



Windows 7 Power Management

Power Management Improvements in Windows 7
Beta

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For the latest information, please see the Windows 7 Springboard web site
(<http://technet.microsoft.com/en-us/windows/dd361745.aspx>).

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Overview

Today, organizations focus on power management as a way to reduce costs and decrease their carbon emissions. One way to reduce the cost of running client computers is to reduce the power that is consumed. Regulatory compliance and a focus on green information technology (IT) provide additional motivation to better manage power consumption. Also, IT pros need to quickly identify and resolve energy inefficiencies on individual computers—especially portable computers—to enable higher levels of productivity for their users.

Multiple factors contribute to energy efficiency and portable computer battery life. A single component—whether a device, a device driver, the operating system, or an application—can significantly affect battery life. Optimizing for energy efficiency and battery life requires continuous investments by the entire ecosystem to ensure that platforms are optimally designed and configured. Microsoft is committed to making this ongoing investment to help extend battery life for portable computers and improve energy efficiency for all PCs and servers.

The Windows® 7 operating system provides several opportunities to decrease power consumption across the enterprise. The power management technologies in Windows 7 provide platform and processor efficiencies that reduce power consumption and can help lower energy costs. Windows 7 can also extend battery life for specific scenarios. Additionally, it provides diagnostic tools that enable OEM, IHVs, ISVs and IT pros to better manage and troubleshoot power management issues on computers and to extend the battery life for portable computers.

This white paper describes power management enhancements in Windows 7, including improvements that reduce power consumption, enhance user experiences, and enable greater enterprise power management.

Reduced Power Consumption

Microsoft designed Windows 7 with a strong focus on reducing the overall power consumption by investing in key areas of the platform including performance optimizations, idle resource utilization, device power management, and key end-user scenarios.

Energy efficiency requires investments across the entire platform, not only in the core hardware or in the operating system. While Windows 7 can have a significant impact on platform energy efficiency, attached devices, and non-Microsoft and end-user applications, other platform extensions often have a larger total impact. The complexity and quantity of platform extensions require a broad approach to energy efficiency beyond focusing on a single component in the platform.

In addition to core investments in Windows 7, Microsoft has emphasized ecosystem engagements for energy efficiency. Ecosystem partners, including IT pros, may leverage Windows 7 technical documentation, built-in diagnostic tools, and rich performance analysis tools to help identify issues across the enterprise.

Idle Resource Utilization

Idle efficiency is critical for the overall battery life of a PC because idle time dominates most scenarios. Reducing idle power consumption reduces the base power consumption. For example, if a portable computer uses 12 watts when the system is idle, all other scenarios increase power by some amount over the base 12 watts. Reducing idle power consumption benefits all other end-user workloads and scenarios, from DVD playback to office productivity.

Reducing idle power consumption can be achieved by reducing the resource utilization of the system when it is idle. It can also be achieved by enabling the hardware to go into lower power states during long periods of inactivity.

Resource utilization includes the processor, disk, memory, and network activity on the system. Windows 7 helps improve efficiency by reducing resource utilization when the system is idle. Reducing processor activity is particularly critical because of the large dynamic range of power consumption in modern processors. The typical portable computer processor consumes nearly 0 watts when idle, but it can consume up to 35 watts when fully utilized.

Windows 7 provides greater idle efficiency by reducing (and in many cases eliminating) background activity on the system. Where periodic activity cannot be eliminated because of strict polling requirements (such as timers on the USB stack), Windows 7 exposes a new timer coalescing feature. (For more information, see [“Timer Coalescing API”](#) later in this document). Timer Coalescing allows Windows 7 to align various background activities and execute them at the same time to keep the processor idle for longer periods of time. Additionally, Windows 7 defers non-critical background activity when the system is on battery power to help extend the battery life of a portable computer.

Trigger Start Services

System services often start automatically, run in the background, and wait for infrequent events to occur. Windows 7 can reduce background activities by trigger-starting system services, which starts background processes only when a specific event occurs. Events like device insertion and IP address changes can trigger-start services. For example, in Windows 7 the Windows Bluetooth service only starts when a Bluetooth device is attached to the computer.

Idle processors help reduce power consumption, allowing users to benefit from longer battery life. By reducing the number of background services running, Windows 7 helps improve energy efficiency and computer responsiveness. IT pros can take advantage of this capability by enabling trigger-starting for services that are part of their enterprise image, and they can validate performance impacts with the [Windows Performance Tool Kit \(XPerf\)](http://go.microsoft.com/fwlink/?LinkId=147988) (<http://go.microsoft.com/fwlink/?LinkId=147988>).

For more information regarding the Windows service improvements in Windows 7, see the paper “[Developing Efficient Background Processes for Windows](http://go.microsoft.com/fwlink/?LinkId=147990)” (<http://go.microsoft.com/fwlink/?LinkId=147990>).

Enhanced Processor Power Management

Windows 7 includes device driver support for the latest processor power management (PPM) technologies. Performance and power consumption modes for the processor are called *performance states*. The PPM technologies allow the operating system to choose the right processor performance state depending on the load, and then scale the performance of the system accordingly.

Windows 7 features significant changes to the accounting of processor activity, which enables much greater accuracy in determining which performance state is appropriate for the processor based on current system activity. These improvements enable greater energy efficiency across a broad range of workloads. In-box support of these technologies enables power-saving benefits immediately after installation.

Timer Coalescing

Modern processors are able to reduce their power consumption by taking advantage of the periods of idle time between executing instructions for software activity. However, many PPM technologies require a minimum amount of idle time to obtain a net power-savings benefit. If the processor is idle for very short periods of time, the power required to enter and exit the low-power state can be greater than the power saved.

Windows Timer Coalescing can help increase the duration of processor idle periods by combining various software timer expirations. Combining various software timer expirations allows the kernel to execute all of the timer activity on the same timer interrupt, which enables longer periods of idle time on each processor by waking up several timers concurrently and doing the work together. When the work is complete, the processor is able to return to a deep idle state for an extended period of time. Windows 7 provides new application programmer interfaces (APIs) for driver developers and for application and service developers to take advantage of Windows Timer Coalescing.

Device Power Management

Windows 7 provides enhanced device power management. It enables low-power modes across several technologies, including Adaptive Display Brightness, Smart Network Power, and other device classes. The following sections describe these improvements.

Adaptive Display Brightness

On today's mobile platforms, the display is a significant part of the overall system power usage—up to 40 percent. Previous versions of the Windows operating system include power policy settings to turn off the display after a period of inactivity and lower power consumption. The display is typically powered down after 10–15 minutes of user inactivity. However, there may be many periods of user inactivity that are shorter than the display-off power policy. These short periods of user inactivity occur frequently throughout the day.

Adaptive Display Brightness defines additional power policy settings to dim the display after a period of inactivity. Dimming the display can help reduce the display power

consumption, although not as much as turning off the display. Adaptive Display Brightness also supports hardware Ambient Light Sensor (ALS) devices to automatically adjust display brightness to the surrounding ambient light, even when the user is interacting with the system.

Low-Power Audio

Windows 7 supports the latest Intel HD Audio low-power specification. This specification introduces a fourth power state—D3Cold—which is defined as the lowest unresponsive power state that a codec can go into yet still wake up. The Windows 7 HD Audio Class Driver takes advantage of this power state to further conserve power when an audio device is not in use. Windows 7 also supports USB audio-class selective suspend, which reduces the complexity of platform integration for array microphone and USB Web camera solutions. Support for selective suspend in audio-class devices helps make USB-based solutions possible without significantly affecting battery life.

Bluetooth Power Improvements

Windows 7 helps increase battery life by enabling state of selective suspend when it detects that a Bluetooth device has entered a lower-power state. Typically, when the client computer is connected to a Bluetooth device, the radio and the USB bus are always active, whereas the device may be entering a lower-power state if it does not need to use the Bluetooth connection. With Windows 7, if the device enters its low-power (or “sniff”) mode, Windows 7 enables a state of selective suspend on the computer, allowing both sides of the connection to save power.

Networking Power Improvements

Windows 7 provides new power management features for wired and wireless networking technologies. In Windows 7, when users disconnect the network cable, Windows 7 can automatically place the network adapter into a lower-power state known as *D3*. (*D3* is only available when the adapters and drivers support this power state.) This provides an additional power savings of as much as 0.5 watts. These results will vary depending on the hardware configuration and network controller. When the user reconnects the network cable, Windows 7 automatically places the network adapter in the full-power state, known as *D0*.

Windows 7 enables wireless network controllers to enter low-power modes. This capability is configurable through power policy settings. Although this functionality was available in the Windows Vista® operating system, many wireless access points did not correctly support low-power modes, which caused the computer to suddenly disconnect from the wireless network. In Windows 7, the networking driver stack queries the access point for low-power capabilities and enters the low-power mode only if the access point supports it. This arrangement allows the default power policy setting to be configured for power savings without compromising network connectivity when the computer is connected to access points that do not support low-power modes.

Enhanced User Experiences

Windows 7 can provide users with a richer experience when they are travelling by offering greater responsiveness and energy efficiency. Windows 7 provides enhanced processor power management to deliver energy savings and performance on portable computers, which will provide longer battery life.

The networking power improvements improve power consumption and battery life across a broad range of scenarios. Following are examples of specific scenarios:

Optimizations to key user scenarios. By focusing on the core infrastructure (as described earlier), Windows 7 enables power savings opportunities across a broad range of scenarios, including office productivity. In addition to these core infrastructure investments, Windows 7 provides power savings opportunities across specific end-user scenarios. For example, Microsoft has optimized the extended battery life during playback of standard definition content with Windows Media® Player.

DVD playback is an example of a key scenario that highlights the investments made in energy efficiency in Windows 7. These optimizations span several areas, which include the following:

- **Processor power management improvements** that allow the processor to stay in lower performance states without impacting playback performance.
- **Architectural changes** that improve the Desktop Window Manager (DWM) graphics processing unit (GPU) utilization.
- **Playback pipeline scaling** that allows lower power operation without significantly impacting playback quality.
- **Audio stack and operating system improvements** that enable high-fidelity playback without requiring increased timer resolution.
- **Smart data caching mechanisms** that allow aggressive optical disk drive spin-down.

In addition to the focused optimizations for DVD and audio playback, Windows 7 offers additional performance optimizations across several scenarios including search, Internet browsing, and casual games. These optimizations reduce power consumption and help extend battery life.

Improved power troubleshooting. Windows Troubleshooting diagnoses and repairs common issues, such as display settings, network issues, and printing issues. Windows 7 also includes a troubleshooter to diagnose and improve power usage. This troubleshooter helps end-users resolve common issues without having to call the Help desk.

Better low-battery user interface (UI) experience. Windows 7 improves low-battery notifications, which alert users when their batteries are below a critical threshold. Battery-life notifications provide more timely and accurate information about the status of portable computer batteries in Windows 7, encouraging users to connect to a power source before the computer enters Hibernate mode.

As shown in Figure 1, the operating system introduces a threshold at 7 percent, which displays a warning dialog box. Users must take an action to dismiss this warning. This threshold is configurable. These notifications are also more prominent in Windows 7, and they encourage users to be aware of their power consumption. IT pros can manage low-battery thresholds by using Group Policy.

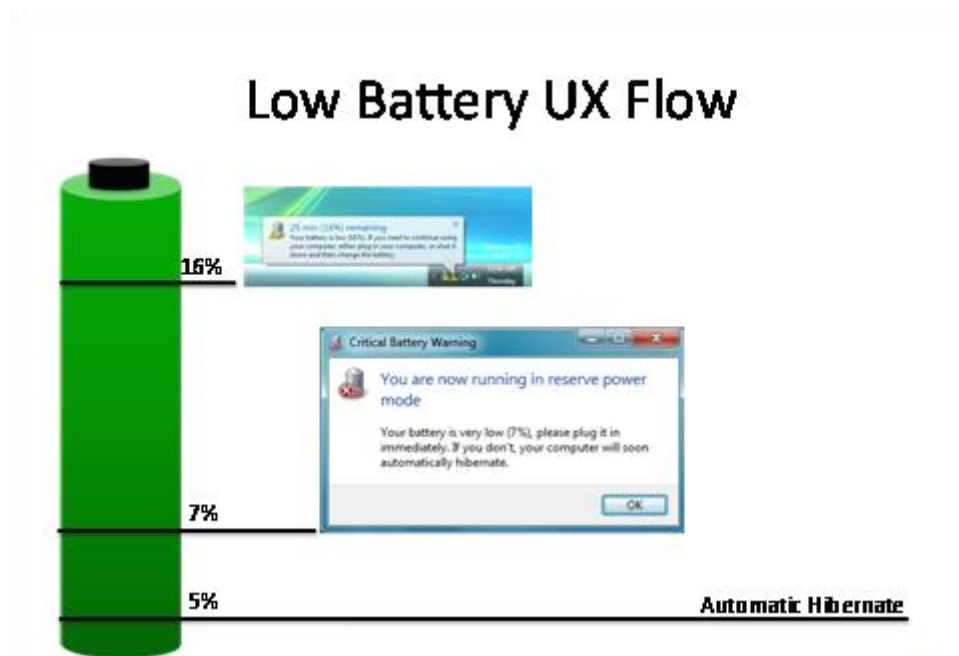


Figure 1 Battery life notifications in Windows 7

Greater Enterprise Power Management

Windows 7 provides IT pros the tools they need to configure and resolve issues with power management, including power-management diagnostics. IT pros can configure Windows 7 power management by using **PowerCfg.exe** (a command-line power-management utility), Group Policy, and Windows Management Instrumentation (WMI). With Windows 7, IT pros are able to centrally manage more power management settings on a more granular level.

Power Efficiency Diagnostics

Windows 7 provides diagnostics that enable IT pros to identify problems across their enterprise. This set of diagnostics has been incorporated into the **PowerCfg.exe** utility, and it enables IT pros to quickly determine common problems that may impact energy efficiency. They can also identify applications and open network files that prevent a computer from entering Sleep and Hibernate modes.

Specifically, Windows 7 instruments event tracing for power management and related services. Typing **powercfg /ENERGY** in an elevated Command Prompt window starts event tracing on the computer. This command generates Hypertext Markup Language (HTML) or Extensible Markup Language (XML) reports that identify energy efficiency–related issues. These reports contain information about hardware and software issues that affect battery life and the general health of portable computer batteries. With this knowledge, IT pros are able to determine whether inefficiencies are related to batteries or another source. This tool is particularly well suited for IT Pros that are qualifying new PCs for their organization and for IT Pros that create standard PC images.

Additionally, running **powercfg /REQUESTS** inspects the computer for outstanding availability requests, determining which applications and processes are preventing the computer from automatically going into Sleep mode. IT Pros can use **PowerCfg.exe** to override individual availability requests that might prevent the computer from entering a low-power state.

Windows 7 also provides a diagnostics platform that enables IT pros to customize and develop their own set of diagnostics, which can be deployed across their enterprise to help identify a broad range of problems.

Group Policy

Windows 7 supports more granular power management Group Policy settings. IT pros can configure power management settings like Adaptive Display Brightness, Reserve Battery Notification Level, and Allowing Automatic Sleep with Open Network Files. They can also use Group Policy Preferences to choose which settings to enforce and which settings are simply defaults that end-users can change.

Windows Management Instrumentation

IT pros can configure power policy settings by using a new power provider in WMI. WMI is a widely used, industry-standard management interface that enables configuration of power setting values and activate a given power plan. Windows 7 exposes WMI to other management tools, enabling IT pros to write scripts (for example, by using Windows PowerShell™ 2.0, which is built into Windows 7) that query and manage power-management settings on multiple remote computers.

Power Policy

Windows 7 continues to provide the three power plans (Performance, Balanced, and Power Saver) that were available in the Windows Vista operating system. Additionally, Windows 7 provides several power policies that end-users and IT pros can customize based on specific hardware platforms, regulatory requirements, expected usage patterns, and power savings or performance preferences. They can also customize policies for AC (plugged-in) and DC (battery) power usage.

Ecosystem Engagement

Energy efficiency requires focus across hardware, the operating system, and applications. Microsoft is actively engaged with its hardware and software partners to help ensure that their products are optimized for Windows 7. This engagement includes providing tools and guidance to partners for resolving issues more quickly. The result is better-quality products and higher customer satisfaction.

Additionally, Microsoft is using real-life data to implement changes. For example, the company is using telemetry to gather information from customers through the Customer Experience Improvement Program (CEIP) and sharing its findings with partners.

Customer Experience Improvement Program

The CEIP enables users who opt in to the program to send anonymous feedback data to Microsoft. Microsoft uses this data to improve the experience with the Windows operating system and to identify performance and reliability issues on real-world systems.

Historically, this data has focused on performance, reliability, and other fundamental areas. Windows 7 extends CEIP feedback data to other areas, including energy efficiency, by adding instrumentation for power management–related events. Additional events include USB devices that do not enter the state of selective suspend and applications and services that alter the system-timer resolution.

Tools and Documentation

Windows 7 introduces energy efficiency diagnostics in-box to identify common problems affecting battery life on portable computers. For portable computers to take advantage of the enhancements in Windows 7, Microsoft recommends that partners use the energy efficiency diagnostics to ensure that their platforms have no errors.

In addition to built-in tools, Microsoft continues to invest in the Windows Performance Toolkit to help partners optimize their applications, drivers, and platforms for the Windows operating system. The Windows Performance Toolkit enables IT pros to diagnose a broad range of problems, including resource utilization, performance-related issues, and issues affecting battery life.

The tools are available at the [Windows Performance Analysis](http://go.microsoft.com/fwlink/?LinkId=147991) site on MSDN® (<http://go.microsoft.com/fwlink/?LinkId=147991>).

Microsoft also provides guidance to enable partners to deliver client computers that are optimized for Windows 7. The Battery Life and Energy Efficiency Portal provides a central repository for documentation related to new features. In particular [Mobile Battery Life Solutions: A Guide for Mobile Platform Professionals](http://go.microsoft.com/fwlink/?LinkId=147996) (<http://go.microsoft.com/fwlink/?LinkId=147996>) provides recommendations for optimizing battery life.

Active Partner Engagement

Improving energy efficiency and extending the battery life on current mobile platforms requires a concerted effort across the entire Windows ecosystem. Enabling efficiency in the ecosystem of applications, services, and driver extensions is equally important to the new innovations in Windows 7 power management. Microsoft is committed to enabling partner readiness for Windows 7 and ensuring that the platforms are optimized for battery life. Active engagements are ongoing with our independent hardware vendor (IHV), independent software vendor (ISV), and original equipment manufacturer (OEM) partners.

Conclusion

Companies are focused on reducing costs, and a simple way to contribute to those cuts is by reducing energy bills. Windows 7 helps companies reduce the costs of running their computers by enhancing the operating system's power consumption and management features. Microsoft continues to advance power management across the Windows ecosystem and work closely with industry partners to ensure that Windows 7 delivers great power savings for our enterprise customers.

Windows 7 provides several opportunities to decrease power usage across the enterprise. The power management technologies in Windows 7 provide platform and processor efficiencies that reduce power consumption and can help lower energy costs. It also provides a better user experience with longer battery life for specific scenarios. Additionally, Windows 7 provides diagnostic tools that enable IT pros to better manage and troubleshoot power management issues on computers and to extend the battery life for portable computers.

More Information

- The white paper “[Mobile Battery Life Solutions: A Guide for Mobile Platform Professionals](http://go.microsoft.com/fwlink/?LinkId=147996)”
(<http://go.microsoft.com/fwlink/?LinkId=147996>)
- The [Battery Life and Energy Efficiency](http://go.microsoft.com/fwlink/?LinkId=147997) portal
(<http://go.microsoft.com/fwlink/?LinkId=147997>)
- The white paper “[Processor Power Management in Windows Vista and Windows Server 2008](http://go.microsoft.com/fwlink/?LinkId=147999)”
(<http://go.microsoft.com/fwlink/?LinkId=147999>)
- [Windows Performance Toolkit](http://go.microsoft.com/fwlink/?LinkId=147988)
(<http://go.microsoft.com/fwlink/?LinkId=147988>)
- The white paper “[Developing Efficient Background Processes for Windows](http://go.microsoft.com/fwlink/?LinkId=147990)”
(<http://go.microsoft.com/fwlink/?LinkId=147990>)
- The MSDN [Windows Performance Analysis Developer Center](http://go.microsoft.com/fwlink/?LinkId=148000)
(<http://go.microsoft.com/fwlink/?LinkId=148000>)
- [Event Tracing](http://go.microsoft.com/fwlink/?LinkId=148005)
(<http://go.microsoft.com/fwlink/?LinkId=148005>)
- The white paper “[On/Off Transition Performance Analysis of Windows Vista](http://go.microsoft.com/fwlink/?LinkId=148007)”
(<http://go.microsoft.com/fwlink/?LinkId=148007>)
- Windows Springboard page at <http://www.microsoft.com/springboard>.