease power consumption and decrease heat production. The processor alters performance by changing bus-to-core frequency ratio and voltage. Only the internal core frequency is altered - the front side bus (FSB) is not affected. To run at reduced power consumption, the voltage is changed in step with the bus ratio.

## What is AMD Cool 'n' Quiet?

Cool'n'Quiet is the term AMD uses for its processor power management technology. This processor feature dynamically adjusts the operating frequency and voltage of a processor up to 30 times per second depending on the CPU load. When full processor performance is not needed, the processor slows its frequency, resulting in significant power savings, which results in cooler and quieter performance.

While Cool'n'Quiet technology is new to desktop processors, a similar technology from AMD has been used in mobile processors for several years. This mobile processor technology is known as PowerNow!

## Why are EIST and Cool'n'Quiet needed?

EIST and Cool'n'Quiet were created to lower power consumption when software activity does not require the full capabilities of the processor. Reduced power consumption means reduced operating costs and reduced heat production. Reduced heat production means reduced fan speed requirements. Reduced fan speed requirements also mean reduced system noise.

This technology is also especially useful for portable computers, as reduced power consumption leads to increased battery life.

## What are the required components for EIST and Cool'n'Quiet to function?

For a system to take advantage of EIST or AMD Cool'n'Quiet, the following system components must support the feature:

- Processor
- Chipset

- System BIOS
- Operating system
- Processor driver

### Processor

Intel's 800, 900 and E6000 series processors support EIST. AMD's Athlon line of processors support Cool'n'Quiet. Both technologies may become a standard feature for future processors.

### Chipset

EIST requires the Q965/Q963 or later chipset. AMD Cool 'n' Quiet requires the ATI RadeonExpress 1150 chipset or later. Current HP business desktop systems with qualifying chipsets include:

#### Intel Q965:

- dc7700

#### Intel Q963:

- dc5700

#### ATI RadeonXpress1150:

- dc5750

### System BIOS

You can enable or disable the Runtime Power Management (RTPM) option in the BIOS of Intel Q965/Q963 and ATI RadeonXpress 1150 chipsets. This option is located in F10 Setup in the **Power/OS Power Management** section. The default EIST BIOS support setting depends on several factors.

<b>EIST Support</b>	<b>TM2 Support</b>	<b>Default Runtime Power Management (RTPM) Setting</b>
Yes	Yes	RTPM Option Shown in F10 Setup - Enabled
No	Yes	RTPM Option Shown in F10 Setup - Disabled
No	No	RTPM Option Not Shown in F10 Setup

Thermal Monitor 2 (TM2) is an older Intel processor feature that allows CPU throttling to slow down the processor. EIST will replace TM2. Some older processors support TM2, but do not support EIST, while even older processors do not support either TM2 or EIST. All processors shipped with HP Q995/Q963 chipsets support both EIST and TM2.

You can enable Runtime Power Management (RTPM) on systems that only support TM2. This setup allows the BIOS to control processor throttling. EIST uses the operating system to control throttling.

For processors that support both EIST and TM2, CPU throttling is controlled by EIST and the operating system. The HP BIOS controls CPU throttling on TM2-only processors, resulting in support for RTPM. See "Known Issues" on page 9 for possible compatibility issues. There is no RTPM capability for processors that do not support EIST or TM2.

## Operating System

Microsoft implemented EIST support in Windows XP Service Pack 2. All future Microsoft operating systems will include EIST support.

Several Microsoft operating systems support Cool'n'Quiet, including Windows XP, Windows 2000, and Windows ME. All future Microsoft operating systems will include Cool'n'Quiet support.

## Processor Driver

Microsoft Windows controls the performance of a processor with the kernel power policy manager, a processor driver, and the system BIOS. The kernel power policy manager sets the rules for using the correct performance state at a given time. Once the performance state is determined, Windows uses the processor driver or system BIOS to make the changes. The processor driver changes the performance state if the processor is not Hyper-Threaded (HT). The system BIOS changes the performance state if the processor is HT-enabled.

The use of a processor driver, such as the generic *processr.sys*, allows Windows to interact and control different processors - for example, Intel, AMD, and Transmeta. Vendor-specific processor drivers are also available, such as *intelppm.sys* for Intel processors in Windows XP Service Pack 2. You can add support for future processors, if needed.

The processor performance control policy is linked to the power management scheme. See the table in the Power Management Scheme section for detailed information about the relationship between power management scheme and control policy.

There are four control policies:

- Constant - Always runs at lowest performance state.
- Adaptive - CPU usage determines performance state.
- Degrade - Starts at lowest performance state and slowly reduces performance as battery discharges (notebooks only).
- None - Always runs at highest performance state.

## Power Management Scheme

EIST will function only if the operating system is using an adaptive power management scheme. The following table shows the relationship between power scheme and the control policy used.

Power Scheme	AC Power	DC Power
Home/Office Desk	None	Adaptive
Portable/laptop	Adaptive	Adaptive
Presentation	Adaptive	Degrade
Always On	None	None
Minimal Power Management	Adaptive	Adaptive
Max Battery	Adaptive	Degrade

For more information about processor performance control, go to:

<http://www.microsoft.com/whdc/system/pnppwr/powergmt/ProcPerfCtrl.msp>

## Power Scheme - Adaptive or Not

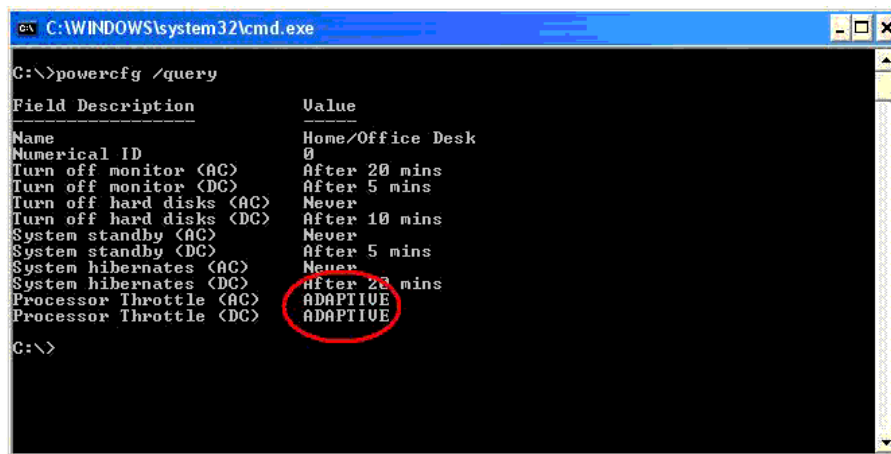
An adaptive power scheme allows the operating system to dynamically adjust performance of a processor (frequency and voltage) according to the amount of processor usage. You can determine whether a power management scheme is adaptive. If a power management scheme has not been modified, it will have the default processor performance control policy. However, a modified power scheme will not provide external notification regarding its current control policy.

To verify processor performance control policy, perform the following steps:

1. Click **Start > Run**.
2. Type CMD.
3. Type `powercfg /query`.

The system displays the current power configuration. **Processor Throttle <AC>** and **Processor Throttle <DC>** indicate which control policy is implemented when the system is using AC power or battery power.

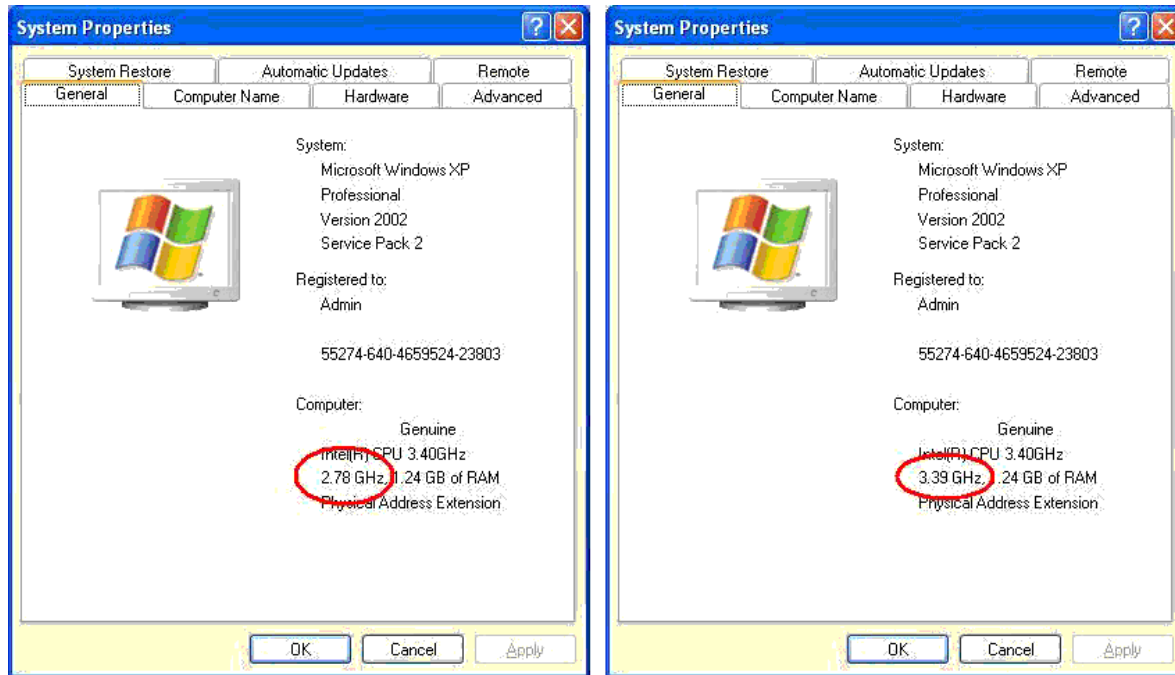
## Home/Office Desk in adaptive state



```
C:\WINDOWS\system32\cmd.exe
C:\>powercfg /query
Field Description      Value
-----
Name                   Home/Office Desk
Numerical ID           0
Turn off monitor <AC>  After 20 mins
Turn off monitor <DC>  After 5 mins
Turn off hard disks <AC>  Never
Turn off hard disks <DC>  After 10 mins
System standby <AC>      Never
System standby <DC>      After 5 mins
System hibernates <AC>   Never
System hibernates <DC>   After 20 mins
Processor Throttle <AC>  ADAPTIVE
Processor Throttle <DC>  ADAPTIVE
C:\>
```

## System Properties - EIST

The System Properties window displays current processor speed on computers installed with an EIST-capable processor and Windows XP Service Pack 2 that are using an adaptive power scheme. The following images illustrate a drop in processor speed for an Intel Pentium 4 system (3.4 GHz) under throttled conditions with EIST both enabled and disabled



## Maximum Processor Speed

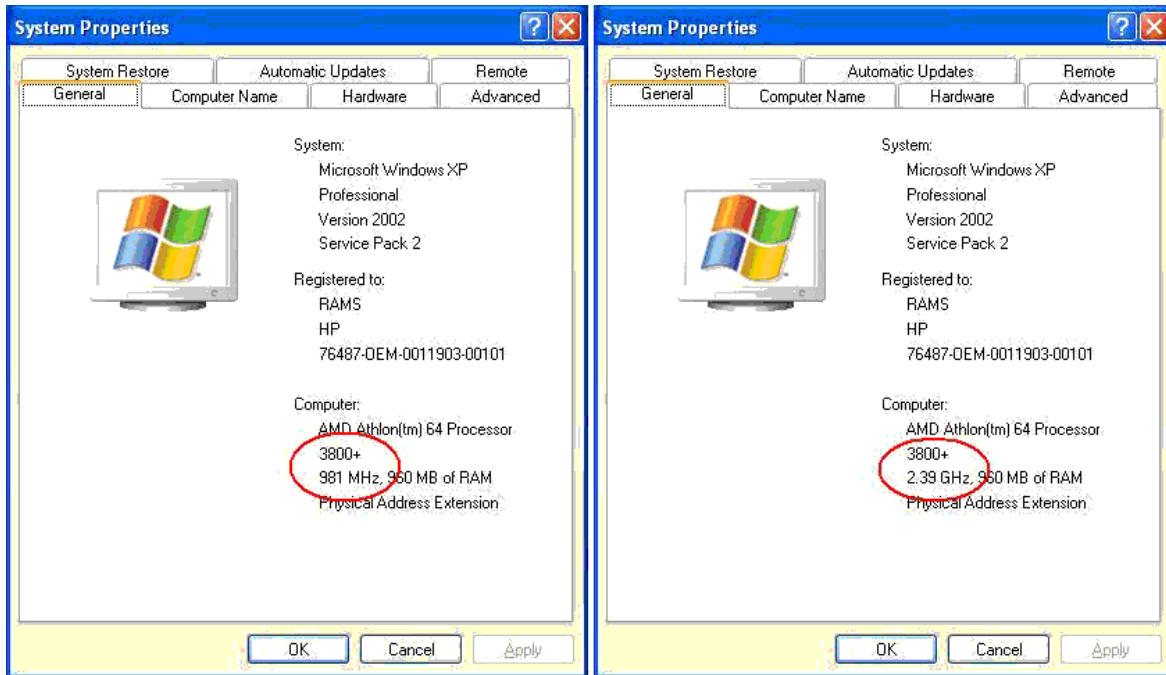
You can check the maximum speed setting for systems with EIST or Cool'n'Quiet enabled by performing the following steps:

1. Click **Start > All Programs > Accessories > System Tools > System Information**.
2. Locate the **Processor** listing.

The maximum speed of the processor (listed in MHz) displays in the right pane next to **Processor**. The System Information screen reports only the maximum speed of the processor.

## System Properties - Cool'n'Quiet

The System Properties window displays current processor speed on computers installed with a Cool'n'Quiet capable processor and Windows XP Service Pack 2 that are using an adaptive power scheme. The following images illustrate a drop in processor speed for an AMD Athlon 64 3800+ system (2.4-GHz) under throttled conditions with Cool'n'Quiet enabled and disabled.



## How will EIST and Cool'n'Quiet impact HP Customers?

HP tests its images and deliverables for EIST and Cool'n'Quiet compatibility. These tests include:

- Applications bundled with HP bPC computers
- Operating system images bundled with HP bPC computers
- Peripheral drivers bundled with HP bPC computers
- Samples of popular applications and games

By default, the **Home/Office Desk** power scheme that is shipped with the HP image is non-adaptive. This means that under normal circumstances, a system will not see any power saving benefits with an EIST or Cool'n'Quiet capable processor. HP resolves this issue by making the Home/Office Desk power scheme adaptive using the Microsoft supplied *powercfg.exe* utility. During unbundling, if the system contains an EIST or Cool'n'Quiet capable processor, the **Home/Office Desk** power scheme is modified.

## Advantages of using EIST/Cool'n'Quiet

Enabling EIST/Cool'n'Quiet provides the following benefits:

- Increased power savings.
- Lower operating costs.

- Less heat production.
- Potential for less noise from slow fan speeds.

## Disadvantages of using EIST/Cool'n'Quiet

There are no known disadvantages to using EIST/Cool'n'Quiet if you use the latest HP BIOS and/or the latest service packs for Microsoft operating systems.

## Known Issues

- There are known EIST compatibility issues for i915/i945 systems using older Intel processors, older HP BIOS, and older Windows XP service packs. These problems may include both Windows blue screens and operating system hangs/delays. These issues have been fixed in the following:
  - HP BIOS for DDR i915 systems - 786C1 v2.14 or later
  - HP BIOS for DDR2 i915 systems - 786C2 v1.06 or later
  - Windows XP Service Pack 2
  - Windows Server 2003 Service Pack 1

Systems running Windows XP Service Pack 2 with older Intel processors that only support TM2 do not provide RTPM capability. Windows XP Service Pack 2 supports RTPM for only EIST processors.

- Windows XP may report inaccurate processor speed. For more information about this issue, as well as information about determining processor speed, see the following Microsoft Knowledge Base articles:

<http://support.microsoft.com/default.aspx?scid=kb;en-us;316965&Product=winxp>

<http://support.microsoft.com/default.aspx?scid=kb;en-us;888282>

- Windows XP on portable computers may display the following message: STOP 0x000000D1. For more information about this error message, see the following Microsoft Knowledge Base article:

<http://support.microsoft.com/default.aspx?scid=kb;en-us;888399>

## Resources for EIST and Cool'n'Quiet

The following web sites provide additional information about EIST and Cool'n'Quiet.

[http://www.intel.com/cd/channel/reseller/asmo-na/eng/products/box\\_processors/desktop/proc\\_dsk\\_p4/technical\\_reference/203838.htm](http://www.intel.com/cd/channel/reseller/asmo-na/eng/products/box_processors/desktop/proc_dsk_p4/technical_reference/203838.htm)

[http://www.amd.com/us-en/Processors/ProductInformation/0,,30\\_118\\_9485\\_9487%5E10272,00.html](http://www.amd.com/us-en/Processors/ProductInformation/0,,30_118_9485_9487%5E10272,00.html)

[http://www.amd.com/us-en/Processors/TechnicalResources/0,,30\\_182\\_871\\_9706,00.html](http://www.amd.com/us-en/Processors/TechnicalResources/0,,30_182_871_9706,00.html)

## Frequently Asked Questions

- Q. How can I verify if my power usage is actually lower?
- A. To perform an isolated test, you can hook the system up to a power meter to see how much power a computer uses when EIST is on or off.
- Q. Does the "speedstep" or "Cool'n'Quiet" feature cost more?
- A. These features are incorporated into newer processors and have minimal affect on processor pricing.

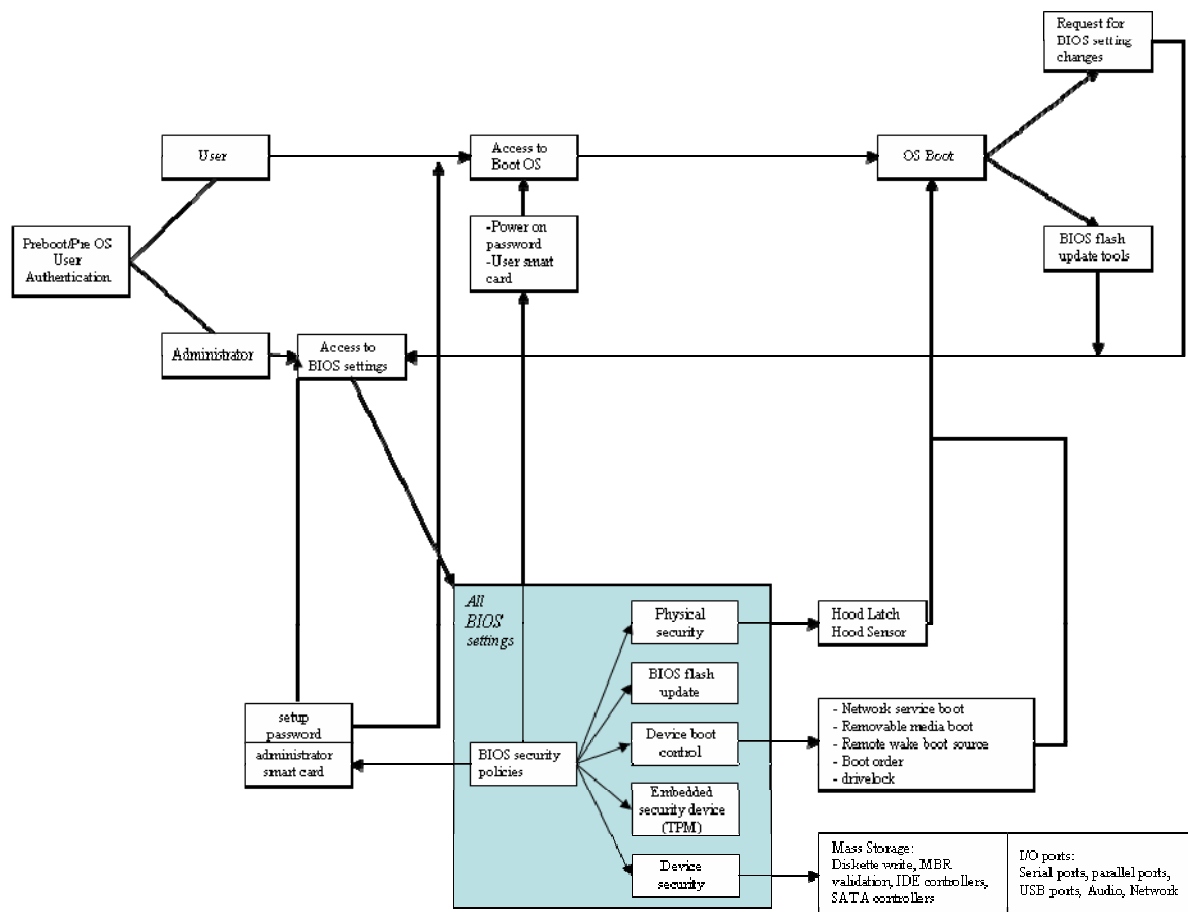
- Q. What will the lower power do to the performance of my system?
- A. The lower power consumption has no affect on perceived system performance. While the system does operate at a reduced speed, it only does so for applications that require lesser speeds, so the actual performance of these applications is not affected. You will not see a performance drop since the processor only throttles down when the extra speed would have been wasted anyway.
- Q. If an application requires more performance, how long will it take the system to return to full performance state?
- A. When the processor determines that greater performance is required, it can return to full performance state immediately. The user will perceive no loss in performance.
- Q. Does the constant variation in processor speed reduce the quality of the product?
- A. No. In actuality, the added functionality provided by the ability to vary processor speed increases the quality of the product.
- Q. Does the integration of this functionality imply that the processor speeds available are really too great for standard needs?
- A. No. This functionality simply provides more flexibility when you use applications that require less processor performance. Today's world constantly offers more applications that require greater processor performance. And while you may use these resource-intensive applications, you will likely also use applications, such as email, that do not require full processor capability.
- Q. If I have a system that supports this – can I turn it off in the BIOS without disrupting the system configuration or the software image?
- A. Yes, you can turn off EIST/Cool'n'Quiet support in the BIOS at any time with no software impact. Doing so simply means you will not conserve power.
- Q. If after the feature is turned on and runs for a while, if the system performance worsens, should I turn the feature off before calling support?
- A. Turning off the feature can be a good debug step before calling support. However, if performance worsens after a significant amount of time, the chances of a relation to EIST is low. Testing has indicated no noticeable performance degradation.

## Power Management and the HP BIOS

*Step 2: Choose a system that has a BIOS that offers a wide range of configurable power management options. The HP BIOS available in all dc5000 and dc7000 products provides five system states that can be configured to provide increased levels of power efficiency. All HP dc7000 and dc5000 products ship out of the factory with all system states enabled to achieve maximum power efficiency.*

**Figure 1.** Overall BIOS security picture

The following diagram represents the various security levels and interactions enabled by the HP BIOS.



## Thermal and Power Management

The HP BIOS provides and enables thermal and power management technologies to assist in operating the HP Business Desktop computer in any enterprise environment.

## Balancing thermal and acoustic requirements

HP designs thermal solutions to help assure that the computer performs optimally in the customer environment. The HP BIOS actively controls the environment of the computer by balancing the thermal requirements of the configuration and the acoustic levels of the computer. With today's faster and hotter processors, thermal management becomes paramount. If the processor becomes too hot, it may "throttle" (slow down) the computer until the temperature decreases. Throttling involves reducing the performance of the processor significantly during periods of elevated temperatures. The HP BIOS automatically manages the air flow in the computer to minimize elevated temperatures that could lead to thermal throttling.

The HP BIOS, by default, optimizes the acoustic characteristics of the computer while providing complete protection for the hardware thermal needs. Some customers may wish to control the computer airflow in their computers manually. The HP BIOS allows the user or administrator to configure the nominal fan speed to best suit the work environment. Air flow can be maximized for environments where thermal concerns are most important or minimized for acoustically sensitive environments. However, the user configurable speed does not compromise the thermal protection over the computer environment. The HP BIOS will adjust air flow to necessary levels when computer conditions require additional cooling regardless of the user settings. Through careful analysis and testing, the HP BIOS minimizes unnecessary fan noise for better idle acoustics and meticulously controls fan ramps to prevent overheating with smooth fan speed transitions.

The HP BIOS also provides thermal alerts to remote management consoles when the computer temperature rises to cautionary or critical levels. With this information, system administrators can adjust computer settings or environmental conditions to eliminate thermal concerns before they become real problems. Combined with the HP Business Desktop computer thermal hardware and cooling components, the HP BIOS plays an active and key roll in controlling the thermal environment and acoustics for a better overall Total Customer Experience (TCE).

## Saving power and money

Power cost and consumption are important concerns of the business client. The HP BIOS provides robust power management functionalities and can help address these concerns. Using the industry-standard Advanced Configuration and Power Interface Specification (see ACPI specifications at <http://www.acpi.info/spec.htm>), the HP BIOS enables the operating system to control the computer's power level safely and efficiently. The HP BIOS helps the business customer safely enable lower power management states. This functionality allows individual subsystems and peripherals to enter low power or off states without affecting other elements of the system.

The HP BIOS offers a wide range of configurable power management options to meet the customer's unique needs. The ACPI defines several system states described below, all of which HP supports:

- S1—Standby state resulting in the processor being halted, but context is not lost. All other devices remain at the normal power state. This state offers the fastest wakeup time and the lowest power savings.
- S3—Standby state known as Suspend to RAM. All devices in the system are powered down, except for computer memory. Recovery is almost instant (approximately 2 to 3 seconds) and power consumption is very low (typically <5W).
- S4—This state is referred to as Hibernation. The computer's memory content is saved to the hard drive, then most power is removed from the system.
- S5—This state is often referred to as Soft Off. The computer is off. This state offers the slowest wakeup time and the greatest power savings (typically <2W).

To understand the cost savings, consider an example using the power difference between enabling Suspend to RAM (system power dissipation is under 5W) versus simply allowing a system to idle (system

power dissipation is approximately 90W in a mainstream Pentium4 configuration). In this scenario, assume users simply let their system idle when they are not working. Calculate the cost savings during after-work hours (5pm to 8am) in an enterprise with 1000 systems. Saving approximately 80W for 15 hours/day at an average energy cost of 12 cents/kWh, for an average work year of 250 days, would result in a cost savings of \$36,000.00 annually for an installation of 1000 systems.

Typically, computer users will also not power off their systems at the end of the work day due to the inconvenience of waiting for the system to power up and complete the initial loading of their operating system. In the Suspend-to-RAM state, HP Business Desktop computers are available approximately 2 seconds after the touch of the mouse, keyboard, or power button.

The HP BIOS has also been a key component in achieving power management accreditations such as Energy Star, Blue Angel, and Federal Energy Management Program (FEMP) Standby Power compliance (refer to <http://www.eere.energy.gov/femp> for more information on the FEMP). Both the software image (operating system and applications) and the HP BIOS provide a cohesive power management environment that is fully tested and robust. Helping to lower power costs, improve user convenience, and increase product durability are all positive Total-Cost-of-Ownership (TCO) impacts of the HP BIOS.

### **Enabling future power savings**

HP BIOS engineers are working constantly with partners such as Intel and Microsoft to help ensure that HP Business Desktop computer designs will enable the latest processor and operating system thermal and power management technologies. The HP BIOS also provides runtime power management for some configurations that support processor throttling of frequency and voltage during situations where the operating system detects excess computing capability for the tasks it needs to perform. Runtime power management involves lowering the processor's power requirements when the computer is not executing processor intensive activities. The computer is completely on and responsive to the user, but, when the processor is not fully engaged, it can be throttled to save up to 40% power consumption without affecting the user's productivity. Typically, this feature is available in high performance processors. These computers can dissipate system power, up to 90W idling at normal operating frequency and voltage and significantly more in the working state. The runtime power management feature can save tens of KWHs per machine per year without sacrificing computing performance.

### **Serviceability**

Unplanned downtime can be extremely costly to any business. The HP BIOS can play a key role in the serviceability of the HP Business Desktop computer. Constant feedback from customers and field service personal is integrated into each successive HP BIOS family, resulting in improved serviceability and customer satisfaction. Some of the serviceability features in the HP BIOS are problem diagnosis and resolution and detailed service information

### **Problem diagnosis and resolution**

HP Business Desktop computers, designed with the HP BIOS, provide information to aid the user in diagnosing problems. Visual alerts are produced by blinking the power LED light red instead of the normal green color. Audio beep alerts are supported on computers containing a computer speaker. These alerts allow the user, administrator, or service technician to diagnose problems quickly at the component level and take effective action onsite. Issues can be diagnosed correctly the first time to avoid random replacement of computer components and costly computer downtime. See the Troubleshooting Guide on the *Documentation CD* that shipped with the computer for more information. Problem alerts are provided for the following failures:

HP BIOS Diagnostic Codes	
Problem	Computer Reaction
Processor Thermal Protection Activated	Power LED blinks RED 2 times, one every second, followed by a 2-second pause.
Processor not installed (not an indicator for a bad processor).	Power LED blinks RED 3 times, one every second, followed by a 2-second pause.
Power Failure (power supply is overloaded)	Power LED blinks red 4 times, one every second, followed by a 2-second pause.
Pre-video Memory Error	Power LED blinks RED 5 times, one every second, followed by a 2-second pause. Also 5 simultaneous beeps will be heard.
Pre-video Graphics Error	Power LED blinks RED 6 times, one every second, followed by a 2-second pause. Also 6 simultaneous beeps will be heard.
PCA failure (ROM detected failure prior to video)	Power LED blinks RED 7 times, one every second, followed by a 2-second pause. Also 7 simultaneous beeps will be heard.
Invalid ROM based on bad checksum	Power LED blinks RED 8 times, one every second, followed by a 2-second pause. Also 8 simultaneous beeps will be heard.
Watchdog timer alarm (no BIOS code being executed)	Power LED blinks RED 9 times, one every second, followed by a 2-second pause. Also 9 simultaneous beeps will be heard.

## Energy Efficient Processors

*Step 3:* Choose a system processor that provides the maximum level of power efficiency.

There are many watt classifications of processors. The most common wattage of processors available today are 95w, 65w and 35w processors. 35w processors achieve the maximum in power savings and 65w and 95w provides mainstream power savings.

### AMD Systems

Selecting an AMD configuration with an X2 3800+ 35w processor configuration will yield the best energy efficiency versus other AMD wattage classifications. AMD 35w processors at idle, average and peak reduce energy consumption up to 5%, 20% and 15% respectively versus AMD 65w processors in a similar configuration.

### Intel Configurations

Selecting an Intel system with a Core 2 Duo 65w processor configuration will yield the best energy efficiency. 65w processors at idle, average and peak reduce energy consumption up to 11%, 36% and 26% respectively versus Intel 95w processors with similar configurations.

## Standard Power Supplies vs 80% Efficient Power Supplies

*Step 4: Choose a system configuration with an 80% efficient power supply. 80% power supplies reduce energy consumption, provide RMS and peak AC current reduction.*

The losses in an 80% efficient power supply are reduced by up to 33% compared to standard supplies. Reduced losses lead to lower temperatures and improved reliability.

80% power supplies are designed with active power factor correction, which reduces the RMS input current by nearly 50% and the peak AC input current by over 75% compared with non power factor corrected power supplies.

80% efficient power supplies operate over the entire AC voltage range (90VAC to 264VAC) with no input voltage select switch.

Another important benefit of the 80% efficient power supply is its .9 active power factor correction (PFC). In a perfect scenario, there is a direct correlation between voltage and current with respect to our power supply. In this ideal situation, on an AC circuit at maximum voltage, maximum current is delivered. When the voltage alternates, so does the current. This is what happens in a simple resistive load like a toaster or similar appliance. PCs present a much more complex mode to a power supply. Current and voltage don't track each other nicely. Active power factor correction uses an active circuit to help current and voltage correlate with each other as was the case with the toaster. When this happens, apparent power and real power approach each other. Apparent power is the current drawn by a system. Real power is the current actually available for use by the system. If they are equal, then the power factor is 1. A .9 PFC means that 90% of apparent power is actually transferred to available real power. Power supplies that aren't power factor corrected tend cause unpleasant variations in AC voltage that can affect or even damage other equipment on the same circuit.

Other benefits of 80+ power supplies with active power factor correction are:

- Increased system reliability due to reduced heat output
- Decreased system maintenance due to increased reliability
- Lower TCO due to reduced maintenance and longer equipment life
- Improved worker environment due to use of quieter fans to cool low heat systems
- Increased reliability, decreased system maintenance and lower TCO for devices on the same power grid

## Reasons to upgrade to LCD technology today

*Step 5: Replace CRT monitor with LCD technology. LCD technology provides up to 70% power savings and provides up to twice the lifespan of CRT monitors.*

Replacing CRT technology with TFT technology can provide substantial power savings. For example, a floor with 100 workstations would require energy consumption of 9,000 Watts per hour (W/Hr) if equipped with CRTs, versus only 1700 W/Hr when equipped with comparable 15-inch TFT monitors.

The following table shows power consumption for CRTs and comparable TFTs. In addition to the benefits TFTs offer in these areas, they also require less desk and office space, so more people can work in a smaller space. This aspect helps conserve general overhead costs such as office furniture, lighting and rent.

**Figure 1.** A comparison of overall solutions offered by HP and by Dell.

Table 1 – Power Consumption of Common Displays

	17" CRT	15" TFT	21" CRT	19" TFT
Full Power (Watts)	70	25	120	40
Hours of Op/Day	10	10	10	10
KW/hr	.7	.25	1.2	.4
Working Days	240	240	240	240
Total kWhrs/yr	168	60	288	96
Cost at \$.069/khr*	\$11.59	\$4.14	\$19.87	\$6.62

\* Cost/kwhr based on California power costs. Source: California Capital Review; [www.capitalweek.com/energy/energy.htm](http://www.capitalweek.com/energy/energy.htm)

## For More Information

For more information about HP Business Desktop computers, visit our website at [www.hp.com](http://www.hp.com).

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