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MANAGING PLUG LOADS *with* ADVANCED POWER STRIPS

by Lieko Earle & Bethany Sparn

Photos by Bethany Sparn, NREL

In recent years, the number and diversity of consumer electronics used in homes has grown substantially. Look around you right now—how many devices do you see plugged in?

But the convenience and entertainment these devices offer us come at a price. They all consume energy, often when they aren't even being used. Many devices continue to draw current even when they are switched off, as long as they remain plugged into AC receptacles. According to Lawrence Berkeley National Laboratory, this standby power draw, or phantom load, can account for 5–10% of a typical home's annual electricity use. There is a solution to this problem, and it is available today. Advanced power strips (APSs) are designed to save energy in offices and home entertainment centers, where the concentration of electronics is typically high. They employ smart control strategies to shut off the supply power when electronics are not in use. Many of these devices are simple to use and can be very effective when used correctly. They come in a variety of configurations, each well suited to a particular usage pattern, so it is important to select the right one for your application. In this article, we show you how to choose the APS that best suits your client's, or your company's, needs.

Types of APS and How to Choose the Right One

When the National Renewable Energy Laboratory (NREL)—the organization we work for—first began exploring the variety of APS technologies on the market, we quickly learned that the data were limited as to how effective APSs are at energy abatement, and whether they affect the functionality of the end-use appliances they serve. For utility and government efficiency programs to incorporate plug load reduction via APSs, the technology must first be shown to be cost-effective. But this cannot be accomplished without knowing whether these devices perform their basic functions reliably. Published studies were all based on market research and occupant behavior data. These studies provide key statistics that make it easier to predict how much energy is available to be saved. But they do not address the technical capabilities of specific APS products or product categories.

To address this need, we conducted a focused laboratory study to evaluate the technical performance of APSs under common home office and entertainment center use case scenarios. The tests were guided by the February 2012 draft of the "APS Test Protocol," which was written by the APS working group headed by the Northeast Energy Efficiency Partnerships (NEEP). NREL led an industry working group subcommittee that developed the test protocol for the NREL study. Following this protocol, the subcommittee then evaluated 20 APS devices to determine whether each device worked as designed, and what, if any, behavior on the user's part was required to make it do so.

APSs have control options and configurations that differentiate them from traditional power strips. Many employ auto-switching, where the unneeded supply power is automatically shut off. Most

Phantom loads can account for 5–10% of a home's annual electricity use, but we have the tools to stop that

The entertainment center for APS laboratory tests consisted of an LCD TV, external speakers, a stereo amplifier, a DVD player, and an Xbox game console.

APSs have some outlets that are controlled and some outlets that are always on. Because the technology is rapidly evolving, many products fall into more than one category, so we organized them into seven basic types, based on our research. They are

- master-controlled power strips;
- masterless (current-sensing) power strips;
- infrared (IR)-based activity monitor power strips;
- motion-sensing power strips and activity monitors;
- remote-switch power strips;
- timer-controlled power strips; and
- USB power-sensing power strips.

Opinions vary as to which technologies constitute truly advanced power strips, but we chose to err on the side of inclusiveness because sometimes the simplest solution (e.g., a remote switch) can be just what you need for a particular application.

Master-Controlled Power Strips

A master-controlled (also called master-slave) power strip uses the power state of the "master" appliance to determine whether the supply power to the controlled outlets (where peripheral devices are plugged in) should be shut off. It works on the (usually accurate) assumption that, for example, you do not need your DVD player (peripheral) to be on if your TV (master) is off. The master appliance (your choice, but typically the TV or computer) is plugged into a special outlet that does not turn off. The controlled outlets are powered only when the master appliance is in use. Most master-controlled power strips use current sensing to determine the power state of the master appliance, and many have adjustable current thresholds so that you can control the load level that should be considered "off."

This type of APS is probably the most common. It reduces the active and standby power waste of peripherals, but it does not reduce the master appliance's energy use. It works only if you are diligent about turning off the master appliance, but it's a good choice if you have numerous peripherals and you like the convenience of not needing to turn off and unplug each device. Some master-controlled power strips designed for the home office rely on a USB connection to determine the power state of the computer. These are described below under "USB Power-Sensing Power Strips."

Master-controlled power strips generally work as designed, but sometimes they falsely detect an off state for the master if the power draw is low. The power draw of some TVs can drop substantially when the screen goes dark, which can happen when the FBI warning screen appears in a movie, or between levels in a video game, for example. We found that this can trigger the power strip to turn itself off.

Advanced power strips come in a variety of configurations.

Masterless (Current-Sensing) Power Strips

A current-sensing power strip monitors the power draw of the controlled outlets to determine whether the connected devices are on or off. If they are off, the APS shuts off the supply power to the controlled outlets. You must then take some action to restore power to those outlets. In an entertainment center, an infrared (IR) signal from a remote control may be used to "wake up" the power strip. For use in an office environment, you must usually press a button on the power strip to restore power. The algorithm the APS uses to determine when the controlled appliances are off varies. Some algorithms look at peak power use for all the connected devices and shut off the supply to all outlets when the total power has dropped by a certain percentage. Others monitor smaller groups of outlets and control each group independently.

A current-sensing APS can essentially eliminate standby power draw, because if the appliances are turned off, the supply power is automatically turned off. A current-sensing APS is a good solution if you are generally diligent about turning off your appliances when you are through using them, and your aim is to reduce standby consumption without the inconvenience of switching off your power strip manually. One downside is that you must always do something (e.g., press a button) to restore power to the outlets when you want to use your appliances again.

IR-Based Activity Monitor Power Strips

There are two different types of IR-based APS. A simple IR-based power strip uses the IR signal to activate a switch that turns the controlled outlets on and off; it is basically a traditional power strip with a remote switch. This can be a good choice if the power strip is inconveniently located (e.g., you would normally power it off when you're not using it, except that it's buried in a spider web of cables under your desk).

IR sensing can also be coupled with a current-sensing power strip. In this case, the IR signal "wakes up" the power strip and restores power to the controlled outlets. Some IR detectors can detect signals from any remote, while others must first be paired with the IR signal from your remote control. We found that this can be frustrating and is sometimes impossible.

Motion-Sensing Power Strips and Activity Monitors

A motion-sensing power strip turns off the controlled outlets when it detects no motion in the room for some period of time. Unlike many APS designs that target only standby energy use, a motion-sensing power strip turns off power to appliances when they are on but are no longer in use (assuming that motion is a good indicator of use). The motion sensor is typically attached to the power strip by a long cable so that it can be installed where it will best detect occupancy. We did not test motion-sensing power strips in our laboratory because we were studying the APS algorithms, and we felt that testing this kind of power strip amounted to testing the reliability of the motion sensors.

An activity monitor may employ a more complex suite of sensors than a motion detector. We tested one device that relied on activity from a remote control to determine whether someone was actually using the TV. If no remote control activity (e.g., changing the volume or pausing a TV show) was detected for a certain period of time, the activity monitor would emit a warning flash, and then shut off the power strip. This can be a good solution for active and standby reduction—if you fall asleep in front of the TV, or simply forget to turn it off when you leave the house, this type of APS will automatically turn it off for you. Obviously this is not the power strip to use if you like having the TV on constantly for background noise, or if you like to turn it on to keep your pets company when you leave the house.

Remote-Switch Power Strips

The on-off switch on a traditional power strip can be hard to reach if it is located behind an entertainment center or under a computer workstation. A remote switch uses IR or radio signals to allow you to turn outlets on and off remotely. Some products have a subset of remotely controllable outlets on an otherwise conventional power strip. As we said above, a remote switch is a good choice if you are simply looking for a convenient alternative to crawling behind your entertainment center to switch everything off.

Timer-Controlled Power Strips

A power strip with a timer switch can be programmed to shut off supply power during times when you know you will not need the appliance. The primary advantage of a timer-controlled power strip is that you don't need to remember to switch it off. For enhanced automation, you can also incorporate a timer switch into a current-sensing power strip, where the timer starts counting down once the APS determines that the appliance is in the off state. We did not test timer-controlled power strips in our laboratory because the control algorithm is

Selecting an APS

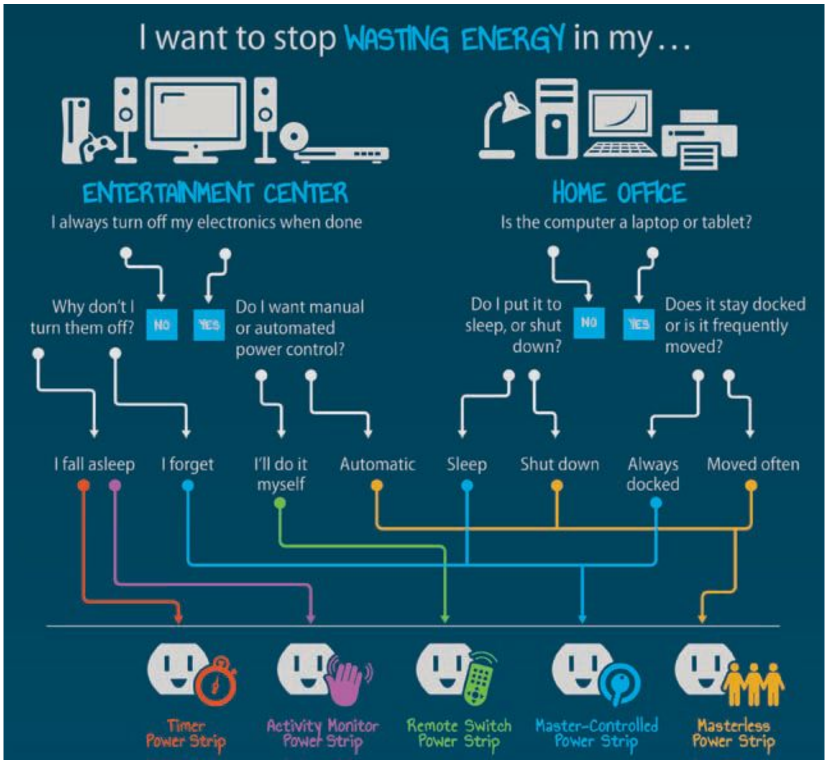

Figure 1. Depending on how your clients use energy in their homes, one type of APS may be better for them than another. This infographic simplifies the selection process.

straightforward, and we felt that testing timer functions was outside the scope of our study.

A timer-controlled power strip is great if you have a predictable schedule. Even if you don't have a predictable schedule, you can probably program it for some windows of time when you know you won't need your appliance (e.g., between 2 am and 5 am). In this way, it can be useful without interfering with your daily routine. This type of APS is often deployed in office settings to eliminate nighttime standby consumption when workers are not at their desks.

USB Power-Sensing Power Strips

The USB power-sensing APS is a variation of the master-controlled power strip. It uses a USB sensor to determine the power state of the master appliance. Designed primarily for use with computers, it relies on a USB sensor that must be plugged into the master device's USB port. Some plugs are remote; others are physically tethered to the power strip. Power supply to peripherals is shut off if the sensor determines the computer to be in an unused state. Based on our test results, USB power sensing does not appear to be a good choice for office settings, because some USB ports remain powered when computers are sleeping, while others are powered off, making it difficult to determine the use state of the computer by relying solely on USB power.

Navigating the APS World

To help you navigate the world of APSs, we've created an infographic that simplifies the selection process (see Figure 1).

We found that nearly all APS devices worked as intended, and that, with the exception of the USB power-sensing problems described above, few of them demonstrated functional problems. Some products required more user interaction than others, and more research is needed to determine the true effect of user interaction on efficiency.

The effectiveness of an APS, and how much it interferes with the use of electronic appliances, depends partly on the vintage of those appliances. Interestingly, some newer appliances have built-in energy-saving features that can interfere with the assumptions inherent in APS design.

The choice of an APS depends on your particular needs, and on your energy-saving goals, as well as on such things as price, aesthetics, form factor, and number of outlets. In most cases, products that target standby loads and those that target active loads use different control strategies; motion-sensing and activity-monitoring power strips can serve both purposes equally well, but can be more expensive than other APSs.

The energy use characteristics of, and the intelligence built into, end-use appliances continue to improve, and we do not believe that APSs will reduce plug load energy consumption over the long term. However, we feel that APSs provide an inexpensive, short-term solution to this problem. And this solution is flexible enough to target a variety of consumer electronics, including legacy devices that you may continue to use for many more years.

Lieko Earle *and* **Bethany Sparn** *are both senior engineers on the residential buildings research staff at NREL.*

>> learn more

If you have any questions about this article, contact the authors at lieko.earle@nrel.gov and bethany.sparn@nrel.gov.

To learn more about standby power, go to standby.lbl.gov.

To learn more about the "APS Test Protocol," go to www.neep.org/sites/default/files/resources/Report_APSTestingProtocolFINAL.pdf.

Figure 1 is a piece of a larger infographic, which you can view at www.nrel.gov/docs/fy14osti/60461.pdf.

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