Energy Savings Opportunities with Home Electronics and Other Plug-Load Devices: Results from a Minnesota Field Study

Scott Pigg, Energy Center of Wisconsin
Ingo Bensch, Energy Center of Wisconsin
Rana Belshe, Conservation Connection Consulting
Karen Koski, Energy Center of Wisconsin

ABSTRACT

Energy efficiency programs are seeking the next frontier of savings opportunities to meet ever-increasing goals and overcome the loss of some “low hanging fruit.” Consumer electronics and other plug-in devices – widely believed to represent a growing load – have received repeated mention as a possible source of new savings in the residential sector. Yet, we know comparatively little about what makes up this electrical load or where the savings opportunities lie.

This paper presents the results of a comprehensive study of residential plug-in devices in Minnesota. The study suggests that consumer electronics, audio-visual entertainment, and portable space conditioning devices account for 15 to 25 percent of residential electrical load in Minnesota single-family homes. On average, roughly 500 kWh per year per home (5%) could be saved through low- and no-cost approaches. In-depth interviews suggest that typical households might entertain practices that would achieve about half of these savings. However, to obtain these savings, energy efficiency programs need to overcome informational barriers that inhibit many households from taking action on their own. The greatest plug load opportunity – and the easiest to implement – lies in enabling computer power management on existing desktop computers.

Introduction

Utilities, third party energy efficiency programs, and others are under increasing pressure to effect reductions in energy use due to concern about global climate change and energy security. A manifestation of this is that end-uses that have in the past not been a major focus of energy efficiency efforts are being looked at more closely by program implementers and regulators seeking to meet mandates for energy savings. One of these areas of interest is the diverse array of home electronics and other devices that are plugged into outlets in homes. Conventional wisdom holds that these plug-in devices are a significant and growing part of electricity consumption in an increasingly dependent, connected and gadget-hungry society.

However, compared to the body of knowledge about other home energy uses, such as heating, cooling, lighting and refrigeration, less is known about how much electricity is used—and more importantly, wasted—by these devices in homes. Efforts to characterize and quantify energy use by “miscellaneous” home devices date back at least to the mid 1980s (see Meier et al. 1992), but field data have been hard to come by. The most extensive study in the U.S. to date was conducted in 2005 in California (Porter et al. 2006). That study sought to get a more accurate estimate of miscellaneous electricity use in California homes, and parse this usage by device type and mode of operation.

The study described here (Bensch et al. 2010) adds to the body of knowledge about energy use by plug-in devices in homes. More importantly, we examine here the electricity savings potential from some specific low- and no-cost strategies that could be implemented among existing devices in homes, and discuss how this potential might be realized in the context of state, utility or local programs to promote energy efficiency. Most states rely on the federal government to set energy-related standards for plug-in devices, and most state and local programs piggyback heavily on federal Energy Star labeling efforts to drive purchase decisions for new devices. What remains solidly within the purview of state and local programs are efforts to reduce electricity waste among the array of devices that are present in homes at any given time. In keeping with the interests of the study's funding sources (the State of Minnesota and Minnesota Power Company), such is the focus of this study. However, we do include a brief discussion of the implications of our data for efforts at the federal level to improve manufacturing standards and promote the purchase of efficient products.

Methods

The study relied on three nested levels of data that we collected in 2009 for Minnesota homes: (1) a random-sample telephone survey completed by 1,013 Minnesota households; (2) a mailed appliance survey completed by 260 households; and, (3) on-site data collection and interviews involving 50 households.

The telephone survey collected demographic and attitudinal information, as well as saturation data for televisions, computers and a few other devices. The appliance survey collected saturation information on many types of devices, and also gathered more detail about these devices (e.g., type and size of television, computer operating system, etc.).

The on-site data collection involved: (a) conducting an inventory of all visible plug-in devices in the home (excluding lighting and major appliances); (b) metering a subset of these devices for approximately a month; and (c) conducting a detailed interview with the household at the end of the metering period about energy using habits, motivations, and inclination to adopt specific energy-saving practices based partly on feedback from the metering. Across the 50 on-site homes, we inventoried 1,624 devices, and inferred the existence of a small number of additional devices from the survey data.

The meters used on individual devices recorded six-minute time series data of elapsed watt-hours, minimum and maximum watts (for some devices, we recorded data at 90-second intervals). The metering was focused on home electronics (particularly computers, televisions and the peripherals associated with these), but we metered a wide variety of small appliances and other devices as well. We metered an average of 16 devices per home, but this ranged from five to 30, depending on the number (and nature) of devices present. Altogether, we metered 705 devices in the 50 homes in the on-site sample.

The post-metering interviews were conducted when the meters were picked up, and lasted from 20 minutes to more than two hours. The interviews included talking about any strategies that the household had employed to reduce electricity use, and their level of interest in pursuing additional strategies. The interviews also included reviewing preliminary results from the metering data, gauging the household's level of interest in these, and discussing specific savings strategies related to devices with apparent savings opportunities.

All three levels of data collection occurred in four separate rounds (to help ensure seasonal balance), starting in December 2008 and ending in October 2009, and were geographically and demographically stratified and weighted to help ensure that the final samples were statistically representative of the population of Minnesota homes. Note that while the telephone and appliance surveys included renters, the on-site data collection (and the results presented here) is confined to single-family, owner-occupied housing. While this study's focus was on Minnesota, comparisons with a preceding study in California suggest that most key results have fairly widespread applicability. The main exception would be results for portable heating, cooling, and dehumidifying devices.

Results

Electricity Use by Plug-In Devices

We estimate that plug-in devices in Minnesota owner-occupied homes use an average of about 2,300 ± 700 kWh per year per home, or roughly 15 to 25 percent of typical electricity use in Minnesota homes.[1] About 60 percent of this amount (1,300 ± 400 kWh per year) is attributable to the three home electronics categories of televisions, computers and audio, and their various peripherals (Figure 1). Electricity use by televisions dominates usage in home electronics due to a combination of the ubiquity of these devices (the average home has three sets), relatively high power consumption among home electronics devices (about 90 watts on average), and frequency of use (the average TV that we monitored was used for about 4 hours per day). Although LCD televisions make up only about 20 percent of the televisions in Minnesota homes, our data suggest that they constitute about 40 percent of TV electricity consumption.

Plug-in devices for heating, cooling or otherwise maintaining indoor comfort constitute almost a quarter of the total above. However, our estimates here are somewhat tenuous given that we could only meter these seasonally variable loads for a month-long period for only about a dozen homes per season. Note also that usage in this category is likely to differ substantially in other climate regions.

The data suggest that about 20 percent of plug-load electricity use is for standby mode. Electricity consumption in standby mode dominates for some devices, however, such as printers. Furthermore, some active mode usage clearly results from devices being left running while they are not being used, such as computers and compact stereos that we observed being left on for days at a time.

After allowing for climate differences, the above figures are somewhat higher than the 2005 California study, which estimated 1,000 to 1,200 kWh per year for plug-in devices excluding portable HVAC devices. After deducting the HVAC category, our estimate is about 1,700 ± 500 kWh per year per home, of which 40 to 50 percent is attributable to home entertainment (compared to 60% found for the California study), and 20 to 30 percent is attributable to computer-related devices (compared to 31 percent for the California study).

---

[1] The stated uncertainty on this estimate represents an approximate 90 percent confidence interval accounting for sampling error as well as uncertainty from estimating usage (using a hot-deck type imputation procedure) for the roughly 60 percent of inventoried devices that we did not meter.

Figure 1. Point estimates of electricity use for miscellaneous plug-in devices in Minnesota single-family homes (2,300 kWh/year/home)

Analysis of Savings Opportunities

After reviewing early data, we settled on five low- and no-cost savings strategies that we systematically considered for each home we visited:

1. Implement computer power management settings.
2. Manually unplug or disconnect devices when not in use to eliminate standby power consumption.
3. Manually turn off devices that are left on when not in use.
4. Use a timer to automatically disconnect power to a device at times of the day.
5. Use a "smart" power strip to reduce standby power consumption for peripherals.[2]

The first three strategies are no-cost actions that can be taken to reduce electricity consumption by plug-in devices—though manually unplugging devices can be greatly facilitated by using a switched (or remotely controlled) power strip instead of physically pulling the plug on a device. Also, note that Strategies 2 and 3 above require habitual action on the part of the household, while Strategies 1, 4 and 5 require only one-time implementation.

We reviewed the data for all metered devices, and flagged savings opportunities that met a threshold of offering at least 25 kWh of annual savings.[3] This threshold—which roughly represents the savings from eliminating a 3-watt standby load—was simply a way to set a lower limit on opportunities that we were willing to consider, since some small amount of savings could conceivably be obtained from just about any device.

The metering data that we collected told us when devices were turned on and off, but for the most part did not indicate whether anyone was using a device when it was turned on. Because of this, our savings opportunities for turning off devices derive mainly from identifying instances where devices were left on for inordinate lengths of time, such as a TV peripheral being left on for several days in a row. The exception to this is desktop computers: here, we considered the question of unattended idling to be of sufficient importance that we deployed portable occupancy sensors (typically for one computer per household) that provided us with ancillary data about whether someone was sitting in front of the computer when it was on.

Our analysis of savings opportunities started with assessing the technical savings potential from perfect implementation of all strategies in all cases. However, a more realistic sense of saving potential needs to account for the fact that the degree of motivation to save energy, as well as the willingness and practicality of engaging in available energy-saving actions varies across household. Furthermore, strategies that require habitual action are unlikely to be perfectly implemented all the time even by highly motivated individuals.

To factor in these limitations, we developed a high/medium/low set of behavioral probabilities (Table 1) that we applied to the technical savings estimate for each opportunity based on our knowledge of the household from the post-metering interviews. Multiplying the technical savings for each opportunity by its behavioral probability assignment gave us a second set of what we call behaviorally-adjusted savings estimates.

---

[2] A smart power strip works by disconnecting power to some outlets on the power strip when a master device (such as a television) that is plugged into a special control outlet is turned off.

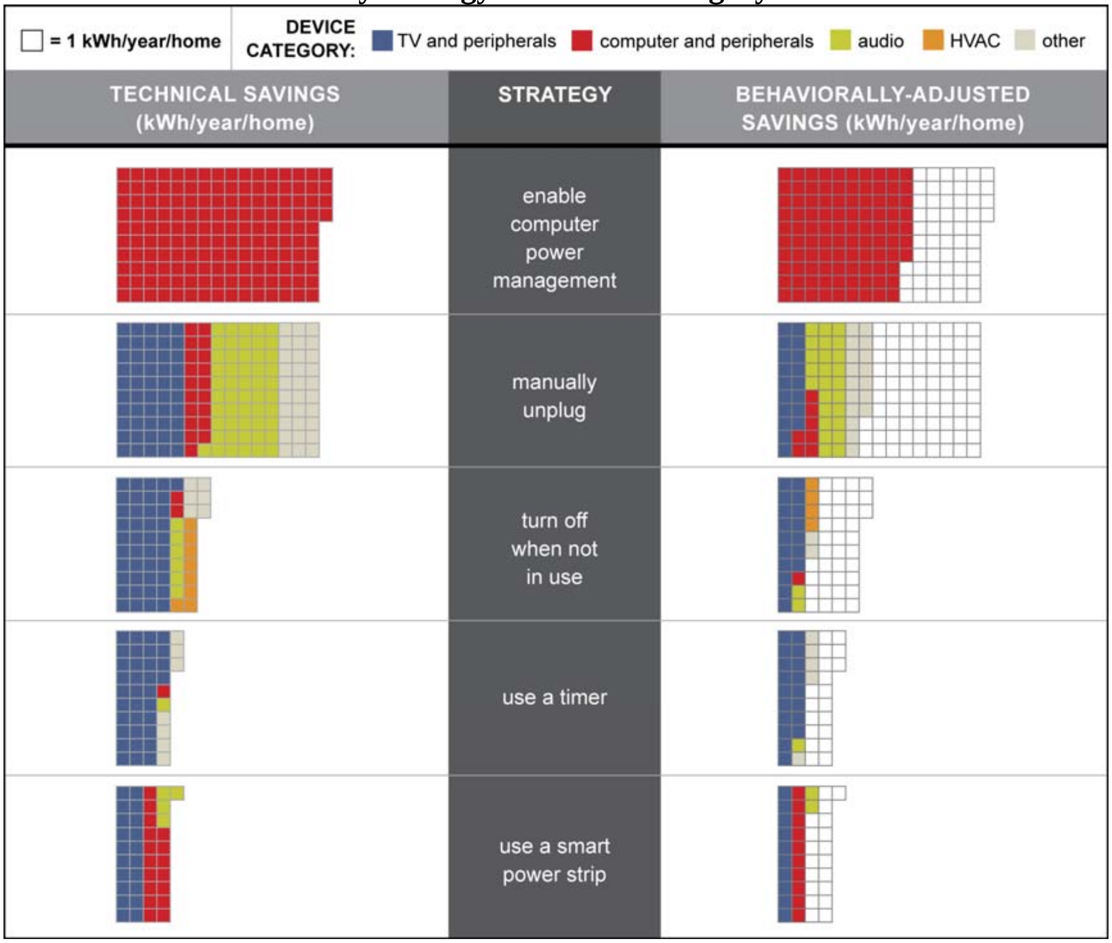
[3] We then extrapolated the findings from metered devices to the inventory of unmetered devices in homes using a hot-deck matching procedure similar to the one we used to extrapolate usage from metered to unmetered devices.

The results of this analysis suggest that there is an average of about seven savings opportunities per home involving the five strategies we outlined. Together, these have the potential to reduce electricity consumption by about 450 ± 180 kWh per year per home if fully implemented, or about 240 ± 80 kWh per year per home when adjusted for level of interest and imperfect implementation, representing roughly 5 and 2.5 percent of total electricity use in Minnesota homes, respectively.[4] Figure 2 and Table 2 show how our point estimates of these technical and behaviorally-adjusted savings opportunities map out by strategy and device type.

Table 1. Behavioral probability assignments

	Requires habitual action?	
	No	Yes
High	85%	66%
Medium	50%	33%
Low	15%	0%

Figure 2. Point estimates of technical (451 kWh/yr/home) and behaviorally-adjusted (236 kWh/yr/home) no/low-cost savings opportunities per home, by strategy and device category



---

[4] The confidence interval for behaviorally-adjusted savings estimates reflects sampling and imputation uncertainty, but not uncertainty in our behavioral probability assignments.

Table 2. Distribution of opportunities and savings by strategy

Strategy	Percent of opportunities	Percent of total estimated savings	
		Technical	Behaviorally-adjusted
Computer power management	10 ± 5%	35 ± 10%	40 ± 15%
Unplug manually	50 ± 10%	30 ± 10%	30 ± 10%
Turn off manually	10 ± 10%	15 ± 20%	10 ± 20%
Timer	15 ± 5%	10 ± 5%	10 ± 5%
Smart power strip	15 ± 5%	10 ± 5%	10 ± 5%

Stated confidence intervals are at an approximate 90% confidence level, and account for sampling and imputation uncertainty. All values are rounded to the nearest five percentage points.

Computer power management (about 40% of identified potential). The telephone survey revealed a saturation of 0.84 desktop computers (and 0.56 laptops) per single-family home. From the metering and occupancy-sensor data, we were able to classify desktop computer operation into four categories:

- <u>always on</u> (about 20% of systems) — computers that were typically left running continuously;
- <u>long idle periods</u> (about 40% of systems) — computers that were not left on continuously, but that often idled for long periods when no one was at the computer;
- <u>off when not in use</u> (about 25% of systems) — computers that were regularly turned off when not being used; and,
- <u>not used much</u> (about 15% of systems) — computers that simply were not used much.

Computer power management offers a savings opportunity for the first two patterns of use above by automatically putting the computer into a hibernation or sleep mode after a period of inactivity. We were able to check the operating system's power management settings for 32 desktop computers: we found that while about 80 percent of systems automatically powered down the monitor (typically after 20 minutes of inactivity), only about 20 percent had sleep/hibernate enabled for the computer itself. At an average active-mode power draw of 70 watts for a desktop computer, this translates into a significant power management savings opportunity in about two out of every three Minnesota homes.

Moreover, we found a high degree of interest among households in enabling power management. In fact, 18 households immediately implemented standby and/or hibernate for their systems when our post-metering interview revealed to them such a setting was available but not enabled on their computer. This suggests that the main barrier to widespread adoption is lack of awareness rather than lack of willingness. Taken together, the potential for substantial electricity savings, high willingness, and relative ease of effecting new settings all suggest that this strategy is highly worthy of pursuit for states and utilities looking to address in-home savings opportunities.

From an upstream perspective, large manufacturers have shipped computers with power management enabled by default since about 2006 (Tiernan, 2010), and the current Energy Star specification for computers (Version 5.0, which took effect in July 2009) requires Sleep-mode activation within 30 minutes. As older systems are retired—and as laptops, netbooks and other mobile devices supplant traditional desktop systems—the incidence of this opportunity can be expected to decline naturally.

Manually unplug (about 30% of identified potential). Unlike computer power management, where the savings are concentrated in a small number of devices of a single type, the "unplug" category comprises a more diverse array of devices and generally smaller savings per opportunity. However, four types of devices make up about 80 percent of the savings opportunities that we identified in this category:

- Some compact stereo systems that we metered drew 20 to 30 watts continuously, and offered up to 200 kWh per year of savings if kept unplugged.
- Older CRT televisions drawing at least 5 watts of standby power still made up about 20 percent of TVs in Minnesota homes at the time of the study (which occurred during the U.S. switchover to digital broadcast TV).
- Computer printers that we metered were typically used for only a few minutes per week, but drew an average of 4.5 watts when not actively printing.
- Some TV peripherals were not used at all during our month of metering, and could be left unplugged most of the time. VCRs and (more prevalently) VCR/DVD combination players made up the bulk of these opportunities. At least some of these are probably legacy devices that are no longer used.

Manually turn off (about 10% of identified potential). We observed instances of devices like DVD players that were used for a couple of hours and then left in an active/idle mode for days thereafter. Our data also suggest that about five percent of televisions (representing about 20 percent of TV electricity use) are routinely left on overnight. And we observed three cases where stereo receivers were left on for most or all of the month-long monitoring period.

However, a significant portion of the identified savings in this category also arose from unattended or inappropriate use of portable HVAC or other devices that used a significant amount of electricity, including a space heater in a basement bedroom that had been turned on by a guest and was still running in early June, and a shoe dryer that the household simply left running continuously. Opportunities such as these were relatively rare (about one in 20 homes), but offer substantial electricity savings when they occur.

Timers (about 10% of identified potential). We considered the use of timers for devices that are typical left on continuously, but that could potentially be disconnected from power overnight or routinely at some other time of day. Three types of devices readily fit this category: satellite and cable set-top boxes, computer networking equipment and cordless tool chargers.

Set-top boxes consume a significant share of plug-load electricity (see Figure 1) due to a combination of their power draw (averaging about 25 watts, but exceeding 50 watts in some cases), the fact that they draw the same amount of power continuously with no ready means to turn them off, and a saturation of about one box per Minnesota home. Putting these on overnight timers could save about 30 percent of the 200 kWh per year of electricity that the average set-top box uses. However, a number of factors thwart implementing this strategy in most cases, including long start-ups following a loss of power to the box, and the fact that newer boxes often have DVR recording capability. Moreover, we found that many households were simply leery of routinely disconnecting power to their rather mysterious and skittish set-top box.

We found that DSL and cable modems, routers, and other computer networking devices were nearly always left on all the time, and could in theory be put on an overnight timer. The savings potential is limited by the fact that these devices typically draw only 4-5 watts, amounting to about 35 kWh per year per device. Also, as more laptops and other devices connect wirelessly to these, the period of time that they are unused can be expected to shrink.

Finally, we found a few cordless tool chargers that drew 10 or more watts continuously (likely due to poor power supply design) for a tool such as a drill that typically was not used at all during our month of metering. These could be put on a timer that powered up the charger for an hour or two daily to keep the battery charged while substantially reduce the electricity wasted by the charger.

Smart power strips (about 10% of identified potential). We considered three main home applications for smart power strips: TV centers, computer centers and audio centers. In many cases, we found that the estimated savings was well below our 25 kWh per year threshold, because there were few peripherals or the peripherals drew little standby power. Some technical considerations also limit the application of smart power strips: (1) stereo receivers often play a dual role: they are peripherals from the standpoint of the TV audio, but are master devices when it comes to listening to CDs or the radio; and, (2) computer printers may suffer adverse consequences if power is disconnected without properly parking print heads. We took these considerations into account when classifying smart power strip applications.

Program Strategies

Although we found some households already engaging these strategies, many others were not. For those households that seemed inclined to implement the savings strategies we presented, the main barrier is informational in nature. In fact, we observed at least three significant informational barriers:

1. Households did not know a particular savings strategy existed. We ran into this barrier numerous times for computer power management settings. Households were willing to implement power management, but they did not realize their computers' operating systems had this feature.
2. They did not know how to implement a particular strategy conveniently. Unplugging devices to eliminate standby load is a good example. Even if households understand that unplugging some devices can save energy, they don't realize that they can use power strips and remote switches to cut power conveniently and thus avoid the need to access difficult-to-reach plugs and outlets.
3. They don't know which devices and actions make a real difference. We conducted this study, in large part, because energy efficiency professionals did not have sufficient information about which plug-in devices accounted for how much electricity consumption. How could average consumers be expected to know what devices and practices matter? We found that study participants were interested to learn which of their devices accounted for meaningful amounts of electricity usage and where the savings opportunities lay. Such information allows households to focus on energy-saving actions that will be most likely to make a difference in their electricity usage.

Energy efficiency programs seeking to harvest energy savings from plug-in devices will need to overcome these informational barriers. This could be done with various levels of interaction. Our interviews suggest that well-designed educational campaigns offer a promising opportunity to prompt energy saving practices. Indeed, it was mere information that appeared to spur numerous households in our study to enable power management without any direct prompting from us. We think that a share of desktop owners could be prompted to follow suit with a carefully designed educational campaign. The challenge lies not in providing sufficient program rebates or making an economic argument, as seems to be the case in many other energy efficiency program approaches. Instead, the challenge lies in getting the right information (that a substantial share of their computer's energy usage occurs when they are not even using it) to consumers at the right moment (when they are near the desktop and have an opportunity to follow simple step-by-step instructions on how to enable power management).

We refer to informational campaigns as "low touch" program strategies because they reach large audiences at comparatively low cost per household. Low touch program strategies have been used in public health campaigns and other efforts to change behavior. They have been used in only limited ways in the energy efficiency field—and generally without the expectation of performance (and evaluation rigor) that accompanies traditional rebate programs. Given our experience with households changing their power management settings during our interviews, we can't help but think that a focused information campaign on this opportunity in particular could achieve measurable results. Evaluation of such an effort would face some challenges due to the broadcast nature of information campaigns, but similar challenges have been successfully overcome in other fields.

We recognize that energy efficiency programs tend to operate at a higher level of engagement with their target audiences and that a "medium touch" program approach offers a potentially higher implementation rate as well as an opportunity to count the number of households that have taken a given action. Medium touch program approaches can still reach large numbers of households, albeit at a greater cost, by complementing an informational campaign with additional program support for motivated households. This support could include a "help line" that can walk callers through the process of enabling power management or provide other advice. It could also comprise providing subsidized technical aides – such as power strips, remote switches, or timers – that help customers unplug their high standby devices. Notably, utilities in some regions already provide funding for placing portable meters in local libraries for customers to be able to do their own sleuthing for wasted electricity. The information from studies such as this one provides guidance in directing motivated households about where to look for savings opportunities.

In some cases, energy efficiency programs have the opportunity to interact with customers in their homes. These "high touch" program interventions provide a piggy-backing opportunity to address plug-load savings opportunities. Here, communication can be customized to the particular devices and practices of the household, and the eye of a trained energy auditor can be enlisted to identify opportunities that might otherwise be overlooked. While the savings potential from these opportunities is unlikely to justify in-home visits solely for this purpose, existing high-touch programs such as low-income weatherization and home performance consulting services could add a formal plug-load component and capture many of the opportunities identified here.

At all levels of intervention, we recommend that messaging be focused on electricity "waste" rather than bill savings or payback. Many of the individual savings opportunities that we identified result in only a few dollars per year worth of bill savings. We found that people were more likely to respond to statements along the lines of: “Did you know that 95 percent of the electricity used by your printer is consumed when it is doing nothing but waiting for a print job?”

Implications for Device Performance Specifications

The focus of this study was on in-home strategies for reducing electricity usage by plug-in devices, and reflects a mix of new and old products. However, compared to the challenge of tracking down and addressing electricity waste after devices are in homes, it is far preferable to tackle these opportunities at the manufacturing stage. The data gathered here on how devices are actually used in homes provides some insights that we think are of use for defining performance criteria for standards and voluntary labeling programs such as the Energy Star program, particularly in the arena of home electronics.

Auto Power Down (APD) for Audio/Visual (A/V) Devices

The most recent Energy Star specification for A/V devices (Version 2.0) phases in mandatory APD starting in July 2010, requiring APD within two hours of inactivity. Our metering data confirm many clear instances when devices were left in an active-idle state for days on end, and suggest that the new APD requirements will result in significant active-mode electricity savings.

However, our data also suggest that if consumers end up disabling APD because they find a two-hour power-down annoying, a longer default APD period would still deliver significant benefits. For example, among the 63 DVD and VCR players that we metered, fully 75 percent of the active-mode electricity consumption (20% of total consumption if standby power is also included) occurred during active-mode cycles that lasted 12 hours or more. In other words, most of the electricity waste occurs for very long active-idle periods, and if the choice is between a stringent APD requirement that results in APD being disabled by many consumers versus a more relaxed requirement that most find acceptable, the latter is probably preferable.

Set-Top Boxes

While set-top boxes use a significant amount of electricity, reducing use by these devices once they are in homes appears to be difficult due to the way the devices work and how people relate to them. Voluntary or mandatory energy standards are clearly needed to effect savings among these devices. Of note from this study is the finding that nearly 90 percent of the set-top boxes that we encountered in Minnesota homes were satellite boxes. Although cable subscribers out-numbered satellite subscribers by a two-to-one margin in our sample, many cable subscribers did not require a set-top box—while many satellite subscribers had multiple boxes. Although the satellite industry may be moving to newer technology that obviates the need for a set-top box for each TV (Dulac, 2009), the Minnesota data suggest that the focus for manufacturing standards should be on satellite set-top boxes.

Automatic Brightness Control for Televisions

Televisions with automatic brightness control (ABC) adjust the picture brightness (with consequently varying electricity consumption) dynamically in response to changing room ambient levels. We metered two such units, both of which were 42-inch LCD sets of the same make and model. We observed active-mode power draw for these routinely drop by a third (from 150 watts to 100 watts) in the evening as ambient light levels dropped. Given the aggregate amount of electricity used by TVs, this suggests there may be significant promise in promoting the manufacture and sale ABC-enabled models.

Conclusions

This study confirms that plug-in devices account for 15 to 25 percent of home electricity use, and is concentrated among television and computer home electronics devices. It further suggests that there are about 250 kWh per year per home of achievable savings opportunities among plug-in devices in Minnesota homes that could readily be pursued by state, utility and local programs, with computer power management chief among these.

The landscape for these devices is changing rapidly—particularly for home electronics—and the shelf life for some of these findings is likely to be relatively short. We encourage continued field research in this traditionally data-poor area. Data such as that gathered in this study provide insight not only about where to look for savings opportunities among the mix of old and new devices in homes, but also provide real-world data about how people use their devices that is valuable in setting energy performance standards for emergent technologies.

Study participants were intrigued with the metering results. Most declared being surprised by one or more specific findings. While most surprises related to how high the standby use or monthly consumption was, a number of people were surprised by how little a particular device was using. This confirms that most people do not have a good understanding of where electricity is consumed in their homes.

References

Bensch, Ingo, Scott Pigg, Karen Koski and Rana Belshe. 2010. "Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes: A technical and behavioral field assessment," Energy Center of Wisconsin Report 257-1. May 2010. Available at www.ecw.org.

Dulac, S. (DIRECTV). 2009. Letter to Kathleen Vokes (Environmental Protection Agency), dated December 11, 2009. Retrieved from www.energystar.gov on March 7, 2010.

Meier, A., L. Rainer and S. Greenburg. 1992. "Miscellaneous Electrical Energy Use in Homes." *Energy* 17(5): 509-518.

Porter, S., L. Moorfield and P May-Ostendorp (Ecos Consulting). 2005. *Final Field Research Report*. Prepared for the California Energy Commission.

Tiernan, P. (Climate Savers Computing). 2010. Personal communication. March 3.