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FINAL PROJECT REPORT

A SURVEY OF COMPUTER POWER MODES USAGE IN A UNIVERSITY POPULATION

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PREFACE

The California Energy Commission Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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- Renewable Energy Technologies
- Transportation

A Survey of Computer Power Modes Usage in a University Population is the final report for the project (work authorization number 2) conducted by the University of California, Irvine. The information from this project contributes to Energy Research and Development Division's Building End-Use Energy Efficiency Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

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ABSTRACT

The University of California, Irvine, administered an online survey about computer power management to 2,081 students, staff, faculty, and retirees. Respondents were asked about all the computers they use at least three hours a week. Detailed information was obtained for 1,041 office desktops, 599 home desktops, and 1,729 laptops; less attention was given to tablets, computer labs, and other desktops. Respondents report an average of 30 hours of use per week for office desktops and laptops; home desktops are used less. Most computers have some kind of automatic power management reported, including 96 percent of laptops, 88 percent of home desktops, and 86 percent of office desktops. Most computers with automatic power management enable only sleep mode; more energy-saving automatic modes are less commonly reported. Respondents more often manually put computers into sleep or shutdown mode (manual power management) for laptops and home desktops than for office desktops. Manual power management is usually reported in conjunction with automatic power management rather than used alone. Office desktops are most likely to have no power management (neither automatic nor manual) and include most of the computers with no power settings enabled. Users have less control over and are less likely to change the power management settings for office desktops compared to home desktops and laptops. Sharing computers is common and affects power management behaviors. Important reasons given for leaving computers on include slow restarting and keeping computers on for updates, backups, and remote access. Other variables addressed include users' role, computer knowledge, age, and gender. A follow-up monitoring study of a subset of office desktops showed lower automatic power management rates than in the survey but agrees with the survey in other respects; implications for the survey results are explored. California taxpayers will benefit because power management behaviors will be better understood.

Keywords: Computers, energy, efficiency, power management, university, ENERGY STAR®, laptops, desktops, upgrades, monitors, sleep, hibernate

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EXECUTIVE SUMMARY

Background

A significant portion of plug load energy in both residences and businesses is used for computers, including desktops, laptops, and related computing devices. Studies have indicated that computers account for about 2 percent of California's electricity consumption.

Computers typically have built-in features providing for reduced energy consumption when the computer is not in active use. These features allow the computer to be switched to one or more low-power modes or to go into such a mode automatically. Full and proper use of these modes could save sizeable amounts of energy, but there are two interrelated challenges: ensuring that low-power modes actually use minimal power and ensuring that such modes actually get used. Consumers want functionality and convenience as well as energy efficiency, so understanding user behavior is an important part of reducing energy consumption.

Many research studies have addressed power management in computers, but no single study can cover all aspects of this issue. There are many studies in which the energy use by some pre-selected computer model or category of computer is measured, from which projections could be made of the total possible energy savings from power management; however, those estimates depend on various assumptions about user behavior. There is a plethora of literature encouraging computer users to use their power management settings and explaining how to do so. However, the effectiveness of those efforts is difficult to evaluate. There have been many energy audits of devices in use in commercial and university buildings and in residences, measuring hours of use and power levels of computers. Monitoring alone cannot determine which power settings were selected or why, or whether users are employing manual power management options, such as switching computers into sleep mode. There are also many surveys asking individuals about their use of power management; however, most of the studies on these issues have been restricted to a few questions in a broader study of energy use in households. Further, studies often blur the distinctions between automatic power management settings and manual power management actions, by not addressing how power saving modes were actually engaged.

Although there is general agreement among all of these studies that users do not shut down their computers or engage power-saving modes as often as they could, the findings, definitions and situations vary widely, so there is little consensus on estimates of power management behavior.

Purpose

This study was designed to learn more about users' behaviors toward the power management features on their desktop and laptop computers, both at home and at work. The California Plug Load Research Center conducted an online survey at the University of California, Irvine. The survey asked questions about all the computers respondents use at least three hours a week.

Detailed information was obtained about the respondents' use of office desktops, home desktops, and laptops; less attention was given to tablets, open computer labs, and desktops used elsewhere. Responses were received from 2,081 individuals, representing the four major role groups at the university: students, staff members, faculty members, and retirees. Respondents reported on a total of 3,369 computers, including 1,041 office desktops, 599 home desktops, and 1,729 laptops. Some additional information about the respondents was also gathered.

This report is organized primarily around the following issues:

- patterns of computer use on weekdays and weekends
- rates for enabling automatic power management settings
- rates for changing power states manually
- who controls the power management settings
- reasons users give for changing the power management settings or for leaving their computers on when not in use

The report further examines factors that might affect the use of power management, such as:

- age of the computer
- operating system
- the sharing of computers
- user's level of knowledge about power management
- demographic variables such as user age, gender, and occupational role (staff, faculty, student, retired)

This study focused entirely on computer usage and power management behaviors. It did not attempt calculations or projections of actual energy used or saved. However, the report does offer observations about user subgroups and different types of computers. Thus this study is a departure from most previous studies and serves to complement them.

In a follow-up monitoring study conducted in 2014, more than 100 office desktop computers reported in this survey were remotely monitored with Verdiem Surveyor software. For this subset, the automatic power management settings enabled on the computers were directly observed by researchers and the power states were measured continuously over a few weeks. The results of that study are reported in detail in a separate report to the Energy Commission. However, as the findings of that study affect the interpretation of a few of the survey results, the monitoring study is briefly described in this report, along with some of the results from that study

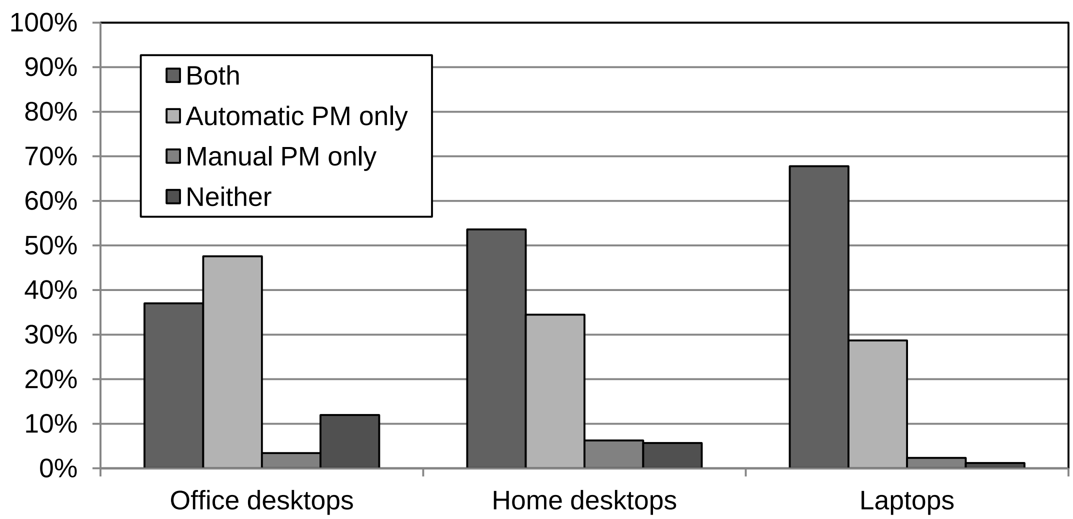
Conclusions

This report summarizes survey responses from more than 2,000 students, staff, faculty, and retirees associated with the same university. The main conclusions from the survey are summarized below.

- Respondents report enabling automatic power management in some form for most computers, often in combination with manual power management. In this survey, automatic power management was reported to be enabled more often for laptops (96 percent) than for home desktops (88 percent) or office desktops (86 percent). Manual power management—defined as switching the computer off or to a low-power mode at least 80 percent of the times the respondent stops using it—is reported most often for laptops (69 percent), somewhat less often for home desktops (60 percent), and least often for office desktops (39 percent).

  Users may engage one or both types of power management, so it is important to look at how automatic and manual power management are combined in practice. Figure ES-1 shows how the two types were combined by respondents in the survey. Using both manual and automatic power management is most common for laptops, found in more than half of home desktops, and less common for office desktops. Conversely, the use of no power management is most common for office desktops. Only a small fraction of the users rely on manual power management alone.

  Figure ES-1: Percentage of Computers of Each Type Using Combinations of Power Management: Automatic, Manual, Both, or Neither



  The finding that users report worse power management behaviors for office desktops than home desktops and laptops has particularly negative implications for energy efficiency, as desktops use more power per machine than laptops and more desktops are used in workplaces than in homes.

- Comparing the survey results to the follow-up monitoring study indicated that a large percentage of respondents in the monitoring subsample had over-reported the use of automatic power management for their office desktops. Accuracy in reporting automatic power management use is higher for participants with greater knowledge of, experience with, and control over power management settings.

- Even if reporting accuracy rates were as low for home desktops and laptops as for the office desktops in the monitoring study, the adjusted estimates would still indicate that the majority of computers exhibit at least one form of power management—either automatic, manual, or both—at least 55 percent of office desktops, 70 percent of home desktops, and 79 percent of laptops.
- Respondents report having changed the power management settings themselves for 20 percent of office desktops, 41 percent of home desktops, and 50 percent of laptops. Respondents know less about who changed the settings for their office desktops than other computers.
- Respondents' self-ratings of their knowledge about computers and knowledge of power management are both positively correlated to the likelihood that they changed their computers' power management settings.
- For home desktops and laptops, the likelihood of changing the power management settings is fairly high for respondents aged 18 to 34 and decreases with age. However, for office desktops -- over which most respondents report having little control – the likelihood of changing the power management settings is relatively low across all age groups.
- Among respondents who changed the power settings themselves, by far the most common reason given was to save energy, cited for over half of all types of computers. For laptop users, saving energy to operate on battery power for longer also ranked highly. The next most-cited reason for office desktops was that the computer needs to stay on (for instance, for backups or remote access).
- Among respondents who leave their computer on even though they will not be using it for several hours, the most common reasons given were, "Restarting it is too slow," and, "Computer will automatically go into sleep or other low-power mode anyway." The concern that others may need to use the computer was prevalent for both office and home desktops. For office desktops, two other main reasons cited were that the computer must remain on for updates or backups, or for remote access. Relatively few people reported leaving computers on because someone else asked them to, but this reason was cited most commonly for office desktops.
- Almost half the people in the sample use more than one computer, often of different types, such as a laptop and a desktop, or desktops both at home and at work.
- Sharing of computers influences power management behaviors. Overall, 31 percent of computers in this study are shared with other users, but sharing is less common for laptops than for home and office desktops. Respondents are more likely to have changed the power management settings themselves if they are the sole users than if they share the computer. Respondents who share computers were substantially more likely to say they leave those

computers on because someone else might need to use it and are indeed less likely to use manual power management steps for office desktops and laptops that are shared.

- A substantial proportion of computers have had hardware components such as hard drives or graphics cards added or upgraded. The results show no relationship between whether or not respondents have upgraded components and their automatic or manual power management behaviors.
- The age of the computer (estimated year of manufacture) is not related to whether automatic power management settings are reported nor to whether the power management settings had been changed.
- The results show no relationship between whether or not respondents are responsible for the electric bill and their automatic or manual power management behaviors.

Recommendations

These results suggest several implications for future research and government policy on computer power management:

- **Computer software and hardware should be designed to make it easier for users to know what power management settings are in place.** Many respondents reported not knowing what their automatic power settings are or whether they had been changed, especially for office desktops. Identifying the actual settings on different computers is difficult even for trained personnel. Power management settings that are easier to locate and easier to understand would allow more people who want to save energy to do so.
- **Educational efforts to improve power management behaviors should address the issues of computer sharing and control over power management settings.** People should be educated not only about power management options, but about how to communicate more effectively with their fellow users and with their IT managers about these issues.
- **The default times for automatic power management settings to transition into sleep mode could potentially be set lower and still be acceptable to many users.** The current ENERGY STAR® standards are based on having sleep mode engaged within 30 minutes, but in this sample many computers are reported to transition to sleep mode within 10 minutes.
- **Hibernate and shutdown modes should be given more prominence in the user interfaces for power settings, which currently are primarily geared toward sleep mode.** If time-to-hibernate and time-to-shutdown were included on the same screen as time-to-sleep, it is likely that more users would take advantage of these power saving options.
- **Solving the problems that respondents mention as reasons why they leave their computers on or change their power settings could increase their use of power management.** In particular, many people gave slow restart times as a reason they changed their power management settings or left their computers on. Faster restart times might

encourage such people to use power management more often. Another major problem mentioned both as a reason for changing power settings and for leaving computers on is that computers need to be on for backups, updates, and remote access. Developing reliable options for waking computers from low-power modes or shutdown could potentially result in much higher use of power management.

- **Studies of workplace computers should be complemented by more research that looks at power management behaviors for the same users' home computers and laptops.** For instance, in this study users are less likely to change the power management settings on their office desktops than on their other computers.

Benefits to California

Power management behaviors and the reasons for the behavior are better understood, which enables:

- More effective education of computer users and training of information technology managers
- More precise and realistic estimates of user behaviors toward power management
- Better understanding of the determinants of user behavior toward power management
- More effectively targeted future research on computer use and variation in user behavior
- Better design of computer restart procedures and network access in low-power modes
- Better understanding of the differences between the home environment and the office environment for computer use that affect energy saving.

CHAPTER 1: Introduction

A significant portion of plug-load energy goes into the use of computers, including desktops, laptops, and related computing devices, in both residences and businesses. Various studies estimate that computers account for about 2 percent of California's electricity end-use consumption and annually consume approximately 7.8 TWh (Delforge 2013a), and a 2011 study estimated that computers accounted for 66 percent of the energy use by IT equipment in several offices (Moorefield et al. 2011).

Computers typically have pre-programmed automatic power management settings that enable reduced energy consumption when the computer is not in active use. These settings allow the user to control how and when the computer switches to various power modes. In sleep mode, the computer reduces power to unneeded subsystems and powers RAM at a minimal level; open programs and files are held in RAM, allowing for quick revival of recent activity. Hibernation deactivates almost all computer functions, storing the current state of processes to the hard disk and then powering down. Like sleep, hibernation restores any open programs and files upon reactivation, but it requires more time to reactivate. By contrast, shutdown also powers down the computer but does not save the current processes, meaning all programs must be closed. An open industry standard exists for such settings and is used by most manufacturers: the Advanced Configuration and Power Interface (ACPI). Hybrid sleep is a relatively new option, combining sleep and hibernation; it consumes as much energy as sleep mode, but it also saves processes to the hard drive for retrieval in case of power loss.

Computers displaying an ENERGY STAR® label have automatic power management enabled when shipped by the manufacturer. More specifically, the manufacturer's sleep mode must be set to transition to sleep mode within 30 minutes of inactivity. The ENERGY STAR requirements set the sleep mode, specifically ACPI level "S3," commonly referred to as "sleep, standby, or suspend to RAM" (Intel 2009). However, the energy savings actually achieved by these default settings depend on what people do once their computers are in use. There is little consensus on if and how those settings are used, disabled, or changed, or when and how often the power mode change is made manually.

Computer users can also save energy using manual power management: specifically, turning computers off when they are not needed or manually putting them into either sleep or hibernate mode.

When considering user behavior, the two types of PM are quite different. Changing PM settings requires a certain level of skill or familiarity for the user, but once changed, the settings automatically affect computer energy use without additional user input, potentially for very long periods. By contrast, switching the computer manually into shutdown, sleep, or hibernation is relatively simple but requires regular repetition by the user to be effective.

Past research shows that too many computers are on left for long periods and spend fairly little time in sleep mode, indicating that automatic PM settings are not widely enabled (Barr et al. 2010, Mercier and Moorefield 2011, Roberson et al. 2004).Many studies have sought to define the extent of that problem and to understand why it happens. However, studying the “enabling rate” of power management is quite difficult due to a wide variation of power management settings and profiles used by manufacturers and operating systems.

The survey covered faculty members, staff members, students, and retirees on the campus of the University of California, Irvine (UCI). The responses were analyzed to find levels of, and patterns in, the usage of automatic and manual PM options. This study includes one of the largest populations ever studied for PM issues and helps in understanding a wide range of behaviors and collecting data on all the users’ multiple computers. In a follow-up study (Pixley and Ross 2014), the researchers also remotely monitored a subset of respondents’ office desktops to correlate survey results with monitoring results.

This survey is groundbreaking in several respects, addressing more combinations of issues and situations than in most related studies. By addressing both work and home, both laptops and desktops, and both automatic and manual power management, this survey advances the understanding of existing issues and raises new questions.

CHAPTER 2: Background

2.1 Prior Studies

The energy consumption of computers is affected by many factors, and prior studies of the topic have taken many approaches. Prior studies include physical measurements as well as user surveys, studies of households and studies of offices, tightly structured studies and open interactive ones, economic analyses and behavioral ones, and studies that include more than one approach. The specific findings about duty cycles and enabling rates still vary widely, and few studies have explored user behavior toward computer power management in detail.

Much of the prior research on computer power management has been device-focused rather than user-focused. That is, studies address the power states of computers over time with little attention paid toward which user behaviors cause those states. Many studies focus on directly measuring the energy consumption of some specific computer models and making projections of energy savings based on the estimated number of computers and the assumed usage pattern. Some of these studies incorporate variations depending on various possible power management (PM) settings.

Numerous studies have performed physical audits or monitoring of computers and other electronic office equipment in situ, in commercial and university buildings. These studies typically incorporate one-time measurements of power levels or long-term monitoring. For example, Roberson et al. (2004) performed physical audits of office IT equipment in three states. Schoofs et al. (2011) used remote monitoring to track 450 office machines in a university department. Barr et al. (2010) monitored more than 91,000 desktops and more than 19,000 laptops in several large companies over about six weeks. Kawamoto et al. (2004) studied computers and other equipment in offices in Japan to determine the effects of power management settings. Acker et al. (2012) monitored computers and other plug loads in six offices in Idaho to assess energy-saving interventions such as smart plug strips. Cabrera et al. (2011) monitored three computer labs at a university. Moorefield et al. (2011) monitored 450 plug-load devices in 25 offices in California. Mercier and Moorefield (2011) inventoried plug loads in a library and a small office in California, in 2010. Lawrence Berkeley National Laboratory and Ecova (formerly Ecos) have done several related studies, with support from the California Energy Commission and other sponsors.

These types of audits and monitoring studies have found that in practice a high percentage of computers were left on unnecessarily, when not being actively used, and that substantial energy savings could be possible with better power management alternatives (for example, Mercier and Moorefield 2011, Bensch and Pigg 2010, Cabrera et al. 2011, Acker et al. 2012). However, if studies have insufficient data from the users or access to the internal settings of the computer, these studies cannot determine why, by whom, or in what particular mode the computers were left on.

There have also been substantial efforts to understand residential computer use. For example, Bensch, Pigg, et al. (2010) surveyed more than 1000 households in Minnesota and monitored electricity use in 50 of those homes, including computer usage, to estimate the feasible energy savings. Chetty et al. (2009) monitored computer use and interviewed users in 20 households. Urban et al. (2011; 2012) used physical measurements as part of a national study of energy consumption by consumer electronic devices in U.S. homes. The U.S. Energy Information Administration (2013) conducts a Residential Energy Consumption Survey (RECS) of households every four years, including questions about computers. Tiedemann (2013) surveyed more than 1,400 households in British Columbia about their electricity use. Meier, Nordman, et al. (2008) used surveys and monitoring to study residential use of devices with low power modes. Overall, these studies, like the ones in commercial settings, found that computers are often left on unnecessarily and spend little time in low-power modes.

Some research, including some of the studies mentioned above, has specifically covered user behavior and PM issues, addressing either users or IT managers. Larger surveys are often focused on broader topics and are limited to only a few questions about computer power management. Urban et al. (2011; 2012) conducted a survey of energy usage by televisions, set-top boxes, and computers in 1,000 U.S. households to determine hours of active use, idle, and off. They asked questions about how long the computers were used at various times of the day and week, when computers were turned off, and how power was managed for monitors. TIAX LLC conducted a similar study for the Consumer Electronics Association (CEA) in 2006 (Roth, et al. 2006a). Dimensional Research (2009) surveyed more than 500 IT administrators and managers from around the world for KACE Systems Management; the survey focused on the managers' awareness and implementation of power management systems for the computers in the manager's organization. The study by Chetty et al. (2009) included interviews and survey questions about power management; so did the study by Bensch and Pigg (2010). The consulting firm 1E and the Alliance to Save Energy surveyed adults in the United States, United Kingdom, and Germany in 2008, asking whether and why employees turned off computers at night or otherwise powered them down (1E 2009). The RECS study asked several questions about home energy use, including one question about computer shut down and one follow-up question about computer sleep, for the primary and secondary computers in the household. The California Energy Commission has sponsored a similar study of California residences, the *California Residential Appliance Saturation Survey* (RASS), also last published for 2009 (KEMA 2010). Tiedemann, Sulyma, and Mazzi (2013) surveyed residential customers online about their energy conservation practices for computers.

Fewer studies have integrated physical measurement of computers and users' self-report of behavior. The work by Bensch and Pigg began with a telephone survey of 1,000 homes in Minnesota and mailed an appliance survey to 260 of those homes before physically monitoring 50 of them (Bensch et al. 2010). Chetty et al. (2009) focused on computer use, employing interviews as well as monitoring in their study of 20 households in the Seattle area. The study by Kawamoto et al. (2004) included surveys with the office workers to understand the impact of alternative delay times for sleep modes. The interviews provide rich multiple perspectives but typically cover smaller populations.

A few of the studies on power management discuss the possibility that a computer is shared among two or more persons, although sharing might reasonably affect each user's power management behaviors. Exceptions include the studies by Chetty et al. (2009) and Bensch, Pigg, et al. (2010). The Fraunhofer survey (Urban et al. (2011) and the TIAX survey (Roth et al. 2006a) acknowledge sharing but do not investigate it. Outside the field of energy conservation studies, analyses of domestic computer use and studies of privacy do confirm that sharing occurs, and there are popular how-to articles about setting up multiple users on one computer. See, for example, Brush and Inkpen (2007) and Simons (2010).

In addition, a few studies have considered multiple computer use by one person, particularly comparisons between a person's computer use at work and computer use at home. The Lawrence Berkeley National Laboratory (LBNL) and Ecos (now called Ecova) have done studies on home and office IT equipment, but not studying both types with the same population.

In general, these studies reveal that many computers are left on all night, that users do not often employ the possible energy-saving features, and that a substantial amount of energy is wasted during periods when computers are on but are not being used. Here are a few of the specific findings:

- A study at LBNL found among various offices that on average only 36 percent of the computers were turned off at night and only 6 percent of the computers that were not off were in a low-power mode. The study did not address automatic PM settings or manual PM behaviors, but the results suggest that both types of power management are used little (Roberson et al. 2004). The 36 percent was an average of rates that ranged among from 5 to 67 percent, but the EPA used that 36 percent figure as the default in its website's calculator for life-cycle savings for bulk computer purchases (see www.energystar.gov).
- Barr et al. (2010) found, by electronic monitoring in offices that had no corporate enforcement of PM modes, that only 7.6 percent of desktops and only 59.8 percent of laptops had automatic PM turned on.
- Bensch and Pigg (2010) found in the study of Minnesota homes that "about two-thirds of desktop computers in homes either are left on all the time or are idle for long periods each day"(p. 18) and that 26 of 32 home desktops they physically checked did not have any automatic PM settings enabled. They also estimated that better computer power management would account for about 40 percent of all the potential plug load savings they identified in households. The study found that "many homeowners were not aware that their computers were not optimally configured to save energy" (p. 19).

- Chetty et al. (2009) found that 24 of 51 home desktops and laptops in their Seattle study of 20 homes had no PM settings turned on at all.
- In a national household survey, Urban et al. (2011) asked respondents how long it took their computers to wake up after being left idle for an hour or more. They estimated from these answers that 30 percent of home desktops had the PM settings disabled, 33 percent were left in auto-sleep mode, and 37 percent were set in auto-off or auto-hibernate.
- In the TIAX survey, Roth et al. also used time-to-wake to estimate power states and found that the PM enabling rate for desktops was about 20 percent and about 40 percent for laptops (2006a, p. 4-9 and p. 4-13), also in a national household survey. They also found that the PM enabling rate for home computers was higher than for workplace computers, which had been studied in an earlier TIAX project.
- The RECS study (U.S. Energy Information Administration 2013) found that only 38 percent of the primary computers in California households with computers had "sleep" or "standby" engaged for when the computer is on but is not in use.
- 1E and the Alliance to Save Energy (1E 2009) found that 38 percent of U.K. respondents, 17 percent of German respondents and 32 percent of U.S. respondents "said they either have no idea what power scheme settings are, or how to change the power settings on their PCs."
- Tiedemann et al. (2013) found that 86 percent of the respondents in their survey of residences report using the power management settings on their computers.

The exact findings and situations vary widely. In a workshop on computer energy efficiency regulations, a staff member of the California Energy Commission noted the lack of consensus about the best figures for turn-off rates, duty cycles, or PM enabling rates (Rider 2013). The diversity of answers achieved so far has occurred partly because of a lack of information about behavioral factors that might explain the observed differences. Schoofs et al. (2011) noted that, "Usage patterns have the greatest uncertainty of any component in annual energy consumption calculations." Acker et al. (2012, p. 21) stated, "Further work is needed to better define the saving potential of behavior-based interventions." Mercier and Moorefield (2011, p. 55) observed that "differences in [desktop computer] energy consumption stemmed from variations in user behavior and power management settings (or lack thereof)." Somavat et al. declare that "the cost of electricity for computing …requires careful thought on usage behavior" (2010, p. 148). Chetty et al. (2009, p. 1034) observe that "Fewer studies explore what people would like their devices to do or account for user behaviors," Meier et al. (2008), Moorefield and Calwell (2011), and Moezzi et al. (2009) echo similar concerns.

Acknowledgement should therefore also be made to another group of studies that takes a much broader review of the behavioral issues in energy efficiency studies, such as Moezzi et al. (2009).

That review is generally critical of the "bottom-up" approach to energy efficiency, which focuses on device efficiency. The authors note, "For most developers of energy efficiency potential studies, the basic structure of these studies poses behavior as *detracting* from the potential promised by technology" (p. 14; emphasis in the original). They further note, "Automation does not necessarily provide savings over manual control" (p. 60). These authors and others argue for a broader view of possible societal changes, not simply changes in the specific behavioral steps associated with most conservation measures.

There is a plethora of efforts encouraging computer users to employ their PM settings and explaining how to do so. However, given the lack of consensus on the research findings, these efforts typically vary widely, and evaluating their effectiveness is often difficult. On its website (www.energystar.gov), ENERGY STAR has a set of activation instructions for computer users and an "EZ Wizard" that guides the reader through using power management settings, although it covers only Windows 2000, XP, and Vista. The federal government established the Federal Electronics Challenge, requiring federal agencies to be sure that ENERGY STAR power management features are enabled on their computers. (See www2.epa.gov/fec.) Many universities, cities, and large companies have websites, fliers or posters providing instructions and encouraging the using of PM options (for example, City of Irvine 2014; Picklum, Nordman, and Kresch 1999; Boston University 2010). See also the works by Bernowski (2010), Sator (2008), and Dickerson (2011).

2.2 The Study Approach

This study was designed to address some of the gaps in knowledge about power management behaviors of computer users. The approach incorporates an unusual breadth and depth of topics in a large sample, including details about all the computers respondents use and what power management behaviors they report for each one, as well as substantial information about the users. Unlike prior research, this design enables direct comparisons within the same group of users for desktops at home versus at work, as well as for desktops versus laptops.

The research team used an online survey to capture data from a broad range of people affiliated with a large university campus—students, faculty, staff members, and retirees. One of the advantages of a user-based survey is that the research team can learn not only about a wider range of users, but also about each person's experiences and behaviors toward multiple computers. By contrast, if the study were to focus on computers, it would be very difficult to learn much about the many users of each computer.

This approach enabled the gathering of data about the behaviors of many people toward their many computers fairly quickly and inexpensively. Researchers asked about all the computers each respondent used at home and at work, how much each was used, whether computers were shared with other persons, the respondent's behaviors and observations about automatic PM settings and manual PM steps, and basic demographic information.

The emphasis in this study was primarily on behavior, seeking to add information where the literature most needs it. The survey approach allowed coverage of a large number and range of respondents and allowed many behavioral questions, although it did not allow for any way of directly measuring or estimating the energy used. The research team focused exclusively on computers, excluding other energy-consuming devices, such as printers or scanners, although a question about the PM settings for monitors was included.

Unlike many other studies, this study paid close attention to the combinations of, and interplay between, manual and automatic forms of power management. Users may leave their computers on precisely because they anticipate an automatic transition to lower power, and users may also turn their computers off sooner than the automatic transition would have occurred. The decisions made may depend on the person's circumstances and the type of computer.

By studying the users rather than the computers, researchers are better able to see that many people are associated with more than one computer each, and many computers have more than one user. The one-user, one-computer model is accurate only for some subcategories of computer users and is not a realistic model for broader use.

Universities and colleges are important to study for understanding PM issues because they represent a significant portion of the adult population and a broad range of computers and circumstances for computer use. Adding the figures drawn from institutional websites shows that California universities and colleges include more than 105,000 faculty members, more than 170,000 staff members, and approximately 3 million students: in short, about 10 percent of the state's population. Second, university employees and students use a broad range of computers in many different circumstances of computer use. Academic roles and responsibilities cover a wide range of possibilities: faculty members are similar to professionals in other fields, generally working long hours and on evenings and weekends, and traveling more, yet also having more flexibility and control over their work situations. University staff members, by contrast, are more comparable to other 8-to-5 workforce groups. Faculty members and graduate students typically have different schedules in the summer than during the academic year.

A university population offers some different characteristics than the populations sampled in many previous surveys. In general, the persons at universities are more educated and more computer savvy than the public. Compared to the general population, a university population has a narrower distribution of ages (fewer children and elderly persons). However, many retirees remain active at universities as part-time staff or emeritus faculty. Retirees are about 10 percent of the California population, yet the literature on computer energy consumption has little if any information on their computer use; to the researchers' knowledge, this study is the first one. Large campuses rightly claim that they have most of the varied physical attributes of a small city—office buildings, stores, laboratories, utility systems, residences, medical facilities, and police forces. Other studies have been done at universities (a review is given in Bishop 2013), but most of those studies are about measuring energy savings in computer labs rather than studying broader ranges of behavior. A general review of IT practices at universities is given in Sheehan and Smith (2010).

A follow-up monitoring study was conducted a year after this survey. Office desktops used by a subset of 125 survey respondents were examined by researchers and then remotely monitored for several weeks. The monitoring study procedures and results are fully described in a separate report (Pixley and Ross 2014). The results from the monitoring study differ in some significant ways from the self-reports given in the survey and offer important insight to interpreting the survey results. For this reason, the monitoring study is briefly described in this report, along with relevant results.

The complete survey instrument is shown in Appendix B. This report will use the terminology in Table 1 in discussing the methods and results.

Table 1: Study Terminology

Survey	Unless otherwise noted, this term refers to the UCI survey on computer power management described in this report.
Monitoring study	Unless otherwise noted, this term refers to the follow-up study of the office desktops used by a subset of survey respondents. The monitoring study includes three types of data: remote monitoring data of computer power states, direct observations of participants' desktops, and data from a brief questionnaire administered to participants at the initial research visit.
PM	Power management, including both automatic power management settings and manual power management actions.
Respondent	Person who provided answers in the spring 2013 survey.
Participant	Respondent selected from the survey who participated in the spring 2014 monitoring study.
User	Respondent or other person who uses the computer(s) in question (one of them or none of them may be the owner). The owners of the computers may or may not be respondents in the survey, and there can be several users for one computer.
Role, role group	The four role groups designated for study are students, faculty members, staff members, and retirees. In any large university, these roles often overlap – graduate students teach classes, staff members take classes, and faculty members take on administrative positions. The survey instrument asked respondents first to designate all their roles (for instance, student and instructor, or faculty member and administrator) and then to indicate which role was primary. In the analyses reported, the primary designation is used.
Computer	In this report the term "computer" refers to desktops used on campus, unless otherwise noted. The term "desktop" is used in preference to the term "PC" to avoid implications about the operating system in use.
Type of computer	This report will use the phrase "type of computer" to refer to the three general categories the researchers have studied—office desktops, home desktops, and laptops—and within each type whether the computer is primary, secondary, or more, based on the respondent's reported hours of use per week. In differentiating among other characteristics of the computers, such as their age, operating system, or manufacturer, the report will use other more specific terminology.

CHAPTER 3: Methods

3.1 Sampling

The research team selected 7,250 subjects from the university's e-mail directory. The e-mail directory is maintained by the UCI Office of Information Technology (OIT) and draws on information from the personnel office. The team asked OIT to select 3,800 students, 1,000 faculty members, 2,200 staff members, and 250 retirees, choosing randomly within each group. In seeking to represent the whole university and have adequate numbers for analysis of smaller groups, the study slightly undersampled students and oversampled smaller groups; although students were 64 percent of the total university population, they were 53 percent of the sample.

The choice of e-mail addresses as a sampling frame did not present a significant sampling bias in a university population, as every employee and student is assigned a UCI e-mail address, which is used for official communications and announcements. The use of e-mail is almost universal. Even many retirees retain their campus e-mail addresses.

Other sampling procedures would not have been as effective for this purpose. The university telephone directory vastly underrepresents students, few of whom have publicly available phone numbers. Physical mailing addresses on or off campus would be even more difficult to gather and verify. An openly announced Web-based survey would not be randomly sampled (and thus not representative), or as readily controlled, and would likely overrepresent computer-savvy persons, creating self-selection bias.

Prior related surveys were consulted for possible questions and approaches. These sources included the U.S. Energy Information Administration's Residential Energy Consumption Survey (2013), Bensch et al. (2010); Roth et al. (2006a); Roth and McKenney (2007a); and Urban et al. (2011). The majority of the computer-related questions were pretested for comprehension and clarity through in-depth cognitive interviews with 12 people. The full online instrument was pretested in live sessions on computers with 11 people. These answers are not included in the reported results.

Since the e-mail recruitment and survey procedures required no personal contact with the respondents, researchers were able to protect subjects' confidentiality by replacing the university e-mail addresses (which usually suggest the person's name or initials) with substitute email addresses provided by OIT. When OIT selected the e-mail addresses (chosen randomly from within each of the four role groups), it also linked each to a substitute e-mail address, so that e-mails sent to the substitute addresses would be routed to the real e-mail address. These substitute addresses were coded for the role group (student, staff member, faculty member, or retiree) by using a certain range of numbers for students, another range for faculty, and so forth. Only the lead researcher had access to the links between the real and substitute addresses, so other team members conducted the communications and analyses without knowing each subject's identity. These substitute addresses thus also functioned as unique identification numbers for tracking survey responses. To help protect confidentiality, reporting of data here is in aggregate terms, usually percentages, avoiding situations in which individual identities could be inferred.

In the recruitment materials that were sent out, no attempt was made to disguise the topic of the survey, but the writers did attempt to word the study topics neutrally.

The recruitment e-mails provided each subject with a hyperlink to the survey instrument that was uniquely coded to his or her substitute e-mail address. People who clicked on that link were directed to a website where they took the survey and their answers were recorded. The survey instrument was programmed using software by Qualtrics. The researchers used Qualtrics for (a) structuring the survey flowchart and skip pattern of questions, (b) using the substitute e-mail database to reach subjects, and (c) recording answers online as given by respondents. When respondents reached the end of the survey, they were forwarded to a secure Calit2 website; there they were prompted to enter their real email addresses in a separate part of the program for verification and were automatically sent an e-mail with an Amazon gift certificate code worth $5.

The research team sent up to five follow-up email messages to encourage participation, as well as a final reminder to respondents who had saved incomplete surveys but not yet returned to finish them. All responses were stored in secure files on a Calit2 server. All responses were collected between May 30 and July 17, 2013.

The study period used is reasonably representative of the school year, at least as an average across diverse experiences. The period from late May to mid-July included just over one week of regular class schedules, one week of final examinations, and four weeks of summer. However, as the highest response rate was in the first week, almost half of the respondents (48 percent) completed their surveys by the last day of classes, and three-quarters (78 percent) finished before the academic quarter formally ended. There were no notable differences in survey timing across the role groups. The main variables affected by timing of the survey would probably be use of various computers in the previous week. For students and faculty, final exams week and the first weeks of summer could include heavier and lighter computer use, respectively—or perhaps only different computer use. For staff members and retirees, the two periods would not be as different from each other. A variation in work load over time is typical of many occupations and organizations, and thus common for studies in workplaces. Workers may not have uniform computer use over time, but experience occasional days of unusually heavy or light use. Collecting data over multiple weeks helps ensure that the overall results are not overly influenced by such anomalies.

Campus and federal procedures and requirements for research on human subjects were followed: approval by the campus Institutional Review Board was obtained, verifying that researchers were taking adequate steps to protect the privacy and confidentiality of the participants and to obtain their voluntary and informed consent.

3.2 The People Studied

The researchers received 2,047 completed surveys; 24 were rejected for ineligibility (for example, under the age of 18 or no longer with the university) or, in 3 cases, for nonsense answers. Thus, there were 2,023 valid and complete responses, a good response rate of 28 percent. Another 584 persons began the survey but did not finish it. Of those, 222 stopped after reading the introductory "Survey Information Sheet" and did not begin the survey, and 74 others did not start the third section that asked for details on their computers. (See below.) Of the incomplete responses, 58 respondents gave sufficient information on at least one type of computer to be used in certain analyses. (For example, some answered all the questions for their office desktops but not all the questions on laptops.) Thus, the total sample size including partial cases is 2,081. The partial cases cannot be used in analyses involving all of a respondent's computers, such as total computer hours per week or comparing laptops to desktops. The total number of respondents reported is therefore not always the same for each type of computer or for each question.

The respondent population consisted of 1,107 students (graduate and undergraduate), 720 staff members, 193 faculty members, and 61 retirees, as shown in Table 2.

Table 2: Role Groups Among the Survey Respondents

	Number	Percent
Students	1,107	53%
Staff Members	720	35%
Faculty Members	193	9%
Retirees	61	3%

The role group designation for each respondent was made first by OIT when it did the sampling, using the information for each person drawn from the departments for Human Resources or Academic Personnel. However, the survey asked each respondent to designate his or her primary role on a list of 12 standard academic categories, such as undergraduate, postdoctoral scholar, retired faculty, and medical staff. The survey also asked staff respondents to choose their occupation from a list of widely accepted occupational titles, drawn largely from the U.S. Census (Questions A4 and A5). These further designations make the study more reproducible in other universities or large organizations. Where respondents' self-reports of their primary roles in the university did not match the role designation from OIT, the use of the additional information made a selection straightforward in most cases. In a few dozen ambiguous cases out of more than 2,000, the lead researcher and co-lead researcher reviewed the respondent's situation more closely, without violating confidentiality, and decided the final categorization.

At a large university the four role categories encompass a wide variety of actual occupations. The sample of staff members included senior administrators, analysts, nurses, receptionists, medical support staff members, and lab technicians, among others, although very few maintenance workers, security officers, or manual laborers responded. The sample of students included all levels from freshmen to graduate students, full-time and part-time, in many majors. The sample of faculty members included full-time full professors as well as part-time instructors in extension courses. More than 80 percent of the staff and faculty respondents were full-time employees, and 11 percent were part-time. Persons on leave or absent for other reasons made up a small percentage of the sample. Thus, unlike many other studies of power management (PM) settings, this study has some information on the job category of every respondent.

The sample population consists entirely of persons aged 18 or older, but the population is nevertheless younger on average than the statewide over-18 population because the sample has a much higher percentage of young people aged 18 to 24 and a much lower percentage of persons over 65 (Table 3). The staff and faculty age groups in the sample more closely resemble the age groups studied by other researchers mentioned earlier.

Table 3: Age Distribution of the Survey Sample and of the California Population

The UCI sample		California population	
Age		Age	
18 & over	2,074	18 & over	27,958,916
			%
18-19	16%	18-19	4.1%
20-24	28%	20 – 24	9.9%
25-34	21%	25 – 34	19.0%
35-49	18%	35 – 49	28.2%
50-64	14%	50 – 64	23.6%
65 & over	4%	65 & over	15.2%

Source: California statewide data from U.S. Census 2010

The sample population includes slightly more females than the university population, which in turn includes slightly more females than the California population.

The survey instrument listed race and ethnicity categories in the same question (Question A3) and allowed multiple responses, so the resulting responses are not exactly comparable to U.S. Census data, which asks about race separately from a question about Hispanic ethnicity. In this study, the majority (81 percent) of respondents who listed themselves as Hispanic did not also select a race category, resulting in a much lower estimate of respondents who are both white and Hispanic than in the U.S. Census for California. However, it is still possible to distinguish non-Hispanic whites in the data, and the analysis treats those who selected "Hispanic" in this survey as persons who would be Hispanic by U.S. Census ethnicity categories. The survey asked about "Middle Eastern" or "Arab" as a separate category, a category that is included under "white" in the Census figures; for this table the small percentage of respondents in that category have been included with non-Hispanic whites. Finally, the survey instrument included an "Other" option, but almost all of the respondents who chose that and wrote in something could be recoded into one of the other categories. For example, "Chinese" was recoded as "Asian."

By race and ethnicity, the sample population is distinct from the state population (Table 4). The UCI sample respondents include a higher percentage of Asians than does the state population, and lower percentages of whites, Hispanics, and African Americans.

Table 4: Demographic Characteristics of Survey Sample, UCI and the State of California

	UCI Undergrads Spring 2013 (UCI data)	Sample Undergrads	Sample Population Total	California Population Per U.S. Census 2010
Gender				
Female	55%	58%	59%	50%
Male	45%	42%	41%	50%
Race/Ethnicity				
Asian	50%	57%	44%	13%
Non-Hispanic White	18%	15%	35%	58%
African-American	3%	2%	2%	7%
American Indian/ Alaska Native	1%	0%	0%	1%
Native Hawaiian/ Pacific Islander [1]				1%
Multi-Racial (not counting Hispanic)		8%	7%	4%
Other race				17%
Other (e.g., unknown, or international student)	9%			
Hispanic (any race)	20%	19%	16%	38%

[1] Pacific Islanders are included under "Asian" by UCI and in the sample.
Percentages may add up to more than 100% because of overlapping definitions.

There were notable race and ethnicity differences among the role groups in the sample. Just over half of the students (53 percent, including graduate students) were Asians, while only 21 percent were non-Hispanic whites, and 16 percent were Hispanics. By contrast, 74 percent of the faculty members in the sample were non-Hispanic whites, with only 17 percent Asian and 4 percent Hispanic. Retired persons were almost all non-Hispanic whites (90 percent). The staff respondents were the most mixed group—including 42 percent non-Hispanic white, 31 percent Asian, and 20 percent Hispanic. As shown in Table 4, the undergraduate students in the sample are similar to those in the UCI population at the time, although slightly more likely to be Asian. No further attempt was made to define and compare all the possible ethnicity groups in the sample (for example, among graduate students, staff members or faculty members) to the UCI populations because, as noted, the personnel categories used in the study (in part defined by the respondents) differ slightly from the university's personnel distinctions or external reporting requirements.

The analyses of the relationships between demographic variables and the behavior toward computer power management are shown in the last section of Chapter 4.

3.3 The Computers Studied

The study focused on computers that met several criteria: (a) types of computers that use the most energy, (b) computers for which the user would feasibly know something about the history of the computer and about other users, and (c) computers for which the user would feasibly have some control over the PM settings. For the detailed questions, the survey therefore focused on desktops used at home or at work and laptops, including computers that were shared with other users, which were used at least three hours a week.

To get a broad sense of the scope of respondents' full computer use, the survey also asked respondents to estimate how often they used three other categories: tablets, desktops other than at home or on the UCI campus (such as at a friend's house or at another job), and desktops in open computer labs at UCI (such as libraries or student computer labs). The research team excluded computers that respondents accessed only remotely from one of the computers they physically used, as well as computers that were dedicated solely to specific duties like equipment maintenance. Although smart phones can be used for many of the same functions as computers, the research team did not include them because the user's role in managing power is so different for smart phones.

The survey did not ask who purchased the computers used by respondents; ownership is not assumed from use.

Further information about the computers reported by respondents is described in Chapter 4.

3.4 The Survey

Respondents took the survey online on the Qualtrics server. To encourage survey completion, the software allowed respondents to save an incomplete survey and come back to it later. As Qualtrics records only a respondent's first start and last finish time, a meaningful average interview length could not be calculated. However, a rough estimate is possible: of the persons who started and finished the survey on the same day, more than half finished within 15 minutes and more than three-quarters finished within 25 minutes.

The survey was divided into five segments, A through E. The full survey instrument can be seen in Appendix B.

In Section A, respondents were asked questions about themselves, including their age, gender, race and ethnicity, and primary job or position at UCI.

In Section B, before asking questions about specific computers, respondents were asked to rate their knowledge and competence with computers. Next, respondents were asked to mark on a list all the categories of computers they "currently use" at least three hours a week. For computers in an open lab, tablets, and desktops somewhere other than home or campus, the research team asked only one follow-up question: the number of hours each category was used each day in the previous week. For the three main types of computers—office desktops on campus, home desktops, and laptops—researchers also asked how many of each type the respondent uses at least three hours a week. (The "campus" was defined to include the medical school and other university-controlled locations nearby.) Respondents were asked how many computers of the three main types they used at least three hours a week at home or at work. Respondents with multiple residences (which is common for students) were instructed to consider "home" as the residence where they spent the most time during spring quarter. If respondents reported using more than one computer of a given type, they were asked to assign a name or label to up to four computers of each type (such as "Mac laptop" or "Dad's computer"). The survey program displayed these names in subsequent questions to help the respondents keep track of which computer was being asked about. Other studies have considered multiple computers per household, but this study is the first to consider multiple computers for each person, both at home and work.

In Section C, respondents were asked questions about their use of each of the three main types of computers they had reported using in Section B. For each respondent, the set of questions in Section C was repeated for each computer they reported. Thus, a respondent reporting one office desktop and two laptops would have been guided through Section C three times. For each computer, the respondent was asked about the number of hours the computer was used each day in the previous week. Using a standard calendar program, the survey could provide correct days of the week to help with recall. For instance, if the survey was taken on a Sunday, the seven days would be labeled starting with "Sunday" and ending with "Saturday (yesterday)." Past survey research indicates that one previous week is a recent enough time frame for which people can reasonably recall activities.

The bulk of Section C asked about recollections about automatic power management (PM) settings, the use of manual power management (for example, turn-off rates), and reasons for changing PM settings or leaving the computer on when not in use. Some of the questions were different for laptops than for desktops, such as questions about monitors and questions differentiating between laptops running on battery power versus plugged into AC power. Other questions in Section C concerned such matters as sharing the computer with other people, the year of manufacture, the operating system used on the computer, component upgrades, and whether the computer was used for any of a list of high-energy-consumption tasks. The survey instrument avoided questions that would require the respondent to reveal the use of specific programs or websites.

In later data processing, if a respondent had reported more than one computer of each type, the researchers used the total hours reported for each computer in the previous week to order them by amount of use. For instance, the most-used office desktop was designated as primary, the second-most-used office desktop as secondary, and similarly for the third- and fourth-most-used computers, if applicable.

Some of the data analyses in this report are focused on the primary computer in each type and are designated by "primary." In some cases secondary computers are examined separately for comparison or included for breadth. A small proportion of the respondents reported three or four computers of a type. Those cases are included below where appropriate for totals, but those cases were too few for separate analysis. Where no designation is made about primary or secondary—for example, in a reference to "office desktops"—the responses are drawn from all computers of that type. Unless otherwise noted, results for all computers of one type are computer-based analyses rather than respondent-based analyses. That is, a percentage calculation for office desktops is based not on all respondents, but on all office desktops, including multiple ones reported by the same respondent, and does not include respondents who reported no office desktops.

For respondents with incomplete surveys, analyses include the data only if the person had answered the questions for all their computers of that type. For instance, say that a respondent reported having two office desktops and two laptops, but quit the survey before finishing the question set for the second laptop. That respondent's data would be included in analyses of office desktops, but not in analyses of laptops or in analyses comparing or totaling data across computer types. Therefore, the subsample size of respondents differs across analyses.

In Section D, respondents were asked about variables that might affect their decisions about power management, such as whom respondents live with, who pays the electric bill, part-time vs. full-time work status, and school or work unit affiliation within UCI. The researchers chose not to include questions about environmental attitudes or knowledge, partly to reduce the length of the survey, partly because appropriate metrics for those behavioral attributes are not yet agreed upon, and partly because such results would be difficult to translate into recommendations for improving power management.

A final Section E included only two questions. One question asked for any open-ended comments about the survey, including corrections to answers given earlier. In some cases, comments about errors or ambiguities helped us to understand apparently conflicting answers or led the research team to reexamine the respondent's prior answers and recode them correctly. The second question asked if the respondent would be willing to be contacted for a possible follow-up study later. Willingness to do so was one of the essential criteria for selection potential participants for the follow-up monitoring study of office desktops in the spring of 2014.

At the end of the survey, respondents were directed to click on a link to complete arrangements for delivery of the gift certificate to their real email addresses, by exiting the Qualtrics program and connecting to a separate secure server at UCI.

For many structured questions, respondents were given the opportunity to type in an "other" response (for example, if respondents weren't sure which category to select for their race or ethnicity, or for describing a different reason for changing PM settings). Most of the time the researchers were able to recode those answers into one of the existing response options, but in a few cases, enough respondents mentioned a response category researchers hadn't anticipated that a new code for those answers was created.

All questions were programmed in Qualtrics to require a response from the respondent before proceeding to the next question. With a few exceptions, respondents had the option of answering "don't know" or "prefer not to answer." This strategy makes the data more straightforward to interpret than allowing respondents to skip questions, as it is then not clear if questions are skipped accidentally. Also, the validity of the data is increased by giving respondents who do not know the answer the option of saying so, whereas the absence of a "don't know" option can force respondents to make arbitrary guesses. Unless otherwise noted, results shown here only included responses with substantively valid values; the substantively invalid responses of "don't know" and "prefer not to answer" are coded as missing and are omitted.

3.5 The Monitoring Study

In the spring of 2014, the research team conducted a follow-up study, directly monitoring the office desktops of a small subset of respondents from the 2013 survey. The procedures for this monitoring study are summarized here. A more thorough explanation is presented in Pixley and Ross (2014).

The research team recruited survey respondents who reported using at least one office desktop three hours a week or more, were the sole or primary user for this desktop, and were staff members, faculty members, or graduate students (specifically excluding undergraduates and retired persons). All survey respondents had been asked if they would be willing to be contacted about a possible follow-up study. Of the 572 respondents who were eligible based on the criteria given above, 372 had given permission to be contacted. Recruiting from this group produced a sample of 125 participants who completed the initial research visits; 119 participants have complete monitoring data.

Considering sampling variability, the 125 participants do not differ significantly on demographic or work measures from the 572 criteria-eligible participants and are reasonably representative of the statewide working population. The majority of participants are staff members (77 percent), with 15 percent faculty and 8 percent graduate students. Almost all participants are between 25 and 64 years old (94 percent). A slight majority of participants are female (57 percent).

The monitoring study produced three sources of data:

- First, during the software installation visit, a researcher recorded the power management profile in use and many specific automatic PM settings.
- Second, during the same visit, participants completed a brief questionnaire. They were asked about any corrections or changes to selected personal data given in the survey and whether the office desktop they were currently using was the one (or one of the ones) they had reported in the earlier survey. The questionnaire also asked whether the participant or anyone else had changed the automatic power management settings on the target desktop since taking the spring survey.
- Third, the power state of the user's computer was monitored remotely for a few weeks.

The software used to monitor the desktops was Verdiem Surveyor Version 6. Computer use was recorded for a minimum of 14 days up to 35 days, excluding vacation and travel days. Surveyor records four possible power use states of the CPU: off, sleep, on, and unknown. The software records user activity by recording mouse movements and keystrokes, recording three possible states for the user: active, idle, and unknown. These measures were collapsed into four possible computer states: CPU-off, CPU-sleep, CPU-on/user active, and CPU-on/user inactive.

One limitation of the data is that software that monitors CPU states cannot determine the cause of a state transition. A transition from CPU-on to CPU-off is registered the same way whether the computer is turned off manually or shuts down due to an automatic power management setting. Another limitation is that in the Surveyor data, hibernation mode is not distinguished from CPU-off.

CHAPTER 4:
Results and Discussion

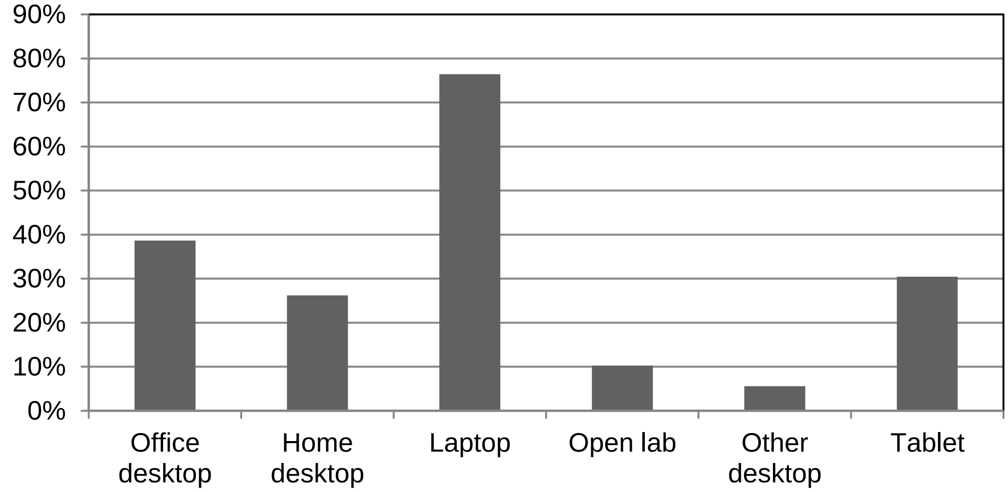
The first three sections of this chapter characterize the population of computers used by the respondents, analyzing the computers by number, age, and operating system. The subsequent section discusses the use of automatic and manual power management settings. Then other topics are covered that might be related to power management behaviors: the age of the computers, the operating systems in use, sharing computers, the respondents' self-rated computer knowledge, patterns of high-energy use, upgrading of components, the cost of electricity, and demographic variables. With data on more than 2,000 respondents, several patterns of computer use are discernable.

4.1 Patterns of Computer Use

The main focus of the study was on office desktops, home desktops, and laptops. To get a broader sense of respondents' overall computer use, the survey also asked respondents if they used three other types of computers: tablets, computer labs, and desktops in other locations and if so, how much. The minimum use threshold was defined as at least three hours in the past week; all results in this report are limited to computers that meet that criterion. This section addresses how many respondents use computers of each of these six types. Detailed analyses of hours of usage, by category of computer and by day of the week, follow in the next section.

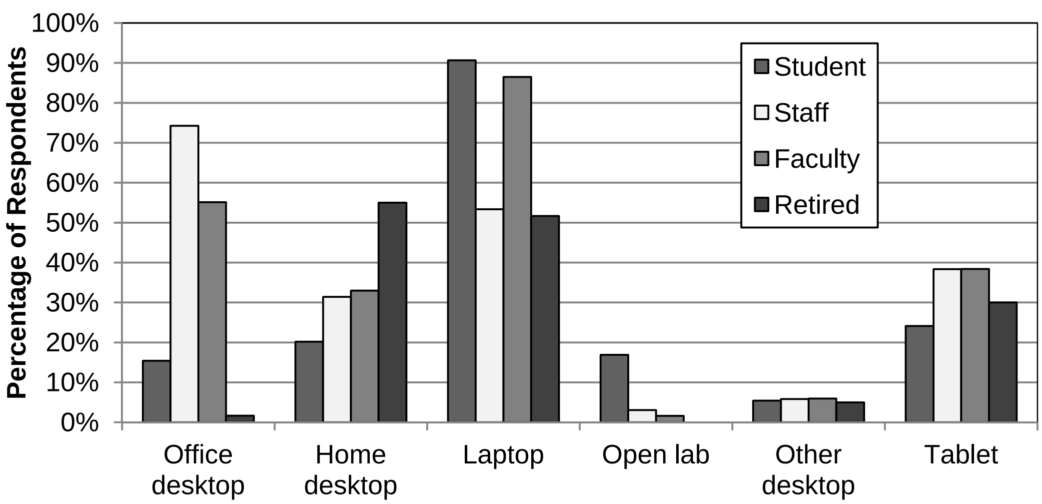
Figure 1 indicates the percentage of respondents who reported using each of the six categories of computer. As respondents can use more than one type, the percentages in the figures add up to more than 100 percent. Laptops are the most commonly used type of computer in the sample, with more than 70 percent of the respondents using one at least three hours a week. However, a substantial portion use desktops as well—almost 4 in 10 use office desktops, and one-quarter use home desktops—and 3 in 10 use tablets. The two other categories of computers were not as widely used; only about 10 percent of the respondents reported using open computer labs in the previous week, and 6 percent reported using desktops in locations other than the UCI campus or home.

Figure 1: Percentage of Respondents Who Use Any Computers of Each Category



The high percentage of respondents using laptops is partly due to the large number of students in the sample, who are highly likely to use laptops to meet their need for mobility. As seen in Figure 2, students are significantly more likely than staff members or retirees to use laptops (53 percent and 52 percent, respectively). However, students are also less likely than people in the other role groups to use computers of the other types; for example, only 15 percent of students use office desktops, compared to 74 percent of staff and 55 percent of faculty. The use of tablets exceeded the use of home desktops for all role groups except retirees, but the use of tablets is far behind the use of laptops.

Figure 2: Percentage of Respondents with Any Computer of Each Category, by Role



This study provides a rebuttal to the common impression that tablets are replacing, or soon will replace, other computers. Supplementary analysis shows that among students and staff members, those who use tablets use more total computers (desktops and laptops) on average, not fewer. Also, the total time spent using desktops and laptops is no lower for those with tablets than for those without tablets, supporting the idea that tablets supplement rather than substitute for other computer use in this sample. This finding is consistent with the observation by Rotman Epps (2010) about the role of tablets in the computer market.

The remainder of this section focuses on the three main types of computers studied here—office desktops, home desktops, and laptops. The total number of computers of these three types used by respondents is shown in Table 5, broken out by role group. Drawing from the 2,023 completed surveys, there are 981 office desktops, 588 home desktops, and 1,729 laptops, for a total of 3,298 computers covered in this study. The 58 partial surveys included in the dataset provided sufficient information on at least one type of computer to be used in certain analyses, adding data on 60 office desktops (for a total of 1,041) and 11 home desktops (for a total of 599), for a grand total of 3,369 desktops and laptops.

Table 5: Number of Computers Used at Least Three Hours per Week, by Role Group and Type of Computer

	Complete data only			Including partial data		
	Office desktops	Home desktops	Laptops	Office desktops	Home desktops	Laptops
Student	216	253	1087	230	257	1087
Staff	644	237	425	682	241	425
Faculty	120	63	183	127	65	183
Retired	1	35	34	2	36	34
Total	981	588	1729	1041	599	1729

The large number of computers (especially laptops) used by students (Table 5) is due to the large number of students in the sample rather than especially high computer use by students. Figure 3 provides a per-person perspective. On a per-person basis, faculty members use as many laptops as students: an average of 0.99 laptops per faculty member compared to 1.0 laptop per student. Staff members are more likely to use more office desktops than laptops. These comparisons point to the structural differences in the roles of student, faculty, and staff. Students and faculty spend more time moving from one classroom to another, and faculty members often travel for conferences and meetings, while most staff members can conduct their computer work in one office, allowing them to depend on a desktop (perhaps less expensive or more comfortable). Retired persons had few office desktops but had as many laptops per capita as home desktops.

Figure 3: Mean Number of Computers of Each Type per Person, by Role

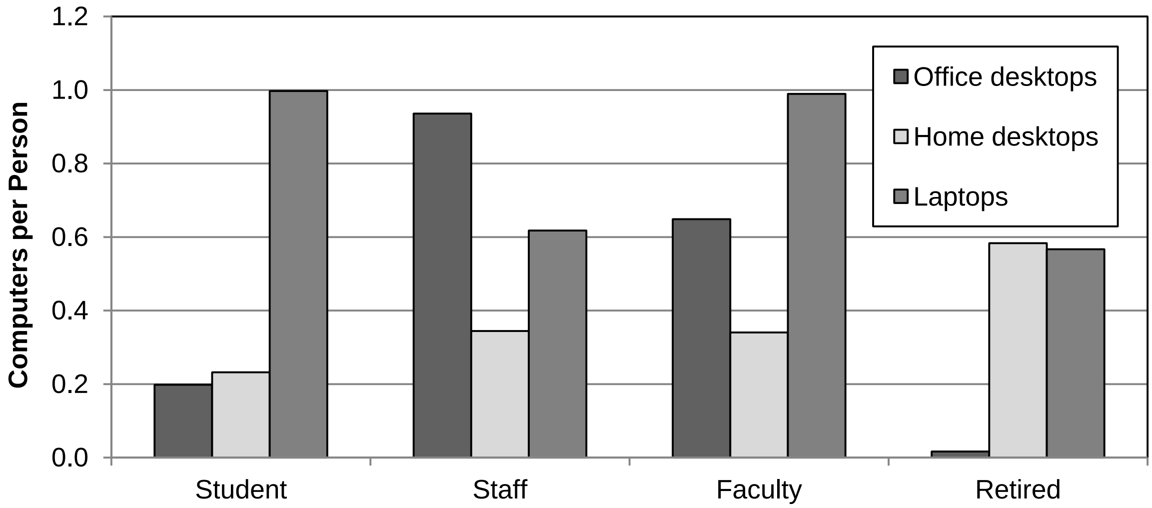
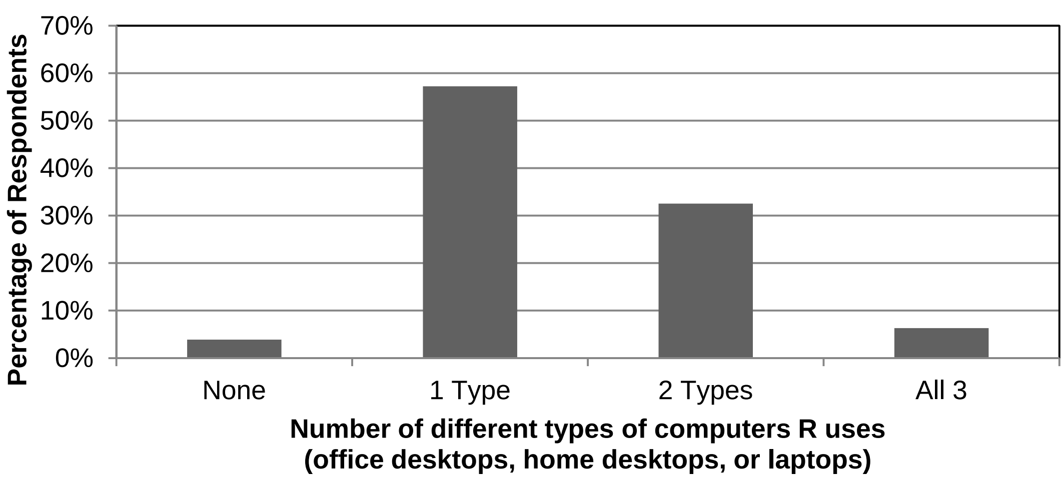


Figure 4 shows how many respondents use multiple types of computers. More than half of respondents use only one of the three types (office desktop, home desktop, or laptop), although they may use more than one computer of that type. One-third use computers of two of the types, while only 6 percent use all three types. A minority of respondents (4 percent) report not using any of these types of computers at least three hours per week, although half of those respondents report using another category of computer (for example, tablets or computer labs).

Figure 4: Percentage of Respondents Using Multiple Types of Computers



Adding the number of office desktops, home desktops, and laptops that respondents use gives a picture of the total use per person across all three computer types. For the full sample, 51 percent use one computer, 30 percent use two computers, and 15 percent use three or more computers; 4 percent use none of these three types of computers. The distributions vary substsantially across role groups, and the overall percentages are skewed by the predominance of students in the sample. As shown in Figure 5, retired respondents use the fewest computers, at an average of 1.2 per person. Students use significantly more, with an average of 1.4 computers. Staff members and faculty members use the largest number of desktops and laptops, at 1.9 and 2.0, respectively (significantly different from the other groups but not from one another). Figure 5 illustrates that the difference in means is not driven only by who has one versus two computers, but by the greater likelihood of faculty members and staff members to use three or even four computers.

Figure 5: Percentage of Respondents Who Use a Given Number of Home or Office Desktops and Laptops, by Role

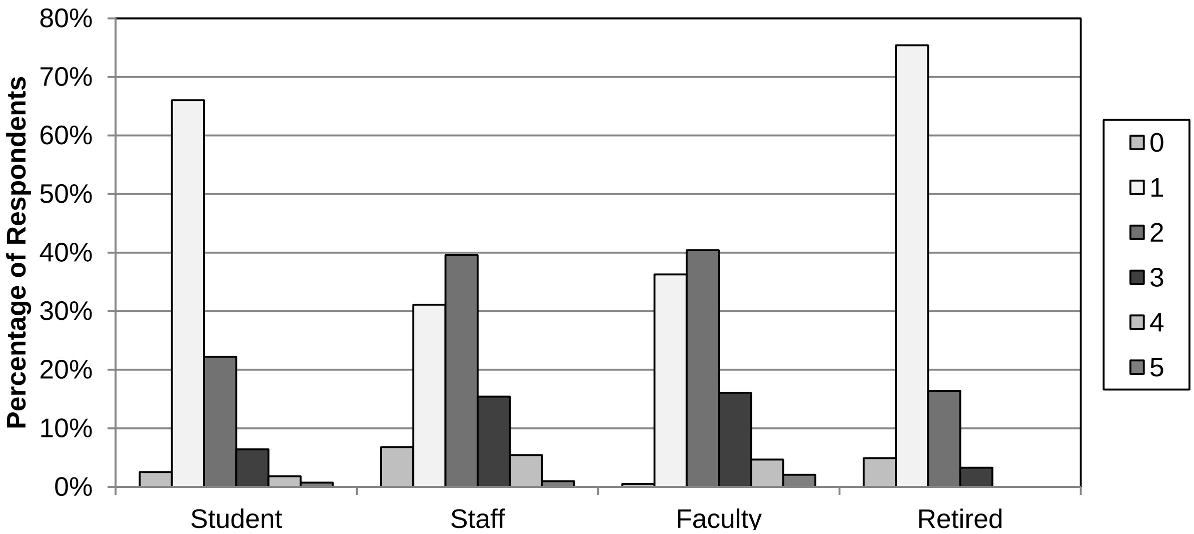


Table 6 shows the percentage of persons in each role group exhibiting the possible combinations of usage for the three main types of computers. About two-thirds of the students use only a laptop, whereas retirees are likely to use only a laptop or only a home desktop. Almost one-third of staff members and faculty members use an office desktop and a laptop; staff members are more likely than faculty to use only an office desktop while faculty members are more likely to use only a laptop. Although few responents use all three types of computers, this is much more common for faculty and staff than for students or retirees.

Table 6: Percentage of Role Group Members in Each Usage Category

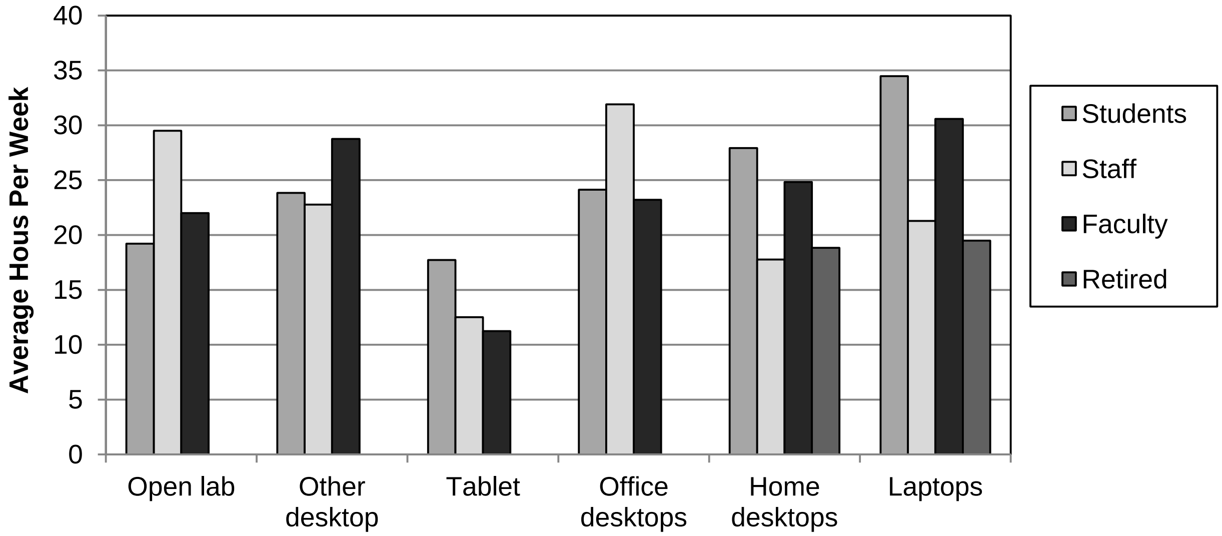
	None	Office only	Home only	Laptop only	Office and Home	Office and Laptop	Home and Laptop	All three	N
Student	2%	1%	5%	67%	1%	10%	11%	3%	1090
Staff	7%	20%	4%	12%	16%	29%	2%	10%	688
Faculty	1%	1%	4%	34%	9%	32%	6%	14%	185
Retired	5%	0%	43%	38%	0%	2%	12%	0%	60

4.2 Hours of Computer Use and Weekly Patterns of Computer Use

Total energy consumption depends on total hours of use. This section looks at which respondents used which computers more hours, as well as the patterns of individuals' computer use over a week. In Question C2, repeated for each computer the respondent reported, the survey asked the respondent to recall the hours of use on each of the previous seven days. The survey program captured the date when the respondent answered the specific question, so researchers could determine which days of the week those were. These results show variations in respondents' hours of use for all the computers they use on a regular basis. However, these results cannot be interpreted as showing the total hours that an average computer is used, because researchers do not have data from other individuals who may share the same computers.

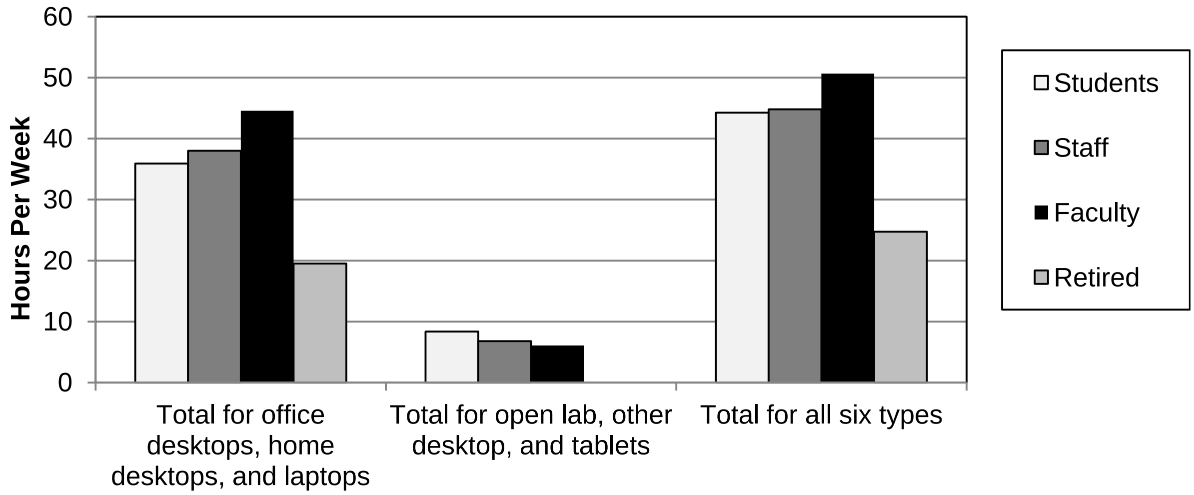
Figure 6 shows the average hours per week for each of the six categories of computer, among those respondents who use that type of computer, by role group. Although relatively few people use open lab computers or other desktops (Figure 1), those who do use these types use them frequently, an average of 20 and 24 hours per week, respectively. By contrast, although more respondents use tablets, they use them for fewer hours per week, an average of 15 hours overall. For the three main types of computers, laptops and office desktops are used about the same number of hours per week (30 and 31, respectively), while home desktops are used less often (23 hours per week). There are some notable role differences, with staff members using office desktops more hours per week than other groups, and students and faculty members using home desktops and laptops more hours per week. The high usage rates for students make sense considering that students are likely to use only one computer, which is usually a laptop. This finding puts the faculty members' similarly high use of laptops in perspective, as the laptop is more often one of two or more computers for them. Retired persons average similar weekly hours on home desktops and laptops as staff do. Although a few retired persons do use the other four types of computers, there are too few of them to calculate reliable means.

Figure 6: Mean Hours of Use per Week for Respondents Who Use Each Type of Computer, by Role Group



The total hours across the categories of computers, including respondents who do not use one or more of these categories, are shown in Figure 7. Adding up weekly hours of use for office desktops, home desktops, and laptops, students and staff report similar weekly hours (36 and 39 hours, respectively), while faculty report significantly more (45 hours) and retired persons report significantly less (20 hours). Adding up hours for the other three categories of computers, students report slightly more than other groups. Adding the hours from this second set of computer types to those for the main computer types naturally increases the total average hours, but the relative pattern across role groups remains the same.

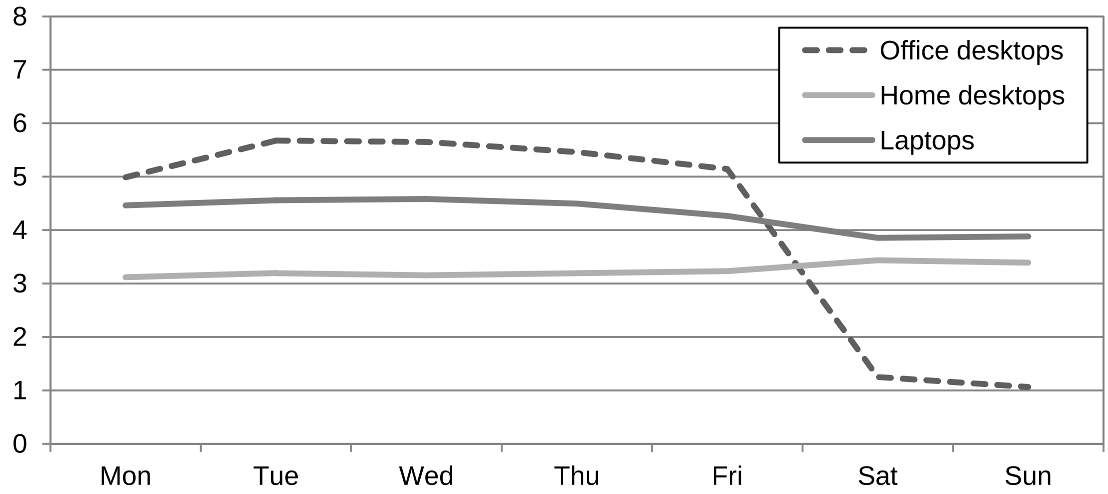
Figure 7: Mean Hours of Use per Week for All Respondents by Type of Computer, by Role



The pattern of hours across the days of the week is important in most studies of computer energy use. Although most studies use a one-worker-one-computer approach, these results include the totals for multiple computers of the same type. For instance, for respondents with two office desktops, hours reported from both desktops are included in the daily and weekly office desktop hours. The figures for hours in specific days use slightly different samples than the figures for total hours across computer types. The total hours analyses use only respondents with complete data on all computer types and omit computers from the 58 partial cases. The days of the week figures exclude 1.4 percent of computers that are missing data about which day the question was answered.

The pattern that emerges for office desktops is familiar: much more computer use on the workdays and less (but still some) on the weekends (Figure 8). For office desktops, the average hours of use per workday was 5.4 hours, and the average hours of use per weekend day was 1.1. The weekend use of home desktops and laptops is not so markedly different from weekday use.

Figure 8: Mean Reported Hours of Use, by Day of Week, for All Role Groups Combined



Hours per day for each type of computer is broken out by role group in the next three figures. The role group differences for office desktops are striking (Figure 9): staff members showed much more use during the week (average 5.9 hours per weekday versus 0.7 hours per day on weekends). Students showed the same pattern, to a lesser extreme: oddly, their average hours with office desktops is higher on weekends than for staff and faculty. This result remains even if the analysis separates undergraduate and graduate students. A likely explanation is that students are less often kept home by family responsibilities on weekends than are staff members and faculty members.

Figure 9: Mean Hours of Use for Office Desktops, by Role and Day of the Week

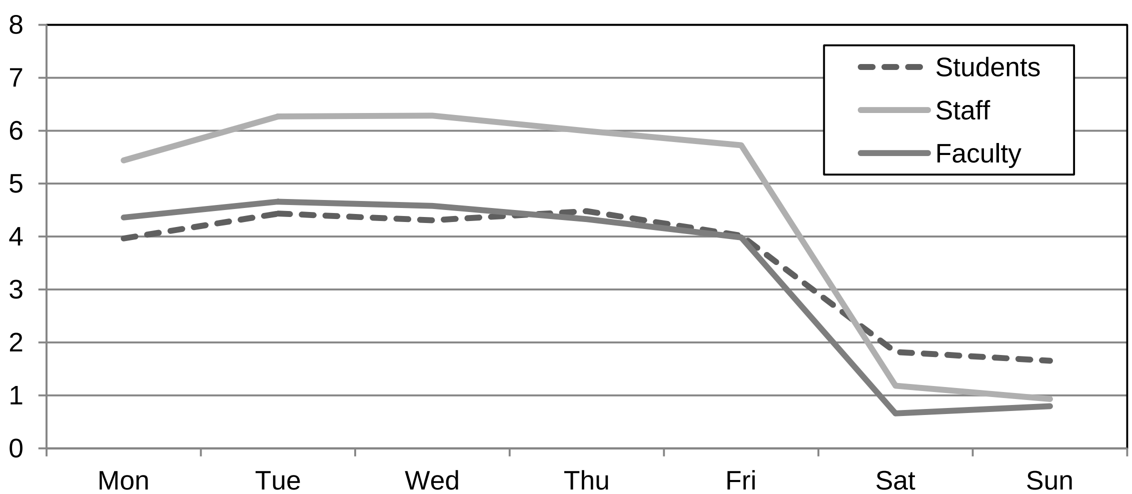
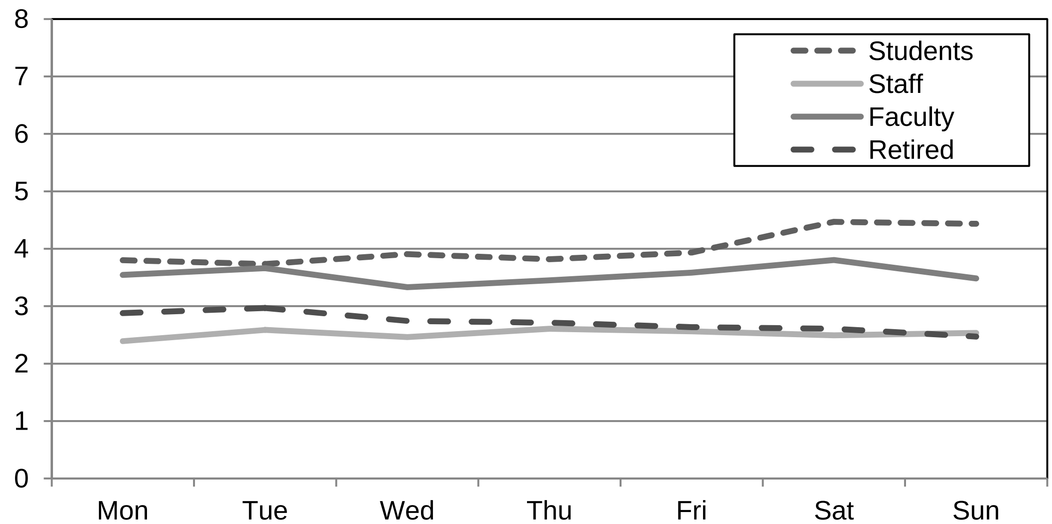


Figure 10 shows the patterns of average hours over the week for home desktops, by role group. For home desktops, usage is relatively more level across the whole week—that is, fewer hours than office desktops during the week but more than office desktops during the weekend. The overall averages are 3.2 hours per day on weekdays and 3.4 hours per day on weekends.

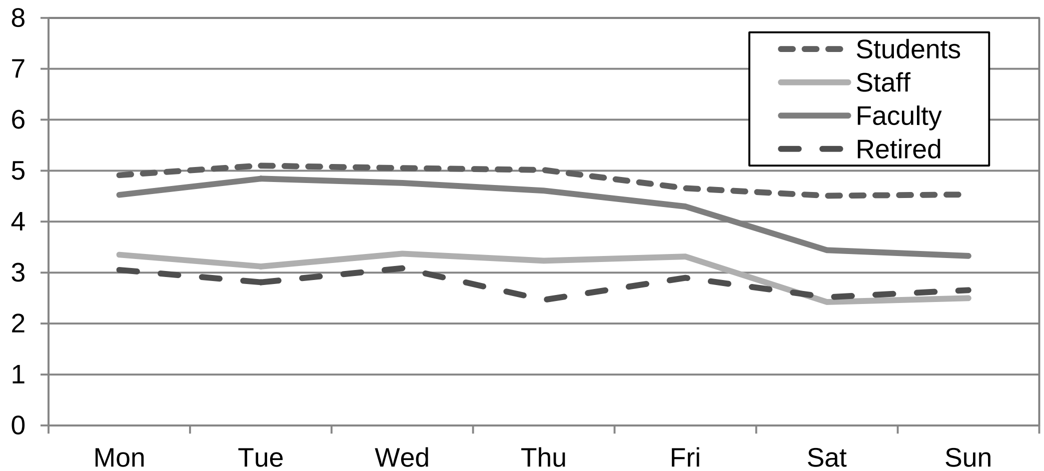
Students and faculty stand out from the other two groups, using their home desktops more hours than the other groups, a difference that is statistically significant for most days of the week.

Figure 10: Mean Hours of Use for Home Desktops, by Role and Day of the Week



A somewhat intermediate picture appears for laptops—staff and faculty use laptops less on Saturdays and Sundays than on weekdays, although the difference is not nearly as pronounced as for office desktops (Figure 11). This pattern is similar but weaker for students and not exhibited by retirees, suggesting that laptops are being used more for work by staff and faculty than by students and retirees. As students are most likely to use only a laptop, it is not surprising that they use laptops the most hours per day, although the differences are only statistically significant on the weekend. Students and faculty both use laptops on weekends significantly more than staff. For the aggregate of all respondents in the sample, the average hours of laptop use per workday is 4.5, and the average hours of use per weekend day is 3.9. The variation across the week for retired respondents may be a result of unstable means due to the small subsample size (n = 29).

Figure 11: Mean Hours of Use for Laptops, by Role and Day of the Week



The follow-up monitoring study conducted in 2014 provided more precise duty-cycle data on use of office desktops for the subset of 119 staff, faculty, and graduate students. The observed active-use hours for the office desktops studied were similar to the hours of use participants reported in the survey for their primary office desktops. The overall average difference in weekly hours was only 0.2 hours, and there was a significant positive correlation between self-reported and observed hours ($r = .38$, $p < .0001$). Correlations between reported usage hours and observed usage hours were lower for weekends and Mondays and higher for other weekdays.

4.3 Enabling of Power Management Features

This analysis is framed more broadly than many other studies, asking separately about the enabling of automatic PM modes and about manual steps to achieve lower power or shutdown. Both are important. A conscientious manual power management strategy of initiating shutdown immediately after every use would, of course, save more energy than if the computer waited 30 minutes in active-idle before automatic transitions took place. But it is also true that users who rely only on manual steps may waste considerable energy the few times they forget. (Bensch and Pigg [2010] mention this gap between possible and likely manual power management.) In practice, it is likely that the most energy will be saved if both methods are employed to support each other. Most other surveys have asked about only one type of power management behavior or looked only at whether the computer is turned off without asking how, which gives an incomplete picture of what user behavior led to that outcome.

This section looks first at the automatic and manual power mode approaches that respondents report using, then at who reports using one, both, or neither approach. It also covers who controls and changes the PM settings, the reasons given for power management behaviors, and power management for monitors.

Studying the "enabling rate" of automatic PM settings is difficult in part because of the wide variation of PM settings and profiles used by manufacturers and OS programmers. Even among the UCI team members and colleagues, all of whom were familiar with computers, sharing information about profiles and menus was frustrating, and discussions foundered on differences in terminology. Studies using physical power measurements made externally can detect various low-power states, but they cannot infer which particular PM menu option on the particular computer has been chosen, or if the transition to that state was made automatically or manually. Researchers relying on physical monitoring have been hampered by this complexity; Roberson (2004), Moorefield et al. (2011) and Bensch and Pigg (2010) all reported that it was difficult using meters alone to determine what specific power mode was activated. A better way to determine the precise current PM settings is for researchers to inspect the computer, as the current research team did in the 2014 monitoring study that supplemented the data from this survey (Pixley and Ross 2014). But each direct inspection provides only a one-time snapshot. Ideally software could identify and characterize each change in PM settings as it happened, but such an approach was impractical for this study.

An online surveys could identify the exact power settings only by asking complex, multipart questions. Respondents would have to leave the survey window temporarily, follow directions on how to look up their settings, and then return to the survey to record the data accurately on a complicated form. Using such a set of questions would greatly lengthen the survey for some respondents and increase the likelihood of their quitting before finishing the survey. Moreover, the current study asks about all the desktops and laptops respondents use, but respondents could only look up the power management settings for the computers they had access to while completing the survey. Asking the question in a different way for the respondents' other computers would result in incomparable data across computers.

Therefore, this study used a set of questions that did not require respondents to access the actual power-mode menus and could be used for any computer the respondent reported in the survey. For each computer used by the respondent, the respondent was asked first whether the computer ever transitions automatically into any of a list of low-power states, which were described in detail as they would appear to the observer: sleep, hibernate, and shut-down. A fourth category was added to reduce nonresponse or guessing: sleep or hibernate but the respondent isn't sure which one it is. If the answer was "yes" to any of these, the respondent was then asked to recall how long the computer is idle before it transitions to this state. For laptops, the timing question was asked separately for when the laptop was plugged in and when it was running on battery power. The response options offered time intervals that would distinguish fast, medium, and slow transitions (specifically, less than 10 minutes, 10 minutes to less than one hour, or one hour or longer) without expecting the respondent to recall exact time settings. Other versions of the same approach were used in the studies by Roth et al. (2006a) and Urban et al. (2011). The full text of these questions (C10 and C11) can be seen in the survey instrument, in Appendix B.

Thus, these questions about automatic power management should not be seen as objective measures of the actual settings of the computers, but as what users know about how their power settings operate in practice—or in some cases, what they think they know, or admit that they do not know. It is not assumed either that the respondents had set the modes themselves or that the modes were the ones shipped by the manufacturer; the questions asked only about the recent automatic behavior of the computer.

In addition to asking about automatic power management settings, the survey also asked about manual power management. Respondents were asked, “In the past two weeks, when you knew you wouldn't be using this computer for several hours or more, what percentage of the time did you do each of the following?” The three options were: turned the computer off, manually put it into sleep or hibernate, or left the computer on (Question C13). The question noted explicitly that computers left on may later automatically transition into a low-power state. As these three states are mutually exclusive and exhaustive, the percentages given to the three states had to sum to 100 percent; answers that did not add up to 100 percent prompted an error message to the respondent from the online survey program.

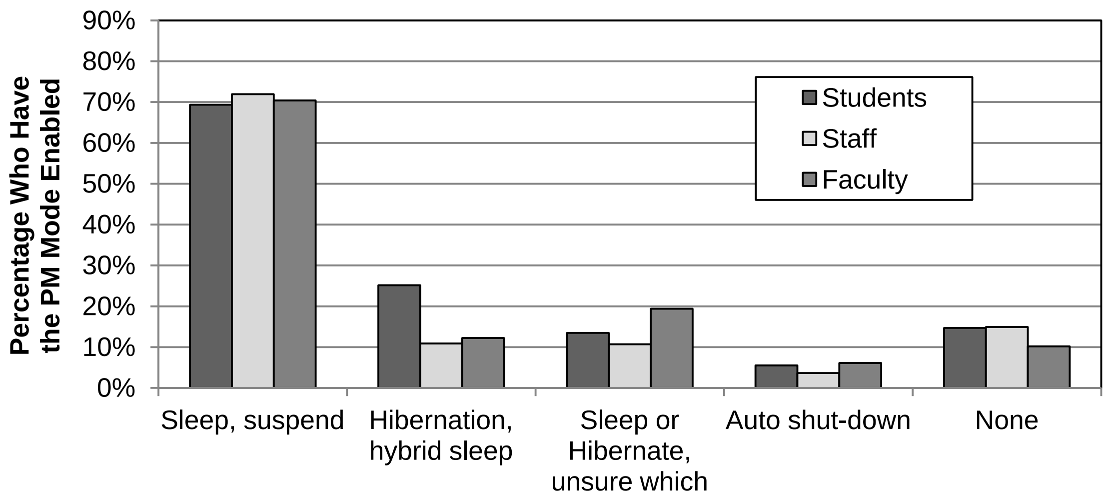
Some previous surveys took a similar but more limited approach. The study by Urban et al. for the CEA (2011) asked respondents four questions about power management behaviors for computers—how often the computer is turned off overnight, how the computer was left at the last time of use, how often the computer is shut down manually if an absence of at least half an hour is expected, and how long the computer takes to recover if left on for an hour or more. Roth et al. (2006a), in the national study of households conducted by TIAX for the U.S. Department of Energy, asked two questions about power management for each of the respondent’s computers—how often the computer was left on for more than half an hour during the day when it was not being used, and how often the computer was turned off at night. The RECS study (U.S. Energy Information Administration 2013) asked one question for each of the two most used computers: “When this computer is not in use, is the power usually turned off?” but did not ask whether the shutdown occurred automatically or manually. All three studies addressed only home computers.

4.3.1 The Use of Automatic PM Modes

As noted earlier, in order to obtain comparable data on all the computers respondents used, the survey asked respondents to report their recollections how their computers behaved, rather than to look up the exact computer settings. The results for automatic PM behavior are shown in Figure 12 (primary office desktops), Figure 13 (primary home desktops), and Figure 14 (primary laptops).The question allowed respondents to check multiple automatic modes for each computer. Across all four role groups and all three types of computers, more than 60 percent of respondents reported that their primary computers automatically entered some “sleep, suspend, or standby” mode when it was inactive. Less than 20 percent of the respondents reported that their computers made no changes when left inactive for a prolonged period. In all groups and all types of computers, less than 9 percent reported that their computers automatically shut down.

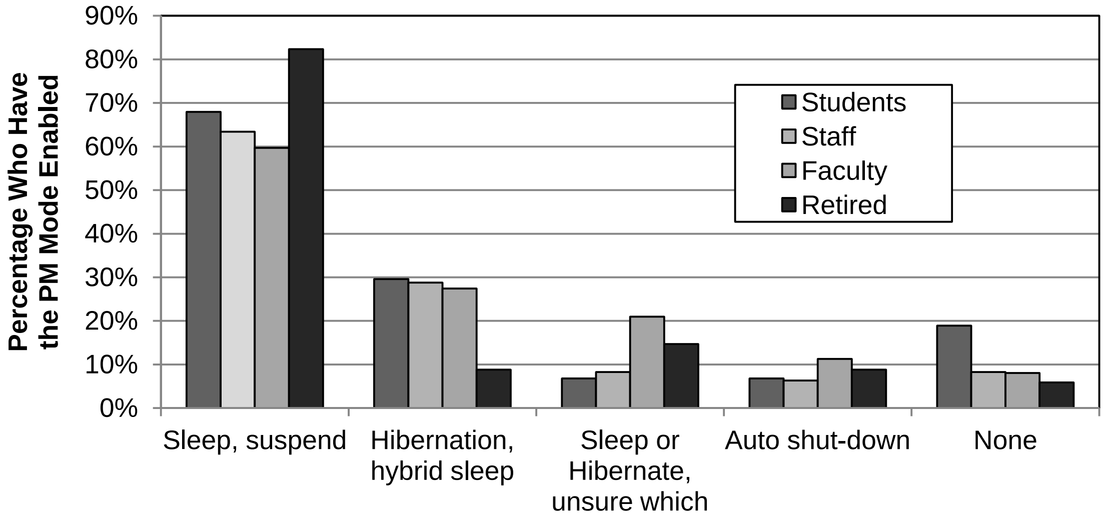
There are only a few statistically significant differences by role for office desktops (Figure 12): students are significantly more likely to report hibernate mode than staff or faculty, and faculty members have higher rates of "sleep or hibernate, unsure which" than staff. There are too few retired respondents who use office desktops to include in these analyses.

Figure 12: Enabling of Automatic PM Settings on Primary Office Desktop



By contrast, there are many role differences for home desktops (Figure 13). Students are significantly more likely than staff or faculty to report no low-power settings (they are more likely than retirees as well, but the relationship only approaches significance, at $p = .06$). Retirees are more likely than staff or faculty to report sleep and less likely than all other groups to report hibernate, and faculty members are more likely than staff or students to report "sleep or hibernate, unsure which."

Figure 13: Enabling of Automatic PM Settings on Primary Home Desktop



For laptops (Figure 14), staff members were less likely to report sleep mode than any other group. Students were more likely to report hibernate for laptops than staff or faculty, and staff members were more likely to report hibernate than faculty.

Figure 14: Enabling of Automatic PM Settings on Primary Laptop

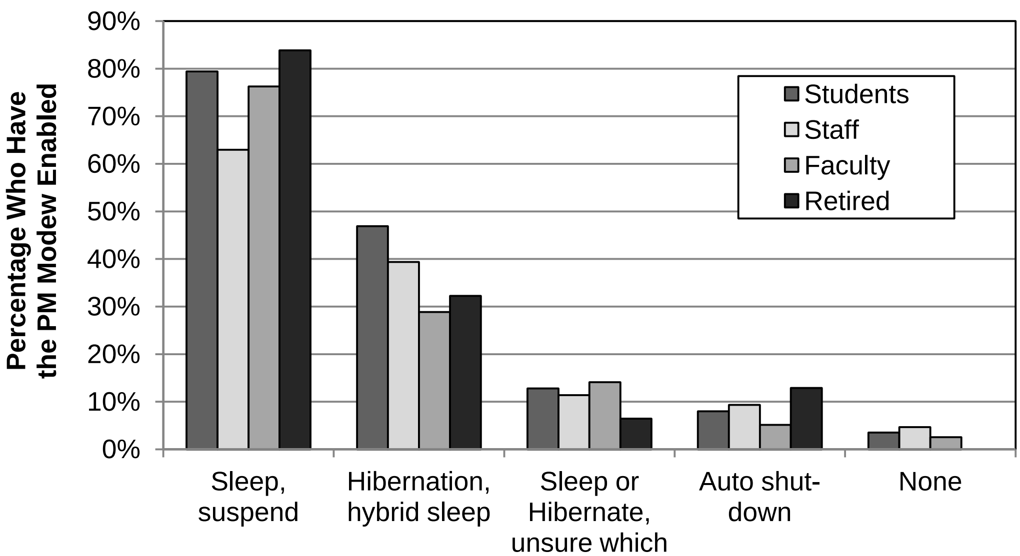
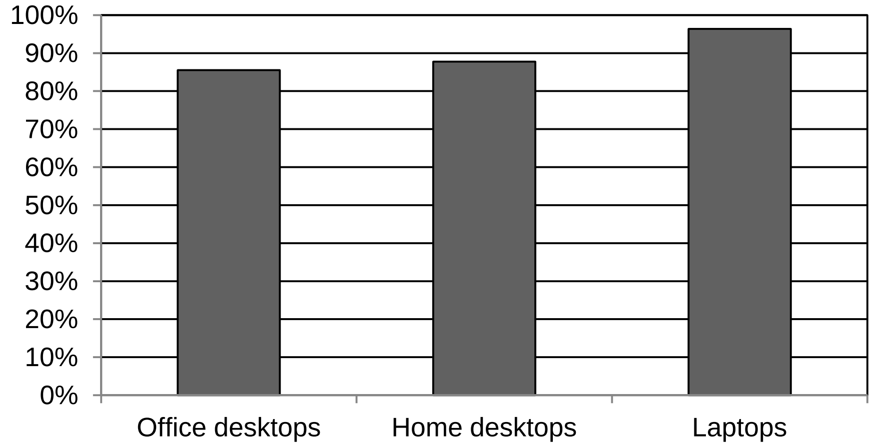


Figure 15 shows the percentage of computers reported to transition automatically into some low-power mode, or to automatically shut down, when idle. Looking at all role groups combined and collapsing the low-power modes indicate more clearly that respondents report using some type of automatic PM for most computers, for all three types. Automatic power settings are significantly more prevalent for laptops (96 percent) than for home desktops (88 percent) or office desktops (86 percent); the difference between home and office desktops is not significant.

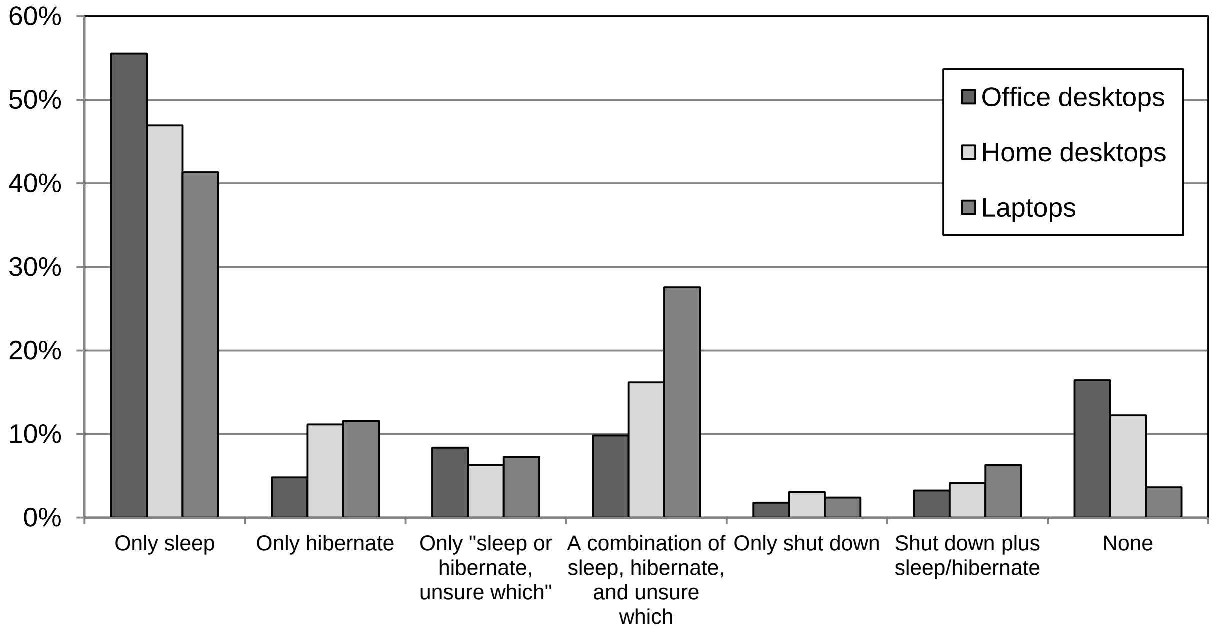
Figure 15: Percentage of Computers Reported to Automatically Enter a Low-Power Mode or Shut Down, for All Role Groups Combined



Like most figures shown in this report, Figure 15 includes only the computers for which respondents gave valid data: it excludes those who marked "don't know" or "prefer not to answer." Respondents were much less confident about reporting automatic PM for office desktops than for home desktops and laptops: 10 percent gave invalid responses (mostly "don't know") for office desktops, compared to 6 percent for home desktops and 4 percent for laptops.

Respondents could select more than one low-power mode in Question C10. It was expected that many respondents would report combinations of settings: for instance, sleep mode followed by hibernate or by shutdown. Figure 16 shows the combinations that were reported across all three types of computers. Using only sleep mode was the most common response, for all three types of computers. Respondents report only one automatic PM setting for more than two-thirds of these computers (that is, only sleep, only hibernate, only "sleep or hibernate, unsure which," or only shutdown). Reporting multiple low-power modes is more common for laptops than desktops. More than one-quarter (28 percent) of laptops show a combination of sleep and hibernate, and another 6 percent combine a sleep or hibernate mode with shutdown. By contrast, 10 percent of office desktops and 16 percent of home desktops combine sleep and hibernate, and even fewer (3 percent and 4 percent, respectively) combine a sleep or hibernate mode and shutdown.

Figure 16: Percentage of Computers Having Various Combinations of Low-Power Settings



For the computers that were reported to enter some low-power mode automatically, the survey also asked for recalled estimates of how long this transition takes once the computer is idle (Question C11). For each automatic power mode named in Question C10, respondents were asked to estimate a time interval for activation: less than 10 minutes, 10 minutes to less than an hour, or an hour or more. Table 7 summarizes the data by recording the shortest time given by the respondent for each computer to enter any low-power state (usually "sleep").

Table 7: Percentage of Computers That Automatically go Into Some Low-Power Mode, by Time Interval Reported

	All office desktops	All home desktops	All laptops, plugged in	All laptops, on battery
Less than 10 minutes	41%	32%	40%	57%
10 minutes to less than 1 hour	48%	52%	45%	33%
1 hour or more	11%	16%	15%	9%
Other (e.g., at a specific time)	0%	1%	0%	1%

According to respondents' recall, more than 70 percent of the computers that are reported to go into some low-power mode do so within an hour, across all types of computers. Not surprisingly, laptops operating on battery power were the most likely to be set for an automatic low-power mode to occur within 10 minutes.

These results are consistent with past findings that rates of automatic PM settings are generally higher for laptops than for desktops (for example, Barr et al. 2010 and Chetty et al. 2009) and generally higher for home desktops compared to office desktops. Chetty (2009), Bensch and Pigg et al. (2010), and Urban et al. (2011) all record low rates for home desktops, but even lower rates were recorded in the office studies by Barr et al. (2010) and Roberson et al. (2004.)

These reported rates of use of automatic PM settings are similar to or higher than results from self-reports in earlier surveys. Exact comparisons are difficult because of different methods or question wordings across studies. For example, Tiedemann et al. (2013) found in a web-based survey of more than 1,400 households in 2008 that 86 percent of respondents reported using automatic PM for their home computers, but this combines desktops and laptops. Urban et al. (2011) inferred automatic PM settings from respondents' reports of how quickly computers responded after being idle for an hour or more; they concluded that 70 percent of home desktops had automatically transitioned to a low-power mode.

As discussed in the next section, the 2014 monitoring study results indicate over-reporting of automatic PM for office desktops. Similar over-reporting likely affects results for other computers in this study and in other survey studies of power management as well. However, the higher rate of automatic PM reported here compared to some previous surveys does not imply that over-reporting is more of a problem in the current data. There are several plausible reasons why the actual rate for automatic PM would be higher in this sample than in some previous surveys. One possible reason is simply that this study is more recent than the others, and using automatic PM settings may have become more prevalent than before. Over time, more people become familiar with new technology and more users come of age who have grown up using computers. Organizations continue to emphasize energy conservation in computers, and there is more public discussion of energy issues. Perhaps more computers have default automatic settings enabled when they are purchased. Another possible factor behind the higher rates of reporting automatic PM is that the sample population differs from other workplace and household studies: persons associated with universities may be more highly educated or more familiar with computers. Finally, differences in the ways the use of power modes and settings were investigated may be key. This study asked respondents about automatic settings separately from any manual transitions or states, and asked about multiple low-power modes. It is possible that by asking the question differently than other surveys have done, more automatic PM was captured.

4.3.2 Comparison to the Monitoring Study

As described earlier, a follow-up monitoring study examined a subset of 125 office desktops used by staff, faculty, and graduate students (but not undergraduate students or retired persons). Researchers looked up and recorded several automatic power management settings on each desktop, including the same categories used in the survey: sleep or standby, hibernate, and shutdown. Overall, 20 percent of these desktops were observed to have at least one of these automatic PM settings enabled: all of these had sleep or standby enabled, two also had hibernate enabled, and none had shutdown enabled.

Some participants in the monitoring study had changed computers in the intervening year, while others reported that their PM settings had been changed. For automatic PM results, direct comparisons between the survey and monitoring project use the 74 computers that were included in both studies and for which the settings had not been changed. This comparison across the two studies is shown in Table 8. The first two columns of data show the number and percentage of monitoring study participants who had reported in the survey that automatic PM was or was not enabled. The measure of whether any automatic PM settings were reported includes participants who reported one or more of the modes shown: sleep, hibernate, and/or shutdown. Five participants reported only "sleep or hibernate, not sure which one"; this response cannot be directly compared to the actual PM settings and is not shown in Table 8, but the 5 participants are included in the "any automatic PM" category. The last four columns show the percentage of these cases that were observed in the monitoring study to have automatic PM enabled, disabled, not available on that specific operating system, or missing. Reading the top row, for example, 57 of the 74 matched computers (77 percent) were reported by participants to have sleep or standby enabled in the survey; of these 57 computers, 30 percent were observed by researchers to have sleep or standby enabled in the monitoring study.

For observed PM settings, missing cases arise when the trained researcher was unable to locate the setting on a computer that should have had that setting (based on the OS), and erroneously marked the setting as "not available" for that computer. Rather than remove these cases from the analysis, they are treated as not enabled on that feature for the "any automatic PM" measure, potentially undercounting the "yes" category for that particular measure. However, given the current results, if any of these computers marked as "not available" actually had been set for automatic hibernate or shutdown, it is likely that they would also have sleep enabled, and thus would already be counted as having any automatic PM.

Table 8: Automatic Power Management Settings on Primary Office Desktop for Survey Self-Reports Versus Monitoring Study Observations

PM reported in survey				PM settings observed in monitoring study			
		N	%	Enabled	Disabled	Not available	Missing
Sleep or standby	Yes	57	77%	30%	67%	0%	4%
	No	17	23%	12%	88%	0%	0%
Hibernate	Yes	8	11%	13%	75%	13%	0%
	No	66	89%	2%	48%	23%	27%
Shutdown	Yes	2	3%	0%	0%	100%	0%
	No	72	97%	0%	4%	78%	18%
Any automatic PM	Yes	64	86%	30%	70%		
	No	10	14%	0%	100%		
N = 74 office desktops from the monitoring study that were also reported in the survey and for which participants report that nobody has changed the PM settings since then.							

For the 74 office desktops that were included in both studies and for which respondents reported that nobody changed the PM settings between the two studies, 86 percent were reported in the survey to have at least one automatic PM setting enabled. In the monitoring study, 19 of these 74 computers were observed to have at least one automatic PM setting enabled; all of them had been reported to have automatic PM in the survey. All 10 of the computers that were reported in the survey to have no automatic PM enabled were observed to have no settings enabled in the monitoring study. Thus, in this subsample, the accuracy rate for those reporting any automatic PM enabled is 30 percent, the accuracy rate for those reporting no automatic PM enabled is 100 percent, and the overall accuracy rate is 39 percent.

This shows a clear direction to the errors, rather than arbitrary guessing. However, there were reverse errors for specific PM settings. For example, for some participants who reported in the survey that sleep or standby was not enabled, it was observed to be enabled in the monitoring study, suggesting that users were confused about *which* automatic setting was enabled. Despite the large discrepancies between self-reports and researcher observations, the survey and monitoring study results are statistically correlated: those who report automatic PM are significantly more likely to have some automatic PM setting enabled than those who do not.

The difference between the survey responses and the monitoring study results is broadly consistent with past studies of power management that show low enabling rates for monitored computers, and with some other survey results that show higher enabling rates from self-reports (U.S. Energy Information Administration 2013 and Tiedemann 2013, for example). A few other studies have applied both survey techniques and monitoring to the same computers for a deeper understanding (for example, Chetty 2009; Bensch, Pigg, et al. 2010; Kawamoto 2004). However, the research team can locate no prior studies that systematically compare survey self-reports of automatic PM settings to researcher observations of those same settings, for so large a number of cases. No prior studies have quantified the accuracy rate of survey responses for such a large group, much less analyzed the possible causes of differences in enabling rates across the two research designs.

Given the differences found in the monitoring study results, the rates of automatic PM reported by respondents in the survey—especially the high rates of sleep and standby—should be interpreted cautiously. However, any accuracy estimate based on the monitoring study results and applied to the survey data should also be interpreted carefully and be limited to office desktops. These issues are discussed later in the section on interpreting the survey results in light of the monitoring study.

The differences between observed and reported automatic PM settings do not make the survey responses categorically unreliable. There are several points on which the survey results and the monitoring project agree, suggesting that other measures do not show the same level of over-reporting. Also, respondents who report using automatic PM are more likely to use it than those who do not; although the absolute numbers of computers using automatic PM may be overestimated, the relationships between using automatic PM and the wide range of other variables provided in the survey should still be valid. Furthermore, the survey results provide an important measure of whether respondents believe they are using automatic PM, which may be as important to understanding their behavior as knowing the actual automatic PM rate.

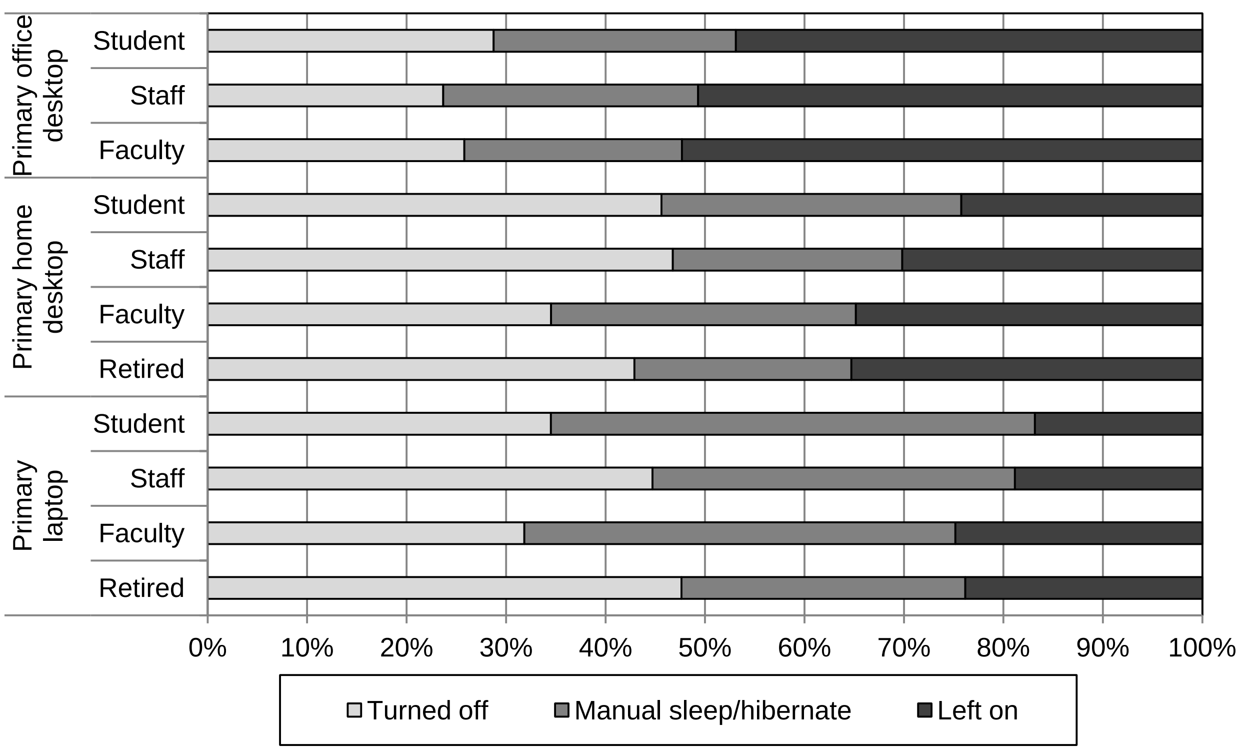
The results in the rest of this section use respondents' self-reported rates of automatic PM from the survey, acknowledging that this is a perceived rather than an objective measure. After presenting the results from the survey itself, additional discussion is included on how these results may be interpreted in light of the monitoring project results.

4.3.3 The Use of Manual PM Modes

The survey also asked respondents about their *manual* use of PM features: "In the past two weeks, when you knew you wouldn't be using this computer for several hours or more, what percentage of the time did you do each of the following?" (A) turned the computer off, (B) put it into a sleep or hibernate mode, or (C) left it on (it may or may not go into a sleep or hibernate mode automatically)" (Question C13). The respondent was provided with a sliding scale from 0 to 100 percent.

Figure 17 shows the use of manual PM actions grouped by type of computer and by role group. The results show that office desktops are left on a much larger percentage of the time, on average, than home desktops or laptops. Home desktops are turned off more than 40 percent of the time most users leave them, except for faculty, who still turn them off more than 30 percent of the time, on average. Laptops are also turned off somewhat less frequently by most groups and tend to more often be manually put into sleep or hibernate.

Figure 17: Mean Percentage of Times the Computer is Left in Each State When User Leaves for Several Hours

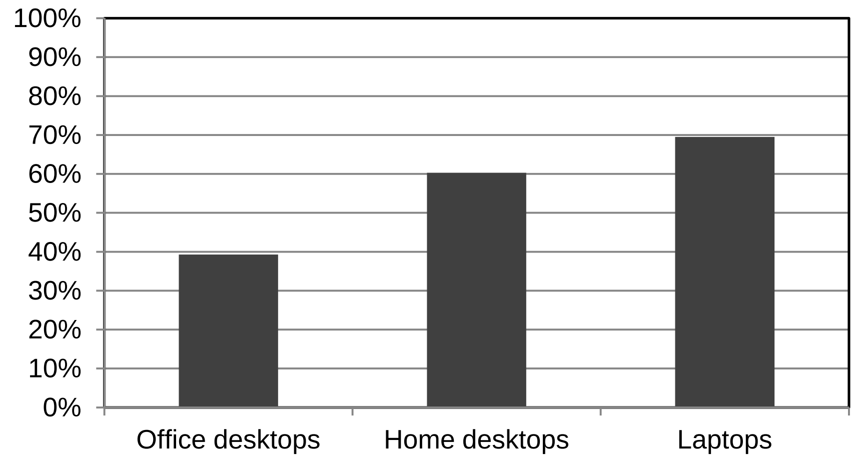


While Figure 17 is a useful summary of the average rates of manual power management use, averages can mask great variation. For instance, primary office desktops are left on for an average of 50 percent of the times they are left idle, but this includes some users who always leave their desktops on and some who never do, and many computers in between these two extremes.

A measure of whether respondents ever employ manual PM steps at all would include those who use them very infrequently. A more strict criterion is needed, to assess use that is frequent enough to save a reasonable amount of energy and to be comparable to the consistent effects of having automatic PM is engaged. Past studies have asked whether users "usually" or "often" turn off their computers, but the frequencies for these terms are not quantified (for example, U.S. Energy Information Administration 2013 and Urban et al. 2010). The research team chose a cut-off point of 80 percent as the criterion for regular or consistent use of manual power management. For the rest of this report, the use of manual PM is defined as users manually putting the computer into sleep or hibernate mode or shutting it off at least 80 percent of the times they know they won't be using it for several hours.

Manual power management use is least common for office desktops: only 39 percent are manually switched to shutdown or sleep at least 80 percent of the times they are left (Figure 18). Put another way, 61 percent of these computers are left on 80 percent or more of the times the respondents leave them. Manual PM is reported significantly more often for home desktops (60 percent) than for office desktops, and significantly more often for laptops (69 percent) than for either type of desktop.

Figure 18: Percentage of Computers That Are Manually Put Into Sleep or Shut Down, 80 Percent or More of the Times That the Respondent Leaves the Computer for Several Hours



It is difficult to compare the survey results for manual PM to many prior studies, as most other studies look only at the state of the computer and do not distinguish between manual and automatic transitions to those states. However, the results appear to be roughly comparable to the results of the Energy Information Administration's Residential Energy Consumption Survey (RECS). The national RECS study (U.S. Energy Information Administration, 2013) found that 59 percent of the respondents said that their home computer is "usually" turned off if it was not in use, while this study found that 60 percent of the home desktops were manually put to sleep or shut down at least 80 percent of the time. The UCI survey questions allowed for a range of answers rather than a yes-no option, which allows the research team to quantify "usually," and specified a manual operation at the end of computer use.

4.3.4 Comparison to the Monitoring Study

As was done earlier with the automatic PM results, the manual PM survey results can be compared to the results from the monitoring study. This comparison includes the 90 office desktops that were included in both studies and had both valid data for the manual PM survey question and usable duty cycle data. The comparison is not as precise as it is for automatic PM because the measures of manual PM differ more across the two studies. The survey question asks the *percentage of times* (that is, what proportion of occasions) the computer is left on, left off, or put into sleep mode, whereas the monitoring study data show the *total percentage of time* (that is, percentage of minutes in the day) that the computer is on, off, or in sleep mode. These are similar but not the same: for instance, users may diligently turn off their computers 100 percent of the times they stop using it, but the computers will still not be off 100 percent of the day. Still, useful comparisons can be made.

In this subset of computers, results from the monitoring study indicate that computers spend more time on and slightly less time off than would be expected from survey reports. It is possible that the manual PM behaviors changed over the period between the survey and the monitoring study, but it is reasonable to assume that survey respondents somewhat overestimated how often they turn off their computers. Without fully comparable measures, a specific accuracy rate cannot be estimated, but the differences across studies are smaller than those for automatic PM. The survey and monitoring study results are strongly correlated, at $r = .70$ ($p < .0001$) for percentage of times reportedly turned off and amount of time the computer spends off and at $r = .42$ ($p < .0001$) for percentage of times reportedly left on and amount of time the computer spends on. This evidence suggests that the manual PM reports given in the survey are reasonably accurate.

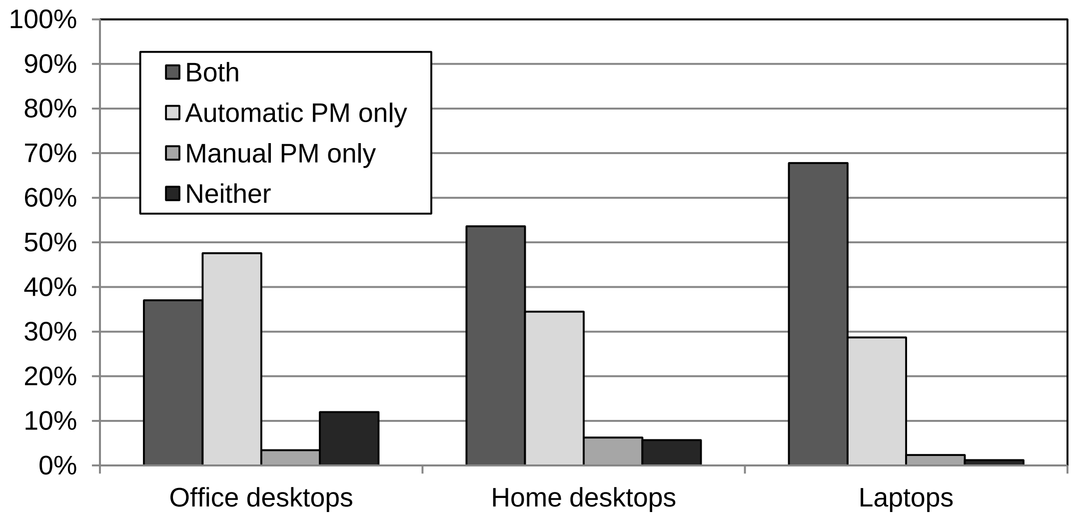
The greater reliability for manual PM reports than for automatic PM reports is understandable. Users may not always remember what they did over multiple instances of leaving their computers idle. However, being present and engaged in their own manual PM behaviors gives users an advantage in noticing, understanding, and remembering those actions—which all increase reliable reporting of events—compared to inferring the PM settings their computers automatically enact while the users are absent.

4.3.5 Combinations of PM Modes

Preceding discussions have argued the importance of characterizing both the separate and combined use of automatic and manual PM behaviors. Here, two separate measures are combined: any automatic PM (the computer automatically transitions into at least one low-power mode) and manual PM (the respondent turns the computer off or manually puts it into sleep or hibernate at least 80 percent of the times it will be idle). The joint measure indicates if the respondent reports using only automatic PM, only manual PM, both, or neither.

The results are shown in Figure 19. In all cases, the predominance of reporting automatic PM is clear. Although manual PM is indeed used alone sometimes, the "both" category is much larger: that is, those who report manual PM almost always also report using automatic PM. Furthermore, there are some clear differences across the three computer types. Office desktops are most likely to be subject to only automatic PM, with somewhat fewer using both automatic and manual. By contrast, the majority of laptops are reported to use both automatic and manual PM, with relatively fewer using only automatic PM. Home desktops resemble laptops in this regard, although the difference is not as great. There is also a great difference across computer types in the likelihood of having no PM reported at all: this is twice as common for office desktops as for home desktops, and very rare for laptops.

Figure 19: Percentage of Computers of Each Type in Each Combination of Automatic PM and Manual PM

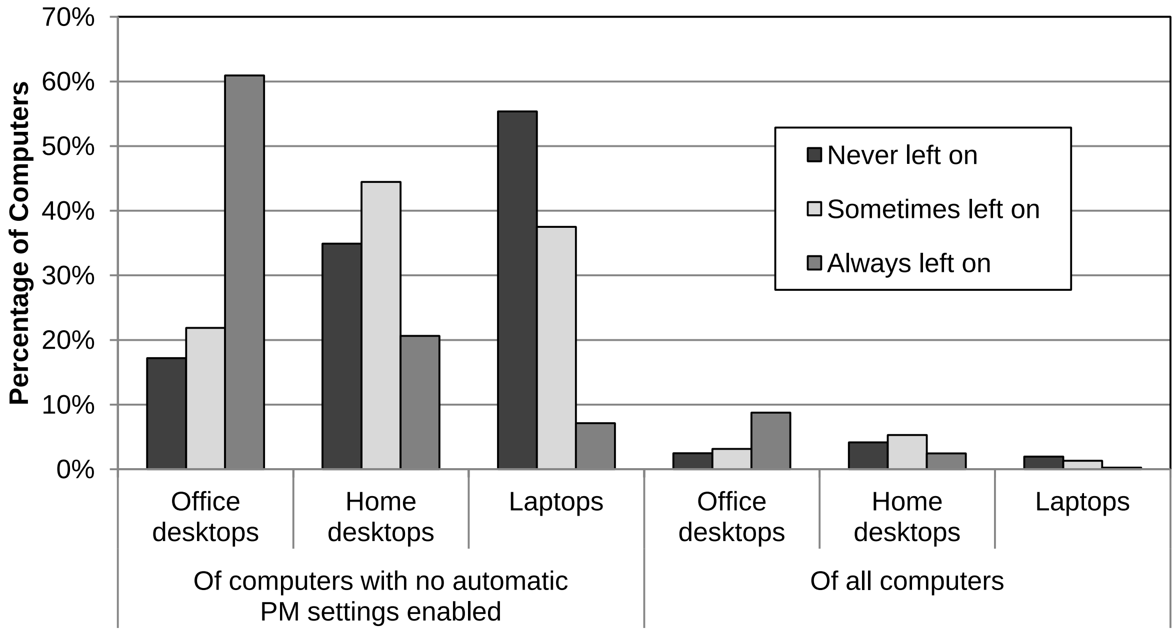


It is instructive to look more closely at manual PM for the computers that do not automatically go into any low-power mode. Are they never left on, sometimes left on, or always left on? The results are shown in Figure 20. The first three sets of bars show how often the computer is left on, among computers that have no automatic PM settings. The results on the left-hand side of the figure indicate that that most of the consistent energy wasters in terms of PM behaviors are office desktops: of the 128 office desktops that have no automatic PM settings enabled, 61 percent of them are always left on. The study by Schoofs et al. (2011) identified a similar group using remote monitoring: 32 of 466 office machines were on more than 98 percent of the time during three months. By contrast, the majority of respondents reporting that their home desktops and laptops have no automatic PM settings use manual PM at least some of the time, and a substantial percentage (one-third for home desktops, more than half for laptops) use manual PM all the time.

Even among office desktops, relatively few computers in the full sample are left on all the time. The three sets of bars on the right in Figure 20 show the frequency of being left on across all computers, regardless of automatic PM settings. Since most office desktops are reported to have automatic PM settings enabled (Figure 16), the office desktops that are always left on make up a relatively small proportion (9 percent) of all office desktops. The comparable figures are much lower for home desktops, and almost nonexistent for laptops.

In other words, office desktops are much more likely than other types of computers to not only have no automatic PM settings enabled, but to also not benefit from manual PM. Although this group is a small percentage of the total, these computers waste a disproportionate amount of energy.

Figure 20: What Percentage of Computers Are Reported to be Always or Never Left On, Among Computers with No Automatic PM Enabled and Among All Computers, by Type

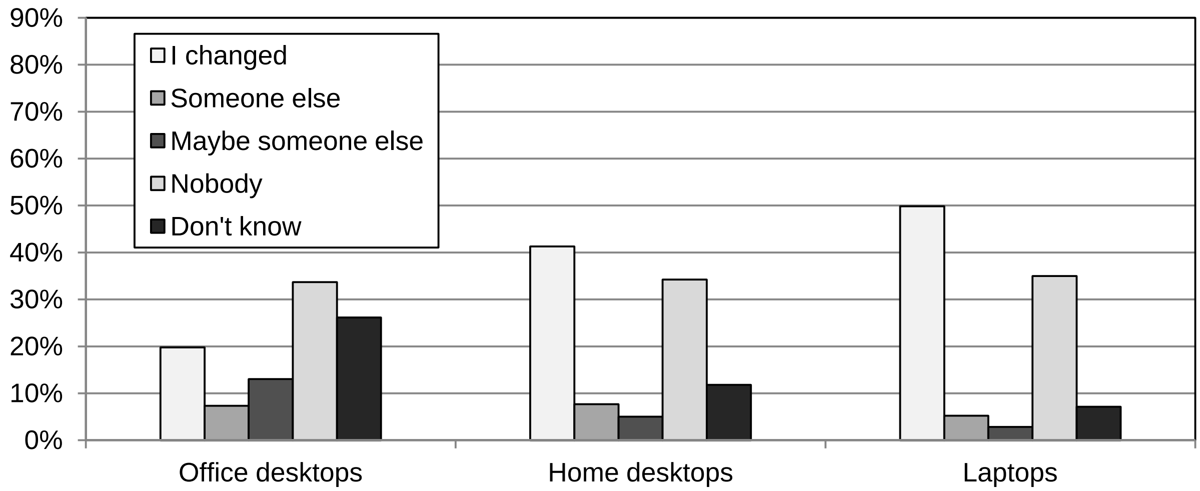


4.3.6 Who Controls the Power Management Settings

An important factor in understanding power management behavior is whether anyone changes or disables the automatic PM settings, particularly for computers shipped with default settings enabled. The current results show that the PM settings for most computers have been changed at least once, although determining the direction(s) of change and the identity of the changer(s) would have required much more investigation. Here the authors offer some initial findings on the issues.

The survey asked if the respondent or anyone else had changed the PM settings on the respondent's computer (Question C15). Specifically, the options were nobody has changed the settings; I changed them; someone else changed them; I did not change them but maybe someone else did; don't know; and prefer not to answer. The "maybe someone else" option helps distinguish between respondents who don't know if the settings were changed because other people have had access to the computer and those who don't remember if they did it themselves. In some of the following analyses, the authors group "maybe someone else" with "someone else." The survey text advised the respondent, "If the settings were changed multiple times, answer for the most recent change." Thus, some respondents may have changed the settings in the past, but not marked "I changed them" because they were not—or didn't know if they were—the last person to do so. The results are shown in Figure 21.

Figure 21: Who Changed the Power Management Settings, If Anyone



Respondents reported that nobody changed the PM settings for only about one in three computers overall—for 34 percent of office desktops, 34 percent home desktops, and 35 percent of laptops. Respondents are most likely to have changed the PM settings themselves for laptops, somewhat less likely to do for home desktops, and substantially less likely for office desktops. Respondents with office desktops are not only less like to have changed the PM settings themselves but are also less likely to know whether the settings have been changed at all. The responses of "maybe someone else" and "don't know" occurred more than twice as frequently for office desktops as for home desktops or laptops.

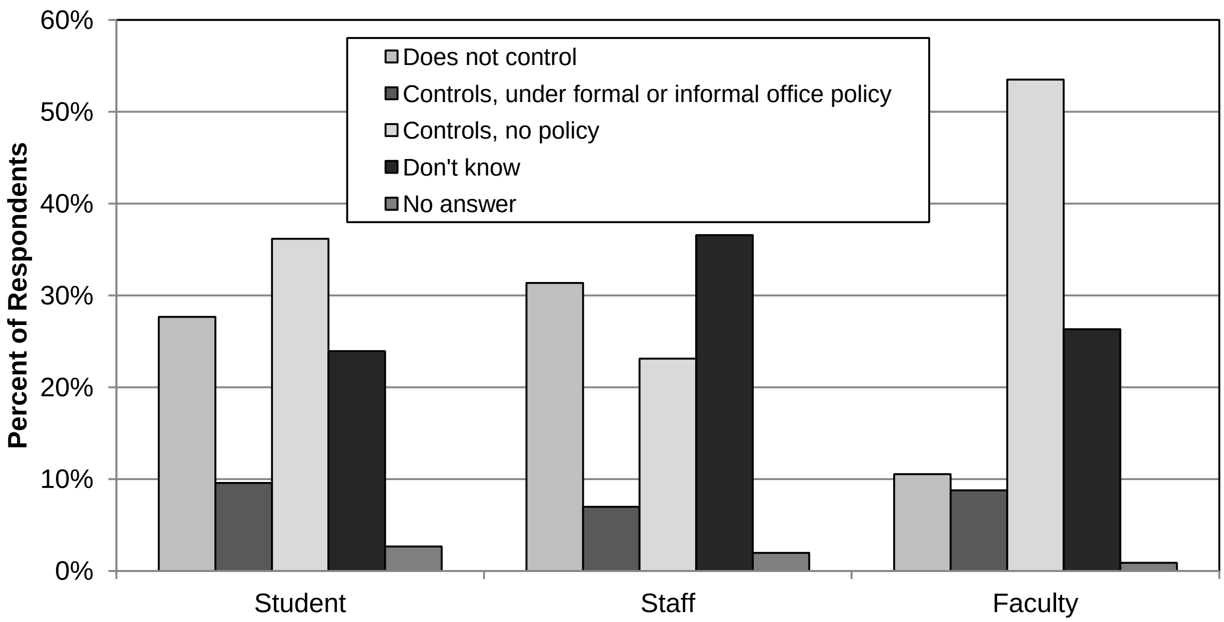
For the computers where respondents said "maybe someone else" and "don't know," the settings may or may not have been changed. Considering them all changed or all not changed, the estimated ranges for how many computers have changed settings are 27 to 66 percent for office desktops, 49 to 66 percent for home desktops, and 55 to 65 percent for laptops.

The study by Chetty et al. (2009) found results that are roughly comparable with these results, given the differences of settings and questions. That study found that 45 percent of respondents said they had not changed the PM settings, 39 percent said they had, and 11 percent said they didn't know, for a mix of desktops and laptops in 20 households.

Additional analyses indicate there was variation by role in who changed the settings. For office desktops, faculty are most likely to change the PM settings themselves (39 percent) whereas students and especially staff are much less likely to have changed the settings themselves (24 percent and 15 percent, respectively) and more likely to say that someone else did or may have. The role patterns for home desktops are similar to those for laptops: students are the most likely to report changing the settings themselves, retirees are the least likely, and staff and faculty are in the middle.

This evidence suggests that people feel less control over their PM settings in the office environment. The research team asked the respondents about their office desktop, "Do you have control over the power management settings on that computer?" (Question D1). If they had reported more than one office desktop, they were prompted to think about the one they used most (which should be the same one researchers later coded as the "primary" office desktop, based on the reported hours per week). Overall, 28 percent of respondents report having no control over the PM settings for their primary office desktop, 38 percent report having control, 32 percent say they don't know, and 2 percent give no answer. Detailed results for each role group are shown in Figure 22. Relatively few respondents in any role group report following a formal or informal policy about PM settings. Only for faculty members does more than half of the group feel they have unconstrained control over the PM settings. Staff members are especially likely to report that they have no control over the PM settings (31 percent) or that they don't know whether they do (37 percent).

Figure 22: Respondents' Reported Control Over PM for Office Desktop, by Role and Type of Control



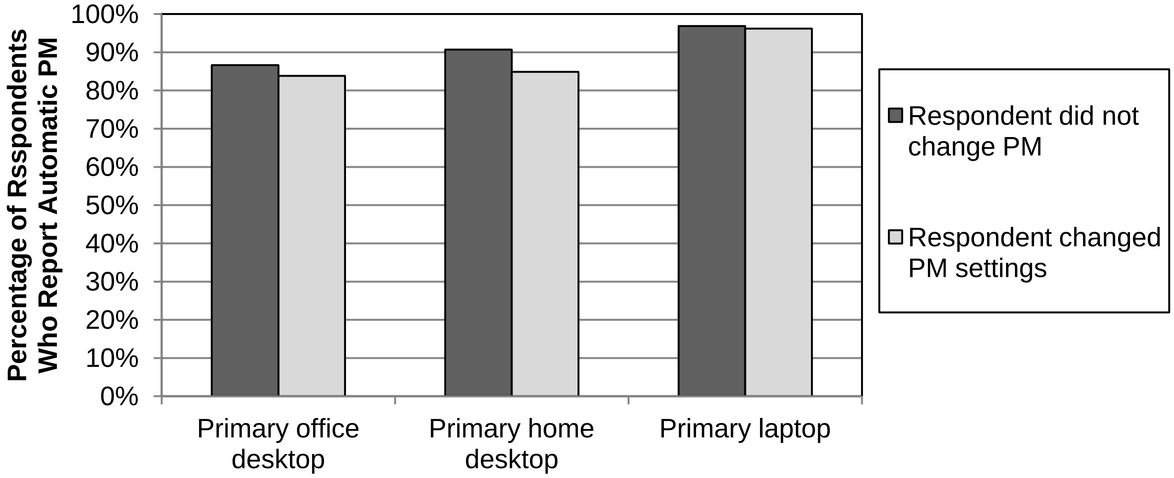
Whether respondents control the PM settings on their main office desktop is also related to their knowledge of those settings. Specifically, giving a "don't know" response to the question about the automatic PM settings for their primary office desktop was more common for respondents who reported not controlling their settings (7 percent) or not knowing if they controlled the settings (11 percent) than for those who controlled their settings. either with a policy (3 percent) or without one (2 percent). No question about controlling the PM settings on home desktops or laptops was included on the survey, as little variation was expected. Assuming most respondents do control their home desktops and laptops, that control could help explain the lower rates of "don't know" responses for automatic PM settings in those computers.

Respondents would have less control in a situation in which the PM settings for a group of office computers are centrally controlled by an IT manager. The respondents in this study are in many different departments and other units, which vary in how they do or do not control their IT resources. The authors have no independent data on whether the respondents in a given unit have administrative control over their computers.

The intervention of IT managers and others who control users' computer settings—indirect "users" of the computers—is a special problem for office desktops. For users who have no control over their PM settings, user behavior would seem to have little relevance for computer efficiency. However, at least some of those users have the flexibility to use manual power management. Additional analyses show that among respondents who reported having no control over their office desktops, 63 percent report turning off their primary office desktop or putting it into sleep mode at least some of the time, and 40 percent meet the 80 percent criterion used here for regular use. Furthermore, while 28 percent of respondents report not having control over their office desktop, 24 percent say they don't know if they have control (and thus might), and another 21 percent of respondents report having control but have not actually changed the settings on their primary office desktop. That means that for every user constrained by their IT manager, there are almost two more users who could potentially save energy with automatic PM if they pursued the option.

Without knowing what default settings these computers initially had, and what the respondents and others changed about the settings (for instance, disabling sleep, enabling sleep, or changing the length of time for the transition to sleep), the fact that settings were changed could be positive, negative, or neutral for automatic PM enabling. In this study, computers for which respondents changed the PM settings are no more or less likely to have any automatic PM reported, for any of the three types of computers. (Figure 23.) The same is true when comparing computers changed by the respondent, someone else, or maybe someone else to all the others. In other words, there is no evidence that changing settings by itself is positive or negative for automatic PM settings.

Figure 23: Whether Automatic PM is Engaged, by Whether Respondents Changed the Automatic PM Settings

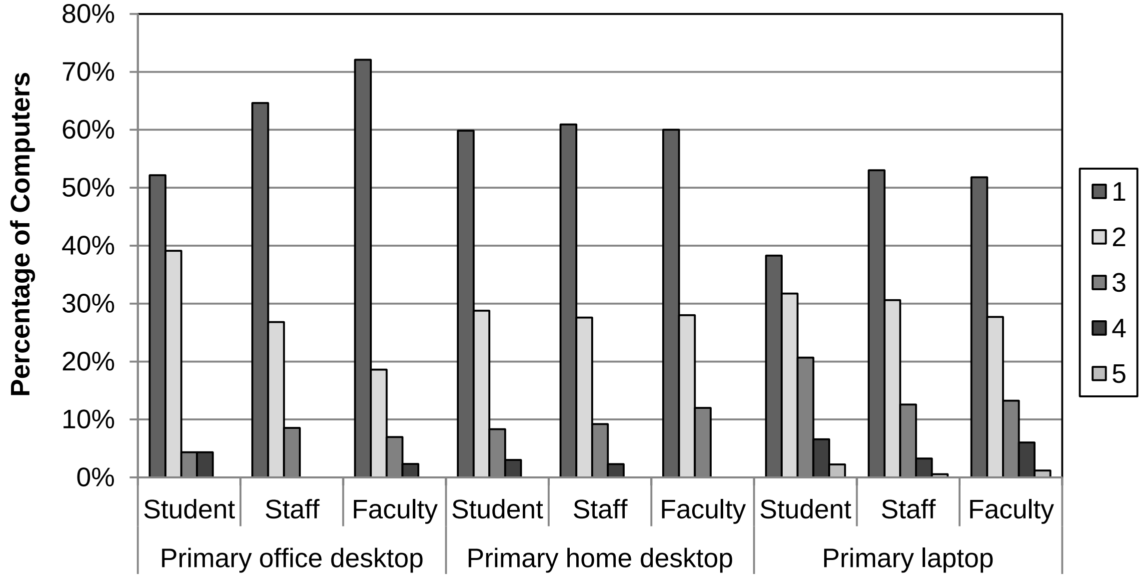


4.3.7 Reasons Given for Power Management Behaviors

Previous studies have shown that people give various reasons for their PM decisions to leave the computer on, turn it off, or change the PM settings, and such reasons were probed in this study as well. For respondents who reported changing the power management settings themselves (Question C15), the survey asked their reasons for doing so (Question C16). For respondents who reported leaving their computer on at least 1 percent of the times that they stopped using it (Question C13), the survey also asked about their reasons for doing so (Question C14). In both cases, the text provided several possible reasons, based on previous studies as well as options or versions generated by the research team. The text allowed respondents to provide multiple answers for each computer on each question and allowed for "other" text responses; many of these were recoded into one of the original response options during data processing. For each group, the discussion that follows reviews the number of responses given and the reasons themselves.

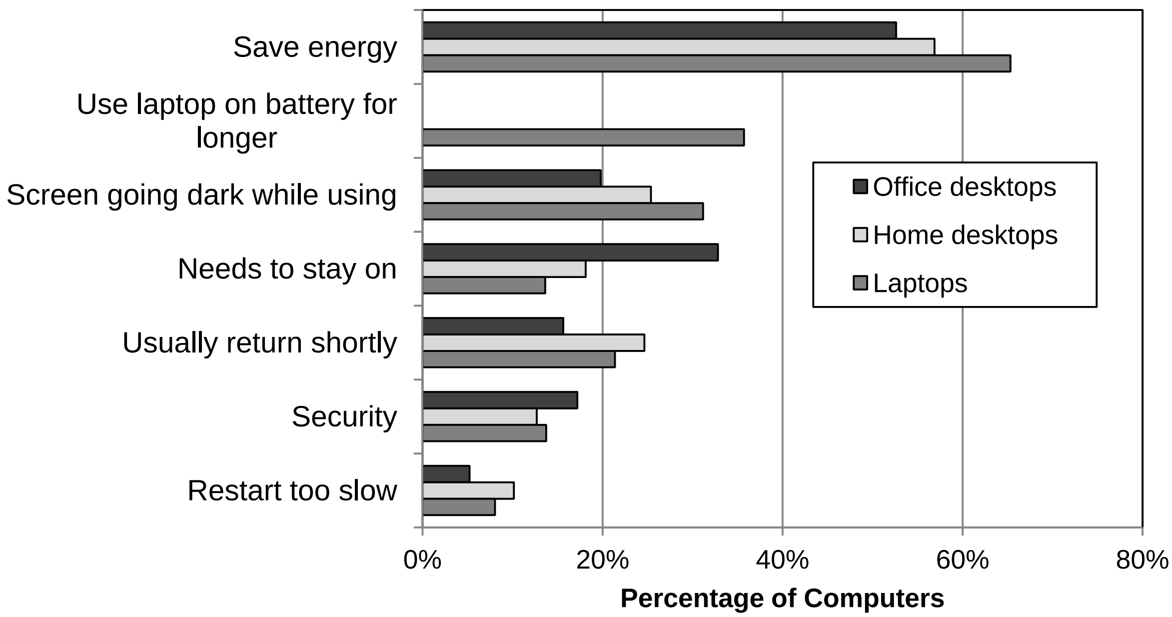
Many respondents who reported that they had changed the PM settings gave more than one reason for doing so in Question C16 (Figure 24). Respondents were most likely to give multiple reasons for changing their power management settings for their primary laptops, with 57 percent giving at least two reasons and 26 percent giving at least three. Multiple reasons were much less common for primary office and home desktops, with a large majority giving only one reason—63 percent and 61 percent, respectively. There are also differences across role groups. For primary office desktops, faculty members are much more likely to have a single reason for changing the power management settings, while students are most likely to have multiple reasons. Students are also more likely to give multiple reasons for changing the PM settings on their primary laptop than are staff and faculty. By contrast, the role groups are similar for home desktops. The answers by retirees are not reported because the numbers were too small to report reliable percentages.

Figure 24: Number of Reasons Given for Changing the Power Management Settings



The frequency of the various answers given for why respondents changed the PM settings (Question C16) is shown in Figure 25. (The reasons given by less than 5 percent of the respondents are not shown.) The reason given most often is "to save energy." A similar response about using laptops for longer on battery power was recorded separately and cited frequently. These responses suggest that settings were changed to go into a power-saving mode sooner or into a power-saving mode that consumes even less energy. One possible explanation for this high rate of concern about energy may be a demand effect or other type of reporting bias, since respondents did know that the survey was about energy use. However, a demand effect or self-serving bias should affect respondents similarly across computer types, whereas saving energy is cited less often for office desktops than for home desktops or laptops, and varies across role groups as well. It is unclear why, for instance, students answering about their laptops would more affected by reporting bias (with 68 percent citing "save energy") than students answering about office or home desktops (41 percent and 47 percent, respectively).

Figure 25: Reasons Given for Changing Power Management Settings, by Computer Type



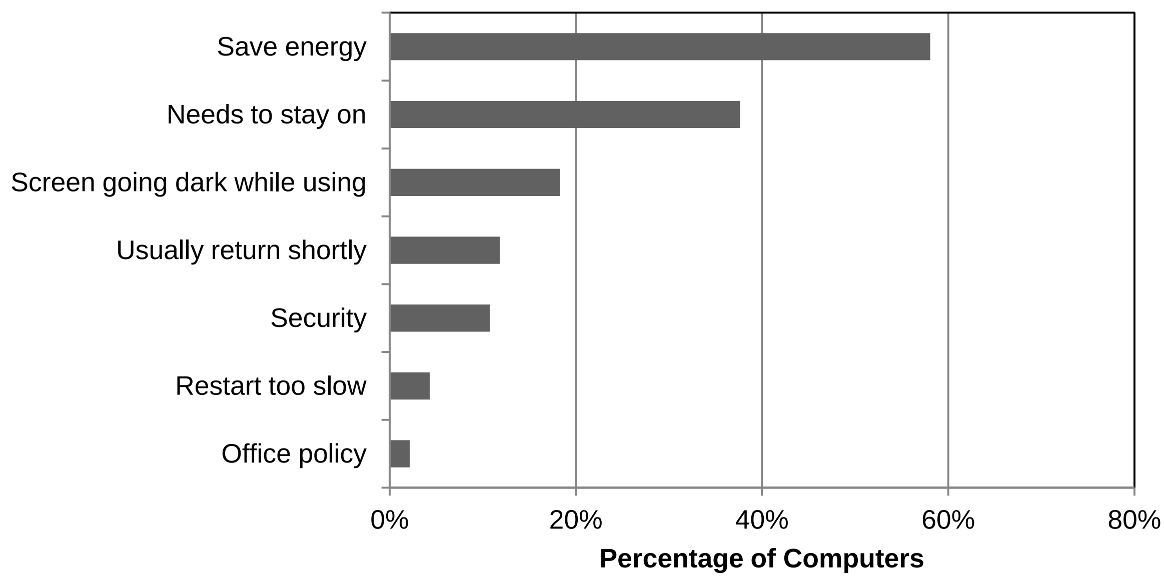
Respondents who cite "for added security" may inadvertently be saving energy, as quicker triggering of lower-power modes does make the computer less accessible to others. The other top reasons show more concern with performance and accessibility: avoiding the screen going dark too quickly while the computer is being used, some activity that requires the computer to stay on, an expectation of returning to the computer shortly, and avoiding a slow restart.

Looking at the reasons given by the type of computer, saving energy is the top issue regardless of computer type, and two other patterns stand out— "needs to stay on" is cited much more often for office desktops than for the other types, and "screen going dark" is clearly a bigger concern for laptops than for the other two types.

While this part of the analysis has aggregated the role groups, there are a few interesting differences among the role groups. Students are significantly less concerned about saving energy than staff members are for home desktops, but more concerned than faculty about saving energy with their laptops, and more likely than both staff and faculty to be concerned about laptop battery life. For laptops, staff members are significantly less likely to cite the anticipation that they will return shortly. Other differences did not reach the $p < .05$ criterion for significance, in part because of the somewhat small number of respondents (especially in the smaller role groups) who changed their own PM settings and thus answered this question.

While the categories of reasons shown are similar to those used in other studies, exact matches or comparisons have not been attempted. For closer comparison with workplace studies, Figure 26 shows the reasons given by staff members for changing the settings on their office computers. Note among other points that very few staff members report the existence of any office policy on PM, consistent with the small number of respondents who reported that they control their office desktop PM settings and follow a formal or informal policy (Figure 22).

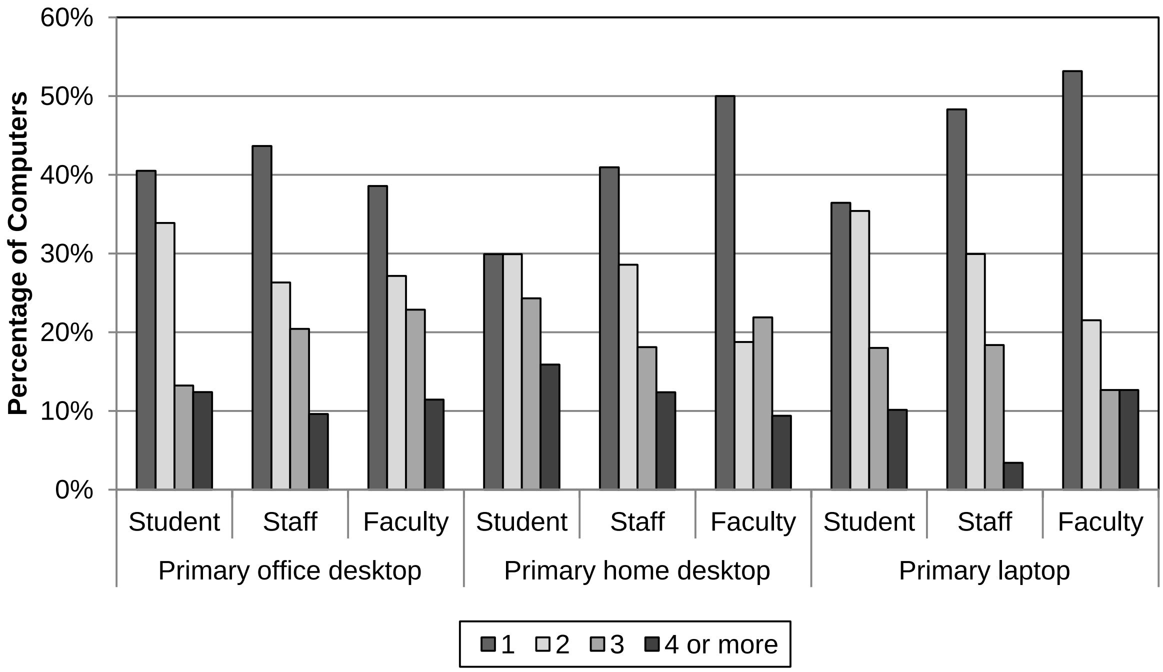
Figure 26: Reasons Given by Staff Members for Changing PM Settings for Office Desktops



This study did not seek to determine if individual changes at any particular time were in the direction of saving or using more energy; trying to make that determination would be beyond the capabilities for a survey, and raise conceptual and methodological issues. Power management settings may have been changed many times on a computer, both increasing and decreasing energy efficiency. In the study by Chetty et al., (2009), the researchers had direct access to the computers and they looked up the PM settings themselves, enabling them to review whether settings had been changed from the default profiles in 24 machines. For some of the computers, the researchers were able to record changes in PM settings made during the study. "[A]bout half the time settings were changed … low power mode settings were made more power efficient and half the time, timeouts were increased, we assume to make the machines more available." (More than half of the laptop changes were toward efficiency, while less than half of the desktop changes were.) Those investigators compared the current settings to the default settings or past settings, and this study asked if there had been any changes.

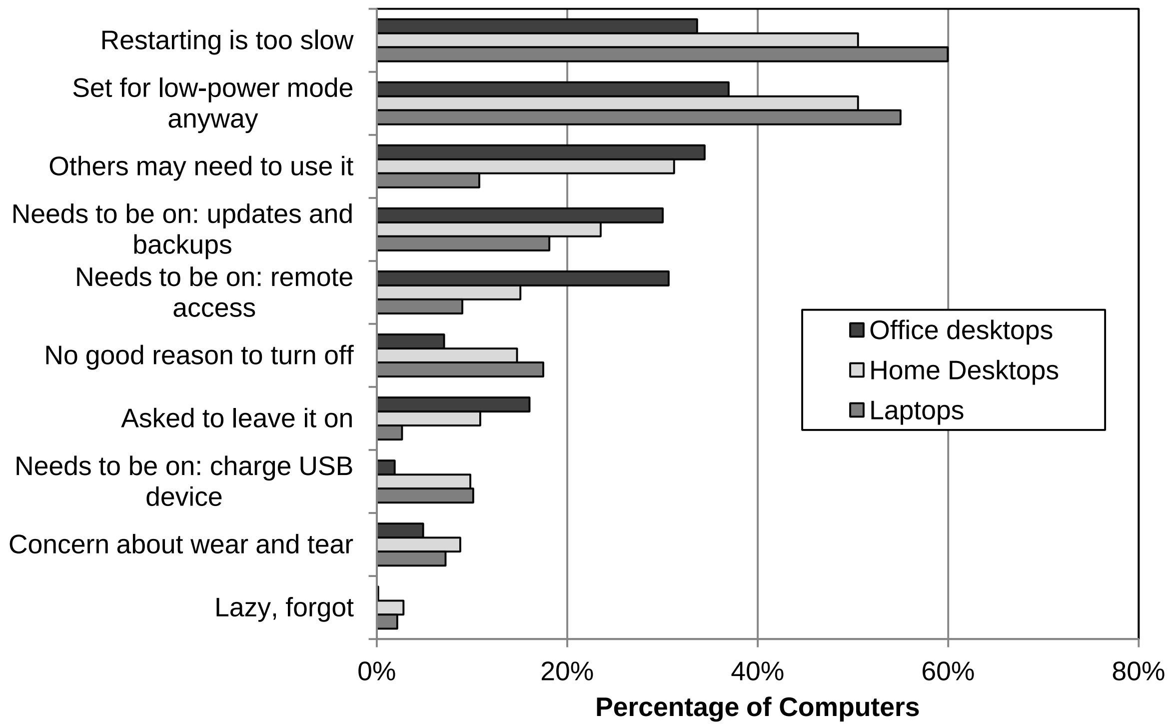
The study also investigated the reasons respondents give when asked why they leave their computers on when they will not be using it for several hours. Many respondents gave more than one reason. For primary office desktops, 58 percent gave at least two reasons, and 30 percent gave at least three. The figures were similar for primary home desktops (63 percent and 35 percent) and for primary laptops (59 percent and 26 percent) (Figure 27). In other words, on average, respondents give more reasons for leaving their computers on than for changing their PM settings. Giving multiple answers may indicate the respondents' desire to justify socially inappropriate behavior. On the other hand, most respondents have many more occasions to use manual PM (or in this case, not use it) than automatic PM. That is, most people walk away from their computers substantially more times in any given week than they change their PM settings. The larger number of reasons may merely reflect the variability of the decisions on different occasions. Without additional probes, it would not be possible to tell which of the cited reasons are the most important to each respondent or if a particular reason given applies to every instance of leaving the computer on.

Figure 27: Number of Reasons Given for Leaving Computer On



The reasons stated for leaving the computer on are shown in Figure 28. The first nine reasons shown were provided to respondents in the text of the survey online, and multiple answers were permitted. Some additional codes were created based on the written "other" responses given by respondents that were different enough conceptually from other reasons to code separately. Only one additional code was frequent enough for inclusion in this chart: "Lazy, forgot."

Figure 28: Top Reasons Given for Leaving the Computer On



A few patterns are clear. For laptops, two reasons for leaving the computer on rank significantly above the others: restarting would be too slow, and the computer is set to go into a low-power mode soon anyway. For home desktops, those two reasons are also the leaders, but "others may need to use it" and "needs to be on for automatic updating or backups, or for moving large files" were cited by more than 20 percent of respondents. For office desktops, the reasons are somewhat more diverse. The first two reasons were not as dominant, and the next two reasons were cited by more than 20 percent of respondents. Those two, about updates or backups and remote access, were cited much more often for office desktops than for the other two types. Relatively few respondents report being asked to leave the computer on, although it is more common for office desktops (16 percent) than for the other types.

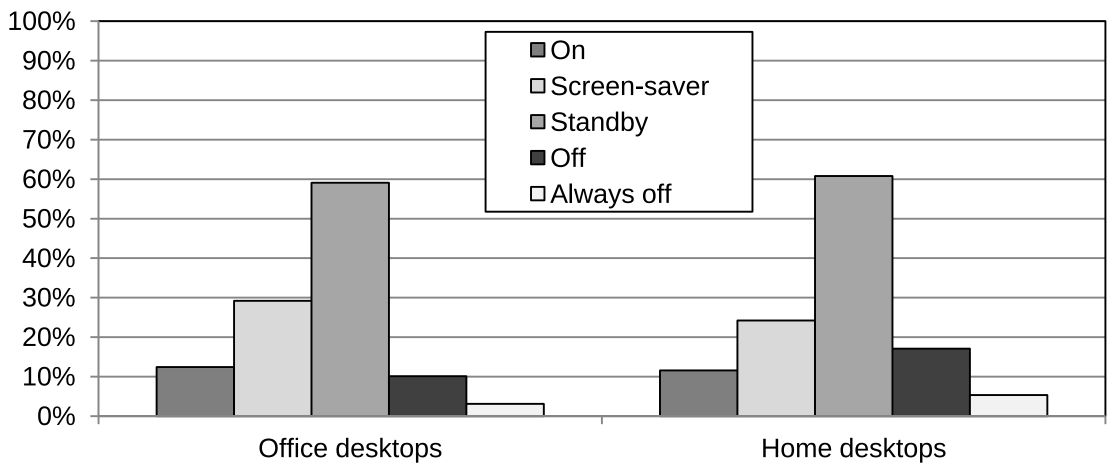
These findings are roughly consistent with the reasons found by other studies, although the phrasings, samples, and situations differ, so exact comparisons are not feasible. The study of computer use in 20 Seattle area households by Chetty et al. (2009) allowed unstructured answers and found that the reasons given varied with the anticipated length of time away from the computer, and that people who shared a computer often left it on because others needed to use it. In the study for KACE Networks, Dimensional Research (2009) reported on reasons given by the sample of more than 500 IT managers for not using commercially available software for PM settings. The top reason given was "Computers must be available to apply upgrades and patches during off hours." Similarly, IT managers' perception that engaging automatic power management would interfere with the needs for system maintenance (updates, backups, and security) were also cited by the comments to ENERGY STAR by Horowitz (2005). The study of the United States, the United Kingdom, and Germany (more than 2,000 persons in each) found that the top two reasons given were "Other people use it" and "My computer automatically goes into hibernation or sleep mode." (1E and Alliance to Save Energy 2009).

4.3.8 Power Management Settings for Monitors

The challenges in obtaining the specific power management settings for monitors are similar to those for the computer settings: there are many possible settings and many models, and past research has not yielded agreement on the results. In the case of this study, even the distinction between CRT and LCD monitors proved difficult to convey; photographs and brief descriptions were not sufficient to elicit clear data from the respondents.

Again, the team's strategy was to ask the respondent to report how the monitor behaves if it is "left on and not used for a while." This question was asked only for desktops; screen activity and computer activity are much more closely linked for laptops. Furthermore, laptops are typically closed when not in use, and closing typically triggers a sleep mode. The options offered in Question C12 included on, screen-saver, standby, off, and "does not apply—the monitor is always turned off when not being used." The question included descriptions of the various low-power modes, and respondents could mark all options that applied in their case. Desktops are much more likely to go into standby mode than transition to screensaver; since screensaver mode is not an energy-saving mode that finding may be taken as good news. However, while respondents may not realize that screensavers do not save energy, they should be aware that leaving monitors on uses energy, and about 12 percent of monitors for both home and office desktops are reported to stay on at least some of the time (Figure 29).

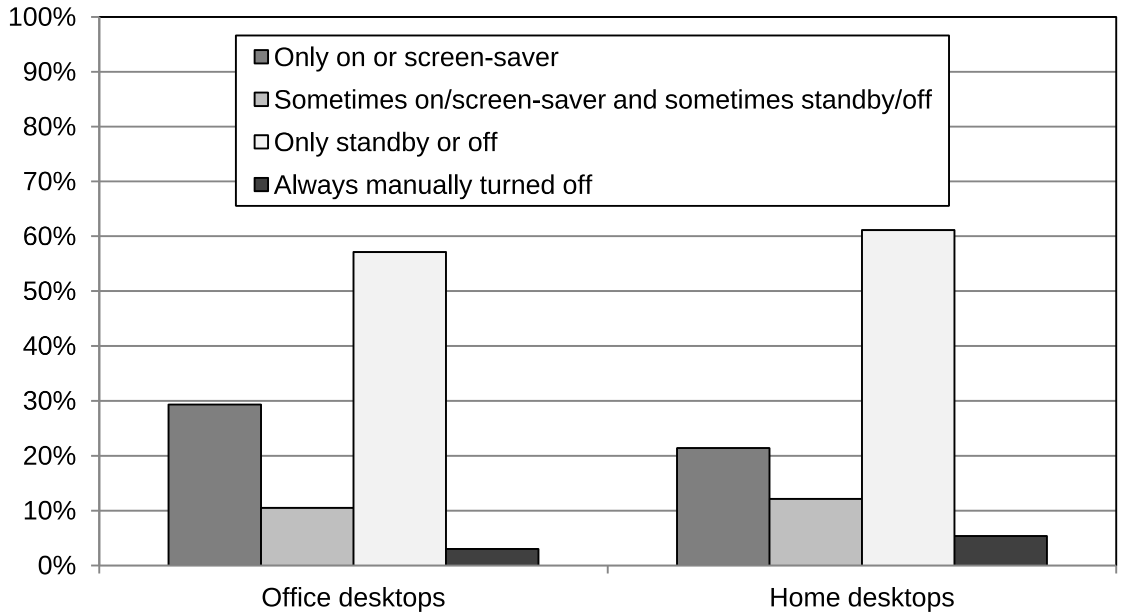
Figure 29: Percentage of Monitors Reported to Ever Transition to Low-Power States



Respondents could report multiple states for their monitors, so the percentages in Figure 29 add to more than 100 percent. To get a better sense of the energy consumption of the monitor, answers were organized into the following categories, according to energy-saving potential:

only "on" and/or "screensaver"; only "standby" and/or "off"; some combination of "on/screen-saver" and "standby/off"; and always turned off. The results are shown in Figure 30.

Figure 30: Percentage of Monitors in Each Category of Low-Power State

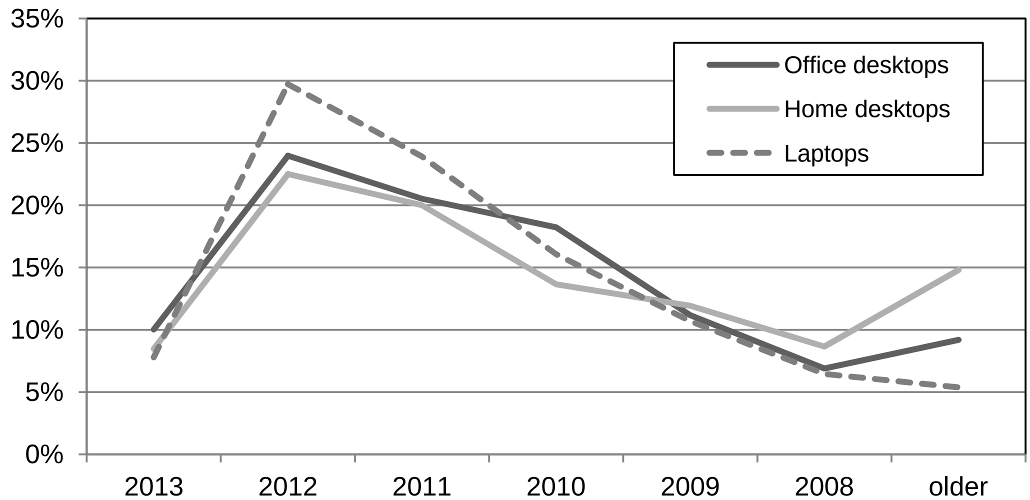


More than half of the monitors reported do transition automatically into standby mode (dark screen) or off when idle, for both office and home desktops. Few respondents reported a combination of the on/screensaver choices and the standby/off choices, and an even smaller proportion always turn their monitors off. The results suggest a substantial amount of untapped energy savings potential, because in 21 percent of home desktops and 29 percent of office desktops, the monitors either stay on or transition into a screensaver mode, which uses as much energy as being on.

4.4 The Age of Computers in the Sample

The researchers hypothesized that newer computers would have more efficient power management settings, so the survey included a question asking the respondents to report the year the computer was manufactured (or to estimate it, if the respondent did not get it new). As response options, the authors offered each year from 2013 back to "2007 or earlier" (Question C6). The results are shown in Figure 31. The lower level for 2013 is largely attributable to the fact that the researchers asked the question in May and June 2013. The majority of the computers were manufactured since 2010, and the proportion of computers that are new is highest for laptops and lowest for home desktops. (Further, analysis indicates that this result is not explained by the preponderance of students in the sample; while undergraduates are especially likely to have recently purchased laptops, at about the time they started college, laptops tend to be somewhat newer than desktops among older respondents as well.) Although fewer than half as many computers had been purchased by halfway through 2013 as in the previous year, it is likely that for a university-based sample more new purchases occur in the fall, at the beginning of the school year.

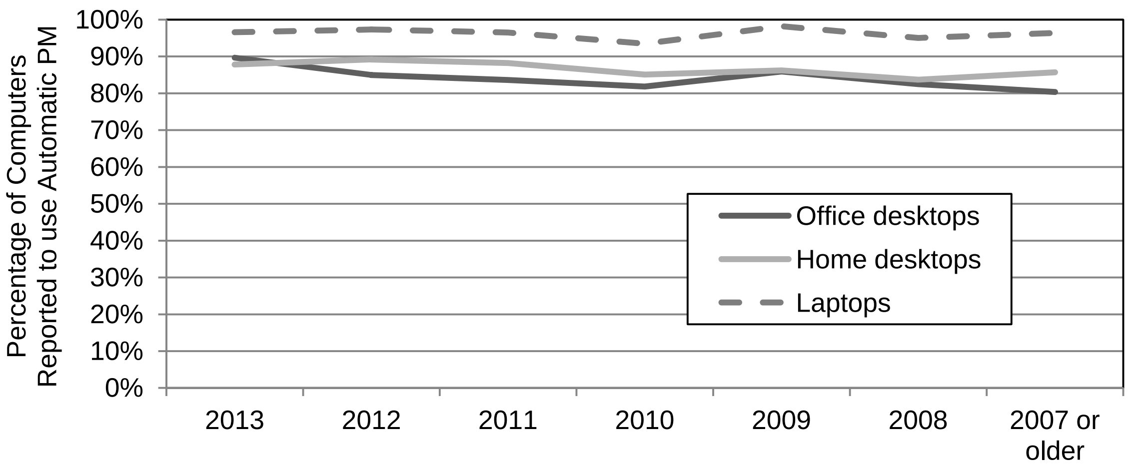
Figure 31: Percentage of Computers in Sample by Type and Year of Manufacture



Many respondents didn't know the age of their computer or didn't answer (40 percent of office desktops, less than 15 percent for the others), and those computers are not included in Figure 31. The higher uncertainty about the ages of office desktops could be because workers were assigned to computers previously used by other persons and were therefore unaware of the purchase dates. This reasoning is consistent with the finding that "don't know" responses for office desktops were much higher for students and staff than for faculty. If so, then there could be a selection bias, in which newer office desktops are more likely to have ages reported for them, suggesting that the true average age of office desktops could be older than shown here.

Given the increasing concern about the implications of energy consumption, the researchers hypothesized that manufacturers would have increased efforts in recent years to ship more computers with automatic power management enabled and to make power settings easier and more convenient to use. If so, the research team would expect to find greater use of automatic power management settings in more recently made computers. However, the analyses showed no significant relationship between the age of computers and whether respondents report that they ever transition automatically to a low-power mode (Figure 32). The research team tested age as a linear variable and compared computers purchased in the past two years to older computers, but no differences in reported PM enabling were found. The research team also tested whether respondents would be more likely to have changed the PM settings for older computers, simply because they have had the computers longer or would be more likely to change the settings on newer computers, because the settings may be more salient. However, there was no statistically significant relationship between the age of the computer and the likelihood of respondents reporting that they had changed the automatic PM settings. The only relationship that approached the usual significance threshold of $p < .05$ is for primary office desktops, for which respondents are more likely to report that nobody changed the settings for newer computers ($p = .07$). However, the levels of reported PM engagement were already high for computers in the earliest years studied here, so there was relatively little room for improvement.

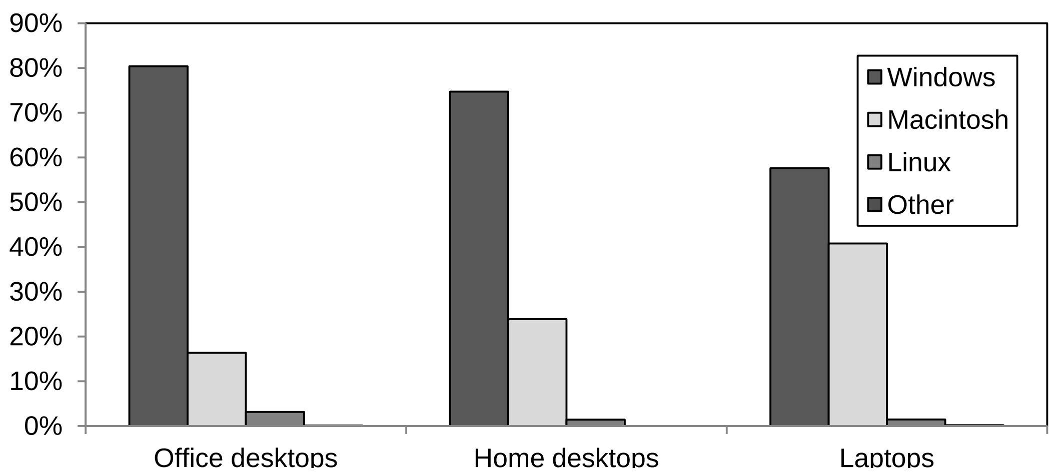
Figure 32: Percentage of Computers Reported to Use Automatic PM Settings, by Age of Computer



4.5 The Operating Systems Used by the Respondents

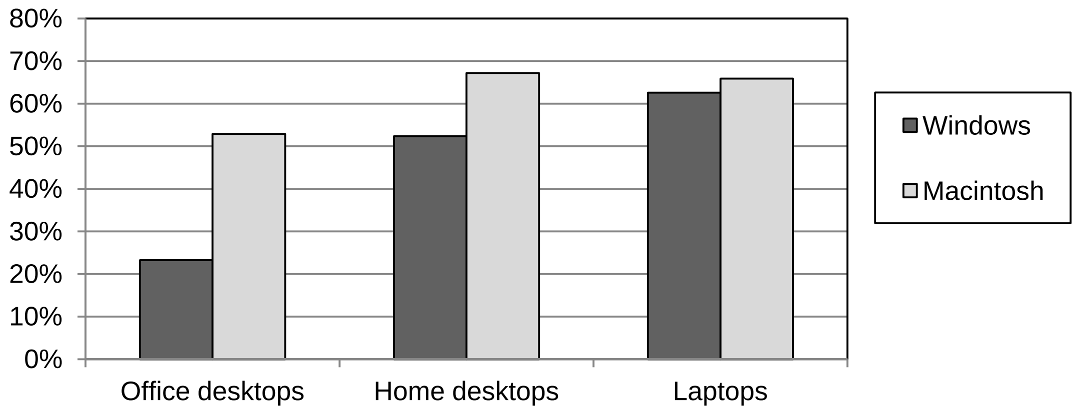
The great majority of desktops, both at home and on campus, used Windows operating systems, while less than one-quarter used Macintosh operating systems. Windows is still more common than Macintosh among laptops, but the difference is much less pronounced. A small percentage of computers use Linux or some other operating system (Figure 33).

Figure 33: Percentage of Computers of Each Operating System, by Computer Type



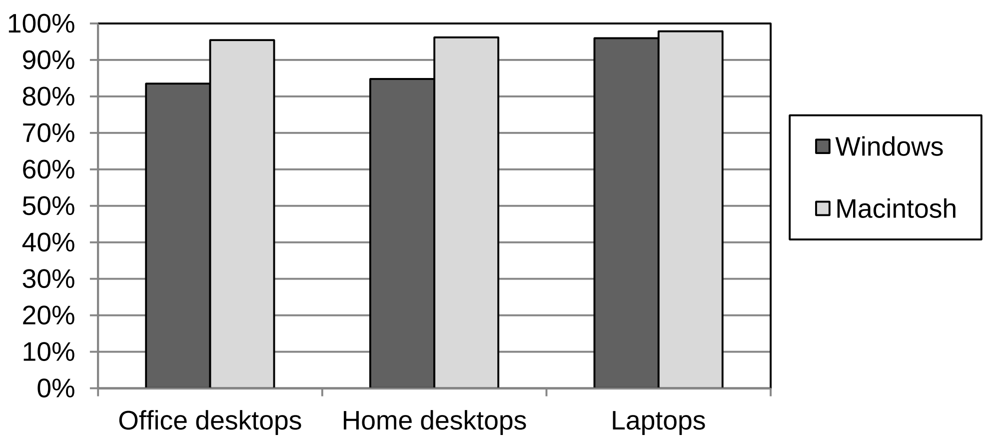
The next two figures show that operating system is related to both changing automatic PM settings and what those settings are. Respondents are more likely to report changing the automatic PM settings themselves on Macintosh desktops than on Windows desktops (Figure 34). There is no significance difference for laptops.

Figure 34: Percentage of Computers for Which Respondents Changed the PM Settings Themselves, by OS



In addition, respondents with Macintosh computers were significantly more likely to report that their computer automatically transitions to a low-power mode (Figure 35). This difference is statistically significant for all three types of computers, although the difference for laptops is very small and may not be substantively meaningful. Respondents were also more likely to report that nobody changed the PM settings for Windows desktops than for Macintosh desktops.

Figure 35: Percentage of Computers for Which Respondents Reported Automatic Power Management, by OS



The reasons for these differences are difficult to determine without additional information. It is possible that users find Macintosh settings are easier to use, but it is not clear why such a difference would affect desktops and not laptops. Perhaps users are less motivated to use automatic PM settings to save energy on desktops than on laptops, as laptop users are often operating on battery power. If so, users may be more willing to take the time and effort to locate and understand a confusing PM user interface for laptops, but give up more easily for desktops. It is also possible that Macintosh users differ on some other, unmeasured factor.

Because the survey data set includes all the computers of each respondent, it identifies the 12 percent of the respondents (219 people) who use both Macintosh and Microsoft Windows, and, in theory, those respondents could be analyzed to see if their PM behaviors are different with different operating systems. However, many of those comparisons are also across computer types—for example, respondents who use a Macintosh laptop and a Windows office desktop, or Macintosh at home and Windows at work. Because there are also PM behavior differences across computer types, determining if OS makes a difference for the PM behaviors of each person would require further multivariate analysis; that level of analysis is beyond the scope of this report and might prove to be beyond the statistical power of the sample size.

4.6 Sharing of Computers

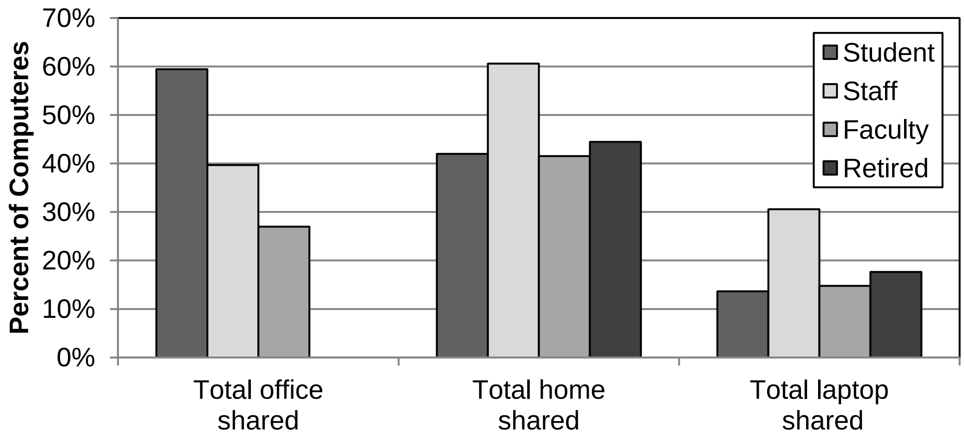
Whether a computer is shared with other users could potentially affect power management behaviors in several ways. Any user may be less likely to change the power management settings, either because another user is in charge of such things or to avoid annoying the other user. Nonetheless, with each additional person who uses a computer, the chances could increase that someone has changed the settings from the factory default. The settings themselves may be different for shared computers because, in some cases, different user “profiles” in the computer can accommodate different PM settings. Finally, manual power management behaviors may also differ on shared computers: on the one hand, users may be more likely to leave the computer on if others might soon use it, whereas if at least one user is concerned about saving energy, that person might make sure the computer is turned off at the end of the day.

The researcher team asked respondents about who else used each of the computers reported—only the respondent, mostly the respondent, others about equally, or mostly someone else (Question C1). The categorizations of “primary” and “secondary” in this study, by the respondent’s hours of use, do not necessarily correlate with sharing—a respondent’s primary computer by hours of use might still be used by someone else, and a secondary computer might be used only by the respondent.

Overall, 31 percent of the computers in this sample are shared to some extent. Sharing is more common for desktops than laptops: the respondent is the only user for 82 percent of laptops, compared to 58 percent of office desktops and 50 percent of home desktops.

Sharing of computers varies across the role groups (Figure 36**).** Students are much more likely than others to share office desktops, whereas staff members are more likely than other groups to share home desktops; in both cases, sharing occurs in almost two out of three computers. Staff members are also more likely to share laptops than other groups. The research team did not attempt to distinguish personal laptops from work laptops, a distinction that would not have made sense for many of the respondents; thus, the authors cannot tell whether laptops are being shared with coworkers or with household members, although the latter seems more likely. Additional analyses show that respondents are substantially more likely to share their primary laptop if they live with a spouse, parent, or other family members than if they live alone or with friends, suggesting that laptops are more often shared at home rather than at work.

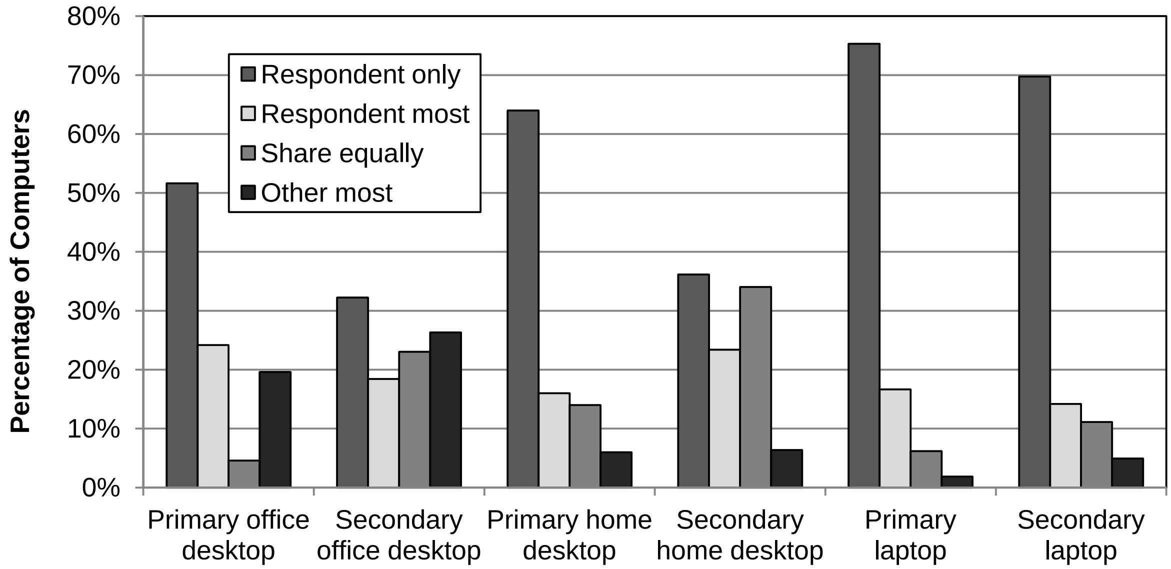
Figure 36: Percentage of Computers that Are Shared, by Type of Computer and Role Group



As mentioned earlier, there are few studies about physical sharing of computers, although there are many studies of shared access via networks. The study by Bensch and Pigg (2010) asked subjects how many people use each computer, but in the available publications on the study, those results are not given. The questionnaires by Urban et al. (2011) and by Roth et al. (2006a) clearly acknowledged that computers are shared but did not report on or quantify the degree of sharing or investigate the effect of sharing on the use of PM behaviors. The RECS study by the U.S. Energy Information Administration (2013) asked about the first, second, and third "most used" computers in the household, but not about any differences between sole use and sharing. The study by Chetty et al. (2009), using a much smaller sample, did investigate sharing explicitly and found slightly higher levels of sharing than the research team did: 63 percent of the home computers they monitored were shared (a mix of laptops and desktops in 20 households). Their result is close to the 61 percent figure the research team found for home desktops for staff members (Figure 36), but higher than what the researchers found for the other role groups.

Figure 37 compares sharing for primary computers (the one the respondent uses the most hours per week) to secondary computers, for respondents who use more than one computer of the same type. As expected, across all three types of computers, secondary computers are more likely to be shared than primary computers. The difference between primary and secondary is greatest for home desktops –for primary home desktops the respondent is the sole user in 64 percent of the cases, whereas for the second-most-often used home desktop, the respondent is the sole user in only 36 percent of the cases. By contrast, for laptops, even secondary machines are unlikely to be shared: more than 60 percent are for the sole use of the respondent.

Figure 37: Percentage of Computers that are Sole or Shared, by Primary versus Secondary Computer and by Type



Curiously, the research team also found that for office desktops and laptops, people who use two or more computers of that type are more likely to share the first one than people with only one computer of the type, for office desktops and laptops.

The research team also looked at sharing by role group as well as primary and secondary type of computer. Students and staff do at least some sharing across all types of computers—for example, 86 percent of students using office computers reported that their secondary office desktops are shared, and 60 percent of staff members report sharing a home desktop that is secondary to them. In general, it appears that staff and students experience more sharing of computers than do faculty members or retired persons.

Sharing of computers is related to power management behaviors for those computers. Figure 38 shows the percentage of primary computers for which the respondent or someone else changed the PM settings, broken out by whether the respondent is the sole user and by computer type. As expected, respondents were much more likely to have changed the PM settings themselves if they are the sole users than if they shared the computer, for all three types of computers. Respondents were also less likely to know whether anyone changed the settings if they share the computer. However, there are no statistically significant differences in whether respondents reported that nobody changed the settings. For office desktops, even if the respondent is the sole user, fewer than one in three had changed the PM settings themselves, with higher rates of “someone else,” “maybe someone else,” and “don’t know” compared to home desktops and laptops. Recall from Figure 36 that for faculty and staff, sharing itself is not higher in the office than at home. These findings suggest that the lack of control over office desktops is not solely attributable to shared use but also to the involvement of nonusers such as IT managers, supervisors, or perhaps previous users.

Figure 38: Who Changed the Power Management Settings, by Whether the Computer is Shared

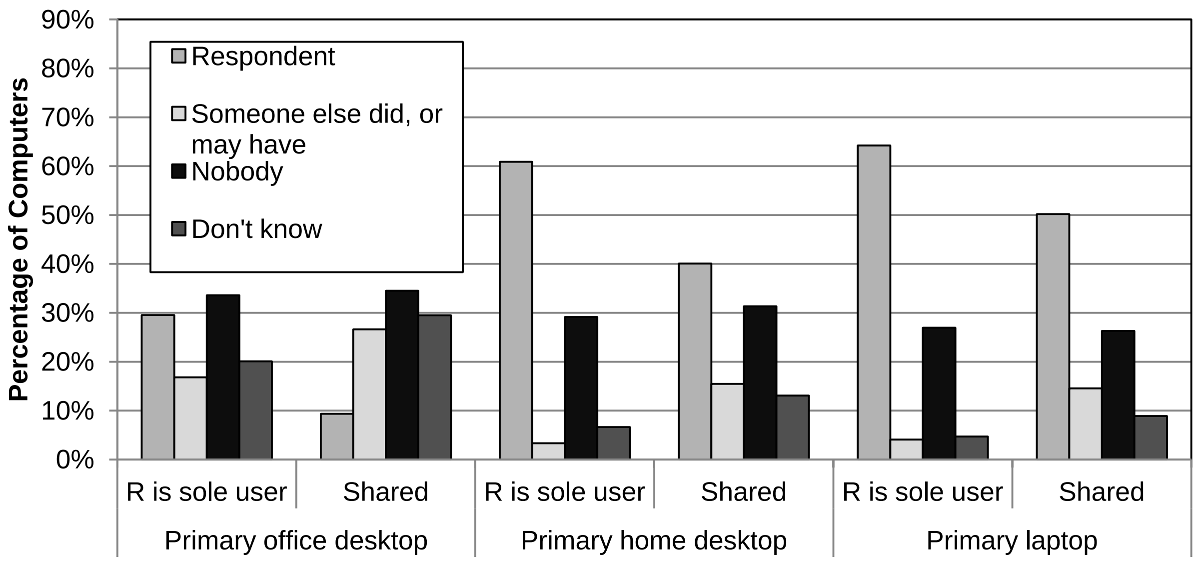
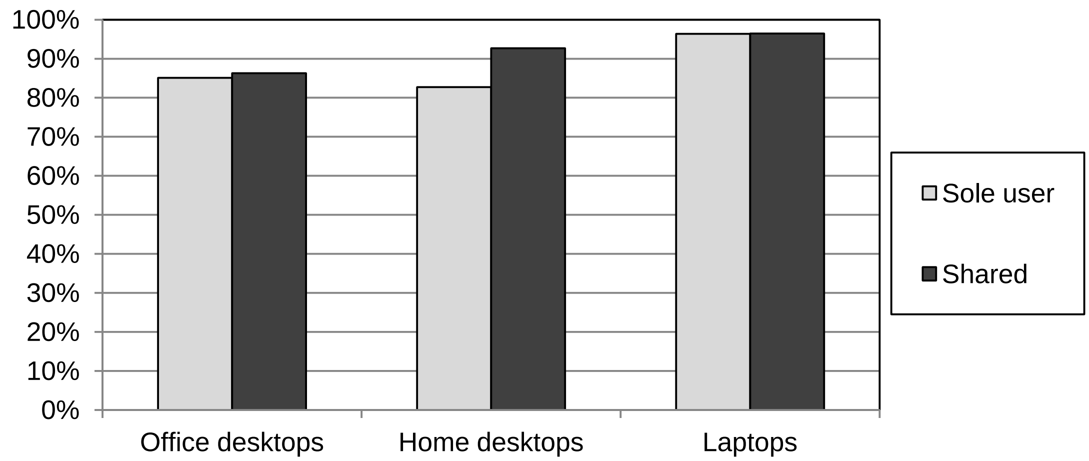


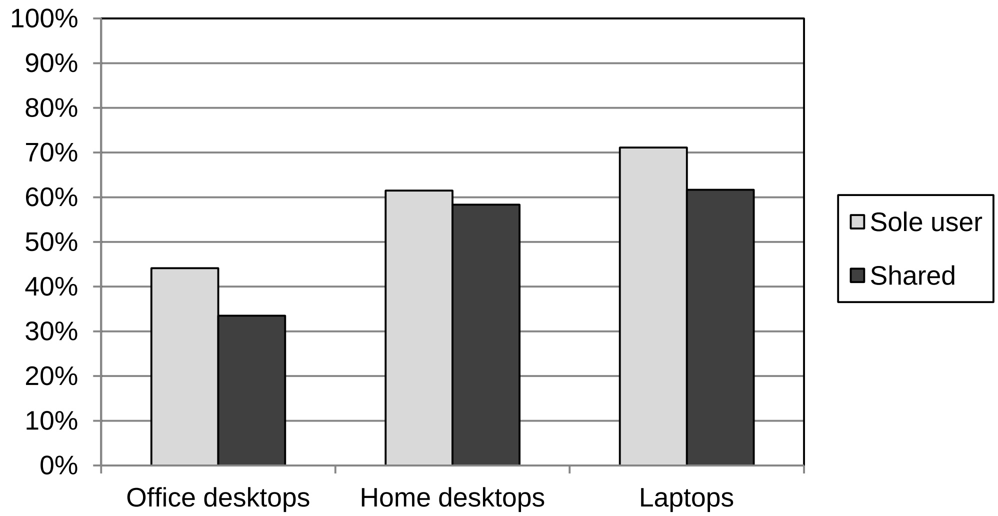
Figure 39 addresses whether respondents are more likely to report using automatic PM settings for shared or nonshared computers. For home desktops, shared computers are significantly more likely to have any PM settings reported than are nonshared computers (that is, respondents were less likely to say "none" for which low-power modes the computer transitioned into in Question C10). One possible explanation is that increasing the number of people who use a computer increases the chances that at least one user will be energy-conscious and knowledgeable about PM settings and enable automatic PM. However, it is not clear why the same does not hold true for office desktops and laptops, for which automatic PM enabling does not differ by whether the computer is shared. Few laptops are shared, and those might be special circumstances. Many office desktops are shared, however. It is possible that office desktops may be likely to be managed by one person (for example, one of the users, a supervisor, or an IT manager), such that having additional users does not increase the number of people authorized to change the settings of the computer.

Figure 39: Percentage of Computers With Any Automatic PM Engaged, by Whether Computer Is Shared



While sharing computers affects automatic PM behavior for home desktops but not for other types of computers, the opposite is true for manual PM behavior, as indicated in Figure 40. For office desktops and laptops, respondents are more likely to report using manual PM (that is, turning the computer off or manually putting it into a low-power mode at least 80 percent of the time they leave it for several hours). This occurs predominantly when they are sole user rather than when they share the computer. In other words, respondents are more likely to leave computers on if the computers are shared, compared to nonshared computers. One likely explanation is that people leave the computer on because someone else might need to use it, and indeed, this reason was mentioned often by respondents as a reason for leaving the computer on (Figure 28). However, this raises the question of why the same mechanism is not at work for home desktops. It is possible that people who share computers at home have a better idea of the other users' schedules than people who share at work and, thus, are more likely to know that the other person will not need the computer shortly. This hypothesis is consistent with additional analyses showing that the majority (61 percent) of respondents who share their primary home desktops report living with a spouse or partner (with or without children), while only 10 percent of sharers report living with friends (whose schedules may be less well-known).

Figure 40: Percentage of Computers for Which Manual PM is Used, by Whether Computer Is Shared



The reasons respondents give for why they leave their computers on (Figure 28) also differ across shared and sole-use computers. The main differences are that "others may need it" is cited more often for shared primary computers of all three types, as expected, and "asked to leave it on" was cited more often for shared laptops and home desktops than for office desktops. For office desktops, the need to be on for backups or updates and the need to be on for remote access were cited more often for sole-use computers, as was concern that restarting was too slow. The need to be on for updates or backups was also more often cited for sole-use computers among primary home desktops, while "set for low-power mode anyway" was more often cited for shared computers.

The extent to which computers are shared (especially desktops) and the relationship between sharing and PM behaviors suggest complications in conducting and evaluating educational programs about PM. At the least, the degree of sharing means that tracing the effects of education on energy consumption would be difficult. Furthermore, without further research the very nature of the effect is difficult to determine: Figure 38 suggests that shared computers are no more likely than others to have the settings changed by someone (the "nobody" level is about the same), and Figure 39 suggests that users who are more educated about PM may improve the automatic PM performance of their shared computers. However, Figure 40 suggests that educating one user in a sharing group may not be sufficient, given the practical constraints of sharing computers.

4.7 Knowledge of Computers and Power Management

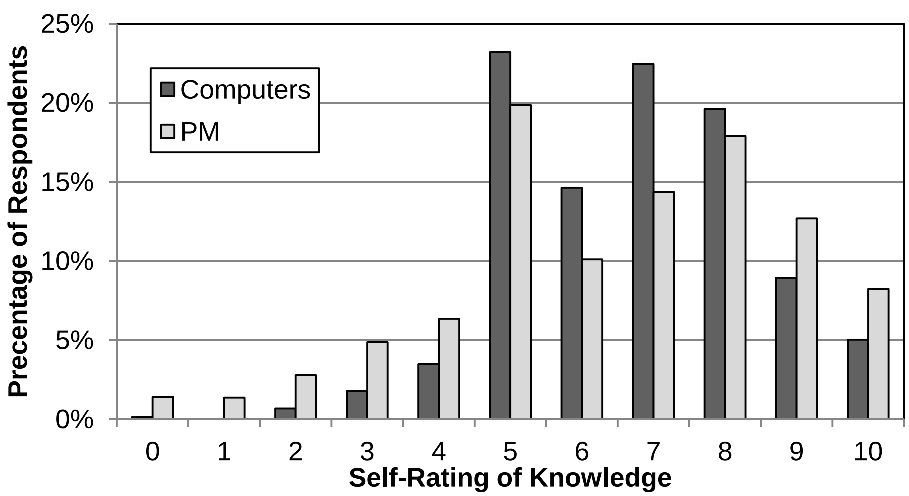
Using automatic power management requires knowing how to access the power settings and how to use them, so it seems plausible that more knowledgeable persons might do things differently. The theory behind educational efforts in this field is based in part on the idea that users will be more likely to use power management options if they are more familiar with them.

The research team included a measure of computer competence in the survey to address whether lower (perceived) knowledge of computers or of power management is indeed related to lower rates of PM behaviors.

An online survey cannot easily test a respondent's competence in computer use or PM, but a survey can ask for self-assessments and can see if the pattern of answers corresponds to groups presumed to be more knowledgeable (for example, computer scientists, in this case). In two questions in Section B (B1A and B1B), respondents were asked, "How would you rate your knowledge of computers in general?" and "How would you rate your knowledge of power management settings?" The response scale ranged from zero to ten, where zero means a beginner, ten means an expert, and five is the midpoint. (Fuller definitions were given to the respondents; see Appendix B.)

The overall mean scores of self-rankings are 6.7 for knowledge of computers and 6.5 for knowledge of PM, with standard deviations of 1.7 and 2.3, respectively. The distribution of the values for each of these variables for the full sample is shown in Figure 41. Most respondents rated themselves as above average (a score of 5) on both types of knowledge. This is consistent with the well-known cognitive bias for positive self-assessments (for example, Hoorens 1995; Hornsey 2003). However, even without such a bias, the research team would expect that knowledge of computers is, in fact, above average among university employees and students. The two types of knowledge are strongly positively correlated, as expected (r = .59), although the measures sometimes differ in the strength of the correlation to other measures in the study. A similar 1-to-10 scale on energy expertise was administered to "knowledge workers in different domains with a strong scientific background" in the study by Schwartz et al. (2010), with similar results.

Figure 41: Distribution of Values for Self-Rated Knowledge of Computers and Knowledge of Power Management



On average, respondents ranked themselves as more competent about computers in general than about power management settings; however, closer examination shows this is not true for all groups. Table 9 shows the self-ratings of the groups in the researchers' sample. Staff members, faculty members, and retirees considered themselves less knowledgeable about PM than about computers overall, but students rated themselves equally knowledgeable about both. Comparing across role groups, retirees rated themselves significantly lower than the three other groups for both measures, and staff scored lower than students for PM knowledge. This finding is generally consistent with the age patterns, in which knowledge of computers and PM was highest for ages 25 to 34 and dropped steadily for each older group. The youngest age group rated itself equally knowledgeable about both topics, but for all other age groups, self-rated knowledge was higher for computers overall than for PM.

Table 9: Mean Scores for Self-Rated Knowledge by Role, Gender, and Age Group

	Knowledge of Computers	Knowledge of Power Management
Role		
Students	6.7	6.7
Staff	6.8	6.2
Faculty	6.9	6.5
Retired	5.7	5.4
Age Group		
18 to 24	6.5	6.6
25 to 34	7.2	6.8
35 to 44	6.9	6.4
45 to 54	6.6	6.0
55 to 64	6.2	5.8
65 to 74	6.1	5.7
Gender		
Men	7.2	7.2
Women	6.3	5.9
Both knowledge scales range from 0 (beginner) to 10 (expert).		

There is also a strong gender difference: men rated themselves significantly higher than women did on both computer knowledge and PM knowledge. Further, women rated themselves as more knowledgeable about computers generally than about power management, but men's self-ratings for both types of knowledge are equal. Yet despite the large difference in self-reported knowledge for men versus for women, and the large difference in computer versus PM knowledge for women but not for men, these gender differences do not fully explain knowledge differences (or lack thereof) in the role categories. For instance, both faculty members and staff members rated their knowledge of computers significantly higher than that of power management (like women), despite the fact that more faculty members are male (57 percent), while more staff members are female (67 percent); and students rated their two types of knowledge equally (like men) despite being just over half female (54 percent).

The self-reported knowledge scores are consistent with what would be anticipated for school specializations, an indication of convergent validity: for faculty and students, computer scientists and engineers score the highest. Among staff, those in professional occupations report the highest knowledge of both computers and PM, significantly higher than those in support occupations. (The sample does not include enough workers in service or manual labor jobs to include in this calculation.) Within every school specialization or occupational type, knowledge is often significantly higher for computers than for power management.

Many of the factors discussed above—gender, role group, age, and school specialization—are interrelated; determining the independent effects of each on computer knowledge would require multivariate analyses beyond the scope of the current report.

Likewise, the scale for self-rated knowledge of computers and PM is strongly correlated to another question about computer competence. Respondents were asked, "If you got a new computer at home for your personal use, who would probably install the software and manage the settings?" Just over half of respondents said they would do it themselves (54 percent), 25 percent said they would need a little help, 5 percent said they would need a lot of help, and 16 percent said they would ask someone else to do it for them. Self-rated knowledge is highest for respondents who said they would set up their own computers (ratings of 7.4 for computer knowledge and 7.3 for PM knowledge), significantly lower for those who would need a little help (6.3 and 6.0) and lowest for those who would ask someone else (5.5 and 4.8).

Although an average difference between knowledge of computers and knowledge of power management is not observed for all groups, there are no groups for which knowledge is significantly higher for power management than for computers overall. The finding that respondents rate themselves as less knowledgeable on average about power management than about computers more generally poses important puzzles for improving both education and design. The opposite finding could be expected. Power management is a small subset of the range of knowledge required for overall computer expertise, and the menus and settings for power management are not intrinsically more difficult than the menus and settings in most commercial software. Moreover, most users get at least some exposure to power management discussions. Perhaps users believe that power management is more complicated than it really is or, as suggested earlier, they feel less control over it. Making further improvements in PM behaviors will require a better understanding of how computer users perceive these distinctions.

As described in the beginning of this section, a positive relationship was expected between knowledge of computers and PM and whether respondents had changed the PM settings. Indeed, this is the case here (Table 10). Changing the PM settings is positively associated with greater knowledge about computers, and the relationship is even stronger for knowledge about PM settings. Although respondents who have changed their PM settings in the past may then rate themselves higher in PM knowledge, the relationship probably also operates in the other direction, perhaps even more frequently: that is, that respondents with more knowledge of computers and especially of power management are more likely to change the PM settings of their computers.

Table 10: Self-Rated Knowledge of Computers and Knowledge of PM, by Whether PM Settings Have Been Changed and Computer Types

	Primary office desktop		Primary home desktop		Primary laptop	
Knowledge of:	Computer	PM	Computer	PM	Computer	PM
Did not change PM Settings	6.8	6.2	6.6	6.0	6.4	5.8
Changed PM Settings	7.7	7.9	7.6	7.6	7.0	7.2
Both knowledge scales range from 0 (beginner) to 10 (expert).						

Knowing that self-reported knowledge is linked to changing PM settings does not tell researchers how the settings were changed or what settings were used. Contrary to the expectations of many educational efforts, the analyses show a positive relationship between knowledge about computers and PM and the likelihood of having no automatic PM enabled (Table 11). These relationships are statistically significant across all primary computers, except for PM knowledge and automatic PM for office desktops. A closer examination of the likelihood of enabling PM settings at each point on the PM or computer knowledge scale shows a general linear relationship (rather than, say, an effect driven by a few extreme outliers): as self-rated knowledge increases, the likelihood of reporting no automatic PM also increases. As in the discussion about changing PM settings, the causal direction could go in either direction.

Table 11: Self-Rated Scores for Knowledge of Computers and Knowledge of Power Management, by Power Management Behaviors and Computer Type

	Primary office desktop		Primary home desktop		Primary Laptop	
Knowledge of:	Comp.	PM	Comp.	PM	Comp.	PM
Automatic PM						
Yes	6.9	6.5	6.9	6.6	6.8	6.7
No	7.4	6.9	7.9	7.7	7.2	7.4
Manual PM						
Yes [1]	6.8	6.5	7.0	6.7	6.8	6.7
No	7.0	6.5	7.2	6.8	6.8	6.5
Combinations						
Both Automatic and Manual PM	6.8	6.5	6.9	6.7	6.8	6.7
Automatic PM only	6.9	6.5	7.0	6.6	6.7	6.5
Manual PM only	7.0	6.3	7.8	7.7	7.0	7.4
Neither	7.5	7.1	8.3	8.0	7.6	7.5

Both knowledge scales range from 0 (beginner) to 10 (expert).
[1] Use of manual PM is defined as manually switching to a low-power mode 80 percent or more of the times the user will not be using the computer for several hours.

Findings from the follow-up monitoring study shed new light on the relationship between knowledge and reporting automatic power management shown in Table 11. For the small subset of office desktops in the monitoring study, knowledge of computers and knowledge of PM were negatively related to the likelihood of having reported in the survey that automatic PM modes were enabled, as was found for the larger sample. However, when comparing self-rated knowledge to the actual PM settings observed on participants' office desktops, the relationship was reversed: more knowledgeable participants were more likely to have automatic PM enabled, although this was only significant for knowledge of PM. There are limits to extrapolating results from a small study on office desktops to a more diverse sample or to different types of computers. However, this result does offer an alternative explanation for the survey results noted above: respondents with less knowledge of computers and less knowledge of PM report higher rates of automatic PM, but they seem more likely to be incorrect. More knowledgeable respondents are both more likely to use automatic PM and less likely to overreport their use.

Despite finding both that knowledge is related to changing PM settings (Table 10) and that knowledge is related to having no automatic PM settings enabled (Table 11), it bears repeating that there is no relationship between whether respondents change the PM settings and whether automatic PM is enabled (Figure 23).

As discussed earlier, disabling automatic settings does not necessarily mean using no power management; perhaps more highly knowledgeable users are managing power closely with manual actions. That is, they may be less likely to report using automatic PM but they might make up for it by using manual PM only. However, the figures in Table 11 do not support this idea. There are no significant relationships between knowledge of computers or of PM and likelihood of using manual PM for any of the computer types. The relationships between combined PM behaviors and knowledge are thus driven by knowledge differences in automatic PM use. For primary home desktops, knowledge (both of computers and PM) is positively related to using only manual PM, and for primary laptops, the same is true for knowledge of PM. However, knowledge is also positively related to using *neither* type of PM in almost every combination of computer type and knowledge type (all but laptops and PM knowledge). The relationship is not precisely linear, but neither is there any threshold level of knowledge marking a significant change in behavior.

Respondents’ self-reported knowledge about computers does not differ by operating system for primary computers of any type. Respondents’ self-reported knowledge about PM settings is higher for Macintosh office desktops than for Windows office desktops, but this difference does not hold true for home desktops. Therefore, knowledge differences between Macintosh users and Windows users do not explain the PM behavior differences between Macintosh and Windows that was noted above.

Other areas to be explored in the future could include additional multivariate analyses to analyze whether the relationship between automatic PM use and knowledge of computers and PM can be explained by other factors, such as interrelationships between knowledge and gender, age, university department, extent of computer use, or something else.

4.8 The Use of Computers for Higher-Energy Tasks

Some computer tasks use more power than others. For instance, playing “World of Warcraft” is more power-consuming than playing solitaire, and rendering complex graphics draws more power than checking e-mail. Some computer tasks may not draw a great amount of power but do draw moderate power over a long time commitment: streaming movies is a good example. Within that general understanding, however, it is difficult to make useful generalizations or draw useful dividing lines. User styles, task types, and software packages come in wide and overlapping categories, and different technical specifications can make big differences. There are many studies on energy consumption of streaming video, but fewer on the energy consumption of other tasks such as word processing or various games. See, for example, Delforge (2013b), Reinhard et al. (2011), Principled Technologies (2007), Hoque et al. (2012), Choi et al. (2003) or Han (2012).

The team developed a new measure to try to assess the degree of user behavior in such tasks. The research team identified four categories as "high-energy" tasks (ones that require a high combination of power and/or time), and the researchers asked respondents about the time they spent on those tasks. (Question C3). The categories were:

(1) Streaming music, movies, or videos.

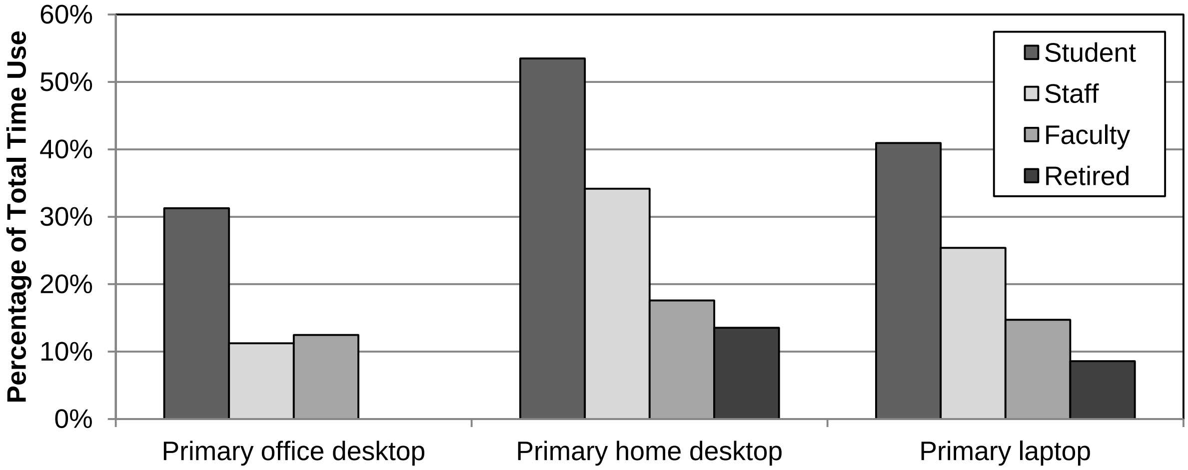
(2) Downloading or uploading very large files (takes more than 20 minutes or larger than 100 MB).

(3) Playing graphics-intensive games (like Diablo, World of Warcraft, Minecraft, or League of Legends).

(4) Running processes that take more than 20 minutes to complete or using computationally intensive software (like MatLab and other computation tools, Photoshop or image/video rendering software, video editing software, or IDEs).

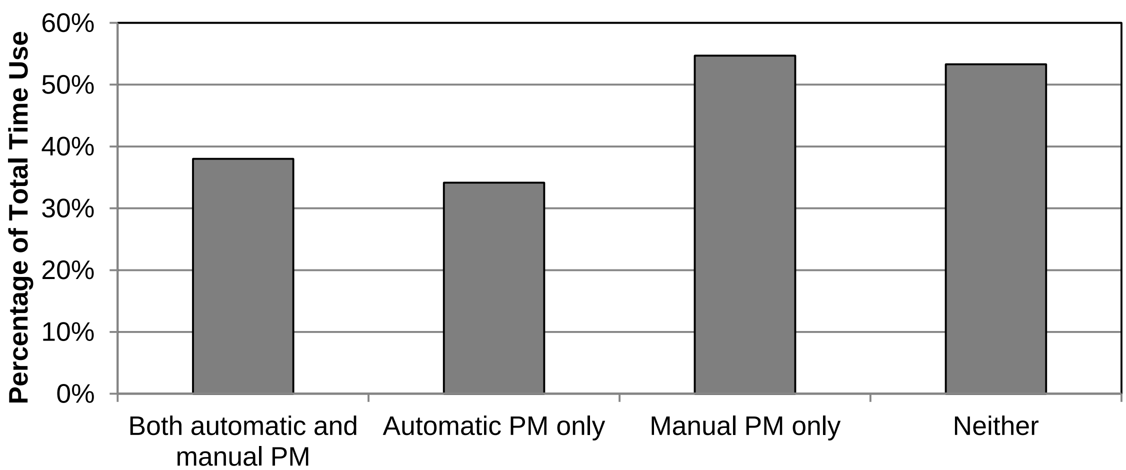
The question did not mention that these are tasks that likely use more energy than most other tasks, but some respondents may have grasped that distinction. The research team found distinct differences among the role groups, as shown in Figure 42. These results are largely consistent with conventional wisdom—students engage in such tasks more than do the other groups and retirees the least. Additional analyses show there is a negative correlation with age across the sample as a whole. On average, there is greater use of high-energy tasks on home desktops and laptops than primary office desktop. Staff members average more time on energy-intensive tasks than faculty on home desktops and laptops, but not on office desktops, so this difference between the staff group and the faculty group is probably in leisure use rather than work use.

Figure 42: Percentage of Usage Time Respondent Uses Computer on High-Energy Tasks, by Role and Computer Type



The use of high-energy tasks use is positively correlated with both knowledge of computers and knowledge of PM. The correspondence between high-energy tasks and PM behaviors is less clear and depends on the specific measure of PM. The amount of time spent on high-energy tasks is much higher on home desktops that do not have automatic PM enabled than on those that do, but there is less difference in manual PM, leading to the pattern seen in Figure 43. This finding does not hold for other computer types. It is plausible, for example, that people who are streaming movies might disable automatic PM and not re-enable it afterward. A more precise definition of the high-energy tasks may be needed to obtain clearer results.

Figure 43: Percentage of Usage Time Respondents Uses Home Desktop for High-Energy Tasks, by Reported PM Behaviors



4.9 Alteration of Computer Components After Purchase

This survey asked whether users upgraded or change hardware components, as this can result in increased power usage, and may be related to power management behaviors. Many desktops, and some other computers, are constructed to allow for addition or replacement of some components, and the popular literature includes many discussions about upgrading, but the authors know of no prior studies on the actual proportion of computers that get component upgrades.

Components that are commonly upgraded can account for a significant fraction of the total power used by the computers. See, for example, Delforge and Wold (2012), Dewart et al. (2013), Information Technology Industry Council and Technology Network (2013), Wallossek (2011) and Somavat et al. (2010). The Natural Resources Defense Council (NRDC) provided additional detail in a response to the California Energy Commission (Delforge 2013a); it notes that "high-end graphics cards can use more power in idle than the rest of the computer altogether."

There might be many reasons for changing or adding components in a computer. Perhaps existing components fail, perhaps the computer was sold without the desired component (for example, a DVD drive), or perhaps the user wants to upgrade for better performance. Informal observations of users and of the literature suggest that the majority of cases are additions or performance upgrades and that these typically lead to greater power consumption: hard drives, DVD drives, and graphics cards are typical examples. The exceptions could include the replacement of a conventional hard drive with a solid-state drive (although at present prices that change is still unusual), more efficient graphics cards, and smaller cheaper drives. Even the exceptions pose uncertainties for predicting the effects of regulations on assembled computers.

For each computer reported by the respondent, the survey asked, "Have any of this computer's internal components been added or upgraded?" and the research team offered five choices: hard drive, graphics card, CD/DVD/Blu-ray drive, wireless card, and CPU. (The research team did not distinguish between a CPU and a motherboard.) (Question C8). For laptops the research team also asked if the battery had been upgraded to a larger size or a second battery added. The survey questions did not explore whether upgrades were made before the current respondent had use of the computer, whether computers were upgraded as part of the purchase decision, or whether computers were assembled from multiple custom parts.

The percentage of computers that have had one or more of those components upgraded since manufacture is shown in Figure 44. Most computers have not had additions or upgrades, but 20 percent or more have had such changes.

Figure 44: Percentage of Computers That Have Had the Specified Number of Components Upgraded or Added, by Type

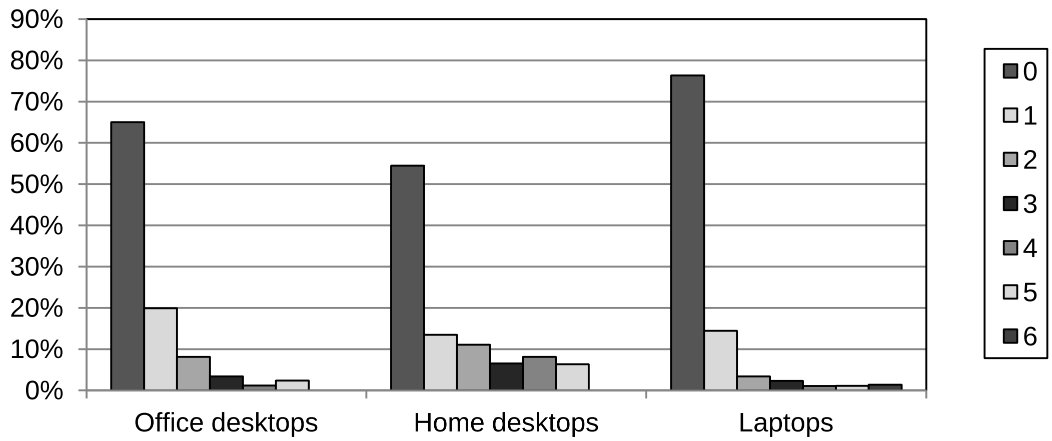
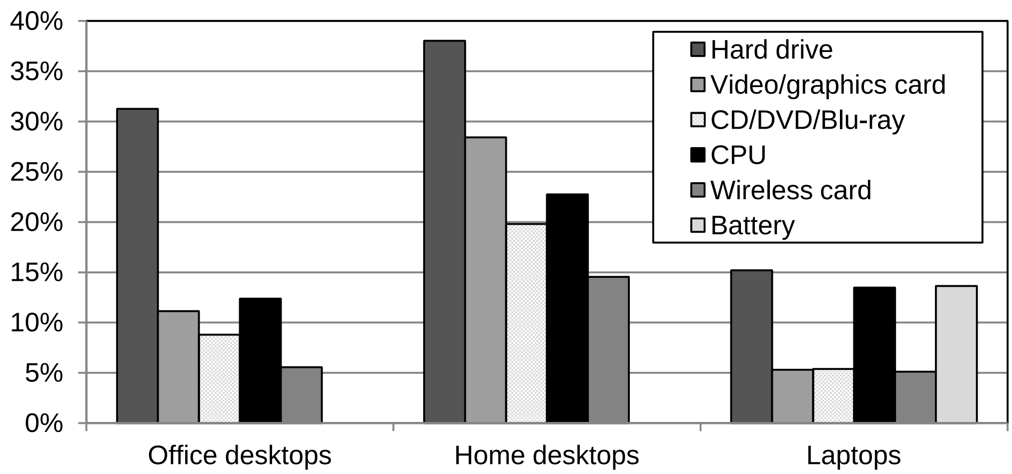


Figure 45 shows the percentages of computers that have had each kind of change, by type of computer.

Figure 45: Of Computers with Any Upgrades, Percentage that Upgraded Selected Components, by Type



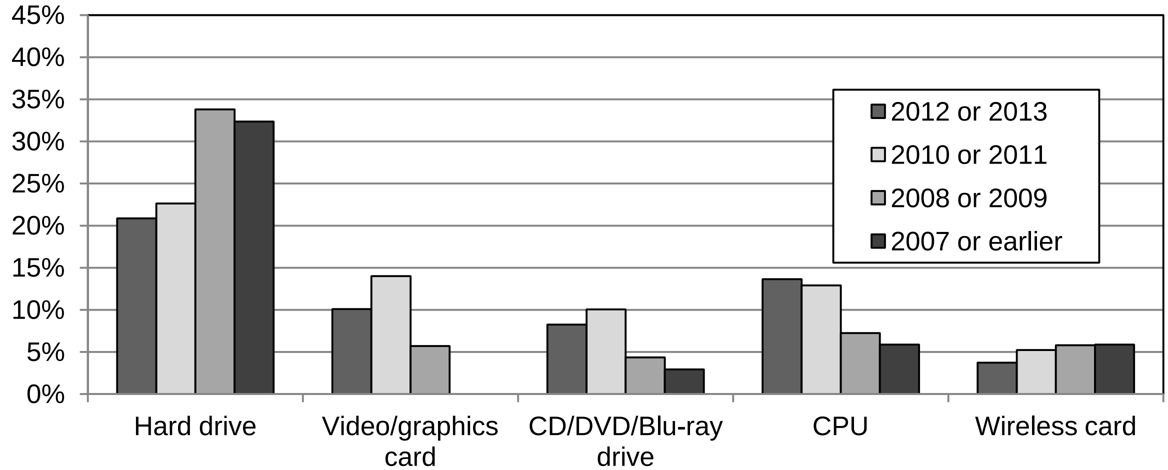
For all three types of computers, replacement of the hard drive was the most common upgrade among those listed here, ranging from 15 percent for laptops to 38 percent for home desktops. Every type of change or upgrade was more common for home desktops than for either office desktops or laptops. For home desktops, one-fifth had the CPU upgraded, and just over a fourth had the video card upgraded. The lower rates of component upgrades for office desktops than home desktops may be seen as confirmation of the common impression that large organizations replace whole computers rather than components, or it may reflect that office staff members have low rates of awareness about computer and component replacements. Laptops display low levels of component replacement, as expected: only hard drives, CPUs, and batteries were upgraded in more than 10 percent of cases.

The above figure shows only respondents who gave valid responses; as in most analyses, the "don't know" and "no answer" cases are omitted. However, as described earlier, when a large proportion of invalid responses are given, omitting them can complicate the interpretation of results. There was a very high rate of uncertainty about component upgrades for office desktops: 41 percent of respondents who use office desktops said "don't know" or "prefer not to answer" for all of the components in Question C8, and more did the same for one or more of the items. By contrast, the invalid response rate was only 14 percent for home desktops and 10 percent for laptops. It is reasonable to assume that a large proportion of respondents who said they didn't know whether any components were added or upgraded did know that they personally had not changed the components but weren't certain whether someone else (for example, an IT manager) had done so. If researchers consider all these invalid responses to be "no components changed" responses, thus adding them to the baseline, the figures for office desktops change fairly substantially: for instance, instead of 31 percent of hard drives changed, the research team would estimate 17 percent changed, and instead of 12 percent of CPUs changed, the research team would estimate 6 percent. Realistically, the true figures would be between those two estimates, as some unknown proportion of the office desktops for which respondents said "don't know" did have components changed by someone else without their knowledge.

It is reasonable to hypothesize that component replacement is more likely among older computers because users would find it cheaper to upgrade older (less efficient) computers than to buy new computers. The relationships between computer age and component replacement for primary computers are shown in Figure 46 (office desktops), Figure 47 (home desktops), and Figure 48 (laptops).

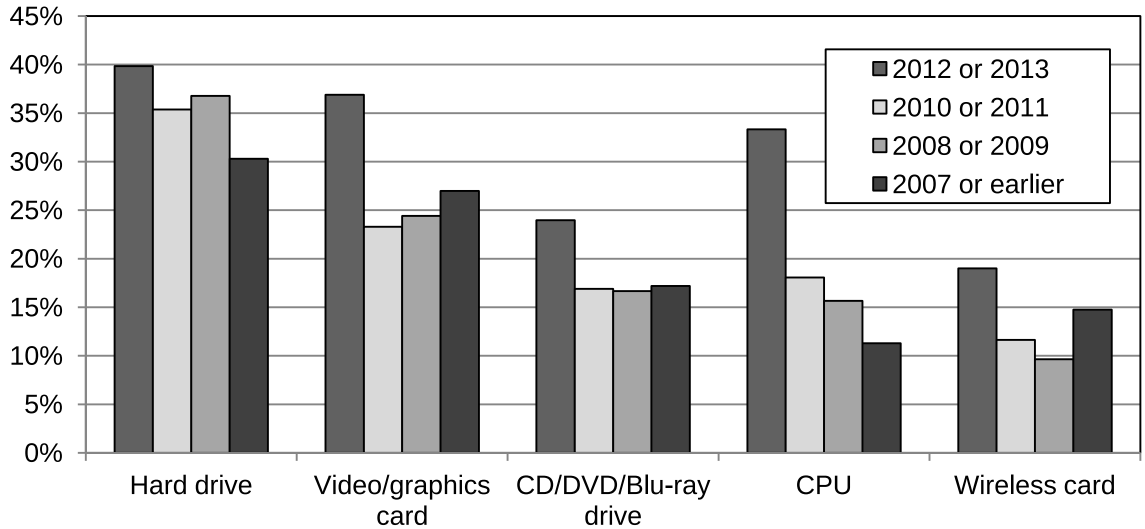
For primary office desktops, the overall differences in upgrading rates by computer age are not statistically significant (whether tested as linear age or in two-year groups). However, if researchers collapse the time line into two groups—2010 to 2013 versus 2009 and before—two significant results emerge: hard drives are more likely to be purchased for older computers, and video/graphics cards are more likely to be purchased for newer computers.

Figure 46: Percentage of Computers Bought in Each Period That Have Upgraded Components: Primary Office Desktops:



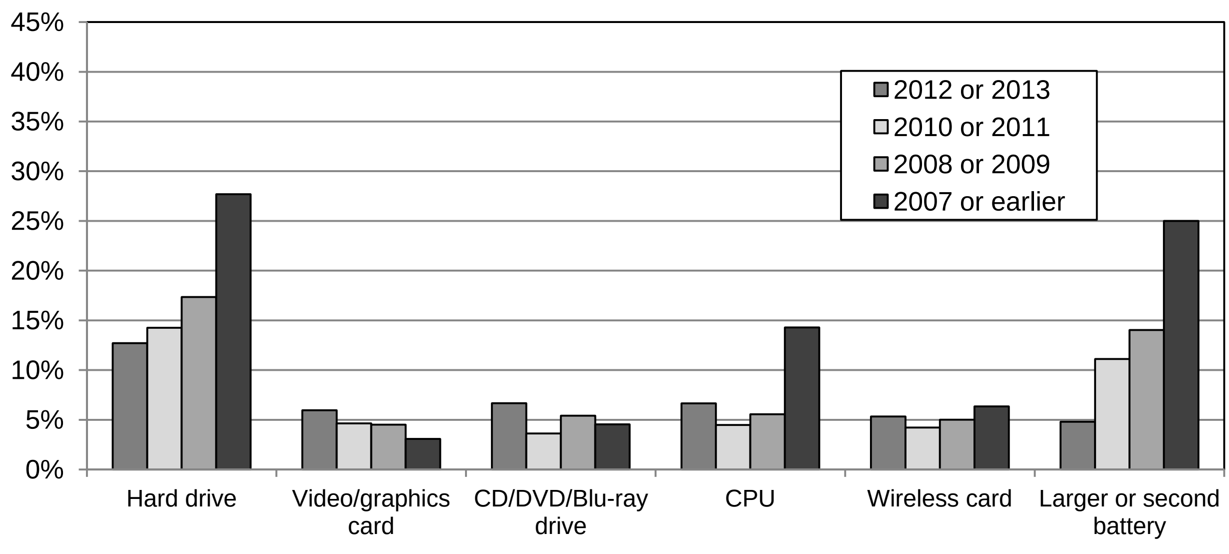
For primary home desktops, those purchased in the last two years are significantly more likely to have upgraded CPUs and video or graphics cards. The same pattern appears less strongly for the other components and almost reaches statistical significance for wireless cards. The prevalence of changes in recently purchased computers could suggest that the new components were purchased at the same time as the computer itself, perhaps to upgrade an inexpensive desktop with a few more high-performance parts. However, researchers are not sure why this would not also be the case for computers purchased several years ago. One possible explanation is that if respondents are buying upgraded components at the time of purchase, they are simply more likely to remember recent purchases than those several years ago; however, if so, the research team would expect to see a similar effect for the other two types of computers. It may be that replacing parts has become easier with more recent models of desktops, although the authors have no evidence for that.

Figure 47: Percentage of Computers Bought in Each Period That Have Upgraded Components: Primary Home Desktops



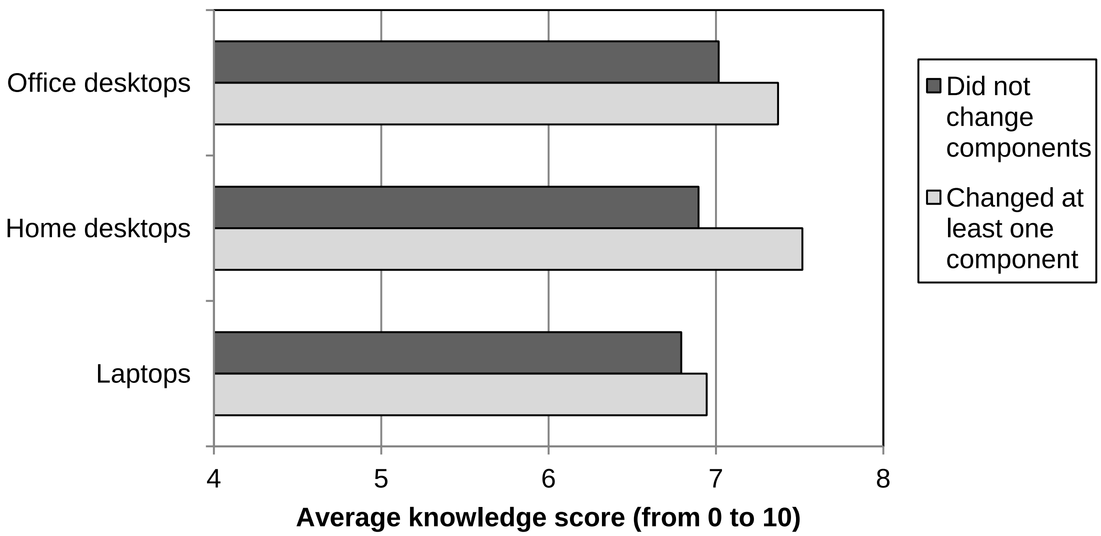
Primary laptops present a different story: while fewer components are replaced in laptops compared to desktops, the replacement rate is more closely tied to computer age for laptops, in the direction researchers initially anticipated. Hard drives, CPUs, and batteries are more often upgraded for older laptops, consistent with the idea that respondents are extending the lifetime of these computers rather than replacing them.

Figure 48: Percentage of Computers Bought in Each Period That Have Upgraded Components: Primary Laptops



Positive relationships exists between the self-ratings of knowledge of PM and of computers (Questions B1A and B1B) and the alteration or upgrading of computer components. As Figure 49 shows, for office and home desktops (but not for laptops), respondents who report that components have been changed score significantly higher on self-rated computer knowledge than respondents who report no change. Although having changed components might well make respondents feel more knowledgeable about computers, the relationship seems more likely to operate in reverse: respondents with greater computer knowledge are more likely to replace their computer components.

Figure 49: Self-Reported Knowledge About Computers and Computer Type by Whether Components Were Changed

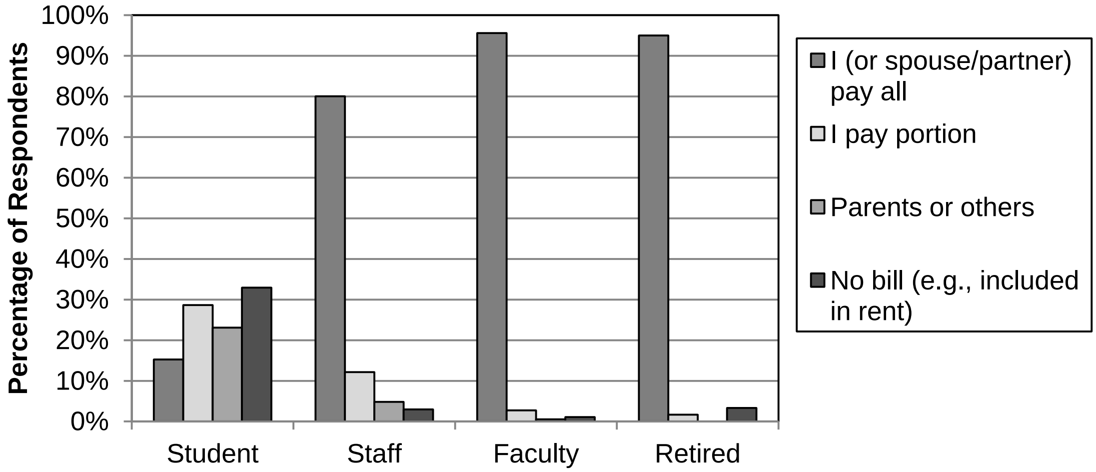


Additional analyses show no significant relationships between whether hardware components have been upgraded and whether respondents report enabling automatic PM or using manual PM.

4.10 The Effect of Paying for the Electricity Used

Economic incentives can be powerful, so people might be motivated to save energy if doing so lowers their electric bill, and many studies proceed on that assumption. However, this study found little evidence of such a relationship in the case of computer power management. The research team asked respondents a question (D3) about whether the electric bills at their home are paid in full by the respondents or their spouse or partner, paid in part by the respondent (for example, split with roommates), paid by someone else, or if they receive no bill (for example, it is included in the rent). The expectation was that respondents would be more motivated to save energy if they would have to personally pay more for more usage, or perhaps if someone else (for example, their parents) would have to pay more, rather than if the bill is embedded in the rent, which is unresponsive to actual energy use. The research team did not inquire about, or assume, the size of the bill or the rate per kWh. The pattern among the four role groups, shown in Figure 50, is not surprising: students are the least likely to pay the full electric bill, and 33 percent of them do not pay a separate electric bill at all, whereas the majority staff, faculty, and retirees are conventionally more responsible for their household’s electric bill.

Figure 50: Who Pays the Electric Bill, by Role Group



The research team tested the relationships between who pays the electric bill and whether respondents report engaging in automatic or manual power management for their home desktops, but found no significant relationships, either overall or for any role group. Contrary to expectations, respondents who are responsible for their bills are no more likely than others to report using automatic PM settings or manual PM steps for their home desktops. There could be many reasons for the lack of a correlation: perhaps respondents simply do not think about whether using PM would reduce their electric bill, or perhaps they see the potential savings as too small to outweigh other preferences for computer operation. Bensch and Pigg (2010) found that computer power management was the biggest opportunity for savings, when measured against other plug loads, but Tiedemann (2013) found potential savings for greater efficiency to be smaller for computers than for other household devices. An important caveat to the finding reported here is that almost all the respondents who do not pay their own electric bill are students; extrapolating to a broader population may not be warranted. Furthermore, paying versus not paying for electricity is a blunt way to measure financial motivation, especially since the vast majority of adults do pay their electric bill. The fact that researchers see no correlation with this particular measure does not indicate that energy costs don't matter: among those who do pay for their electricity, the *amount* they have to pay could still have an effect on computer power management behaviors.

4.11 The Effect of Demographic Variables

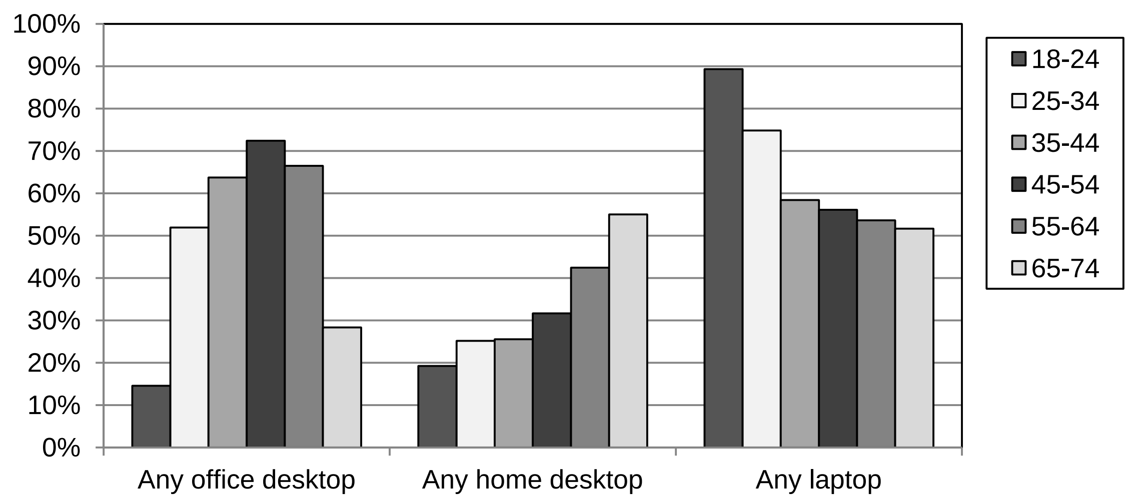
The researchers know of no other studies that examined whether demographic variables affect power management behaviors. One study of office plug load monitoring explicitly stated that "plug load energy use [is] not expected to be heavily dependent on employee demographics" (Moorefield et al. 2011). Using the method of a large survey offers the opportunity for some limited investigation on the issue: specifically, aggregate results for differences by age and gender. (At UCI, racial differences are strongly associated with role and occupational differences and so are not useful without more complex multivariate analysis.) For both age and gender, differences in what types of computers each group uses are first presented, then any differences in automatic PM behaviors and manual PM behaviors for those types of computers. More detailed analyses may be possible later.

4.11.1 Differences by the User's Age

Several studies have suggested that older persons are less adept at using new technology, including computers (for example, Charness and Boot 2009; Morris and Venkatesh 2000). However, the authors are aware of no evidence on age differences in computers power management use specifically. As the option of setting alternative power modes is relatively new compared to standard on-off operations, one might expect to find that older persons are more likely to use manual options, specifically turning the computer off, rather than changing the automatic power settings.

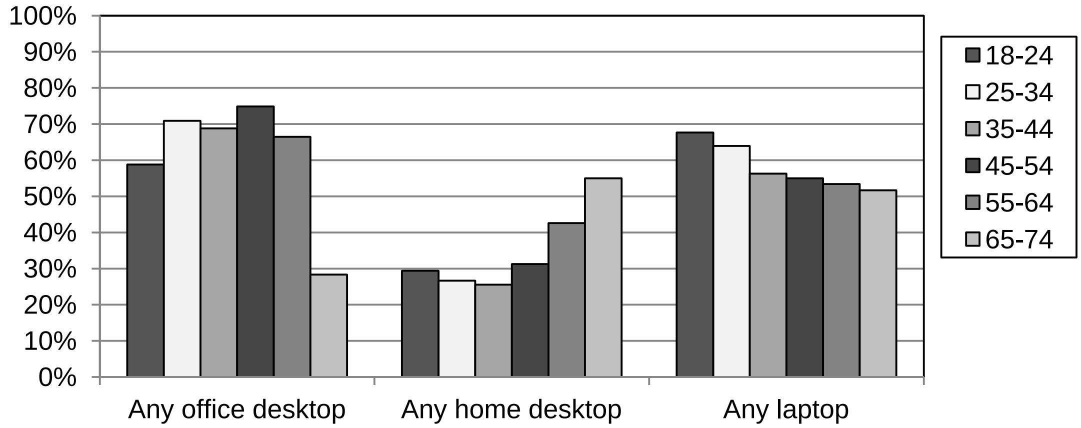
First, researchers examine whether age relates to what kind of computers are used and find clear age patterns for all three types (Figure 51). Office desktops are more often used by those in the standard "working age" groups, with fewer used by the youngest age group and increasing significantly each decade until the 45-54 group before declining fort the oldest age group. Home desktop use is low for the youngest group, rises and stays stable up to the mid-fifties, and then rises to be most common in the two oldest age groups. Finally, laptop use is most common in the youngest age group, decreases until the 30s, and is then stable from the 30s to the 70s.

Figure 51: Percentage of Respondents in Each Age Group Who Use Computers of Each Type



Researchers would expect this figure to be similar for other universities, but perhaps not for the broader population: university students have more need for mobility and less access to home or office desktops than others in their age group. For this reason, the research team also looked at age differences in use of computers for the sample with the students removed (Figure 52). As expected, younger people who are not students do not show as extreme of a difference in likelihood of using office desktops or laptops; in fact, the differences across the first three age groups are no longer significant.

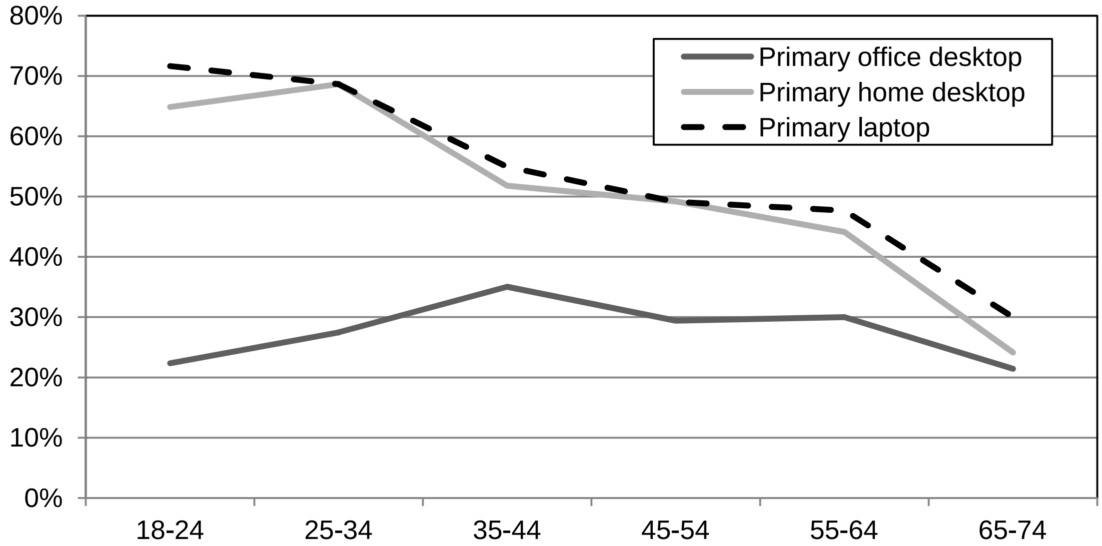
Figure 52: Percentage of Respondents in Each Age Group Who Use Computers of Each Type, Excluding Students



Without data collected over time, the research team cannot test whether the age difference is an effect of aging or a cohort effect. If it is an aging or life course effect, then as people get older or change roles in life, they will become less likely to use laptops and more likely to use home desktops. If it is a cohort effect, then older people today are more likely to use home desktops rather than laptops because they are more comfortable with the computer types available when they first started using computers, whereas today's younger people will continue using laptops as they get older (but will be less likely to adopt whatever technology is new decades from now).

The results do not show a clear, linear pattern between user age and reporting automatic PM use. However, for home desktops, the two highest age groups (ages 55 and above) show significantly higher rates of automatic PM than the younger groups, which is contrary to the initial expectations. The likelihood of the respondent changing the automatic PM settings shows a clear age pattern for primary home desktops and laptops: younger respondents are much more likely to change the settings themselves than older respondents (Figure 53). If older persons received computers with automatic PM enabled by default and are less likely to change the settings, this would help to explain their higher use of automatic PM.

Figure 53: Percent of Computers for Which Respondent Changed Automatic PM Settings, by Age Group



For manual PM behavior, the only clear age pattern is that older persons are more likely to turn laptops off or to leave them on, whereas younger persons are more likely to manually put them into sleep or hibernate mode. This would be consistent with the team's general expectation that older persons would be less likely to adopt the (relatively) new possibility of manually putting a computer into a low power mode. However, since the same effect does not occur for desktops, perhaps older respondents do not often understand that closing a laptop should usually be counted as putting it to sleep rather than leaving it on (despite the fact that closing the laptop is mentioned in the "put it into sleep or hibernate" option in Question C10).

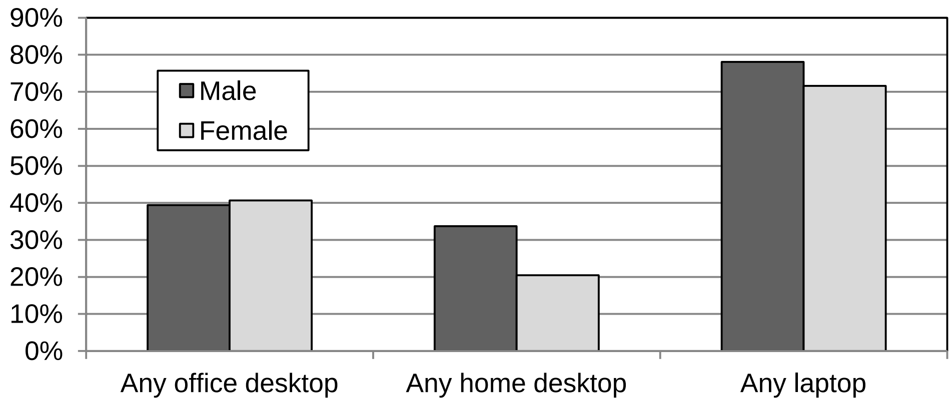
In sum, user age has a strong relationship with what types of computers respondents use and whether respondents change the power settings on their home desktops and laptops. However, the effect of age on active use of manual and automatic PM is less clear and deserves additional study.

4.11.2 Differences by Gender

This study also explored whether there are gender differences in the use of each type of computer and in behaviors toward power management. As noted elsewhere in this report, gender is correlated with role group, computer knowledge, and school of specialization. Multivariate analyses beyond the scope of this report would be needed to differentiate the independent effects of each of these factors on power management behaviors. The descriptive results shown here should thus be interpreted cautiously.

There is no significant difference between men and women in the likelihood of using office desktops, but women are somewhat less likely than men to use laptops and even less likely to use home desktops (Figure 54). Men use a slightly higher number of computers overall than women do (1.8 versus 1.5), largely because on average men use more types of computers than women: within each type, the number of computers per person does not differ by gender (for example, among laptop users, men are no more likely than women to use multiple laptops.)

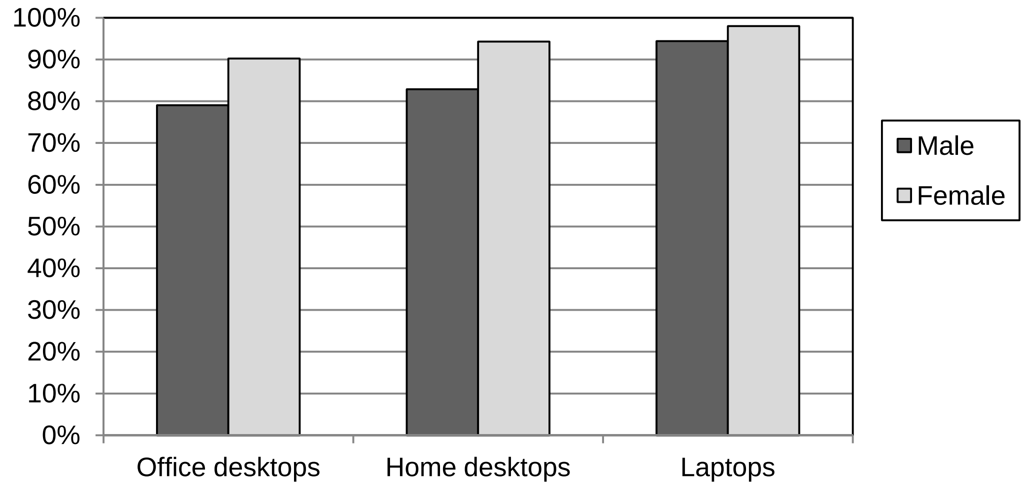
Figure 54: Percentage of Respondents Who Use Computers of Each Type, by Gender



The researchers hypothesized that women would be more likely to engage in energy-saving PM behaviors. Although no prior research on gender differences in computer power management behavior could be found, there has been substantial research on gender and environmentalism. Although results are somewhat mixed, women are generally found to have more pro-environmental attitudes than men, and these attitudes are linked to higher rates of pro-environmental behaviors (Mobley et al. 2010; Zelezny et al. 2000). In particular, women have been found to engage in more private behaviors, such as recycling (rather than, say, engaging in public protests), which may correspond to other private energy-saving behaviors (Hunter et al. 2004).

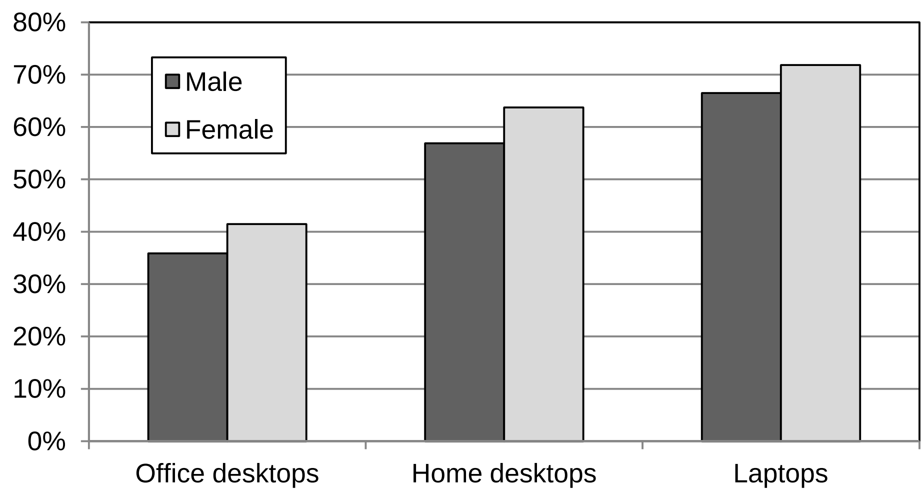
The results from this survey show a strong gender difference in power management behaviors. Figure 55 shows that women are significantly more likely than women to report that their computers ever transition into a low-power state, for all three types of computers.

Figure 55: Percentage of Computers for Which Any Automatic PM is Reported, by Gender



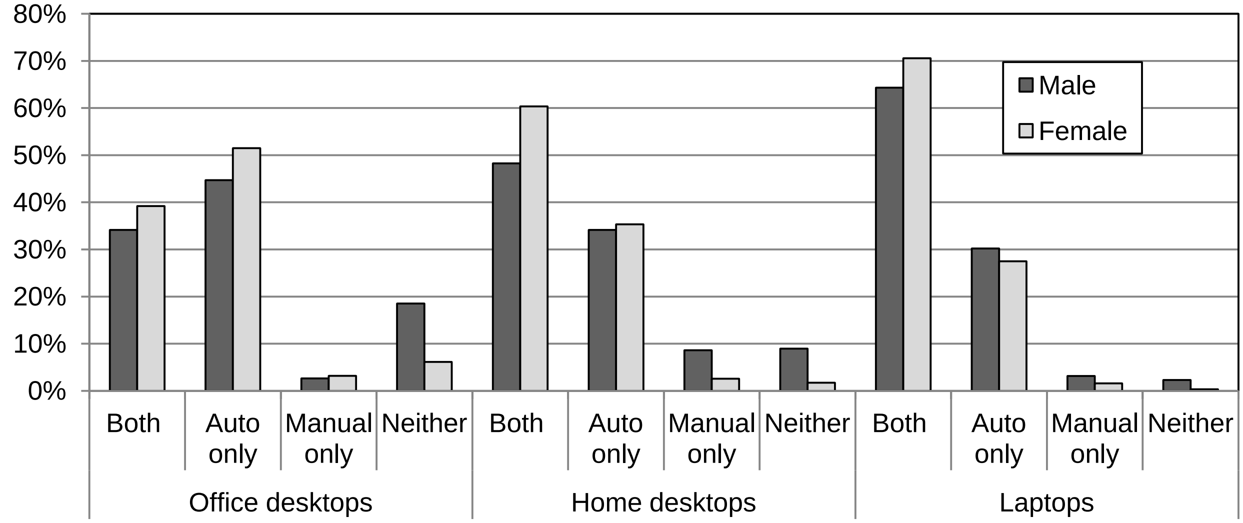
For manual power management actions, for all three types of computers, women are significantly more likely than men to use manual PM steps at least 80 percent of the times they leave their computer for several hours (that is, turn off the computer or manually put it into sleep or hibernate mode) (Figure 56).

Figure 56: Percentage of Computers for Which Use of Manual PM is Reported, by Gender



The gender difference can also be seen in the combination of automatic and manual PM (Figure 57). For all three types of computers, women are more likely to report using both automatic and manual PM, and men are more likely to use no PM at all.

Figure 57: Percentage of Computers with each Combination of Automatic PM and Manual PM, by Gender



4.12 Understanding the Survey Results in the Context of the Monitoring Study Results

In the follow-up monitoring study, the observed automatic power management settings indicated that some survey respondents had overestimated their use of automatic PM, at least for these specific office desktops. Being able to directly compare self-reported and observed measures within the same sample offers a unique opportunity to explore the source of these differences. Doing so grants important insights into what users believe about their power management behaviors.

The monitoring study report (Pixley and Ross 2014) examines the possible causes for the discrepancy in automatic PM results across the two studies in detail. Although some difference between self-reported and observational data is common, due to either error or biased reporting, reporting on automatic PM appears to be a special case. The discrepancy between survey and observational data was substantially larger for automatic power management than for other questions in the survey, including hours of computer use and manual PM behaviors, for which respondents were reasonably accurate in their reporting. Moreover, this level of discrepancy far exceeds the effect of social desirability found in other surveys of socially desirable activities. For comparison, there is a well-known bias in over-reporting voting behavior, but even the accuracy rates in those studies are typically substantially higher than what is observed here (for example, 80 percent accuracy found by Belli et al 1999). In short, something more than self-serving bias is affecting reports of automatic PM.

The overall conclusion in the monitoring study report is that the differences between observed automatic PM enabling and reported use of automatic PM are probably driven largely by user confusion about power management and cannot be fully explained by social desirability bias or other reporting biases. That is, many or even most reporting errors may be due to respondents who believe their computers really are automatically transitioning to low-power modes, rather than respondents who are deliberately misrepresenting their PM behaviors. This conclusion is based in part on finding higher usage of automatic PM and higher reporting accuracy rates for respondents who had control over their PM settings, who had changed their own automatic PM settings, and who rated themselves as more knowledgeable about computers and, especially, about PM. The report also discusses the difficulty users probably have noticing and interpreting computer behavior when they lack direct knowledge of the PM settings. Such a conclusion is consistent with past studies that found that users were confused by how to use power management settings. For example, an international survey found that 17 percent to 38 percent of office workers did not understand PM settings (IE 2009). Likewise, an in-depth study of households in Seattle found that "many people we interviewed claimed they did not know how to alter their power settings to be more energy-efficient" (Chetty e al. 2009: p. 1036).

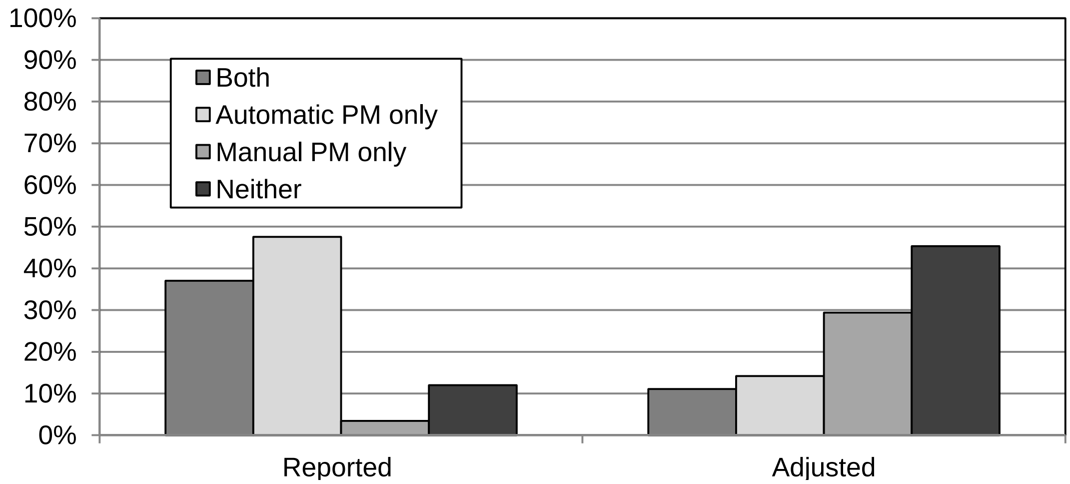
The comparison between self-reports from the survey and observed settings in the monitoring study provides a rough estimate for the accuracy of reporting on automatic PM for office desktops within the monitoring study sample. The monitoring study included a subset of 74 office desktops that were the same computers reported on in the survey and for which the PM settings had not been changed since the survey. Participants' self-reports in the survey about whether any automatic PM was enabled were compared to the PM settings observed by researchers on these computers in the monitoring study. For these 74 office desktops, the accuracy rate for those reporting any automatic PM enabled was 30 percent, the accuracy rate for those reporting no automatic PM enabled was 100 percent, and the overall accuracy rate was 39 percent (Table 8).

Any accuracy estimate based on the monitoring study results and applied to the survey data should be treated even cautiously and considered tentative. To the extent that the monitoring participants are representative of the broader survey sample, the accuracy rate found for this subset could reasonably be applied to the primary office desktops of staff, faculty, and students in the survey. However, even this requires caution, given the small size of the monitoring study sample (that is, 96 staff, 19 faculty, and 10 graduate students) and possible differences across the two samples due to self-selection into the follow-up study. It is not known how well the reliability estimates based on the monitoring study would apply to undergraduate students or retired persons, who were not included, or to office desktops other than those used most often. Furthermore, as no similar comparisons are available for home desktops or laptops, no reasonable estimates can be made for these types of computers.

In the survey, 86 percent of all office desktops were reported to use at least one type of automatic PM (for example, sleep). If the accuracy rate for the larger survey sample is assumed to be the same as that for the monitoring study, the adjusted rate would be estimated at 30 percent of 86 percent, or 26 percent of office desktops with automatic PM enabled. Respondents' reports of manual PM in the survey were substantially more accurate when compared to monitoring study data than those for automatic PM, so those results are not adjusted.

Even after adjusting automatic PM rates based on the monitoring study results, the majority of office desktops would still be expected to be using at least one type of power management. The result of the adjustment is shown in Figure 58. In this figure, the bars on the left show the percentages of office desktop computers in each combined automatic-manual PM category using the survey data; this reproduces the results presented in Figure 19. The bars on the right shows the adjusted percentages of office desktop computers in each category, if only 30 percent of computers reported to have automatic PM enabled were actually enabled. As a result of this adjustment, a large number of cases have been shifted from "both" to "manual only," while others were shifted from "automatic only" to "neither." Even so, more than half—55 percent—of office desktops would still be benefiting from at least one type of power management, either manual or automatic or both, given these assumptions.

Figure 58: Percentage of Office Desktops in Each Combination of Automatic and Manual PM, Self-Reported and Adjusted for Accuracy Estimate



The adjustments shown in Figure 58 apply only to office desktops. No estimates can be made for home desktops and laptops, which were not covered in the monitoring study. However, there are reasons to believe that the adjusted enabling rates would be higher for these types of computers. To begin with, the reported rate for automatic PM in the survey is significantly higher for laptops (96 percent) than for office desktops (86 percent), and somewhat higher, if not significantly so, for home desktops (88 percent). (See Figure 15.) Likewise, the reported rates for manual PM are significantly higher for both home desktops (60 percent) and laptops (69 percent) than for office desktops (39 percent). (See Figure 18.) Thus, even if the accuracy rates for reporting PM were the same for all three types of computers, home desktops and laptops would still exhibit higher rates of power management than office desktops.

Another reason to believe reports of automatic PM would be more accurate for home desktops and laptops than for office desktops stems from users' greater control over those computers. For office desktops in the monitoring study, users with more control over and experience with automatic PM settings are more likely to have been accurate when reporting their automatic PM usage in the survey and are more likely to exhibit automatic PM in the monitoring study (although not all of these relationships are significant in that small subsample).

Results from the survey indicate that respondents generally have more control over and knowledge about their home desktops and laptops than their office desktops. For example, respondents were much more likely to report not knowing whether their computers ever transitioned automatically to a low-power mode for office desktops (10 percent) than for home desktops (6 percent) or laptops (4 percent). Also, as shown in Figure 21, respondents were much more likely to report not knowing whether anyone changed the automatic PM settings for office desktops (26 percent) than for home desktops (12 percent) or laptops (7 percent). They were also much less likely to report changing the automatic PM settings for office desktops (20 percent) than for home desktops (41 percent) or laptops (50 percent). Only 38 percent of survey respondents reported having control over the automatic PM settings on their main office desktop. No comparable question was asked for home desktops and laptops. However, it may be assumed that most users do have control over the settings in those cases.

Thus, if the links between reporting accuracy, computer expertise, and experience shown for office desktops in the monitoring study hold true for the broader sample, accuracy rates for reports of enabling automatic PM should be higher for home desktops and especially for laptops than for office desktops. Additional research that compares self-reports of power management behaviors to observations would be needed to estimate specific accuracy rates. However, if the accuracy rate for reporting automatic PM is at least no worse for home desktops and laptops than it is for office desktops in the monitoring study, the majority of computers are still estimated to be subject to some form of power management. Office desktops, which have the lowest reported enabling rate, have an adjusted rate of 55 percent that are subject to either automatic power management, manual power management, or both. If respondents are no more accurate at reporting automatic PM for home desktops and laptops than for office desktops—which is highly doubtful—the worst-case adjusted estimates would still by 70 percent of home desktops and 79 percent of laptops benefiting from some form of power management.

CHAPTER 5: Conclusions

This study summarizes survey responses from more than 2,000 students, staff, faculty, and retirees associated with the same university. It includes data on 1,041 office desktops, 599 home desktops, and 1,729 laptops. This section first summarizes the main findings of each of the previous sections before proceeding to the researchers' broader recommendations.

Almost half the people in the sample used more than one computer, often of different types, such as a laptop and a desktop, or desktops both at home at work. The number and types of computers used varied substantially by respondents' roles or positions in the university. Students and retirees were most likely to use only one computer; for students, this was overwhelmingly likely to be a laptop, whereas retirees were more evenly split between having a laptop or a home desktop. Staff and faculty averaged about two computers each, and while they were equally likely to use home desktops, staff members were relatively more likely to use office desktops, while faculty members were more likely to use laptops. Only 15 percent of respondents reported using three or more computers at least three hours a week. There was much less use of tablets, desktops at locations other than home or campus, or computer labs on campus.

Considering hours of use for office desktops, home desktops, and laptops reveals both occupational and locational differences. Students and staff report similar total weekly hours of computer use (36 and 39 hours, respectively), while faculty report significantly more (45 hours) and retired persons report significantly less (20 hours). Students and faculty use laptops much more than the other role groups. Laptops and office desktops are used about the same number of hours per week, while home desktops are used less. As expected, office desktops are used much more on weekdays than on weekends, while for laptops and home desktops, usage patterns are more stable across the week.

Survey respondents report that the majority of their computers are subject to some type of power management (PM), although there is still a large amount of opportunity for improvement. Respondents report that automatic power management is enabled for the majority of computers, although less often for office desktops (86 percent) or home desktops (88 percent) than for laptops (96 percent). However, deeper sleep and shutdown modes are seriously underused. The most common automatic setting was sleep mode only; hibernate or a combination of sleep and hibernate was less common, and automatic shutdown (with or without a prior stage of sleep or hibernate) was rare.

Manual power management—that is, manually putting the computer into sleep or hibernate mode or turning it off when leaving it for several hours—was reported less frequently than automatic power management. However, the pattern across computer types was the same, with the most manual power management activity observed for laptops and the least for office desktops. The threshold of using manual power management at least 80 percent of the time was met for 69 percent of laptops and 60 percent of home desktops, but for only 39 percent of office desktops.

The study results show that among respondents who are not using automatic power management, relatively few are compensating by using manual power management instead. Looking at the combinations of manual and automatic power PM reveals that the great majority of people using manual PM also report automatic settings being enabled, with only a small fraction using manual alone. The use of both manual and automatic PM is most common for laptops (68 percent), found in more than half of home desktops (54 percent), and least common for office desktops (37 percent). Conversely, reporting using no power management at all is most common for office desktops (12 percent), half as prevalent for home desktops (6 percent), and rare for laptops (1 percent). Among computers that do not have automatic settings engaged, 61 percent of office desktops are reported to be left on 100 percent of the time.

The follow-up monitoring study indicated that a large percentage of respondents in that subsample overreported the use of automatic power management for their office desktops. Reports of manual power management did not exhibit the same level of discrepancy with observed results. As detailed in the separate report on that study (Pixley and Ross 2014), accuracy in reporting for automatic PM is higher for participants with greater knowledge, experience with, and control over power management settings. Caution must be employed in extrapolating the accuracy rate found for the small monitoring subset to the larger sample of the survey, and no accuracy rate can be calculated for home desktops or laptops, which were not examined in the monitoring study. As respondents on average have greater control over and experience with the PM settings for their home desktops and laptops than for their office desktops, it is likely that the reported rates of automatic PM are more accurate (and thus higher) for home desktops and laptops than for office desktops. However, even if accuracy were as poor for all computers as for the office desktops in the monitoring study, the adjusted estimates would still indicate that the majority of computers exhibit some form of power management, either automatic PM settings, manual PM steps, or both—at least 55 percent of office desktops, 70 percent of home desktops, and 79 percent of laptops.

Although the survey shows that many computers have had their power settings changed at some point, the most recent change was often not made by the respondents themselves. Respondents report having changed the power management settings themselves for 20 percent of office desktops, 41 percent of home desktops, and 50 percent of laptops. However, this varies greatly across roles. In particular, faculty members are much more likely than staff to have changed the settings on their office desktops, but this difference disappears for home desktops and laptops. For one in four office desktops, respondents don't know if the settings have ever been changed, and in another one-fifth of cases, they report that someone else changed the power settings or may have done so. When asked directly whether they control the settings on their office desktops, faculty members are much more likely to report having control than staff or students. However, a substantial proportion of all groups report not knowing whether they have control over the power settings on their office desktops, including 37 percent of staff. Fewer than 10 percent report that they have control over the PM settings on their office desktop, but there is an office policy governing those settings.

Respondents who changed the power management settings often gave multiple reasons for doing so. By far the most common reason given for changing the power settings was to save energy, cited for 53 percent of office desktops, 57 percent of home desktops, and 65 percent of laptops. For laptop users, saving energy to operate on battery power for longer also ranked highly (36 percent). The next most-cited reason for office desktops (33 percent) was that the computer needs to stay on (for example, for backups or remote access), while the next most-cited reason for laptops (31 percent) and home desktops (25 percent) was "screen was going dark too soon while I was using the computer."

Most respondents who ever leave their computers on when not in use for several hours gave several reasons for doing so. The answers most frequently given were "restarting it is too slow" and "computer will automatically go into sleep or other low-power mode anyway." The concern that others may need to use the computer was mentioned frequently for both office desktops and home desktops. For office desktops, two other main reasons cited were needing to leave the computer on for updates or backups or to be available for remote access. Relatively few people reported leaving computers on because someone else asked them to, but this was most common for office desktops.

The majority of monitors for desktops are subject to either automatic transitions or consistent manual shut-off. Unfortunately, many monitors transition only to a screensaver mode, which does not save any energy. In total, monitors for 29 percent of office desktops and 21 percent of home desktops are always either on or in screensaver mode when not being used. This study and others suggest that PM transitions by monitors may mislead users about the power status of their computers.

This study shows no significant relationship between the age of the computer (estimated year of manufacture) and the reported use of automatic power management or the likelihood that the power settings had been changed. The lack of improvement in power management utilization for newer computers suggests little progress towards achieving the latent energy savings potential of PM features.

This sample includes more computers with Windows operating systems than Macintosh. The gap was substantial for desktops (78 percent Windows, 19 percent Macintosh) but narrower for laptops (58 percent Windows, 41 percent Macintosh). There are greater differences in power management behaviors across operating systems for desktops than for laptops. For Macintosh desktops, respondents were more likely to report changing the power management settings themselves and less likely to report that nobody had changed the settings than for Windows desktops. According to respondent reports, Macintosh computers are also more likely than

Windows computers to automatically transition into a low-power mode, although this difference is very slight for laptops.

Sharing computers influences power management behaviors. Overall, 31 percent of computers in this sample are shared, although sharing is much less common for laptops (18 percent) than for home desktops (50 percent) and office desktops (42 percent). For all three types of computers, respondents are much more likely to have changed the power management settings themselves if they are the sole users than if they share the computer. Respondents are less likely to know whether anyone changed the settings if they shared the computer, but there are no significant differences in whether respondents reported that nobody changed the settings. Respondents who share computers were substantially more likely to say they leave their computers on because someone else might need to use it, and are indeed less likely to use manual PM steps for shared office desktops and laptops. For home desktops only, shared computers are more likely to have automatic power management enabled than sole-use computers.

Power management behaviors are correlated to respondents' self-ratings of their knowledge about computers in general and about power management in particular. Greater knowledge about computers is associated with higher rates of changing power settings, but the relationship is even stronger for knowledge about power management, as predicted. It may be that respondents who change their PM settings later rate themselves higher in PM knowledge, or that respondents with more knowledge of computers and especially of power management are more likely to have adjusted the PM settings themselves. In the survey, there is a negative relationship between knowledge of computers and of power management and reporting that automatic PM is enabled; that is, more expert users are most likely to say that their computers never automatically transition to a low-power mode. However, analyses of the follow-up monitoring study indicate that, at least in that subsample, more expert users are actually more likely to use automatic PM than less expert users, but also more accurate in reporting their automatic PM settings. There is no relationship between knowledge of PM or of computers and likelihood of taking manual steps to save energy (that is, turning off the computer or manually switching it to a low-power mode).

Because some computer tasks require more power than others, the survey asked about tasks that are typically thought to require considerable energy, meaning high power usage, long time commitments, or both. Complex graphics or massive data downloads would be examples. Home desktops are used most often for high-energy tasks, with laptops a close second and office desktops much less often used for such tasks. There are substantial differences by role group, with students engaging in more high-energy uses for all computer types, and staff engaging more often than faculty or retirees for home desktops and laptops. For home desktops, there is a negative relationship between amount of time spent on high-energy tasks and likelihood of reporting automatic PM, suggesting that users may disable automatic PM settings if the settings interfere with tasks such as streaming movies.

As changing hardware components could increase power usage, thus frustrating any attempt to ensure the efficiency of computers being sold, the survey asked about added or upgraded components. A substantial proportion of computers have had hardware components upgraded, including 46 percent of home desktops, 35 percent of office desktops, and 24 percent of laptops. However, given the large proportion of respondents who gave "don't know" responses for their office desktops (43 percent), that figure should be evaluated with caution. The respondent's self-rated knowledge about computers is positively related to upgrading components. The survey data showed no statistically significant relationship between whether hardware components had been upgraded and either automatic or manual PM behavior.

Almost all staff, faculty, and retirees in the research team's sample pay their electric bills themselves, but one-third of students reported receiving no electric bill (such as, it is included in the rent payment). The team tested whether responsibility for the electric bill helped to predict automatic or manual power management behaviors but found no significant differences, even among students. It is possible that power management behavior would be related to a different measure of how much respondents pay for electricity, or by their awareness of how their computer use affects their energy bill. However, the current results do not support the idea that saving money on electric bills motivates users to save energy through computer power management.

Respondents aged 55 and over are more likely to report having automatic PM enabled on their home desktops than younger respondents. For home desktops and laptops, there is also a strong relationship between user age and likelihood of having personally changed the power settings, which is highest among younger respondents and drops gradually to the oldest age groups. However, for office desktops—over which most respondents report little control—likelihood of changing the PM settings is relatively low across all age groups. Respondent age also has a strong effect on what types of computers are used. Office desktop use is most prevalent among respondents in their mid-30s to mid-50s, while home desktop use increases with age and laptop use decreases with age.

In this survey, women are much more likely than men to report using automatic power management and manual power management. However, the follow-up monitoring study casts doubt on the gender differences in the survey. In this sample, gender is correlated with role in the university (for example, more staff members are women, and more faculty members are men), and both gender and role are related to knowledge of computers, knowledge of PM, and control over PM settings. As the monitoring study revealed relationships among those variables are related to the use of automatic PM and to accuracy at reporting automatic PM, multivariate analyses would be necessary to separate the individual effects of these determinants. In the meantime, these findings on gender differences should be treated cautiously.

5.1 Implications and Recommendations

Stepping beyond data summaries, these results suggest several implications for future research and government policy in computer power management:

- Studies of workplace computers should be complemented by studies that also look at power management behaviors for the same users' home computers and laptops. The survey results indicate that for office desktops, power management is influenced strongly by the workplace environment. Estimates of energy use by computers would benefit from more systematic comparison and integration of residential and commercial studies.
- Educational efforts to improve power management behaviors use should address the issues of computer sharing and distributed control over PM settings. Given the high degree of computer sharing and the diffusion of control in office settings, people should be encouraged and enabled to communicate more about power management with their fellow users and their managers.
- Computer software and hardware should be designed to make it easier for users to readily see what PM settings are in place. PM settings that are easier to locate and easier to understand, including using the same interfaces and standardized terminology across multiple platforms and manufacturers, may allow more people who would like to save energy to do so.
- The default times for automatic PM settings to transition into sleep mode could potentially be set lower and still be acceptable to many users. The current ENERGY STAR standards specify that new computers should be set to transition to a sleep mode within 30 minutes, but in this sample, a substantial proportion of computers are already reported to transition into a low-power mode within 10 minutes. Many users may be willing to accept a faster transition time if it were the default setting.
- Hibernate should be given more prominence in the user interface for power settings. Very few computers in this study are set to automatically transition into hibernation mode, which would clearly save more energy than sleep mode does. If time-to-hibernate were included on the same screen as time-to-sleep, instead of hidden in the advanced settings, it is likely that more users would take advantage of hibernate as a power-saving option. Current user interfaces for both manual and automatic transitions are geared primarily toward sleep mode and do not easily allow users to enable hibernate.
- Solving the problems that respondents mention as reasons why they leave their computers on or change their power settings could increase their use of power management. Many respondents changed their PM settings because they felt restarting was too slow or because they usually return to their computer shortly anyway; faster restart times might encourage such people to enable automatic PM or to set shorter transition times into low-power states. Faster restart times could also increase use of manual PM steps, since "restart too slow" is the most common reason given for leaving computers on, and the concern that others may need to use the computer would not be

as problematic if the other person faced a shorter restart time. The other major problem mentioned, both as a reason for changing PM settings and for leaving computers on, is the computer requiring to be on for backups, updates, and remote access. Educating users, simplifying procedures, and increasing the reliability of options for waking computers from low-power modes or shutdown, could potentially result in much higher use of automatic and manual PM options.

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GLOSSARY

AC	Alternating current, typically 110-120 volts
ACEEE	American Council for an Energy-Efficient Economy
ACPI	Advanced Configuration and Power Interface, an industry-wide open standard for managing computer devices and components, including power management
CA	California
CEC	California Energy Commission
CEA	Consumer Electronics Association, the leading national trade organization for consumer electronics
CPU	Central processing unit
DK	Don't know, as an answer to a survey question
DOE	U.S. Department of Energy
EIA	Energy Information Administration, in the U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HD	Home desktop(s)
HP	Primary home computer(s)
IEEE	The Institute of Electrical and Electronic Engineers
IT	Information technology
L	Laptop
LP	Primary laptop(s)
NRDC	Natural Resources Defense Council
OIT	Office of Information Technology, a unit at UCI
OD	Office desktop(s)
OP	Primary office desktop(s)
OS	Operating system

PM	Power management, including both automatic power management settings and manual power management actions
R	Phe respondent to a survey question
RECS	Residential Energy Consumption Survey, produced by the U.S. Department of Energy
REF	Prefer not to answer, or refuse, as an answer to a survey question
UCI or UC Irvine	University of California, Irvine
XP	Windows XP®, a computer operating system for some desktops and laptops

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APPENDIX B:
The UCI Survey Instrument

Section A

A0. Thank you for participating!

Please take your time and answer each question to the best of your ability.

If you realize you just gave an incorrect answer, you can click on the "Back" button to back up.

DO NOT use the "back" arrow on your browser. If you try to back up and get an error message, click on the Refresh / Reload icon on your browser.

If the question does not fit on your screen, you can use Page Down to see the rest of it.

If you need to take a break from the survey, you can leave the screen up as long as you need to. Or you can close the window; later you can get back to where you were by clicking the survey link in the email we sent you.

If you ever accidentally close this window and exit the survey, just click the survey link in the email we sent you, and it will open the page you were last on.

Note that your browser must have Javascript enabled for this program to work properly. If you have disabled Javascript, please enable it while doing the survey.

To start, click the "next" button below.

A1. First, we'd like some basic information about you and what you do at UCI.

How old are you?

_________ YEARS OLD
998. Don't know → GO TO A1B
999. Prefer not to answer → GO TO A1B

IF A1 < 18, GO TO A1A
IF A1 >= 18, GO TO A2

(IF A1 < 18)

A1A. This survey is only for people who are 18 or older. However, to thank you for being willing to help, we are happy to offer you the $5 Amazon gift certificate anyway. Click on the "Next" button below to end the survey.

[END SURVEY]

GO TO END

A1B. What is your age group?

1. Under 18
2. 18 to 24
3. 25 to 34
4. 35 to 44
5. 45 to 54
6. 55 to 64
7. 65 to 74
8. 75 or older
9. 18 or older, not further specified
98. Don't know → GO TO A1C
99. Prefer not to answer → GO TO A1C

A1C. This survey is only for people who are 18 or older. We cannot verify that you are eligible if you do not report an age. However, to thank you for being willing to help, we are happy to offer you the $5 Amazon gift certificate anyway. Click on the "Next" button below to end the survey.

[END SURVEY]

GO TO END

A2. What is your gender?

1. Male
2. Female
7. Other (please describe) [____________________]
9. Prefer not to answer

A3. What is your race or ethnicity? (Mark all that apply.)

1. African American, Black
2. American Indian, Native American, Alaskan Native
3. Asian, Pacific Islander
4. Hispanic, Latino
5. Middle Eastern, Arab, North African
6. White, Caucasian
7. Other (please describe) [___________________]
8. Don't know
9. Prefer not to answer

A4. What is your position at UCI? (Mark all that apply.)

1. Undergraduate student → GO TO B1
2. Graduate or professional student → GO TO B1
3. Postdoctoral scholar → GO TO A5
4. Research staff (e.g., Researcher, Specialist, Project scientist, Lab technician) → GO TO A5
5. Administrative or management staff → GO TO A5
6. Faculty (including Lecturers and Instructors) → GO TO B1
7. Physician → GO TO B1
8. Medical staff (e.g., Residents, Fellows, Nurses, Interns, Technicians) → GO TO A5
9. Staff, all other → GO TO A5
10. Retired faculty → GO TO B1
11. Retired staff member → GO TO A5
12. Former employee, not retired → GO TO A4B
13. Not affiliated with UCI (e.g., spouse of retiree) → GO TO A4B
97. Other (please describe) [___________________] → GO TO A5

Note: Forced choice -- R cannot skip this Q or choose don't know.
Note: If marks more than one eligible category, ignore skip patterns above and continue to A1a. If marks one eligible category and also 12 (Former employee), skip according to eligible category.

(IF MARKED MORE THAN ONE IN A4)

A4a. Which of these is your primary role, that is, that you currently spend more time doing?

…

Note: Forced choice: R cannot skip this Q or choose don't know.
Note: Show only options marked in A4. For coding purposes, the answer should have the same number for this question. For instance, if R chose options 5 and 6 for A4, the answer here should be either 5 or 6 (not renumbered to 1 or 2).
Note: Use same skip patterns as in A4.

A4b. This survey is only for people who are current employees, retired employees, or students. However, to thank you for being willing to help, we are happy to offer you the $5 Amazon gift certificate anyway. Click on the "Next" button below to end the survey.

[END SURVEY]

GO TO END

(STAFF AND RETIRED STAFF)

A5. Below is a list of official Census occupation categories, with examples for each type. Which of the following best describes the type of work you {currently do/last did} at UCI?

If you aren't sure which category to choose, please give a detailed description of your work in the "Other" category.

1. Laborer or helper (examples: grounds maintenance worker, construction laborer)
2. Operative (examples: machine operator, parking lot attendant, bus driver)
3. Craft worker (examples: electrician, plumber, construction worker, painter)
4. Service worker (examples: cook, food preparation worker, custodian)
5. Security support (examples: police officer, security guard)
6. Commercial/sales support (examples: sales supervisor, cashier, travel agent)
7. Medical support (examples: medical assistant, healthcare worker)
8. Administrative support (e.g., office manager, library technician, secretary, payroll clerk, accounting assistant)
9. Technician (examples: laboratory technician, LPN, diagnostic related technologist)
10. Professional (examples: instructor, engineer, scientist, physician, pharmacist, registered nurse, librarian, computer programmer, HR specialist, accountant, financial analyst, athletic coach)
11. Manager or official (executive officer, mid-level manager)
97. Other (please describe) [____________________]
98. Don't know
99. Prefer not to answer

Section B

B1A. In this survey, we ask about the computers you use and how often you use them. Think of a scale from 0 to 10, where 0 means a beginner (say, someone who needs help using email or playing simple games) and 10 means an expert (say, someone who could do advanced programming or teach college classes in computer science).

On this scale, how would you rate your knowledge of computers in general?

0 1 2 3 4 5 6 7 8 9 10
Beginner Average Expert
[Don't know] [Prefer not to answer]

B1B. Power management settings allow you to reduce the energy your computer uses. These settings can put your computer into a low-power mode, like sleep or hibernate, if you don't touch the keyboard or mouse for a while. These settings can turn off your hard disk and dim or turn off your monitor after a period of inactivity. They can also be set to shut down your computer at a particular time.

On the same scale as above, how would you rate your knowledge of power management settings?

0 1 2 3 4 5 6 7 8 9 10
Beginner Average Expert
[Don't know] [Prefer not to answer]

Note: DK = 98, REF=99.

Programming note: Show B1A and B1B on same screen; no page break.

B3. If you got a new computer at home for your personal use, who would probably install the software and manage the settings?

1. I would do it myself
2. I would do it, but might need a little help
3. I would do it, but would probably need a lot of help
4. I would ask someone else to do the set-up for me, like a friend or a tech support service
8. Don't know
9. Prefer not to answer

B4. Which of the following types of computers do you currently use at least <u>three hours a week</u>? Please answer for the computers that you use directly for your own work or leisure, whether the computer is owned by you, by UCI, or by someone else. Do not include computers that you maintain primarily for others, like in a lab, or that monitor lab equipment or building functions.

Place your cursor over the colored phrases to see the help text.

(Mark all that apply.)

1. Desktop computer(s) on the UCI campus in an office
2. Desktop computer(s) on the UCI campus in an open computer lab
3. Desktop computer(s) at home
4. Desktop computer(s) somewhere else (examples: at an off-campus job or someone else's home)
5. Laptop or notebook computer(s) (include netbooks and convertible tablet computers)
6. Tablet(s) (examples: Apple iPad, Google Nexus, Kindle Fire)
7. I do not use any computer at least three hours a week → GO TO D2
9. Prefer not to answer → GO TO D2

Help for "desktop computer": Desktop computers are personal computers designed to stay in a single location (unlike laptops). Standard desktop computers have a "tower" or "box" and a separate monitor, keyboard, and mouse. "All-in-one" personal computers combine the tower and monitor; count these as desktops. Do not count servers.

Help for "an office": This is not limited to your own office. Include any computers you use in the office of a research advisor or research colleagues, or any shared computers that are available only to certain people, such as a work team, research team, or students of a particular professor.

Help for "campus": Throughout this survey, "campus" refers to all parts of UCI campus, including the Medical Center, North Campus, and Research Park.

Help for "open computer lab": An open computer lab is open to all UCI students, staff, and faculty, or to anyone in a particular department, such as student labs and library computers. If you use a computer lab that is limited to your research team, or to students of a particular professor, consider this a desktop in an office on campus.

Help for "home": "Home is your primary residence; that is, the place where you spent the most time during this (Spring) quarter.

Help for "convertible table computers" or "tablet": A convertible tablet computer has a built-in keyboard; typical screen size at least 10 inches diagonally; and uses Windows or Linux operating systems (examples: Lenovo IdeaPad Yoga, Sony Duo 11, ThinkPad Twist). By contrast, tablet has no built-in keyboard; typical screen size 7 to 10 inches diagonally; and uses iOS or Android operating systems. Do not count basic readers, such as a Kindle or Nook.

Note: First we ask for weekly hours spent using open lab computers, desktops not at home or at UCI, and tablets, since we're not going to ask any other questions about those. Then we ask how many of the types of other computers they have. If there is more than one, we ask R to name or label each one, to help keep track. In the following section, if there is only one type, we use the generic label (e.g., "home desktop") whereas if there is more than one of that type, the questions are repeated and we use both the generic and specific labels -- e.g., "home desktop (NAME)" where the NAME is filled in from the name/label given by R (for instance "home desktop (kitchen)".

(IF B4 = 2, COMPUTER LAB)

B5. In the past week, how many hours have you used a desktop computer in any open computer lab on campus? Count all the ways you use the computer, such as typing, reading online, playing games, or listening to music. If you are going back and forth between the computer and a nearby task (such as reading a book or doing paperwork), count the whole period as using the computer.

Please fill out your best estimate for each of the past seven days. If you don't remember, make your best guess based on a typical week. Partial hours can be entered as decimals (example: 3.5).

____ # HOURS MONDAY
____ # HOURS TUESDAY
____ # HOURS WEDNESDAY
____ # HOURS THURSDAY
____ # HOURS FRIDAY
____ # HOURS SATURDAY
____ # HOURS SUNDAY (YESTERDAY)

= ____ # HOURS PER WEEK

998. Don't know
999. Prefer not to answer

Note: The # hours per week at the bottom should be calculated automatically, not something R fills in. Each day should be set at 0 to begin with. The days themselves should be linked to the day the survey is being taken, so that the last day in the list (here, Sunday) is the day *before* the survey is taken.

Note: Use same Help text for open computer lab as in B4.

(IF B4 = 4, DESKTOP OTHER LOCATION)

B6. In the past week, how many hours have you used a desktop computer located somewhere other than your home or the UCI campus (for example, at an off-campus job or at someone else's home)? If you used more than one, combine hours for all of them.

Count all the ways you use the computer, such as typing, reading online, playing games, giving presentations, or listening to music. If you are going back and forth between the computer and a nearby task (such as reading a book or doing paperwork), count the whole period as using the computer. Do not count any time when you access this computer remotely.

Please fill out your best estimate for each of the past seven days. If you don't remember, make your best guess based on a typical week. Partial hours can be entered as decimals (example: 3.5).

[HOURS PER DAY = HOURS PER WEEK, SAME AS B5]

Note: Use same Help text for campus as B4.

(IF B4 = 6, TABLET)

B7. In the past week, how many hours have you used a tablet (such as an iPad or a Nexus)? If you used more than one, combine hours for all of them. Count all the ways you use a tablet, such as typing, reading online, playing games, or listening to music. If you are going back and forth between the tablet and a nearby task (such as reading a book or doing paperwork), count the whole period as using the tablet.

Please fill out your best estimate for each of the past seven days. If you don't remember, make your best guess based on a typical week. Partial hours can be entered as decimals (example: 3.5).

[HOURS PER DAY = HOURS PER WEEK, SAME AS B5]

Note: Use same Help text for tablet and tablet computer as B4.

(IF B4 = 1, CAMPUS DESKTOP)

B8. How many desktop computers do you currently use at least three hours a week at your UCI office, or at another office on the UCI campus?

If you share multiple computers of the same type with others in your work unit or research team (like a computer lab specifically for one professor's research), count this as one computer, even if you do not always use the same one. Do not count computers in open computer labs.

______ # COMPUTERS

Note: Use same Help text for an office computer and open computer labs as in B4.

(IF B8 > 1)

B8A. Later, we will ask some questions about each of your campus desktop computers. To help keep track of which computer you mean, please write in a name or label for each desktop computer you use on campus at least three hours a week (for example, “Main office” or “Team PC”).

Campus desktop #1: [___________________________]

Campus desktop #2: [___________________________]

(etc.)

Note: generate up to 4 lines, based on # of computers given in B8.

(IF B4 = 3, HOME DESKTOP)

B9. How many desktop computers do you currently use at least <u>three hours a week</u> in your home?

______ # COMPUTERS

(IF B9 > 1)

B9A. Later, we will ask some questions about each of your home desktop computers. To help keep track of which computer you mean, please write in a name or label for each desktop computer you use at home at least three hours a week (for example, "My XP PC" or "Kitchen Mac").

Home desktop #1: [___________________________]

Home desktop #2: [___________________________]

(etc.)

Note: Generate up to 4 lines, based on # of computers given in B9.

(IF B4 = 5, LAPTOP)

B10. How many laptop or notebook computers do you currently use at least <u>three hours a week</u>? (Include netbooks and convertible tablet computers.)

______ # COMPUTERS

(IF B10 > 1)

B10A. Later, we will ask some questions about each of your laptops or notebook computers. To help keep track of which computer you mean, please write in a name or label for each laptop or notebook you use at least three hours a week (for example, "work laptop" or "my Dell").

Laptop #1: [___________________________]

Laptop #2: [___________________________]

(etc.)

Note: Use same Help text for convertible tablets as in B4.

Note: generate up to 4 lines, based on # of computers given in B10.

Section C

Note: Repeat the set of Qs in Section C for each campus desktop, home desktop, and laptop computer used at least several hours a week mentioned in Section B, in that order. Use the same variable names, with a suffix indicating which computer it is, HD for home desktop, CD for campus desktop, LT for laptop. For instance, C1_HD1 for first home desktop, C1_LT2 for second laptop.

SKIP PATTERN: If R does not use any campus desktop, home desktop, or laptop computer regularly, go to D1 (attitudes).

C1. The next section asks about computers you use on a regular basis, including desktops on campus, desktops at home, or laptops,.

{For the following set of questions, think about your desktop computer on campus {: NAME}.}
{For the following set of questions, think about your home desktop computer{: NAME}.}
{For the following set of questions, think about your laptop or notebook computer{: NAME}.}

First, who uses this computer?

1. I am the only user
2. I use it most often, but one or more others also use it
3. Someone else uses it more often than me
4. I share it about equally with someone else
8. Don't know
9. Prefer not to answer

Note: If more than one computer, show reminder. Have the reminder text in brackets above appear as a header at the top of each page for the rest of the Qs reminding R about which computer to answer for, but worded as, "For this question, think about..."]

C2. This question is very important for our research. Please take your time and think carefully.

In the past week, how many hours did you use this computer? Count all the ways you use the computer, such as typing, reading online, playing games, projecting presentations, or listening to music. If you are going back and forth between the computer and a nearby task (such as reading a book or doing paperwork), count the whole period as using the computer. Do not count any time when you access this computer remotely.

Please fill out your best estimate for each of the past seven days. If you don't remember, make your best guess based on a typical week. Partial hours can be entered as decimals (example: 3.5).

____ # HOURS MONDAY
____ # HOURS TUESDAY
____ # HOURS WEDNESDAY
____ # HOURS THURSDAY
____ # HOURS FRIDAY
____ # HOURS SATURDAY
____ # HOURS SUNDAY

= ____ # HOURS PER WEEK

998. Don't know
999. Prefer not to answer

Note: Same as B5.

SKIP PATTERN: If C2 < 3 hours per week total, end C series and go to next computer, or to D1 if no more computers.

C3. What percent of the time you used this computer in the past week was spent doing one or more of the following tasks? Please make your best estimate.

- Streaming music, movies, or videos
- Downloading or uploading very large files (takes more than 20 minutes or larger than 100 MB)
- Playing graphics-intensivegames (like Diablo, World of Warcraft, Minecraft, or League of Legends)
- Running processes that take more than 20 minutes to complete or using computationally-intensive software (like Matlab and other computation tools, Photoshop or image/video rendering software, video editing software, or IDEs)

Never Half the time Always
0% -- 100%

[Don't know]
[Prefer not to answer]

C4. What is the operating system of this computer?

1. Windows 7 or 8
2. Windows Vista
3. Windows XP
4. Windows 2000 or ME
5. Windows 98 or older
6. Windows but not sure which version
7. Mac OS X version 10.8 "Mountain Lion" (2012)
8. Mac OS X version 10.7 "Lion" (2010)
9. Mac OS X version 10.6 "Snow Leopard" (2009)
10. Mac OS X version 10.5 "Leopard" (2007)
11. Mac OS X version 10.4 "Tiger" (2005)
12. Mac OS X version 10.3 "Panther" (2004)
13. Mac OS X version 10.2 "Jaguar" (2003)
14. Mac OS X version 10.1 "Puma" (2002)
15. Apple, Mac OS from 2001 or earlier
16. Apple, Mac but not sure which version
17. Linux, Unix
18. Android
97. Other (please describe) [____________________]
98. Don't know
99. Prefer not to answer

C6. What year was this computer made? If you bought or received it new, assume it was made that year.

If you bought or received it used, make your best guess.

1. 2013
2. 2012
3. 2011
4. 2010
5. 2009
6. 2008
7. 2007 or earlier
8. Don't know
9. Prefer not to answer

C8. Have any of this computer's internal components been added or upgraded?

C8A.	Hard drive	[Yes] [No] [Don't know] [Prefer not to answer]
C8B.	Video/graphics card	[Yes] [No] [Don't know] [Prefer not to answer]
C8C.	CD/DVD/Blu-ray drive	[Yes] [No] [Don't know] [Prefer not to answer]
C8D.	CPU	[Yes] [No] [Don't know] [Prefer not to answer]
C8E.	Wireless card	[Yes] [No] [Don't know] [Prefer not to answer]
C8F.	Larger or second battery	[Yes] [No] [Don't know] [Prefer not to answer]

Note: Show option F only for laptops.

C9. How many monitors of the following types are {usually} hooked up to this computer?

[Show image of CRT and LCD monitors.]

#______ Integrated (built in) monitor

#______ CRT monitor(s)

#______ LCD or LED monitor(s)

#______ Other type or not sure which type (Please describe: [__________________])

Help for CRT: CRT monitors are the oldest type; they are deeper front-to-back and usually heavy. Pictured above, on the left.

Help for LCD or LED: LCD monitors are newer and much thinner, at about 3 to 5 inches deep, and look like flat screen TVs. Pictured above, on the right. LED monitors are newer and even thinner than LCDs.

Note: Show "usually" only for laptops.

C10. These next few questions are very important for our research. Please take your time and think especially carefully about your answers.

Does this computer automatically go into any of the low-power modes listed below after a period of being inactive or at a specific time? If you aren't sure, read the descriptions and think about how the computer acts when nobody has used it for a while. (Mark all that apply.)

Note that pausing for a password may be required in any of these situations; do not consider that as a distinction among them.

1. Sleep, Suspend, or Stand by (The computer goes in a low-power mode; the power light may be off or may be blinking. When you touch the power button, keyboard, or mouse, the computer resumes quickly, usually within several seconds. Any programs that were running or files that were open before are still there.)
2. Hibernation or Hybrid sleep (The power goes off, but the last session is saved. When you press the power button -- or on some computers, the keyboard or mouse -- it takes more than several seconds to restart the computer. Any programs that were running or files that were open before are still there.)
3. Either “Sleep, Suspend, or Stand by” or “Hibernation or Hybrid Sleep” but I'm not sure which one
4. Automatic shut-down (The power goes off. When you press the power button, it takes at least a minute to start the computer. Any programs that were running or files that were open before have been closed.)
7. No, none of these
8. Don't know
9. Prefer not to answer

(IF C10 = sleep, hibernate, sleep/hibernate, or shut down)
(DESKTOPS ONLY)
C11A. How long do you think this computer is inactive (receives no input from keyboard, mouse, or network) before it goes into {one of these states/this state}? Please think carefully, and make your best guess.

A. Sleep, Suspend, or Stand by
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

B. Hibernation or Hybrid sleep
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

C. Either Sleep or Hibernation, but I'm not sure which one
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

D. Shut down
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

C11A2. If the computer goes into a low-power mode at a specific time instead of after a period of inactivity, please describe here: [___________________________________]

Note: Only show those states that R marked in the previous Q.

(IF C10 = sleep, hibernate, sleep/hibernate, or shut down) (LAPTOPS ONLY)

C11B. How long do you think this computer is inactive (receives no input from keyboard, mouse, or network) before it goes into {one of these states/this state}? Please think carefully, and make your best guess.

If the laptop is plugged in:

A. Sleep, Suspend, or Stand by
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

B. Hibernation or Hybrid sleep
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

C. Either Sleep or Hibernation, but I'm not sure which one
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

D. Shut down
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

C11B2. If the computer goes into a low-power mode at a specific time instead of after a period of inactivity, please describe here: [___________________________________]

Note: Only show those states that R marked in the previous Q.

Note: No page break between C11B and C11C: show both at once.

(IF C10 = sleep, hibernate, sleep/hibernate, or shut down) (LAPTOPS ONLY)

C11C. How long do you think this computer is inactive (receives no input from keyboard, mouse, or network) before it goes into {one of these states/this state}? Please think carefully, and make your best guess.

If the laptop is running on battery power:

A. Sleep, Suspend, or Stand by
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

B. Hibernation or Hybrid sleep
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

C. Either Sleep or Hibernation, but I'm not sure which one
1. Less than 10 minutes
2. 10 minutes to less than 1 hour
3. 1 hour or more
4. Never
7. Other: Enter in box below
8. Don't know
9. Prefer not to answer

D. Shut down
   1. Less than 10 minutes
   2. 10 minutes to less than 1 hour
   3. 1 hour or more
   4. Never
   7. Other: Enter in box below
   8. Don't know
   9. Prefer not to answer

C11C2. If the computer goes into a low-power mode at a specific time instead of after a period of inactivity, please describe here: [_________________________________]

Note: Only show those states that R marked in the previous Q.

(DESKTOPS ONLY)

C12. Which of these options describe how this computer's monitor acts when it is left on and not used for a while?

If more than one monitor is hooked up to this computer, answer for the primary monitor. (Mark all that apply.)

1. On -- ready to use
2. Screen-saver -- changing pattern; you press a key or move the mouse and the regular display appears
3. Standby -- dark; the display appears when the computer is activated
4 Off -- dark; you have to press the monitor power button to make the display appear
7. Does not apply -- the monitor is always turned off when not being used
8. Don't know
9. Prefer not to answer

C13. In the past two weeks, when you knew you wouldn't be using this computer for several hours or more, what percentage of the time did you do each of the following? (Must total to 100%.)

A. Turned it off / shut it down completely:

Never Half the time Always
0% -- 100%

B. Put it into a sleep or hibernate mode (using menu options or by closing the laptop):

Never Half the time Always
0% -- 100%

C. Left it on (may or may not go into a sleep or hibernate mode automatically):

Never Half the time Always
0% -- 100%

[Don't know]

[Prefer not to answer]

(IF C13C = LEFT ON > 0%)

C14. People have many reasons for leaving their computer on when they will not be using it for several hours. Which of the following reasons are true for you? (Mark all that apply.)

1. Others may need to use it
2. Restarting it is too slow; I want it to be ready when I need it
3. Needs to be on for automatic updating or backups, or for moving large files
4. Needs to be on so it can be accessed remotely
5. Needs to be on to recharge a USB device
6. Computer will automatically go into sleep or other low-power mode anyway
7. Concern that rebooting causes wear and tear to the computer
8. Asked to leave it on by someone else {e.g., IT policy at work}
9. There's no good reason to turn the computer off
97. Other (please describe) [____________________]
98. Don't know
99. Prefer not to answer

C15. Computers come with default settings for power management, such as whether the computer goes into sleep mode after a period of inactivity. Have you or anyone else changed any of the default power management settings on this computer? If the settings were changed multiple times, answer for the most recent change.

1. Nobody has changed the settings
2. I changed them
3. Someone else changed them
4. I did not change them but maybe someone else did
8. Don't know
9. Prefer not to answer

(IF C15 = 2, R CHANGED SETTINGS)
C16. Why did you change the power management settings? (Mark all that apply.)

1. Computer was restarting too slowly
2. For added security
3. Screen was going dark too soon while I was using the computer
4. I usually return to the computer in a short time
5. To save more energy
6. Computer needs to stay on (for backups, remote access, recharging devices, etc.)
7. Office policy
8. [for laptops only] To use my laptop on battery power for longer periods
97. Other reason (please describe) [______________________]
98. Don't remember / Don't know
99. Prefer not to answer

SKIP PATTERN: If any more computers, repeat series C. Else, go to D1.

Section D

(IF ANY CAMPUS DESKTOPS)

D1. Think about the desktop computer you use {most often} on campus. Do you have control over the power management settings on that computer? That is, can you change the settings for whether and when it goes to sleep, goes into hibernate mode, or automatically shuts down after a period of inactivity or at a certain time?

1. I don't have control over the power management settings
2. I control the settings, and there is a formal or informal policy about what they should be
3. I control the settings, and there is no policy about what they should be
8. Don't know
9. Prefer not to answer

(ALL VALID Rs)

D2. The last set of questions are about your living situation and your work or school situation.

First, who do you live with? (Mark all that apply.)

If you live in more than one residence, think about the one where you spent the most time during the Spring quarter.

1. Nobody / alone
2. Friend(s), roommate(s), housemate(s)
3. Spouse
4. Unmarried partner, boyfriend, girlfriend
5. My child(ren) under 18
6. My child(ren) age 18 or older
7. Parent(s)
8. Sister(s), brother(s)
97. Other (please describe) [____________________]
98. Don't know
99. Prefer not to answer

D3. Who pays the electric bill at your residence?

If you live in more than one residence, think about the one where you spent the most time during the Spring quarter.

1. I{and/or my spouse/partner} pay all of the electric bill
2. I pay a portion of the electric bill (example: shared among roommates)
3. My parent(s) or other guardian(s) pay the electric bill
4. I do not receive an electric bill (example: electricity is included in the rent)
7. Other (please describe) [___________________]
8. Don't know
9. Prefer not to answer

(STUDENTS)
D4. Are you taking at least one class on the UCI campus this (Spring) quarter?

1. Yes → GO TO D6
2. No
8. Don't know
9. Prefer not to answer

Note: Keep in mind that OIT is screening out emails of students who aren't enrolled.

(IF D4 = 2)
D5. On average during this (Spring) quarter, how often have you come to the UCI campus, whether to work, attend meetings, programs, or talks, or any other reason?

1. Once a week or more
2. One to three times a month
3. Once or twice this quarter
4. Never
8. Don't know
9. Prefer not to answer

D6. Which UCI school are you primarily affiliated with?

1. Arts
2. Biological Sciences
3. Business
4. Education
5. Engineering
6. Health Sciences (Nursing, Pharmaceutical Sciences, Public Health)
7. Humanities
8. Information & Computer Science
9. Law
10. Medicine
11. Physical Sciences
12. Social Ecology
13. Social Sciences
14. Interdisciplinary Studies
97. Other (please describe) [____________________]
98. Don't know
99. Prefer not to answer

GO TO D10

(RETIRED STAFF AND RETIRED FACULTY)

D7. On average, how often do you come to the UCI campus, whether to work, attend meetings, programs, or talks, or any other reason?

1. Once a week or more
2. One to three times a month
3. Once or twice a quarter
4. Several times a year
5. Less often or never
8. Don't know
9. Prefer not to answer

GO TO D10

(STAFF AND FACULTY)

D8. Which of the following best describes your current work status?

Note that throughout this survey, "campus" refers to all parts of UCI campus, including the Medical Center, North Campus, and Research Park.

1. Working full-time on campus (at least 30 hours per week/75% appointment)
2. Working part-time on campus (less than 30 hours per week/75% appointment)
3. On medical leave or family leave → GO TO D9
4. On sabbatical, but located locally → GO TO D9
5. Away from UCI/Irvine for work (e.g., research, sabbatical)
6. Away from UCI/Irvine for another reason (please describe) [____________________]
7. Other (please describe) [____________________]→ GO TO D9
8. Don't know
9. Prefer not to answer

GO TO D10

(IF D8 = 3 OR 4)

D9. On average during this (Spring) quarter, how often have you come to the UCI campus, whether to work, attend meetings, programs, or talks, or any other reason?

1. Once a week or more
2. One to three times a month
3. Once or twice this quarter
4. Never
8. Don't know
9. Prefer not to answer

(CURRENT STAFF AND FACULTY, RETIRED STAFF AND FACULTY)

D10. Which UCI work unit {are/were} you primarily affiliated with?

If your organization is not listed or you are unsure, please choose "other".

1. School of the Arts
2. School of Biological Sciences
3. School of Business
4. School of Education
5. School of Engineering
6. School of Humanities
7. School of Information & Computer Science
8. School of Law
9. School of Medicine

10. School of Physical Sciences
11. School of Social Ecology
12. School of Social Sciences
13. Accounting & Fiscal Services
14. Administrative & Business Affairs
15. Administrative & Business Services – Other (Office of the Vice Chancellor for Administrative & Business Services, Design & Construction Services, Internal Audit, Material & Risk Management, Administrative Policies & Records, Environmental Planning & Sustainability)
16. Campus Recreation
17. Chancellor's Office and Chancellor's Office – Other (Campus Counsel, Chief Executive Roundtable, Alumni Association, Strategic Communications)
18. Division of Undergraduate Education
19. Enrollment Services (Admissions & Relations with Schools, Registrar's Office, Center for Educational Partnerships, Financial Aid & Scholarships, Enrollment Services)
20. Environmental Health and Safety
21. EVC/Provost/Academic Affairs – Other (Office of the Executive Vice Chancellor and Provost, Academic Senate, Academic Personnel, Academic Planning, ADVANCE Program, Office of Equal Opportunity & Diversity, Ombuds Office, University Editor, Whistleblower Coordinator)
22. Facilities Management
23. Graduate Division
24. Health Sciences (Nursing, Pharmaceutical Sciences, Public Health)
25. Hospitality and Dining Services
26. Housing
27. Human Resources
28. Intercollegiate Athletics
29. Libraries
30. Medical Center or Gottschalk Plaza
31. Office of Information Technology
32. Office of Research (including institutes and centers under this office)
33. Planning and Budget
34. Police
35. Student Affairs
36. Student Affairs – Other (Office of the Vice Chancellor for Student Affairs, Student Affairs Budget Office, Student Affairs Communications Office, Student Affairs Research and Evaluation, Child Care Services, Student Affairs Human Resources & Staff Development, Student Affairs IT Strategic Planning, Student Government)
37. Student Center & Event Services/Bookstore
38. Student Life & Leadership
39. Transportation & Distribution Services
40. University Advancement
41. University Extension and Summer Session

42. Wellness, Health & Counseling Services (CARE, Career Center, Student Health, Health Education, Counseling Center, Disability Services Center)
97. Other (please describe) [_______________________]
98. Don't know
99. Prefer not to answer

Section E

E0. If you have any comments, please write them here.

* Do you think you made a mistake with one of your answers?
* Did you have an answer that did not fit into the response categories offered?
* Did you have any problems with the online survey program?
* Any other comments on the survey?

[Open ended]

E1. Thank you very much for participating! On the next page, you will be shown a link to get a $5 Amazon gift certificate, as a token of our appreciation for helping us with this research.

But first, one last question: After we look through all the answers from this survey, we may have a few more questions for our respondents. Would you be willing to consider doing another online survey like this one in the fall quarter, to help us continue our research? Saying "yes" only means you give us permission to contact you again. You would then be able to decide whether to take a follow-up survey when you learn more about it.

1. Yes, you may contact me in the fall
2. I won’t be on campus and/or with UCI in the fall
3. No, please do not contact me in the fall

END.

Follow the link below for your Amazon gift certificate. After clicking the link, read the instructions and enter your email address to receive your gift code.

Amazon gift certificate

If you have any problems with accessing the gift certificate, please contact
surveyhelp@calplug.org

Thank you!