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Energy Efficiency: Plug Load Management

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Energy Efficiency: Plug Load Management

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Introduction

Consumer electronics, office equipment and other equipment that is plugged into electrical outlets are called "plug loads" and consume 15 to 20 percent of total residential and commercial electricity in the United States. Much of this energy is consumed when these devices operate in low-power modes but are not actually in use. Any device that plugs into wall outlets distributed throughout a building is a plug load. These loads do not relate to general lighting, heating, ventilation, cooling, or water heating, and typically do not provide comfort to the occupants. Plug loads account for an average of 9% and perhaps as much as 30% of the electricity consumption in office buildings depending upon the nature of the work.

One way to reduce this unnecessary electricity consumption is to use smart plug strips. *Smart plug strips* vary in design, but typically employ some combination of load sensors, remote controls, occupancy sensors, and timers to automatically power down plug loads when they are not in use.

By automatically turning off plug loads when not in use, smart plug strips can provide energy savings in residential and commercial sectors. Applications for smart plug strips include workstations, home offices, and home entertainment systems.

Standby power–electricity used by appliances and equipment while they are switched off or not performing their primary function–associated with plug loads presents a large opportunity for energy savings. This power is consumed by power supplies, the circuits and sensors needed to receive a remote signal, soft keypads and displays including miscellaneous light-emitting diode (LED) status lights. Standby power use is also caused by circuits that continue to be energized even when the device is off.

Plug loads can also increase cooling loads, and decrease heating needs, and affect the associated HVAC energy use. An entity that strives to reduce energy use and energy costs must have a strategy to reduce plug load electricity consumption.

This course looks at the size of the problem, strategies that can be used to mitigate the problem, and discusses devices that may help minimize plug load energy consumption.

Chapter 1
What's the Problem?

Plug load is the term for energy used by electric equipment while plugged into an electrical socket. In commercial buildings, this includes a variety of devices, such as personal computers, printers, coffee makers, and vending machines. While all electric devices are plugged in, plug loads are often difficult to manage because they are decentralized. Because of this, facility managers often focus energy-efficiency efforts on manageable areas such as lighting or space conditioning. Reducing plug load, however, can be a fast, cost-effective way to save on energy costs.

Research shows that desk-based technologies and other electronics in office settings consume significant amounts of energy that are often neither metered nor managed in energy monitoring and reduction strategies. Recently, however, several technologies that meter and control office equipment has become available. Those that employ control strategies that match office equipment energy use to user work schedules are particularly effective. An APS successfully reduces plug loads for equipment that (1) is used on a predictable schedule, and (2) is left powered on during non-business hours, weekends, and holidays.

Office equipment is the fastest-growing commercial end use energy consumer. A recent survey by the U.S. Energy Information Administration, reported that 19% of the total energy used in an office building is attributed to plug load energy use, which includes office equipment, computers, and other energy using equipment. This is higher than the traditionally assumed average of 9% and may indicate a growing trend in new plug loads. A 2008 California study found that plug loads comprise 30% of total office electricity consumption. Among office plug loads, computers and monitors account for the largest share of energy, while office electronics such as printers, faxes, multifunction devices, and computer speakers account for 17% of plug load energy use. Miscellaneous devices such as portable lighting, telephones, and coffee makers make up the remaining 17%.

Much of this is wasted energy, consumed on nights and weekends when buildings are unoccupied. According to a recent study, 60% of personal computers and 34% of printers remain on after hours, consuming energy when not in use. Energy-saving power management functions are not used effectively either. Only 6% of personal computers and 5% of fax machines are put in *low power mode* when the building was unoccupied.

Plug Load issues

- Plug load is the energy used by equipment that is plugged into a socket.
- Plug loads account for up to 30% of electricity used in offices and much of this energy is wasted.
- Data servers and vending machines are often overlooked plug loads that present energy-saving opportunities.

Plug load energy efficiency

Although total plug load energy use is increasing, the actual plug load equipment stock is getting more efficient: technical advances such as low power consumption by computer monitors, more effective sleep modes and the increased use of laptop computers in lieu of desktop computers have produced lower plug load power levels. Newer equipment including computers, fax machines, scanners, and printers may use up to 50% less energy than previous models.

Although the efficiency of this equipment category is improving, many studies have indicated that user behavior may be a factor for its overall increasing energy use. One study of office building energy use found that only 44 percent of computers, 32 percent of monitors, and 25 percent of printers were turned off at night.

Additionally, equipment power management adds some uncertainty to estimating plug load energy use. While most plug load products have "off" and "on" states, the "sleep" or "low power" states can represent a wide range of power savings, from 55% in desktop computers to as much as 94% in computer monitors.

There have been many studies using sub-metering systems to quantify and understand how plug loads consume energy and the amount of time spent in active mode or sleep mode. There have also been many psychology studies about how to influence human behavior.

Previous research using sub-metering systems to monitor plug loads have quantified various metrics about plug load energy consumption. For example, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) published a great deal of information about diversity factors and power consumption in active, standby, and off modes. Sub-metering systems have also been used to examine how specific pieces of equipment contribute to the bigger picture energy consumption of the building and metrics such as kilowatt-hours per square foot (kWh/ft^2) have been used to extrapolate annual energy consumption. Other studies have used sub-metering to establish baselines and have extrapolated market analysis for plug load-related policies. These publications are extremely useful for understanding how and when energy is being consumed by various office plug load equipment.

One confounding factor with estimating plug load energy use is the discrepancy between the rated or nameplate energy power consumption and the actual average power consumption, which can be as little as 10-15% of the nameplate value. Plug loads and office equipment emit heat into the environment which requires the building to supply additional cooling loads, a side-effect which contributes to the total energy use of this energy category. On the opposite, when heating is needed, plug loads and office equipment are reducing the energy requirement.

One simple concept is to just be sure that office workers turn off their office equipment or program standby and sleep modes for the equipment. This requires a behavioral change though. The psychology of behavioral change is a very important topic that needs further examination in the context of energy consumptions. A study entitled Changing Behavior and Making It Stick: The Conceptualization and Management of Conservation Behavior by Raymond De Young is an excellent resource. De Young's study examines conservation behavior in order to change individual behavior while reducing the need for repeated intervention. It also categorizes and evaluates behavioral change techniques. This previous work has found informational prompting to be untrustworthy and nondurable, with varied effectiveness. Material incentives initiate rapid change and effective results but are nondurable once the material incentive has been obtained. Social pressure and material disincentives were found to initiate rapid change and effective results but also create negative psychological resistance from individuals. Commitment techniques encouraging individuals to "pledge" their commitment to behavioral change for a specific amount of time were found to be the most durable and effective. However, securing individual commitment has proven to be difficult to accomplish.

Table 1 gives an idea of the size of the problem. As you can see from this table, office equipment consumes a significant amount of power and most products continue to use some amount of power even when they are not being used.

Table 1 **Typical Plug Load Energy Consumption**				
Device	**Operating Wattage**	**Standby/Off Wattage**	**Diversity Factor**	**Estimated Annual Consumption kWH's**
Desktop Computer	125	5	75%	821
Monitor	60	1	60%	315
Printer	80	2	33%	231
Computer Speakers	6	2	33%	17
Laptop Computer	25	2	75%	164
Copier	700	3	33%	2,024
Scanner	80	8	33%	231
Fax Machine	80	9	33%	231
Space Heater	1,000	3	25%	2,190
Personal Fan	50	1	33%	145
Clock Radio	10	3	100%	88
Phone Charger	2	1	50%	9
Coffee Maker – Personal	900	3	15%	1,182
Coffer Maker - Commercial	1,100	60	30%	2,890
Television	80	3	15%	105
Drink Vending Machine	800	n/a	25%	1,752
Microwave Oven	1,000	3	10%	876

The term "diversity factor" in Table 1 refers to the percentage of the equipments power demand is being used. For instance a device that is rated for 60 watts that operated continuously for an entire year would consume,

Energy consumption = 60 watts / (1000 w/kWh) *8,760 hours = 526 kWh/yr

If the equipment has a diversity factor of 60%, then the unit will only consume 60% of the possible consumption (526 kWh) or 315 kWh per year.

In residential applications the devices shown in Figure 1 are the largest plug load power consumers. Some of these - such as a room air conditioner - are not suitable for plug load control, but they remain as major plug load energy consumers.

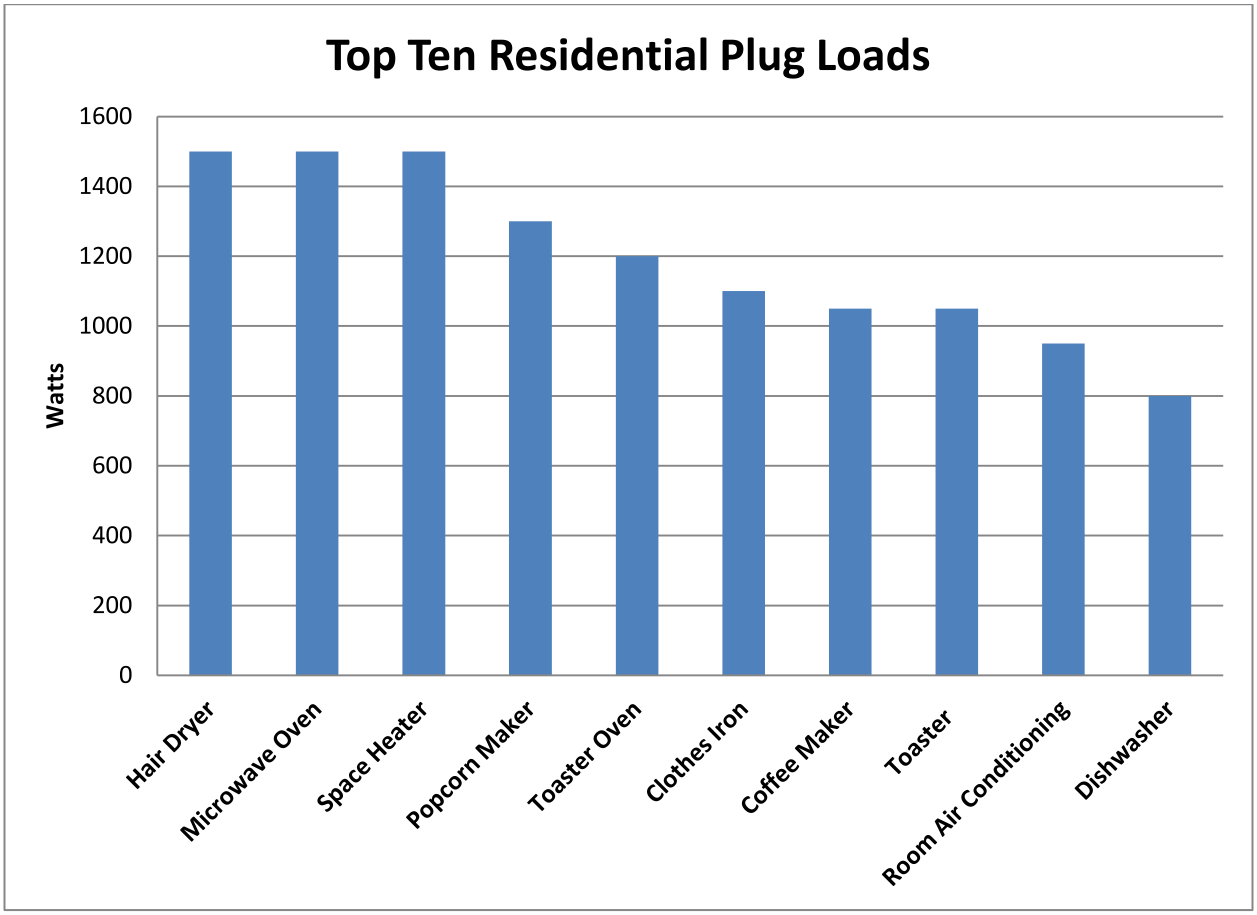

Figure 1

There are opportunities to reduce plug load energy consumption in both residential and commercial applications. The next chapter discusses strategies to reduce plug loads.

Chapter 2
Managing Plug Loads

Plug load control comes in two basic forms. Energy savings are achieved when the device is either transitioned to a low-power state, or it is de-energized to eliminate the power draw. Both can be executed either manually or automatically. A low-power state is between a de-energized state and a ready-to-use state. This includes standby, sleep, and hibernate modes as well as any "off" state that has a parasitic power draw. A de-energized state is when electricity is not being provided to the device. This is analogous to physically unplugging a device's power cord from a standard electrical outlet.

Advanced Power Strips (APS's), such as simple timers, have been commercially available for a long time but market transformation/penetration has been slow. Newer electronic and logic-based controls have started becoming commercially available in recent years. The most significant improvements in APSs have been related to electronic logic controls and communication techniques.

Potential barriers for APSs include: occupant acceptance, communications, lack of personnel time for analysis, and complex controls in some instances. These devices may require operations and maintenance to update controls, manage data, and troubleshoot incorrect operations and communication failures on a regular basis.

The most effective control strategies provide manual override to accommodate atypical times when a plug-load device wouldn't normally be in use (e.g., using a device outside normal business hours). The energy manager must evaluate each control strategy relative to a specific plug-load, examine its parasitic load versus the plug-load's parasitic load, and determine its costs versus the energy cost savings.

Most plug loads are electronic, and thus require power supplies to convert the 120 V AC that comes out of wall outlets into low-voltage DC. Whatever the device, power supplies use small amounts of energy for this continuous conversion. It is key to understand that electronic plug loads don't just operate at one power level when on, and using no power when off, they operate in a variety of power levels, or "modes." These modes can be defined as:

- **Active.** A device is on and performing its intended function. For example, a printer is active when it is printing.

- **Idle.** A device is on and ready to perform work but is not actively doing anything. A printer is idle when it is not actively printing but is ready to do so quickly without warming up. Some products consume surprisingly large amounts of energy in this mode.

- **"Sleep" or Standby.** A device has been turned off, either with an automatic power-down feature, or manually, with a "soft-off" switch, and draws a minimal amount of power. A printer in sleep mode still draws power and experiences a small delay between a request to print and when it actually begins printing. Many products appear to be off when they are actually in a sleep or standby mode.

- **Off.** In this mode, a device does not draw any power, either because it is unplugged or has been turned off with a "hard-off" switch. Plug loads can spend a large amount of time in sleep or standby mode, and power supplies and battery chargers typically draw power during this time.

See Figure 2 for a graphical look at how these modes are typically used.

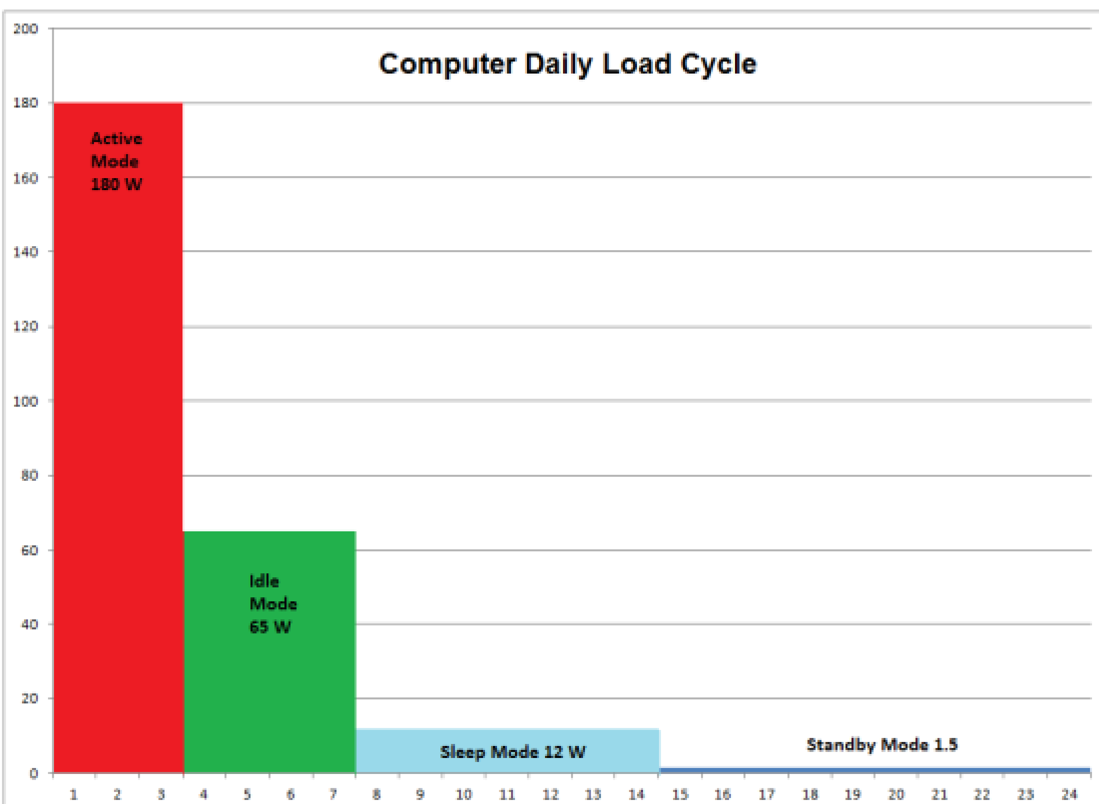

Figure 2

Efficient plug loads power down to sleep when the device is not performing its intended function. This is commonly achieved with power management software that automatically puts the device to sleep after a period of inactivity. Today's computers come equipped with power management software; however, computer users often disable the power management settings so that updates can be installed during the evening, or so there is no wake-up time after a period of inactivity. Thus, some pieces of IT equipment may use energy needlessly at night and on weekends because they never go to sleep.

Network connectivity also prevents many plug loads from going to sleep. For example, when a computer is sleeping, it often becomes invisible to a network, which is problematic when IT personnel want to send software updates via the network. One way to address the issue is with a network proxy—a hardware component integrated into the network card of a device (e.g., a computer). A proxy is like a watchdog; it maintains a presence on the network with minimal energy consumption, while allowing the host to sleep and waking the device only when necessary.

Some plug loads take the power-down concept further, by dynamically adjusting power draw to meet the demands of the task; this is referred to as *power scaling*. Consider the following: when checking e-mail, a computer should need only a fraction of the energy it uses to play a graphics-intensive game. Currently, most devices do not power scale very well. Mobile devices, for which a premium is placed on battery life, are a notable exception. In the future, as the issue of plug load energy use attracts more attention, non-mobile devices are likely to incorporate power scaling capabilities that will generate additional savings opportunities.

Control Strategies

There is significant opportunity to deploy some of the simpler and lower-cost schedule timer power strips to address the majority of office plug loads. This would both optimize energy savings and require a lower initial investment. The following are some of the control strategies that may be employed.

Manual Control

Most plug-loads can be manually powered down with built-in power buttons, shutdown procedures, or a control device that energizes and de-energizes electrical outlets based only on manual input. Depending on the equipment, a built-in switch may provide a quick-and-easy manual method of powering down or up the device. Other devices may have a shutdown procedure that users must perform to shut down the device. For some devices, manual control is the best or only method. Manual control is the incumbent technology and is rarely used because the plug strip is typically located under the desk where occupants do not have easy access to the on/off power switch.

The effectiveness of manual control depends entirely on user behavior and should be implemented only if no other methods apply. Plug-loads could remain powered up at all times if users do not actively use manual control. When manual control is the only option, all users must be made aware that they are responsible for the operation and energy use of their equipment. They need to be educated about proper use and how their behavior can save or waste energy and money.

Automatic Low-Power State

The first, and in some cases most effective, control method is a built-in, automatic low-power state functionality such as standby or sleep. Some manufacturers include this functionality to reduce energy consumption of idle devices. Internal processes monitor idle time, and when the device has been in an idle state for a given period, it will power down to a low-power state.

Built-in automatic low-power state functionality can be a cost-effective control strategy because it is integral to the device and does not require additional control devices. However, it may have several issues: Users can configure computers and other items and deactivate the automatic low-power state functionality. The power draw in a low-power state may be only slightly lower than in the ready-to-use state. In this case, the functionality is working as intended, but the power drop is less than desired or needed. A device may need to be activated or accessed remotely, which may not be possible in a low-power state. The time to transition from a low-power state to a ready-to-use state may be too long.

Automatic low-power states provide limited control, yet they are the most accessible (and cheapest) form of plug-load control.

Schedule Timer Control

Certain plug-loads have predictable load profiles. These devices are used during the same times each day or at regular intervals. A scheduling-control device can effectively manage a predictable plug-load. It applies user-programmed schedules to de-energize the plug-load to match its use pattern and energize the plug-load so that it is ready for use at the time when it is required.

A scheduling-control device can take multiple forms: Basic electrical outlet timers that control a single outlet, or power strips with integrated outlet timers to control multiple outlets, provide local scheduling control. Users program the schedules. Scheduling can be controlled with devices in a centralized location. These are typically wireless, plug-and-play devices that control one or more outlets and communicate with a centralized controller that energizes and de-energizes the outlets based on user-programmed schedules. There are also plug strips that can be scheduled remotely instead of on-site programming.

Scheduling devices are generally straightforward, consistent, and reliable. They target the energy that is wasted during non-business hours, but do not necessarily provide the greatest energy savings. For instance, a plug-load may not be needed during all business hours. All scheduling controls should allow for manual override during the times when energy is needed outside the preset schedules.

With schedule timer controls the best results were achieved for printers, laptops, and miscellaneous workstation equipment. Figure 3 shows the results of a test of controlling office equipment on weekends.

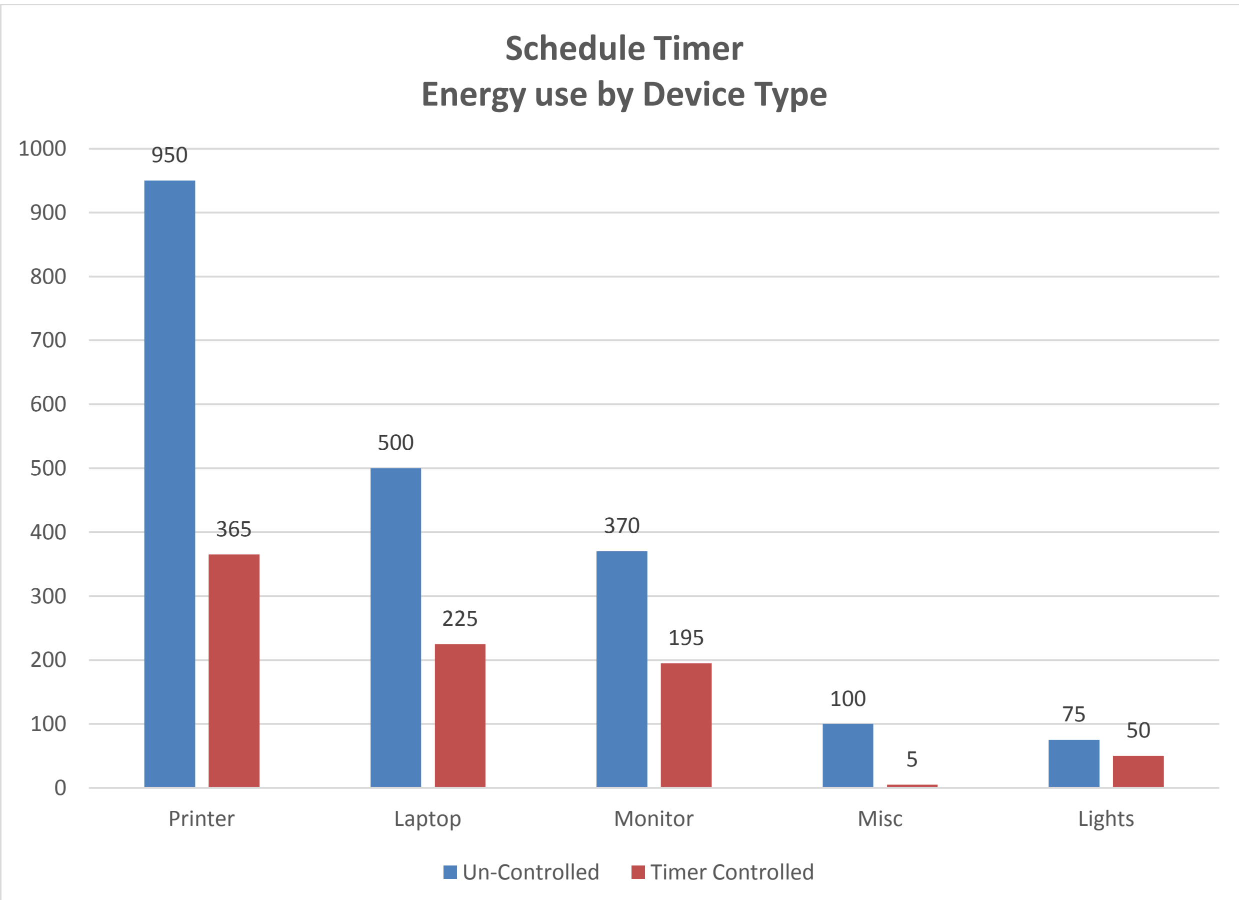

Figure 3

With schedule timer control, savings were achieved in all categories except miscellaneous workstation equipment. The largest savings can be achieved with printers. As can be seen in Figure 3, the scheduling controls reduce weekend usage by 38%. There are also large savings throughout the weekday profile which can be attributed to normal variations in usage between the baseline and controls phase. The laptops also realized good energy savings during the evenings and weekends, in addition to the savings already being achieved by the computer power management system.

Load-Sensing Control

Some plug loads have a primary-secondary relationship. A primary device, such as a computer, operates independently of other (slave) devices. A secondary device, such as a monitor or other peripheral, depends on the operation of other (master) devices. A *load-sensing control device* should be implemented for such a relationship. It automatically energizes and de-energizes secondary devices based on the "sensed" power load of the primary device. Whenever the primary device goes into a power state below a given threshold, the load-sensing control can power down the secondary devices. The sensed (primary) load is typically an electrical outlet or an auxiliary port.

Load-sensing control may save more energy than scheduling control because it can reduce energy use during business and non-business hours; however, it depends on "good" operation of the primary (sensed) device. "Good" operation is where users manually control the primary plug-load by forcing a low-power state when the device is not in use (e.g., a user puts his laptop into standby when away from his desk). Alternatively, built-in automatic, low-power state functionality in the primary device must be working effectively to put devices into a low-power state. Otherwise, the load-sensing control method does not save energy.

A load-sensing device can take several forms including: Power strips that sense the load of a primary device and control several secondary devices locally and central controls, which are typically wireless, plug-and-play devices that control a single outlet or multiple outlets. They communicate with a centralized controller that energizes and de-energizes the outlets based on user-programmed load thresholds. Primary and secondary devices can be in different parts of a building. Also, the controller can be programmed such that when the primary device transitions between states, the secondary device can be either energized or de-energized. Again, like the scheduling control, the central control can be provided by a dedicated plug-load control system or integrated into the building management system.

For load-sensing controls the best results are usually achieved for printers, laptops, and miscellaneous workstation equipment.

With load-sensing control, the most significant savings are achieved with printers and miscellaneous equipment. The printers can be placed into a lower power state during the evenings and weekends. In addition, results show daytime reductions which are only possible with load-sensing controls, but savings may also be attributed to normal variations in usage between the baseline and controls phase. Laptops, monitors, and desktops may not realize any savings or only limited savings. Limited or no energy savings can be attributed to master devices failing to go into a standby mode and never crossing the specified threshold and lack of occupant training which lead to disabling of controls. For laptops, the computer power management system may already turning these devices down to very low-power states during unoccupied hours, and the load-sensing does not add much value to this device type. Finally, the miscellaneous equipment did demonstrate reduced power and effective control by the APS, yet the small total draw of the devices does not add much to the overall savings achieved.

Load-Sensing and Schedule Timer Control – Combined

When both schedule timer and load-sensing controls are employed the best results are achieved for printers, laptops, and miscellaneous workstation equipment.

With the combined control, savings are usually achieved in all categories except for monitors and under-cabinet lights. The largest savings were achieved by the printers. The laptops achieve a slightly lower power state during the evenings and weekends, but again, this may because a computer power management system is already turning these devices down to very low-power states during unoccupied hours. The miscellaneous equipment demonstrates good control by the APS despite the low total power draw by the device type.

Occupancy-Control

In theory, *occupancy control* can save a great deal of energy. It energizes plug-loads only when users are present and de-energizes them when the space is vacant. This approach pinpoints the main source of wasted energy during non-business hours and reduces wasted energy during business hours.

Some of its drawbacks are: It may energize and de-energize outlets at inappropriate times. It must focus on the immediate zone surrounding the plug-load to be controlled, but not extend into other areas. The plug-load should be energized only when a user is nearby. Its significant parasitic load may reduce the net energy saved by de-energizing plug-loads.

Manual-On, Vacancy-Off Control

A *manual-on, vacancy-off control* device is a slight modification of the occupancy-control device. It energizes a plug-load when it receives manual input from a user and de-energizes the plug-load automatically based on lack of occupancy. This control should be implemented for plug-loads that are needed only when users are present (e.g., task lights, monitors, and laptops).

This approach also has an even higher potential for energy savings than a typical occupancy-control device. The plug-load will stay in a de-energized state until a user manually energizes the device, thus eliminating the wasted energy associated with false positives. This strategy is commonly implemented in lighting controls because it effectively reduces wasted energy.

Effectiveness of Different Control Strategies

A recent study assessed the effectiveness of different types of advanced power strips (APS) in managing plug-load energy consumption in office buildings. Three types of plug-load reduction strategies were evaluated: schedule timer control, which allows the user to set the day and time when a circuit will be energized and de-energized; load-sensing control, which monitors a specific device's (master) power state and de-energizes auxiliary devices (slaves) if the master's power consumption dips below a predetermined threshold; and a combination of the two. Results underscored the effectiveness of schedule-based functionality, which reduced plug loads at workstations by 26%, even though advanced computer power management was already in place and nearly 50% in printer rooms and kitchens. The results found,

> **1. Schedule timer most effective.** Use of the schedule timer control, which was the most successful of the three control strategies, resulted in an average energy savings of 48 percent. The largest savings were achieved when schedule timer controls were applied to devices that were powered 24/7. Printers and copiers were among these devices, as were kitchen appliances, such as coffee makers and water coolers.
>
> Other studies have shown that simple payback for the schedule timer is less than 8 years in all applications: kitchens, 0.7 years; printer rooms, 1.1 years; and miscellaneous devices, 4.1 years. Even in workstations, where power management is in place, payback is less than 8-years.
>
> **2. Simple control strategies are best.** Occupant surveys revealed that the majority of users did not wish to have more control over their individual APSs. However, they were willing to program power strips to reflect their personal work schedules. Users also wanted an easily accessible manual override.

Load-sensing and combination controls provide limited energy savings and relatively high simple payback in commercial office space applications. One reason for this is that when applied to kitchens or printer rooms, load-sensing control aggregates power-state data from APSs in surrounding workstations. Because all workstation APSs are monitored in search of a "master" device whose threshold would de-energize auxiliary devices, "slaves" are de-energized only when all workstations are de-energized, which seldom occurs if occupants are present. Because the cost of all monitored APSs must be included in the load-sensing simple payback calculation, payback is also high. That said load-sensing might be worth pursuing for individual workstations when occupants have a variety of desk-top appliances and unpredictable schedules.

Schedule timer control, and the combination of load-sensing and schedule timer control performed better over the entire period than the load-sensing only controls. The largest portion of the savings was generally due to constant loads such as printers that were not being turned off or kitchen/workstation equipment that was not being de-energized.

Studies have shown that schedule timer controls resulted in the largest percent electricity reductions: an average savings of 33% for laptops, 50% for printers, 20% for monitors, 24% for under-cabinet lights, and 46% for shared equipment (office and kitchen combined).

The limited savings realized with the load-sensing control are due in part to difficulties in implementing load-sensing controls. Ideally, the master device would be the monitor (due to its already programmed, short time periods for entering a reduced-power state), yet when the laptops were placed into a low-power state using this load-sensing logic, they may not turn back on immediately upon reactivation. This is due to the fact that the control rules are only checked once per minute leading to a lag in reaction time for the system. Small negative savings for some equipment types can be attributed to normal variations in usage coupled with disabled or non-functioning load-sensing controls.

Opportunities for Plug Load Control

Plug loads present a great opportunity to cut utility costs throughout a home or business. Energy conservation practices and low-cost installations can save a substantial amount of energy and reduce environmental impacts. In commercial building space, the following suggestions should be considered,

General Office Space

- Turn off equipment at night and on weekends. Shut down nightly and on weekends, one desktop PC will save nearly $100 in energy costs annually. Even for office equipment with low-power sleep mode, energy is saved by shutting it off.

- Install power strips in individual offices. This allows employees to plug multiple devices into one place and makes it easy for them to shut off the power at the end of the workday.

- Use sleep or standby mode. During working hours, the use of sleep or standby mode on copiers and printers will help save significantly on energy use.

- Share printers. Printers consume a significant amount of energy, especially in office settings. Networking printers among several employees saves energy, cuts down on maintenance costs, and discourages paper waste.

Information Technology

- Establish aggressive power management settings on all computer equipment. Remind employees to enable power management features. Use network-based power management software is available that allows the information technology department to control power management settings at a central location. Switch from desktops to laptops or small form management settings for individual computers factor desktop computers.

- Server virtualization. The data servers used in most commercial facilities are among the fastest growing plug loads. However, few facilities actively manage server or data center energy use. Data centers typically consist of a variety of dedicated servers that perform specific functions. Virtualization is the use of software configurations to create *virtual*, or fake, servers that combine a number of server functions onto one machine. Essentially, software on one machine can perform the same functions previously reserved for hardware on multiple servers. Energy is saved by reducing the amount of servers used and by lowering data center cooling costs.

- Monitors. Use aggressive power management settings, minimize or disable screen savers monitors and adjust brightness settings to room lighting conditions.

- Printers & Scanners. Consolidate devices which, in some cases, companies have found generates savings of between 30 and 40 percent in reduced printer energy consumption. Printer consolidation saves money by reducing the number of devices an organization's printer fleet, and by ensuring that the remaining devices are more cost effective to own and operate. Strategies include the elimination of inkjet or other high-cost printers, the sharing of workgroup printers, and the use of multi-function devices instead of individual printers, copiers, fax machines, and scanners. Most organizations can achieve a ratio of one device (typically a networked multifunction device) per 10 or more users. Benefits include lower costs for hardware, consumables (paper, ink, and toner), electricity, and maintenance.

Break Room

- Vending machines. Refrigerated vending machines, common in commercial buildings, are often overlooked from an energy-use standpoint. According to the U.S. Department of Energy, vending machines use an average of over 3,300 kilowatt-hours (kWh) of electricity per year. At an average of 10 cents per kWh, the annual operating costs can exceed $300. Consider installing timers or occupancy sensors on vending machines so they only turn on when someone is present or when necessary to maintain product temperature.

- Water coolers. Water coolers use a significant amount of electricity—about 800 kWh a year. Use timers to shut them down at night and on weekends.

- Coffee makers. Commercial coffee makers waste a significant amount of energy heating water overnight. Save energy by attaching a timer that will turn it on just before the workday begins. If possible, use a coffee maker designed for residential use. They consume far less energy and are much easier to control.

Buy the correct equipment

By purchasing the right type of equipment and putting some thought into the arrangement, you will save energy and increase productivity.

- Size equipment properly. Energy use varies significantly among printers and copiers; only buy equipment with only the needed features. Moreover, for most office applications, laptop computers are just as efficient as large, desktop models, and use up to 75% less energy.

- Choose multi-purpose machines. Machines that copy, fax, print, and scan, not only save space, they also save energy by eliminating the standby energy loss of four separate machines.

- Purchase energy-efficient equipment.

Chapter Summary

In most cases, schedule timer controls will achieve the highest energy savings. Load-sensing and combination controls provide somewhat limited savings. This type of control is more complex and requires users to set a threshold for the load of a “master” device. When the “master” goes above or below that threshold, the “slave” outlets are powered on or off. Many companies have found that is it to set the load threshold for some equipment, such as monitors. Without metering monitors before the load-sensing controls are implemented, it is hard to know what the “in-use,” “standby,” and “off” power draws are.

Monitors were initially used as the “master,” and the laptop and workstation peripherals were the “slaves.” This resulted in equipment being powered off when the occupants needed them to be powered on. This control strategy was eventually dropped in favor of a more conservative approach where laptops were not controlled with load-sensing, and only the peripheral equipment was controlled (with the monitor as master device).

APS are a great way to reduce plug-loads for equipment that (1) is used on a predictable schedule, and (2) is left powered on during non-business hours, weekends, and holidays. If this product were to provide some sort of "smart" load-threshold setting functionality (i.e., the plug strip would set a load threshold based on the load profile of the device that it is attached to), there is a potential for significantly saving energy during the daytime when occupants are not at their workstations.

In general, schedule timer and load-sensing controls are effective in saving energy for office equipment. There are advanced plug strips on the market that incorporate one, but not both, of these technologies and have an MSRP (manufacturer's suggested retail price) of approximately $20 to $60.

Another key factor is that user education is important. Users need to know the following: (1) how the plug strip will help them to save energy, (2) what actions are required on their behalf to save energy (i.e., do they need to put their laptops into standby for their monitors and peripherals to turn off), and (3) how to override or reset the plug strip if it is not functioning properly or if the equipment is occupied outside of the defined schedule. Occupant feedback indicates a lack of education and thorough education programs are recommended control programs. Schedule timer controls are simple and easy to understand for users, which should result in energy savings. Load-sensing controls are more complicated and difficult to understand and may lead to complaints or disabling of the control strategy, which, of course, minimizes the energy savings.

Chapter 3
Smart Power Strips

In the previous chapter we reviewed the different types of control strategies that may be employed to reduce plug load energy consumption and the effectiveness of the different strategies. In this chapter we will review a few of the products that are commercially available and currently being used as APS's.

Consider using "smart" power strips to reduce the power consumed by task lighting, computer accessories, fans, space heaters, and other miscellaneous plug loads in cubicles and offices. Since it's not always practical to unplug these items whenever you leave your desk, "smart" power strips can effectively do so for you. There are five types of "smart" power strips (with variations and combinations of each):

1. Timer Control
2. Occupancy Sensing
3. Load Sensing
4. Remote Control
5. Informational Controls

We will now look at a sample of the commercially available products in each of these categories. Please note that this section mentions specific manufacturer's products and the model numbers and the specifications may have changed since this was written. You must verify the correct product with the manufacturer before selecting one of these products.

1. **<u>Timer-equipped</u>**

These power strips have outlets that are controlled by programmable timers. Devices plugged into them can be scheduled to automatically turn off or on at designated times of day or night.

Turning devices on and off with a timer ensures energy savings over night, and on weekends and holidays.

Timers are a good option in cases where, for example, a laser printer or a copier requires a long warm-up. Timers are also a good option with set-top boxes and modems. Many set-top box hard drives unnecessarily draw power 24 hours a day, seven days a week, even if the user has not asked to record programming during all of these hours.

Timers can turn off devices such as set-top boxes and modems during the hours when consumers know they will not need to record shows or access the Internet, thereby reducing annual energy use significantly.

Belkin Timer APS Model # CNS08-T-06 is a device that can control power at a workstation and reduce standby power automatically at a given time.

The average workplace is filled with electronics that use energy day in and day out. Over time—and over an entire organization—this wasted energy adds up and drives up electric bills. The Belkin *Conserve Surge with Timer*™ is an easy-to-use cost-saving business solution that helps reduce the energy wasted by office electronics by turning them off automatically, right at the workstation.

This APS has a convenient timer button that sits on the user's desk. At the start of the work day, the user clicks the button to power up desktop electronics. This also starts a timer with a duration of 11 hours. At the end of the 11-hour time period, the APS automatically turns off power to electronics—eliminating wasteful standby power. For even more savings and to maximize energy conservation, the user can click the button to turn devices off manually, like an ordinary on/off switch.

The Conserve Surge™ controls six Auto-Off outlets for desktop electronics like computer monitors, printers, external hard drives, speakers, chargers and more. Two always-on outlets stay on for devices that need continuous power, like fax machines or desk clocks. The time controls six auto-off outlets for desktop electronics like computer monitors, printers, external hard drives, speakers, chargers and more. There are also two always-on outlets for devices that need continuous power like fax machines or desk clocks. It's the easy way to reduce electric bills and save energy throughout the office.

2. **Occupancy Sensing**

Occupancy sensing power strips have outlets that are controlled by a motion detector. Devices plugged into them can automatically turn off or on in response to a physical presence, or after a user-defined period of time elapses (e.g., anywhere from 30 seconds to 60 minutes). These smart plug strips usually have one or two outlets that are always on, meaning that they remain constantly powered and are not affected by the occupancy sensor.

The *Isole IDP-3050 Power Strip with Personal Sensor*™ is an example of an occupancy sensor type APS. The power strip provides a high degree of surge suppression that protects connected equipment against threats like power surges, lightning strikes and voltage spikes. It features a resettable circuit breaker and two LEDs that indicate that the outlet is wired and grounded properly and the surge protection is functioning. It consists of an eight-outlet power strip and a personal occupancy sensor.

The IDP-3050 turns plug load devices on and off based on occupancy. The personal sensor connects to the eight-outlet power strip with the attached cable. The power strip contains six outlets controlled by occupancy and two outlets that are uncontrolled. The IDP-3050 automatically turns all controlled devices on when the workspace is occupied, and off when the workspace has been unoccupied for the user-defined time delay. Uncontrolled devices remain on regardless of occupancy.

The motion sensor uses passive infrared (PIR) technology to detect occupancy and has a120° field of coverage and a range of up to 300 square feet. The APS has a user-adjustable time delay of 30 seconds to 30 minutes. The motion sensor may be mounted under a desktop to minimize “false ons” and ensure reliable operation to the user. See Figure 4 below.

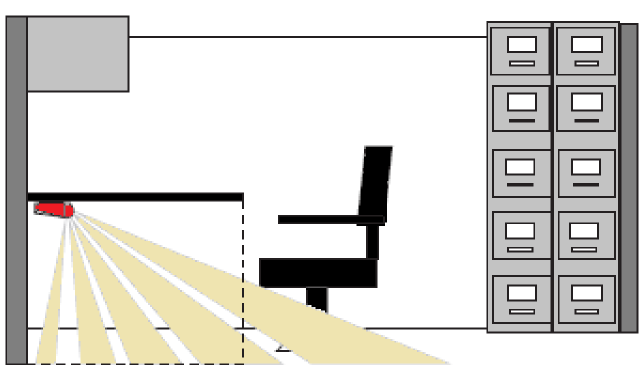

Figure 4

The IDP-3050 is ideal for controlling task lighting and computer monitors. Additional devices for the controlled outlets include space heaters, fans and other equipment that can be turned off during unoccupied periods. Devices such as CPUs and fax machines should be plugged into the uncontrolled outlets. Applications include workstations, open office cubicles, offices and engineering stations. Figure 5 shows a schematic view of the Isole IDP-3050.

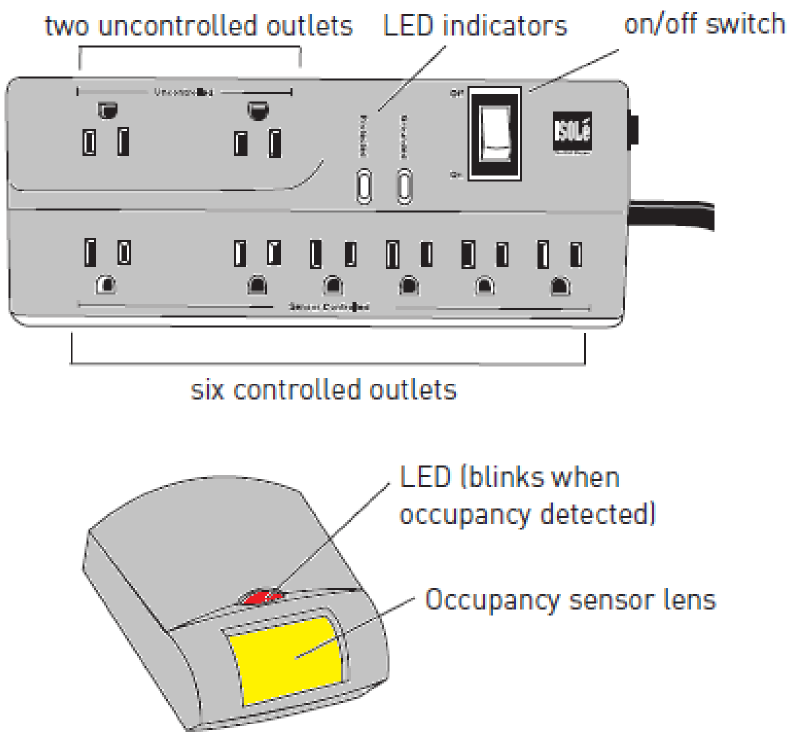

Figure 5

Another option for a motion sensor type APS is the *PlugMiser*™ device. This is a simple and practical approach to power control. The PlugMiser uses a passive infrared (PIR) sensor to power down electrical equipment when not in use. Its 1,230 Watt capacity ensures that a large assortment of loads can be safely controlled. When someone comes within range of the equipment, the device automatically powers it back up.

PlugMiser saves energy on all types of plug-loads, including arcade games, computer monitors, task lights, radios, copiers, personal printers, space heaters and more.

The Miser controls the room PlugMiser's built-in sensor repeater allows several pieces of equipment to be controlled with multiple PlugMisers using only one PIR sensor.

Invisible to the user, PlugMiser is easy to install and features a built-in, selectable power-down delay and a programmable automatic power-down delay for easy installation verification. It has user selectable timeouts in the range of 3 seconds, 15 minutes, 25 minutes, 1-hour, 2-hours, and 3-hours.

These units are not ideal for modular offices because these types of offices are not always closed off from other potential sources of false triggers. Sensor placement is important to ensure there are no false triggers. However, the unit should work in cubicle offices with four walls which are each higher than 5 feet.

PlugMiser™ is capable of controlling copiers as long as the power requirement of the copier does not exceed 12 amps steady state. When using PlugMiser™ on copiers, it is suggested that the timeout be set at either 2 or 3 hours demanded by the activity near the copier. The copier will stay powered on during the day, so no one is inconvenienced by the warm up delay of a copier that has been turned off.

Another, even simpler, occupancy control is the Sensor Plug™. This device has one outlet and simply plugs into an existing outlet. It has two controls, one to select the type of device being controlled and the other to set the time delay to shut down.

The first control is a slide switch that allows the user to select either lighting products or non-lighting products. The first position is for lighting products and turns on when motion is detected only if the ambient light level is low. The second position is for the non-lighting products and turns on whenever motion is detected.

The second control is the variable time and allows the user to choose a time delay of between 2 and 6 minutes. After this time, the device will be powered off if motion is not detected within this time.

3. **Load Sensing**

These power strips can automatically turn several outlets off or on when they detect that a monitor (plugged into the "master outlet") either enters a low powered sleep mode, is turned off, or is turned on. Used in combination with monitor power management features, these power strips can turn just about any electric device off and on automatically.

For example, if the control device is a computer, the load sensor would detect when the computer enters sleep or standby mode, and then disconnect power to the other devices plugged into that strip. As with the occupancy sensing plug strips, load sensing plug strips usually also include always on outlets that are not affected by the control device. Within this category, there are several different models and options. Some have a user-adjustable threshold that can be tuned to correspond to the current the device draws in sleep or standby mode.

Note that load sensors are dependent on the power state of the control device; the controlled devices will be shut off only as often as the control device is powered down. If the threshold of the control device is set incorrectly, the smart plug strip will not detect the reduced current, and peripherals will not turn off.

The LCG *Energy Saving Smart Strip Surge*™ works by monitoring the power increase or decrease, by turning a device "on" or "off" through The *Control outlet*. Then based on the change of the power draw through that outlet the Smart Strip automatically supplies, or removes power, respectively, to the ancillary. Figure 6 is a photograph of the LCG Energy Saving Smart Strip.

Figure 6

This particular device has one control outlet, 3-"hot" outlets (always on) and 6-automatically switched outlets (shown in green). The switched outlets are controlled by the blue outlet. This unit consumes 0.35 watts in stand-by mode, not including the current draw of the devices plugged into the control outlet or "hot" outlets.

The American Power Conversion Corporation's (APC) power sensing strip, model number P7GT, is a 7-outlet, surge protector, plug strip that contains a master control outlet with three slave outlets and three additional un-switched outlets.

When the master control outlet detects that power use has fallen significantly (i.e. the computer plugged into the master control outlet is switched off or goes into sleep mode), the three switched outlets automatically shut off.

A typical application for this product is to plug a cable TV box into the master control outlet and peripherals such as the TV, AV Receiver, DVD Player, etc into the switched outlets. When the cable box is turned off, the power-saving surge protector automatically shuts off power to all of the other devices eliminating phantom load losses from those devices.

"Master/Controlled" outlets are designed to detect when the desktop computer is asleep where it then automatically powers "off" connected peripherals to prevent wasteful power consumption.

Another form of load sensing APS is a *USB controlled* smart strip. Smart plug strips using USB interfaces plug into the computer via a USB connection. When the computer goes to sleep or is turned off, a signal from the USB port shuts down the flow of power to peripherals (e.g. printers, scanners, modems, speakers, and standby lights).

Smart plug strips using USB interfaces plug into the computer via a USB connection. When the computer is turned off, a signal from the USB port shuts down the flow of power to peripherals (e.g. printers, scanners, modems, speakers, and standby lights). This technology is applicable to commercial and home offices.

One such device is the USB smart plug strip model from Ecostrip. The Ecostrip was first introduced in Europe in 2005. According to Ecostrip, sales have grown rapidly in Europe since that introduction.

EcoStrip 2.0™ is an energy saving power strip with surge protection. The device acts like other load sensing APS's in that when the computer is turned off, power is shut down to peripherals eliminating the vampire drain of electricity. The difference is the signal is from a USB connection on the computer. The USB device will sense the computer shutting down and shut down the ancillary devices. Figure 7 shows a diagram of the EcoStrip 2.0.

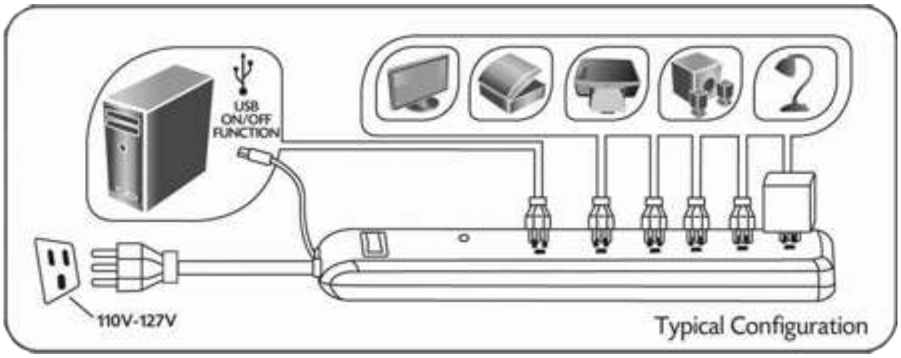

Figure 7

4. <u>Remote Control</u>

Remote control schemes are really “dumb” smart strips. These smart plug strips use wireless remote controls. The advantage of the remote control smart plug strip is that it is a convenient way to control exactly when devices receive power or don’t without having to reach below desks, behind home entertainment equipment, or around furniture to access inconvenient places where plug strips are typically located.

This technology enables a consumer to disconnect power to all devices plugged into the strip using a small remote control. The advantage of the remote control smart plug strip is that it is a convenient way for consumers to control exactly when devices receive power or don’t without having to reach below desks, behind home entertainment equipment, or around furniture to access inconvenient places where plug strips are typically located. The disadvantage of this technology is that, to save energy, users must be highly motivated and remember to use the remote to turn off the strip.

Belkin manufactures a device they call the *Conserve Switch AV Surge Protector with Remote™*, Model # F7C01008q.

This device allows the user to control power to an entire suite of devices with a single click. The remote allows the user to shut off power—including standby power—to all entertainment electronics with one touch of the wireless remote switch.

The wireless remote controls six "remote-switched" outlets for all components: TV, DVD player, VCR, gaming console and more. Two "always-on" outlets stay on for devices that need continuous power, such as a DVR. The remote may be placed in a convenient place such as a table or shelf, or mount it on the wall to avoided bending down behind equipment or under desks to shut down equipment.

5. Informational Devices

Informational smart plug strips incorporate power meters and display screens to show the user how much electricity each of the devices plugged into the strip uses. These are not really control APS's but they are very useful. Informational plug strips may also display power, voltage, power factor and/or current.

The device shown on the right is made by P3 International and is their P4400 unit. It helps users monitor usage of plug loads and reduce energy costs. To use the device, simply plug the easy-to-use device into the wall and connect electronics to the power strip to monitor the usage and to verify the effectiveness of the various operating modes. This unit allows monitoring electric consumption by hour, day, week, month, even an entire year. The unit also provides monitoring of voltage, line frequency, and power factor and can measure devices with a power demand of up to 1,800 watts.

The Belkin *Conserve Insight*TM (shown of the left) is another informational device that allows the user to monitor energy usage. The Conserve Insight Energy Use Monitor assists with understanding the true impact of energy use on an electric bill—and on the environment. The unit also provides an estimate of the amount of carbon dioxide (CO_2) produced in generating the electricity consumed.

So, this device allows the user to see the cost per year to operate devices, and the cost per month.

Leaving an appliance plugged in over a period of time activates the tracking feature which projects monthly and yearly costs of operation, based on actual usage—for example, based on computer usage.

Concerns with Advanced Power Strips

When used correctly, smart power strips can help conserve energy. But it is important to think through the electronics setup to choose the best strip for the given application. There are lots of potential challenges. For instance, when choosing a power strip that uses a USB cable to detect power levels from your computer, keep in mind that many computers power their USB ports all the time. If the computer is one of these, a smart power strip plugged into the USB port would never shut anything down. However, some computers let you configure whether USB ports are powered when the computer is shut down, so with a bit of tweaking, this kind of strip could work just fine.

Smart power strips that plug into the wall can have power detection challenges, too. If the strip's sensors aren't precise enough to detect when devices go into standby mode, electronics can continue to draw power when they don't need to. Some power strip models have controls that let you adjust the voltage sensitivity. If you notice that devices are still in standby when they should be shut down, try adjusting this setting.

Motion detector smart strips may pose problems when used with some types of devices. If you plug a computer into one of these strips and walk out of the room without saving your data, you might come back to find that everything has shut down with your work unsaved. For this reason, motion detector strips are best used with lights and other devices that won't be negatively affected by sudden shutdowns.

Of course, some products, such as a DVR, need ready access to power so they can perform scheduled tasks. An abrupt power loss can also damage some devices, such as inkjet and laser printers that have a controlled shutdown sequence. The best way to turn off these products is to use their onboard power switches rather than a smart strip.

Finally, you don't have to switch to smart strips to fight vampire power. Instead, you can just remember to unplug devices or flip the master switch on your regular power strips. Most computer operating systems also have settings that will let you run your computer in a more energy-efficient mode. No matter which combination of methods you choose to save energy, in the end, you may very well see nice savings on your electrical bill and reduce strain on the environment, too.

Summary

Plug loads are a large – and growing – electrical load. Many products have standby and sleep modes to reduce usage during idle periods, but this capability is often not utilized appropriately. Control systems, which automatically reduce consumption after a preset time is the most effective method of reducing plug load energy consumption

A complex array of technologies that can meter and control office equipment has emerged in the marketplace. Control strategies that match office equipment energy use to user work schedules can save considerable energy in most office buildings. These control strategies are also effective in reducing peak demand.

Developing an appropriate plug load management process can have a significant influence on the success of energy reduction goals. This may include behavioral change mechanisms, controls systems, or other policies.

The most effective method for reducing plug loads is through a control system, which turns off plug load devices after 15 minutes of no occupancy. In office environments, plug loads can be managed through “biggest loser” type competitions that encouraging workers to manage their plug loads better than their co-workers. Informational pieces, brochures, posters, etc, have been found to be largely ineffective at encouraging workers to reduce energy consumption.

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