

## Are Phantom Loads Haunting Your Energy Bill?

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### ABSTRACT

With the growing popularity of ratings systems to quantify energy use in buildings, the ability to effectively measure and minimize plug loads has become increasingly important. Phantom loads by definition are not used to perform a primary device function and thus reducing these loads is one of the easiest ways of cutting plug loads. The present study looked at units at Hilyard House Apartments in Eugene, Oregon. The hypothesis for this study was that more than 25% of total energy use metered would be consumed by phantom power loads. The hypothesis was tested by direct data metering using five data logging meters to record data for 24 hours for each of the three apartment units. In addition, a survey was distributed which asked residents of the complex to identify devices they used, the daily period of use for these devices and what state the device was left in after use. The actual phantom loads measured during this study made up 33% of the total metered energy use and thus these results supported the hypothesis of this study. Although the sample size of this survey was small, 5 out of the 11 respondents reported that they always thought about saving energy and none of the 11 respondents reported never thinking about energy savings. Given this apparent willingness to take steps to save energy and the high percentage of energy use due to phantom loads measured, more research is needed on awareness of phantom loads and what steps could be taken to reduce them.

### 1. INTRODUCTION

With the increasing importance of being able to easily estimate energy use necessitated by the popularity of energy use rating systems, plug loads have remained a difficult

component of energy consumption to quantify. The difficulty in quantifying plug loads is due to complete control the user has over these loads and a lack of reliable data for estimating user behavior. However, because of this level of control, reducing plug load energy use is one of the most immediate, cost effective and achievable ways of reducing residential energy consumption.

A significant portion of residential plug loads is comprised of what is known as phantom loads. According to the Lawrence Berkley National Laboratory, phantom loads, also called standby power or vampire loads, refer to electricity used by appliances and equipment while they are turned off or not performing their primary function (1). Almost any appliance with an external power supply, remote control, continuous display or battery charger will draw power continuously. The Laboratory estimates that phantom loads account for 5-10% of residential electricity use in most developed countries and a rising fraction in developing countries (especially in cities). Standby power use is roughly responsible for 1% of global CO<sub>2</sub> emissions (1). Phantom loads by definition occur when a device is not performing its primary function and thus reducing phantom loads is an easy way to reduce residential energy consumption without requiring a change in lifestyle.

At Humboldt State University's Redwood Manor Dorm, a study investigating energy use and phantom loads was conducted as part of the school's Green Campus Pilot Program in 2005. Students in the program surveyed occupants of the Redwood Manor Dorm and used Kill-A-Watt meters to identify the largest sources of energy consumption. The study intended to teach residents about phantom loads and installed at least one power strip where phantom loads were most predominate. After two months of

educating residents about energy conservation, the study's meter readings began to reflect a decline in energy consumption in many apartments (2).

Initially, the present study sought to survey and educate students living in University of Oregon dorms regarding their daily average energy use and respective phantom loads. The University of Oregon Housing Office was contacted to seek permission to survey students. However, since permission could not be granted to complete such a study on campus, research was conducted at Hilyard House Apartments, an apartment complex close to the University of Oregon central campus. Most occupants are students at the university and often use the following appliances: microwaves, televisions, printers and computers. According to the US Department of Energy, the biggest phantom loads come from televisions, desktop computers and their ancillary equipment like printers and scanners, and stereo and sound system equipment (3).

Inspired by the outcomes of the Redwood Manor Dorm Study, the present study seeks to educate residents of Hilyard House Apartments about ways to reduce phantom loads in their apartments. In the future, if such a study could be conducted in University of Oregon dorms, more students could be reached and educated about ways to conserve energy.

## 2. HYPOTHESIS

Based on national statistics and preliminary research, the hypothesis for this study is as follows:

Phantom loads account for more than 25% of the total daily energy consumption of apartment appliances.

## 3. METHODOLOGY & EQUIPMENT

The methodology selected for this study was to collect information about daily appliance energy use and phantom loads through two methods: An occupant survey and direct data metering. Direct data metering was used to verify the hypothesis while the survey data suggested how the metered data could be applied to a larger population.

### Survey

The survey was distributed to all the residents of Hilyard House Apartments. During the Winter term of 2009 there were 100 residents in 50 units. As an incentive to complete the survey, a piece of Dove chocolate was included with each survey. The survey and chocolate were taped at eye level to the apartment door. The survey asked each occupant the following questions:

- A list of specific electronics and appliances were provided

that included: video game player (Playstation, Wii or Xbox); desktop computer; laptop computer; speakers for computer; printer; stereo system or home theater; microwave; television (small < 20" or large > 20"); DVD Player; and two write-in lines for Other.

- For each of the above, the respondent was asked what the average daily use was in hours and how the item was typically left when not in use – either leave on, turn off, unplug or sleep mode (for computers).
- Respondents were asked how frequently they think about conserving energy: always, frequently, occasionally, seldom or never.
- Respondents were asked what their typical monthly electric bill amount is.
- Finally, respondents were asked if they would be interested in having their energy use monitored and if so to provide contact information (names, phone numbers, email addresses and apartment numbers) for follow-up.

Completed questionnaires were returned to Caitlin Gilman, the Manager who also resides at Hilyard House Apartments.

### Individual Apartment Metering

Individual apartment metering was comprised of two measurement components. The first monitored the electric use of each apartment. The Watts Up Pro meter manufactured by Electronic Educational Devices was the equipment that collected the energy use data in watt-hours for the study. The meter is capable of measuring data in watts and watt-hours on items that function on 120v. The data interval time was 15 minutes over a 24 hour period. There were five meters used in the study, which allowed five appliances or electronics to be metered for energy usage. The selected appliance/electronic was plugged into the Watts Up Pro, which in turn was plugged into the nearest outlet.

In conjunction with the watts meter, a data logger was used to measure ambient light levels in lumens/ft<sup>2</sup> and temperature in °F. The HOBO U12-012 data logger manufactured by Onset was used. The data interval for the data logger was also set at 15 minutes. A data logger was paired with a Watts Up Pro meter. The data logger was typically placed next to the watts meter with the exception of the measurement of microwaves in which the data logger was placed on top of the upper cabinets to read when the kitchen light was turned on and off. The data collection began on Friday March 6<sup>th</sup> at 6 pm at the first apartment. The equipment was then collected and moved to the second apartment on Saturday March 7<sup>th</sup> at 6:15 pm. The equipment was then collected and moved to the third apartment on Sunday March 8<sup>th</sup> at 6:30 pm. The equipment was removed from the final apartment about 7 pm on

Monday March 9<sup>th</sup>. Participants in the study were asked to use their appliances as they normally would.

Phantom loads were assumed to be the sustained base line energy use for each appliance.

4. RESULTS

Survey

From the 100 distributed surveys, 11 were returned. Three of the respondents volunteered to participate in the metering of their individual apartment units. The collected data from the survey is summarized in Table 1 and Figure 1.

In the survey results presented in Table 1, the distribution of how respondents filled out the surveys is presented. The study found that overall, the most common scenario for how an appliance was left after use was ‘turned off’. According to the survey, 62% of the appliances used by the respondents, were turned off after use. The next common response was for the appliance to be left on with 20% of appliances being reported as left that way. Finally, only 10% of appliances were reported to be unplugged after use. For computers, 27% were put into sleep mode after use, which represents 8% of all appliances put into sleep mode.

How Respondents Leave Device	Unplug	Turn Off	Sleep Mode	Leave On	Total
Gaming Console	0	4	0	0	4
Laptop	0	5	3	2	10
Desktop	0	1	0	2	3
Speakers	2	3	0	1	6
Printer	1	4	0	4	9
Television	1	7	0	0	8
DVD Player	0	2	0	0	2
Coffee Pot	0	1	0	0	1
Rice Cooker	1	0	0	0	1
Total	5	27	3	9	44
Percentages	11%	61%	7%	20%	

Table 1: Survey Responses

The study found that the trend of turning off appliances was more common for some appliances than others. For instance, all 4 respondents with video game consoles reported that they turn them off after use. Similarly, 7 of 8 respondents with televisions reported that they switched them off after use with 1 individual reporting unplugging their TV after finishing watching. Printers and computers

were the most likely to be left on. Overall 44% of printers were left on after use with 27% of computers and 17% of speakers being left on after use. None of the other non-computer related appliances were reported as being left on after use. For computer related devices, which were often left on after use, periods in which the device was using power but not performing its primary function were considered as part of phantom power.

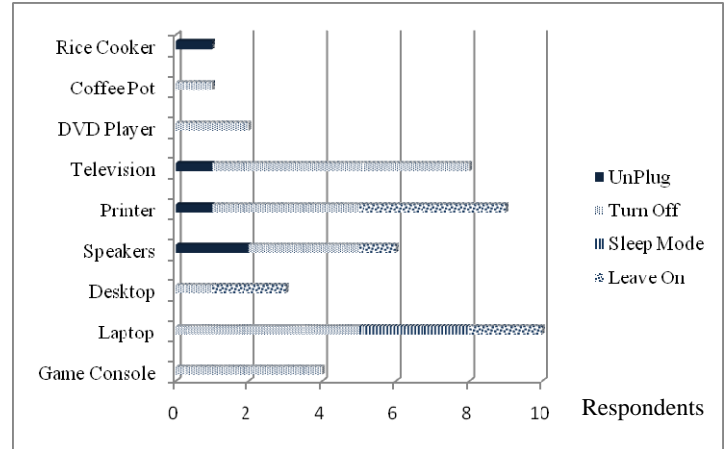


Figure 1: How devices are left after use

Metering

Figures 2 through 6 summarize the study’s findings. A series of graphs describes daily energy use in apartments A, B and C. For apartment A, the total daily energy use was 1946 Wh. For apartment B, this number was 415 Wh. For apartment C it was 519 Wh.

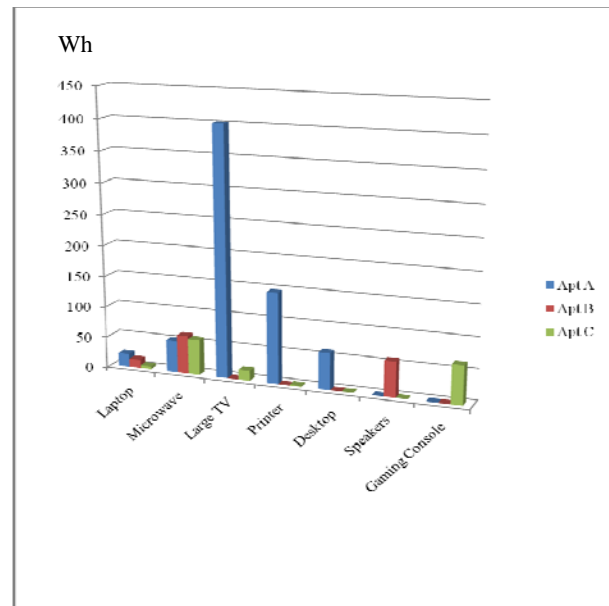


Figure 2: Phantom Power Energy Use by Apartment and Appliance

Figure 3 shows the distribution of in-use and phantom loads. Figure 4 shows the total energy use by appliance for all three apartments. Figure 5 show the distribution of the measured phantom loads for all three apartments by appliance.

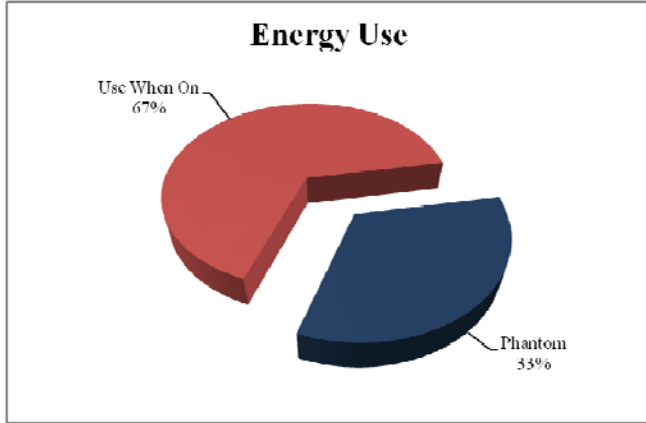


Figure 3: In-Use and Phantom Loads Energy Use Distribution

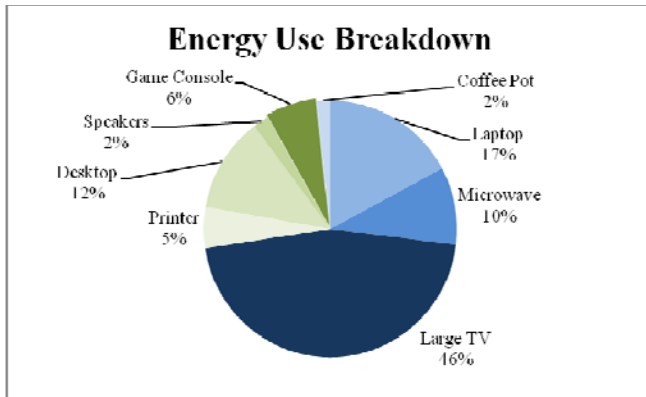


Figure 4: Energy Use Breakdown by Appliance

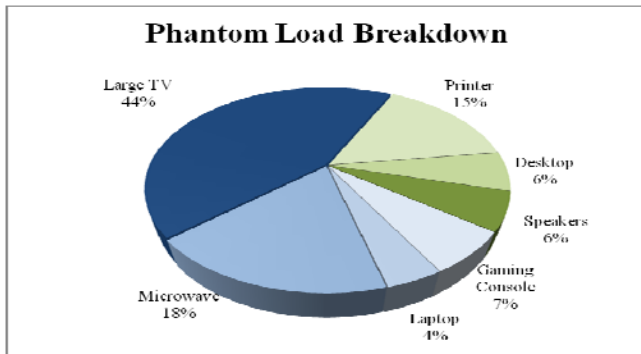


Figure 5: Phantom Load Distribution by Appliance

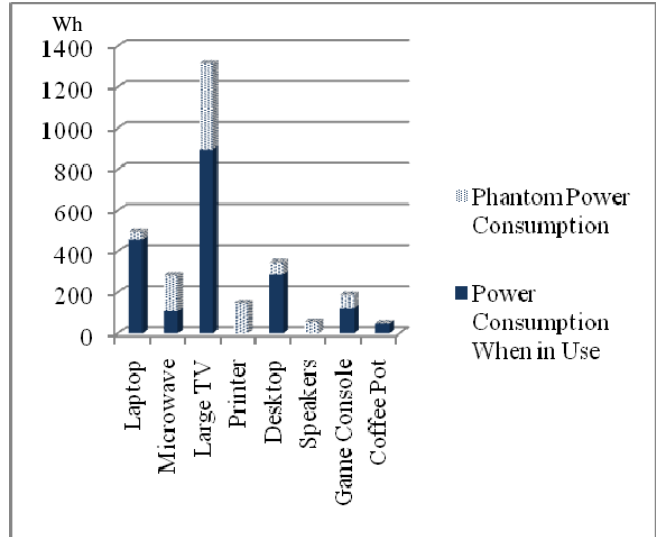


Figure 6: Total Energy Use and Phantom Power by Appliance

Top Power Consuming Appliances

Televisions

Phantom loads of televisions varied significantly between different models. In apartment A, the phantom load of a large television set represented 21% of the total energy consumption for the apartment. The in-use load was even higher and represented 46% of the total apartment energy use. Together, the total energy consumption of this one device represented 45% of the total daily energy consumption metered for all apartments. In contrast, another large television in apartment C, which was never turned on and only consumed 0.8 W of phantom power, accounted for only 3.1% of the energy use for apartment C. Large televisions were owned by 7 out of the 11 respondents. Therefore, a direction for future research would be to determine if the average phantom load power consumption for large televisions is closer to that of apartment A or apartment C.

Microwaves

The phantom loads for microwaves, which were measured varied from 2.2 W to 3 W with an average value of 2.7 W. The phantom loads from these devices represented 6% of the total energy consumption metered. The study found that all surveyed respondents had microwaves and thus phantom loads from these devices were very significant in contributing to total energy use. Although microwaves are typically only used for very short time periods, it was found that microwave use contributed an additional 4% of the total metered energy use.

### Printers

The phantom loads from the only measured printer was relatively high at 6.3 W. Although the printer was never used, the phantom loads from this printer alone represented 5% of the total energy consumption metered. It was found that 9 out of the 11 respondents had printers. Out of these, 1 person unplugged, 4 individuals turned off and 4 respondents left these devices on after they were finished using them.

### Laptops

The phantom loads measured for laptop computers was surprisingly low. The average phantom load measured was 1.4 W, with a range from 0.9 W to 2.1 W. Power consumption from laptop phantom loads only represented 1.4% of the total metered energy use for the three apartments. Thus, although laptops were used frequently and their in-use energy represented 16% of the total energy use, the phantom load contribution from laptops was remarkably low. From the conducted survey, the study found that 10 out of the 11 respondents had laptop computers making them the most popular appliance after microwaves. After use, 2 respondents reported leaving their laptops on, 3 reported putting their laptops in sleep mode, and 5 reported leaving their laptops on.

### Speakers

Like printers, speakers were often found to be left on with very infrequent use. For the single set of metered speakers it appeared that all the energy use was from phantom power. It was found that the phantom power load was 2.4 W and represented 2% of the total metered energy use. Of the 6 out of 11 respondents who had speakers, 2 reported unplugging them after use, 3 reported turning them off and 1 was reported left on after use.

### Desktop Computers

The only tested desktop computer was found to use 2.6 W of phantom load power. The phantom load from this computer represented 2% of the total metered energy use. The in-use power consumption was much higher and represented 10% of the total metered energy use. From the survey data, 3 out of the 11 respondents used desktop computers. Of these, one respondent reported leaving the desktop on, while the other two turned theirs off after use.

### Gaming Console

The gaming console measured had a phantom load power consumption of 2.9 W. This phantom load represented 2% of the total power consumption for the three apartments.

The in-use power consumption for this gaming console represented 5% of the total power consumption metered. Gaming consoles were used by 4 of the 11 occupants surveyed with all four respondents reporting turning their gaming consoles off after use.

### Coffee Maker

The coffee maker tested had no phantom loads. This is likely due to the presence of a simple switch, which allows the device to be switched off completely when not in use. The in-use power consumption of this device represented 2% of the total metered energy use. Only 1 out of the 11 respondents reported using a coffee maker.

## 5. DISCUSSION

### Phantom Loads Are Significant

The results of this study's survey demonstrate that phantom loads are an area of energy consumption that deserves further examination. The fact that phantom loads are responsible for a third of the energy consumed during the time frame measured reinforces this point. Yet in further analysis the determination of what qualifies as a phantom load should be explored. In this study the measurement of lumens/ft<sup>2</sup> was to serve as a benchmark for noting when an appliance was being used. The premise was that a light would typically be turned on if an appliance were being used. This wouldn't necessarily hold true if a respondent were watching television or working on a computer in the dark. Given the data logger didn't necessarily have a corresponding rise in lumens/ft<sup>2</sup> when there was a sustained increase in the use of watts by an appliance shows that a different methodology for determining use is in order. In this study, phantom loads were determined by looking at the metered data and finding the base-line power use. This base line was assumed to be phantom load power.

### Time Frame May Impact Results

In this study student energy use was examined. Therefore, further research should look at a longer time frame for gathering data along with varying the point in the school term that data is gathered. A longer time period would allow for any fluctuations in use due to day of the week. Additionally the collection days fell over the weekend as Dead Week was beginning on campus. Given this is toward the end of the term, use of some appliances such as a television or gaming console might be reduced while use of a laptop computer, desktop computer, printer and computer speakers may be higher than normal. Gathering data at different points during the term would provide a better overall picture of typical energy consumption and phantom loads.

### Variation in Phantom Loads for Categories of Appliances

The variation in the phantom loads for the large televisions raises the issue of variation in phantom loads based on manufacturer and model differences. In future research the survey should be expanded to include information about manufacturer and model for each appliance. Additionally it would be informative to collect information on whether the appliance is ENERGY STAR rated or not. In theory as more appliances pursue ENERGY STAR recognition, there should be a decline in phantom loads. Given college students tend to be purchasing their first computer, microwave and other appliances as they begin their college career it would be interesting to see if their phantom load levels fall over time as ENERGY STAR rated appliances represent a growing proportion of the appliances owned.

### Respondent Bias May Skew Responses for Energy Conservation

The question of how frequently the respondent thinks about conserving energy showed that 5 of 11 respondents “Always” think about it. The expansion of this study into other states could examine if there is any regional differences in how frequently students give any thought to conserving energy. Additionally it could be helpful to create a list of activities that demonstrate actions that conserve energy to establish the frequency of conservation activities in relation to how frequently respondents think about conservation. This would help eliminate any potential respondent bias towards giving what would be perceived as a more popular or socially responsible response.

### Actual Energy Use Versus Perceived Use

Another area of further inquiry would be to link the measured energy use with respondents’ perceptions about the amount of energy used by their appliances and computers. Given the responses in the study’s survey, the respondent providing the lowest monthly electric bill amount had the energy usage during the 24 hour metering period.

### Design Lessons Learned

The design lessons that were learned in this case study are that phantom loads can represent a significant amount of electricity used by appliances and electronics. As architects it is imperative that the energy consumption of a building be minimized. In the case of buildings where people are able to freely plug in their own electronics and appliances, such as group living quarters (dorms, senior housing) or universities (the architecture school as case in point), the design of the building has to recognize how to minimize the plug loads that occur. The need to curtail the pull of plug

loads may necessitate the design of a new method of providing electricity to outlets. One idea would be the development of a monitoring system that allows electricity lines to only be “live” when an area is occupied unless the area is classified as one that necessitates 24 hour electricity provision. For office buildings and elementary or secondary schools that have a set schedule, this may translate to the ability to have the electric lines to be “live” only during operating hours with the exception of select outlets to allow for maintenance, janitorial or administration to work outside the standard operation hours.

## 6. CONCLUSIONS

During the survey conducted among Hilyard House Apartment residents, many have indicated that they do not unplug their appliances when not in use (Table 1). Indeed, throughout the course of this study it was found that appliances were typically left plugged in. An average of 33% of the total daily energy consumption in case of the three test units was found to be due to phantom loads (See Figure 3). The results from the individual apartment metering serve to support the study’s hypothesis.

Based on these findings, the study seeks to educate residents of Hilyard House Apartments to reduce phantom loads in their apartments. Occupants should consider:

- Unplugging appliances that are not frequently used.
- Using a switchable power strip to switch off several devices that are often used together such as a computer, a monitor and a printer.
- When buying new appliances, searching for low standby power products such as ENERGY STAR appliances (3).

While taking such measures may help reduce standby use by about 30% (1), it must be said that eliminating phantom loads, while important and necessary, must always be part of a more inclusive approach to energy conservation. The present study has the potential to be used as the basis of a more extensive survey regarding phantom loads and energy conservation in dorms and apartment complexes in general. Based on the study’s findings, further research could determine savings in energy, CO<sub>2</sub> emissions and energy billing. Measuring energy consumption again after the implementation of some of the above measures might offer even more detailed and conclusive results.

## 7. ACKNOWLEDGMENTS

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