LBNL-39466
UC-1600

User Guide to Power Management for PCs and Monitors

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January 1997

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology State and Community Programs and the Federal Energy Management Program of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098, and the U.S. Environmental Protection Agency, Atmospheric Pollution Prevention Division.

Abstract

Power management of personal computers (PCs) and monitors has the potential to save significant amounts of electricity as well as deliver other economic and environmental benefits. The Environmental Protection Agency's ENERGY STAR® program has transformed the PC market so that equipment capable of power management is now widely available. However, previous studies have found that many Energy Star compliant computer systems are not accomplishing energy savings. The principal reasons for this are systems not being enabled for power management or a circumstance that prevents power management from operating. This guide is intended to provide information to computer support workers to increase the portion of systems that successfully power manage.

The guide introduces power management concepts and the variety of benefits that power management can bring. It then explains how the parts of a computer system work together to enter and leave power management states. Several common computer system types are addressed, as well as the complications that networks bring to power management. Detailed instructions for checking and configuring several system types are provided, along with "trouble shooting" advice. The guide concludes with a discussion of how to purchase Energy Star compliant systems and future directions for power management of PCs and related equipment.

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Acknowledgments

The authors gratefully appreciate the assistance of Andrew Fanara, Linda Latham, Manjunath Athrey, Anthony Balducci, Paul Benson, Theo Dirksen, Erin Craig, Mike Flora, Judy Gerstenberger, Jeff Harris, Barbara Hill, Jon Koomey, Peter van der Linden, Chris Payne, Brian Pon, and CompUSA of Emeryville in the preparation of this guide. This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy under Contract No. DE-AC03-76SF00098, specifically the Office of Building Technology and Federal Energy Management Program, and the U.S. Environmental Protection Agency, Atmospheric Pollution Prevention Division. LBNL-39466.

Chapter 1: Introduction to Power Management

1.1 Reasons for this guide

Power management technology was developed for personal computers (PCs) and monitors to reduce energy consumption when they are not in active use. In addition to the environmental benefits of reduced energy consumption, power management can improve equipment reliability by reducing waste heat. First developed for laptop computers, power management is now common in desktop PCs. As of early 1996, the EPA estimates that upwards of 70% of all new PCs and nearly 100 % of all PC monitors sold have power management capability[1] .

Power management interacts with every part of the computer—the operating system, software, CPU, monitor, network cards, video cards, peripherals, etc. Because of this there is the potential for unexpected interactions between power management and the computing environment. These problems can reduce the positive environmental impact of power management. Computer manufacturers have addressed this problem by making power management more flexible and more compatible with current PC networks. As the technology has matured, power management has emerged as an effective tool for saving energy.

This guide has been developed to aid computer professionals in enabling power management, to help to achieve maximum energy savings with a minimum of problems. The scope of the guide is primarily personal computers and monitors, though one type of computer workstation is also included. This guide is divided into four major chapters; chapters 1 and 2 provide an introduction and background to power management, and chapters 4 and 5 are designed to help computer support personnel implement energy-efficient practices in the office[2].

Power management can only save energy if it is enabled and working properly. Unfortunately, a general lack of information about power management has meant that many computers with power management capability are *not* saving energy—because they were never enabled, because they were actively disabled, or because of interference from the various elements of the computer system or network[3]. To overcome these problems, computer professionals must become better informed about power management. This guide was developed to explain:

- the benefits of power management
- the fundamentals of how power management works
- integrating power-managed computers into a network environment
- avoiding negative interactions between power management and computer systems
- educating computer users about office energy use

1.2 How to use this guide

The chapters need not be read in order, but doing so will lead to the most complete understanding of power management.

- Chapter 2 introduces power management, its benefits to users, and the Environmental Protection Agency's (EPA) ENERGY STAR® program.

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[1]Personal communication, Andrew Fanara, EPA, April 1996.

[2]In this guide we generally use "PC" to refer to the processor and related hardware (that is, excluding external disks, printers, etc.), and not including the monitor. Most desktop monitors are cathode ray tubes; laptop (and occasional other) systems use liquid crystal displays (LCDs). Sometimes "PC" refers to the entire system, but it should be clear from the context when this is meant. “Networks” are typically Local Area Networks (LANs). “Computer” power management includes PCs and monitors, as well as workstations, some of which are now capable of power management. See the Glossary (Appendix A) for further information.

[3]As of early 1996, the EPA estimates that only 10 % of PCs are enabled and functioning for power management; low success rates have been confirmed by Nordman et al. and Norford et al.; see Chapter 8 for complete citations.

- Chapter 3 provides an in-depth explanation of how computer power management works, addressing the relationship among the PC, the monitor, the BIOS, software, etc. While is not necessary to have read Chapter 3 to understand Chapters 4 and 5, it is helpful to be familiar with the basics of power management so readers are encouraged to review it.
- Chapter 4 covers optimum use of power management, enabling computers and monitors for power management, educating computer users, and also provides solutions for potential problems with power management. Details for specific systems are in Appendix D.
- Chapter 5 provides guidelines for purchasing power-managed computers and monitors.
- Chapter 6 discusses possible future directions for PC power management.
- Chapter 7 provides references and resources for further information about power management.

Finally, the appendices provide background and reference material about power management.

1.3 National benefits of power management

Without power management, U.S. businesses could spend $1.75 billion on energy to power PCs and monitors by the year 2000[4]. Ironically, much of this energy would be wasted: research shows that most of the time personal computers are on they are not actively in use[5]—and an estimated 20 % are left running at night and on weekends[6]. A typical PC is actively used 4 hours each work day and idle for another 5.5 hours. The energy saving potential from reducing PC power consumption is enormous, from turning off those that don't need to be on, and from power managing PCs when they are on, but idle. Approximately 13 million PCs are sold each year[7], with most going to offices. Approximately 90% of those in offices are connected to networks[8].

Since the monitor usually consumes at least twice as much electricity as the CPU, turning off monitors is a big step in achieving significant energy savings. If just an additional 10 % of monitors in the U.S. were shut off at night and on weekends, about $140 million of electricity could be saved each year (about 1.7 billion kWh; see Appendix E for assumptions).

First appearing in the laptop computer market, power management rapidly expanded into desktop PCs after 1993, and continues to evolve rapidly. However, despite the success in the manufacture and marketing of PCs and monitors capable of power management, studies show that most systems are not enabled, or are enabled but not operating to save energy. The primary reason for this guide is to realize the latent energy and dollar savings of these machines. The guide addresses power management in the installed base of desktop computers, as well as in new PCs and monitors, and one type of workstation. Power management has only recently been incorporated into high-end workstations, but in the future we should expect the technology to be built-in to more workstations and some servers.

ENERGY STAR Computers and Potential Savings

The Environmental Protection Agency's voluntary ENERGY STAR program was originally developed to promote the use of power management technology in computer equipment. The EPA forms partnerships with manufacturers to identify equipment that consumes less than 30 watts of power in low-power mode (30 W for the computer and 30 W for the monitor). Such computers earn the right to bear the EPA's ENERGY STAR logo, though the EPA does not endorse any specific products or services. The EPA publishes a list of ENERGY STAR equipment, which is updated monthly. A sample of the resource listings is in Appendix B, along with information on how to interpret the product tables. The full, current listings are available on the ENERGY STAR web pages at

[4] Energy savings from Koomey et al., 1995. Assumes 8 cents/kWh for the price of electricity.
[5] Tiller and Newsham, 1993.
[6] Nordman et al., 1995.
[7] Koomey et al., 1995.
[8] Andrew Fanara, personal communication, September, 1996.

http://www.epa.gov/energystar.html. As the PC industry evolves at a rapid pace, check the EPA web pages regularly for new products and information.

By the year 2000, ENERGY STAR computers and monitors are expected to collectively save 330 million dollars worth of electricity per year—several billion kWh—with the potential savings even higher[9]. Appendix B summarizes the current provisions of the ENERGY STAR Office Equipment Program.

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[9]Energy consumption from Koomey et al., 1995. Assumes 8 cents/kWh for electricity.

Chapter 2: What is Power Management?

2.1 What is Power Management?

Power-management does not reduce the performance of a computer, but simply adds features to reduce their power consumption when not in use. These energy-efficient machines save money on electricity bills and reduce pollution from power plants. Most power management savings come from reducing power when the machine is not fully active by adding low-power or “sleep” modes that kick in when idle. “Sleep” modes usually involve slowing the clock rate of the central processing unit (CPU), and may include spinning down the hard disk. While it is possible to reduce energy use in PCs while they are active, the ENERGY STAR® program and this technical guide are concerned with power management during idle periods.

Power management in monitors is accomplished during times of system inactivity (usually defined by mouse or keyboard activity) by dimming or blanking the monitor and reducing or eliminating the beam control power. Because some of the electronics are kept warm in the low power mode, monitor recovery is faster than from a full power-off mode.

2.2 How the User Benefits from Power-Managed Computers

Power-managed computers are available at no additional cost, and a single power-managed computer and monitor may save anywhere from $5 to $50 per year in electricity bills, depending on how many hours per day the computer is left on and on how much of the time the computer is in active use. The amount of electricity savings from power management is highly dependent on user operating patterns—if the computer and monitor are often left on at night and on weekends, savings will be toward the higher end of this range. For a typical office environment with 100 computers, using power-managed PCs and monitors instead of non-efficient equipment could save $2,200 per year.

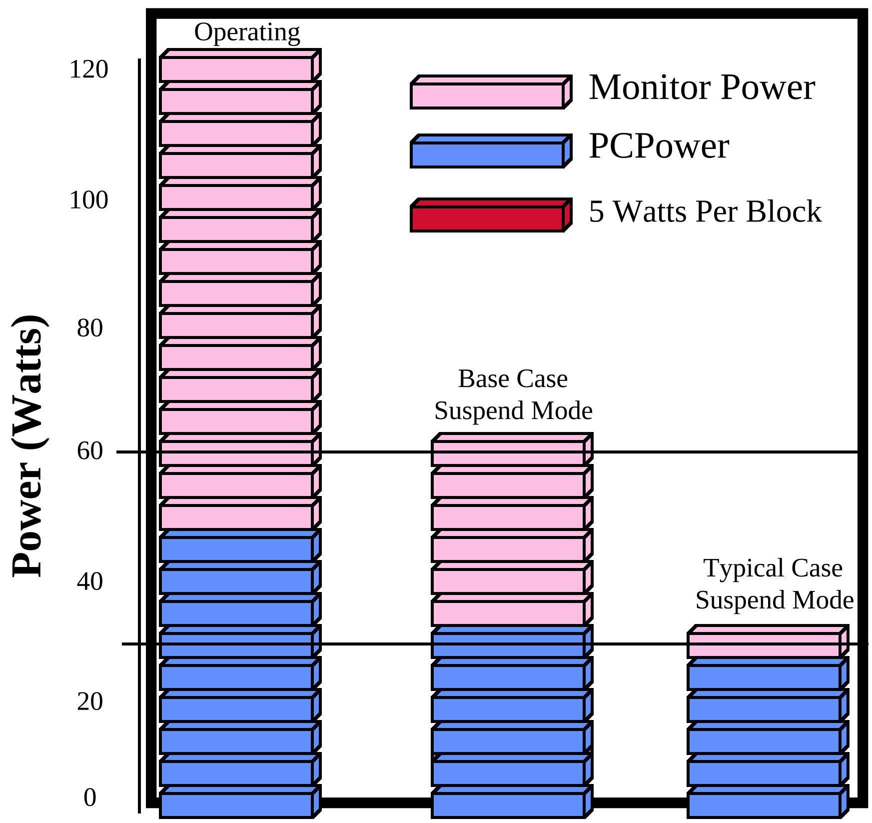
Figure 2.1 shows the total power used by an active computer (PC and monitor; typically about 120 W), one that just meets the ENERGY STAR standard (30 W each for the PC and monitor), and a “best case” scenario for a desktop PC. Some manufacturers have gone well beyond the ENERGY STAR level, however, so that it is easy to purchase a PC and monitor that together use only 30 W in low-power modes (with most of the extra savings from the monitor). Laptop PCs can power down to much lower levels than desktop PCs, but in the future we may see desktop PCs with energy performance comparable to laptops.

Table 2.1 shows a typical PC operating pattern, derived from observations of PCs in actual use[10]. The typical scenario has 9.5 hours of on-time per day—four hours of active use and 5.5 hours of idle time (low-power for power-managing PCs). The user is away one weekday each week (for vacations, travel, etc.), with 20% of machines left on during these days and weekends. A typical year has about 880 hours of active time, another 2280 hours of low-power time, with the remaining time off (see Appendix E for a more detailed summary). Power management savings are a function of the low-power time percentage and the difference between the electricity use at full-on and low-power modes for the particular PC or monitor. A machine on continuously, but power-managed, would save about three times as much as the scenario below shows.

Table 2.1: Typical PC Usage Pattern

	Percent of time in each mode				Hours per day in each mode			
	Active (Full-on)	**Idle** (Low)	**Off**	**Total**	**Active** (Full-on)	**Idle** (Low)	**Off**	**Total**
Workday	17%	35%	48%	100%	4	8.4	11.6	24.0
All Days	10%	26%	65%	100%	2.3	6.9	14.9	24.0

[10]Nordman et al., 1995; see Chapter 8 for complete citations.



Power Consumption at Active Versus Suspend

Figure 2.1: PC and Monitor power use in suspend mode for different computers.

The following formula shows how to calculate the electricity savings for a PC or monitor, with a sample calculation for a typical system.

Annual Electricity Savings = *Hours-in-year* x *Low-time-%* x *(Active-power – Low-Power)*
for example, = 8760 hours/year x 26% x (165 W – 30 W)
= 307 kWh/year

Table 2.2 shows the energy and dollar implications of power managing several typical PC and monitor types, according to the typical scenario above. As can be seen, power management of monitors has higher energy savings potential than it does for PCs alone. There is a considerable amount of variation in energy use in PCs and monitors, so while these values illustrate typical use, yours may differ. Note that PCs and monitors vary considerably in both their active and low-power energy consumption, which, in addition to the operating pattern, greatly influences the energy use and savings you can expect.

In addition to direct electricity savings, power-managed computers generate less heat, and since most offices have to cool the air more than they heat it, for every four kWh of energy saved by the computer, an additional kWh is saved in the cooling and ventilation system[11]. The reduction in waste heat can also increase comfort levels in the office building, and the reduced electricity use can reduce the risk of building wiring overloads.

[11]Cramer, 1995; the cooling savings are net of any extra heating required in the winter.

Power-managed equipment also may actually last longer than conventional products. Because most such equipment will spend a large portion of time in a low-power sleep mode, mechanical wear on disk drives and heat stress on other components can be reduced. Other potential benefits from using power-managed office equipment include reduced electromagnetic field emissions from monitors (because there is less radiation in low-power modes) and reduced noise (since some ENERGY STAR computers have no fans or can turn them off, and hard drives are silent when not spinning).

Table 2.2: Power, Annual Energy Use and Dollar Costs of PCs and Monitors

		Power *(W)*		**Annual Use**	
	PM Status	**Active**	**Idle**	*(kWh)*	*($)*
Computers					
386	without PM	65	65	217	17
	with PM	65	25	117	9
	Savings		*40*	*100*	*8*
Pentium®	without PM	45	45	150	12
	with PM	45	25	100	8
	Savings		*20*	*50*	*4*
Laptop	without PM	15	15	50	4
	with PM	15	3	20	2
	Savings		*12*	*30*	*2*
Monitors					
15”	without PM	75	75	250	20
	with PM	75	5	75	6
	Savings		*70*	*175*	*14*
20”	without PM	120	120	401	32
	with PM	120	5	112	9
	Savings		*115*	*289*	*23*

Notes: These reflect standard operation as defined in [Nordman, et al.] of 9.5 hours/day of operation including 5.5 hours/day of idle time and one weekday each week of non-use. Electricity rate is national average of 8 cents/kWh.

Chapter 3: How Does Power Management Work?

3.1 Introduction

To get the most out of power managing your personal computers, it is helpful to understand the technology underlying power management. This chapter has seven sections. Section 3.2 identifies the parts of a computer system involved in power management, how they function together to reduce energy use, and defines power management modes. Section 3.3 describes power management in PCs, for both x86 processor-based systems and Apple Macintosh® systems. Section 3.4 reviews the implications of networks for PCs. Section 3.5 addresses power management in monitors. Section 3.6 describes power management in workstations. Section 3.7 describes aftermarket devices for PCs and monitors that lack power management features, and Section 3.8 outlines some existing barriers to power management.

Power management in personal computers relies on the fact that for most of the time a typical PC is on, it is not doing anything productive. As long as the computer is idle, energy use can be reduced without interfering with work. Common methods used to reduce energy use are slowing down or stopping the processor clock, spinning down the hard disk, and turning off entire system components such as video or sound cards or disk controllers. Monitors can be power-managed by dimming or blanking the monitor, or by turning off the main beam and possibly also the control electronics.

PC power management was first introduced in laptop computers to allow longer operating times while running on battery power; later, it was brought into the desktop PC market. Many early power management systems had long recovery times, awkward configuration methods, and low energy savings. However, power management has improved rapidly, becoming more powerful, reliable, and easier to use; it also now delivers considerably more energy savings. In 1993, Intel and Microsoft introduced Advanced Power Management (APM[12]), which is becoming an industry standard. The APM protocol supports power management by defining how power management commands are communicated within the PC system.

3.2 Power Management Modes and System

As Figure 3.1 shows, computers are logically organized as a hierarchy of layers. Those at the top are the software that the user directly interacts with; those closer to the bottom direct the physical control of electrical signals. Power management *can* involve the application software and the operating system (sometimes these are not involved), and *always* requires action by the firmware (BIOS), processor and peripheral hardware.

The BIOS (Basic Input/Output System) is a combination of hardware and firmware (software in read-only memory), distinct from the operating system, that intermediates between the processor and other parts of the system[13]. In the first generation of power management (machines built through 1993 or 1994), it was controlled solely by the BIOS. As of 1996, the BIOS is still a key component, but more of the configuration and control is rising into the operating system and occasionally into application software. However, control signals must still pass through each intermediate layer for action to occur.

Accomplishing power management has four components. The first is to monitor activity levels of the processor, input devices (such as the keyboard and mouse), and communication peripherals (network or modem). The second component is to utilize timers to decide when to initiate the shift to a lower power mode. Third, changes in power management status need to be communicated to the correct device and actually occur. Finally, power management needs to recognize when activity resumes and return to a higher power (or full-power) mode.

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[12]Intel & Microsoft, 1993; see Chapter 8 for complete citations.

[13]To simplify the discussion, we treat the core chipset as if it were part of the BIOS, though in fact they are distinct.

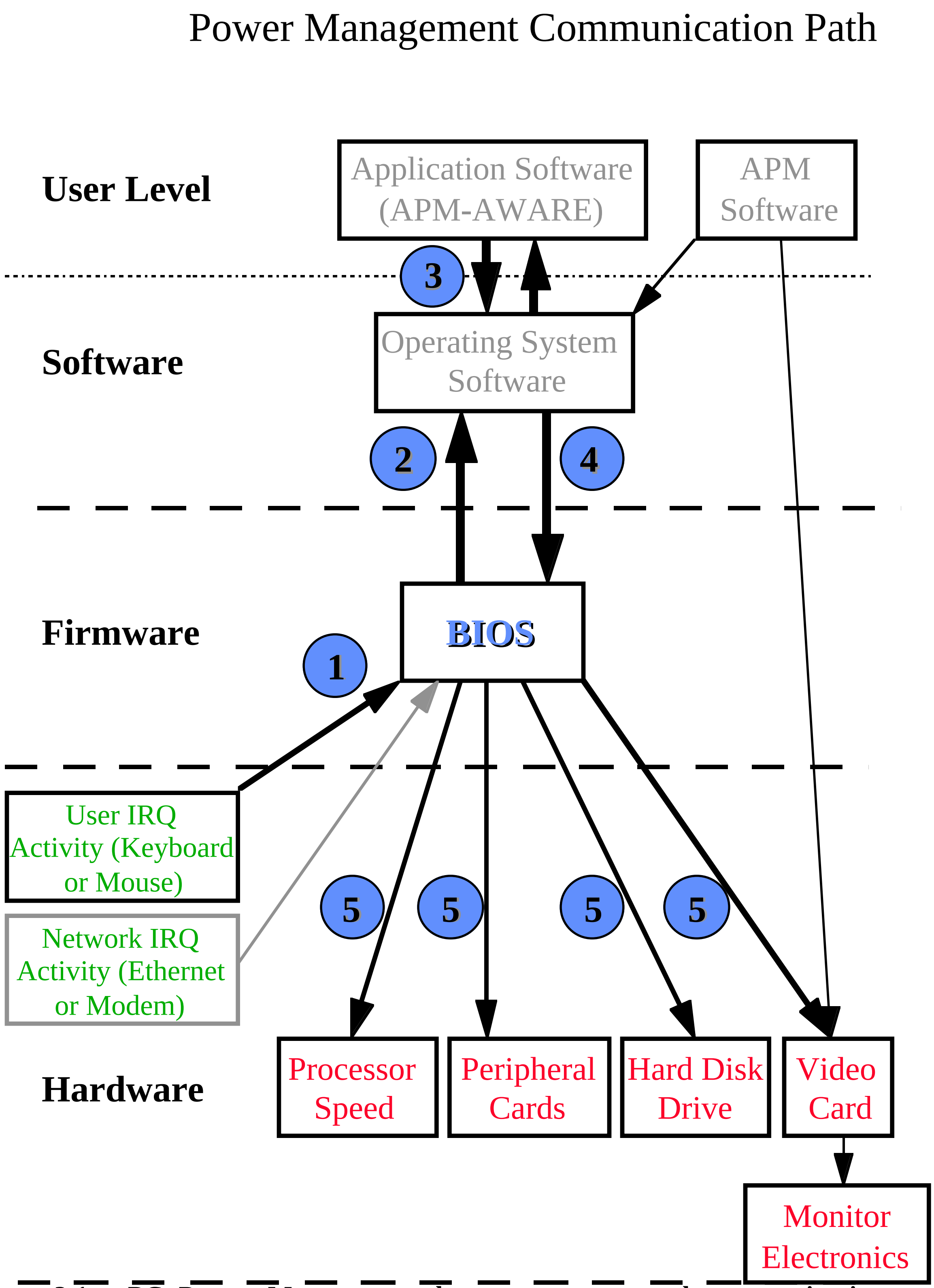

Figure 3.1: PC Power Management key components and communication paths. The numbers indicate the various steps in initiating power management, as described in the main text.

Figure 3.1 shows the communication paths which allow power management to occur. The BIOS send periodic signals (about once per second) to the operating system to begin power management (see number 2). If this signal is passed through by the operating system, it will trigger the start of the power management timers in the BIOS. The operating system will only pass the signal through if it detects no activity from the application software (number 3). If there is no activity, the operating passes the signal back to the BIOS (number 4), which begins a timer. The BIOS continues to monitor keyboard and mouse activity (number 1). After a specified time with no activity, the BIOS will initiate power management by sending appropriate messages to some or all of the hard disk, peripheral cards, processor, and video card (number 5). After initiating a change in mode, the BIOS begins another timer which indicates when to initiate the next power management mode. If at any time the BIOS receives an interrupt request (keyboard, mouse, or network activity), the BIOS will signal the required peripheral cards, processor, and video card to return to an active mode (usually only a demand for hard disk activity will cause the hard disk to spin up). Examples of peripheral cards include network interfaces and CD-ROM drives.

System Modes

The ability to enter and leave low-power modes is the key to active PC power management. The following discussion is of power management as defined by APM. Earlier implementations (circa 1993) were similar, but often had fewer modes.

A computer without power management has two power modes, *on* and *off*. When a power-managed computer is on, it can be in one of several (usually four) modes. When the computer is active and at full power, this is the *full-on* mode. After a period of inactivity, the computer can enter *doze*, the first of three reduced-power modes. In the *doze* mode, the system does not operate, but is capable of responding to activity with no delay. *Doze* is not defined by APM, but often added to systems that use APM. With no intervening activity, the computer will enter *standby* and finally *suspend* modes after specified delays. Each successive power management mode represents a lower level of CPU function. With lower power management modes, less energy is used, but more time is required to bring the computer back to full activity. Some PCs reach the 30 *W* ENERGY STAR® program standard in standby mode, while others need the further savings from the suspend mode (typically about 5 *W*) to comply.

Not all BIOS systems have the same number of power management modes, and even when they do, the same mode may not represent the same level of activity. Table 3.1 shows power management modes for a typical BIOS system. Note that some kinds of activity, such as responding to a network query, may not require the entire system to wake up, so that a system may only shift from standby to doze rather than to full-on.

The timing of the power management modes is determined by settings (usually in BIOS) specifying the delay between each power management mode and the next. Most components are controlled by a single timer. Devices like the hard disk may have an independent timer since they only need to become active for hard disk access. Figure 3.2 shows how the power level changes over time in response to system activity or inactivity.

The fact that some PCs can shift from standby to doze (rather than to full-on) shows the sophistication of APM. Some actions, such as many responses to network activity, do not need all parts of the computer (e.g., not the video card nor the monitor) to be accomplished. Thus, some PCs can move from standby to doze then back to standby to maximize energy savings.

3.3 PC Power Management

Before the release of Windows 95®, Microsoft operating system software was only minimally involved in desktop PC power management (and application software was only used for monitor power management, not for controlling the PC itself). Thus the BIOS was, and remains, a critical component. Three companies dominate the production of BIOS systems used in x86-based PCs. This means that computers from different manufacturers may use the same power management

Table 3.1: PC Power Management Modes

This table applies to Advanced Power Management (APM), and *not* necessarily to early (1993 and earlier) implementations of power management. To enter APM modes, they must be enabled, and the specified amount of time must pass without activity. Note that hibernate is not an APM mode.

<u>Full-on Mode:</u>
- All components fully powered; no power management occurring.

<u>APM Enable Mode:</u>
- CPU is slowed or stopped (depending on BIOS); all other devices still draw full power.
- Some systems have a 'doze' mode that is similar to APM Enabled.

PC Savings: 0-25% *Recovery time:* instantaneous

<u>APM Standby Mode:</u>
- CPU may be stopped depending on operation or activity; most devices are in low power mode.
- Monitor enters its first power management mode.
- Activity can trigger a return to enabled or full-on, depending on the system and activity.

PC Savings: 20-30%
Monitor Savings: 60-90%

<u>APM Suspend Mode:</u>
- CPU is stopped; most power-managed devices are not powered (network card may stay on).
- Maximum power savings under APM.
- Activity can trigger a return to standby, doze or full-on, depending on the BIOS

PC Savings: 25-45%
Monitor Savings: 0-10% *Recovery time:* 3 to 10 seconds

<u>Hard Disk Power Down :</u> *(this is not an APM mode)*
- Hard disk spin in stopped; this is independent of other power management (hence not a system mode), so that the remainder of the system can be fully operational or power down.
- Disk control electronics are still powered to facilitate quick reactivation

PC Savings: 10% *Recovery time:* 3–10 seconds (disk savings independent of other savings)

<u>Hibernate:</u> *(this is not an APM mode)*
All memory contents and system state saved to disk.
System resistant to power loss
PC Savings: 90-100% *Recovery Time:* 15-60 seconds
Workstation Savings: 95% *Recovery Time:* <60 seconds (usually)

<u>Off Mode</u>
- No operational parameters are saved
- System resets and starts at full-on mode
- Most systems use no power (a few draw a small amount).

technology. However, over time, each BIOS manufacturer has produced several versions of BIOS software that operate in different ways. With the introduction of APM, power management is becoming more standard across PCs, which should make power managing them easier and more reliable.

The key to a properly configured power management setup is ensuring that the system properly determines what signals to respond to, and what delay times to use before changing modes. The rest of this section addresses general principles of power management configuration.

While power management systems differ in many details, the configuration mechanisms follow some common patterns. The BIOS on most PCs can only be configured at system start-up (bootup). As power management moves into the operating system, some of the configuration can happen there, usually through a control panel.

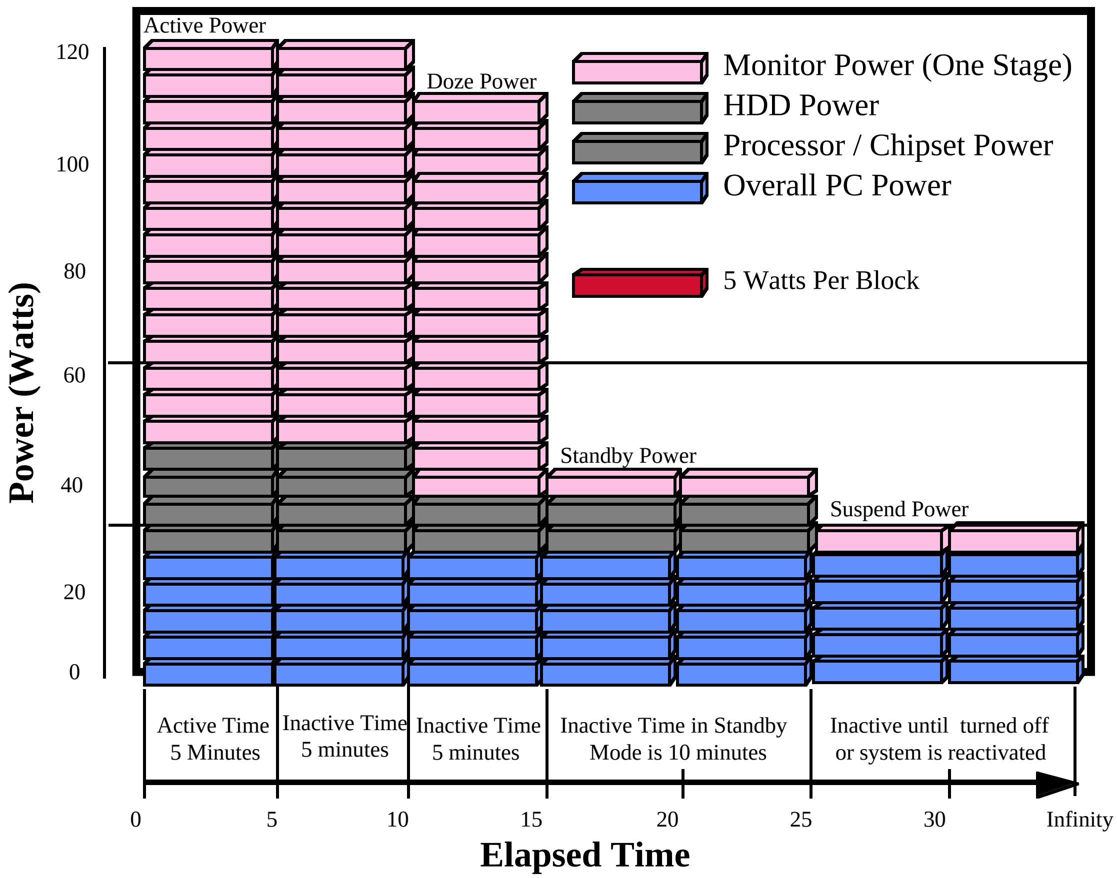

Figure 3.2: Power consumption over time in several power management modes.

For most systems, there is one main "switch" (in the firmware) that, when turned off, disables all power management; on some machines this is called the "green switch" or "green feature". However, turning the main switch on will not necessarily enable all power management features. The subsidiary switches, timers, and other settings must also be set properly. Other switches may enable specific power management modes (e.g., suspend) or specific devices (e.g., the hard disk or monitor). They may also set variables such as the amount of processor speed reduction or the monitor power management method.

The power management timers allow the power management sequence to occur in a sensible manner, compatible with the ways that system is used. Steps which have minimal impact on system operation (those with quick recovery, such as slowing the processor clock speed), can reasonably be set to operate with small delay times, such as 20 seconds or a minute. Modes with a longer recovery time should have longer delay times. The hard disk timer and reactivation controls usually respond only to actual access to the disk, and can operate even when other activity keeps the rest of the system fully operational. Appropriate disk timer settings depend on how long the disk takes to "spin up." For example, if a disk takes 3 to 5 seconds to recover, a 15 to 20 minute delay may make sense; for disks with a shorter recovery time a shorter delay can be considered.

The number and character of the timers varies considerably among machines. On some, each time delay can be adjusted to a specific minute value (e.g., "2 minutes", or "5 minutes"), while on others they are reduced to terms such as “low”, “medium”, and “high” which imply particular pre-set delay times (e.g., 5 minutes, 10 minutes, and 20 minutes respectively). When specific times can be set, they usually operate in series, with a timer starting each time the computer changes mode. For example, a system with timers set at 5, 10, and 15 minutes would “go off” after 5, 15, and 30 minutes of no activity. In some versions of power management, timers operate in parallel (all timers count from the last activity). In this example, timers in parallel would expire at 5, 10, and 15 minutes after the last activity. Whether the system timers run in series or in parallel should be checked during configuration. The audit discussion in Appendix G has more details.

Some BIOS systems allow the user to specify how much to slow down the CPU in the doze and standby modes (e.g., to one eighth of the normal speed).

While entering low-power modes is controlled by timers, the return to full power (or higher-power modes) is directly triggered by activity from the keyboard, mouse, modem, or network. Such activities generate interrupt requests, or IRQs, which signal the processor that it needs to respond to them. Even when a PC has powered down (but is not off), the BIOS still monitors IRQ activity.

Some peripherals are connected to the PC through SCSI (Small Computer Serial Interface) ports. External SCSI devices have their own power sources, unlike the internal hard disk in a typical PC (which usually uses an IDE—Integrated Drive Electronics—interface). Turning the power switch off is always a good power management strategy, particularly for devices such as scanners that are only used occasionally.

A few PC models have a ‘hibernate’ mode in which the entire system state (including all memory contents) is written to memory and the system halts. All power can then be removed from the system, as coming out of hibernation involves beginning a reboot of the system, but reloading the system state from that saved to disk rather than following the default restart path. This type of power management saves more energy, and is resistant to power failures, but requires a longer recovery time. Sun workstations utilize hibernation, as described in Section 3.6.

The underlying power management technology in Apple Macintosh® systems is similar to that in x86-based systems. Newer models (some PowerMacs) use a power management software utility that offers user-defined timers for the PC and monitor. The power-management utility is available with the system software, but must be specifically installed and enabled to have any effect. Once installed, the utility can be configured via a Control Panel. Most Quadra and PowerMac models turn themselves completely off as a PC power management strategy rather than entering a sleep mode. Since this entails entirely rebooting the computer on wake-up (losing network connections and perhaps even data), power management is rarely enabled on these computers. Some currently available models do not have this problem, but many that do will be in active use in offices for some time. Monitor power management can be successful on any Macintosh (provided the monitor is capable of it), even if processor power management is not an option or does not work for one reason or another. Internal disks on Apple Macintosh systems are generally SCSI (not IDE) drives.

3.4 PC Power Management with Networks

Networks pose special challenges for power management. Depending on the systems (hardware and software), the network can partially or entirely defeat power management, or may require extra configuration changes for it to function.

As more and more computers are connected in networks, people become more dependent on the ability to access individual machines at any time of day. Not only do individual users want to access their own files, but people are relying more on accessing data on other people’s systems. As software becomes more sophisticated, we become less aware of how many machines may be required to be on and running to accomplish any particular task.

Local area networks (LANs) are generally united by a single communications protocol, and are usually confined to a single site (or portion of a site). Specialized hardware is used to connect LANS to each other and to the Internet at large. Within a LAN, a network may operate "peer-to-peer" (many systems of equal "rank" within the network), "client-server" (with a small number of high-powered machines providing core computation services for a larger number of individual PCs), or "heterogeneous" (with both peer-to-peer and client-server present) (Bachmann and Brüniger, 1996). A client-server model can be operating at the communications protocol level, or be implemented solely in software. The type of network may affect whether power management is possible for a given system, and how it must be configured to successfully do it.

Maintaining network connections during power management was a problem for many earlier systems. Some new systems continue to have problems with this, but many have been tested to work properly under common networking systems, with the results listed in the ENERGY STAR tables. Currently, most power management problems with networked PCs are a result of the way the network operating system works rather than with the PC hardware. You may need to do your own tests with your particular networking environment.

In many networks, a central server will send out periodic "Are you there?" messages to see which computers are still on and connected to the network. For many computers, these messages cause enough activity to keep the PC and monitor awake, defeating power management. If the PC does successfully go to sleep, it may fail to respond to the "Are you there?" message, so that the server (or other computers on the network) assumes the machine is off and terminates network services to it. When the user brings the PC back to full-on operation, the network connection has been lost. This latter problem usually results in power management being disabled, though it may not be necessary to disable all power management on such computers to maintain the network connection. For example, a processor that is operating more slowly in a low-power mode may not react quickly enough to maintain the network connection, so that increasing its doze speed may solve the problem.

Some newer BIOS systems are able to treat network activity differently from other activity, such as from the keyboard. Network activity on these PCs will only power up those parts of the system needed to respond to the network request. For example, the processor may switch from 'stopped' to half of the normal speed, process the task, then return to a stopped mode. The PC is not returned to a full-on mode, and the monitor is not activated.

A growing number of systems are able to successfully power manage and maintain full network services. Some of these have smart network interface cards that respond to the routine messages without bothering the CPU. Others can awaken only partly and briefly to handle the network request before resuming the low-power mode. Others have a chip installed that bypasses operating system operation that would otherwise defeat power management.

3.5 Monitor Power Management

Power management has been more successful in monitors than in PCs, even though the PC must be the initiator. Compared to power managing PCs, monitors are usually simpler, have much more energy savings potential, power manage more reliably, and are less likely to interfere with operation or network connections. Because of this, it is even more important to enable monitors for power management than it is to enable PCs.

Monitor power management is in most cases independent of PC power management in that the monitor can power down even if the PC doesn't, and vice-versa. However, the monitor is still dependent on the PC for power management initiation; this is necessary since the monitor does not directly receive the activity information needed to know when to begin and end power management. Once the first low-power mode is entered, however, the monitor has an internal timer and will shift to succeeding low-power modes even if the PC doesn't send additional signals. While delay times may differ, for the most part, the monitor and PC are driven by the same activity for beginning and ending low-power modes (though network activity is an exception to this).

Some PCs will “dim” the monitor so that the image is present, but not bright enough for use. This results in some energy savings, but the savings are small compared to sleep modes. However, dimming does provide a transition mode to full blanking of the screen as well as having instant reactivation.

Most computer monitors are controlled through Display Power Management Signaling (DPMS[14]) which defines a method for the PC to send power management signals to the monitor. For DPMS to work, both the monitor and (usually) the PC must be designed to use DPMS. Also, the PC must be properly enabled and send the correct signals. DPMS has modes similar to the PC power management modes defined by APM (standby, sleep, etc.), with two reduced power levels. In most cases, both power levels appear the same—a blank screen is displayed—but the lower power level has a longer reactivation time.

The structure of monitor power management control is shown in Figure 3.1. The PC always initiates the process, with the initial timers within the BIOS, or special software that comes with the video card. When the timer indicates that the monitor should be put into sleep mode, the BIOS (or software) signals the video card which in turn sends the appropriate DPMS signal to the monitor. Successive power management modes can be activated by either the PC's timer or the monitor's internal timer.

Some video cards can send out DPMS signals even in PCs that cannot power manage on their own, provided the appropriate software is installed and enabled. In addition, software is available that will allow a non-DPMS video card to send DPMS signals[15]. As the monitor is connected to the video card, not directly to other parts of the processor, it is dependent on the video card to pass through DPMS signals. When reviving the monitor is called for (usually by keyboard or mouse activity) the PC sends the proper DPMS signal, and the video card redisplays the current image.

While most monitors are power-managed with DPMS, there are two other methods available on some systems: blanked screens, and switched monitor outlets. These were particularly useful in early power management applications, but over time may disappear.

A “universal” monitor will begin power management from either a DPMS signal or a blanked screen. Rather than originating with the BIOS, however, a blanked screen (no color at all—entirely black) is usually accomplished by a screensaver or video card control software. “Universal” monitors are so named because they do not require the PC to have DPMS to power manage (although they can also respond to DPMS signals). When a “universal” monitor receives the blanked out video signal, it begins power management. The monitor’s internal timer can then activate subsequent power management modes. The ENERGY STAR list suggests that about 10% of power managing monitor models are universal.

Some PCs have a “convenience” electrical outlet on the back for plugging in the monitor. PCs that can switch off the power to this outlet allow energy savings from monitors that can't power manage on their own. Some of these PCs cannot send DPMS signals, so rely on the switched outlet for monitor power management. In addition, if the monitor is plugged into the PC (whether the outlet is power-managed or not), then the monitor will be switched off when the PC is switched off (otherwise they often remain on, albeit with a blank screen). These outlets are often designed for flat 3-prong plugs and do not accommodate ordinary 2- or 3-prong plugs.

3.6 Power Management in Workstations

Every Sun® desktop workstation offered for sale as of January, 1994 complies with the EPA ENERGY STAR requirements, though larger systems (servers) do not. Power management is similar to that for PCs in that the monitor and other devices (such as hard disks) can be powered down

[14]VESA, 1993.

[15]OptiGreen®, distributed by ViewSonic (originally OptiQuest), is an example of this type of software.

independently, depending on activity. Sun power management differs from that in PCs in that there is only one low-power state for the processor, a hibernation state, and that powering the system down and back up can be accomplished (on some models) by a time clock as well as by system activity (or lack of it). On Sun systems, all power management controls are within a single system utility.

Processor power management is based on an inactivity timer, but also can include times during the day in which processor power management is locked out (such as the user's typical work hours). When a workstation determines that the system has been inactive and ready for power management, all processes are stopped, all devices instructed to power off (if they are capable of it), and the entire system state (including all memory contents) written to a disk before the system is powered off. In the suspend state the system consumes minimal power, and unplugging the system entirely does not affect its ability to later recover to full operation. Note that 'suspend' on Suns is different from the suspend mode defined in APM for PCs.

Monitor power management on Suns is accomplished by DPMS signals as with PCs, though not all Sun monitors are power management capable. Some external devices (e.g. scanner, disks) can power off on signals from the processor; others must be manually turned off after the system reaches suspend and turned back on before the system resumes in order to save energy.

The system can be brought back to active operation by either pressing the 'power' key on the keyboard (which can also be used to power off the system), or (on some models) by a time clock at a pre-set time. The time to full recovery is typically less than one minute.

Aside from saving energy, this form of power management allows the system to be unplugged and moved, protects it from power loss within the building, and is quicker than rebooting the system from scratch after turning it off. There are potential problems with using power management; these are discussed in the section on enabling Sun power management in Appendix D (D.6).

Some IBM RS/6000 systems running OS/2 can power-manage, as can some clones of Sun workstations.

3.7 Aftermarket Devices

For PCs or monitors that lack built-in power management features, "Power Controlling" (or "aftermarket") devices are available that sense activity (usually keyboard or mouse) and cut power to a device when appropriate. Most commonly these are used with monitors, sensing either keyboard/mouse activity, or the presence of a person in front of the screen.

Power controlling devices can substantially reduce the cost of operating computers, monitors, printers, copiers and fax machines by turning off the equipment when it is not being used. These devices are most beneficial in offices where equipment is normally left on continuously or if the equipment has no power reduction functions. The add-on device is connected externally to the PC or monitor and may be controlled by software (which is often installed incorrectly or not at all[16]). These factors, combined with your electricity cost (dollars per kWh), will determine the payback period for power management devices. See the EPA ENERGY STAR listing for control devices for specific model information.

For PCs, some control devices work with software that will save any open documents and include a "book marking" feature to return to the file previously being worked on when the machine is powered back up. Some printer control devices intercept commands sent to the printer and store them until the printer is back up and fully functioning.

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[16] ESource, 1994.

3.8 Potential Barriers To Power Management

Even though a computer or monitor may have power management features, power management may not always operate effectively. There are many reasons why power management can be defeated in systems that have the feature.

Networks

Computer networks pose special challenges for power management. Once a PC is connected to a network, the user may want to access the machine remotely, others may rely on being able to connect to it at any time, and services such as disk backups may operate during nights or weekends. This can mean that the simplest power management strategy, simply turning the machine off, can no longer be used for the PC (though the monitor can and should be turned off). Remote access by modem has the same effect as does a computer set up to receive faxes.

Power management also affects a PC's network response (see Section 3.4). If a machine cannot successfully wake up when warranted by network activity, or if it loses its network connection while power managing, the user will want power management disabled. In some cases these types of network problems cannot be fixed without some change in the network operating system or the PC hardware. These type of network responses should be tested before ordering large numbers of PCs (see Chapter 5 for purchasing guidelines).

Upgrades

Power management capabilities may change when PCs are upgraded by replacing the processor, the motherboard, or add-on cards (e.g., the network interface). Software upgrades of operating systems or utility software can cause power management to be disabled. Before upgrading many similar machines, determine if the proposed change interferes with power management. If it does, consider looking for alternatives that do not.

Software Interactions

Some application software can interfere with power management, depending on how it is configured and the particular machine it is used on. One example is the 'auto-save' feature on many word processors and spreadsheets. If the feature saves the document even if no changes have been made, this will unnecessarily cause the processor and hard disk to stay awake, defeating power management partially or entirely. Some screensavers will periodically load complex images from the hard disk, keeping the disk from powering down. A screensaver can keep the monitor and processor from power managing, unless set to a specific power management mode; many screensavers lack a power management mode and so need to be turned off for power management to occur. If you need to leave your PC on overnight, try to exit any applications with such auto-save features before leaving for the day so that power manage can operate. Operating system software is also key for power management, and can make power management easy, difficult, or, in some cases, impossible.

Section 4.4 provides a troubleshooting guide for dealing with these and other problems.

Chapter 4: What can I do with my existing stock of PCs?

This chapter is intended to help computer support personnel implement energy saving strategies in their offices. This includes both enabling power management and turning off computers at night and on weekends. Section 4.1 presents strategies that work for *all* computers, regardless of power management capability. Section 4.2 focuses on identifying computers with power management capability and enabling power management. Section 4.3 provides an overview of what we recommend for power management settings. Details of how to enable specific systems is presented in Appendix D, which covers x86, Apple, and Suns systems, as well as installing aftermarket devices. Figures 4.1 and 4.2 present decision-making flow charts of the most important questions to ask as you address power management on your PCs and monitors. Finally, Section 4.4 provides troubleshooting insights and suggestions for use when problems occur.

If you are not a computer support person at your company, you should consult them before changing some power management settings. They may have knowledge about your computing environment (and power management in particular) that can alert you to potential pitfalls, or to strategies that make power management work best in your environment.

4.1 Turn off computers at night and on weekends

One of the simplest and most effective ways to save energy is to turn off computers (PCs and monitors) when not needed, especially nights and on weekends. Sometimes computers are left on for legitimate reasons—for automatic backup or remote access, for example. However, many computers that could be shut off are left on by users who either mistakenly believe that shutting off their computer is harmful to the equipment or who simply forget to turn them off.

The belief that frequent shutdowns are harmful persists from the days when hard disks did not automatically park their heads when shut off; frequent on-off cycling could damage such hard disks. Conventional wisdom, however, has not kept pace with the rapid technological change in the computer industry. Modern hard disks are not significantly affected by frequent shut-downs[17]. Shutting down computers at night and on weekends saves significant energy without affecting the performance, and may increase (rather than decrease) the operating lifetime of the equipment.

In cases where the computer is deliberately left on for network services or remote access, the monitor can be safely shut off without interfering with those activities. Since the monitor can consume two or three times as much electricity as the PC, turning off monitors is a big step in achieving significant energy savings.

Misinformation and bad energy habits are major stumbling blocks to achieving these energy savings. Computer users need to be informed about the real effects of shutting down their computers. Appendix B provides some resources for educating computer users about the benefits of shutting off their equipment at night and on weekends.

4.2 Determining Power Management Capability and Enabling Power Management

Specific instructions for checking and enabling power management are presented for many common systems in Appendix D. They explain how to check if your current PCs and monitors are capable of power management, if they are enabled, and how to best configure them for your needs.

[17]ESource, 1994, Koomey et al., 1993, and Sheperd et al., 1990; see Appendix D for complete citations.

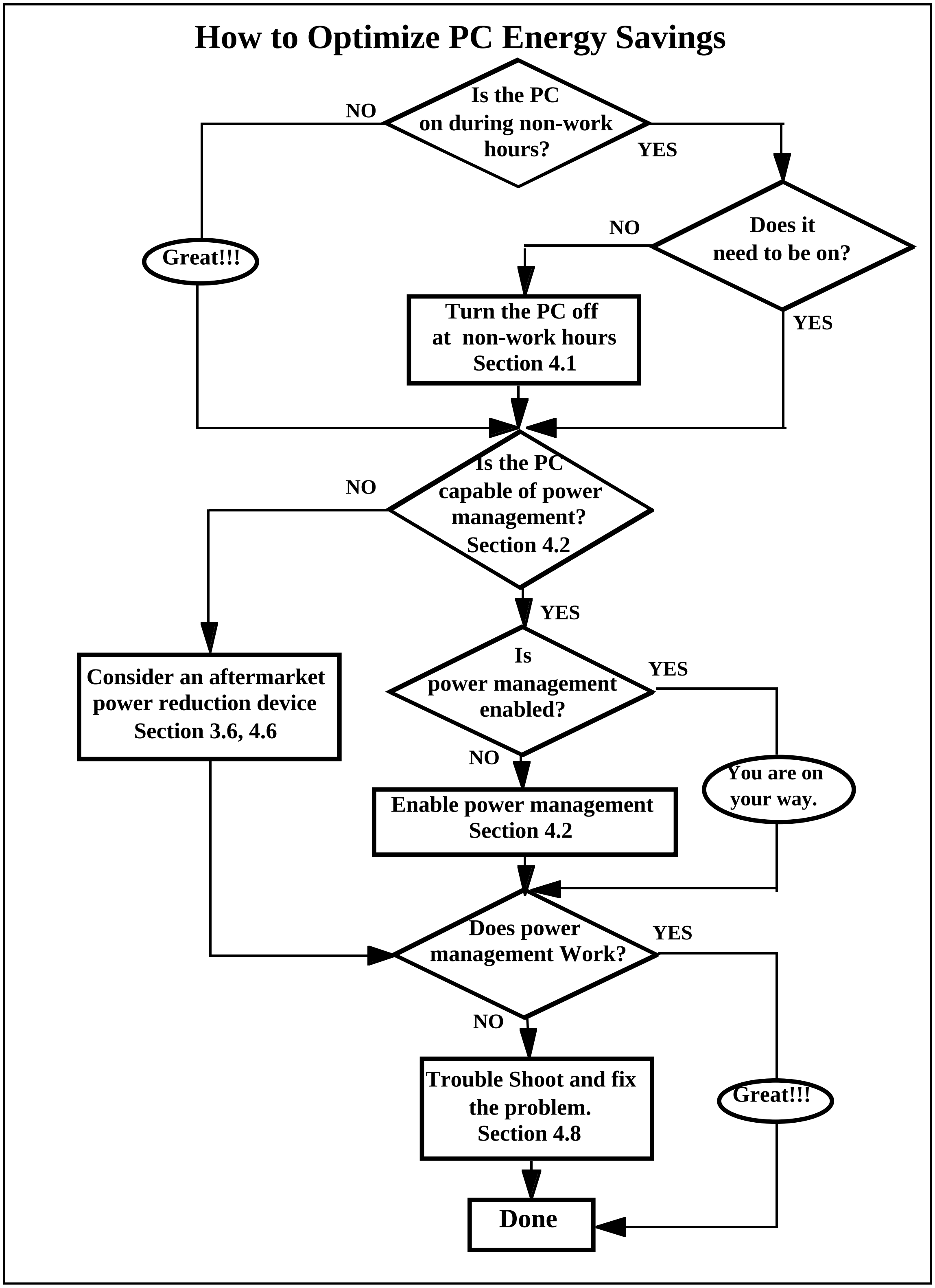

Figure 4.1: PC Power Management Decisions and Actions

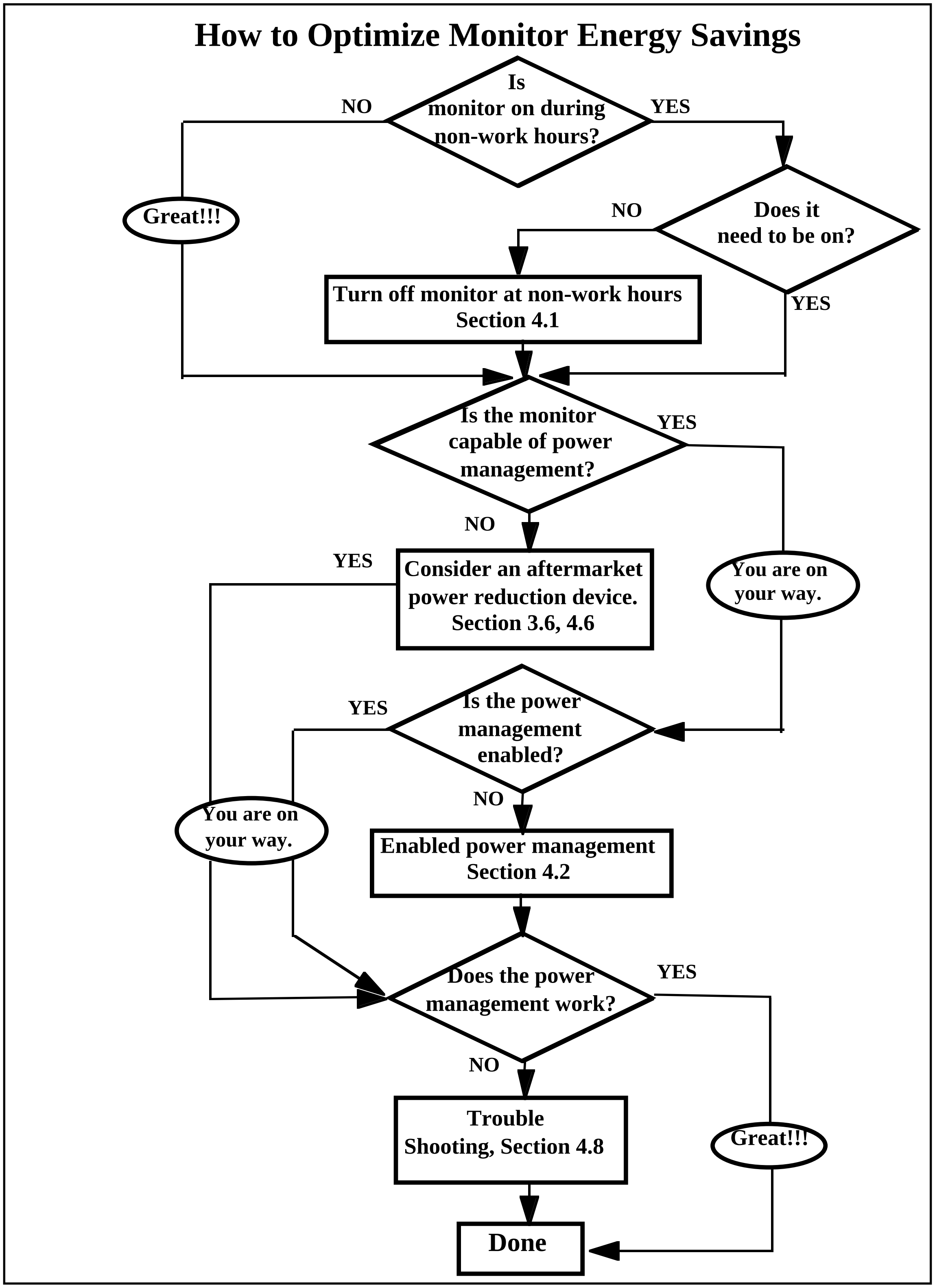

Figure 4.2: Monitor Power Management Decisions and Actions

Before changing the power management configuration on a machine, you may want to record the current power management settings. This will reassure the user that the previous machine mode can always be reconstructed if any changes that are made create problems.

Table 4.1 shows the methods for changing power management configuration that are applicable to each system (hardware and software) type. Find the row which matches the hardware and software for your system to see which sections of Appendix D have applicable instructions. As the table shows, in most cases there are several mechanisms that can be used to enable power management. In most cases, it is only necessary to enable power management through one of them. For example, either the BIOS timer or a screensaver program (accessed through a control panel) can initiate monitor power management on an ENERGY STAR PC. In most cases, it is easier to configure power management through the operating system rather than through BIOS; however, this is not always possible. If power management is enabled through more than one mechanism, the power management signals may be inconsistent or interfere with one another. In some cases it may be necessary to enable power management with several methods, in several places, in order for it to work.

Table 4.1: Power Management Configuration Methods, Appendix Section Key

	Energy Star PC			Energy Star Monitor		
	BIOS	**Operating System**	**Other**	**BIOS**	**Operating System**	**Video**
x86						
MS-DOS®	D.4			D.4		D.2.1
Windows® 3.x	D.4		D.3.1	D.4		D.2.2
Windows 95®	D.4	D.3.2		D.4		D.2.3
Windows NT®	D.4			D.4		D.2.2
OS/2®	D.4	D.3.3		D.4		
Apple Macintosh®						
auto-off only			D.5.1		D.5.2	D.5.2
low-power modes		D.5.1			D.5.2	D.5.2
Sun®						
hibernate/suspend		D.6			D.6	

Notes: See Section D.2.4 for monitor power management on the monitor itself. Windows 3.x is not actually an operating system (it is a graphical user interface), but it is useful to treat it as one. "BIOS" is the Basic Input/Output System. "Other" is additional software that is not an inherent part of the operating system. "Video" includes some video card control programs as well as specific power management software such as OptiGreen® for x86 PCs and CDU® for Apple systems.

To properly check and enable power management, you will want to know the operating system, the BIOS type (for x86 machines), the screensaver software, and any other software used for power management. The operating system used should be immediately apparent. You do not need to know the BIOS type by name, but can match your BIOS to one of several typical systems we describe in Appendix D. Identifying the screensaver, video card control program or other software for monitor power management is discussed in Appendix D.

4.3 Overview

In general, we recommend the delay times for power management shown in Table 4.2, though you may discover that shorter or longer times better suit your own needs (all times consecutive). IRQ settings for keyboard and mouse activity (see Section D.2) should be enabled, so that they can trigger activity and reawaken the system. Unless specific problems arise with particular IRQs, it is best not to tamper with manufacturer default settings.

4.4 Trouble Shooting

In the past, the only solution to many power management related problems was to disable power management entirely. This is no longer the case. Power management is now more flexible and has more options, which allows specific problems to be addressed without disabling all power management features.

Table 4.2: Recommended Delay times for Power Management

Item	Delay time	Comments
Hard disk	10 to 20 minutes	depending on how quickly it spins back up
Processor		
Doze	20 seconds to 1 minute	if applicable
Standby	5 minutes	
Suspend	10 minutes	
Hibernate	2 hours	due to longer recovery time
Monitor		
Dim	5 to 10 minutes	if applicable
Standby	5 to 15 minutes	depending on recovery time and if ‘dim’ mode operating
Suspend	15 minutes	

When making trouble shooting decisions, it is important to weigh the potential energy savings against the costs of a particular power management option (in terms of recovery time and system interference). Both savings and costs depend on how the computer is used, but a few general guidelines should be kept in mind. Power management of monitors typically saves more energy than it does for PCs (unless the monitor is turned off nights and weekends but the PC is left on). Monitor power management is less likely to be defeated by network activity, and is also less likely to cause problems than PC power management. Even if there is some reason why the PC can’t accomplish power management, or power management interferes with use of the PC and has to be disabled, the monitor can usually still be power-managed. People who are particularly fond of their screen art should try to configure the system to display the screensaver for a few minutes, then begin the power management cycle (some screensavers can do this; in other cases the screensaver and BIOS can work together).

Common Problems

I can’t tell if the PC is powering down

Many PC power management functions have no discernible delay in returning to full power, so that it can be difficult to determine if power management is working. To be certain that power management is occurring, it is necessary to actually measure the power the system uses (see Appendix D), which is not a realistic option in most offices. Apart from that, the most obvious feedback of a PC powering down is hearing the hard disk power down and spin back up. Recovery from ‘doze’ modes is nearly instantaneous, and even lower-power modes have very quick recovery times, making it difficult to be sure that PC power management is occurring.

I can’t tell if the monitor is powering down

If the recovery from a blank screen is instantaneous, then the monitor is probably not in a suspend mode (the lowest power state), though it could be in the first power management mode, sleep. Some monitors will “beep” as they revive, and others signal low-power modes with an indicator light on the front of the monitor. Check the manual to see if any such indication happens automatically (or is optional) during low-power modes.

Power management is enabled, but not working

There are many reasons this could be occurring, including:

- The ‘main switch’ for power management is on, but subsidiary switches (e.g., for each low-power mode) are off. Turn these on and see if power management occurs (see Figure 4.1; the switches are generally found in BIOS setup screens).
- The timers are set to such long delays that the power management does work but rarely has the opportunity. Try reducing the delay times.
- The network (or network operating system) is keeping the PC awake. To diagnose the problem, try rebooting the machine with the network cable disconnected, or even with the network card removed to see if this changes power management behavior; also check the network operating system documentation. A different network card may not have this problem, but the replacement cost may be greater than power management savings warrant.
- The operating system may not support power management.
- The PC may have been upgraded in a way that interferes with power management. If it was custom built, rather than a standard model from a manufacturer, parts may not properly work together to accomplish power management. There may be no solution to this problem.
- If the monitor is not entering sleep mode, it may not be capable of power management, or a screensaver may be interfering with power management operation. To help diagnose the problem, try temporarily using a monitor that you know works well with power management, and changing screensavers to the blank screen option.
- Application software is keeping the system awake. For example, some software for controlling CD-ROM drives will poll the drive frequently to see if a disk has been inserted; some printer software routinely polls the printer for its status. Disabling an IRQ may alleviate this, but the system may go to sleep while a CD is playing, or while a long print job is in progress.

Power management is occurring, but only partially or with extremely long delays

The machine may be configured to operate this way for a good reason, such as to avoid network problems or avoid long recovery delays. However, it is also possible that there is no good reason for the settings. Try to determine why the machine was configured how it was, and whether it can be set to more typical settings, such as those recommended in this guide.

The user tells me power management causes her problems

In certain environments power management can cause problems, and it may be necessary to leave power management disabled. However it is important to address specific complaints (e.g., “The hard disk spins down every five minutes and takes forever to spin back up”) rather than general ones (“Power management is causing problems”). It may be possible to fix *specific* problems by changing power management settings. *General* problems may not be the fault of power management at all. Power management is often a convenient scapegoat for system problems, sometimes resulting in power management being unnecessarily disabled.

It is important to keep in mind that users who have had trouble with power management in the past (or have heard stories from others who have had problems) are often distrustful of the technology, even though great improvements have been made. Educating users about power management will make them more comfortable with the technology.

The monitor goes to sleep, then wakes up a few minutes later.

This can be caused by some screensavers. If that is the case, the screensaver can usually be reconfigured to not do this. Avoid screensavers or screensaver options that require hard disk access, and make sure that the screensaver delay time is less than the first monitor power management delay time. Some networks can cause a machine to reawaken after a short period of power management.

See if the machine power manages correctly when not connected to the network, and if so, if the server or network card can be reconfigured.

A calculation which used to take 2 hours now takes all night to finish

This occurs if the PC goes into the doze mode, slowing the processor clock, while the computation is in process. If such calculations are rare, then either doze or power management in general can be disabled while it is in process. If the computer is routinely used in this way, disable doze only so that the rest of power management will occur.

I can't find the power management controls in the BIOS

That machine might not be capable of power management. PCs that appear similar on the outside can be quite different on the inside, so that even if one PC in the office has power management, a similar PC might not. Try calling the manufacturer and provide them with the serial number to help determine if the machine has power management features.

The user has locked the BIOS with a password

Consider changing the power management settings with the user present so that she can be reassured that the changes are acceptable.

The PC (or monitor) won't return to full-on status with keyboard or mouse input

Check the BIOS settings. The interrupt requests for the keyboard or mouse may not be enabled (these are typically IRQ1 and IRQ12 respectively).

The PC loses its network connection in low power modes or fails to respond to network activity

Power management may be slowing CPU activity too much for it to respond to network activity. Some versions of BIOS have options to specify how much to reduce the processor speed in doze or standby. Try reducing the speed reduction value; this speeds up the processor (when in the low-power mode) and increases its ability to respond to network activity. If the problems persist, or if changing the speed is not an option, try disabling the doze or standby option.

My screensaver is password protected. Every time I want to reactivate the monitor, the hard disk has to spin back up.

If password protection cannot be disabled for security reasons, try increasing the delay time for hard disk spin down (to 15 minutes or more) in order to reduce the occurrence of the problem. If this is still unacceptable to the user, it may be necessary to disable the hard disk spin-down. The energy savings potential for the monitor are greater than from the hard disk, so keeping power management enabled for the monitor should be the priority.

Power Management works in Windows, but not in MS-DOS.

DOS can override the BIOS. Try routinely turning the machine off *or* remaining in Windows.

My computer must be on all night because the disk is backed up over the network in the middle of the night

One response to this situation is to move the back-up time to during the work day. Another is simply turn off the computer when not many files have been changed that day. A third response (on machines capable of it) is to have the system completely power down at a time at which the backup will have finished.

My computer takes too long to recover from power management

Consider increasing the delay times for the power management modes that are causing the problem. The hard disk recovery time is often a source of user complaints about excessive recovery time. If an auto-save feature is spinning up the hard disk while the person is typing, consider turning off that feature. Try increasing the delay time for the hard disk while keeping them as-is for the processor and monitor. Even if some power management methods must be disabled for the user, don't turn off all features—keep active the power management features that are not interfering with work.

My computer shuts off entirely when power management is enabled. Rebooting the system is time consuming, and I have lost data when the system has shut down.

A few models of PCs (most notably early Apple PowerMacs) shut off entirely rather than go to sleep. Few users find this acceptable, so be cautious about enabling this form of power management.

Chapter 5: How do I buy new ENERGY STAR® computers?

For PCs and monitors to successfully power manage, the hardware and software must support the technology (primarily by being ENERGY STAR compliant). Having compliant systems is the result of a responsive purchasing system. This chapter provides guidelines for purchasing power-managed computers and monitors.

When procuring new computer equipment, simple steps can be taken to ensure that it has power management features and that they work properly in your computing environment. The first step is to check if the models under consideration are on the EPA ENERGY STAR lists (see Appendix B for the web address and phone numbers). This usually will tell you if the models are ENERGY STAR compliant, though some compliant models may not be on the list (possibly because they are relatively new), and a few PC models have power management capable and non-capable variants under the same model name. Thus, you will want to confirm the results with the manufacturer.

Be sure to specify ENERGY STAR compliance on the purchase order. If you will be purchasing many PCs of a similar type, consider borrowing or purchasing one and testing it in your computing environment, with typical applications, network connections, etc., to insure that it power manages properly. Since the performance of power management varies depending on the configuration and the computing environment, field testing is really the only way to guarantee performance. Some PCs are put together by private assemblers; they may require extra attention to insure that power managing equipment is procured.

Generic Issues (PCs and Monitors)

You should ask for documentation of the following:

- *ENERGY STAR compliance.* Make sure that the devices comply with the EPA ENERGY STAR program and not just a vague promise of (or label attesting to) "greenness".
- *Description of power management features.* This should include the role of power management, power modes, and energy consumption data.
- *Instructions for operation of power management.* This should include user instructions on how to configure power management through the operating system and the BIOS (Basic Input/Output System), as well as what settings are appropriate for typical offices.
- *Known equipment interactions.* The manufacturer should provide a list of any known problems or most asked questions and their answers.
- *Low default time settings.* The delay times set in the PC and monitor (as shipped) should be low, but not unreasonably so (for example, ten minutes between mode changes; see Section 4.3 for recommended times).
- *Low low-power use:* Look for PCs and monitors with low-power energy use levels that significantly exceed the 30W ENERGY STAR standard. Many monitors, in particular, can power down to 5 W or less.
- *Availability of on-line help.* The availability of documentation resources on-line is becoming an increasingly important and useful way to find up-to-date and detailed information about your equipment.
- *Feedback.* Look for front panel lights that indicate when power management is occurring.

Monitors

ENERGY STAR monitors must power down to 30 watts or less in sleep mode, however many new monitors can go much lower, such as to 5 watts or less in suspend mode. The ENERGY STAR list reports the sleep mode power consumption. An additional feature helpful to power management is the presence of on-screen controls. Power management time ranges should be adjustable. Inquire about how easy it is to adjust settings and what the defaults are. Check to see if monitors are DPMS or universal in signaling of power management. Universal monitors are preferred since they respond to both DPMS signals and blanked screen (from a screensaver, for example).

Other considerations in purchasing monitors include the location of the power switch. Research has shown that monitors are more likely to be switched off at night and on weekend when the power switch is located at the front of the device. Some monitors also provide an indicator light showing when the monitor is on but in low power mode. This feedback can improve the success of power management. Some monitors also have a suspend switch on the front, to enable the user to more easily put the machine in suspend mode manually.

The Swedish NUTEK[18] specification for monitor power-down has more rigorous energy criteria than does the ENERGY STAR program, and also includes standards for radiation and other health and environmental factors. The standby level is 15 W, with a 3 second maximum recovery time, though standby is not required if the monitor uses less than 30 W when active. A lower power mode of 8 W is required after at most 70 minutes of inactivity. There is currently no separate NUTEK standard for the PC itself.

PCs

As shipped from the manufacturer, ENERGY STAR PCs must be capable of powering down below 30 W while idle, as shown on the ENERGY STAR list (though systems with an integral PC and monitor must power down to 60 W or below). However, as extra memory, disk space, or other peripherals are added, the power consumption will increase, so a compliant machine with many extras may use more than 30 W. When buying an add-on device for many systems, ask the manufacturer how much the item will increase your systems' energy use when full-on or when in suspend.

Monitor/CPU compatibility

Monitors cannot power down by themselves and must rely on an external signal (from the CPU or a video card) to activate the low power modes. Generally, both the computer signaling output and monitor must be DPMS compatible for power management to occur. Verify that the monitor was tested with BIOS and operating system in the PC. The power management capability must be compatible with all CPUs supported by the monitor.

Network Considerations

The ability to perform with computer networks is a critical part of successful power management. You should consider the following issues to address PC/network interaction.

- *Network tested.* Be sure to purchase PCs that have been tested with your network software. The ENERGY STAR list provides information on network testing, specifically for the Novell, Banyan Vines, Windows NT, and Lan Manager network systems.
- *Network response.* Power management should not lose network connections in low-power modes.
- *Network software*. It may be desirable for network management software to be able to send power management signals to (or check BIOS configuration on) individual PCs on the network.

Workstations and Terminals

Though desktop workstations are generally higher powered than a PC, they are still usually used primarily by one person, and so are good candidates for power management. Terminals, such as X-terminals, usually have fewer components than a PC, and so use less power, but their monitors will use the same power as a PC monitor of the same size, so that they are also still a good application for power management. Several companies offer machines in each category that can successfully power manage. See the ENERGY STAR list for specific products.

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[18]NUTEK reference; see Appendix D for complete citations.

Servers

Servers generally consume more power than PCs. Because of this they rarely meet the ENERGY STAR criterion of 30 W in low power mode. Some of these machines may have power management, and so offer energy savings. However, because they are likely to be accessed at any time, they are less promising candidates than other types of computers for power management. Ask the manufacturer about power management in these devices.

Chapter 6: Future Directions

Computers are one of the fastest changing technologies in our society. Not only is the hardware and software changing at the desktop, but the "information superhighway," the Internet, the World Wide Web, and other such emerging information systems offer new uses for computers and information technologies that are changing our lives. The systems of tomorrow may drastically differ from those we see on our desktops today. Much of what has been discussed in earlier chapters could be out of date or obsolete in a few years. We encourage forward-thinking readers to familiarize themselves with the emerging approaches and trends in power management that will likely be prominent features of PC systems available in the near future.

Power Management in Monitors

Although the trend in computer displays is toward larger, high-resolution, color monitors, there are several important emerging monitor technologies that offer some relief in the historical increase in power. Most of today's monitors are Cathode Ray Tubes (CRTs). The two technologies that show promise in gaining significant market share in the near future are Liquid Crystal Display technologies, and thin CRTs. These new technologies use less than 30 W when fully active.

Flat-panel displays used with today's laptop computers use far less power than CRTs, but currently their high cost limits their use with desktop PCs. This is changing as manufacturers seek to bring costs down and build larger displays. Color LCDs are likely to increase their share of the monitor market. One manufacturer offers a 23 W, 10 inch LCD for use with desktop computers. LCDs can also be powered up and down more rapidly than most CRTs.

A new thin CRT is under development to compete in the flat-panel display market. Developers are hoping to provide them at lower costs than LCDs. Thin CRTs are based on the same tube technology that is used in standard desktop monitors, but use a thin flat tube instead of the traditional bell shaped tube Thin CRTs are reported to use only about 2 W for a standard monitor.

Power Management in PCs

While this guide is focused on power management for PCs for periods when they are not fully active, there are also opportunities to reduce active power. Active power can be lowered with techniques such as reducing the chip count through more integration of functions, lowering the power supply voltage, using a more efficient power supply, or switching to smaller (less energy-intensive) expansion cards.

Power management in PCs is migrating upwards from the BIOS to the software operating level. This evolution is apparent in both Microsoft's OnNow® initiative, and in IBM's proposed architecture for power management with future PowerPC® systems which are discussed below.

OnNow represents Microsoft's plans for the future of power management, where the PC stays on continuously and power-manages connected peripherals. It is a comprehensive approach to power management that allows all devices and all applications to use their power management features. The goal is the make this transparent and simple for end users. Microsoft is particularly interested in developing these features for home computers which they believe require instant accessibility. They are also interested in integrating the features into all PCs, whether they are portables, desktops, or servers.

Microsoft states that (Microsoft, 1996):

> *"The OnNow PC platform will be expected to function in these ways:*
> - *The PC is ready to use immediately when the user presses the On button*

- *The PC is perceived to be off when not in use but is still capable of responding to wake-up events. Wake-up events might be triggered by a device receiving input such as a phone ringing, or by software that has requested the PC to wake at some predetermined time.*
- *Software adjusts its behavior when the PC's power mode changes. The operating system and applications work together intelligently to operate the PC to deliver effective power management in accordance with the user's current needs and expectations. For example, applications will not inadvertently keep the PC busy when it is not necessary, and instead will pro-actively participate in shutting down the PC to conserve energy and reduce noise."*

For any of this to work, component manufacturers need to build systems and peripherals that can communicate power management information with the PC. There will be a transition period during which design changes are needed for related systems and peripherals as well as for software. OnNow defines a standard interface for power managing PC peripherals such as CD-ROMs, network cards, hard-disk drives, and printers, as well as entertainment and consumer electronics. Over time, Microsoft hopes that the proliferation of OnNow-capable systems (running either Microsoft's or other operating systems) will make a major contribution to conserving energy, in line with the goals of the EPA's ENERGY STAR® and related programs. Microsoft believes that OnNow represents a paradigm shift.

As part of OnNow, Microsoft, Intel and Toshiba are also defining a new specification called The Advanced Configuration and Power Interface (ACPI, 1996). The ACPI specification provides for the operating system to direct power management operation. ACPI is expected to be implemented on all classes of computers, including desktop, mobile, home and server machines.

A related evolution in power management technology has been proposed by IBM with the PowerPC platform (Rawson, 1995). IBM has developed a specific architecture, methodology, and system of terminology for power management to work with both hardware and software (though it parallels APM in many respects). They suggest that power management can only be optimized by taking advantage of synergy between the operating system power management facilities and power-management-aware application software. Rawson summarizes:

> *"The user will benefit as the reserve computational capacity of systems increase while at the same time the average power requirements decrease. Ultimately the environment benefits as well. Reaching this goal, however, requires cooperation of component manufacturers, system hardware designers, operating system providers, and application software developers.*"

Power Management in Networks

The sections above focused primarily on power management in stand-alone PCs. As described in Section 3.4, energy savings in networks is more complex than in stand-alone equipment. A Swiss research project and an emerging network controller technology from the computer industry demonstrate new concepts for power management at the network level.

In an effort to evaluate the feasibility for efficient energy management at the network level, a small client-server network was developed to test a prototype energy management device (Bachmann and Brüniger, 1996). The device consumed less than one Watt, and is being prepared for commercialization. The device reduced the energy use of the server computer (with two, 2 GB hard drives) and central equipment (a monitor, digital audio tape system, and CD-ROM reader) by fifty percent for three months during the test period.

While this last example described energy savings on a server system, this next example emphasizes network-level power management. Hewlett-Packard (HP) and Advanced Micro Devices (AMD) co-developed a new protocol (and chipset) called Magic Packet™. According to AMD:

> *"The Magic Packet™ technology is used to remotely wake up a sleeping PC on a network. This is accomplished by sending a specific packet of information called a Magic Packet*

frame, to a node on the network. When a PC capable of receiving the specific frame goes to sleep, it will enable the Magic Packet mode in the LAN controller, and when the LAN controller receives a Magic Packet frame, it will alert the system to wake up. The Magic Packet technology is designed to be implemented entirely in the LAN Controller."

This relatively new technology is being shipped in some current PCs and other manufacturers are expected to follow suit. HP extended the technology to allow remote powering up from an off mode.

New Metrics

It is clear that the evolution of power management brings increasing complexity, and potentially includes more effective techniques to mitigate future increases in energy requirements for computers and monitors. One important issue in this evolution is that it will require re-evaluating our current methods for describing the energy efficiency or performance of a PC. Simply stating whether or not it can meet a 30 W low-power target will not adequately characterize the power-management features. Thus, it is likely that there will be new methods to convey this information to consumers, allowing them to evaluate energy saving features.

The emerging power-management technologies described in the previous section will also migrate into larger workstations and servers, including UNIX-based systems. This evolution also illustrates the need for new metrics for higher-end computers. Discussions are underway with several manufacturers to develop a version of the Energy Star Computers program for larger computers.

Chapter 7: Summary

This guide presents considerable detail about how power management is implemented, and steps sometimes necessary to get it to work satisfactorily. Despite the volume of this information, in most cases it is fairly straightforward to enable power management. Some key points to bear in mind are (relevant chapters in parentheses):

- Power management can save the country significant energy, money, and reduce pollution (Chapter 1)
- Without an effort to properly enable power management, much of this will not be realized (Chapter 1)
- Power management saves energy by reducing electricity use when machines are not in active use. Most of this time is during nights and weekends (Chapter 2).
- For many machines, power management is not a substitute for turning off machines.
- It is estimated that a typical machine is in active use less than 10% of the time (Chapter 2)
- Monitors can save more energy than PCs and are usually easier to enable for power management (Section 3.5).
- For many PC systems, the BIOS is the key to successful power management (Chapter 3)
- Several low-power operating "modes" are defined, some within the Advanced Power Management standard, and some beyond it (Chapter 3).
- Networks and network operating systems can pose significant challenges to power management (Section 3.4).
- Power management can be found in many types of computer systems, including many PCs running DOS, Windows, MacOS, or OS/2, or workstations running UNIX or OS/2 (Section 4.2).
- There are many specific barriers that can arise to defeat power management, but most are solvable (Section 4.4).
- For existing PCs, the simplest energy savings strategy is to simply turn devices off when not in use (Chapter 4)
- Delay times of 10 to 20 minutes are recommended for each power management state (except hibernation) (Section 4.3).
- New computer purchases can be made with power management in mind (Chapter 5)
- The future is bright for power management (Chapter 6).
- Keeping up-to-date is important (Chapter 6).

Get Educated and Provide Feedback

The most significant factor that could lead toward a quick evolution of effective power management systems in computers is consumer demand! Most PC users are unaware of the energy-saving features in today's PCs. An educated consumer is a powerful consumer. We encourage interested readers to provide direct and pointed feedback to computer suppliers and manufacturers about their power management features. If the consumer requests these features, the manufacturers will modify their equipment to meet demand.

Chapter 8: References

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Koomey, Jonathan, Michael Cramer, Mary Ann Piette, and Joseph Eto, "Efficiency Improvements in U.S. Office Equipment: Expected Policy Impacts and Uncertainties", Lawrence Berkeley National Laboratory, LBL-37383, December 1995.

Microsoft, 1996, http://www.microsoft.com/hwdev/onnow.htm.

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Norford, L.K. and K.L. Bosko, "Performance of Energy Star Compliant Personal Computers and Monitors", Building Technology Group, Department of Architecture, Massachusetts Institute of Technology, September, 1995.

NUTEK, "1 Year Later: A one year follow up on 'One watt after one hour in one year'", October 1994, edited by Olof Molinder, NUTEK: Swedish National Board for Industrial and Technical Development, Stockholm.

Rawson, Andrew R., "PowerPC™ Reference Platform: Architectural Aspects of Power Management", Power Personal Systems Architecture, IBM, February, 1995.

Shepard, Michael, and Amory B. Lovins, Joel Neymark, David Houghton, and Hr. Richard Heede, "The State of the Art: Appliances", Rocky Mountain Institute, Snowmass, CO, 1990.

Szydlowski, R.F., and W.D. Chvala, Jr., "Energy Consumption of Personal Computer Workstations", PNL Report Number-9061, Richland, Washington, Pacific Northwest Laboratory presented at the American Council for an Energy Efficient Economy Summer Study on Energy-Efficiency in Buildings, August 1994.

Tiller, D. and G. Newsham, "Desktop Computers and Energy Consumption: A Study of Current Practice and Potential Energy Savings", Institute for Research in Construction, National Research Council of Canada, prepared for the Canadian Electrical Association, Montreal, Quebec, April, 1993.

VESA, Display Power Management Signaling - DPMS 1.0, Video Electronics Standards Association, 1993.

Appendix A: Glossary

Activity

Actions from either outside of the PC (e.g., the keyboard, mouse, network or modem connection), or internal sources (computations, internal timers). The occurrence, or lack of occurrence, of different kinds of activities are used to determine when the PC should enter and leave low-power modes.

APM (Advanced Power Management)

APM is a standard that defines mechanisms by which the CPU controls power use by various system components while the system is in active use (see Intel/Microsoft, 1993 for further details).

BIOS (Basic Input/Output System)

The BIOS is the interface among the processor, cache and main memory and system busses which lead to add-on cards and some external peripherals, and also controls the initial stages of system start-up. The BIOS is a key element in most implementations of power management.

CRT

A Cathode Ray Tube is the standard “television”-like screen found on most PCs.

Doze

The doze mode is the first level of processor power management. The system clock slows or even halts.

DPMS (Display Power Management Signaling)

DPMS defines four power management modes for monitors: On, Stand-by, Suspend and off. The presence or absence of particular (horizontal and vertical) synchronization signals or the entire video signal indicate to the monitor which power management mode to enter.

ENERGY STAR

The ENERGY STAR program was created by the U.S. Environmental Protection Agency to encourage the manufacture and use of office and other equipment that reduces energy use and hence pollution from power plants. Section 1.3 and Appendix B describe it in more detail.

Full-on

A mode in which the CPU is fully active, and either computing or capable of doing so with no delay. The hard disk may be powered down with the processor in full-on mode.

IDE drive

Integrated Drive Electronics (IDE) drives are used on nearly all Intel-based PCs for the internal hard disk. Secondary disks may be IDE or SCSI. Both schemes define how information and control is communicated between the processor and disk.

IRQ (interrupt request)

An interrupt request is the method that one part of the PC uses to signal the processor that some event of possible interest has occurred and might require action. IRQs relevant to power management include the mouse, keyboard, and network interface, as they may indicate that the machine should emerge from a low-power mode.

LCD

A Liquid Crystal Display (LCD) screen is used on most laptop computers. LCDs use much less energy than a CRT

Monitor

The monitor for a PC is usually a cathode ray tube (CRT), and serves to display visual information.

NUTEK

The Swedish organization NUTEK publishes a specification for monitor power management.

PC

In this guide we generally use "PC" to refer to the processor and related hardware (that is, excluding external disks, printers, etc.), and not including the monitor. Sometimes "PC" refers to the entire system, but it should be clear from the context when this is meant. “Computer” power management includes PCs and monitors, as well as workstations.

Power/Energy

Instantaneous electricity use (power) is measured in Watts (W), with the amount of electricity used over time typically measured in kilowatt-hours (kWh).

PM (Power Management)

Power management uses firmware, hardware and software solutions to conserves energy when the computer sets idle and enters defined states of inactivity.

SCSI

The Small Computer Serial Interface protocol defines how a processor and many device types can communicate, including, but not limited to, hard disks. The most common other protocol is IDE.

Sleep Mode/Standby Mode

Sleep and Standby are the first low-power stages that turn down or turn off some peripherals and allows for almost immediate recovery.

Suspend Mode:

The lowest powered mode for a PC. As many system components as possible are powered down, and the processor is halted.

Universal (/blanked)

A Universal monitor will begin power management from either DPMS signals or a completely blank screen (typically generated by a properly configures screensaver program) and so can be used on a PC not designed for power management.

x86 processor

A microprocessor in the family 286, 386, 486, and Pentium®, usually made by Intel, but also by other manufacturers.

Appendix B: Resources

U.S. Environmental Protection Agency
Atmospheric Pollution Prevention Division
ENERGY STAR Programs
401 M Street, SW (6202J)
Washington, DC 20460
ENERGY STAR Hotline: 202-233-9114; fax back system: 202-233-9659
Office Equipment Program: 202-775-6650 or 1-800-STAR-YES; fax: 202-233-9575;
http://www.epa.gov/energystar.html

- ENERGY STAR Computers, Listing of Compliant Products: Monitor/Terminal, Computers/Portables/Work-
  stations, Printers, Copiers, Controlling Devices, Fax Machines. All updated monthly; also available on World Wide Web.

U.S. Department of Energy
1000 Independence Ave, SW
Washington, DC 20585
202-586-2731 (main #)

Office of Building Technology
Anthony Balducci; Anthony.Balducci@hq.doe.gov
phone: 202-586-8459; fax: 202-586-4617

Federal Energy Management Program
Anne Crawley; Anne.Crawley@hq.doe.gov
phone: 202-586-1505; fax: 202-586-3000

American Council for an Energy-Efficient Economy
1001 Connecticut Avenue NW
Suite 801
Washington, DC 20036
202-429-8873; fax: 202-429-2248
ace3_info%ace3-hq@ccmail.pnl.gov
http://www.crest.org/aceee

- ACEEE, "Guide to Energy-Efficient Office Equipment", Revision 1, prepared by the American Council for an Energy-Efficient Economy for the Office Technology Efficiency Consortium under the auspices of the Electric Power Research Institute.

EPRI
Electric Power Research Institute
3412 Hillview Rd.
Palo Alto, CA 94304-1395
415-855-2000
http://www.epri.com

ESource
1033 Walnut Street
Boulder, CO 80302-5114
phone: 303-440-8500; fax: 303-440-8502
http://www.esource.com

Green Seal
1730 Rhode Island Ave. N.W.
Suite 1050
Washington, DC 20036-1301
phone: 202-331-7337; fax: 202-331-7533
http://solstice.crest.org/environment/GreenSeal

NUTEK (Swedish Institute of Industrial and Technical Development)
Department of Energy Efficiency (EFF)
S-117 96 Stockholm, SWEDEN
http://eff.nutek.se/engelsk/office.html
phone: +46 8 681 91 00; fax: +46 8 68195 85

How to use the ENERGY STAR lists

The tables below are fictional entries from the PC and monitor lists, showing examples from both the paper and on-line versions of the list.

When you use these lists, you will should note the date of the list, as very recent models or particularly old (not long in the computer industry!) may not be listed.

Paper List:

The "ENERGY STAR Computers, Listing of Compliant Products" is available for Monitors/Terminals, Computers/Portables/Workstations, Printers, Copiers, Controlling Devices, and Fax Machines. It is available via fax, mail, or over the World Wide Web. For a listing via fax, call 202-233-9659 for automated delivery.

Table B-1 shows the format of the paper list for PCs. PCs are divided into groups by the processor type, then listed alphabetically by manufacturer.

Table B-2 shows the format of the paper list for monitors. Monitors are divided into groups by the display size and color/monochrome, then listed alphabetically by manufacturer.

Table B-1: ENERGY STAR PC paper listing sample.

Brand	Model	MHZ	RAM	HD	Other Features	Monitor	Network Tested	W/S	GSA Number
ACME	NX 888	75	16	540	LBV, K, TR, VRAM, CD-ROM	DPMS	NV LM NT	23.8	GS00K95AT85999
XYZ	Omni 25	90	32	1200	PCI, K&M, 2MB VRAM	SW		25.2	

Table B-2: ENERGY STAR Monitor paper listing sample.

Brand	Model	Resolution	Features	Watts in Sleep	GSA Number
ABC Monitors	NJ 8988	1024x768	MPRII, flicker free	12.00	
Brand X	5600A	1024x768	SVGA, Interlaced		

On-line (Web) List:

Go to `http://www.epa.gov/energystar.html`, and click on `Office Products`, `Computers` (or `Monitors`), and `Energy Star Product Listing`. This will take you to `gopher://gopher.epa.gov:70/11/.data/energy_star`.

Table B-3 shows the format of the on-line list for PCs; Table B-4 shows the format of the on-line list for monitors.

Table B-3: ENERGY STAR PC on-line listing sample.

```
Brand                  Type         Model            Chip          Mhz RAM    HD   Cache    Watts/Sleep

ACME                    PC    NX 888                 486DX/2        75  16    540    256         27.3
XYZ                     PC    OMNI 25                486SX          90  32    1200   256         26.5
```

Table B-4: ENERGY STAR Monitor on-line listing sample.

Type	Brand	Model	Size	Resolution	Watts/Sleep
DPMS	ACMEVIEW	XX997	15" Color	1280X1024	15.00
UNIV	XYZView	WWT84	14" Color	1024X768	13.40

Energy Star Program Requirements

The specific requirements for the ENERGY STAR program are subject to periodic revision. Check the ENERGY STAR web pages to see the current requirements in case they have evolved from the following specifications. The core of the requirements is low-power modes that occur after a delay time (which often can be adjusted by the user), bringing electricity consumption to below a specified power level. Voluntary standards help shift the market to devices that can and do enter low-power modes.

Table B-5. ENERGY STAR Office Equipment Program

Equipment Category	Default Time to Low-Power Mode	Max. Power in Low-Power Mode	Date in Force
PC (without monitor) [a]	≤ 15 minutes	30 W	mid 1993
Monitors [a]	≤ 15 minutes	30 W	mid 1993
Printers and Printer/Fax Combos:			
1-7 pages per minute	15 minutes	15 W	1 Oct 95
8-14 pages per minute	30 minutes	30 W	1 Oct 95
Color and/or >14 pages per minute	60 minutes	45 W	1 Oct 95
Fax Machines:			
1-7 pages per minute	5 minutes	15 W	1 July 95
8-14 pages per minute	5 minutes	30 W	1 July 95
>14 pages per minute	15 minutes	45 W	1 July 95
	Default time to Low/Off	**Max Power Low/Off**	
Copiers-Tier 1 [b]			
1-20 pages per minute	NA[d]/30 minutes	NA/5W	1 July 95
21-44 pages per minute	NA/60 minutes	NA/40W	1 July 95
>44 pages per minute	NA/90 minutes	NA/40W	1 July 95
Copiers-Tier 2 [c]			
1-20 pages per minute	NA/30 minutes	NA/5W	1 July 97
21-44 pages per minute	15 min./60 min.	(3.85·cpm + 5W)/10W	1 July 97
>44 pages per minute	15 min./90 min.	(3.85·cpm + 5W)/15W	1 July 97

[a]Updated requirements for PCs and monitors went into effect 1 Oct 95. The update requires that the equipment be shipped with the power saving features enabled.
[b]There are no low-power requirements for Tier 1 machines (only off-mode power requirements).
[c]Additional Tier 2 requirements for copiers include a required recovery time.
[d]"NA" means "Not Applicable", which implies that no requirement exists.
Source: Koomey et al., 1995.

Appendix C: Sample BIOS Setup Screens

The following are samples of BIOS 'Setup Screens'. They are reproduced here to show the range and variation of BIOS screens that it is common to encounter when enabling systems for power management.

```
                NEC: Phoenix Ver. 4.05.7 1995 NEC 133Hmz
                          (Setup Access Key <F1>)

       PhoenixBIOS Setup Copyright 1985-1995, Phoenix Technologies LTD

MAIN        ADVANCED          SECURITY    POWER       BOOT        EXIT

      WARNING:                                        Item Specific Help

If keyboard Wakeup and Mouse Wakeup
are disabled, then only the Sleep button              Description Text:
will wake the system from sleep mode.                 Listed for each
                                                      underlined topic
      APM                 [Enabled]

      Power Savings       [Customize]

      Keyboard Wakeup     [Enabled]
      Mouse Wakeup        [Enabled]


  Navigation and edit instructions are displayed on the bottom of the Page.
```

```
            Packard Bell: AMI American Megatrends INC. 1992
                         Ver. 1.00.03.CPOR 166Mhz
                                Ver. 150MHz
                         Ver. 1.00.07.BYOR 120MHz


      [DISABLED]
```

```
        Hewlett Packard Pavilion 7125: (Setup Access Key <F3>)


                      Power Management Configuration


      Advanced Power Management     [Enable]                Help Options

      IDE Drive Power Down          [Enable]

      VESA Video Power Down         [Sleep]                 Navigation
                                                            Section
      Inactivity Timer (Minutes)    [0]
```

```
         IBM  SurePath  Setup  Utility  (Setup  Access  Key  <F1>)
                    BIOS  Version  BG2US03  03/06/96

                              Rapid  Resume
     APM  BIOS  Mode
          Rapid Resume                        [32 BIT PROTECTED]
               Automatic Power Off            [DISABLED]
               Initialize adapter cards       [DISABLED]
          Standby Timer                       [DISABLED]
               Standby Snapshot               [DISABLED]
               Halt CPU While Idle            [ENABLE]
               Monitor Mode                   [VESA STANDBY]
               Blink Led in Standby           [DISABLED]
          Wake up on Ring                     [DISABLED]
               Indicator                      [DISABLED]
          Wake up on alarm                    [SINGLE EVENT]
               Alarm Date                     [01/01/96]
               Alarm Time                     [00:00]
```

```
       Compudyne:  PhoenixBIOS  Ver.  4.05  R.01,  1995  NEC  133Hmz
                1985-1995,  (Setup  Access  Key  <DEL>)

                            Green  PC  Options

     Power Savings:          [Disabled]

     Idle Timeout:           [Disabled]
     Standby Timeout:        [Disabled]
     Suspend Timeout:        [Disabled]
     Hard Disk Drive Timeout:[Disabled]
```

```
                COMPAQ:  (Setup  Access  Key  <F10>)
    Setup  Screens  were  windows  based  in  appearance.   Menu's  had
                     indexed  keys  for  editing.
Screen  One

                            Power  Management

     Energy Saver Mode
          ON                                                OK

          OFF

     System Idle Timeout                                    Cancel
          ON
                    15   Min
          OFF
                                                            More
     Hard Drive Timeout
          ON
                    15   Min
          OFF                                               Help = F1
```

```
Screen  Two

                        MORE  POWER  SAVINGS

     Monitor Savings Level
          Maximum Energy Savings                            OK

          Quick Monitor Response
                                                            Cancel
     Standby Features

          Blink LED During Energy Save                      F1
```

```
          Zenith:  Award  Software  ROM  PCI/ISA  BIOS,  V4.50PG,
                   2959CB3H  (Setup  Access  Key  <DEL>)

                         Power  Management  Utility

Power Management:       [Disabled]        IRQ7  LPT1        OFF
PM Controlled by APM    [No]              IRQ9  IRQ2 Redir  OFF
Video Off Method        [V/H SYNC+Blank]  IRQ10 Reserved    OFF
                                          IRQ11 Reserved    OFF
Doze Mode:              [Disabled]        IRQ12 PS/2 Mouse  OFF
Standby Mode:           [Disabled]        IRQ13 Coprocessor OFF
Suspend Mode:           [Disabled]        IRQ14 Hard Disk   OFF
HDD Power Down:         [Disabled]        IRQ15 Reserved    OFF

IRQ3  (Wake up events)  OFF
IRQ4  (Wake up events)  OFF                     Help and Navigation
IRQ8  (Wake up events)  OFF                          Section
IRQ12 (Wake up events)  OFF

Power Down Activities
IRQ3  COM1:             OFF
IRQ4  COM2:             OFF
IRQ5  LPT2:             OFF
IRQ6  Floppy Disk:      OFF
```

```
          Cannon  Innova  350CD:  Phoenix  Power  Mizer  (Laptop)
   Phoenix  Setup  Utility  Ver.  1.0  1994  Phoenix  Technologies  LTD.
                    (Setup  Access  Key  <Ctrl-alt-S>)

         (c) Phoenix Technologies LTD, 1985-1994, All rights reserved

                    PicoPower "Redwood" Feature Control

     Auto Suspend Control          [ENABLE]
     System Idle After:            [4 seconds]
     System Standby After:         [1 minutes]
     System Suspend After:   [5 Minutes]
     Hard Disk Off After:          [1 Minutes]

     Mask Video Access:            [DISABLE]
     Resume Modem Ring:            [DISABLE]
```

Hitachi: Phoenix Ver. 1.36 1996 C-Series Power Panel (Laptop)
PhoenixBIOS Ver. 4.04 1995 Phoenix Technologies LTD.

```
              Phoenix Ver. 4.04 1995 Phoenix Technologies LTD

MAIN        ADVANCED          SECURITY    POWER      BOOT        EXIT

      Power Management:            [Max Performance] Item Specific Help
      CPU Suspend:                 [Fast]
      Standby Timeout:             [15 Minutes]      Hard Drive Timeout:
      [5 Minutes]       Description Text:

      Suspend Timeout:             [15 Minutes]
      Video Timeout:               [15 Minutes]      Listed for each
           LCD Brightness Control: [DISABLE]         topic as reviewed
      Audio Power Management:      [DISABLE]

      Save to Disk                 [DISABLE]
      Cover Down Switch            [DISABLE]
      Resume on time:              [DISABLE]
      Resume Time:                 [00:00:00]

   Navigation and edit instructions are displayed on the bottom of the Page.
```

Sharp PC-3070: Phoenix Power Mizer (Laptop)
Phoenix Note BIOS Ver. 4.0 1995 Phoenix Technologies LTD.

```
              Phoenix Ver. 4.04 1995 Phoenix Technologies LTD

MAIN        ADVANCED          SECURITY    POWER      BOOT        EXIT

      Power Management:            [Max Battery Life]      Item Specific Help
      CPU Suspend:                 [Power Saving]
      Standby Timeout:             [3 Minutes]
      Suspend Timeout:             [2 Minutes]
      Hard Drive Timeout:          [5 Minutes]             Description Text:
      Video Timeout:               [1 Minutes]             Listed for each
           LCD Brightness Control: [ENABLE]                topic as reviewed
      Audio Power Management:      [ENABLE]

      Save to Disk                 [DISABLE]
      Cover Down Switch            [DISABLE]
      Resume on time:              [DISABLE]
      Resume Time:                 [00:00:00]

   Navigation and edit instructions are displayed on the bottom of the Page.
```

Appendix D: What can I do with my existing stock of PCs?

D.1 Introduction

This appendix has details of how to check and enable power management for specific hardware and software systems, building on the general instructions in Chapter 4. Sections D.2, D.3, and D.4 address power management in x86-based systems. One sample (Basic Input/Output System) setup is described, with more presented in Appendix C. Windows 3.x[19] and Windows 95® are discussed separately. Apple Macintosh® systems are discussed in Section D.5. Sun computers are covered in Section D.6. Section D.7 addresses installing aftermarket devices.

D.2 Enabling Monitor Power Management in x86-based machines

Power management for monitors can usually be accomplished through the operating system or through the BIOS. Most users will find it more convenient to be able to change their monitor power management delays through the operating system. Three types of software can accomplish this: screensavers, video card control programs, and special power management software.

Screensavers can be used to initiate power management in universal monitors if they are set to blank the screen after a period of inactivity. The blank screen signals the monitor to begin power management. Screen savers that involve graphics do not have this effect, but most can be configured to display a blank screen. A few screensaver programs can display screensaver graphics for a limited time, *then* go to a blank screen (the "Ecologic" feature in After Dark® is an example of this), though many do not have this feature built-in.

Some video card control programs offer power management features. Since there are so many different video cards (and control programs) available, we recommend you use refer to the manual for your specific software.

OptiGreen® is power management software which can send DPMS signals through video cards that are not designed for power management. (If your PC has DPMS signaling capability, OptiGreen is unnecessary). OptiGreen is provided with some monitors so that they can be power-managed by any PC running Windows 3.1. The software needs to be installed and configured to operate.

Even if one of these types of software is installed, it may be difficult to locate and identify. Unfortunately, there is no simple, precise way to locate screensaver and other software relevant to power management. The best strategy is to check through directories where the software may reside, such as the `Control Panel` directory. Or, you can search for common screensaver software by name ("After Dark" is the largest selling program, for example).

D.2.1 Monitor power management in MS-DOS

Monitor power management does work on some systems running MS-DOS, though in many cases software such as screensavers will either not run under DOS, or be more difficult to initiate or control than through Windows. Most systems with DOS that are recent enough to have power management, probably have Windows installed.

D.2.2 Monitor power management in Windows 3.x

Most versions of Windows 3.x (Windows 3.0 and higher) do not explicitly support power management, so that settings and control resides in screensaver and other software, and in the BIOS.

[19] "Windows 3.x" refers to versions 3.0, 3.1, and 3.11. DOS refers to MS-DOS versions 5, 6, 6.1, 6.21, 6.22, etc.

Beginning with Windows 3.x, facilities were included to enable APM-aware applications to communicate with compliant BIOS systems. Unlike Windows 95, Windows 3.x is not a true operating system, but relies on a version of DOS to be present and running.

Windows 3.1: Screensaver

With the PC on and running Windows 3.1:

- Open the `Control Panel` folder (usually located under the `Main` icon on the Program Manager).
- Open `Desktop`.
- Locate the `Screen Saver` settings.
- Set the screensaver to `Blank Screen.`
- Set the delay time. We recommend a 10 minute delay for typical office use, depending on recovery time.
- Select `Test.` The screen will blank immediately. A universal monitor will power down soon afterwards.

Look through the Control Panels present on the machine for any other screensavers that may be present on the machine. Some may be installed, but not enabled, so check the settings of any screensaver programs that you find.

The recovery time from the standby mode on a power-managed monitor is 0 to 2 seconds. From suspend the delay may be from 3 to 10 seconds.

If the user prefers to have an active screensaver, or if software options are not available for power management, the monitor can be power-managed through the BIOS. The times set in the BIOS will activate the sleep mode to override screen saver operation.

Windows 3.1: BIOS
See the section on changing BIOS power management settings below in Section 4.3.2.

D.2.3 Monitor Power Management in Windows 95

Windows 95: Screensaver

With the PC on and running Windows 95:

- Open `My Computer`.
- Open the `Control Panel` folder
- Open the `Display` control panel
  - Open `Settings`.
    - Select the `Change Display Type`.
    - Make sure that the monitor brand and model are consistent with the actual monitor.
    - If the `ENERGY STAR Compliant` option is not checked, do so.
    - Close the window.
  - Open `Screen Saver`.
    - Note the two `Energy Savings` settings, `Low Power Standby` and `Shut Off Monitor`. These are parallel, not serial, timers, and affect standby and suspend mode respectively. We recommend that both be enabled with delay times of 10 and 25 minutes respectively. The monitor would then enter standby after 10 minutes, and shut off 15 minutes later (after a total of 25 minutes of inactivity).

D.2.4 Monitor Power Management in the Monitor Itself

ENERGY STAR monitors need the PC to initiate the first stage of power management, but the monitor can power down to successive stages on its own. The timing of these successive stages may be fixed, or may be configured through switches at the bottom of the screen or even through on-screen menus on some newer monitors.

D.3 Enabling PC Power Management in x86-based Machines

D.3.1 PC Power Management for Windows 3.1 and Windows NT

Windows 3.1 does not have direct PC power management capability; it must be done through the BIOS. Similarly, most versions of Windows NT do not address power management, so that power management on machines running Windows NT will generally be accomplished by the BIOS. Some versions of Windows NT, particularly those designed to run on laptops, do incorporate power management. For both systems, see instructions below on configuring power management in BIOS (Section D.4).

D.3.2 PC Power Management for Windows 95

Windows 95 provides power management control capability that other Microsoft operating systems lack.

With the PC on and running Windows 95

- Open `My Computer` on the Main Screen.
- Open `Control Panel`.
- Open `System Devices`.
- Open `Advanced Power Management`.
- If the `Enable power management support` option box is checked, then APM support is enabled. We recommend that the remaining three options be set to 'off'. If `Force APM 1.0 Mode` is on, then the newer APM version (1.1) will not be used. `Disable Intel SL support` will disable doze mode if needed. `Disable Power Status Polling` will eliminate compatibility problems with the mouse on some systems.
- Open the `Power` control panel. Power management can be set to `Advanced`, `Standard` or `Off`. We recommend setting it to `Advanced`. `Standard` also enables power management. (note: The `Power Status` and `Battery Meter` items do not need to be enabled on the PC's "task bar" for power management to operate; these are for laptop computers).

D.3.3 Monitor Power Management in OS/2

By default, OS/2® installation automatically configures and enables power management for machines whose BIOS support APM. To check the power management settings, perform the following with the PC on and running OS/2.

- Open `OS/2 System` folder
- Open `System Setup` folder.
- Open `Power` object.

If the `Power Status` window is displayed, power management is enabled.
If the `Power Properties` window is displayed, select the `Power Management On` button; this will enable power management.
If the `Power` object is not present in the `System Setup` folder, then necessary power management software has not been installed on the machine. Use the `OS/2 Selective Install Utility` to install this software.

D.4 Enabling Monitor and PC Power Management in BIOS

There are many different BIOS systems in use today. Many of these differ in ways unrelated to power management, or have power management differences that are fairly subtle. In this section, one sample BIOS configuration systems is shown, with many more described in Appendix C (which cover most of the installed base of power-managed PCs). There are many similarities among BIOS configuration systems, so you should review this section as well as the discussion of the particular BIOS systems you have. Power management in newer systems is more standardized than in earlier ones, making it both easier to use and more likely to be effective once it is enabled.

PC Controls

A critical part of power management is the major system timers; these are typically called *doze*, *standby* (or *sleep*), and *suspend*, and occur in that order. *Doze* reduces power during periods of inactivity by lowering processor speed and powering down unused logic and memory. *Standby* sends a signal to power down the monitor. *Suspend* sends the command to go to lowest power operation by sending the off signal to the monitor and CPU and cutting system board power. See Table 3.1 for more details about the different system modes.

There may be options for *doze* and *standby* to specify how much to reduce the processor speed, e.g., `DOZE Speed (div by)` or `Stby Speed (div by)`. Choosing a *doze* speed of 8 reduces processor speed to 1/8 its original speed. These options are important on network based applications where network connections or file sharing can be lost if the processor speed falls too low. Since many machines will operate on a network even at reduced processor speeds, you should generally leave this option as set unless problems occur. If problems occur, try reducing the `Stby (div by)` (if available) to a lower number. This speeds up the processor and increases its ability to respond to network activity. If the problems persist, try disabling the `Standby` option.

The timer for the hard disk is usually independent since most activity that needs to reawaken the CPU does not require hard disk access. The BIOS tracks disk activity separately from other system activity, and spins up the hard disk only when it needs to be accessed.

Monitor Controls

Monitor power management usually consists of an on/off switch, and sometimes a control for the power management method used (e.g., DPMS, blank screen, or switched outlet). BIOS systems usually use the PC timers for monitor power management with the first stage initiated as the PC is put into the standby mode.

Entering BIOS Setup Mode

If you are starting with a computer that is off, turn on the monitor before turning on the PC. This is important because most systems display a “hot key” at the beginning of the boot-up process (such as *<del>*, *<f2>*, or *<ctrl><alt><f1>*). Pressing the hot key will stop the normal boot-up process and put the machine into BIOS setup mode (if your computer does not indicate the hot key, check the manual). It is only possible to enter BIOS setup mode before the memory test begins. Once that test has started, you cannot enter BIOS setup mode without again rebooting the system.

As you enter the BIOS setup mode, a menu of different setup screens should appear. One of the options should be a power management menu. If there is no power management menu listed, the computer may not capable of power management, or the power management options may be hidden in a sub-menu. Systems with BIOS dates before 1993 are unlikely to have power management.

Navigating in BIOS Setup Systems

- Turn the computer on or do a 'soft reset' (reboot).
- Press the indicated hot key to enter setup mode.
- Select the power management menu using the arrow keys. This is the only screen that needs to be accessed in configuring power management.
- Use the arrow keys to move around the power management screen. Command and editing instructions are also listed on the screen.
- When you are done making changes, use the arrow keys to select `Save Changes And Exit`. The BIOS will ask for confirmation; the PC will resume the boot-up process and continue normally.

If any problems arise while you are in setup, or you are unsure what you are doing, you can always press the <*esc*> key once to return to the main setup window. Select `Exit Without Saving` and any changes you made will be ignored.

Sample BIOS System

Following is an explanation of the BIOS configuration options for one common BIOS System. If your BIOS setup screen looks significantly different, check the examples in Appendix C.

The 7 to 10 lines on the top left of the power management setup screen (shown in Figure D.1) are the most critical to power management.

Figure D.1: BIOS System Screen Example (Award v4.50G, 1994)**:**

Power management:	User Defined	IRQ1-Keyboard:	On
PM Control by APM:	Yes	IRQ3-COM2 (Comm PORT):	Off
VGA Adapter Type:	Green	IRQ4-COM1:	On
Doze Mode:	20 Sec.	IRQ5-LPT2:	Off
Standby Mode:	5 Min.	IRQ6-FDD controller:	On
Suspend Mode:	10 Min.	IRQ7-LPT1:	Off
HDD Power Down:	15 Min.	IRQ8-RTC Real Time Clock Alarm:	Off
IRQ3 (wake up event):	Off	IRQ9-IRQ2 Redir:	Off
IRQ4 (wake up event):	On	IRQ10-(Reserved):	Off
IRQ8 (wake up event):	Off	IRQ11-(Reserved):	On
IRQ12 (wake up event):	Off	IRQ12-ps 2 Mouse:	On
Power Down Activities =========		IRQ13-Numeric Data Processor:	Off
COM Ports accessed:	Off	IRQ14-HDD, IDE/ESDI Controller:	On
LPT Ports Accessed:	Off	IRQ15-Reserved:	Off
DMA Active (DMA):	Off		

Note: The underlined items are the only ones that you are likely to need to change in enabling power management.

Power management: This is the "main switch" for power management. Setting it to `Disabled` will disable all power management features, regardless of the settings on the rest of the setup screen. Setting it to `User Defined` enables the settings the user has chosen in the rest of the power management setup screen. Set the master switch to `User Defined`. Some systems provide settings of `Max. Savings` and `Min. Savings` that define preset values for the rest of the power management settings. The `User Defined` option is preferable since it allows the user more control.

PM Control by APM: This can be set to `Yes` or to `NO` and specifies whether APM is used to accomplish power management.

VGA Adapter Type: This can be set to `Green` or to `Disabled`; this acts as an on/off switch for monitor power management, and so enabling it is critical.

Doze Mode, **Standby Mode**, and **Suspend Mode:** These timers specify the delay time for each of these modes. The times are sequential, so that in the above example the timers expire at 20 seconds, 5 minutes and 20 seconds, and 15 minutes and 20 seconds after the last activity, respectively. These values (20 seconds, 5 minutes, and 10 minutes) are what we recommend for most offices. A few systems may initiate monitor power management in *doze* mode; such systems should have the doze timer set for a longer delay (at least 2 minutes).

HDD Power Down: The optimal hard disk delay time depends on how long it takes the disk to spin back up. If recovery is quick, a shorter delay time is appropriate. A 10 minute delay time here is recommended for a typical 3 second delay for newer disks. For older disks, which may have a 5 to 10 second recovery time, a 20 minute delay may be appropriate.

IRQ switches: Most of these should be left as-is. The interrupt requests (IRQs) for keyboard and mouse activity (usually IRQ 1 and IRQ 12, respectively) are particularly important for power management. These should always be set "on" to ensure that the keyboard and mouse will wake up the system from low-power modes. Network connections typically raise IRQ 11 and so this should also be on if the PC is connected to a network. See Section 3.3 for more information on interrupt requests.

D.5 Enabling Power Management in Apple Systems

Power management for Apple monitors has been available for several years. "Full" CPU power management for Apple PCs (described below), however, has only recently become a reality. Apple's approach to PC power management was fundamentally different from that used with x86 systems. Rather than entering a low power mode, early versions of power management for Apple PCs completely powered down the PC. Since this meant performing a time-consuming hard reboot, most users chose to disable the feature. Fortunately, some of the recent models of Apple PCs have a full array of power management features, including reduced processor speeds, a range of delay times, and a separate hard drive spin-down option (only one of these models, however, qualifies as ENERGY STAR).

D.5.1 Monitor Power Management for Apple Systems

Monitors have a much greater energy savings potential than PCs. Many 70 Watt monitors can power down to only 8 Watts, for a savings of 62 Watts (by comparison, a 52 Watt Macintosh 7200 might only power down to 27 Watts, for a savings of 25 Watts). Monitor power management is much more widespread than PC power management--which means that many ENERGY STAR monitors are paired with non-ENERGY STAR PCs. Fortunately, monitor power management for Apples is available independent of PC power management.

Unlike x86 based systems, in which almost all power management is based in the BIOS, Apple systems use software to control monitor power management. There are a number of different types of software used for power management. Some screensaver programs have explicit power management options which can send DPMS signals to the monitor. If the monitor is a Universal monitor (see Section 3.5), any screensaver which can create a blank screen can be used to initiate monitor power management. Other power management options include add-on software such as Connectix Desktop Utilities® (CDU)[20]. Software such as CDU can accomplish limited monitor power management even if the PC does not have power management capability. Some Apple systems are shipped with CDU or a utility called Energy Saver, which uses DPMS signals to send the monitor into suspend mode. Energy Saver can also be installed as add-on software. Finally, some monitors are shipped with software that causes the system to send DPMS signals.

To determine what types of power management software you have, starting from the desktop, look under the (Apple) icon on the top left of the screen and select Control Panels. Look for "CDU" or "Energy Saver" control panels. Screensavers will also be located here (common screensaver programs include After Dark® and Moire®.)

Screensavers

With the system fully on and operational:
- Under the (Apple) icon on the top left of the screen, select Control Panels.
- Review these to identify which might be screensaver (or simply monitor power management) software. Some of these have explicit monitor power management options.

[20] CDU is add-on software that accomplishes monitor power management. Newer Apple machines (currently the 7200, 7600 and 8200) have power management capabilities similar to that found in Intel-based machines.

- Choose the power management option, if available.
- Set the delay time. We recommend a 5 to 15 minute delay for typical office use, depending on the recovery time.

Screen saver or other programs that show a clock feature may interfere with system network connection or shutdown functions. See Section 4.4 for troubleshooting information.

Add-on software

Many Macintosh systems use add-on software such as Connectix Desktop Utilities®. Not all versions of CDU have power management options.

If CDU is available on your PC:
- Under the (Apple) icon on the top left of the screen, select Control Panels.
- Open the CDU control panel.
- Set desired time delay for auto-dim. We recommend a 5 minute delay.
- Set desired dimming level (expressed as a percent of full brightness). We recommend a 0% dimming level (blank screen).

  If the Auto-Dim feature is set to 0%, the screen will completely darken. If the user prefers to preserve the image on the screen, but at a much lower illumination level, the dimming level can be set to a higher value (e.g. 25 %). This saves a small amount of energy and provides a first stage of power management with instant recovery time. CDU's monitor power management does not send the monitor into its lowest power state.

Energy Saver utility

The newest versions of Energy Saver control power management for the PC as well as the monitor. These instructions are for the most recent versions. If your version offers only monitor power management, there will only be one timer present.

With the system fully on and operational:
- Select the "Energy Saver" control panel.
- Select "Sleep Setup."
- Set desired time delay for sleep mode (this delay applies to the CPU, and applies to the monitor and hard disk drive unless separate delays are selected.)
- You may choose to have separate timing for the monitor display sleep mode. We recommend a 10 to 15 minute delay, depending on the recovery time.

D.5.2 PC Power Management for Apple Systems

First generation ENERGY STAR Apple PCs do not have low power modes. In order to meet ENERGY STAR energy consumption requirements, these machines automatically shut themselves off after a specified delay time. This means losing network connections and possibly losing data, and requires rebooting the system on wake-up. Understandably, few users find this to be a viable option, and the feature is usually disabled. Low power modes first became available in Apple PCs with the arrival of the model 7200. Table D.1 summarizes the power management capability of various models.

While Apple Macintosh® computers have the equivalent of a BIOS, users do not interact directly with it. Rather, mechanisms such as control panels are used to change the configuration from the user interface. The following instructions are for the most recent systems.

Table D.1 Examples of power management capabilities in Apple Macintosh® Personal Computers

No PC Power Management	Centris 610, Centris 650, IIsi, 6100/66,6100/66 AV, Quadra 610, Quadra 630, and related models
Shutdown Only	Quadra 950, PowerMac 8100/100, PowerMac 7100/80
Low Power Modes Present	PowerMac 7200, PowerMac 7600*, PowerMac 8200 (not available in U.S.)

*The model 7600 has power management, but does not power down to less than 30 W (it is not ENERGY STAR compliant). See the most recent Energy Star list for a complete list of compliant models.

In general, models equipped with Mac OS 7.5.1 and earlier operating systems have limited PC power management capability. Models equipped with System 7.5.2 have only a shutdown option, while recent models equipped with System 7.5.3 have full PC power management, including a separate hard drive spin-down option. To check which version of the operating system (system software) you are using, from the desktop bring up the "About This Macintosh" window under the Apple () symbol at the top left of the screen. You may be able to install a version of the control panel that is newer than your operating system, but make this change independently of other changes to be able to identify it in case it causes any problems PC power management was first included in System 7.5, so if you have an earlier operating system, PC power management will most likely not be present (you also are unlikely to have hardware capable of power management if you have system software earlier than System 7.5.)

Auto-Shutdown with CDU

The only power management option available for some Apple PCs is auto-shutdown (see Table D.1). This feature should only be used if the user fully understands the function, and when it can be expected to be useful. Examples include situations in which the computer disk is backed up or may be remotely accessed in the evening. Power management can be set to shut down the PC after these are likely to be finished. This software allows one to set "bypass times" during which the machine will *not* automatically shut down, although other power management features (e.g. monitor dimming and suspend) will continue to operate normally.

To enable auto-shutdown:

- Select the "CDU" control panel.
- Set the desired time delay for auto-shutdown.
- Select "Save Documents at Shutdown," if desired.
- Select "Don't Auto-Shutdown between" option, if desired, and choose starting and ending times for your "bypass period."

Low Power Modes with Energy Saver

If low power modes are available on your PC (see Table D.1):

- Select the "Energy Saver" control panel
- Select "Sleep Setup"
- Set desired time delay for sleep mode. We recommend a delay of 10 to 15 minutes.

  You may choose for the computer to shut down completely rather than enter sleep mode. We do not recommend that this option be enabled unless there is a specific reason to do so *and* the user fully understands this feature.

- Set desired time delay for hard disk sleep mode. We recommend a delay of 15 to 20 minutes.
- Select "Scheduled Startup & Shutdown." This feature allows the user to specify times for the computer to turn itself on and off.

For users with a regular daily schedule, scheduled startup and shutdown allows them to set times so their computers are on and ready to go when they arrive at the office. Also, if network backups or other services are performed after hours, the PC may be scheduled to turn itself off afterward. For users with erratic hours, however, this feature entails some of the risks of any other automatic shutoff option. This feature should only be used if the user fully understands its function.

D.6 Enabling Power Management in Sun Systems

Sun desktop workstations in the sun4m and sun4u platform groups support power management. Server computers in the sun4c and sun4d do not support power management. You need to be running Solaris 2.3, or preferably Solaris 2.5 which has the full power management features described here. Sun sun4u systems are shipped with power management enabled, with a 30 minute delay timer; sun4m systems need to have the power management software installed before it can be used. Diskless machines cannot be enabled for power management.

To enable power management, start the `dtpower` utility by either selecting its icon, type `/usr/openwin/bin/dtpower &` (as the superuser), or select `Power Manager` from the `Workspace` menu under the `Programs` option of the default `OpenWindows` menu. Drag the inactivity slider or type in the adjacent box to set the inactivity timer (e.g. 60 minutes) for the screen, any other power-management capable devices, and the 'system' (the processor). On sun4u systems you can define the times between which AutoShutdown[21] can occur (e.g. between 6pm and 8am), and whether the AutoWakeup feature is enabled to reawaken the system at the end of the AutoShutdown period (e.g. before the user arrives at work). Select `Apply` to put these changes into effect, then `Quit` the tool or close the window. Power management can also be configured by editing the configuration file directly. See the system documentation for further details.

There are several issues to be aware of before implementing power management on a Sun. If electronic mail is delivered to that system, it may be returned as undeliverable if the system remains off for three days; using a separate server for mail delivery avoids this potential problem. Remote access to a system in hibernate is not possible from either network or dial-in modems. Periodic '`cron`' jobs are not executed when the system is in hibernate. See system documentation for further details on these and other possible concerns.

The accessory outlet on Sun workstations is not switched off by powering off the processor, and so does not help accomplish power management.

D.7 Install Aftermarket Devices

When appropriate and cost-effective, consider installing power-controlling "aftermarket" devices. Aftermarket devices can be used on any kind of PC or monitor, and either require no configuration, or come with their own configuration software. The ENERGY STAR program includes aftermarket devices and as with PCs and monitors, compliant devices can be found with the ENERGY STAR lists. The ACEEE "Guide to Energy-Efficient Office Equipment" is also a good source of information on this; Appendix B lists where to obtain this and other resource information.

[21]"AutoShutdown" is the transition to the Sun's suspend mode. Note that 'suspend' on a Sun is comparable to the 'hibernate' mode on some PCs, and not like the suspend mode defined in APM for PCs.

Appendix E: Assumptions for Calculations

For Section 1.3, it is assumed that monitor use is reduced from 168 hours/week to 48 hours/week, average power of 65 W (no power management), a U.S. stock of 46 million monitors, and an electricity price of 8 cents/kWh. The average monitor power and the U.S. stock of monitors were taken from Koomey, et al, 1995.

Table E.1 shows a standard PC operating pattern, derived from observations of PCs in actual use[22]. This is derived from a typical scenario with 9.5 hours of on-time per day, with four of those hours in active use and 5.5 hours in idle mode (low-power for power-managing PCs). Idle mode is taken as the lowest-power mode of the system[23] . One weekday each week is taken as an "absence" day to account for vacations, travel, etc. Power management savings are a function of the low-power time fraction and the difference between the full-on power and the low-power for the particular PC or monitor. A machine on continuously, but power-managed, would save about three times as much as the standard scenario shows.

Table E.1: Standard PC Operating Pattern *(percent of time by mode)*
"On" is the sum of "Full-on" and "Low". "Off" is all time that is not "On".

	Full-on	Low	On	Off
Standard Operating Pattern				
Workday	16.7%	35.0%	51.7%	48.3%
Weekend	0.0%	20.0%	20.0%	80.0%
Absence	0.0%	20.0%	20.0%	80.0%
Weekday Average	13.3%	32.0%	45.3%	54.7%
All Days Average	9.5%	28.6%	38.1%	61.9%

For Section 2.2, the above time distribution is used, and the combined PC and monitor power is assumed to be 140 W in active and 30 W in suspend. Eight cents/kWh (approximately the national average electricity rate) is used to estimate the dollar savings in the example.

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[22] Nordman et al., 1995; see Appendix D for complete citations.

[23] An actual system would have to have more than 5.5 hours in some low-power mode to get the equivalent savings of 5.5 hours in the lowest mode.

Appendix F: One-page Summary

Saving Energy with Desktop PCs and Monitors

Wasted energy, wasted money
Most of the energy computers use is wasted, since the average office computer is only used 4 hours each day, but is on for much longer. Even if you turn your computer off at nights and on weekends, half of the energy consumed by your computer could be wasted. If you don't turn off your computer when you go home, your company could be spending an extra $85 each year for your computer to do nothing but keep your desk area warm.

Turn off devices when not in use
Leaving your PC and monitor on at night and on weekends is like throwing money down the drain. Your monitor should always be turned off when you leave the office since there is no reason for it to be on if no one is there to see it. Turning off the monitor alone reduces your computer's energy consumption by about 2/3. If you don't need your CPU for network services or remote access, it should be shut down, too. SCSI devices, printers and other peripherals should also be turned off.

Energy Star Computers
Some computers can reduce their power consumption if their power is left on but they aren't actually in use. This is called power management. PCs and monitors which can reduce their power to below 30 Watts can be identified by EPAte s ENERGY STAR label. Look on the ENERGY STAR web pages at `http://www.epa.gov/energystar.html` for a list of ENERGY STAR devices.

Using power management
Once power management is enabled, it works automatically. Internal timers measure how long it has been since you last used the mouse or keyboard. After a specified amount of time (the length of time is chosen when power management is configured) most power-managed computers take a nap--the CPU slows down, and power to devices is reduced. The monitor, usually on a separate timer, is blanked. As soon as you hit a key or move your mouse, the computer wakes back up, right where you left off.

Configuring power management
Sometimes power management can be configured through a control panel. Power-managing Apple Macintosh® PCs have this feature, but only a few x86-based computers do. Monitor power management can be set through power management control panels, but can also be set using an "energy saver"-type screensaver, some video card control software, or for some monitors even a blank screen (check the ENERGY STAR list for "universal" monitors). Most x86-based computers have to be configured through their BIOS. If you don't know how to configure power management (whether through a control panel or the BIOS), talk to a computer support person in your office.

For more information
[References for Energy Star lists, web version of tech guide, full users guide.]

Appendix G: Auditing and Evaluating Power Management in Personal Computers

An audit of the hardware and software computer professionals supervise can help clarify the potential and actual power management capabilities of their equipment . An audit can be of one particular system, or of a large set of systems. When many similar systems are audited, there are economies of scale, but many PC system characteristics need to be individually checked since both hardware and software details can vary for systems which may appear identical.

Audit types

We have divided audits into three types[24], from the most simple to the most rigorous. The procedure for each succeeding level incorporates the earlier levels.

Level One

Observe brand and model information by visual inspection of the outside of the case, without relying on the machine being on. A level one audit can be combined with power ratings and likely use patterns to indicate overall electricity use rates and potential savings from power management.

Level Two

Examine configuration settings in any appropriate BIOS screens and control panels, observing the presence and configuration of any relevant software (such as screensavers, video or network card drivers), and potentially contacting the manufacturer for any power management information they can provide. A level two audit indicates the overall degree of enabling and whether some machines are configured in the same or a similar state.

Level Three

Measure the power drawn by the device over enough time to observe all important power management modes occurring, recording the amount of time between mode changes and the power level at each mode. A level three audit may also include opening the PC case and temporarily removing some expansion cards. A third level audit verifies that potential power management modes actually occur, and that power and timing are as expected from the configuration and equipment inventory.

Guidance

For some equipment, contacting the manufacturer may be necessary to obtain information about how to check, interpret, or change system configuration. From the serial number, the manufacturer can also tell the date of manufacture and the configuration-as-shipped status. For any audit, an initial walk through of the audit area should be done to evaluate the general types of equipment present. It is often easier to conduct audits when most people are not around, such as on nights and weekends.

First level Audit

The first level of audit generally takes only that information visible from the exterior of the device. For the most part this is "nameplate information" found on the back panels of the PC or monitor, particularly the Manufacturer Name, Model Number, Serial Number, Manufacturer Date, and rated current or power draw (in amperes or Watts). Manuals for the PC or monitor may provide information about default power management settings, or if add-on software is provided. Also, check to see if the monitor is plugged into the PC convenience outlet.

[24] See Nordman et al., 1995 for further details.

Try recording whether the equipment was on during the audit, and if so, what state (e.g. full-on, visibly in suspend, running a screensaver, etc.). This can help indicate how much energy is being saved by power management, and how much more could be saved by enabling more power management or turning equipment off when not in use. Then, if the machine is on and in a suspend mode, press a key or move the mouse and record how many seconds it takes to revive to the full-on state. You can use this information to decide on delay times appropriate to each piece of equipment.

Second Level Audit

A second-level audit begins with rebooting the computer to observe any relevant information (e.g. amount of memory, number and size of hard disk drives) as the system comes up. To determine a model number, it is sometimes necessary to check what type of system the operating system thinks it is running on. It is also helpful to know the version of operating system. You should be able to determine power management details such as the number of power management modes it supports, whether it supports APM, whether power management is enabled (and how), the power management options available and the delay times.

For monitors, you may want to record the number of options for screen saver or other power management software, whether power management is enabled, if video card software is present, the type of screen used for screen saver or screen dim, the number of power management states it supports, and the delay times specified.

Dynamic Testing: Second or Third level

To see if power management actually occurs, it is necessary to turn the system on and wait till delay timers in the system have had a chance to run out and attempt to initiate power management. This can be done with or without power metering, though without one can only observe monitor power management and hard disk drive spin-down. These can be noticed through any delays in returning to full power, or often in the case of the disk, by its sound.

Compare observed times with those listed on the configuration screens (or monitor manuals). Note if screensaver defeats monitor or PC power management; this may require waiting until the screensaver has a chance to begin operation which may be well after the power management begins.

Once the dynamic test is complete, if any changes were made to the power management configuration, return the system to original setup parameters unless the user requests otherwise.

Third Level Audit

A third level audit requires a current or power meter; it is preferable to have two such meters available, to be able to measure both the PC and the monitor at the same time. Because of the effort involved, dynamic testing is most commonly used when there are many machines of similar manufacture so that the lessons learned from studying one will apply to many others.