

PUGET SOUND AREA RESIDENTIAL COMPACT FLUORESCENT LIGHTING MARKET SATURATION STUDY

FINAL

Prepared For:

Puget Sound Energy
Seattle City Light
Snohomish County PUD

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1. EXECUTIVE SUMMARY

This report summarizes the results of secondary and primary research conducted on behalf of three Puget Sound utilities in the State of Washington. The overall purpose of this study is to provide data to each of these utilities to enable the development of effectively targeted and positioned residential efficient lighting programs.

BACKGROUND

To enable their program planning and implementation efforts, the four largest utilities serving Puget Sound customers sponsored a residential Compact Fluorescent Lighting (CFL) research study. Collaboratively, representatives from Puget Sound Energy, Seattle City Light, Snohomish County Public Utility District (PUD), and Tacoma Power¹ designed this study to focus on the lighting needs and purchasing habits of residential customers within and across their collective service areas.

The research effort was conducted between August 2006 and June 2007. These data will be used by each utility to update conservation potential assessments, to better understand the overall saturation of CFL bulbs within Puget Sound homes, to design and modify residential lighting programs, and to assess the overall saturation of CFL bulbs in Puget Sound homes.

RESEARCH SCOPE

The utilities had two primary research objectives to be achieved by this study, for the Puget Sound area overall and for each utility service area:

- 1) To quantify standard (one-inch) screw-base sockets and the current placement of CFL bulbs, by room, fixture type, and control type; and
- 2) To quantify the saturation of CFL bulbs and assess consumer likelihood of installing additional CFL bulbs where they have not already done so.

To facilitate the design of the primary research study, a secondary data review was completed early in the project, which reported on 26 (out of 59 identified) of the most relevant lighting research studies. This review was conducted between August 2006 and November 2006. The primary research was conducted using a paper-based survey mailed to a randomly selected sample of households across the utility service territories. The survey was fielded as part of a pilot test during January 2007, and was then fully implemented during May and June 2007.

¹ Tacoma Power was initially involved with the research study. While the process, discussions, and survey versions over the several months of instrument development was very useful for understanding a framework for this type of survey, Tacoma staff had concluded that overall the survey did not meet their needs. As a result, Tacoma withdrew from the project, and began development of a separate survey instrument.

FINDINGS & RECOMMENDATIONS

The CFL market has changed considerably over the last 10 years. CFL bulbs have achieved a significant level of market penetration in the region though, as this study shows, a great amount of potential for these bulbs still remains. Different rooms, fixtures, and segments of the population each face unique situations and issues with respect to energy efficient lighting. Utilities will need to focus on developing strategies to specifically address these issues in order to realize the full potential CFL bulbs offer for their service territory and for the region. Following are key recommendations based on the findings from this research designed to aid future utility planning and marketing efforts aimed at increasing CFL bulbs in the residential sector.

Key Finding #1: Opportunity Exists for More CFL Installations

Data indicate that opportunities to install CFL bulbs exist in every area of the home and in each type of lighting fixture assessed through this survey. Additionally, CFL rebate and coupon programs are likely to increase customer willingness to purchase CFL bulbs.

Recommendation #1: *Encourage installation of additional CFL bulbs throughout the house.* Data indicate that a significant amount of potential still exists across all rooms, fixtures, and segments of the population.

Recommendation #2: *Continue to facilitate consumer purchases through utility CFL rebate and coupon programs.* Of survey respondents, 70% indicated that they would be more likely to purchase CFL bulbs with a rebate or coupon.

Key Finding #2: CFL Programs Should Be Targeted

There were some key differences observed between home owners and renters and type of home, between different types of rooms and when looking at type of control for specific fixtures, all of which should be addressed when developing programs.

Recommendation #3: *Develop a strategy that focuses on encouraging individuals in the multifamily sector to try CFL bulbs for the first time.* Both renters and apartment or condo dwellers were identified as the only two groups being significantly more likely than the rest of the population to have zero CFL bulbs in place.

Recommendation #4: *Promote the use of CFL bulbs in low saturation rooms.* Areas of the house such as bathrooms and dining rooms are two of the highest energy usage areas in the home, but have the lowest CFL saturation levels in the household.

Recommendation #5: *Promote and provide information on all specialty bulbs currently available and continue efforts to promote development of specialty bulbs not yet available in the market.* Specialty bulbs may be required for up to 35% of all fixtures in the average household in the Puget Sound area in order to work properly with lighting controls (i.e., dimmers, three-way switches, and sensors) and specific fixtures such as recessed cans. Since these bulbs may be required for a significant percentage of fixtures, utilities should continue and/or step up efforts to

more vigorously work with manufacturers to make high quality specialty CFL bulbs more readily available for consumers.

Disseminate Research Findings

It is important with a study such as this that the sponsoring utilities disseminate the findings of this research broadly so that other organizations can benefit from this knowledge. Sharing these findings can and should result in conversations regarding how best to estimate savings from CFL programs, how to define and measure “attainable” savings, and how to address CFL “stockpiling”. These conversations may also result in regional utilities joining efforts to co-market CFL programs and marketing messages to achieve even greater impact with their conservation and energy efficiency dollars. Utilities may also wish to join forces to work with manufacturers, as well as wholesalers and retailers.

Continue to Measure CFL Saturation

The regional CFL saturation baseline established by this study should be used to ground future studies to assess how far the region has come with regard to residential CFL installations and whether future CFL programs are needed and in what form. It is recommended that the next study be performed two years from the beginning of this research effort (i.e., January 2009). If possible, to improve accuracy, the data should be collected through an on-site visit by a trained interviewer rather than relying on self-report data gathered via mail-based survey or even telephone interview.

2. INTRODUCTION

MOTIVATIONS FOR STUDY

Puget Sound energy utilities, like many others, are expecting to achieve substantial energy savings through delivery of conservation and energy efficiency programs as a way to meet both short- and long-term load growth projections documented in their Integrated Resource Plans. These utilities already have a history of including conservation as a major component of their resource acquisition strategies, due to its low cost and the low level of risk involved when compared to other power generation options. Given the recent focus in the State of Washington on evaluating its electricity production options to meet future demand—as evidenced by the passing of I-937—kilowatt hour savings through energy efficiency are expected to play a major role in helping utilities meet load growth. Simply put, energy conservation and efficiency are viewed as environmentally friendly and do not require the costly investments that are necessary for building new power generation facilities.

In its fifth and most recent Power Plan (2005), the Northwest Power and Conservation Council identified residential lighting as the number one source of conservation savings for the Pacific Northwest through the year 2025, which is expected to achieve 530 aMW of cost-effective savings at a total resource cost of 1.7 cents per kWh. As such, residential lighting has become a “big bet” of Puget Sound utilities and is expected to play a major role in resource acquisition efforts over the next 20 years.

Still, relatively little is known about the market and, to some extent, the technical potential of efficient residential lighting in the Puget Sound. To enable their program planning and implementation efforts, the four largest utilities serving Puget Sound customers sponsored a residential Compact Fluorescent Lighting (CFL) research study. Collaboratively, representatives from Puget Sound Energy, Seattle City Light, Snohomish County Public Utility District (PUD), and Tacoma Power designed this study to focus on residential customers within and across their collective service territories (see Figures 2-1, 2-2 and 2-3 below for utility service territory boundary maps; Tacoma Power was not included for reasons discussed later in this chapter). Study data will be used by each utility to update conservation potential assessments, to design and modify residential lighting programs, and to assess the overall saturation of CFL bulbs within Puget Sound homes.

Figure 2-1: Puget Sound Energy Service Area

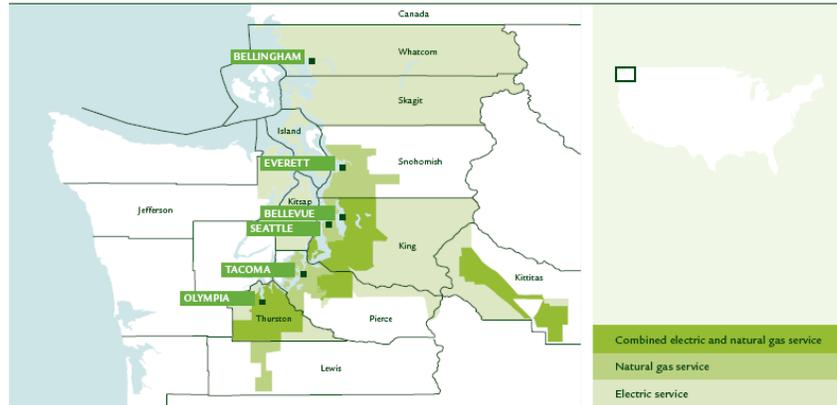


Figure 2-2: Seattle City Light Service Area

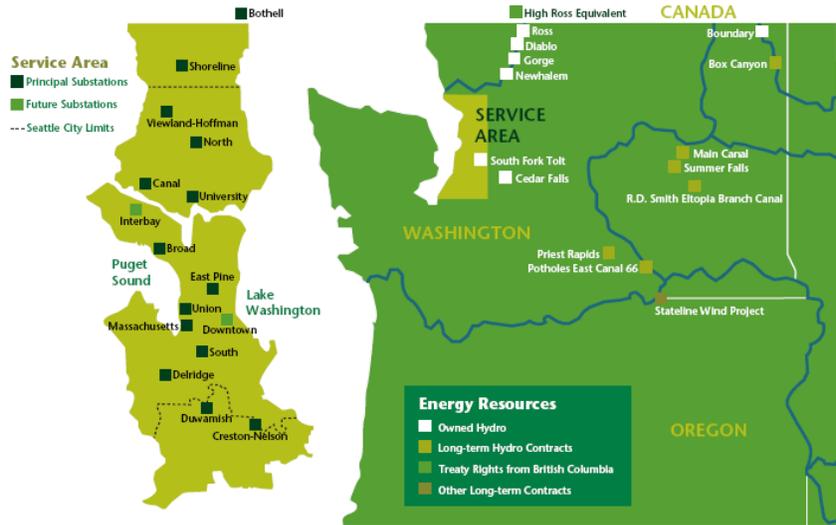
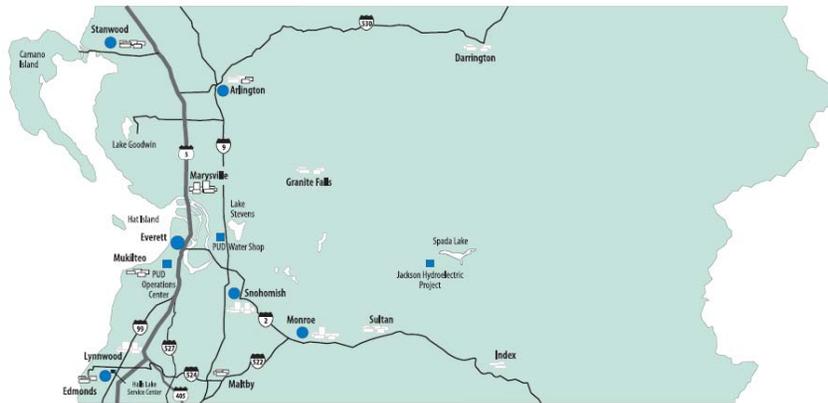


Figure 2-3: Snohomish County PUD Service Area



RESEARCH APPROACH

Objectives and Key Research Areas

The utilities had two primary research objectives to be achieved by this study, for the Puget Sound Area overall and for each utility service area:

- 1) To quantify standard (one-inch) screw-base sockets and the current placement of CFL bulbs, by room, fixture type, and control type; and
- 2) To quantify the saturation of CFL bulbs and assess consumer likelihood of installing additional CFL bulbs where they have not already done so.

In order to achieve both research objectives, primary and secondary research was conducted that focused on addressing two key research areas:

- 1) Remaining potential – What is the remaining potential for CFLs by household, room, fixture type and control type? How much of this is technical potential and how much is attainable?
- 2) Future program design – How can the data and information collected through this study be used to plan future utility programs focused on residential lighting?

The survey was also designed to capture demographic data as well as information on purchasing patterns and motivators, in order to explore what future CFL program designs may include. Key research questions to be answered by these data include the following:

- How do respondent education level, income level and home ownership status impact current and potential future CFL saturation levels?
- How recently were CFL bulbs purchased? Do respondents tend to purchase CFL bulbs within the county in which they live or elsewhere?
- How many CFLs have respondents purchased? Of those, how many have been installed at work? How many are being stockpiled for later use?
- Are respondents more likely to install CFL bulbs right after purchase or to stockpile CFL bulbs?
- What impact may coupons and on-line purchasing options have on future CFL purchasing decisions?

Methodology

The data collection activities for this research study were carried out in two stages:

- Stage 1: Secondary Data Review: This stage included an in-depth review of all research studies available that focused on residential CFL market saturation in other regions and states, lighting placement and usage, and lighting research methodologies. The secondary data review was key to helping guide and shape the primary data collection effort, both in terms of the key questions that needed to be addressed and the specific methodology that should be applied, given the experience of previous researchers. This review was carried out between August and November 2006.
- Stage 2: Primary Data Collection: Although the secondary data review was essential to identify questions that have already been fully addressed by previous research (e.g., overall satisfaction with CFL bulbs), prior and up-to-date research was not available to

calculate the current saturation of CFL bulbs in the Puget Sound Area. For this reason, stage two involved collecting primary data from homeowners and renters. As will be addressed in the next section, this data collection was carried out in two steps. A pilot phase was conducted to help estimate the response rate to quantify the amount of surveys to mail. This was then followed by the full survey implementation that took place between January and June 2007.

Secondary Data Review

Objectives

The secondary data review had the following key objectives:

- Summarize all relevant CFL studies:
EMI staff identified all known CFL studies via three main efforts: consulting with project utility sponsor staff, searching related internet sites, and searching proceedings from recent American Council for an Energy Efficient Economy (ACEEE) Summer Studies on Efficiency in Buildings, and the International Energy Program Evaluation Conference (IEPEC). A comprehensive secondary data matrix was created in which basic information about these studies was captured. EMI staff then reviewed each study and assessed its overall relevance. Relevant studies provided information on the various methodologies used to gather residential end-consumer CFL purchase and/or placement data, end-consumer CFL purchase or placement data, or other related information such as hours-of-use estimates. A brief summary document was then created for each relevant study.
- Enhance our thinking about end-consumer data collection:
A key objective of this effort was to determine the most appropriate data collection methodology to gather saturation data. While that methodology would be based in large part on the types of questions to be answered, it would also be informed by previous studies. To that end, information was gleaned about the relative pros and cons of each type of data collection methodology, including incentives used and overall response rates.
- Further develop the end-consumer survey question bank:
This study, in addition to informing Puget Sound utility program development efforts, is intended to contribute to the existing literature by 1) identifying the gaps that exist in overall industry knowledge, and by 2) developing survey questions using language and response options found in previous studies so that comparisons may be made across studies. To that end, when reviewing relevant research studies, EMI staff pulled survey instruments and identified important research and survey questions. These questions were then added to the working question bank.

Source of Reports

The initial step in this activity was to identify all residential CFL reports. To achieve this, three sources of reports were explored: 1) sponsoring utility staff, 2) related Internet websites, and 3) proceedings from the ACEEE and IEPEC biennial conferences. In total, 59 reports were identified.

Internet websites visited include the following:

- Northwest Energy Efficiency Alliance: www.nwalliance.org
- Northwest Power and Conservation Council: www.nwcouncil.org
- ACEEE: www.aceee.org
- IEPEC: www.iepec.org
- Bonneville Power Administration: www.bpa.gov
- Consortium for Energy Efficiency: www.cee1.org
- California Measurement Advisory Council: www.calmac.org
- Energy Star: www.energystar.gov
- Summit Blue: www.summitblue.com

Review Process

All reports were added to the Secondary Data Review Matrix, an Excel based spreadsheet. The matrix was used as a project communication tool and a one-stop overview of each report. To that end, it provides basic data about each report (e.g., name of study, date of study), a quick assessment of the relevance of the report (i.e., high, medium, low), and a few specifics from the study (i.e., methodology used, data type gathered, incentive used, response rate achieved) and, lastly, provided space for EMI staff to include notes about the report. The matrix is available as a separate document.

Reports rated as having high or medium relevance were then summarized using the following process:

- Create summary report
 - If a research study -
 - Report on: population surveyed, methodology used (incl. incentives), response rate achieved, and key findings;
 - Extract key research questions;
 - If not a research study - report on: report objective(s), key data of interest;
- Update secondary data review matrix.

A total of 40 summary reports were created, of which 26 are referenced in this secondary data review. The following chapter provides an overview of the key findings from these summaries. The detailed process and results of the Secondary Review are summarized in a separate report.

Primary Data Collection

Methodology Selection

The following data collection methods were considered for the data collection effort:

- 1) Telephone-based survey
- 2) Mail-based survey
- 3) Internet-based survey
- 4) In-home audits conducted by trained staff

Strengths, weaknesses, and other aspects of each type of data collection method were reviewed to determine which would be the most appropriate for this project. The sources for this assessment included the following:

- *Secondary Data Review*: the secondary data review provided good feedback from previous research studies on the relative pros and cons of different data collection methodologies.
- *Client and Research Team Experience*: the collective experiences of both the utility client representatives and the EMI research team were taken into consideration.
- *Mail and Internet Surveys: The Tailored Design Method* (Dillman 2007). Dr. Don Dillman is considered by many to be the expert on mail-based data collection methods. The EMI research team both consulted his recent book and engaged Dillman in a phone consultation regarding an early draft of the survey to identify necessary refinements.

After careful consideration of the objectives of the research effort and the costs, benefits and likely outcomes of the various research methodologies, the research team decided to move forward with a mail-based survey. This decision was due to its relatively low cost, its ability to collect a large amount of data from each household, the freedom individuals would have to move around their households and collect complete and accurate data, and that all segments of the population would be reached².

Survey Design

The survey development phase began by compiling a list of all potential research questions to be addressed. Through a facilitated workshop, the utility representatives identified their 14 high-priority research areas and questions and then ranked those in order of importance. This list was used to develop the content of the survey and ensure that data collected would be helpful for future planning efforts at the utilities.

Careful attention was placed on designing the survey instrument to achieve maximum return rates³ and Dillman's book and advice was taken into consideration during this phase. As such, the ordering of questions, the numbering used, the layout style, use of colors and the type and quality of paper were all considered during the design phase. A \$10.00 gift card in exchange for a returned survey was chosen as the incentive, which met the utility's constraints of only paying for returned surveys, gave respondents flexibility by allowing them to choose the store the gift card would come from, and rewarded the respondents for the detail the survey would require from them.

Additionally, the research team created a survey implementation process that was designed to increase response rates. This process was as follows:

- Two days before the survey packet is mailed, send a pre-survey letter signed by person of authority within the utility and/or city.

² There was a concern that young adult customers would be difficult to reach through a telephone survey since many only have cell phones, and that older customers would be difficult to reach through an Internet-based survey.

³ While previous utility mail-based surveys have achieved a 65% response rate, the research firm employed to field the survey suggested this effort may yield a response rate of 15% given recent research efforts with other clients and Dillman suggested a response rate of up to 10% given the complexity of this survey. The research team, based on all of this input, indicated that a response rate of 25% may be achievable with careful planning.

- Send the survey packet (personalized for each utility) to a specific individual within the residence. Include in the packet a reminder letter and instructions on how to acquire a non-English version of the survey⁴, a survey booklet with instructions built into the layout, a reference card (to correctly identify types of fixtures and bulbs), a pre-paid return envelope custom made for the survey to fit in without folding, and a pre-stamped postcard to be sent back separately from the survey to assure anonymity.
- One week after the survey packet was mailed, send a reminder post-card as a reminder of the return date (i.e., two weeks after receipt of packet).
- Send a thank you card once the survey time period has closed, that includes details on how to receive their \$10.00 gift card.

Final Survey Development

To identify any potential challenges, both with the way in which the questions were asked and with the layout and format of the survey, an early draft of the survey was pre-tested by each utility representative for a total of 15 complete surveys. Upon completion of the survey, each respondent was asked to provide information on the amount of time it took to complete, what type and level of incentive would be most appealing, and overall user-friendliness and clarity.

The pre-test identified the following:

- The survey was generally understandable though more visuals would be helpful.
- The survey took approximately 20 minutes to complete.
- Most people enjoyed completing the survey.
- A \$10 gift card for use at any store tended to be the most appealing incentive for completing the survey.

Final survey development commenced with graphic designers experienced with utility mailings and surveys, creating a professional-looking survey booklet. After several rounds of edits, final versions of all survey materials were approved by each utility representative. These versions focused specifically on sockets with a standard size (about one-inch) screw-in base, three types of lighting fixtures (surface mount or hanging, recessed can, and table or floor lamp), and four control types (on-off, sensor, dimmer and three-way). The surveys included a pull out reference card with images of the sockets, fixture types, bulbs and control types. This card and other survey materials are included in the appendix.

A pilot test was conducted with 375 utility customers. The pilot test was conducted to identify and determine the following:

- *Likely response rate to be achieved upon full survey implementation:* Projected response rates were used to determine the total number of surveys sent out during the main wave. This would help ensure that printing, mailing and incentive costs were kept to a minimum during the data collection process.

⁴ An independent translation company was hired to translate the phrase “If you cannot read English, please find someone who can translate and help you complete this survey” into nine different languages. This translated phrase in its nine different forms was included with its English counterpart on the back of the pre-survey letter and the cover letter.

- *Representativeness of respondents in comparison to the population:* When doing research of any kind, there is always the potential to have a high level of response bias, resulting in a group of respondents that are unrepresentative of the population from which the sample was drawn. To determine whether response bias occurred, two analyses were conducted. First, the respondent and population demographics were compared. Second, for everyone who did not return a survey as part of the pilot test, an attempt was made to contact each by phone, and the researcher gathered specific demographic data that were compared to the respondents and to the associated population for each utility.
- *Challenges experienced by respondents when completing the survey:* The completed survey forms were examined to determine if individuals incorrectly responded or left parts of the survey blank. Additionally, when non-respondents were interviewed they were asked if there were questions or items on the survey that made it more or less likely that they would complete the survey. If so changes could be made to the survey before it was implemented with the full sample.

The pilot phase began on February 12th, 2007 and the response period closed on March 5th. The following pilot wave response rates were achieved for each of the three utilities⁵:

Table 2-1: Pilot Wave Response Rate

	Puget Sound Energy	Seattle City Light	Snohomish County PUD	Total
Total Sample Mailed	125	125	125	375
No Response Returned	104	102	79	285
Response Returned	21	23	46	90
Response Rate	16.8%	18.4%	36.8%	24.0%

Response Bias

Non-respondent telephone interviews were conducted with individuals who were sent but did not return a response. EMI drafted a non-respondent telephone interview guide that consisted of eleven questions about the survey and six demographic questions; it was designed to last less than five minutes.

One attempt was made to contact each customer. If for any reason the individual was not spoken to directly (i.e., answering machine, busy signal, hang up, disconnected number), messages were not left and additional attempts were not made. Individuals were contacted approximately one month after they first received the survey in the mail. Calls were made during the following evenings for each of the utilities:

- Puget Sound Energy: Monday evening, 6:00-8:30

⁵ It was upon completion of the pilot phase that Tacoma Power decided not to move forward with the larger survey implementation. While the process, discussions, and survey versions over the several months of instrument development was very useful for understanding a framework for this type of survey, Tacoma staff had concluded that overall the survey did not meet their needs. As a result, Tacoma withdrew from the project, and began development of a separate survey instrument.

- Seattle City Light: Tuesday evening, 7:00-9:15
- Snohomish County PUD: Wednesday evening, 7:00-9:00

The interview began by asking if the individual or someone in their home remembered receiving the mail survey. If they did not remember, even after a physical description of the survey was given, demographic data were gathered and the call was ended. If they did remember seeing the survey, questions were asked about their perceptions of the survey, why they did not complete it or mail it back, and what could have been done differently to encourage them to respond. After this series of questions, demographic data were collected and the call was ended.

Review of Data Accuracy with In-Home Audits

Given the large under-reporting error reported in other CFL saturation studies⁶, an assessment of the accuracy with which individuals completed the survey was conducted to determine if this study was encountering the same problem. A small number of audits were conducted with respondents within the Snohomish County PUD service territory. The PUD research client assigned a staff member to conduct the audits and provided training on the audit protocol. This person scheduled in-home audits with ten respondents and then visited the home with a blank copy of the survey as if they were the homeowner walking through the home. The original survey form was not provided to the auditor, to prevent the audit from being influenced by the homeowner's responses to the same questions. In exchange for participating in the audit, the participating customers were offered a \$30 gift card (in addition to the \$10 they already received).

Data collected from the in-home audits were then compared to the respective survey each individual had filled out during the pilot-testing phase, to check for the degree and nature of misreporting.

Sample Selection

Based upon the pilot test response rates, it was decided that the following number of surveys would be sent out during the full implementation of the survey to achieve a total sample size of 1200 (400 per utility).⁷

- Puget Sound Energy: 2,600
- Seattle City Light: 2,600
- Snohomish County PUD: 1,500

To achieve these numbers, each utility drew simple random samples for the survey from their respective billing databases. Utilities were first asked to provide sample sizes of 2,000 for the pilot and main wave of the survey. Due to lower than expected pilot wave response rates, both Puget Sound Energy and Seattle City Light generated new, larger samples to accommodate a larger mailings.

⁶ Two studies reported on potential misreporting in previous CFL self-assessments, though only one provided actual measurements of an observed reporting error. Kates et al (2005) found that a telephone survey provided a 30% downward bias on estimations of CFLs in the home. No data was available on mail surveys.

⁷ The utility representatives hoped to achieve a 95% confidence interval with a 5% margin of error. Receiving 400 surveys per utility was necessary to achieve that goal.

Total final sample sizes generated for each utility were:

- Puget Sound Energy: 3,500
- Seattle City Light: 3,691
- Snohomish County PUD: 2,000

Table 2-2 provides further detail on sample size, attrition, response rate and usable data.

Table 2-2: Puget Sound Survey Sample Attrition

	Puget Sound Energy	Seattle City Light	Snohomish County PUD	Total
Residential Electric Customers	912,000	341,000	280,000	1,533,000
Sample Drawn	3,500	3,651	2,000	9,151
<i>Pct of Population</i>	<i>0.4%</i>	<i>1.1%</i>	<i>0.7%</i>	<i>0.6%</i>
Total Sample Mailed	2,725	2,725	1,625	7,075
Pilot Wave	125	125	125	375
Main Wave	2,600	2,600	1,500	6,700
Incorrect Address, Undeliverable	0	36	9	45
<i>Pct of Total Sample Mailed</i>	<i>0.0%</i>	<i>1.3%</i>	<i>0.6%</i>	<i>0.6%</i>
Total Sample Deliverable	2,725	2,689	1,616	7,030
No Response Returned	2,160	2,065	1,247	5,472
Responses Returned	565	624	369	1,558
<i>Pct of Sample Deliverable</i>	<i>20.7%</i>	<i>23.2%</i>	<i>22.8%</i>	<i>22.2%</i>
Responses Returned				
Unusable Data⁸	28	15	27	70
Complete Data	537	609	342	1,488
<i>Pct of Responses Returned</i>	<i>95.0%</i>	<i>97.6%</i>	<i>92.7%</i>	<i>95.5%</i>
<i>Pct of Total Sample Mailed</i>	<i>19.7%</i>	<i>22.3%</i>	<i>21.0%</i>	<i>21.0%</i>

⁸ See Chapter 6 for detailed information on criteria used to screen out unusable data.

3. SECONDARY DATA REVIEW FINDINGS

DEFINING SATURATION

The definition of saturation was explored by Kates et al. (2005). Here, they make a distinction between saturation and penetration. Saturation is defined as “the percentage of lighting sockets in the average home that are filled with compact fluorescent lighting” (p. 885); whereas penetration is defined as “the number of homes that have at least one CFL installed” (p. 885). This distinction is important when considering not only the research questions to be answered to estimate CFL saturation, but also the data collection methodology to use to gather appropriate data.

They further indicate that saturation evaluations can provide data on:

- Number of bulbs purchased per customer;
- Whether CFL sales are leading to an increase in the number of CFL users;
- Whether consumers purchase [CFL bulbs] for use in non-program geographic areas; and,
- Persistence – the amount of replacement of CFL bulbs by CFL bulbs and the extent to which CFL bulbs are being used, or placed in storage. (p. 887)

Skumatz and Howlett (2006) suggest saturation “can be measured by the percentage of lamps with screwbase sockets that contain CFL rather than incandescent bulbs, or the total number of CFL bulbs per household” (p. 3).

Importance of Findings to This Study

When developing the survey approach it was important to ensure a clear, distinct definition of compact fluorescent bulb saturation had been created and was being used to guide the data collection effort. Without such a definition, the survey questions and the methodology selected might not yield the expected data points.

DATA COLLECTION METHODOLOGIES

In addition to other authors, Kates et al. (2005) promote the use of in-home visits to gather saturation data, arguing that self-report data gathered via mail questionnaire or telephone interviews are inaccurate. They also suggest that studies relying solely on CFL sales data provide a limited view into a complex market. Vine and Fielding (2005) indicate “most researchers believe that self-reported data are less reliable than monitored data...self-reported hours of use are higher than monitored data among the same participants (p. 836).” And, Rasmussen, Gaffney and Rubin (2005) indicate households tend to overestimate their daily bulb usage (hours-of-use) by one-third.

Table 3-1 provides a summary of the relative challenges of each data collection method, as discussed by authors of the relevant studies, when estimating CFL market saturation.

Table 3-1: Challenges of Data Collection Methodologies for Estimating Saturation

Data Collection Method	Challenges
CFL Sales Data	While sales data can provide information about program participants it does not provide greater insight into the larger complex market (Kates et al. 2005).
In-Home/On-Site Surveys	In-home/On-site surveys are more expensive than telephone interviews, potentially limiting the total number of surveys that can be completed (Kates et al., 2005; Carlson & Mulligan, 1994).
Telephone Interviews	“Saturation of energy efficient lighting requires understanding the total number of lighting sockets in a home, as well as the efficiency of each bulb. There is a large variation in the number of sockets per home. (p. 888).” Kates et al. estimate a 30% under-reporting of CFL bulbs due to consumers not knowing how many bulbs a fixture holds. Their studies found that only 26% of respondents could accurately estimate the total number of CFL bulbs in their home.

Still, according to Wirtshafter and Weiss (1993), “surveys [mail questionnaires, telephone interviews, on-site interviews, questions on the back of rebate or mail-in forms] have been, and will remain, the predominant data-collection technique, principally because the alternatives are costly and may not significantly improve the precision of the estimate (p. 22).” To improve the quality of the data gathered, they offer several strategies:

1. Develop unambiguous survey questions and assess the quality of questions asked through a stringent pilot testing phase.
2. Provide pictures of CFL bulbs where possible as consumers are easily confused and have a difficult time recalling the type, wattage and location of CFL purchases.
3. Verify survey data with on-site evaluations.

Researchers interested in gathering more comprehensive and reliable information, should explore a triangulation approach to data collection. As shown by Ridge et al. (2000), the use of multiple sources and measures of data can provide the researcher working in a complex and large market with key insights on the findings and important differences to be resolved. Within the CFL market, triangulation might include a combination of secondary data (both sales and existing research) review, interviews with end consumers, and on-site verification of CFL installation.

Importance of Findings to This Study

In any data collection effort, having a clear understanding of the relative challenges associated with various data collection methodologies enables researchers to design studies that help to mitigate those challenges. In this study, knowing that in other studies⁹ self-report data results in approximately 30% under-reporting of CFL bulb installation affected the overall data collection and analysis plan. The team determined that a multiple-method approach (i.e., interviews and

⁹ Two studies reported on potential misreporting in previous CFL self-assessments, though only one provided actual measurements of an observed reporting error. Kates et al (2005) found that a telephone survey provided a 30% downward bias on estimations of CFLs in the home. No data were available on mail surveys.

on-site or other verification) was warranted or that a formula needed to be developed to account for and correct the under-reporting during analysis¹⁰.

CFL SALES TRENDS AND ESTIMATED SATURATION

Pacific Northwest

According to a 2006 presentation on the Savings With a Twist Program (SWAT) (Duncan et al., 2006), market share of CFL bulbs in the Pacific Northwest continues on an upward trend. “Total CFL sales equaled 7.45 million units in 2005, which is 2.35 million more CFL bulbs sold than in 2004 and 1.35 million over projection for the year” (p. 6-74). Additionally, the SWAT study found that the percentage of consumers who have purchased CFL bulbs has increased from 19% in 2004 to 37% in 2005, and the average number of CFL bulbs purchased per household has increased from six (6) in 2004 to nine (9) in 2005 (KEMA, 2006).

Snohomish County PUD (SnoPUD, 2005) estimates a CFL saturation rate of 23% in their service territory. This rate was derived assuming 30 average sockets per home, 274,528 homes, an average of seven (7) CFL bulbs installed per home and 1.6 million bulbs sold through their CFL program (SnoPUD, 2006, p. 8). They estimate that “34% of the standard bulb potential has been achieved while only 7% of the specialty bulb¹¹ potential has been achieved (SnoPUD, 2006, p. 9).”

A Tacoma Power study reports that 64% of customers have at least one CFL. “Of these, 36% have 1-3 bulbs; 31% have 4-6 bulbs; and 32% have 7 or more bulbs.” (Dethman et al. 2006, p. 8) This percentage increased dramatically from the 1996 study in which only 20% of households reported using CFL bulbs (36% had 1-3 bulbs, 31% had 4-6 bulbs, 13% had 7-9 bulbs and 19% had 10 or more bulbs).

Seattle City Light estimated, via their Conservation Kit Program Evaluation study, that the number of CFL bulbs already installed by program participants (an average of 4.0), plus their perceived remaining potential to install CFL bulbs (4.6), was just under nine (8.6) CFL bulbs per household. Survey respondents appeared to exclude from consideration lighting on dimmers, on daylight or motion sensors, in recessed cans, linear fluorescent lighting, and bulbs used for too few hours per day to seem a reasonable application. After the program was concluded, it was estimated that participants had installed 44% of their “perceived maximum saturation capacity”. (Tachibana, p. 47)

Other Regions

In California, the CLASS project (RLW Analytics) reported the prevalence of compact fluorescent bulbs increased from 1.0% in 2000 to 8.6% in 2005 and CFL bulbs increased from

¹⁰ In the present study, on average respondents yielded a ~ 40% under-reporting of CFLs installed and number of sockets; however, their saturation levels when compared to in-home audits were consistent. Give this, a correction factor was not used during the data analysis; rather, reference was made to this under-reporting finding and saturation levels became the primary data point of interest.

¹¹ Snohomish County PUD defines specialty bulbs in the report as bulbs that are used in fixtures and applications where standard spiral bulbs are not acceptable.

1% in 2000 to 10% in 2005. Further, in 2000 only 12.4% of homes had at least one (1) CFL lamp whereas in 2005 that number increased sharply to 56.9%. Further, Skumatz and Howlett (2006) provided data from two studies finding 49-55% of households surveyed had at least one (1) CFL installed and a range of between 5.8 and 7% of screw-base sockets had a CFL installed.

Based on the 2003 – 2004 inventory of CFL bulbs in 100 randomly selected Massachusetts homes (Kates et. al, 2005, p. 894), the following placement patterns and associated saturation by room were found (see Table 3-2).

Table 3-2: Location of CFL bulbs & Saturation by Room Type: *Massachusetts*

Room	Percent of CFL bulbs Installed by Room Type (% total bulbs installed)	Percent of Sockets in Room Type Filled with CFL bulbs
Bedroom	18%	8%
Living room/family room	17%	8%
Kitchen	17%	9%
Basement	11%	6%
Other	9%	Did not calculate
Hallway/stair	9%	Did not calculate
Exterior	6%	7%
Bathroom	5%	3%
Office	3%	8%
Dining room	3%	3%
Garage	2%	Did not calculate

(Source: Kates et. al, 2005)

This same study found that 40% of all sockets have a standard-shape, standard-size, A-type incandescent bulb, making those candidates for CFL conversions. An additional 24% of sockets were thought to be easily replaced with specialty bulbs including frosted or clear bulbs. Thus, the market potential in Massachusetts was estimated at 64% of sockets.

Importance of Findings to This Study

These data show an upward trend both in overall compact fluorescent bulb sales and in installation rates. However, given the previous section’s finding that self-report data may yield an under-reporting of 30%, the Washington saturation findings presented here may need either adjustment or verification to come closer to the true installation of compact fluorescent bulbs. This study should consider these data as indications of compact fluorescent bulb installation, rather than as concrete findings on compact fluorescent bulb saturation.

PURCHASING HABITS

Consumers Who Purchase

The literature review revealed the variables that influence consumer awareness and purchase of CFL bulbs. In general, awareness of CFL bulbs appears to be quite high (65% awareness,

Rasmussen, Goepfrich & Horkitz; 88% awareness, Dethman et al.; 87% awareness, KEMA, 2006; 90% awareness, ECOS).

Several studies cited participation in a program that offered coupons, rebates, or CFL bulbs for free as the primary reason why consumers purchased a CFL. Seattle City Light reported that 66% of participants in their Conservation Kit Program “tried a compact fluorescent (CF) light bulb in their homes for the first time.” (Tachibana, p. 55) Of those who received a kit, 30% purchased additional CFL bulbs, whereas only 8% of non-participants purchased CFL bulbs during that same time period. (Tachibana, p. 32)

Duncan et al. indicate that participation in the Savings With a Twist program provided “consumers who may have had a poor experience with an earlier generation of CFL bulbs...[an opportunity] to give them another chance.” (p. 6-74) These types of programs can give consumers with little to no experience with CFL bulbs an inexpensive way to try CFL bulbs for the first time. Moreover, “shopping frequently at stores that tend to carry CFL bulbs and living in a high-publicity geographic area as defined by the national awareness of ENERGY STAR for 2004 study” are key predictors of who will purchase CFL bulbs. (Rasmussen, Goepfrich & Horkitz, p. 900)

Other factors that increase the awareness of CFL bulbs and likelihood of future purchase include the following:

- Higher Level of Education: Rasmussen et al. (2005), in a study to ascertain future purchase intent among CFL users found that “a college education was the most important factor affecting whether or not a consumer is aware of CFL bulbs.” (p. 900) Similarly, Wiggins (1993) found that participants in a CFL give-away program were more likely to have had some post-graduate education.
- Commitment to Conservation: Although Dethman et al. found that 76% of respondents were motivated to reduce electric consumption to save money, 18% were motivated by both environmental and financial reasons and 8% were motivated strictly by environmental reasons. There is some indication that purchasers, especially those considered early adopters, “have a high regard for energy efficiency.” (Vine & Fielding, 2005, p. 841) Still, early adopters, according to Vine & Fielding, may also use their lighting fixtures less than later adopters, given their bent towards conservation.
- Home Ownership: There is evidence to suggest that homeowners are more likely than renters to be aware of CFL bulbs (Rasmussen et al.; Vine & Fielding; Mass. Div. of Energy Resources (MDER)) and purchase CFL bulbs. Likewise, Skumatz and Howlett purport that because 80% of CFL bulbs are purchased by someone for their home, the current CFL market may be for retrofits rather than installation in new homes.¹² Seattle City Light suggests that “[renters] may be reluctant to spend extra money on household lighting that would remain with the apartment after they move.” (Tachibana, p. 32)

¹² Skumatz and Howlett reference a 2004 survey conducted in New York to support this statement. According to the survey results, “more than 80% (of CFLs) are purchased by someone in the home; households reported that contractors (who might be purchasing for new or remodeled applications) purchased only about 2% of CFLs. The current market for CFLs is retrofit, rather than initial installation in new homes.” (Skumatz and Howlett, p.3)

- Previous Purchase of CFL bulbs: Individuals who have already purchased CFL bulbs are expected to purchase CFL bulbs in the future, especially when compared to those who received a CFL for free in the mail (Rasmussen, Goepfrich & Horkitz).

Interestingly, household income and respondent gender are not thought to affect awareness of CFL bulbs (Rasmussen et. al) and “shopping frequently at stores that tend to carry CFL bulbs, respondent gender, receiving a free CFL in the mail, and living in a high publicity area” do not affect CFL purchases. (Rasmussen, Goepfrich & Horkitz, p. 902)

Age of respondent may have some influence on overall CFL awareness, with one study reporting that approximately 60% of those in their twenties were aware of CFL bulbs whereas all other respondent age groups had awareness levels of 85% or higher (ECOS, 2006). Interestingly, 27% of those respondents aged 30-39 are aware of CFL bulbs but have not yet purchased one.

Most survey respondents indicated they are likely to purchase CFL bulbs in the future either via a utility program or on their own (du Pont & Gooneratne, 2006; KEMA, 2006). Half of their survey respondents indicated they are “very or somewhat likely to purchase new CFL bulbs through the PUD program in the next 12 months”, and 33% said that while they are likely to purchase a new CFL they will not do so via the program (SnoPUD, p. 9).

Previous studies have found that individuals who have purchased CFL bulbs in the past intend to replace them with CFL bulbs (80% of those surveyed in the KEMA, 2006 study indicated this intention). Similarly, the SnoPUD survey estimated that 25% of customers store CFL bulbs in their home, and 76% of respondents to the San Diego Gas and Electric CFL program indicated they would install CFL bulbs again when the units burned out (Itron 2006). However, Geller (2005) reports that one study indicates “70% of CFL bulbs are being replaced with incandescents when the CFL burns out.” (p. 12)

Importance of Findings to This Study

Previous studies have found several demographic variables that may influence an individual’s likelihood to purchase CF bulbs. The findings suggest that consideration should be given, in developing the survey questions for this study, to further explore demographic variables, such as education level, and their impact on CFL purchases. Additionally, few studies explored whether consumers store CFL bulbs, and differences exist among studies on the likelihood that consumers will replace an incandescent or a burned-out CFL with a CFL. Therefore, these areas were identified as warranting further exploration as part of this study.

Barriers to Purchase

Many barriers to purchasing CFL bulbs have been identified via the literature review. KEMA (2006) found that nearly one-quarter of those surveyed in their SWAT evaluation may not purchase CFL bulbs within the next 12 months, regardless of price. Barriers to purchase, as found in the KEMA study, tend to be consistent from study to study with the most common barriers being:

- Lack of awareness of specialty bulbs (Rasmussen, Goepfrich & Horkitz; SnoPUD; JEM Energy)

- First cost (Rasmussen et al.; SnoPUD; KEMA, 2006; ECOS, 2006; Kates & Bonnano)
- “Fit of CFL or appropriate bulb availability (Rasmussen, Goepfrich & Horkitz; SnoPUD; KEMA, 2006; ECOS, 2006; Kates & Bonnano; MDER)
- Quality of light (Rasmussen, Goepfrich & Horkitz; SnoPUD; KEMA, 2006; ECOS, 2006; Kates & Bonnano; MDER)
- Don’t need new bulbs (SnoPUD; KEMA, 2006)
- Lack of concern about energy efficiency in general (Rasmussen, Goepfrich & Horkitz)
- Lack of information about CFL bulbs (Rasmussen, Goepfrich & Horkitz; SnoPUD; KEMA, 2006)
- Harmful and difficult to dispose of (ECOS, 2006)

Importance of Findings to This Study

Because barriers to purchasing CFL bulbs are well documented in the literature, it was decided that this study would not explore the topic further. However, what is missing is information on barriers to placement. That is, do consumers experience difficulties when attempting to install or change-out CFL bulbs? These and other related questions were deemed important issues to explore in this study.

CFL PLACEMENT PATTERNS

Placement Intent

The Northwest Power and Conservation Council cited an evaluation report in which it was found that “80% of the lamps [bulbs] sold are immediately installed” (NWPCC 16). This suggests that, among those who purchase, there is also a strong intent to install. As part of a 1991 CFL bulb give-away program, San Diego Gas and Electric Company found a base self-reported installation rate of 43%, 62% and 70% (rates vary by program type) among program recipients (Wiggins, 1993).

In contrast, the KEMA CFL Metering Study (2005) found that 63% of recent CFL purchasers do not have all of the CFL bulbs they recently purchased presently installed.” (p. 5-1) Of these, 42% are planning to use the CFL bulbs, 7% gave them away, 20% indicated the bulbs had already burned out and 12% said their bulbs were broken.

When purchasers are part of a CFL program, it is expected they are learning of the benefits of placing a CFL bulb in a high-use location (e.g., kitchen, living room and family room). This theory was found to be true when looking across several studies that estimated hours of usage, in which it was found that utility program participants are more likely to place CFL bulbs in high-use locations (43%) than are non-participants (24%) (Vine & Fielding). “Users that understand which CFL applications are most cost-effective generally install their first CFL(s) in the most heavily used light fixtures” (Vine & Fielding, 2005, p. 842).

Furthermore, consumers tend to place newer CFL bulbs in higher-use fixtures (e.g., in living rooms and kitchens) (Vine & Fielding, 2005). This could be due to the newer CFL bulbs being available “in a wider array of applications, sizes and color renditions” (p. 842). This is further

supported by the SnoPUD survey, which found that in 2005 “30% of the bulbs sold through the PUD program were specialty bulbs” (p. 8) suggesting a trend that may continue.

Importance of Findings to This Study

The intent to install bulbs appears well documented and understood; that is, when consumers purchase a CFL bulb they do so with the intention of installing it. However, more information is needed regarding where consumers install CFL bulbs and what has an impact on their placement decision-making process. Thus, it was decided that this study should develop and consider including questions on these topics.

Placement Targets

According to Tribwell and Lerman (1996), “replacing 50-150W lamps [bulbs] that are on at least three hours per day with compact fluorescent lamps [bulbs] (CFL) provides a resource with a levelized cost of approximately 28 mills with a simple payback of three years assuming \$15 per CFL and \$0.04 per kWh” (p. 3.153)¹³. Using this as a basis for further exploration, the following findings regarding hours of usage and CFL placement illustrate how much potential exists to install additional CFL bulbs in residences.

Vine and Fielding report, when looking across CFL hours-of-use studies utilizing both survey and monitored data, “that exterior lighting use is higher than lighting use in all interior rooms, and the highest use interior areas are the kitchen, living room, and family room.” (p. 841) In Bangalore, India, the target areas for CFL placement “include porticos, living rooms, verandas, kitchen, lobbies and security lighting.” (du Pont & Gooneratne, 2006, p. 6-57)

As seen in Table 3-3, Skumatz and Howlett (2006), when considering several studies, concluded that kitchens, family rooms and garages have the greatest potential for energy savings, as determined by hours of usage and current installed CFL percentages for program participants.

¹³ Because of significant changes in the price of CFLs and changes in electric rates since 1996, payback periods are now likely much different than those cited in the Tribwell and Lerman study.

Table 3-3: Average CFL Hours of Use per Room Type: California, Vermont & Massachusetts

Room Type	CFL Hours Per Day (KEMA 2005)	Percentage of Rooms with CFL bulbs		
		California (KEMA 2005)	Vermont (Xenergy 2002)	Massachusetts (Megdal and Associates 2003)
Kitchen	3.5	11%	8.7%	17%
Living Room	3.3	17%	6.9%	17%
Outdoor	3.1	23%	10.8%	6%
Family Room	2.5	8%	4.7%	3%
Garage	2.5	2%	No data	No data
Bedroom	1.6	18%	2.6%	18%
Bathroom	1.5	11%	3.8%	5%
Hall/Entry	1.5	5%	5.2%	9%
Laundry Room	1.2	3%	7.1%	No data
Basement	No data	No data	No data	11%

(Source: Skumatz and Howlett, 2006)

According to Itron (2006), respondents place CFL bulbs more often in bedrooms (27%), living rooms (20%), bathrooms (13%) and kitchens (12%). And, Kates and Bonnano (2005) report that within Massachusetts and Connecticut, as seen in Table 3-4, bedrooms, living rooms, kitchens and basement have the highest percentage of CFL bulbs installed.

Table 3-4: Percentage of Sockets with CFL bulbs by Room: Massachusetts & Connecticut

Room	Massachusetts	Connecticut
Bedroom	17%	15%
Living Room	16%	16%
Kitchen	15%	16%
Basement	15%	15%
Hallway/Stairs	8%	6%
Exterior	7%	9%
Bathroom	5%	11%
Closet	3%	5%
Office	2%	3%
Garage	2%	2%
Dining Room	1%	0.4%

(Source: Kates and Bonnano, 2005)

To better understand the potential for CFL installation, Table 3-5 was created. This table shows, in rank order for the Pacific Northwest¹⁴, the highest usage potential by room based on average annual kWh. Data for the Pacific Northwest is taken from the Tribwell and Lerman (1996) study in which they collected kWh usage data via lighting loggers. The California figures were

¹⁴ Pacific Northwest data collected from the following seven utilities in Washington and Oregon: Tacoma Power, City of Port Angeles, Peninsula Light, Portland General Electric, Eugene Water & Electric Board, Pacific County PUD #2, and Snohomish County PUD.

derived from two on-site evaluation studies: 1) RLW Analytics (2005): total watts installed by room, and 2) KEMA (2005): average hours of room use per year. Please note, because all studies were not conducted using lighting loggers, they cannot be looked at as direct comparisons of kWh by region.

Table 3-5: Average Daily Hours of Use: Pacific Northwest & California

Room	Average Daily Hours of Use	
	Pacific Northwest	California
Kitchen	3.9	3.5
Living Room	3.1	3.3
Bathroom	1.7	1.5
Outdoor	3.4	3.1
Bedroom	1.3	1.6
Family Room	--	2.5
Hall	--	1.6
Garage	--	2.5
Laundry	--	1.3
Other	--	1.9

(Sources: Pacific Northwest: Tribwell and Lerman, 1996; California: RLW Analytics, 2005; KEMA, 2005)

As seen in Table 3-6, kitchens, living rooms, bathrooms and outdoor spaces account for 58% of the total annual lighting energy use per household in the Pacific Northwest, followed by bedroom and family room for a cumulative total annual lighting energy use of 75%. In California, kitchens and living rooms are also the top two lighting energy users in a house, followed by family rooms, garage and halls. It is important to point out that the Pacific Northwest data on bathrooms and bedrooms do not indicate whether this study looked only at the master bathrooms and bedrooms or all bedrooms and bathrooms, while the California study looked at bathrooms and bedrooms of all sizes. This may explain why the California kWh energy use estimates for these rooms are significantly lower.

Table 3-6: Comparison of Household Lighting Energy Use by Room: Pacific Northwest & California

Room	Average Annual Lighting Energy Use Per Household				Average Share of Total Annual Lighting Energy Use Per Household			
	Pacific Northwest		California		Pacific Northwest		California	
	kWh/yr	Rank	kWh/yr	Rank	Share	Cumulative Share	Share	Cumulative Share
Kitchen	342	1	313	1	19%	19%	20%	20%
Living Room	306	2	305	2	17%	36%	20%	40%
Bathroom	216	3	120	6	12%	48%	8%	48%
Outdoor	180	4	109	7	10%	58%	7%	55%
Bedroom	180	4	94	8	10%	68%	6%	61%
Family Room	126	6	231	3	7%	75%	15%	76%
Dining Room	126	6	--	--	7%	82%	--	--
Hall	108	8	121	5	6%	88%	8%	84%
Garage	90	9	212	4	5%	93%	14%	98%
Office	36	10	--	--	2%	95%	--	--
Utility Room	36	10	--	--	2%	97%	--	--
Other	36	10	--	--	2%	99%	--	--
Closet	18	13	39	9	1%	100%	2%	100%
Total	1800		1544		100%	100%	100%	100%

(Sources: Pacific Northwest: Tribwell and Lerman, 1996; California: RLW Analytics, 2005; KEMA, 2005)

Further analysis into the types of fixtures found in the top four lighting usage areas in the Pacific Northwest shows key areas of future opportunity for CFL installations. The following tables provide the average total watts per fixture of the top five most common fixtures (as determined by RLW Analytics, 2005, based solely on California data), as found in each high use area (determined by Tribwell and Lerman, 1996): kitchens, living rooms, bathrooms, and outdoor space. Each table also provides the percentage of homes with each fixture type, with at least one CF bulb by fixture type and with at least one incandescent bulb by fixture type.

In kitchens (see Table 3-7), 15% of all homes from the RLW Analytics study had at least one CFL in at least one fixture. Here, the greatest potential for future CFL installations appears to be with ceiling fixtures, which, while they have a relatively low average watts usage have a larger percentage of incandescent bulbs installed than CFL bulbs. Still, many ceiling fixtures, also as shown in Table 3-7, use fluorescent tube lighting. Recessed cans should also be considered as a high potential area for CFL installations, given that only 4% of homes have at least one CFL in at least one recessed can, and 24% have at least one incandescent bulb in at least one recessed can.

Table 3-7: California Household Fixture & CFL Installations for High Energy Usage Rooms (per Pacific Northwest): Kitchen

Top 5 Fixtures in Kitchens	Average total Watts per fixture	Percentage of Homes...				
		...with fixture type	...with at least 1 CFL in fixture	...with at least 1 incandescent in fixture	...with at least 1 fluorescent T12 in fixture	...with at least 1 halogen in fixture
1. Ceiling Fixture	80	69%	8%	31%	35%	>1%
2. Recessed Can	63	29%	4%	24%	2%	2%
3. Under Counter	N/A	22%	1%	15%	1%	2%
4. Chandelier	150	8%	>1%	6%	>1%	1%
5. Ceiling Fan	126	8%	1%	7%	--	>1%
% of Kitchens with bulb type	--	--	15%	68%	45%	6%

(Sources: RLW Analytics, 2005; KEMA, 2005)

As shown in Table 3-8, the majority of homes (60%) participating in the California study has table lamps, followed by those with floors lamps (35%). Regardless of the relatively low average watts used by this fixture type, given the large number of table lamps and the disparity between those with at least one CFL bulb at least one incandescent bulb installed, table lamps have a high potential for future programmatic focus. Torchieres, with their very high wattage levels, also show a high potential for future CFL installation efforts.

Table 3-8: California Household Fixture & CFL Installations for High Energy Usage Rooms (per Pacific Northwest): Living Room

Top 5 Fixtures	Average total Watts per fixture	Percentage of Homes...				
		...with fixture type	...with at least 1 CFL in fixture	...with at least 1 incandescent in fixture	...with at least 1 fluorescent T12 in fixture	...with at least 1 halogen in fixture
1. Table Lamp	67	60%	12%	52%	--	1%
2. Floor Lamp	90	35%	7%	27%	--	3%
3. Torchiere	165	16%	2%	8%	--	6%
4. Ceiling Fan	150	13%	2%	11%	--	>1%
5. Ceiling Fixture	80	13%	2%	10%	>1%	1%
% of Living Rooms with bulb type	--	--	24%	86%	1%	13%

(Sources: RLW Analytics, 2005; KEMA, 2005)

Wall mount fixtures, as presented in Table 3-9, have the second highest wattage level of the top five fixtures in bathrooms and are present in nearly three-quarters (74%) of all homes in the California study. Given the disparity between those with at least one CFL bulb and those with at

least one incandescent bulb installed, these fixtures represent a tremendous opportunity for CFL installation.

Table 3-9: California Household Fixture & CFL Installations for High Energy Usage Rooms (per Pacific Northwest): Bathroom

Top 5 Fixtures	Average total Watts per fixture	Percentage of Homes...				
		...with fixture type	...with at least 1 CFL in fixture	...with at least 1 incandescent in fixture	...with at least 1 fluorescent T12 in fixture	...with at least 1 halogen in fixture
1. Wall Mount	119	74%	5%	65%	2%	2%
2. Ceiling Fixture	80	48%	8%	36%	7%	>1%
3. Recessed Can	63	21%	4%	14%	1%	1%
4. Table Lamp	67	3%	>1%	2%	--	--
5. Ceiling Fan	126	3%	>1%	2%	--	--
% of Bathrooms with bulb type	--	--	15%	91%	4%	3%

(Sources: RLW Analytics, 2005; KEMA, 2005)

No differentiation was made in the California study regarding the type of fixtures found in outdoor applications. Table 3-10 provides, instead, the prevalence of incandescent bulbs (79.8% of total bulbs installed) and CF bulbs (14.5% of total bulbs installed). This finding strongly suggests that there is tremendous opportunity to focus CF bulb installation efforts on outdoor lighting.

Table 3-10: California Household Fixture & CFL Installations for High Energy Usage Rooms (per Pacific Northwest): Outdoor Room

Bulb Style	Percentage of All Bulbs
Incandescent	79.8%
Compact Fluorescent	14.5%
Halogen	5.6%
Metal Halide	0.1%
Total	100.0%

(Sources: RLW Analytics, 2005; KEMA, 2005)

Importance of Findings to This Study

Two key findings are illustrated by this analysis. First, no comprehensive recent data on hours-of-use or presence of fixtures and CFL installations within those fixtures exists for the Pacific Northwest. In fact, only two utility service areas within the Puget Sound was included in the Tribwell and Lerman study, further suggesting the need to conduct a thorough documentation of lighting usage. Second, based on the findings across all studies reviewed and reported here, a great deal of potential exists across the house and within specific rooms of the house for

installing a greater number of CFL bulbs. These findings have direct relevance to this study and it was decided that this study should attempt to fill this gap for the Puget Sound area.

SUMMARY AND RECOMMENDATIONS

Our review of the current literature on CFL saturation provides an important point of departure for this regional study. Key findings that result from this review, used to guide this study, included:

- **Date collection approaches** – Experience with telephone surveys indicate that this approach may not provide accurate information on CFL saturation or placement. A telephone survey would require developing a correction factor to accurately estimate CFL saturation. Based on this determination, this study utilized a mail based survey, which was believed would provide respondents more flexibility and time to walk through their home and count fixture types, controls and bulb types.
- **Overall barriers to CFL purchase** – Overall, the barriers to purchase of CFL bulbs are well documented. As such, this study did not research these barriers.
- **Specific barriers related to placement** – While overall barriers to purchase have been well documented, there is a lack of research documenting the barriers that preclude CFL installation in desired high use areas. Therefore, it was recommended that we include in this study a series of research questions to address these issues in a focused manner. However, given the complexity of the survey placement barriers were not able to be included but should be included in future research.
- **Characteristics of purchasers** – There is evidence to suggest that little difference exists among CFL purchasers when looking at gender and household income (other than low income levels). The positive influence of home ownership, previous purchases, and participation in a utility program is also well documented. It was recommended that this study augment the collective industry knowledge to expand upon earlier efforts to determine the significance of education level, age, and commitment to conservation. While education level and age were included as demographic variable selections, commitment to conservation was not included and should be explored in future research.
- **Hours of use** – Considerable data from California are available documenting hours of use by room. Based upon a review of these data, there are clearly rooms in which lighting represents a significant end use for energy, while others are clearly less so. Since those rooms with the highest use represent the most cost effective resource for the utilities, this study placed focused on assessing these higher-use rooms.

4. PRIMARY DATA COLLECTION FINDINGS

Upon completion of the secondary data review, a mail-based survey was created (please refer to chapter two for details on its development) to achieve the following objectives:

- 1) To quantify standard (one-inch) screw-base sockets and the current placement of CFL bulbs, by room, fixture type, and control type; and
- 2) To quantify the saturation of CFL bulbs

Additionally, this survey intended to fill in the gaps identified through the secondary data review. The specific areas addressed by this survey include:

- Influence of education attained and current age on CFL purchase and placement behaviors
- Inclusion of high usage areas within the home and evaluation of those areas during data analysis

What follows is the analysis of the findings across all three utilities service areas and identification of specific differences between each utility, where relevant.

OVERALL PUGET SOUND FINDINGS

Data collected from all three participating utilities (Puget Sound Energy, Seattle City Light, and Snohomish County PUD) were merged together to enable extrapolation to their combined service territories. Demographic and lighting data collected using the mail-based survey are summarized in this section at the overall regional level. When reviewing the differences among individual utilities and the overall regional findings, very few statistically or practically significant differences were observed. Where differences exist they are noted and discussed; however all corresponding utility-specific figures are located in the appendix, along with utility-specific tables.

Sample Disposition

In total, 1488 Puget Sound households returned a completed survey for a total response rate of 21%. Of these, 609 came from Seattle City Light's service territory (22% response rate), 537 from Puget Sound Energy's service territory (20% response rate) and 342 from Snohomish County PUD's service territory (21% response rate¹⁵).

Representativeness, Bias, and Accuracy

Representativeness of Sample

Demographic data collected from survey respondents were compared to United States census data from 2000 for King, Snohomish, Pierce and Kitsap counties¹⁶. Survey respondents were slightly more likely than the general population to:

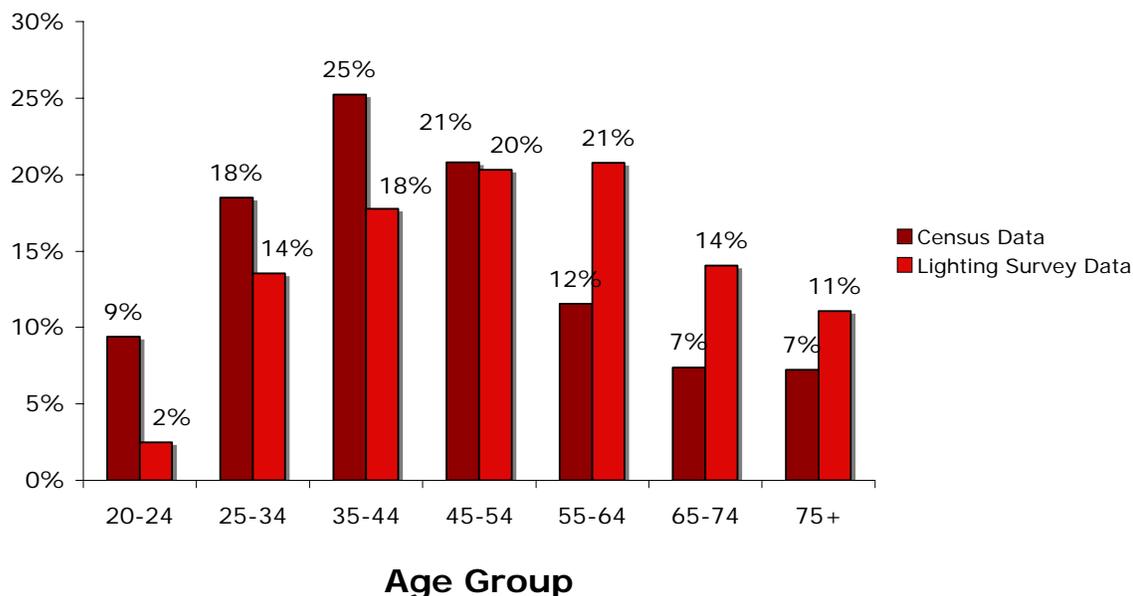
- Be older than adults in the general population (as shown in Figure 4-1)

¹⁵ Please see Table 2-1 for more details.

¹⁶ See the appendix for all figures comparing survey respondent and Census demographics.

- Be more educated: 51% of respondents have their Bachelor’s or Advanced degrees; whereas only 33% in the general population fit into these categories.
- Own rather than rent: Own Home was 62% per the Census 75% per respondents.

Figure 4-1: Comparison of Census Age & Survey Respondent Age: *Puget Sound Sample*



In general, though there were slight to moderate differences observed between the survey respondents and the general population Census data, the sample was deemed to be fairly representative of the population at large. Any slight or moderate influences demographic differences may have had on survey results are discussed within the household lighting data sections of this report.

Response Bias

As previously described, non-respondent telephone interviews were conducted with individuals who were sent the pilot survey booklet but did not return a response. In total, 39 non-respondent telephone interviews were completed. The following summarizes the common reasons cited by individuals as to why they did not complete and return the survey:

- 50% did not remember seeing the survey. Many suggested they likely threw it out thinking it was just another piece of junk mail.
- 17% cited the length and degree of complication as the primary reason for why they chose not to complete it.
- 15% stated that they had intended to fill out the survey, but the deadline had passed before they had a chance to do so.
- 7% of stated they had already filled out the survey and returned it in the mail.

Demographic data were collected from pilot wave non-respondents in order to compare them to those who did respond. The following points summarize the main demographic findings from this process:

- Both the average and median age for the respondent group was roughly ten years greater than those who did not respond.
- Income and education levels were similar for responders and non-responders, but, as will be presented later, both were higher than levels observed in the general population.
- The percentage of renters was much lower in both respondent and non-respondent groups when compared to the statistics for the region, with respondents being slightly more likely than non-respondents to be renters. These differences were the most significant among all of the demographics variables.

As a result of the non-respondent telephone interview process, a decision was made to move forward with the survey using the same process and the same layout and formatting that were used for the pilot wave survey. Only one small change was made to give individuals more instruction on how to fill out the lighting tables when they did not have any sockets or CFL bulbs to report for various fixtures. The decision to leave the survey in its practically original format was due to the fact that only a small number of non-respondents indicated that the complexity of the survey prevented them from completing and returning it and that the respondent and non-respondent groups.

Accuracy of Self-Report Data

To assess the accuracy with which individuals completed the survey¹⁷, ten audits were conducted with respondents within the Snohomish County PUD service territory. Data collected from the in-home audits were compared to the respective survey each individual had filled out during the pilot-testing phase to check for the prevalence and degree of misreporting.

Consistent with the secondary data review findings, the in-home audits found under-reporting of the number of both sockets and CFL bulbs in households—by 41%, on average, though this percentage varied widely among the ten interviewed respondents¹⁸. Interestingly, because reporting on the survey booklet of sockets and CFL bulbs had the same degree of error, self-reported saturation levels were identical to those found during the in-home audits. That is, respondents on their own equally under-counted sockets and CFL bulbs. This is perhaps logical because, as Kates et al. found, people fail to take into account the fact that some fixtures contain multiple sockets and bulbs.

A second and unexpected finding is that, when asked by the auditor how many CFL bulbs they would install, individuals dramatically increased the number of CFL bulbs they would be willing

¹⁷ Please see Appendix 1 for more details on step one of the data cleaning process. What is presented here is considered step two that determined the accuracy of self-report data among those respondents who made the first “cut” in the response evaluation.

¹⁸ While the in-home audits did reveal an average of 41% under-reporting tendency, only ten in-home audits were completed. Given this low number of audits, Seattle City Light is currently implementing this study as an in-home audit to determine the accuracy of this finding.

to install, tripling their original estimate. This was likely due to the social influence of a utility staff member asking individuals this question in person during the in-home audit as opposed to filling it out on a mail-in survey.

Table 4-1 summarizes the main statistics from the in-home audit and compares them to those calculated from the survey.

Table 4-1: Comparison of Self-Report & In-Home Audit Data: *Snohomish County PUD Sample*¹⁹

	Sample Size	Average Number of Sockets	Average Number of CFL Bulbs Installed	Average of Household Saturations*
Self-Reported Data	10	22.2	4.1	18.6%
In-Home Audit Data	10	37.7	7.0	18.5%
Total PUD Survey Data	342	40.9	8.5	23.0%

* Saturation equals number of CFL bulbs divided by number of sockets in each household.

The small sample size used for the in-home audits makes it difficult to determine the accuracy of observed reporting errors. Furthermore, data collected by utility staff through the in-home audit process are highly similar to averages calculated from all previous Snohomish County PUD surveys, suggesting that the misreporting error for this survey might fall well below the 41% observed if more surveys were to be audited.

Saturation Levels

Overall Saturation

This section summarizes overall household lighting data and examines specific findings concerning sockets, CFL bulbs, saturation levels, and market potential for the Puget Sound Area covered by the service areas of the three participating utilities. Issues related to specialty bulbs and fixtures are also discussed in this section with a specific emphasis placed on current perceived barriers and remaining market potential for this segment of compact fluorescent lighting.

Table 4-2 summarizes overall averages reported for the number of sockets and CFL bulbs among respondents of Puget Sound households, and current CFL saturation levels²⁰.

¹⁹ All in-home audit data were gathered from Snohomish County PUD households.

²⁰ Saturation is defined as the total number of CFL bulbs installed divided by the total number of sockets reported.

Table 4-2: Sockets, CFL Bulbs & CFL Saturation: Combined Puget Sound Sample & by Utility

	Sample Size	Number of Sockets		Number of CFL Bulbs Installed		Average of Household Saturations*	
		Avg.	Median	Avg.	Median	Avg.	Median
Puget Sound Energy	537	41.7	37.0	6.9	3.0	18.6%	9.3%
Seattle City Light	609	33.4	28.0	5.6	2.0	18.2%	10.0%
Snohomish County PUD	342	40.9	36.0	8.5	5.0	23.0%	12.3%
Total Sample	1488	38.1	33.0	6.7	3.0	19.4%	10.4%

* Saturation equals number of CFL bulbs divided by number of sockets in each household. Note that this statistic was calculated by averaging all of the household saturation levels reported and is not the saturation level of all sockets in the residential sector of each utility's service territory. For these statistics, see Table 4-B.

Puget Sound Energy and Snohomish County PUD customers both reported close to eight (8) more sockets on average than Seattle City Light customers. This is likely due to the fact that Seattle City Light customers reported a greater number of smaller homes (23% of respondents reported 1000 square feet or less) than respondents from the other two service territories (10% of Puget Sound Energy and 11% of Snohomish County PUD respondents reported 1000 square feet or less). Seattle City Light customers also reported smaller sized homes on average (1798 ft²) when compared to the other two utilities (1977 square feet for Puget Sound Energy and 1954 square feet for Snohomish County PUD).

Snohomish County PUD customers reported the highest average number of CFL bulbs and CFL saturation when compared to the other two utilities. Interestingly, saturation levels in Snohomish County PUD are quite similar to those estimated in their 2005 study (SnoPUD, 2005) in which they estimated each home had an average of 30 sockets per home and an average of seven (7) CFL bulbs installed, for a total saturation of 23%.²¹

Error! Not a valid bookmark self-reference. shows the average number of sockets, CFL bulbs and saturation levels reported for the five different housing types surveyed in this study. Manufactured or mobile homes and detached single family residences reported the highest CFL saturation levels at over 20%. Respondents from detached single family homes also reported the highest number of sockets and CFL bulbs, which is likely due to the fact that these types of homes tend to be larger in area than the other types such as apartments or townhouses. Tables for each utility are included in the appendix.

²¹ The Snohomish County PUD 2005 estimate of saturation was calculated using estimates from different sources collected at different times. As a result, Snohomish County PUD staff believe that the saturation estimate in this study is more accurate than the previous estimate.

**Table 4-3: Average Number of Sockets, CFL Bulbs & CFL Saturation, by Housing Type:
Combined Puget Sound Sample**

Housing Type	Sample Size	Average Number of Sockets	Average Number of CFL Bulbs Installed	Average of Household Saturations*
Single Family, Detached	957	46.7	8.5	20.4%
Townhouse or Rowhouse	37	32.1	3.5	15.2%
Manufactured or Mobile	75	26.4	5.8	25.8%
Duplex, Triplex, Fourplex	67	25.6	4.0	15.8%
Apartment or Condo	320	18.8	2.8	17.0%
Total	1,456	38.2	6.8	19.6%

* Saturation equals number of CFL bulbs divided by number of sockets in each household.

Sockets Installed

Socket data helps generate an overall picture of lighting in the household. It provides information on how lighting is distributed by room throughout the home and what potential remains for CFL bulbs in the residential sector. This section focuses on data collected on the number of sockets in the entire household, individual rooms, and specific types of fixtures as well as those activated by different type of controls.

Total Sockets in the Household

Figure 4-2 shows the distribution for the total number of sockets reported by individual households. Respondents reported a mean of 38.1 and median of 33 sockets per household, with the largest number of individuals reporting a count falling in the range of 12-27 sockets.

Figure 4-2: Distribution of Screw-base Sockets in Households: *Puget Sound Sample*

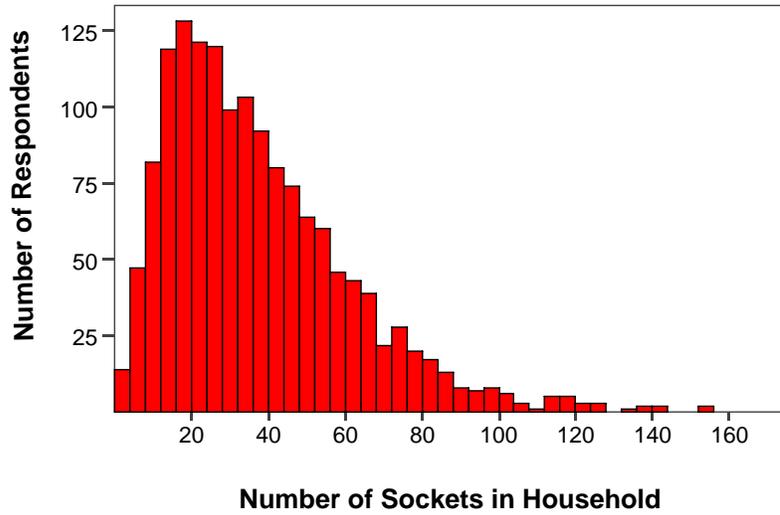
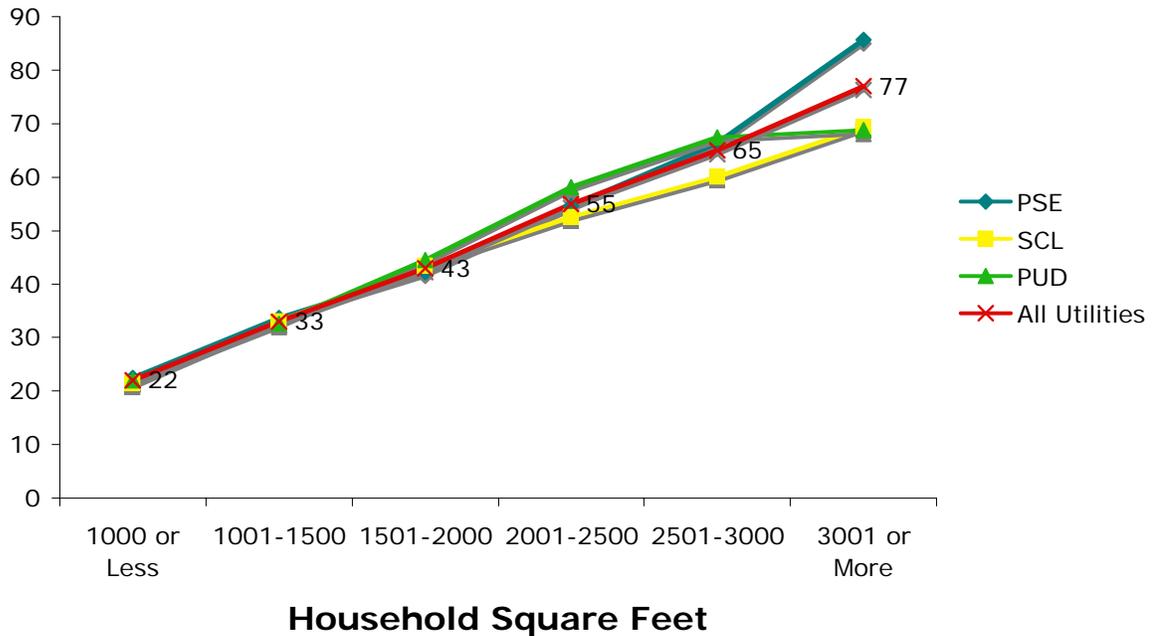


Table 4-4: Distribution Statistics for Screw-base Sockets in Households: *Puget Sound Sample*

N	1488
Mean	38.1
Std. Deviation	24.345
Skewness	1.330
SE of Skewness	0.063
Kurtosis	2.554
SE of Kurtosis	0.127

The wide distribution of the number of sockets reported by households is likely due to factors such as house size, as illustrated by Figure 4-3. Similar distributions of total sockets were observed across all three utilities.

Figure 4-3: Average Number of Sockets by Household Area: *Puget Sound Sample & by Utility*



Regressions were run to gain further insight into the relationship between household size and number of sockets. Each regression was run twice, one with an alpha-intercept and one through the origin. The regressions produced the following equations and results:

Overall Study:

$$\text{Sockets} = 23.966 + 0.011(\text{Household Ft}^2); \quad R^2 = 0.233$$

(1.308) (0.001)

$$\text{Sockets} = 0.020(\text{Household Ft}^2); \quad R^2 = 0.765$$

(0.000)

The constant and coefficients on all regressions were statistically significant at the 1% level. The regression from the origin (without the constant) had a very high R^2 value, suggesting that about 77% of the variation in the average number of sockets can be explained by household floor area. The following sets of regressions present results for the three individual utilities. Again, the regressions from the origin all had very high R^2 values of 0.7 or more. These analyses demonstrate that household floor area is a likely a major factor in determining the number of sockets at the household level.

<i>Puget Sound Energy:</i>	<i>Sockets =</i>	$19.244 + 0.014(\text{Household Ft}^2);$	$R^2 = 0.345$
		$(2.131) (0.001)$	
	<i>Sockets =</i>	$0.022(\text{Household Ft}^2);$	$R^2 = 0.828$
		(0.000)	
<i>Seattle City Light:</i>	<i>Sockets =</i>	$24.588 + 0.009(\text{Household Ft}^2);$	$R^2 = 0.186$
		$(1.995) (0.001)$	
	<i>Sockets =</i>	$0.018(\text{Household Ft}^2);$	$R^2 = 0.711$
		(0.001)	
<i>Snohomish County PUD:</i>	<i>Sockets =</i>	$29.501 + 0.008(\text{Household Ft}^2);$	$R^2 = 0.150$
		$(2.815) (0.001)$	
	<i>Sockets =</i>	$0.020(\text{Household Ft}^2);$	$R^2 = 0.740$
		(0.001)	

Regressions were also run for single family and multifamily (apartments and condos) households to gain insight into the relationship between household size and number of sockets for these classifications. These regressions produced the following results:

<i>Single Family, Detached:</i>	<i>Sockets =</i>	$28.626 + 0.010(\text{Household Ft}^2);$	$R^2 = 0.190$
		$(1.621) (0.001)$	
	<i>Sockets =</i>	$0.020(\text{Household Ft}^2);$	$R^2 = 0.781$
		(0.000)	
<i>Multifamily (Apt & Condos):</i>	<i>Sockets =</i>	$20.534 + 0.003(\text{Household Ft}^2);$	$R^2 = 0.053$
		$(1.656) (0.001)$	
	<i>Sockets =</i>	$0.012(\text{Household Ft}^2);$	$R^2 = 0.491$
		(0.001)	

Again, the regressions from the origin had very high R² values, with 78% of the variation in single family socket counts and 49% of the variation in apartment or condo socket counts being explained by household floor area. These results suggest that household floor area is a major factor in determining the number of sockets at the household level, especially for detached single family homes.

Sockets by Room

Average socket counts for the 12 room types included in the survey are summarized in Figure 4-4. This figure illustrates how sockets are distributed throughout rooms in an average household in the Puget Sound area, and is used as the basis for calculating statistics such as current CFL saturation and remaining market potential.

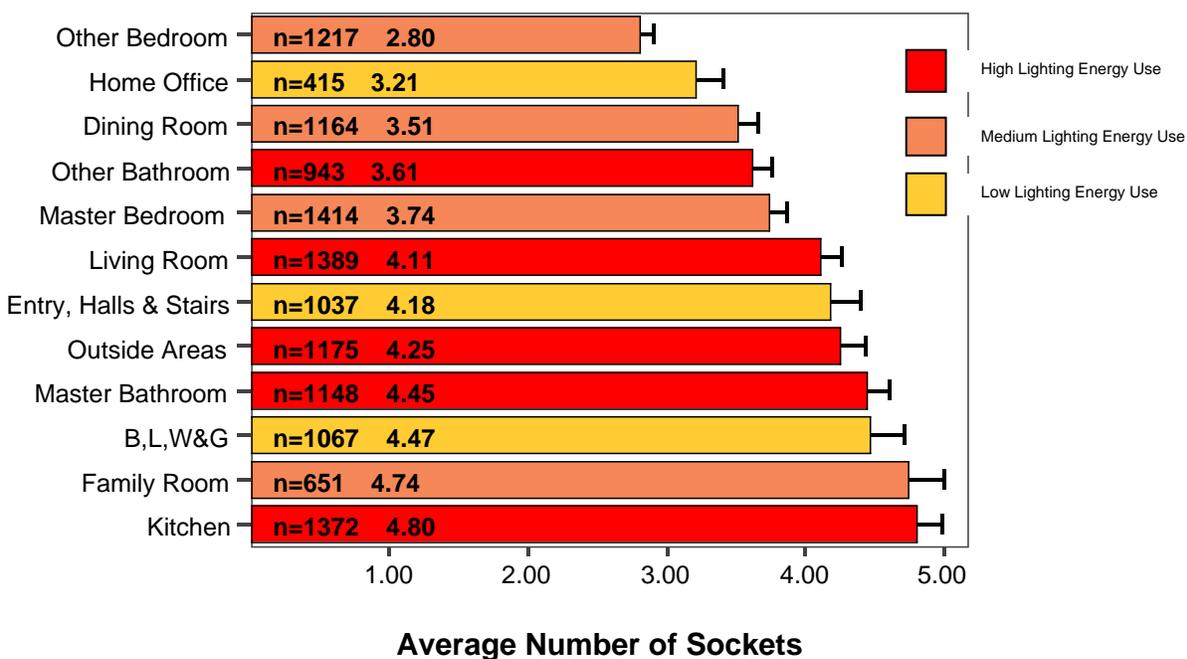
Rooms are displayed in descending order, with average number of sockets (e.g., 4.80 for the Kitchen) and total number of respondents reporting sockets (n) included in each bar. Error bands on the tip of each bar show the upper limit for the 95% confidence interval for the mean.

In addition, each bar is color coded into one of three different lighting energy use classification as determined by the 1996 Tribwell and Lerman study on Pacific Northwest lighting, as well as two studies published in 2005 by RLW Analytics²² and KEMA^{23 24}.

- **High lighting energy use** rooms were identified by the studies as using more than 180 kWh/yr in the Pacific Northwest and more than 100 kWh/yr in California
- **Medium lighting energy use** were those rooms using between 120 and 180 kWh/yr in the Pacific Northwest and between 50 and 100 kWh/yr in California, and
- **Low lighting energy use** rooms were those using less than 120 kWh/yr in the Pacific Northwest.

Though some variation was observed across the three utilities, socket counts and the ranking of rooms tended to be consistent. Individual utility graphs with socket per room averages are included in the appendix.

Figure 4-4: Average Number of Sockets by Room: *Households with Room Type*



B, L, W&G is the abbreviated version of “Basement, Laundry, Workshop & Garage”

²² 2005 California Statewide Lighting and Appliance Efficiency Saturation Study (CLASS).

²³ CFL Metering Study Final Report.

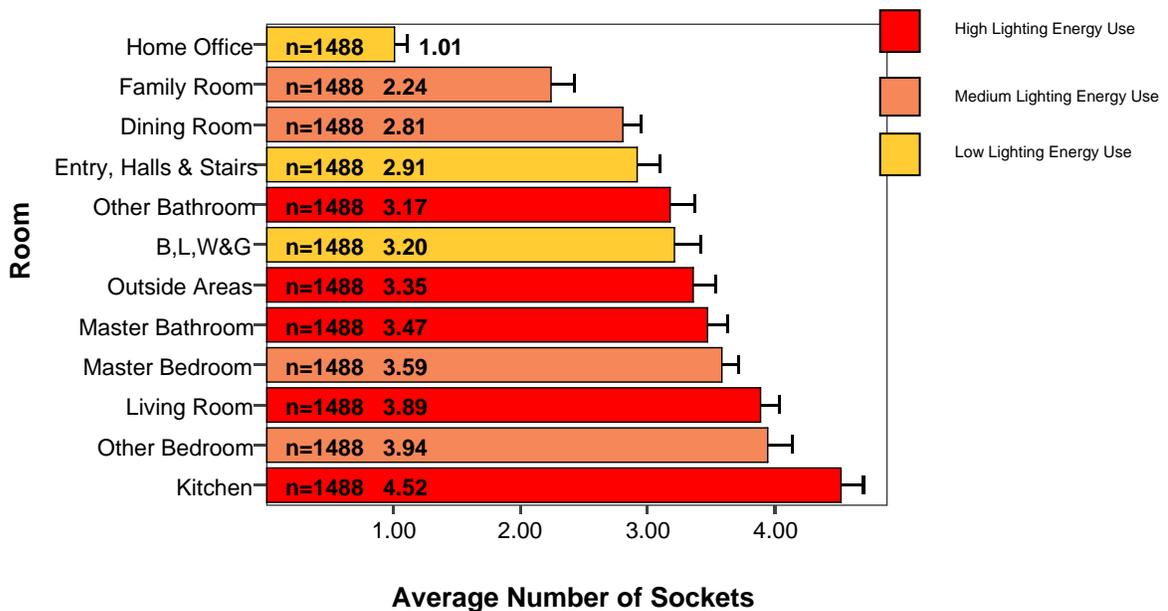
²⁴ Please refer to Tables 3-5 and 3-6 found in Section Three of this report for a more detailed explanation of energy usage areas.

Figure 4-4 shows the average number of sockets by room in households reporting at least one of the rooms surveyed (e.g., 651 respondents reported at least one family room). For comparisons, Figure 4-5 again shows the average number of sockets per room but uses the total number of respondents (1488) as the denominator, thereby including those who did not report specific rooms²⁵.

In Figure 4-4, the range of the average number of sockets reported by room was not that different among room types, with all rooms falling within the range of 2.80-4.80 sockets per room. A larger number of sockets tend to be located in kitchens, family rooms, master bathrooms, outside areas and living rooms. The high number of sockets reported for “basement, laundry, workshop and garage” and “entry, halls and stairs” is likely due to these categories covering multiple rooms and areas within the household.

When all respondents are included, as in Figure 4-5, the range of sockets reported expands to 0.90-4.43. Family rooms and home offices have much lower numbers, which is due to fewer than 50% of respondents reporting this room type in their household. When all respondents are included, high lighting energy use areas such as the kitchen, living room and master bathroom have the highest number of reported sockets.

Figure 4-5: Average Number of Sockets per Room: All Surveyed Households



B, L, W&G is the abbreviated version of “Basement, Laundry, Workshop & Garage”

²⁵ Both figures are presented here for illustrative purposes. With a self-report based survey it is impossible to know whether an individual simply forgot to identify a room and number of sockets in the house or if they truly do not have a specific room in the home. Nearly all homes have a kitchen, living room, and at least one bedroom. However, it appears that the least commonly reported rooms are a family room (separate from the living room) and home offices.

Specialty Bulbs and Fixtures

Socket data were also collected for different lighting fixtures and controls. These data provide more insight into the prevalence of specific fixtures and controls throughout the household and are especially useful when estimating the need for specialty bulbs such as dimmables or reflectors. Figure 4-6 shows the average number of sockets reported for three different fixture types across all rooms.

Out of all respondents in the Puget Sound region, 100% (n=1481) reported having at least one surface mount or hanging fixture, 95% (n=1412) reported at least one table or floor lamp, and 63% (n=942) reported at least one recessed can. The majority of the sockets reported were located in surface mount or hanging fixtures, with smaller yet still notable numbers of sockets also being reported in recessed cans and table or floor lamps. Similar trends were observed across all three utilities. Utility specific fixtures are included in the appendix.

Figure 4-6: Average Number of Sockets per Fixture Type: All Surveyed Households

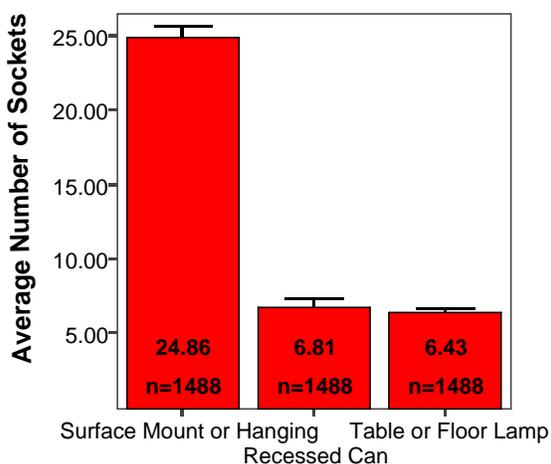


Figure 4-7: Average Number of Sockets per Control Type: All Surveyed Households

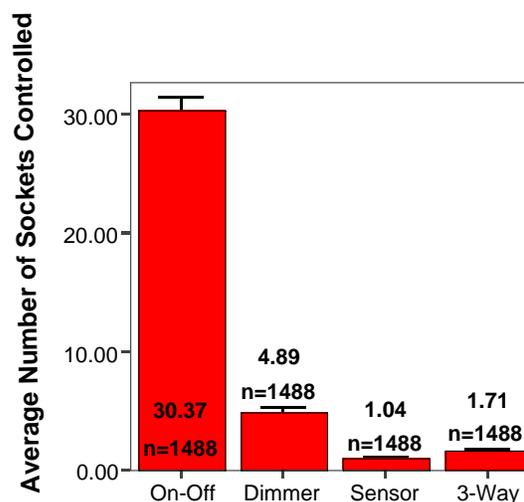


Figure 4-7 presents the average number of sockets controlled by four different types of lighting controls. The majority of sockets are controlled by on-off switches (80%), with smaller numbers of dimmer (13%), sensor (3%), and three-way (4%) switches controlling other sockets in the household. Similar frequencies were observed across all three utilities. These findings suggest that roughly 20% of sockets in Puget Sound households may require specialty CFL bulbs to function properly according to the type of control in place.

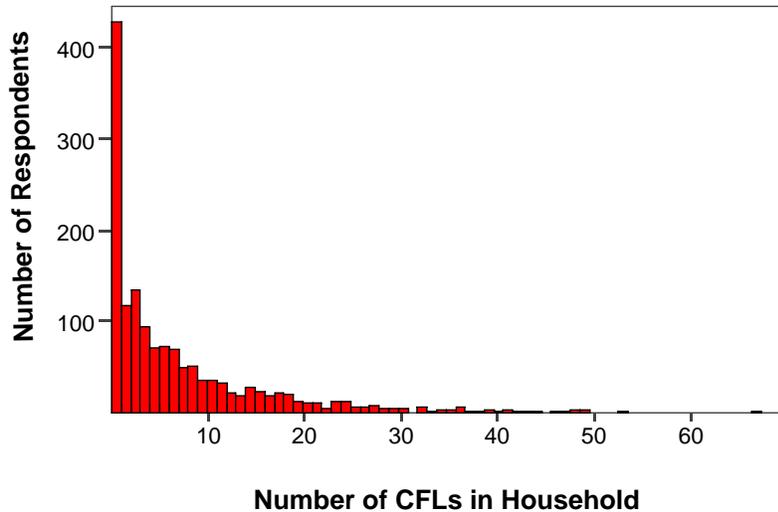
Using marginal values from the two sources of information about sockets in recessed cans and controls other than on-off switches, it is possible to roughly estimate the proportion of sockets requiring a specialty bulb. About 65% of sockets are located in surface mount or hanging fixtures, or in table and floor lamps, and are operated by an on-off switch. The corollary is that approximately 35% of sockets are in recessed cans or are controlled by a dimmer, sensor, or

three-way switch. This implies that 65% of sockets could conceivably use twist or quad CFL bulbs that are now readily available, while a 35% would benefit from a CFL or other specialty bulb application. This deduction takes into account that consumers may prefer bulbs like globes or other covered units in some sockets among the 65% noted above.

CFL bulbs Installed

Figure 4-8 presents the distribution for the total number of CFL bulbs reported by households. The graph illustrates how the total number of CFL bulbs reported varies across survey respondents, with almost all respondents falling in the 0-30 range and a large proportion reporting between 0-10. The number of CFL bulbs and distributions were relatively similar for all three utilities, though Snohomish County PUD customers reported slightly more CFL bulbs than Seattle City Light and Puget Sound Energy customers. The highest bar at the beginning of the graph illustrates the larger number of individuals reporting that they currently have either zero or one CFL installed in their home.

Figure 4-8: Distribution of CFL Bulbs in Household: Puget Sound Sample



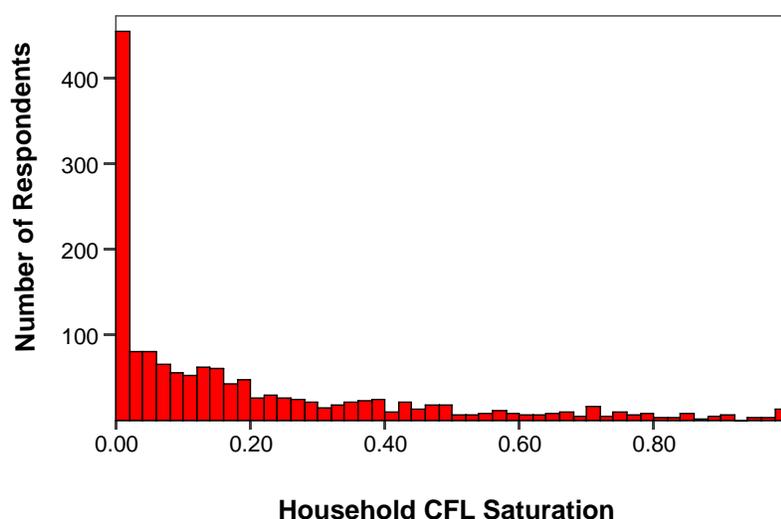
One bar = one CFL bulb (e.g., the first bar represents zero CFL bulbs, the second bar one CFL bulb, etc.)

Table 4-5: Distribution Statistics for CFL Bulbs in Households: Puget Sound Sample

N	1488
Mean	6.7
Std. Deviation	9.258
Skewness	2.300
SE of Skewness	0.063
Kurtosis	6.754
SE of Kurtosis	0.127

Figure 4-9 shows the shape of the distribution for current CFL saturation levels reported by households. The wide distribution presented in the graph indicates that there is a wide range of current saturation levels reported by respondents in the Puget Sound Area, and that households do not tend to cluster around the overall mean saturation level of 19%. Again, as with number of CFL bulbs installed, the height of the bar furthest to the left indicates that a significant number of individuals are reporting current saturation levels at or near 0% (this column combines 0% and 1%). Snohomish County PUD customers reported a mean saturation level of 23%, which was roughly 5% higher than those reported by Seattle City Light and Puget Sound Energy customers. Saturation distributions were similar in shape among all three utilities.

Figure 4-9: Distribution of CFL Saturation Levels in Households: *Puget Sound Sample*

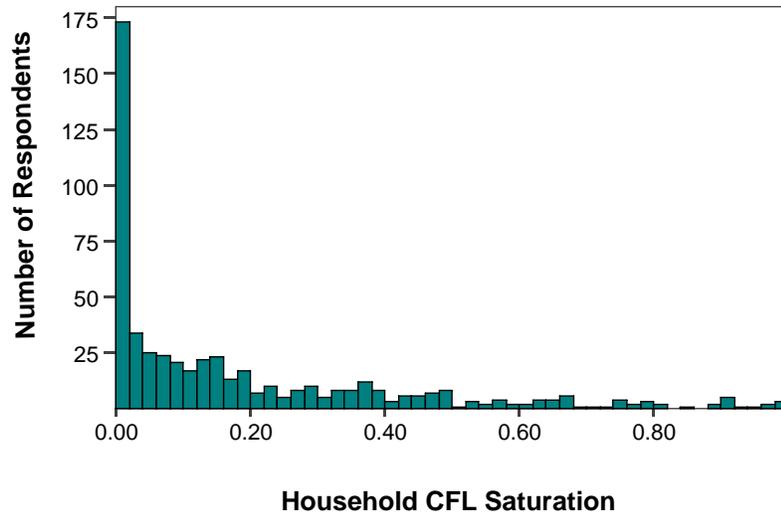


Note: Household Saturation numbers are in percents (i.e., 0.20 = 20%). One bar = two percent (e.g., 0-2% or 0.00-0.02).

Table 4-6: Distribution Statistics for CFL Saturation Levels in Households: *Puget Sound Sample*

N	1488
Mean	0.194
Std. Deviation	0.2406
Skewness	1.498
SE of Skewness	0.063
Kurtosis	1.548
SE of Kurtosis	0.127

Figure 4-10: Distribution of CFL Saturation Levels in Households: *Puget Sound Energy*

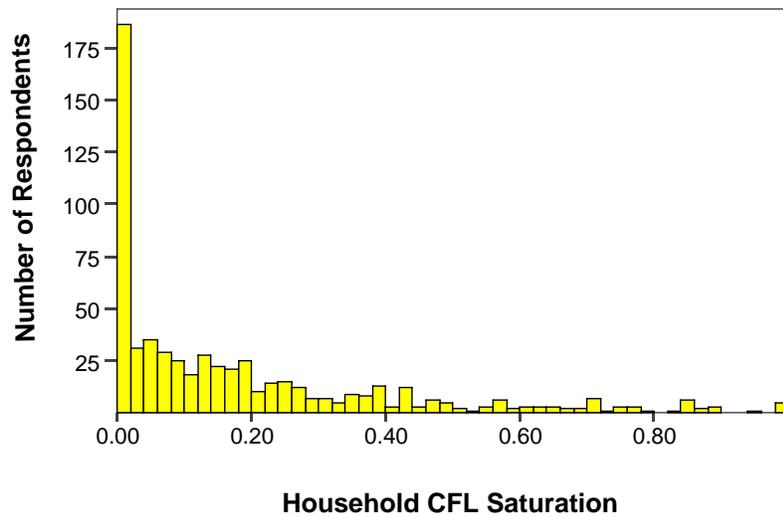


Note: Household Saturation numbers are in percents (i.e., 0.20 = 20%). One bar = two percent (e.g., 0-2% or 0.00-0.02).

Table 4-7: Distribution Statistics for CFL Saturation Levels in Households: *Puget Sound Energy*

N	537
Mean	0.186
Std. Deviation	0.2357
Skewness	1.542
SE of Skewness	0.105
Kurtosis	1.767
SE of Kurtosis	0.210

Figure 4-11: Distribution of CFL Saturation Levels in Households: *Seattle City Light*

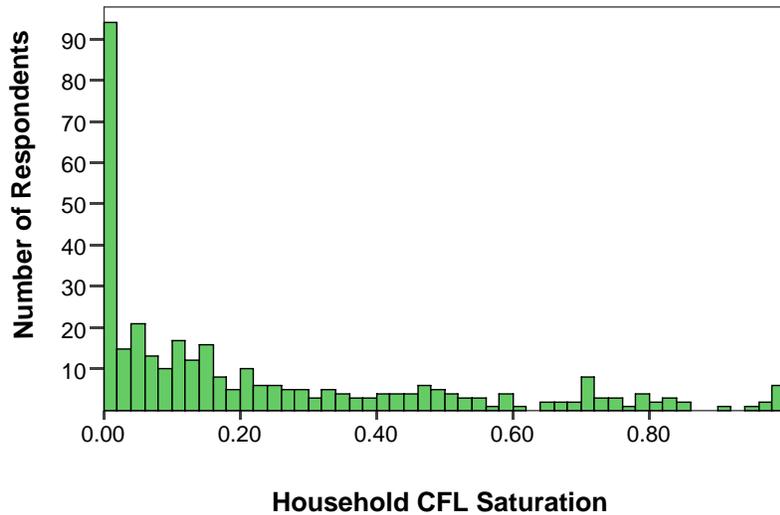


Note: Household Saturation numbers are in percents (i.e., 0.20 = 20%). One bar = two percent (e.g., 0-2% or 0.00-0.02).

Table 4-8: Distribution Statistics for CFL Saturation Levels in Households: *Seattle City Light*

N	609
Mean	0.182
Std. Deviation	0.2256
Skewness	1.612
SE of Skewness	0.099
Kurtosis	2.131
SE of Kurtosis	0.198

Figure 4-12: Distribution of CFL Saturation Levels in Households: *Snohomish County PUD*



Note: Household Saturation numbers are in percents (i.e., 0.20 = 20%). One bar = two percent (e.g., 0-2% or 0.00-0.02).

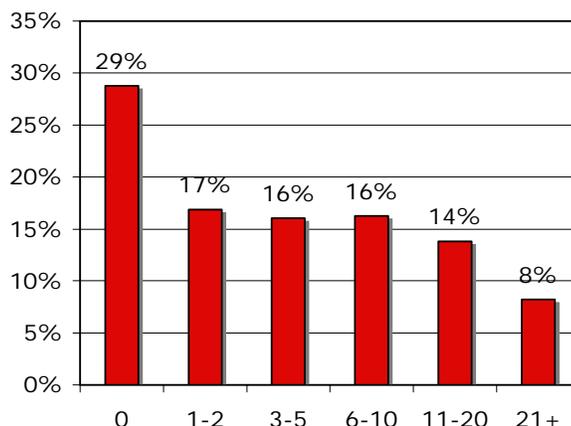
Table 4-9: Distribution Statistics for CFL Saturation Levels in Households: *Snohomish County PUD*

N	342
Mean	0.230
Std. Deviation	0.2696
Skewness	1.240
SE of Skewness	0.132
Kurtosis	0.515
SE of Kurtosis	0.263

Figure 4-9 further examines the number of CFL bulbs currently installed in households by showing the percentage of respondents reporting various numbers of CFL bulbs currently installed in their homes. A large number of individuals reported very few CFL bulbs installed, with roughly half (46%) of all survey respondents reporting two CFL bulbs or fewer. Figure 4-10 through Figure 4-12 provide similar information for each of the three utilities.

Interestingly, nearly one-third (29%) of all respondents indicate they have zero CFL bulbs currently installed, suggesting a tremendous opportunity (see Figure 4-13). This percentage was relatively consistent across all three utilities. In order to better understand the groups of individuals reporting CFL counts and, therefore, saturation levels of zero, demographic data for this group were explored to identify noteworthy differences with all other respondents.

Figure 4-13: CFL Bulbs Currently Installed in Household, by Frequency



This analysis revealed that two demographic variables, home type and tenure, showed statistically significant differences ($p < 0.05$, $n = 1488$, $DF = 1485$) between respondents with zero (0) CFL bulbs installed and those with one (1) or more CFL installed. Table 4-10 and Table 4-11 show that apartment or condo residents were more likely than single family residents to have zero CFLs (42% vs. 23%), while single family residents were more likely to have one or more CFL (77% vs. 58% of apartment or condo residents). As Table 4-12 and 4-13 show, this was also true when comparing renters and owners. Renters were more likely than owners to have zero CFLs (41% vs. 24%), while owners were more likely to have one or more CFL than renters (76% vs. 59%).

Table 4-10: Housing Type: Respondents with Zero CFLs

	Apartment or Condo	Single Family, Detached
Number of Respondents with Zero CFLs	133	216
Percent of Apt/Condo or Single Family Residents	42% (133/320)	23% (216/957)
Percent of "Zero CFLs" Population	34% (133/391)	55% (216/391)

Table 4-11: Housing Type: Respondents with One or More CFL

	Apartment or Condo	Single Family Detached
Number of Respondents with One or More CFL	187	741
Percent of Apt/Condo or Single Family Residents	58% (187/320)	77% (741/957)
Percent of "One or More" CFL Population	19% (187/990)	75% (741/990)

Table 4-12: Housing Tenure: Respondents with Zero CFLs

	Rent or Leasing	Own or Buying
Number of Respondents with Zero CFLs	147	256
Percent of Renters or Owners	41% (147/359)	24% (256/1075)
Percent of “Zero CFLs” Population	36% (147/403)	64% (256/403)

Table 4-13: Housing Tenure: Respondents with One or More CFL

	Rent or Leasing	Own or Buying
Number of Respondents with One or More CFL	212	819
Percent of Renters or Owners	59% (212/359)	76% (819/1075)
Percent of “One or More CFL” Population	21% (212/1031)	79% (819/1031)

In summary, these data suggest that renters and apartment or condo dwellers in the Puget Sound area are more likely to have zero CFL bulbs currently installed in their homes, and that homeowners and those living in detached single family homes are more likely to have at least one if not more CFL bulbs currently installed. This finding is especially important for Seattle City Light, as the 2000 Census estimated that slightly over half of all Seattle residents are renters and roughly 40% live in apartments. Complete demographic breakdowns for the zero CFL bulbs respondent group are provided for each utility in the Appendix as Tables 4-A-1 – 4-A-3.

However, it is still important to consider here that two-thirds (66%) of respondents are single family home dwellers and 75% of respondents own their home, which is comparable to Puget Sound residents among which 62% own their homes and 60% live in single family residences. That being so, although there is a great opportunity to install more CFL bulbs among renters and apartment or condo dwellers, the largest opportunity may still reside with single family home owners.

CFL Saturation by Fixture

Installed CFL bulb counts and saturation levels for the three fixture types included in the survey are presented in Figure 4-14 and Figure 4-15. Reflecting trends reported for average number of sockets, the average number of CFL bulbs by fixture type was highest for surface mount and hanging fixtures (4.25) and lower for recessed cans (1.55) and table and floor lamps (1.53). Reported saturation ranged from 18% to 27%, varying by 9 percent across all three fixture types, though no specific fixture had an abnormally low or high saturation level in comparison to the household mean for the Puget Sound (19.4%). These trends were similar across all three utilities. When considering Figure 4-14 and Figure 4-15 together, please note that although there are a greater number, on average, of installed CFL bulbs in hanging or surface mounted fixtures than in the other two fixtures, hanging and surface mounted fixtures may represent a

large opportunity for future efforts given the overall saturation level of only 18%. That is, the average numbers of sockets that did not contain a CFL bulb were 3.49 for surface mount or hanging fixtures, 1.21 for recessed cans, and 1.12 for table or floor lamps.

Figure 4-14: Average Number of CFL Bulbs per Fixture Type: Households with Fixture Type

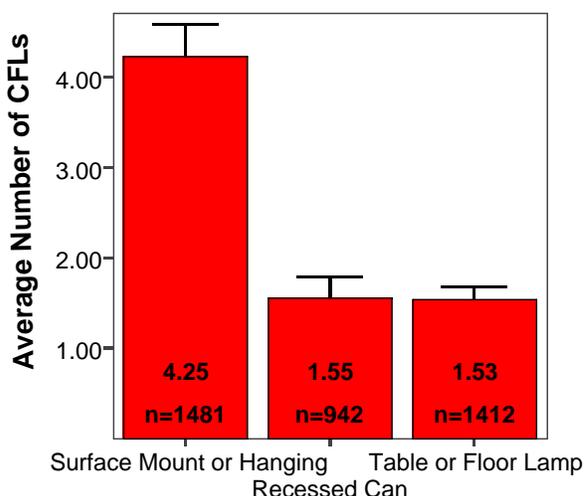
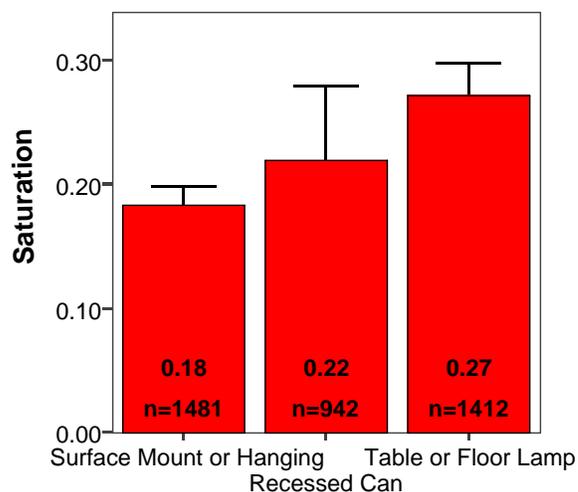


Figure 4-15: Average Saturation of CFL Bulbs per Fixture Type: Households with Fixture Type

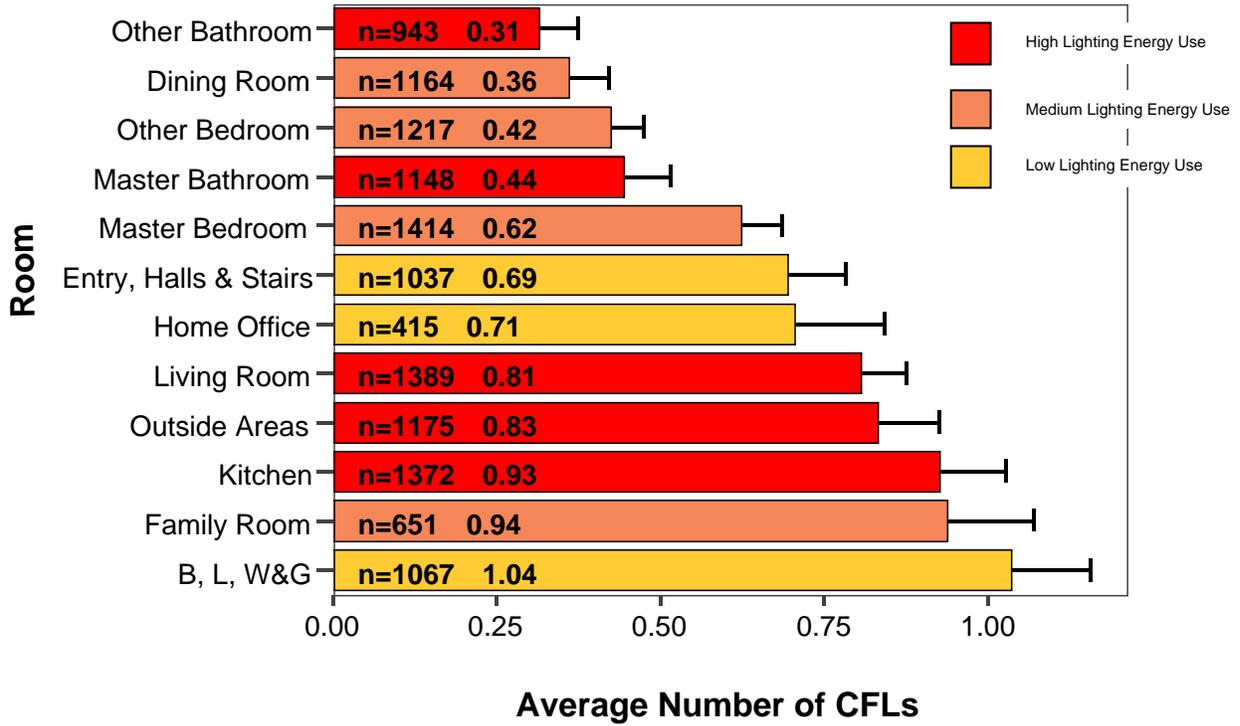


Note – Numbers are percentages (i.e., 0.27 = 27%)

CFL Saturation by Room

Figure 4-16 presents the mean number of CFL bulbs currently installed in each the 12 rooms of the home surveyed in this study. As previously described, each room is color coded to illustrate high, medium and low lighting energy use areas of the home. Based on findings from previous research (Vine & Fielding, 2005) this study expected to find that individuals install their CFL bulbs in the rooms with the highest energy usage. However, as illustrated in the following figure, there is a relatively uneven distribution of CFL bulbs throughout the household, with areas such as the bedroom, bathroom and dining room reporting relatively low averages in Puget Sound homes (0=1.08, 1.00, and .96, respectively). Still, the number of CFL bulbs installed in each room is very small, which necessitates considering the saturation rates within each room.

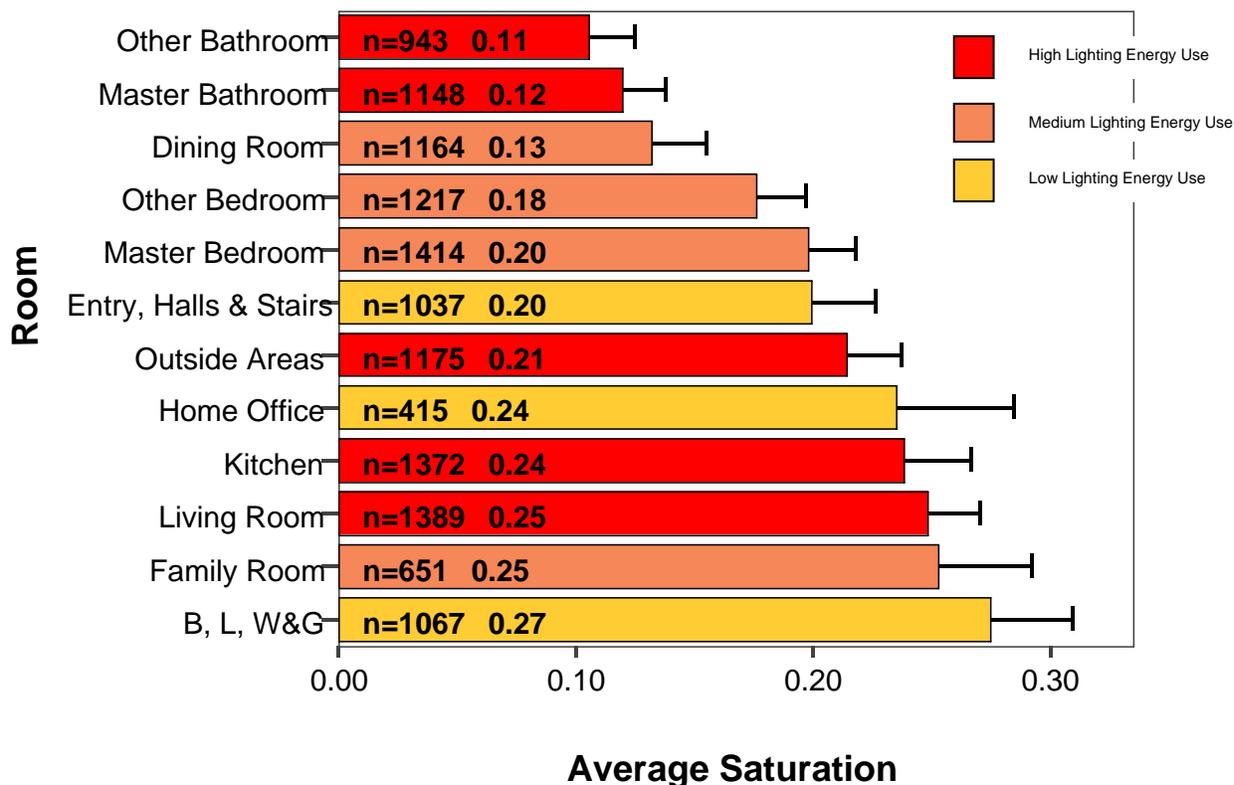
Figure 4-16: Average Number of CFL Bulbs by Room: *Households with Room Type*



Note – B, L, W&G is the abbreviated version of “Basement, Laundry, Workshop & Garage”

As with the earlier discussion of overall CFL saturation across all rooms in the house, Figure 4-17 presents CFL saturation rates by room; the total number of CFL bulbs installed divided by the total number of sockets reported. The saturation level is presented as a percentage and each room is rank ordered in descending order to illustrate which rooms have higher saturation levels. Again, rooms are color coded to identify the level of lighting energy usage.

Figure 4-17: Average Saturation of CFL Bulbs by Room: *Households with Room Type*



Note – Numbers are percentages (i.e., 0.27 = 27%)

Of the five highest CFL saturation areas, two are among the lowest lighting energy usage areas: basement, laundry, workshop and garage (27% saturation) and home office (24% saturation). The saturation level in the first bar (B, L, W&G) may be much higher simply because so many areas were combined into one category. Importantly, only a quarter of respondents reported having a home office, and it is difficult to know whether home offices exist in corners of bedrooms or other spaces (e.g., kitchens).

Especially noteworthy is that one of the highest lighting energy use areas, bathrooms, has the lowest overall saturation levels. Here, both master bathroom and other bathrooms in the home reported the lowest levels of saturation (12% and 11%, respectively), which is consistent with an earlier study (Kates et. al, 2005) researching saturation levels in Massachusetts homes. In this study researchers found that bathrooms and dining rooms had only 3% of the total sockets filled with CFL bulbs while other rooms had as much as 9% filled (kitchen). In the current study, the research team postulates that this could reflect the large number of bulbs required in some vanity lighting fixtures, and the presence of heat lamps that may necessitate specialty incandescent bulbs. The same may be true of bedrooms (master has 20%, other has 18% CFL bulbs) and dining rooms (13%). These are both medium lighting energy usage areas, which may require specialty CFL bulbs to fit into some table lamps where the shade is designed to fit over a bulb, or to fit into chandelier-style fixtures.

Types of fixtures and controls present in these rooms were examined to further explore the relatively low saturation levels in bathrooms and the dining room. Roughly 85% of sockets in the master bathroom are located in surface mount or hanging fixtures (see Figure 4-18). As shown in Figure 4-15 presented above, when examined at the household level, these fixtures had the lowest average saturation level (18%) when compared to recessed cans and table and floor lamps.

Figure 4-18: Average Number of Sockets per Fixture Type: Master Bathrooms

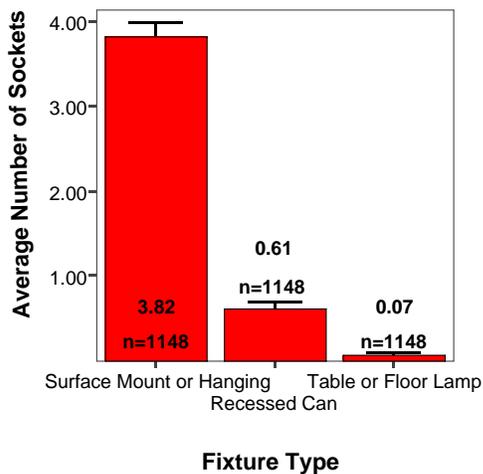


Figure 4-19: Average Number of Sockets per Control Type: Master Bathrooms

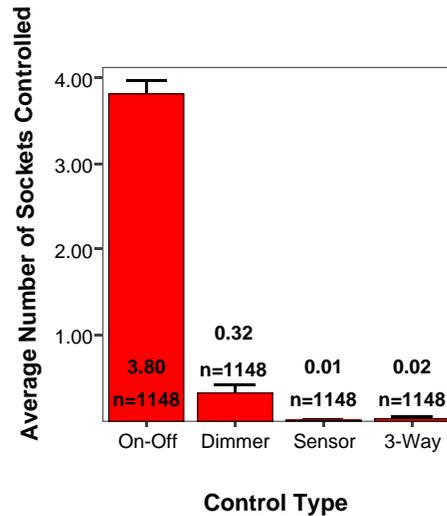


Figure 4-18 and Figure 4-19 present the average number of sockets by fixture and the average number of sockets with specific control types in the master bathroom. The master bathroom has a greater number of sockets controlled by on-off switches than any other type of control (92%), suggesting that the need for specialty bulbs specifically designed for other controls such as dimmers may not be a factor contributing to the low saturation level. However, it is possible that specialty bulb shapes (e.g., globes) may be required to fit some of these fixtures.

Figure 4-20 and Figure 4-21 present the average number of sockets by fixture and control types in dining rooms. As with the master bathroom, the majority of sockets in the dining room are concentrated in surface mount or hanging fixtures (82%). As shown in Figure 4-21, dimmer switches control roughly the same number of sockets as on-off switches in the dining room. In fact, dining rooms have a greater average number of sockets controlled by dimmer switches than any other rooms surveyed, with 27% of all dimmer-controlled sockets in the household located in this room²⁶. In the case of dining rooms, in contrast to the master bathroom analysis, specialty CFL bulbs that work well with existing dimmer controls may be necessary to increase saturation levels of CFL bulbs. This may also be a location where alternative high-efficiency lighting solutions may supply the lighting characteristics that occupants seek (e.g., LED lamps).

²⁶ See appendix for complete graphs and figures.

Figure 4-20: Average Number of Sockets per Fixture Type: Dining Rooms

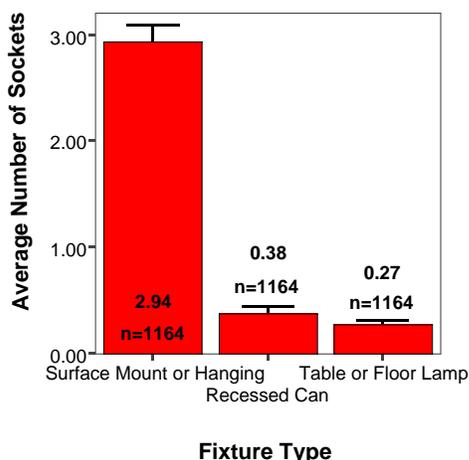
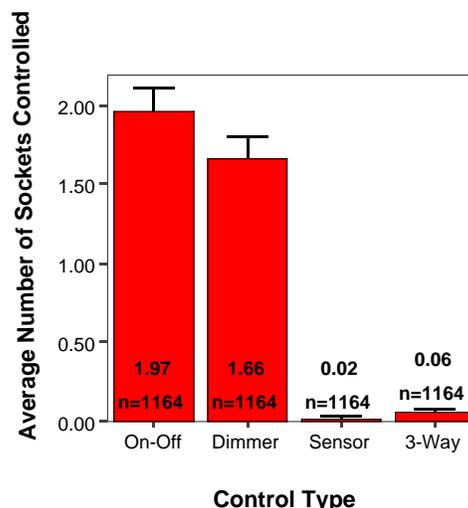


Figure 4-21: Average Number of Sockets per Control Type: Dining Rooms



Remaining Potential

The remaining potential for CFL bulbs in the Puget Sound Area is defined two ways:

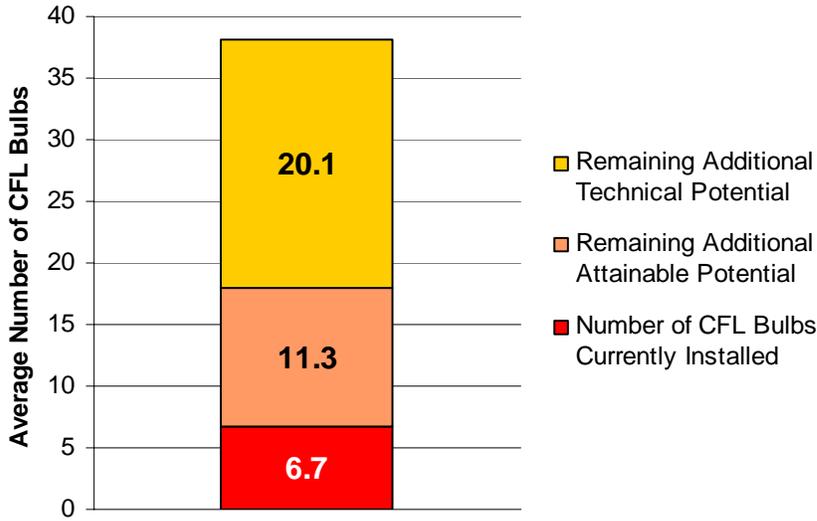
- **Attainable Potential** – the number of CFL bulbs individuals are *willing* to install today. Attainable potential was determined by asking individuals to estimate the number of CFL bulbs they would install if they had the right type of CFL bulb and didn’t have to worry about wasting bulbs currently in place. This measure reflects the current state of awareness, perceptions, and knowledge among consumers.
- **Technical Potential** – the number of CFL bulbs individuals *could* install today (i.e., if all ordinary size screw-in sockets were filled with CFL bulbs). Technical potential was determined by counting the number of sockets²⁷ reported that do not currently have a CFL installed. No decrement is made in this category for specialty bulb applications.

As shown in Figure 4-22, there currently are 6.7 CFL bulbs, on average, installed across all rooms and areas surveyed in homes. On average, individuals indicated they would be willing to install close to 11.3 additional CFL bulbs. In addition, homes have a large number of sockets that currently do not have CFL bulbs installed. These sockets represent the total technical potential (remaining additional attainable potential plus remaining additional technical potential) to install an additional 20 CFL bulbs, for a total of 38 potential CFL bulb installations.²⁸

²⁷ The survey asked only about ordinary size screw-in sockets that work with traditional CFL bulbs.

²⁸ Please refer to the Appendix and Tables 4-B through 4-E for a detailed look at how the remaining potential translates into planning estimates for the Puget Sound area and for each utility service territory.

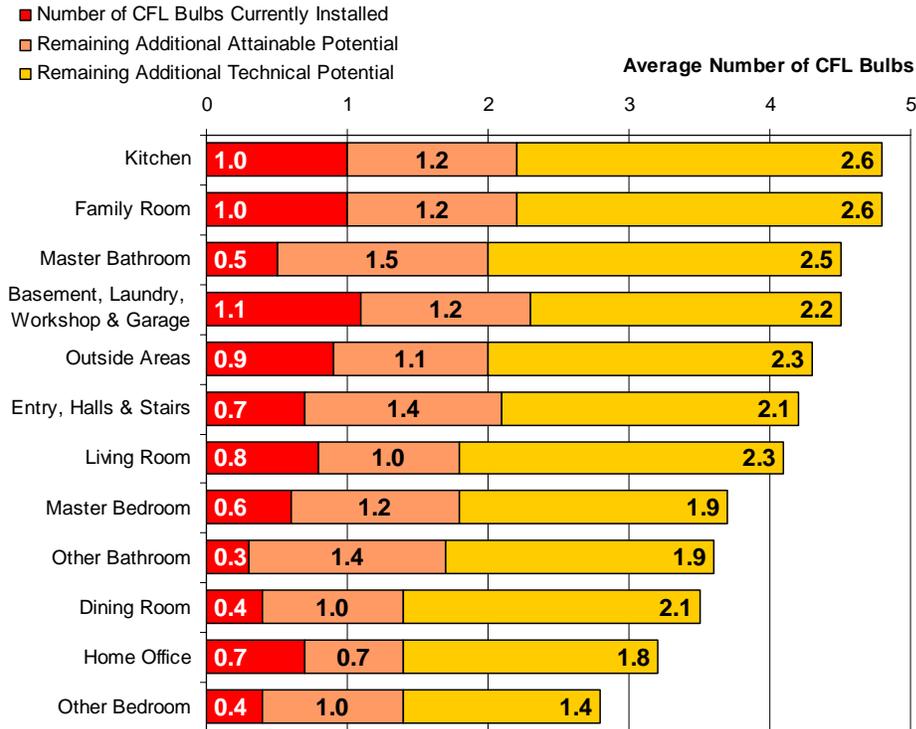
Figure 4-22: Remaining CFL Potential at the Household Level



Note: Attainable Potential refers to the number of CFL bulbs individuals are willing to install today.

As Figure 4-23 illustrates, every room surveyed in this study has potential for additional CFL bulbs to be installed. On average, respondents indicated that they are willing to install approximately one additional CFL in each room in their household and that they have the technical potential to install close to three additional bulbs in each room.

Figure 4-23: Remaining CFL Potential by Room Type



Note: Attainable Potential refers to the number of CFL bulbs individuals are willing to install today.

Figure 4-24 shows the percentage of households reporting at least one of each room type surveyed in the study. Numbers from Figure 4-24 were used to produce weighted averages of remaining potential by room, which are shown in Figure 4-25. These figures suggest that although there exist potential for CFL bulb installations in all rooms in the household, rooms such as the master bedroom, kitchen and living room may offer the greatest potential for additional CFL bulbs across a utility's service territory.

Figure 4-24: Percent of Households with Each Room Type

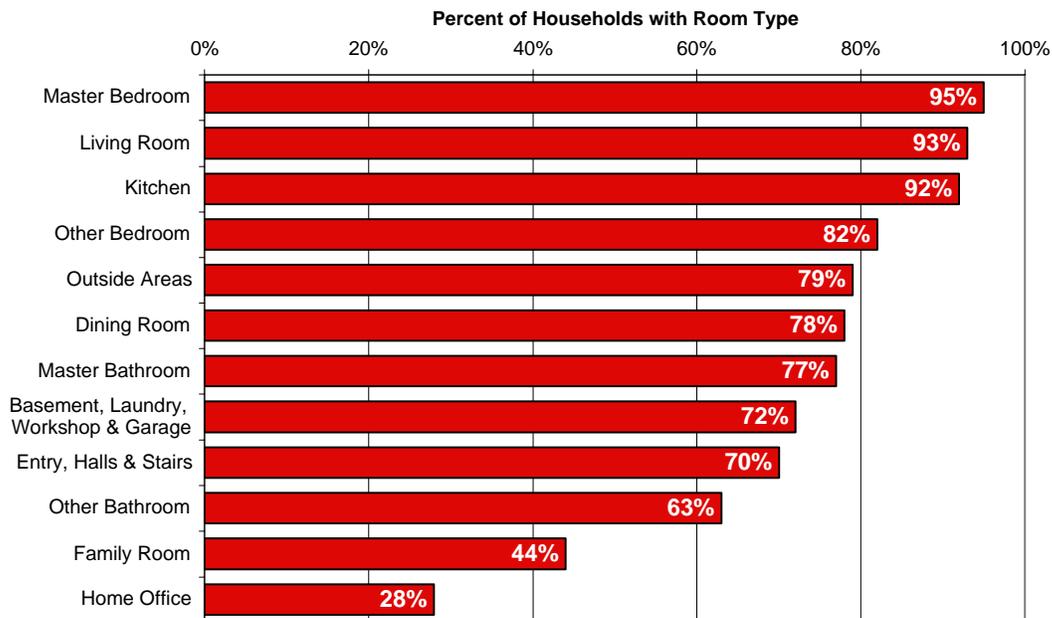
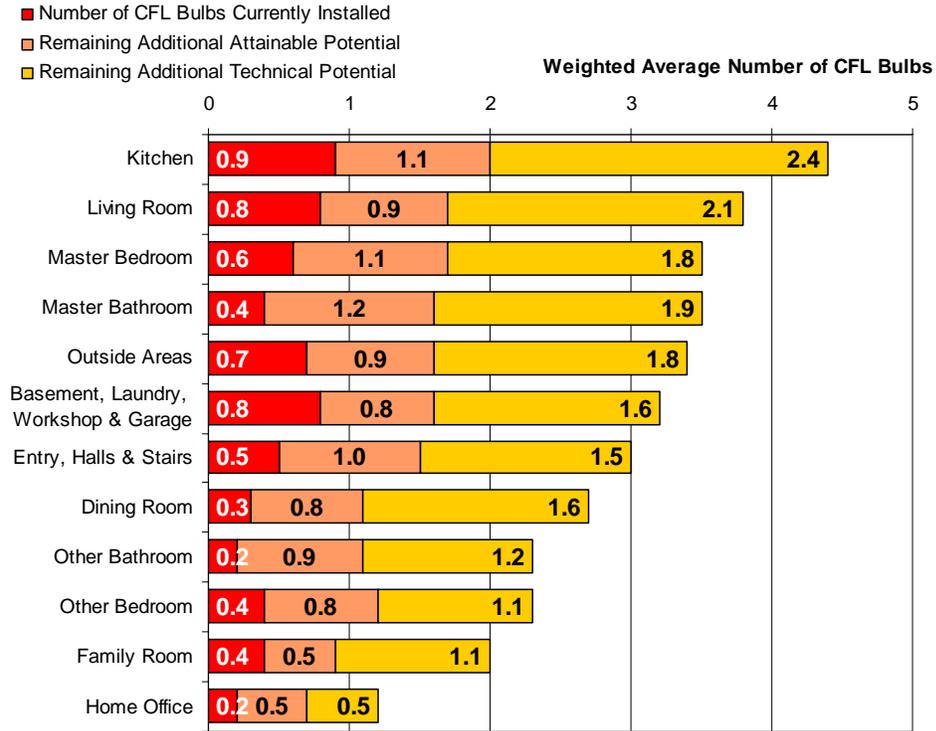


Figure 4-25: Weighted Remaining CFL Potential by Room Type

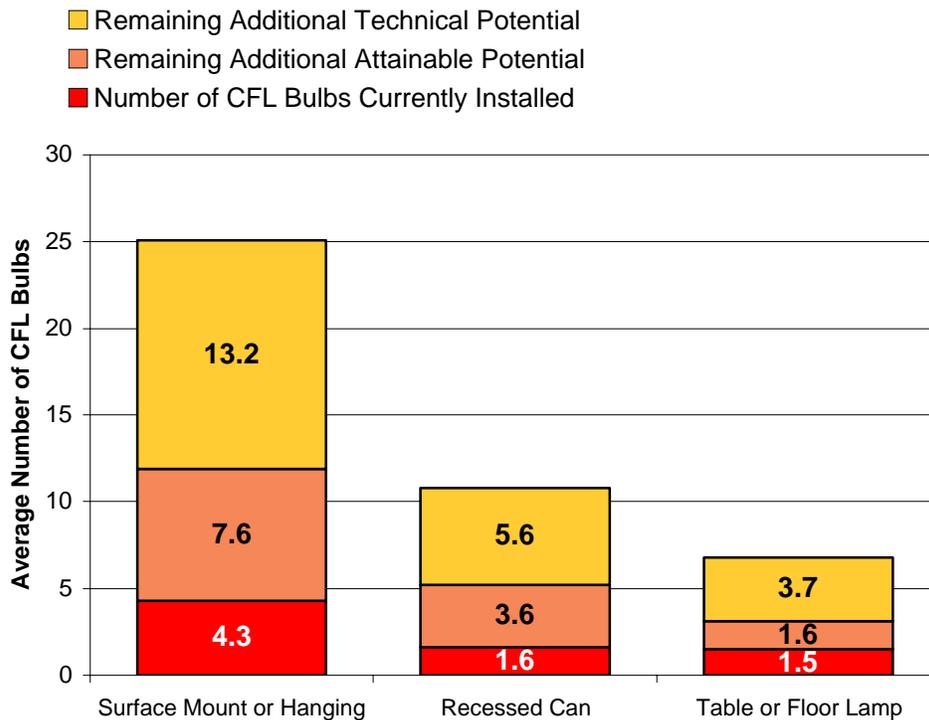


Note: Attainable Potential refers to the number of CFL bulbs individuals are willing to install today.

Figure 4-26 compares the remaining attainable and technical potential for CFL bulbs across the three fixture types surveyed. As previously discussed, some fixtures such as recessed cans and table or floor lamps require a specialty CFL bulb in order to function properly.

Here, we find that surface mounted and hanging fixtures hold the greatest potential for additional bulbs, with individuals indicating they are willing to install, on average, eight additional CFL bulbs in these fixtures (across room types) and that they have the capacity to install close to 21 more. Recessed cans and table and floor lamps do not hold as much potential as surface mount and hanging fixtures due to their lower prevalence in Puget Sound homes, though collectively they have an attainable potential of over five (5) additional CFL bulbs and a total technical potential of nearly 15 additional bulbs. As such, the greatest potential appears to lie with traditional CFL bulbs rather than specialty CFL bulbs.²⁹

²⁹ Please refer to Tables 4-B through 4-E in the Appendix for a more detailed look at the remaining potential by utility and housing type for fixture and control types. These numbers give a better idea of the quantity of sockets that still do not have CFL bulbs in place, sockets that may require specialty bulbs, and the different types of controls currently in place for sockets in the region.

Figure 4-26: Remaining CFL Potential by Fixture Type

Note: Attainable Potential refers to the number of CFL bulbs individuals are willing to install today.

Summary of Remaining Potential

The data gathered in this study indicate that the greatest remaining potential exists with traditional CFL bulbs rather than specialty bulbs. Eighty percent of all ordinary size screw-in sockets are currently controlled by on-off switches in the Puget Sound area (see Figure 4-7). Additionally, an estimated 65% of sockets are controlled by on-off switches and are located elsewhere than in recessed cans.

In the remaining 35% of sockets, there are some cases in which twist or quad CFL bulbs will function properly, and, as shown in Figure 4-15 previously discussed, some respondents indicated they have installed CFL bulbs in all fixture types. Nonetheless, specialty bulbs (e.g., reflectors bulbs, globe style bulbs, three-way bulbs) are designed to better fit a specific fixture or work with a specific control³⁰.

³⁰ While some fixtures do have specific controls such as a dimmer or three-way switch; however, to manage the complexity of the survey, the research team chose to design the questions to facilitate easier response rather than allow a way to link CFL bulbs installed to specific control types.

These findings suggest that traditional CFL bulbs may be adequate for the majority of lighting retrofits and that most of the attainable potential lies within sockets controlled by these switches. Still, the remaining 20% to 35% of sockets requiring specialty bulbs represents a significant portion of the market and should not be ignored, especially in specific rooms such as the dining room in which a large number of fixtures are controlled by dimmer switches.

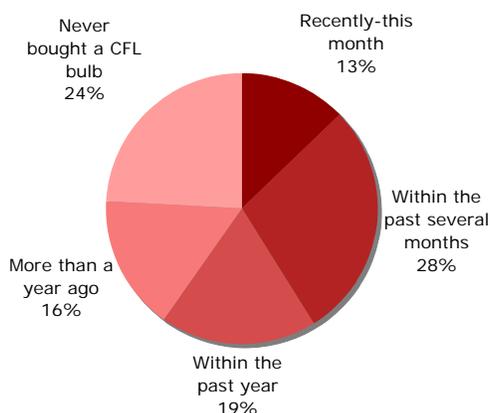
Consumer Purchasing Statistics

The following section explores data concerning recent consumer purchasing behaviors and future preferences. These findings can be used to develop more effective utility sponsored CFL programs and to assist with planning estimates. Specifically, two areas were explored: 1) recent purchasing behavior, and 2) purchasing preferences.

Recent Consumer Purchasing Behavior

Survey recipients were asked how recently they last purchased CFL bulbs, as a way to better understand the perspective from which respondents may have completed the survey. As Figure 4-27 shows, most (60%) purchased bulbs within the past year, while 24% indicated that they had never purchased a CFL bulb. Of this 24%, 79% reported a current installation of zero (0) CFL bulbs, 16% reported one to three (1-3) CFL bulbs installed, and 5% reported four or more (4+) CFL bulbs currently installed in their homes. On average, individuals reported they had purchased 5.47 CFL bulbs during their most recent purchase.

Figure 4-27: Most Recent Purchase of CFL Bulbs



Based on previous research (as shown in Section 2 of this report), it was expected that we would find higher levels of education and home ownership to be associated with recent CFL purchases. While education level does not seem to influence how recently CFL bulbs were purchased, as shown in Table 4-14 and Table 4-15, housing type and home ownership do influence how recently purchases were made. Home owners were more likely to have purchased a CFL recently and apartment or condo dwellers and renters were more likely to have never bought a CFL bulb.

Table 4-14: Most Recent CFL Bulb Purchase, by Housing Type

When did you last buy CFL bulbs?	Single Family, Detached	Apartment or Condo
Recently	16%	6%
Within the past several months	31%	24%
Within the past year	20%	15%
More than a year ago	16%	15%
Never bought a CFL bulb	18%	40%
All Respondents	65%	22%

Table 4-15: Most Recent CFL Bulb Purchase, by Housing Tenure

When did you last buy CFL bulbs?	Own or Buying	Rent or Leasing
Recently	14%	7%
Within the past several months	30%	22%
Within the past year	19%	18%
More than a year ago	16%	15%
Never bought a CFL bulb	19%	38%
All Respondents	75%	25%

Figure 4-28 and Figure 4-29 provide more details about consumer purchases. Here we find 93% respondents purchase CFL bulbs in the same county as their residence, which is important from a utility planning perspective. If individuals were purchasing CFL bulbs in counties other than where they live, utilities might not be able to attribute as much savings to their programs as they would if CFL bulbs were purchased and installed in their territory.

In addition, utilities are interested in knowing what percentage of CFL bulbs are installed in homes, installed at the purchaser’s work place, or stored for later use. Respondents reported that, on average, 62% of bulbs from their most recent purchase have been installed at home, 37% have been put in storage for later use, and 1% has been installed at their place of work. These numbers suggest that consumers may now be storing more bulbs than in the past, as Snohomish County PUD’s 2005 estimate put their customers’ storage rate at 25% (Snohomish County PUD 2006, p.8).

Figure 4-28: County of Most Recent CFL Bulb Purchase

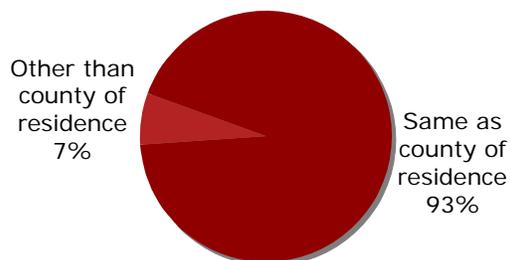
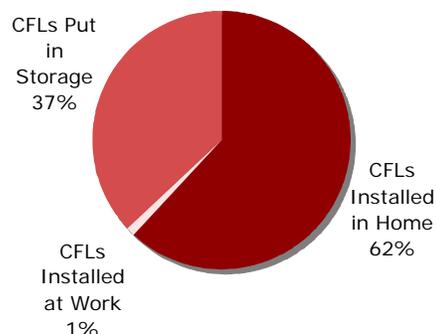


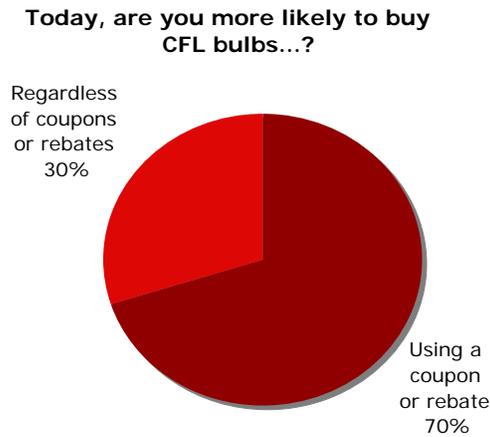
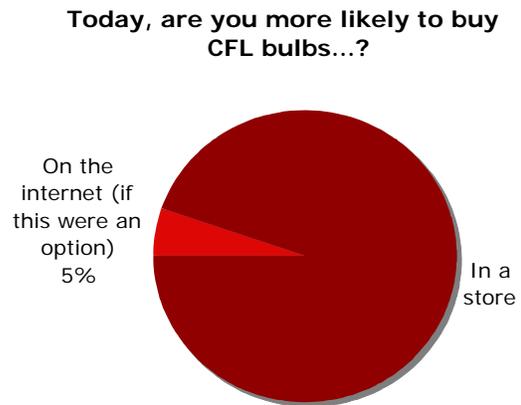
Figure 4-29: Placement of Most Recent CFL Bulbs Purchased



Purchasing Preferences

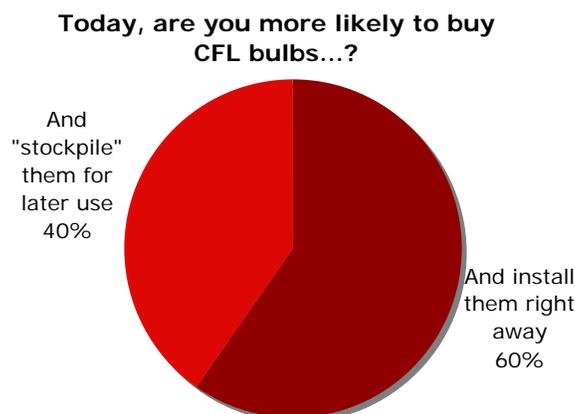
As shown in Figure 4-30, 70% of respondents indicated they would be more likely to purchase CFL bulbs using a coupon or rebate. Puget Sound Energy (73%) and Snohomish County PUD (74%) respondents were slightly more likely than Seattle City Light respondents (65%) to do so. Respondents indicating they would be more likely to purchase a CFL with a coupon or rebate were much more likely to have zero CFL bulbs (32%) than those indicating they would purchase them regardless of coupons or rebates (12%). Only small differences were seen among demographic variables and thus are not reported here. These findings suggest that coupon or rebate programs may help increase CFL saturation levels for both general residential customers and those who currently report having zero CFL bulbs installed.

Figure 4-31 explores the potential demand for purchasing CFL bulbs online. Nearly all of the respondents (95%) are more likely to purchase CFL bulbs in a store than online, suggesting that there is not a significant market for the utilities to sell CFL bulbs over the Internet. Respondents indicating they would be more likely to buy on the Internet were proportionately split among all three utilities and did not show any demographic differences from the rest of the population.

Figure 4-30: Likelihood to Purchase CFL Bulbs with Coupon or Rebate**Figure 4-31: Likelihood to Purchase CFL Bulbs on Internet or in Store**

A key question for utilities is whether or not CFL bulbs get installed immediately after purchase or become stockpiled for later use. This helps to determine when the savings related to their CFL programs may be actualized. Previous research has shown mixed findings, with one study by the Northwest Power and Conservation Council citing a study that found 80% of all CFL bulbs purchases were installed right away while another study (KEMA, 2005) found the opposite in that only 37% of respondents had instead all of the CFL bulbs they recently purchased. Figure 4-32 examines this issue and the data suggest that a substantial percentage of respondents (40%) are more likely to “stockpile” CFL bulbs for later use. This finding should be viewed in the context that currently, in the Puget Sound Area, many CFL bulbs are being sold in “multi-packs”, each containing a single variety of bulb.

Figure 4-32: Likelihood to Store or Install CFL Bulbs



Summary

This survey was designed to accomplish two primary objectives, for the Puget Sound area overall and for each utility service area:

- 1) To quantify standard (one-inch) screw-base sockets and the current placement of CFL bulbs, by room, fixture type, and control type; and
- 2) To quantify the saturation of CFL bulbs

The following summary presents the key findings of this study.

Individuals have difficulty accurately reporting number of lighting sockets and CFL bulbs installed. The in-home audits³¹ revealed a 41% under-reporting tendency, on average, among respondents with both sockets and CFL bulbs, which is consistent with the literature on self-report data that found 30% under-reporting when compared to on-site audit data. This inaccuracy of self-reports makes it challenging to determine how much technical potential exists in different types of homes across and within service territories. Still, given the relatively low saturation rate calculated from these self-report data, there appears to be a very large opportunity to install more CFL bulbs, especially within specific rooms of the house. Sector-wide estimates made from the self-report data likely provide conservative estimates of remaining potential for energy efficiency in residential lighting. Future information from on-site audits will help to form more precise estimates of saturation rates, technical and attainable potential.

Larger homes have more sockets and those sockets tend to be associated with surface mount or hanging fixtures controlled by on-off switches. A positive linear relationship exists between the number of sockets reported and the floor area of homes, which suggests that the technical potential for CFL bulbs varies widely across home sizes in the Puget Sound Area. Still,

³¹ While the in-home audits did reveal an average of 41% under-reporting tendency, only ten in-home audits were completed. Given this low number of audits, Seattle City Light is currently implementing this study as an in-home audit to determine the accuracy of this finding.

the range of average number of sockets per room was between 2.8 and 4.8. In addition, given that 80% of sockets are controlled by on-off switches, and 65% are controlled by on-off switches while being located elsewhere than in recessed cans, there may be an opportunity to introduce programs that focus on specialty bulbs, but this should not be the sole focus of utility programs.

CFL saturation levels varied widely among survey respondents. Saturation levels varied from 0-100%, with respondents reporting saturation levels at almost every point within this range. Among respondents, 29% reported zero installed CFL bulbs, thereby equating to a zero percent CFL saturation rate. These respondents were more likely to be renters and live in apartments or condos, although they do include home owners and single-family dwellings, as well.

High lighting energy usage areas do not equate to high saturation levels. This survey revealed that the greatest opportunity to install more CFL bulbs is in two of the highest lighting energy usage areas: bathrooms and dining room. Low saturation in bathrooms may be due to the presence of heat lamps, a larger number of multiple socket fixtures (e.g., vanity lights), or a need for specialty bulbs like globes; whereas dining rooms appear to require more specialty bulbs that can be controlled by dimmers.

All fixture types have similar and moderate CFL saturation levels. Surface mount and hanging fixtures had the lowest reported saturation at 18%, near the 19% household average. Table and floor lamps showed the highest saturation of CFL bulbs at 27%, with recessed cans showing 22% saturation. Surface mount and hanging fixtures reported the highest total number of CFL bulbs, which is simply due to the fact that the majority of sockets are located in these fixtures.

On average, every fixture, room, and household constitutes a significant opportunity for future CFL installations. Overall, on average, respondents indicated they would install 11 additional CFL bulbs across the household (i.e., attainable potential). Additionally, when examining the possibilities for new CFL bulbs based on respondent data, it appears there is a total technical potential of approximately 25 CFL bulbs. The average attainable potential for individual rooms varied from 0.7-1.5 additional CFL bulbs, with technical potentials varying from 2.4-4.0 additional bulbs. Data on surface mount and hanging fixtures indicate a remaining attainable potential of 8 additional CFL bulbs and a total technical potential of roughly 17 additional bulbs, while data on recessed cans and table and floor lamps showed remaining attainable potentials of 4 (recessed cans) and 2 (table and floor lamps) CFL bulbs and total technical potentials of 8 (recessed cans) and 4 (table and floor lamps) CFL bulbs.

Specialty bulbs could be installed in 20%-35% of sockets and potentially more.

Respondents reported that 20% of sockets were controlled by dimmer, sensor, or three-way switches, all of which require specialty CFL bulbs in order to function properly. This percentage is higher for some low saturation rooms, such as the dining room, in which respondents reported that 45% of all sockets are controlled by dimmer switches. Respondents also reported that 15% of all sockets are located in recessed can fixtures and controlled by on-off switches, indicating that the overall percentage of sockets requiring specialty bulbs may be around 35%. In addition, specific fixtures such as a vanity mirror in the bathroom or pendants in the dining room may also

require specialty bulbs for aesthetic reasons, though the number was difficult to determine from this survey.

Consumer purchasing behavior and patterns demonstrate clear direction for utility programs. Nearly three-quarters of respondents (70%) indicated they are more likely to purchase CFL bulbs if a coupon or rebate program were in place. The overwhelming majority (95%) of consumers currently prefer to purchase CFL bulbs in a store rather than online, and nearly all respondents (93%) purchase CFL bulbs in the same county as their residence. Consumers are both installing bulbs right away (60%) and storing bulbs for later use (40%), and those bulbs are primarily ending up being installed in the home (62%) rather than at work (1%).

5. DISCUSSION & RECOMMENDATIONS

Following are key recommendations based on the findings from this research for future utility planning and marketing efforts aimed at increasing CFL bulbs in the residential sector. These recommendations focus on targeting groups that are more likely to have zero CFL bulbs and increasing the number of CFL bulbs in market segments identified as having the greatest amount of potential. Taken together, these recommendations provide an approach on how to target areas of the market that are currently underserved and that hold the greatest potential for additional energy savings. Such an approach will help utilities more effectively meet their specific lighting and energy conservation goals and further increase the penetration³² and saturation³³ of compact fluorescent lighting in the Puget Sound Area.

Key Finding #1: Opportunity Exists for More CFL Installations

Data indicate that opportunities to install CFL bulbs exist in every area of the home and in each type of lighting fixture assessed through this survey. Additionally, CFL rebate and coupon programs are likely to increase customer willingness to purchase CFL bulbs.

Recommendation #1: Encourage installation of additional CFL bulbs throughout the house.

Data indicate that a significant amount of potential still exists across all rooms, fixtures, and segments of the population. Utilities should develop programs and marketing campaigns that encourage individuals to install additional CFL bulbs beyond those they already have in place or in new locations in the household. For example, utilities could develop a campaign encouraging their customers to install two or three additional bulbs in their homes and indicate the substantial environmental and economic benefits this would have for their service territory. Such a program would take advantage of the large amount of remaining potential reported by customers who indicated they already have CFL bulbs in place.

Recommendation #2: Continue to facilitate consumer purchases through utility CFL rebate and coupon programs. Of survey respondents, 70% indicated that they would be more likely to purchase CFL bulbs with a rebate or coupon. Utilities should continue their efforts in this area and, as will be discussed below, with a specific emphasis on traditionally low saturation groups such as renters and apartment or condo dwellers. .

Key Finding #2: CFL Programs Should Be Targeted

There were some key differences observed between home owners and renters and type of home, between different types of rooms and when looking at type of control for specific fixtures, all of which should be addressed when developing programs.

Recommendation #3: Develop a strategy that focuses on encouraging individuals in the multifamily sector to try CFL bulbs for the first time. Both renters and apartment or condo dwellers were identified as the only two groups being significantly more likely than the rest of the population to have zero CFL bulbs in place. Utilities should consider developing a program

³² Penetration is defined as “the number of homes that have at least one CFL installed.”

³³ Saturation is defined as “the percentage of lighting sockets in the average home that are filled with CFLs.”

that focuses on providing this market sector with incentives and education about energy efficient lighting as a way to increase the number of CFL bulbs installed.

Recommendation #4: *Promote the use of CFL bulbs in low saturation rooms.* Strikingly, while bathrooms and dining rooms are two of the highest energy usage areas in the home, these rooms were reported to have the lowest CFL saturation levels in the household. Marketing efforts that focus on education that specialty bulbs are available for these rooms may help increase saturation in these areas.

Recommendation #5: *Promote and provide information on all specialty bulbs currently available and continue efforts to promote development of specialty bulbs not yet available in the market.* Data suggest that specialty bulbs may be required for around 20%³⁴ to 35%³⁵ or more of all fixtures in the average household in the Puget Sound Area in order to work properly with lighting controls (i.e., dimmers, three-way switches, and sensors) or appropriately fill recessed cans. This number may be even higher when you take into account bulbs that are required for specific fixtures, such as candelabra bulbs for chandeliers and globe bulbs for bathroom vanities. This study found that there is tremendous opportunity to install more CFL bulbs in recessed cans, specifically encouraging the use of indoor reflector bulbs. In other type of fixtures that do not require specialty bulbs, some individuals may still be unwilling to install a standard twist or quad CFL and may instead prefer a less obvious CFL bulb, i.e., a specialty bulb. For these reasons, reflector bulbs for recessed cans should also be a key focus in any programmatic effort.

Utilities should promote messages through marketing materials and at local stores that inform customers about the availability of specialty bulb options and encourage individuals to consider them in their lighting purchases. As an example, bill inserts or point-of-purchase pamphlets may include images of globe style CFL bulbs installed in a bathroom vanity fixture or CFL bulbs in a pendant style fixture in the dining room.

However, there currently are several specialty bulbs that are needed but are not yet available in the market. In specific, there are currently few reliable products available to replace incandescent bulbs on standard dimmers, in chandeliers, and in other applications where point-source light is desirable. In these cases, utilities should continue or step up efforts to more vigorously work with all channels to offer, distribute and manufacturer the needed CFL bulbs. Utilities have had tremendous and demonstrated influence in other arenas (e.g., appliance standards) and have the ability, especially when they join forces with each other, to make more specialty bulbs available and thereby reduce energy usage in key areas of the home and fixtures.

Disseminate Research Findings

In addition, it is important with a study such as this that the sponsoring utilities disseminate the findings of this research broadly so that other organizations can benefit from this knowledge. These organizations may include the Northwest Power and Conservation Council, Bonneville

³⁴ If only sockets with dimmer, sensor, or 3-way controls are classified as those requiring specialty bulbs, the percentage of sockets requiring specialty bulbs is around 20%.

³⁵ If sockets with dimmer, sensor or 3-way controls *and* all sockets in recessed cans are classified as those requiring specialty bulbs, the percentage of sockets requiring specialty bulbs is around 35%.

Power Administration, Northwest Energy Efficiency Alliance, other regional utilities, the Regional Technical Forum, the American Council for an Energy Efficiency Economy, the Alliance to Save Energy, the Consortium for Energy Efficiency, The Energy Ideas Clearinghouse and other similar organizations. Sharing these findings can and should result in conversations regarding how best to estimate savings from CFL programs, how to define and measure “attainable” savings, and how to address CFL “stockpiling”. Puget Sound Area utilities may wish to join efforts to co-market CFL programs and marketing campaigns to achieve even greater impact with their conservation and energy efficiency dollars.

Continue to Measure CFL Saturation

This research effort was able to develop a baseline for CFL saturation in the Puget Sound Area. This baseline should be used to ground future studies that can assess how far the region has come with regard to residential CFL installations and whether future CFL programs are needed and in what form. It is recommended that the next study be performed two years from the beginning of this research effort (i.e., January, 2009). However, as this study found, to establish an accurate count of saturation and potential it will be important to explore using in-home audits as the primary data collection vehicle rather than mail-based surveys. Mail-based surveys and even telephone interviews, as others studies have shown, rely on self-report data, which is often grossly under- and over reported. Similarly, where utilities are already conducting residential in-home audits in other topical areas, they should strongly consider “tagging” this survey onto those data collection efforts.

Utilities should also consider conducting studies on regional residential lighting behavior to fill in gaps where information is inadequate and update previous research conducted in the past. There is a need to conduct current and thorough documentation of lighting usage in the Puget Sound region and the Pacific Northwest, as several studies with such information are now over ten years old (e.g., Tribwell and Lerman, 1996). Such current data would give the utilities a better resource to plan efficiency and conservation programs that reflect the present state of residential lighting rather than having to rely on old data.

6. STUDY LIMITATIONS

Great care was taken by the researchers involved in this study to account and mitigate for the various challenges they might face during the course of the study. A review of secondary research was conducted as a way to learn from previous studies what the likely limitations were for various data collection methodologies. A mail-based-survey expert was consulted in the development of the instrument, which resulted in several changes to the look and feel as well as content of the survey. Finally, researchers from five different utilities/organizations were involved in the design of the survey and the implementation process to ensure a quality survey with a high response rate and no response bias. Still, there are a few limitations of this study that pertain and are worth noting.

- **Representativeness of sample:** The study sample resulted in an older, better educated group more likely to be home owners, in comparison to the utility populations. These differences were statistically significant as well as practically significant. When using these data to inform programmatic decisions it will be important to recognize that younger, less educated individuals and renters may have different CFL bulb installation patterns as well as different perceptions about future CFL bulb installations.
- **Inaccuracy of self-report data:** The secondary data review revealed that self-report data on CFL bulb installations are likely to be inaccurate, and that our study might experience up to a 30% rate of under-reporting. Still, the research team moved forward with a self-report study rather than in-home audit, given budget and time limitations. As a result, this study attempted to thwart the possibility of under-reporting by providing a survey instrument with clear instructions and an easy to use form to count and record sockets and bulbs by fixture type. Ten in-home audits were conducted as a way to quickly assess the inaccuracy rate. Data revealed an under-reporting rate of 41% on both socket and CFL installed counts. One plausible explanation is that respondents may have been reporting at the fixture rather than the socket level; that is, a fixture may have three sockets but only one socket was counted. This may be due to respondents not knowing the fixture contains multiple sockets or to an oversight of this request. Still, only ten audits were completed, making this finding suspect. Seattle City Light is currently undergoing an in-home audit study that will use this survey instrument to collect further data on sockets and CFL bulbs, among those who responded to surveys and other homes not sampled for the current study.
- **Timing of survey implementation:** Time of year to implement a study such as this is important to consider, as it can impact positively or negatively the overall response rate and quality of responses received. The overall response rate to the survey was 22%. In comparison to typical mail-based surveys is fairly good and is higher, based on the complexity of the survey instrument, than the 10% estimate given by the expert mail-based survey individual consulted on this project. However, two of the participating utilities have had higher response rates in past surveys, in the 40-65% range. The original goal was to implement the current survey prior to the holiday seasons. However, survey development took longer than anticipated resulting in a pilot carried out in early January 2007, just after the serious winter storms and massive power outages experienced

throughout the Puget Sound. The pilot resulted in a lower than anticipated response rate for some of the utilities, which may have been due to customer perceptions about the utility's response during the power outage, rather than to the survey itself. The research team then hoped to implement the full survey in late winter while customers were still likely to be indoors and perhaps more likely to respond to such a survey. However, due to unforeseen circumstances with the mail house, the survey was not implemented until late spring/early summer. In the Puget Sound, late spring/early summer is generally when gardening and other outdoor activities begin, perhaps creating an environment in which individuals are less likely to respond to a survey about the interior of their home. So, while a response rate of 22% to a complex survey such as this is acceptable, the response rate may have been higher if implemented during a different time of year.

- **Absence of needed data:** To increase the overall response rate and quality of data received, the research team strove to keep the total number of data points sought to a reasonable level. At one time, there was an in-depth discussion regarding the need to gather data on bulb types by control types (for example, number of CFL bulbs on dimmers). However adding this level of detail significantly increased the complexity of the instrument and the research team agreed to omit it from this survey.
- **Type of incentive:** The type of incentive used in a study can positively or negatively impact the overall response rate. The survey expert recommended including a one dollar bill with each survey as a nominal token of appreciation. In previous research they found, in comparison to no incentive offer, incentives included with the survey that were greater than one dollar and incentives sent after a survey was completed, that the one dollar incentive included with the survey yielded the highest response rates. So as to not introduce a response bias to the survey, the research team determined it was best to keep the incentive the same across all utilities. Given limitations imposed on public utilities by the Washington State law on gifting of public funds, it was not possible to provide payment for work not yet completed, so including one dollar with the survey was not an option. It is difficult to ascertain whether a \$10 gift card had any influence on the response rate or introduced a response bias, but it would be important to explore the relative benefits of type of incentive in future studies

7. APPENDICES

DATA CLEANING PROCESS

The first step in the data analysis process was to identify and remove from the complete data set those surveys or sections of a survey considered to be “bad data”. A survey was considered “bad data” or unusable and was not included in the analysis if at least one of the following conditions were true:

- Total household CFL saturation was greater than 100% (n=51; Puget Sound Energy=23, Seattle City Light=12, Snohomish County PUD=16)
- Zero sockets were reported throughout the entire survey (n=19; Puget Sound Energy=5, Seattle City Light=3, Snohomish County PUD=11)
- Respondents reported they would install more CFL bulbs than there were sockets in the home if given the opportunity (n=59; Puget Sound Energy=19, Seattle City Light=26, Snohomish County PUD=14)

In all, 70 of the original 1558 surveys collected were considered “bad data” and were not included in the analysis. This represents approximately four percent of all returned surveys.

The majority of the data analysis was completed in SPSS with a small portion of tables and charts being constructed using Excel.

SECONDARY DATA REVIEW BIBLIOGRAPHY

Cape Light Compact *Annual Report on Energy Efficiency Activities*. (Massachusetts Department of Public Utilities and Massachusetts Division of Energy Resources, 2005).

Carlson, Leslie and John Mulligan. “Elements of Residential Efficient Lighting Savings.” In *Proceedings of the 1994 Summer Study on Energy Efficiency in Buildings*. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 1994).

Dethman, Linda; David Thomley and Denise Kivlen. *2005 Residential Customer Tracking Survey*. (Tacoma Power, 2006).

Du Pont, Peter and Felix Gooneratne. “Bulk Procurement vs. Market Channels: International Experience with the Promotion of Compact Fluorescent Lamps (CFL bulbs).” In *Proceedings of the 2006 Summer Study on Energy Efficiency in Buildings*. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 2006).

Duncan, Teri; Diane Ferington; Maric Sanders; and Ken Keating. “Savings with a Twist: Market Transformation and Acquisition Working Together (and Showing Both).” In *Proceedings of the*

2006 Summer Study on Energy Efficiency in Buildings. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 2006).

ECOS Consulting. *Puget Sound Energy Customer Lighting Survey*. Powerpoint presentation of key findings. (Presented to Puget Sound Energy, 2006).

Geller, Howard. *Policies and Programs for Increasing the Adoption of High-Efficiency Lighting in Homes in the Southwest*. (U.S. Department of Energy and the Midwest Research Institute, National Renewable Energy Laboratory Division, 2005).

Itron, Inc. *SDG&E Hard-to-Reach Lighting Turn-In Program*. (San Diego Gas & Electric, 2006).

JEM Energy, Inc. *Torchiere Lighting Market Baseline Assessment*. (JEM Energy, Inc., and B.C. Hydro, 2004).

Kates, Brad and Steve Bonnano. *Energy Efficient Lighting in the Residential Market*. Powerpoint presentation . (Presented, April 2005).

Kates, Brad; Jennifer Mitchell-Jackson; Lori Megdal; and Steve Bonanno. “Measuring the Success of CFL Energy Efficiency Programs: It’s the Saturation, Stupid.” In *Reducing Uncertainty Through Evaluation: Proceedings of the 2005 International Energy Program Evaluation Conference*, (New York, August 2005).

KEMA, Inc. *CFL Metering Study Final Report*. (Pacific Gas & Electric Company, Southern California, Edison Company, San Diego Gas & Electric Company, 2005).

KEMA, Inc. *ENERGY STAR® Consumer Products Program: Market Progress Evaluation Report (MPER 2)* (Northwest Energy Efficiency Alliance, Portland, Oregon, 2006).

Northwest Power and Conservation Council. *The Fifth Northwest Electric Power and Conservation Plan* (Northwest Power and Conservation Council, Portland, Oregon, 2005).

Rasmussen, Tami; Kathleen Gaffey and Rob Rubin. “Illuminating Current CFL Usage Patterns: Results from a CFL Metering Study.” In *Reducing Uncertainty Through Evaluation: Proceedings of the 2005 International Energy Program Evaluation Conference*, (New York, August 2005).

Rasmussen, Tami; Valy Goepfrich, and Karen Horkitz. “Drivers of CFL Purchase Behavior and Satisfaction: What Makes a Consumer Buy and Keep Buying?” In *Reducing Uncertainty Through Evaluation: Proceedings of the 2005 International Energy Program Evaluation Conference*, (New York, August 2005).

Ridge, Richard, Mike Rufo, Kathleen McElroy, Rob Rubin and Athena Besa. “The Use of Triangulation in the Measurement of Near-Term Market Effects: The Case of the California Residential Lighting and Appliance Program.” In *Proceedings of the 2000 Summer Study on*

Energy Efficiency in Buildings. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 2000).

RLW Analytics. *2005 California Statewide Lighting and Appliance Efficiency Saturation Study (CLASS)*. (San Diego Gas & Electric, 2005).

Rosenberg, Mitchell. “Measuring Spillover and Market Transformation Effects of Residential Lighting Programs.” In *Proceedings of the 1996 Summer Study on Energy Efficiency in Buildings*. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 1996).

Skumatz, Lisa and Owen Howlett. *Findings and “Gaps” in CFL Evaluation Research: Review of the Existing Literature*. (EEDAL Proceedings, 2006).

Snohomish County PUD. *Screw-Base Compact Fluorescent Lighting: Progress and Evaluation of the PUD’s Retail CFL Program*. (Snohomish County Public Utility District, 2006).

Tachibana, Debra-L.O. *Conservation Kit Program Evaluation. Transforming the Residential Use of Compact Fluorescent Lighting*. (Seattle City Light, 2003).

Tribwell, Lyle and David Lerman. “Baseline Residential Lighting Energy Use Study.” In *Proceedings of the 1996 Summer Study on Energy Efficiency in Buildings*. American Council for an Energy Efficient Economy, Washington DC (Pacific Grove CA, August 1996).

Vine, Edward and Diana Fielding. “An Evaluation of Residential CFL Hours-of-Use Methodologies and Estimates: Recommendations for Evaluators and Program Managers.” In *Reducing Uncertainty Through Evaluation: Proceedings of the 2005 International Energy Program Evaluation Conference*, (New York, August 2005).

Wiggins, Donald. “Cost-Effectiveness Analysis of Residential Compact Fluorescent Distribution Methods.” In *Energy Program Evaluation – Uses, Methods, and Results: Proceedings of the 1993 International Energy Program Evaluation Conference*, (Chicago, August 1993).

Wirtshafter, Robert M. and Jonathan Weiss. “How Many DSM Evaluators Does it Take to Screw in a Compact Fluorescent Lamp? A Summary of Residential Lighting Evaluation Methods.” In *Energy Program Evaluation – Uses, Methods, and Results: Proceedings of the 1993 International Energy Program Evaluation Conference*, (Chicago, August 1993).

COMPLETE TABLES AND FIGURES

See accompanying document.

SURVEY DOCUMENTS

See accompanying document.