SINGLE-FAMILY RESIDENTIAL NEW CONSTRUCTION CHARACTERISTICS AND PRACTICES STUDY

Final Report

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Executive Summary

Introduction

This document is the final report for the Residential New Construction Baseline Study. The study was sponsored by the Northwest Energy Efficiency Alliance, with additional sample points contributed by the Energy Trust of Oregon, Eugene Water and Electric Board, Tacoma Power, and Idaho Power. The study was conducted by RLW and Ecos Consulting. This is the second residential new construction study conducted by the Northwest Energy Efficiency Alliance (herein referred to as "NEEA"). The previous study was published in 2001.

This report characterizes single-family residential new construction using a representative sample of buildings constructed in 2004 and 2005. The multifamily new construction results are available in a separate report. The results of this study are expected to serve as a basis for planning, forecasting, and program development initiatives by various entities in the region. The results will provide a baseline for ENERGY STAR New Homes Northwest specifications.

Objectives of the Project

There are three primary objectives of this study:

> **Objective 1:** Develop a representative sample of newly constructed single-family and multifamily buildings in the states of Montana, Idaho, Washington and Oregon. Conduct on-site surveys to gather detailed characteristics on construction materials, appliances, equipment, lighting, duct performance and infiltration. The lighting, appliance, and equipment data are available online by means of a searchable database.
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> **Objective 2:** Analyze the saturation of high efficiency technologies in the new construction market place for both single-family and multifamily residences.
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> **Objective 3:** Analyze the energy use of the single-family and multifamily dwellings. The analysis will be supported by utility billing data collected for each sample point. This analysis will be performed later in 2007 and will be available on the NEEA website.

Approach

A sample of residential accounts was selected to represent new construction practices in the Pacific Northwest. The sample was proportionally allocated by 2004 Census new home permits by county within each of the four states. For the 2006 study, NEEA decided to look more comprehensively at appliances and lighting using onsite audits of *occupied* residences to gather information about the building. In order to obtain an accurate picture of appliance and lighting saturation, the homes needed to be fully occupied, which made it more difficult to obtain other characteristics such as accurate envelope data.

By comparison, the 2001 study focused on homes that were in the permitting stage, and not fully occupied, which limited the comparisons between the studies. The 2001 study data were gathered from building plans and builder interviews with limited audits. The

2001 residential new construction study was prepared by Ecotope and was called: "Baseline Characteristics of the Residential Sector: Idaho, Montana, Oregon and Washington." The 2001 report is used as a basis for comparison for this report where the different methodologies for data collection allow a comparison. The 2001 study focused on envelope characteristics, as well as heating, cooling, and water heating equipment, with a limited amount of appliance efficiency or lighting data gathered.

Customers were recruited to participate in the study by mail, and each participant was paid $25 for agreeing to allow an onsite surveyor to visit their home to gather the required information. A subset of participants were paid an additional $25 for allowing the surveyor to perform a more complete audit including home performance testing. The onsite survey was implemented using handheld personal digital assistants (PDAs) and an application for collecting the specified information. A total of 804 on-site surveys were completed (604 single-family and 200 multifamily) between October 2005 and June 2006. Of the 604 single-family homes, 264 were tested for duct leakage, infiltration, and system airflow.

While on site, the surveyors collected data on the major appliances in the home: Refrigerator-Freezers, Dishwashers, Clothes Washers, Clothes Dryers, Water Heaters, Heating Equipment, Spa/Pool Equipment, and Cooling Equipment. Data on thermostats, large appliances, and consumer electronics were also gathered. The surveyors collected lamp, fixture and wattage data for each lighting fixture within the home, as well as the front porch fixture. The surveyors also collected data on attic, floor and wall area, insulation R-values, wall construction, and window type, as well as demographic data.

The data underwent quality control measures and model numbers were matched to databases of appliance efficiencies. RLW used data sources from the California Energy Commission (CEC), the Air-Conditioning and Refrigeration Institute (ARI), Association of Home Appliance Manufacturers (AHAM), and more. Once the model numbers were linked, the corresponding efficiency was assigned to the matched appliance.

The appliance and equipment efficiency findings presented in this report do not account for degradation. Most appliances (if not all) have been shown to degrade over time, the result of which can affect performance and energy efficiency. The efficiency information presented in this report is based on manufacturer compliance testing of new products to federal appliance and equipment standards. Therefore, efficiency data presented in this report may not be representative of operating efficiencies since efficiency values are based on manufacturer tested performance. However, since these are new homes, degradation is not as likely to have as much impact on the efficiencies.

The analysis for lighting and appliances is summarized in this report at the regional level. Each site was given its appropriate case weight to project to the population or various subsections of the population. The report contains numerous data queries, which for the most part are summarized by efficiency, size, and capacity bins. The data and analysis queries developed for this project can be accessed by any user. The Pacific Northwest Residential Efficiency Saturation Tool (PNWRES^{EST}) allows users to explore this residential sector data in a myriad of ways that go well beyond what is presented in this "regional" report. The tool can be accessed at www.pnwresest.com.

Key Findings

In this section we summarize some of the more interesting findings occurring at the regional level. Findings are grouped by appliance and equipment type, lighting, and building characteristics. Readers can find additional information and details in the sections of the report that pertain to the topic of discussion in this section.

Lighting

The data collection parameters included a collection of fixture type, number of lamps, lamp technology type and lamp wattage (when accessible). All of the indoor lighting data were characterized by room type.

On average, homes have 49 fixtures and 77 lamps. Recessed cans account for 36% of all fixtures. Less than 20% of homes have a torchiere.

Fifty-two percent of all homes surveyed have one or more compact fluorescent lamps (CFLs) installed. Almost 8% of all lamps are CFLs. Of the numerous types of CFLs, spiral lamp styles are the most common. On average, 9% of all fixtures have at least one CFL. Although recessed can fixtures are the most common fixture type, floor lamps and torchieres are most likely to contain a CFL. The most common room types to have a CFL are family and living rooms and recreation rooms. About 22% of family rooms and living rooms and 20% of recreation rooms contain a CFL. The average wattage for incandescent A-type lamps is 64 watts, while the average wattage for spiral type CFLs is 17 watts.

General Characteristics

Sixty-three percent of the homes were two or more stories. Over 40% of the residences were occupied by two people. The average floor area for homes constructed in 2004 (2006 study) was 2,355, compared to 2,261 for homes constructed in 1998, or 4% higher.

Refrigerators

Data were gathered for primary, secondary, and tertiary refrigerators. The proportion of homes with a second refrigerator is 20%. The percentage of homes with three refrigerators is 2%.

The study found that 91% of primary refrigerators were reported to be less than six years old. Based on manufacturer data obtained through the model number matching process and during the on-sites, the overall average age of refrigerators is 2.5 years. This indicates the overwhelming majority of occupants purchased new refrigerators for their new homes.

The overall average nameplate unit energy consumption (UEC) for primary refrigerators is 625 kWh/year. Overall, 39% of all primary refrigerators qualify with the 2004 ENERGY STAR standards, while 56% of all refrigerators meet or exceed the 2001 ENERGY STAR standards. The average age of primary refrigerators was 2.5 years old which would mean many were manufactured before the 2004 standards were released.

As expected, secondary refrigerators are older and less efficient than primary refrigerators. The average age of secondary refrigerators is 8 years. In terms of nameplate UEC, the secondary refrigerators use 711 kWh/yr. On average, secondary refrigerators are 4 cubic feet smaller than primary refrigerators (24 vs. 20).

Clothes Washers

Approximately 99.8% of all newly constructed homes have a clothes washer. Thirty-six percent of all machines are horizontal-axis, 60% are top loading, 3% are stacked horizontal-axis, and 1% are unknown. Eighty-five percent of washing machines are less than six years old, while 95% are less than eleven years old. The average washing machine age is 3.5 years old.

In 2004 federal standards switched from rating clothes washer efficiencies from Energy Factor (EF) units to Modified Energy Factor (MEF) units. The average MEF for standard washing machines is 1.5, while horizontal-axis units have an average MEF of 1.8. These both meet the Energy Star 2004 standard of a minimum MEF of 1.42.

Clothes Dryers

Overall, almost all homes have a clothes dryer. As one would expect, this saturation estimate closely compares to the saturation of washing machines. Clothes dryer fuel types observed are 89% electric, 9% gas and less than 2% are propane. The average age of clothes dryers is 3.8 years old. ENERGY STAR does not label dryers because most use a similar amount of energy. Clothes dryer databases containing efficiency are limited.

Water Heaters

Data were gathered on many water heater characteristics, including system type, size, age, efficiency, fuel type, output, and insulation. The most common system type (78%) are gas storage systems. Electric storage is the next most common system with 13%, while propane storage accounts for nearly 5% of systems.

The average energy factor (EF) for 40 gallon gas water heaters (the most common type) is 0.58. This compares closely to the current federal standard for 40 gallon systems of 0.59. The average EF for electric water heaters is 0.90, which is consistent with the current federal standard for 50 gallon systems of 0.90.

Cooling Systems

Over half (58%) of all homes have some type of cooling system. The majority of cooling systems are central systems (98%). Split-system central air-conditioners are the most common AC type. Currently this system type represents 81% of all central cooling systems, while heat pumps comprise 14% of central systems, with the remainder made up by packaged systems. In the 2001 study, all states but Idaho had an average cooling equipment saturation of about 20%. Idaho had a significantly higher penetration, with nearly all homes in Boise with AC, and non-Boise areas at about 30%, resulting in a total cooling saturation of over 70% in Idaho. The overall cooling saturation in the region was about 30%. The penetration of AC systems has increased in all states since 2001.

The most common central air-conditioner size is the 3-ton category, 27%, and the next most common size is the 4 ton category. About 60% of all central air-conditioners fall within the 3-4.5 ton capacity range. Of the 370 central systems surveyed, 310 units were matched to an efficiency database to determine the Seasonal Energy Efficiency Rating (SEER). The findings show that 6% of all units are SEER 13 or greater. The majority of units, 82%, fell within the 10-10.99 SEER range, while 1% of all units were found to have a SEER rating of 9 or less.

Heating Systems

The study results show that 44% of homes have one heating system, 44% have two systems, and 12% have 3 systems or more. The most common heating system type is central system forced air furnaces (85%), followed by central heat pumps (8%). The primary heating fuel is natural gas (82.5%), followed by electric systems (13%). About 4.5% of primary heating systems are propane and another 0.1% are pellet stoves.

When comparing the 2006 to 2001 heating fuel type findings, the Idaho fuel saturations have stayed relatively stable. In 2006, all of the Montana homes were heated with gas, but in 2001 82% of the floor area was heated by gas. The electric heating saturation has increased slightly in Oregon, going from 6% to 17% with an error bound of 6% in 2006. The electric heating saturation has decreased slightly in Washington, from 21% to 16%, and gas saturation has increased from 68% to 77%.

The average Annual Fuel Utilization Efficiency (AFUE) for gas forced air heating systems is 83.2. Seventy-seven percent of all central systems fall between 78-85 AFUE and the remainder are between 90-96 AFUE. There is a noticeable trend toward higher efficiency heating units from the 2001 study to the 2006 study. Across all states, the average Annual Fuel Utilization Efficiency (AFUE) increased one to two percent.

Dishwashers

Only one home that we visited did not have a dishwasher. The average EF for dishwashers is 0.54, greater than the current federal energy standard (0.46), but less than the minimum ENERGY STAR qualification (0.58), which is set 25% higher than the federal standard. Of the dishwashers matched in our efficiency databases, 30.7% met or surpassed the Energy Star threshold, while all but 0.5% were better than the federal energy factor requirement.

Windows

The saturation of double pane, metal frame windows is 0.4%, while the remainder of homes have double pane, non-metal windows. The finding that window frame types are largely non-metal in all states in the region is similar to the 2001 study findings. Field surveyors carried low-e detectors for determining the presence of low-emissivity coatings. Overall, 89% of homes have low-e windows.

Infiltration

The qualifying infiltration rate for the Energy Star Homes Program in the Northwest is < 7 ACH50 for homes heated with gas furnaces/heat pumps and < 2.5 ACH50 for homes with zonal electric/propane/oil systems.

The homes in this study had an average ACH50 of 5.6 for central gas furnaces and heat pumps, less than the Energy Star Homes Program threshold. This finding suggests that new homes with central gas furnaces and heat pumps are being built slightly tighter than ESH requires. There were too few zonal systems in our data to compute an average ACH50.

System Airflow

The average overall fan airflow relative to system capacity for furnaces was found to be 15 CFM/kBTU of system *output.* The two heat pumps in the airflow test sample were dropped from the analysis. The 2001 California Residential Title-24 Manual uses 21.7 CFM/kBTU as a rule of thumb for default values for heating system airflow. The average system airflow that we measured in the four state region indicates that either the system ducts are undersized or the fans are undersized or underperforming.

The average measured fan airflow normalized to cooling capacity is 294 CFM/ton for the region. These averages are slightly low based on a nominal system design airflow of 400 CFM/ton, although this metric does not include air system leakage that would decrease the airflow measured by in-situ performance testing.

Duct Leakage

Duct leakage to outside the thermal envelope of the home is given as both a percentage of system fan flow and floor area. The Energy Star Home requirement for duct leakage is given as a maximum leakage per square foot of floor area. Leakage as a percentage of system fan flow is presented as well because it is also an accepted measurement of system performance. The overall average that the 2006 study measured for the region is 21% of total measured airflow and 15% of nominal airflow.

Overall Heat Loss

The overall heat loss (UA/sf) decreased in all states but Oregon, where it is very similar to 2001. Average U-values in all states exceeded code in walls. Floor U-values did not meet the minimum code requirements in Washington, Idaho and Montana. Window U-values were better than code in all states but Montana. In the 2001 study, Oregon was the only state to exceed code for walls, Washington was the only state to surpass code in floor, all but Washington met code for ceiling, and again all but Montana were better than code for windows.

The UA calculations are a major area in which the two study methodologies differed since the residences were completely occupied during the time of the RLW study and Ecotope had access to building plans and unfinished homes for the 2001 study. The 2006 study did not allow for RLW to obtain precise results for the U-value of the assemblies or the compliance path and the results should be used accordingly.

Study Limitations

The AC SEER value was obtained from efficiency databases based on the *condensing* unit model number. The databases that were used in the matching process use an average SEER value of common condenser/evaporator combinations, and therefore provide a relatively accurate representation of the efficiency of the systems observed.

Lamp wattage was difficult to collect in some circumstances. Approximately 6% of surveyed fixtures were inaccessible due to height, delicate fixture enclosures, or homeowner preference. RLW calculated the missing wattages based on average value in other homes with the same fixture type in the same room type.

The databases used for appliance matching are a study limitation. For example, dryer efficiencies were very difficult to match due to the lack of a comprehensive dryer efficiency database. The CEC has recently begun to compile a list of dryer efficiencies, but only 12% of the 762 dryers that we collected model numbers for were in the database. More discussion on the model number matching is in the Introduction.

None of the appliance efficiency databases (i.e., CEC, AHAM, ARI) used for efficiency matching account for efficiency degradation over time. Appliance efficiencies are based on the manufacturer test data at the time of manufacture.

The 2001 Ecotope study was used for comparison purposes where applicable; mainly in the building heat loss performance section. Though it is the most appropriate report for comparison, the two studies are dissimilar enough that a comparison of many tables is not possible, and the comparisons presented should be used with an understanding of the differences between the studies.

The 2001 study focused on the envelope characteristics, as well as heating, cooling, and water heating equipment, obtained from the builders and plans while the current study looks more comprehensively at appliances and lighting using onsite audits of *occupied* residences to gather information about the building. *The current study did not collect any information on code values or other compliance information from building departments.* Since the homes were completely finished and occupied, in many instances, the surveyors had to make assumptions about the insulation. In the previous study, the insulation and code values were on the plans that the contractors obtained. *This is a trade off in the type of data collected that was made during study planning and the envelope results and code values should be interpreted accordingly.*

Therefore, the tables in the insulation and building heat loss performance sections of this report contain RLW's best estimates of the insulation levels in homes. If the study's primary goal were to obtain envelope characteristics, then the study would have been performed on unoccupied, non-finished homes. RLW would also have attempted to obtain the plans for each home. However, obtaining the plans was never a part of this study since the envelope characteristics were not the main focus of the report.

The home characteristics that were comparable between the 2001 and the 2006 study were the heating, cooling, and water heating equipment, and envelope characteristics. RLW compared the differences in the 2001 and 2006 findings for heating fuel types, heating efficiencies, cooling saturation level, water heater fuel type, overall heat loss, U-value of envelope components, window frame, and wall framing types. These comparisons are found in the Single-Family Appliances and Building Characteristics chapter of this report in the relevant equipment or envelope characteristic section.

Introduction

This document is the final report for the Residential New Construction Baseline Study. The study was sponsored by the Northwest Energy Efficiency Alliance, with additional sample points contributed by the Energy Trust of Oregon, Eugene Water and Electric Board, Tacoma Power, and Idaho Power. The study was conducted by RLW Analytics, Inc. and Ecos Consulting. This is the second residential new construction study in a series of similar studies conducted by the Northwest Energy Efficiency Alliance (herein referred to as "NEEA").

The report characterizes single-family residential new construction using a representative sample of buildings constructed in 2004 and 2005. The results of this study are expected to serve as a basis for planning, forecasting, and program development initiatives by various entities in the region. The results will provide a baseline for ENERGY STAR New Homes Northwest specifications.

Objectives of the Project

There are three primary objectives of this study:

> **Objective 1:** Develop a representative sample of newly constructed single-family and multifamily buildings in the states of Montana, Idaho, Washington and Oregon. Conduct on-site surveys to gather detailed characteristics on construction materials, appliances, equipment, lighting, duct performance and infiltration, the results of which are comparable to the previous baseline study.
>
> **Objective 2:** Analyze the saturation of high efficiency technologies in the new construction market place for both single-family and multifamily residences.
>
> **Objective 3:** Analyze the energy use of the single-family and multifamily dwellings. The analysis will be supported by utility billing data collected for each sample point. Gas and electric data will be weather normalized and summarized at a high level and compared to other regions of the US.

Approach

An evenly distributed sample of residential accounts was selected to represent new construction practices in the Pacific Northwest. The sample was proportionally allocated by 2004 Census new home permits by county within each of the four states. Customers were recruited to participate in the study by mail, and each participant was paid $25 for agreeing to allow an on-site surveyor to visit their home to gather the required information. The on-site survey was implemented using IPAQ hand held personal digital assistants (PDA) and a specially designed application for collecting the specified information. This approach provided fast and cost effective on-site data collection. A total of 804 on-site surveys were completed (604 single-family and 200 multifamily) between October 2005 and June 2006. A subset of 264 single-family homes were tested for duct leakage, infiltration, and system airflow.

While on-site, the surveyors collected data on the major appliances and lighting systems in the home. The surveyors collected nameplate data for the following appliances:

- Refrigerator-Freezer
- Dishwashers
- Clothes Washers and Dryers
- Water Heaters
- Heating Equipment
- Cooling Equipment
- Pool and Spa Equipment
- Large appliances
- Plug Loads
- Thermostats

For lighting, the surveyors collected lamp, fixture and wattage data for each lighting fixture within the home, as well as the front porch fixture. The on-site surveyors also collected data on attic, floor and wall area, insulation R-values, wall construction, and window type. The survey also included a brief set of demographic and socioeconomic questions.

As the data were collected, the surveyors uploaded the site data from the PDA units to RLW's SQL database. The data underwent quality control measures and model numbers were matched to databases of appliance efficiencies. RLW used databases from the previous study, in addition to new data sources, including CEC, ARI, AHAM, and more. Once the model numbers were linked, the corresponding efficiency was assigned to the matched appliance. Matching rates varied greatly by appliance type and age. In most cases this was due to the comprehensiveness of the efficiency databases that were available for each appliance.

Table 1 presents each appliance for which we collected data in 2005-06 *for both single-family and multifamily units*. The tables contain the following data in the same column order as listed below:

- Name of appliance,
- Number of each appliance found during all on-site visits,
- Number of model numbers found for each appliance,
- Percentage of model numbers that surveyors were **able** to identify on-site,
- Number of model numbers matched to efficiency database(s),
- Percentage of model numbers matched among **all** appliances recorded,
- Percentage of model numbers matched among appliances with model numbers.

For example, we recorded the presence of 954 refrigerators. During the on-site surveys, the surveyors were able to locate model numbers for 915 of those refrigerators, or 96% of all refrigerators.

When the data were aggregated at RLW's offices and linked to the refrigerator efficiency databases, only 702 of the 915 (77%) refrigerators with model numbers were matched. Another way to look at the match rate is to consider the percentage of the *total* number of refrigerators (954) that were successfully matched (702), which for refrigerators was 74%. This statistic combines the success rate of the matching with the success of the auditors in collecting model numbers. A high match rate among the units with model numbers collected is less meaningful if the auditors were only able to collect data on a handful of units.

Appliance/ Equipment	Total Number in Database (A)	Model Numbers Found (B)	% of Appliances with Model Number (B/A)	Model Numbers Matched (C)	% of All Appliances Matched (C/A)	% of Appliances with Model Numbers Matched (C/B)
Cooling	490	435	89%	352	72%	**81%**
Refrigerator	954	915	96%	702	74%	**77%**
Water Heat	833	780	94%	499	60%	**64%**
Washer	770	714	93%	308	40%	**43%**
Dishwasher	801	784	98%	280	35%	**36%**
Dryer	776	762	98%	93	12%	**12%**
Heating System Fuel	**Total Systems**	**Model Numbers Known**	**% of Systems with Model Number**	**Total Matched and Known Efficiency**	**% of All Appliances Matched**	**% of Systems with Model Numbers Matched**
Electric	497	348	70%	357	72%	**103%**
Gas	902	759	84%	623	69%	**82%**
Wood	23	23	100%	23	100%	**100%**
Propane	61	44	72%	39	64%	**89%**
Pellets	1	-	0%	-	0%	**0%**
Total Heating	1,484	1,174	79%	1,042	70%	**89%**

Table 1: Model Number Match Rates by Appliance

Based upon our experience from previous studies, we anticipated in the design stages of this project that the match rates would approximate what are shown in the table above. We knew that matching model numbers to appliance databases would be a long process. One of the problems is that wildcards (*, /, #, etc.) are often included in the model number. The wildcards add to the complexity of the query designs and decrease match rates. The "layered" queries that we built searched several databases for matching model numbers. Once the automated process was complete, a manual process of looking up the unmatched appliances was undertaken.

Efficiency databases were exhausted using the above protocols for matching appliances. RLW is confident that the great majority of model numbers found on-site were matched if they appeared in any of the efficiency databases. The problem with the low matching rates lies in the efficiency databases themselves. Simply put, much of the equipment found in the field is not documented in publicly or privately available efficiency databases. Furthermore, the private data such as the refrigerator-freezer data that were purchased from AHAM were not in the best condition, and somewhat partial in content.

The analyses of lighting and appliances summarized in this report are at the regional level. Each site was given its appropriate sampling weight to project to the population or various subsections of the population. Analysis queries were written in MS Access and processed using RLW's Model Based Statistical Sampling (MBSS) software. The report contains numerous data queries, which for the most part are summarized by age bins, efficiency bins, size bins and capacity bins.

The data and analysis queries developed for this project can be accessed by any user wishing to do so. As a product of this study, RLW developed a Web-based analytical tool that gives users the ability to "slice and dice" the data from the 2000 and 2005 studies. The Pacific Northwest Residential Efficiency Saturation Tool (PNWRES^{EST}) allows users to explore this residential sector data in a myriad of ways that go well beyond what is presented in this "regional" report. The tool can be accessed at www.pnwresest.com.

Study Limitations

For the most part, all of the data the study aimed to collect through the on-site surveys were easily obtained. It should be noted that the SEER value was obtained from the various efficiency databases based on the model number of the condensing unit. The evaporator coil has an impact on the overall SEER of the system, but gathering information on the evaporator coil involves additional effort on the part of both the surveyor and especially the analyst, as there is no available database that caters to the large scale matching of condenser and evaporator units. However, the databases that were used in the matching process use an average SEER value of common condenser/evaporator combinations, and therefore provide a relatively accurate representation of the efficiency of the cooling systems observed.

Wattage was difficult to collect in some circumstances. Although surveyors were trained to remove luminaire covers if easily reachable and removable, approximately 6% of surveyed fixtures were inaccessible due to height, delicate fixture enclosures, or homeowner preference. For these lamps with unknown wattages, RLW calculated the missing wattages based on average value in other homes with the same fixture type in the same room type.

Field personnel also reported pool and spa information for pumps and heaters to be difficult to access and difficult to locate nameplate data. Compounded by the low overall saturation of homes with pools, limited information was obtained for these particular data points.

Comprehensiveness is a limitation with regard to the databases used for appliance matching. For example, field staff were able to obtain 784 of 801 dishwasher model numbers, yet through the matching process RLW was only able to match 36%, or 280 models, to databases. Dryer efficiencies were very difficult to match due to the lack of a comprehensive dryer efficiency database. The CEC has recently begun to compile a list of dryer efficiencies for newer models, but only 12% of the 762 dryers that we collected model numbers for were in the database. More detailed findings are presented on the model number matching process in Table 1.

None of the appliance efficiency databases (i.e., CEC, AHAM, ARI) used for efficiency matching account for efficiency degradation over time. Appliance efficiencies are based on the manufacturer test data at the time of manufacture. However, over time appliances and equipment do degrade due to various factors that can affect operational performance. Considering this, the efficiencies of matched appliances, particularly of older appliances, are more than likely less efficient than what has been reported here since no attempt has been made to adjust for efficiency degradation. Degradation is less of a factor for cooling, water heating, dishwashers, and other systems installed during home construction for new residences. However, this does factor into efficiencies of appliances such as refrigerators and washers, which are oftentimes brought from previous residences.

The "Baseline Characteristics of the Residential Sector: Idaho, Montana, Oregon and Washington" study prepared by Ecotope in December, 2001 was used for comparison purposes where applicable; mainly in the building heat loss performance section. Though it is the most appropriate report for comparison, the two studies are dissimilar enough that a comparison of many tables is not possible, and the comparisons presented should be used with an understanding of the differences between the studies.

The 2001 study presents data that was gathered from building plans and builder interviews, while the current study used on-site audits of *occupied* residences to gather as much information about the building and appliance characteristics *as possible*. The RLW surveyors faced many obstacles when trying to determine insulation levels for each assembly since the homes were completely finished and occupied. In many instances, the surveyors had to make assumptions about the levels of insulation, whereas in the previous study, the insulation and code values were on the plans that the contractors obtained.

The 2001 study focused on the envelope characteristics, as well as heating, cooling, and water heating equipment, with a limited amount of appliance efficiency or lighting data presented. The RLW study aimed to be more comprehensive with regards to appliances and lighting. To obtain an accurate picture of appliance and lighting saturation, the homes needed to be fully occupied, which made it more difficult to obtain accurate envelope data.

For example, the size of wall cavities is fairly easy to observe, but physically observing the insulation to determine the R-value of the insulation inside the cavity is not easily done in such a manner that the homeowner and budget constraints are satisfied. This is also the case with vaulted ceilings and floor insulation.

Information collected in the RLW study such as dishwasher, clothes washers and dryers, consumer electronics, lighting, functional testing, and other large appliances have no comparison, as these were not included in the 2001 report.

Therefore, these tables in the insulation and building heat loss performance sections of this report contain RLW's best estimates of the insulation levels in homes, however it must be acknowledged that if the study's primary goal were to obtain envelope characteristics, then the study would have been performed on unoccupied, non-finished homes. RLW would also have attempted to obtain the plans for each home. However, obtaining the plans was never a part of this study since the envelope characteristics were not the main focus of the report.

Finally, the 2001 study had the primary goal of developing balanced sample frames across each state in order to develop a representative random sample of each state. This strategy allowed for a comparison between the states and provided a higher level of precision for each state. The primary goal of the current study is to provide the best representation of the four-state *region as a whole.* To achieve this goal, a proportional allocation of the sample across the region was selected and comparisons across the states are less precise.

Sample Design

The 2004 Census housing permit counts by county were used to allocate the sample. This section discusses the single-family sample design. The sample was designed at the region level in order to achieve an error bound of +/-5% at the 95% level of confidence.

RLW and NEEA originally contracted to complete 400 single-family audits. RLW originally planned to perform testing at 25% of the 400 single-family home audits as part of the NEEA contract, for a total of 100 single-family enhanced sites. RLW calculated the allocation of the sample by state as shown below. Washington has almost 48% of the permits, followed by Oregon with 28%, Idaho with 20% and Montana with 4.5%.

State	Permits	Proportion	n	n with tests
Idaho	15,331	20.1%	80	20
Montana	3,425	4.5%	18	4
Oregon	21,094	27.6%	111	28
Washington	36,489	47.8%	191	48
Total	**76,339**	**100%**	**400**	**100**

Table 2: Original Planned Sample by State

The county sample size was computed as follows:

$$\text{County Sample Size} = \left(\frac{\text{County units permitted}}{\text{Total units permitted in 4 States}} \right) \times \text{Desired Sample Size}$$

After the original NEEA contract was signed, the Energy Trust of Oregon, Eugene Water and Electric Board, Tacoma Power, and Idaho Power provided additional funding to increase the total number of single-family audit sites to 604 and the subset of single-family enhanced sites to 264.

Contracts	ID		MT		OR		WA		Total Sites
	Audit Only	Tests	Audit Only	Tests	Audit Only	Tests	Audit Only	Tests	
Original Alliance sample	60	20	14	4	83	28	143	48	400
Energy Trust additions					-47	97			50
EWEB additions					20				20
Idaho Power additions	75	25							100
Tacoma Power							-8	42	34
Total Sites	**135**	**45**	**14**	**4**	**56**	**125**	**135**	**90**	**604**

Table 3: Added Sample Points by Contract

State	Audit Only	Tests	Total Sites
ID	135	45	180
MT	14	4	18
OR	56	125	181
WA	135	90	225
Total Sites	**340**	**264**	**604**

Table 4: Final Planned Sample by State

RLW stratified the sample into three groups of counties:

- Counties with at least 0.6% of the total units permitted in the region *(Group 1)*
- Counties with less than 0.6% of the permits, but at least 250 permits (*Rural A*)
- Counties with less than 250 permits (*Rural B*)

RLW planned to sample homes in each of the group 1 counties. All counties in rural groups A and B were aggregated and one county from each group was selected for sampling. The number of sample sites allocated to the rural groups was in proportion to the sum of the units in each of the counties in these groups.

Table 5 shows the final sample by state. The final sample sizes are very close to the planned sample.

State	Permits	Planned Sample	Actual Sample
ID	15,331	180	179
MT	3,425	18	18
OR	21,094	181	178
WA	36,489	225	229
Region	**76,339**	**604**	**604**

Table 5: Final Sample by State

Table 6 shows the final sample, along with the weight associated with each county with sample points. For many counties, the final sample size is identical to the original sample design. In some cases, we had to revise the sampling plan slightly due to difficulty in scheduling appointments in some counties.

State	Group	County	Permits	Planned Sample	Actual Sample	Weight
Idaho	Group 1	Ada	5,204	95	91	57.19
	Group 1	Canyon	2,349	42	42	55.93
	Group 1	Kootenai	2,090	11	11	190.00
	Group 1	Bonneville	1,093	6	6	182.17
	Group 1	Twin Falls	660	3	3	220.00
	Rural A	*Bannock*	*1,353*	*7*	*7*	*193.29*
	Rural B	*Gem*	*2,582*	*16*	*19*	*135.89*
Idaho Total			*15,331*	*180*	*179*	
Montana	Group 1	Gallatin	1,321	7	7	188.71
	Group 1	Yellowstone	594	3	3	198.00
	Rural A	*Missoula*	*789*	*4*	*4*	*197.25*
	Rural B	*Lewis & Clark*	*721*	*4*	*4*	*180.25*
Montana Total			*3,425*	*18*	*18*	
Oregon	Group 1	Washington	3,377	32	33	102.33
	Group 1	Deschutes	3,196	30	29	110.21
	Group 1	Clackamas	1,971	18	19	103.74
	Group 1	Jackson	1,791	17	16	111.94
	Group 1	Multnomah	1,567	15	18	87.06
	Group 1	Marion	1,556	8	11	141.45
	Group 1	Lane	1,350	27	29	46.55
	Group 1	Linn	1,023	4	4	255.67
	Group 1	Douglas **692		4		
	Group 1	Yamhill	910	4	4	227.42
	Group 1	Josephine	866	3	5	173.13
	Rural A	*Polk*	*2,219*	*12*	*6*	*369.83*
	Rural B	*Umatilla*	*1,269*	*7.0*	*2*	*317.25*
	Rural B	*Morrow*			*2*	*317.25*
Oregon Total			*21,094*	*181*	*178*	
Washington	Group 1	King	6,947	36	41	169.44
	Group 1	Snohomish	4,921	26	28	175.75
	Group 1	Pierce	4,466	57	56	79.75
	Group 1	Clark	3,276	17	19	172.42
	Group 1	Spokane	2,108	11	11	191.64
	Group 1	Thurston	2,099	11	11	190.82
	Group 1	Whatcom	1,647	8	9	183.00
	Group 1	Kitsap	1,308	7	9	145.33
	Group 1	Benton	1,113	6	10	111.30
	Group 1	Franklin	1,104	6	4	276.00
	Group 1	Skagit	770	4	4	192.50
	Group 1	Yakima	759	4	4	189.75
	Group 1	Island	698	4	4	174.50
	Group 1	Clallam	573	3	2	286.50
	Group 1	Mason	508	3	3	169.33
	Group 1	Kittitas **461		2		
	Rural A	*Chelan*	*2,482*	*11*	*1*	*206.83*
	Rural A	*Cowlitz*			*2*	*206.83*
	Rural A	*Lewis*			*9*	*206.83*
	Rural B	*Walla Walla*	*1,710*	*9*	*2*	*855.00*
Washington Total			*36,489*	*225*	*229*	

Table 6: Final Sample and Case Weights by County

Figure 1 through Figure 4 detail the site locations of the regional sample by state. Each tack represents an address where a house was surveyed.

Figure 1: Idaho Final Sample Location

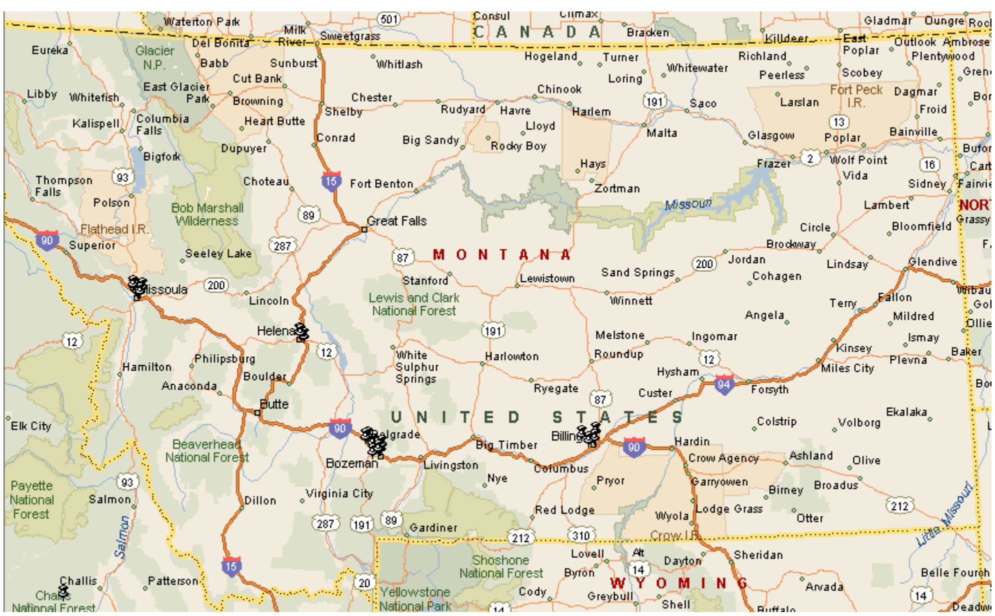

Figure 2: Montana Final Sample Location

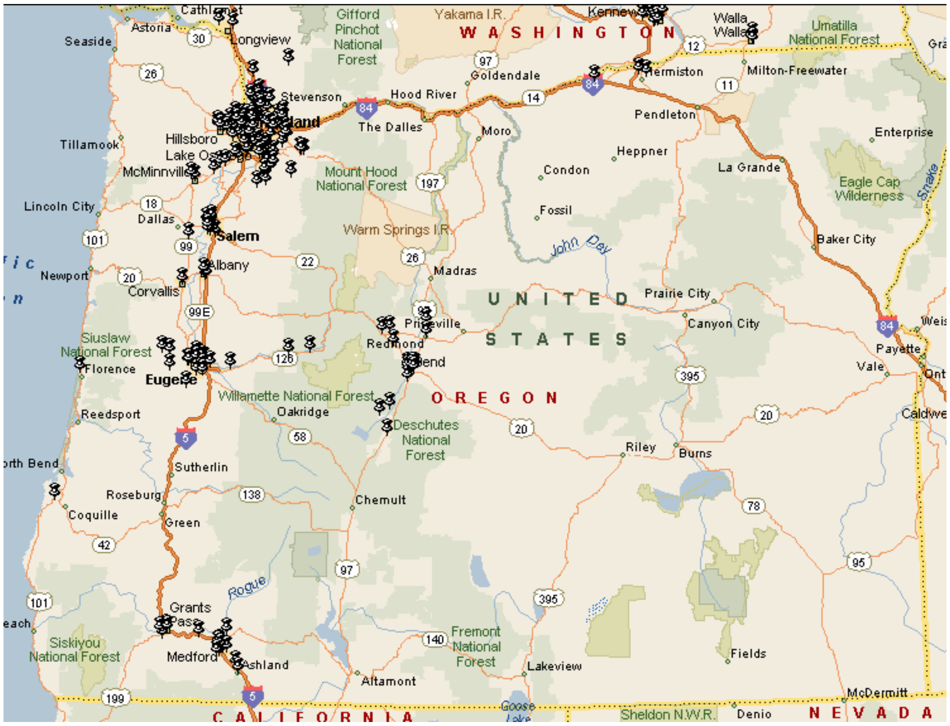

Figure 3: Oregon Final Sample Location

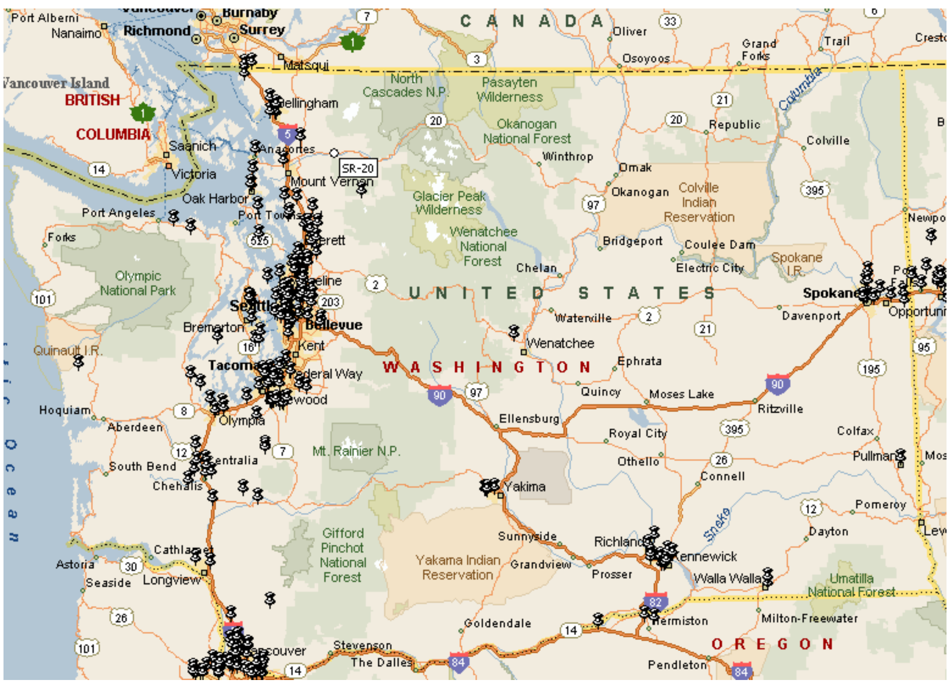

Figure 4: Washington Final Sample Location

Data Collection

RLW performed 604 single-family on-sites and 200 multifamily tenant on-sites. A subset of 264 single-family sites received additional function testing of infiltration, system airflow, and duct leakage.

Figure 5 shows the number of completed sites by month.

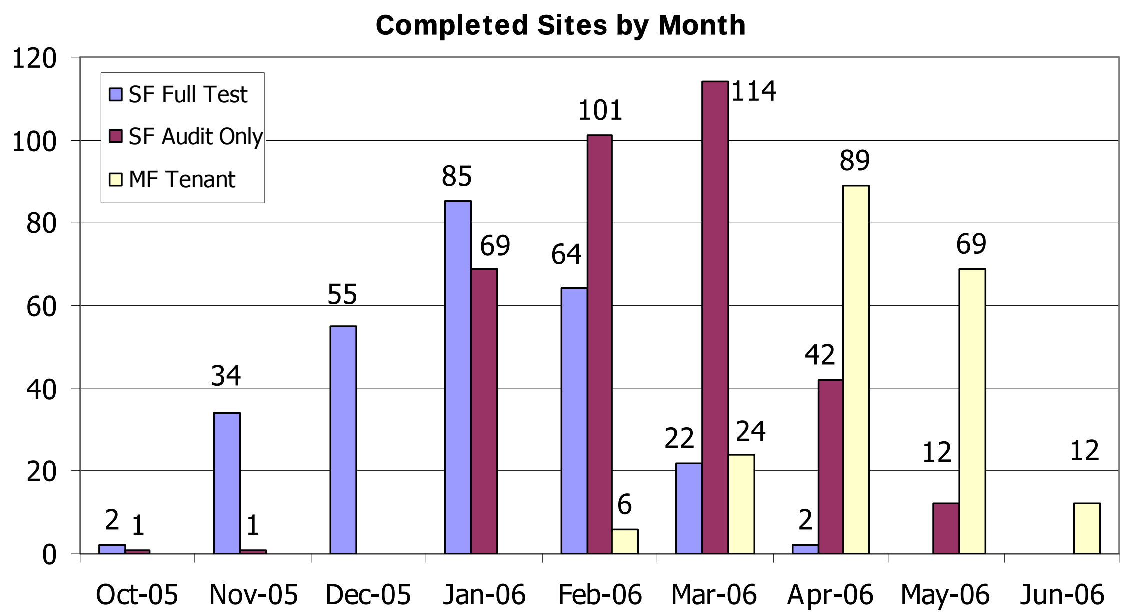

Figure 5: On-sites by Month of Completion

Recruiting

RLW recruiters began the recruiting process by obtaining the final count of sites that needed to be recruited within each county from the sample design. They were also provided a prioritized list of addresses to recruit for the sample by the analysis team. With this list they performed the following tasks:

- Performed reverse address search to obtain occupant name and phone numbers,
- Sent a letter to each residence,
- Fielded any incoming phone calls regarding the study and recruited residents into the study,
- Called residents that did not respond to initial letter (for those where RLW found phone numbers),
- Scheduled appointments,
- Coordinated appointments with auditors,
- Entered data into recruiting database.

These tasks are described below.

Instruments

RLW developed all recruiting instruments that were used in the project. Two main recruitment instruments were used in this study:

- the study introduction and recruitment letter, and
- the telephone recruitment instrument.

Customer Names and Phone Numbers

RLW obtained contact names and numbers for sampled customers from other data sources since the F.W. Dodge data being used for the sample design did not include phone numbers, only addresses. In order for RLW to send letters and telephone each of the sampled residences, we searched for the current occupant's phone number using reverse address lookup using sites such as: www.reverseaddress.com, www.superpages.com and www.switchboard.com. Although, these sites can be helpful, they are not updated frequently enough to have a large percentage of phone numbers for new construction. If we could not identify a customer's name for an address, we sent the letter to 'Current Resident'. Customer letters were mailed and telephone recruiting began shortly thereafter, once we had exhausted all of our sources for phone number lookups.

Customer Letter

The study introduction letter informed residents that they had been randomly selected to participate in a study, why the study was being conducted, how they could participate, and what was involved if they chose to participate. The content of the letter was carefully crafted to clearly convey the purpose of the study and why it was important that they participate with the ultimate goal of improving participation rates, thereby reducing non-response bias. The study achieved a 7.5% overall response rate as a result of the mail recruiting. We provided a toll free number to call if the resident had further questions, or if they were interested in participating. We also included a postage paid postcard that they returned to RLW to express their interest in participating. We initially anticipated a response rate of approximately 4% from the letters, but as mentioned above, the rate was much higher.

On-site Surveys

Surveyor Training

RLW conducted a one-day training session for each auditor before on-site work began. In addition, each surveyor received a Training Material packet for reference in the field. The information packet and training session covered the following topics:

- The purpose of the project,
- The procedure for verifying the site visit with the homeowner,
- The importance of being on time and courteous,
- The protocols for dealing with unanticipated problems,
- The procedure during the survey,
- The best methods of collecting and recording the information,
- How to operate and collect the data using the hand-held,
- The procedure for transferring on-site data to master database, and
- Any other relevant topics.

Ecos Consulting completed the bulk of the on-site surveys in Oregon, and a portion of the on-sites in Washington. Roger Jorstad Construction completed the majority of the on-sites in Idaho. Employees of Tacoma Power performed site visits and additional testing for sites within Tacoma Power territory. RLW Analytics field staff surveyed the remainder of the sites and performed a large number of the functional tests. Approximately 20 surveyors completed the 804 required on-site surveys.

Four training sessions were held, one in Portland for the Ecos surveyors, one in Tacoma for Tacoma Power employees, another in Sonoma for the RLW surveyors, and one in Idaho for Roger Jorstad.

Quality Control

Senior level staff at both RLW and Ecos were available to auditors on a daily basis to answer questions and maintain quality control. Senior staff reviewed random samples of uploaded survey data, held conference calls with all surveyors to discuss unforeseen issues that arose, and provided guidance and training on project efficiency. The field supervisors reported to the RLW Project Manager regularly so that all parties were familiar with current findings and activities.

Fieldwork

The trained auditors conducted the on-site audits according to the schedule set by the recruiter. The PDA application was designed to automatically sync with the recruiting database and download all appointments for the auditor. The daily downloads provided the auditor with every piece of information they needed to conduct the on-site, including special notes provided by the recruiter, directions, and of course customer name, address, and appointment information.

Each on-site visit consisted of two elements: the customer interview and the walk-through inventory. First, the auditor conducted the interview with the occupants to address demographic and behavioral factors. Next, the auditor conducted the walk-through audit of the home and recorded the lighting and appliance data into the hand-held.

Pilot Activities

The RLW/Ecos team piloted the single-family and surveys before the holiday season to streamline the recruiting and field work process so that we could ramp up dramatically after the holidays. A discussion of issues raised from the on-sites was held to resolve problems and streamline the remaining on-site surveys.

All Data Collected

1. Envelope
    a. Windows
        i. Number of panes
        ii. Frame type
        iii. Low-E (RLW uses low-e detectors on all sites)
        iv. Window area
    b. Walls
        i. Framing type
        ii. Insulation R-value
        iii. Wall area
    c. Roof/attic

            i. Insulation R-value
            ii. Radiant barrier
            iii. Attic/vaulted area
    d. Basement
        i. Basement wall R-value
        ii. Basement wall area
        iii. Finished/Unfinished
        iv. Conditioned/Unconditioned
    e. Thermostat(s)
        i. Type
        ii. Temperature set-points

2. Detailed data on heating and cooling systems, primary, secondary, tertiary, etc.
    a. Central or Space
    b. System type (e.g., heat pump, electric resistance, forced-air, etc.)
    c. Fuel
    d. Make and model number
    e. Capacity
    f. Manufactured date
    g. Owner reported age
    h. Usage
3. Detailed data on refrigerator, primary, secondary, tertiary, etc.
    a. System type (e.g., standard, side by side, bottom freezer, etc.)
    b. Make and model number
    c. Options (ice maker, water, combo, none)
    d. Size
    e. Manufactured date
    f. Owner reported age
    g. Usage (other than primary)
4. Water heater
    a. System type (e.g., storage, tankless, heat pump, etc.)
    b. Fuel (gas, electric, solar assisted)
    c. Make and model number
    d. Size (gallons)
    e. Capacity (input BTU-h or kW)
    f. Manufactured date
    g. Owner reported age
    h. Energy Factor (if possible)
5. Dishwasher
    a. Make and model number
    b. Capacity
    c. Manufactured date
    d. Owner reported age

6. Clothes Washer
    a. System type (e.g., h-axis, standard)
    b. Make and model number
    c. Manufactured date
    d. Owner reported age
    e. Energy Factor (if possible)
    f. Usage
7. Clothes Dryer
    a. Make and model number
    b. Fuel type
    c. Usage
    d. Manufactured date
    e. Owner reported age
8. Lighting
    a. Fixture type by room (e.g., ceiling mounted, wall mounted, recessed can, etc.)
    b. Number of lamps per fixture
    c. Lamp technology type by fixture
    d. Lamp wattage
    e. Control type (e.g., switch, dimmer, occupancy sensor, etc.)
9. Pool and spa
    a. Fuel type
10. Other appliances (e.g., TV, microwave, computer, consumer electronics, etc.)
    a. Quantity

Functional Testing

Originally twenty-five percent of the single-family homes surveyed were intended to included functional testing of the HVAC ducting system, including airflow and leakage, and infiltration testing using a blower door, but as other utilities expanded the sample, 264 of the 604 single-family homes (43.7%) were tested. Our approach to conducting these tests is described in further detail in the remainder of this section. In general, the test procedures followed the guidelines for performance testing developed by the Regional Technical Forum (RTF), which are also referenced as Performance Tested Comfort Systems (PTCS)[1].

Duct leakage testing: To measure the HVAC system duct leakage, a Minneapolis Duct Blaster® was used. The Minneapolis Duct Blaster® measures the amount of leakage in the duct system by pressurizing the ducts with a calibrated fan and simultaneously measures the air flow through the fan. The duct blaster fan is connected directly to the duct system in a house, typically at a central return, or at the air handler cabinet. The remaining registers and grilles are taped off. The duct system is then pressurized to 25 Pa and duct system leakage is measured using a digital pressure gauge. The test is done in order to measure duct leakage to outside the thermal

[1]The Energy Star Homes Northwest program utilizes these same performance test procedures.

envelope, as opposed to total duct leakage, which includes leakage inside the thermal envelope of the home.

Airflow testing: To measure air flow of residential air handlers, a TrueFlow® air handler flow meter was used. The flow meter measures air flow from the system fan by an orifice metering plate that is installed in a filter slot as close to the air handler blower as possible. Most residential systems have a filter slot at the return grille or a filter slot built into the blower compartment directly upstream of the blower. The metering plate can be installed in either of these locations. If there are multiple returns then a metering plate needs to be installed at each one. Once the metering plate is in place, the system fan is turned on and the entering air velocity and the exiting air velocity through the metering plate are measured to obtain fan air flow using a digital differential pressure gauge.

Infiltration testing: To measure the infiltration of a home we used the Minneapolis blower door ™. The Minneapolis blower door ™ uses a fan and frame assembly that is temporarily sealed into an exterior doorway. The testing is performed at a pressure difference of 50 Pa (0.2 inches of water column) to create a slight pressure difference between the inside and outside. By measuring the air flow that is required to maintain 50 Pa, the air tightness of the house can be gauged. Again, RLW measured infiltration using a digital pressure gauge.

Appliances

Data were collected for heating systems, cooling systems, washing machines, clothes dryers, dishwashers, pools and spas, refrigerator/freezers, and water heaters. Data were also collected on plug loads, other large end uses, and thermostats.

- The residents were asked for the age of each appliance. If the resident did not know the age of the appliance, the surveyor would estimate the age or the appliance whenever possible.
- The classification of each appliance by type was observed from visual inspections of the appliances and recorded. Appliance types that were noted include; standard or horizontal axis washers, side-by-side, freezer on bottom, freezer on top or other refrigerator types, among others.
- Fuel types, such as electricity, natural gas or propane for heating systems, clothes dryers and water heaters were noted from visual inspection.
- The manufacturer, model number and size were taken from nameplate data when observable. If possible, sizes of some appliances were estimated in the case of missing, or unreadable data tags.
- Residents were asked to estimate the percentage of time in use for refrigerators and freezers to establish seasonal usage.
- Various features relating to energy efficiency were noted such as the existence of a through the door water dispenser for refrigerator-freezers or insulation levels for water heaters.

Lighting

Every lighting fixture in each residence was inventoried by fixture type, number of lamps, lamp type, and lamp wattage. Fixture control type was also noted for all fixtures in this study.

Insulation

The insulation levels of the floor, walls and attic were obtained by visual inspection if possible. Efforts were made to estimate the insulation levels through discussions with the residents and based on educated judgment (i.e. wall construction 2x4, 2x6, etc.) when no visual observations were possible.

Windows

The surveyor recorded the predominant window frame construction, wood, metal or vinyl, found in the home was noted, as was the number of panes found of the predominant window type. Low-e detectors were used to determine whether the window had a low-e glazing.

Final Databases

The data collected during the 804 on-site visits are contained in six final databases. One database contains all appliance and envelope information for single-family residences; another contains all the single-family lighting information. Two identical databases contain the multifamily data. The fifth database contains the single-family testing data, and the final database contains the multifamily common area data.

These databases are in MS Access format. In addition to the surveyor information collected on site, the appliance database contains all information linked from the efficiency databases that pertains to the appliance models in the sample, and contains the efficiency categories that were created in order to analyze the data.

The appendix contains a description of the databases and the steps taken to prepare the databases for analysis and delivery as well as a complete description of each table and query.

Merging of Saturation and Efficiency Information

The surveyors were able to observe make and model number on-site, but in most cases, not energy efficiency. The RLW team used all available resources to match the model numbers collected on-site with a reliable source of efficiency ratings and/or Unit Energy Consumption (UEC). Sources that were used included:

- 2005 California Energy Commission Database of Energy Efficient Appliances,
- 2004 Federal Trade Commission (FTC) databases,
- 2003 AHAM Refrigeration database,
- 2003 Carriers Electronic Blue Book of Heating and Cooling Equipment, and
- 2000 ARI HVAC database.

RLW matched the on-site information by model number with standard efficiency ratings for each end-use. For example, in the case of residential cooling, the energy efficiency rating is provided in SEER, or Seasonal Energy Efficiency Ratio units. End-uses that do not have an associated standard efficiency rating (e.g., refrigerators) are characterized in terms of nameplate annual unit energy consumption or UEC.

The difficulty in matching model numbers should not be underestimated by anyone wishing to conduct this type of study in the future. RLW invested a lot of time manually linking sites, as a result of model number wildcards and irregular alphanumeric characters such as dashes, hyphens, slashes, stars, and other text. These characters made automated matching difficult and resulted in a more rigorous model number matching effort.

Database Summarization Tool (PNWRES^{EST})

The project will deliver a tool that can be used by program designers, managers, evaluators, and other parties for understanding efficiency and saturation characteristics of Pacific Northwest residences. RLW will use a web-based application that allows multiple users to apply stratified ratio estimation methods to the study data. The application was originally designed for the California Lighting and Appliance Saturation Study and has the ability to:

- Calculate ratio estimates, (e.g., of the saturation level of a set of appliances), classified by any available categorical variable such as age of home, residence type, or state.
- Calculate the underlying sample sizes
- Calculate the appropriate model-based error bounds
- Calculate proportions (e.g., proportion of all cooling units that are space vs. central)

The resulting tables can be easily exported to Excel and displayed graphically. The software provided is fully documented in the Appendix, and a help file is available within the software if the user encounters any problems.

The following is a list of some examples of the types of weighted statistics that can be obtained from the database:

- Average Efficiency of primary HVAC and other equipment
- Percentage of Homes with two or three refrigerators
- Average Energy Usage or Wattage of Equipment

This type of information can be developed for all sites, or for various classifications of residences. Using the standard queries that we provide in the database, the sites can be classified by any combination of the following variables:

- State
- Type of Residence
- Size of Household (Total People or Total Adults)
- Square Footage
- Household Income
- Year Built
- Rent or Own

Few of the results provided in this report are grouped by the aforementioned demographic data. The intent of the study was to collect the data, build a database of information, and provide the interested parties with a tool that could be used to analyze the data. Given this, only top-level analyses were conducted for reporting purposes.

However, where the data were thought to differ drastically by the demographics of the household, the data were grouped by the appropriate characteristic.

PNWRES^{EST} Interface

By providing a web-based analysis tool, users have the power to explore the information based on specific needs. This section discusses the technical specifications of PNWRES^{EST}, the Pacific Northwest Residential Efficiency Saturation Tool, to be located at www.pnwresest.com. Once at the site, users can gain access to the full report and user help screens for understanding how to use PNWRES^{EST}.

Users are required to register, for free, in order to access the tool. Registration is an automated process whereby once the user provides their pertinent contact information and valid email address, a unique 8 character password is generated and automatically sent to the user via email. PNWRES^{EST} is a direct port of RLW's MBSS software application. Originally developed in Fortran, MBSS was later reprogrammed in Microsoft Visual Basic in order to support a 32 Bit operating system environment. For the web based tool, all the proprietary algorithms, code and queries were rewritten in CFScript (ColdFusions server-side implementation of Java style classes). This allows the tool to not only process requests more efficiently, but to also be scalable across multiple servers and operating systems.

Single-Family Demographics

A list of demographic data was developed by the study team to be collected by the field surveyors. The following demographic data were collected:

- Type of residence
- Number of residents by age
- Total annual income for the home
- Year residence was built
- Total heated floor space of the home
- Whether the residence is rented or owner occupied
- If rented, the party responsible for the utility bills, (owner or renter)

The remainder of this section contains tables that summarize the demographic characteristics of the sample. These results have not been weighted to reflect the population.

Table 7 shows the percentage of homes by type of residence. Approximately 60% of all the residences are single-family, unattached, 2-story dwellings. The second most commonly visited type of residence was single-family, unattached, 1 story housing, totaling 35.7% of the sample.

Type of Residence	% of Homes
Single Family Unattached (1 story)	35.7%
Single Family Unattached (2 stories)	60.0%
Single Family Unattached (3 or more stories)	3.1%
Single Family Attached	1.1%

Table 7: Percentage of Homes by Type of Residence

Table 8 shows the percentage of homes by number of people occupying the home. The largest percentage of homes, or 40.6%, has 2 occupants. However, it was also common to visit homes with 1, 3, or 4 occupants.

Total Number of People	% of Homes
1	9.8%
2	40.6%
3	17.3%
4	20.0%
5	7.1%
6	4.2%
7	0.7%
8	0.3%
> 8	0.1%

Table 8: Percentage of Homes by Number of People

Table 9 shows the percentage of homes by number of adults occupying the home. Not surprisingly, over three fourth of all homes, or 78.3%, have 2 adults present.

Total Adults in Home	% of Homes
1	13.0%
2	78.3%
3	5.7%
4	2.6%
5	0.3%
> 5	0.1%

Table 9: Percentage of Homes by Number of Adults

Table 10 shows the percentage of homes by total household income. The largest percentage of residents has an annual income between $50,001 and $75,000, totaling 21.2% of the sample.

Total Household Income	% of Homes
<$25,000	3.3%
$25,000-$50,000	19.6%
$50,001-$75,000	21.2%
$75,001-$100,000	12.6%
>$100,000	20.3%
Refused	22.9%

Table 10: Percentage of Homes by Total Household Income

Table 11 shows the percentage of homes by age of home. As can be seen from the table, most homes were built in either 2004 or 2005.

Year Home Built	% of Homes
2003	0.6%
2004	46.8%
2005	51.2%
2006	1.3%

Table 11: Percentage of Homes by Age Range of Home

Table 12 shows the percentage of homes by the total heated floor space of the homes. There were very few homes less than 1,000 SQFT. The homes were generally evenly distributed across the other listed categories.

Total Heated Floorspace	% of Homes
600 to 999 sq.ft.	0.3%
1,000 to 1,599 sq.ft.	18.9%
1,600 to 1,999 sq.ft.	21.6%
2,000 to 2,399 sq.ft.	16.7%
2,400 to 2,999 sq.ft.	21.5%
3,000 or more sq.ft.	20.9%

Table 12: Percentage of Homes by Total Heated Floor Space

Table 13 shows a trend of larger homes built across the region. Every state shows an increase, with the overall increase in the Pacific Northwest of approximately 125 square feet of conditioned floor area.

State	2001 Study		2006 Study	
	Average Floor Area	n	Average Floor Area	n
Idaho	1,941	104	2,165	179
Montana	2,504	61	2,509	18
Oregon (1999)	2,370	80	2,435	178
Oregon (1994)	2,056	283		
Washington	2,259	157	2,375	229
Total	2,261	366	2,355	604

Table 13: Comparison of Average Home Heated Floor Area

Table 14 shows the percentage of homes by type of ownership. Nearly 97.5% of homes were occupied by owners. Renters constituted roughly 2.5% of the sample.

Rent or Own	% of Homes
Own	97.5%
Rent	2.5%

Table 14: Percentage of Homes by Ownership Type

Single-Family Lighting

This section of this chapter presents findings from the lighting analysis. Recall that every lighting fixture in each residence was inventoried by fixture type, fixture control type, number of lamps, lamp type, and lamp wattage. A total of 604 residences are included in the lighting analysis. This chapter of the report is broken up into the following three subsections that present the analyses shown below:

- Lighting Overview (by home)
    - number of fixtures and lamps per home,
    - average number of lamps per fixture,
    - percentage of homes having a certain fixture or lamp type[2],
    - prevalence of compact fluorescent lamps,
    - lamp wattage, and
    - fixture control types
- Specific Fixture Overviews (by home)
    - summary of recessed cans, torchieres, and ceiling fans
    - these fixtures were selected for further analysis because efficient lighting technologies are currently being developed for these fixture types
- Room Lighting Analysis (by room)
    - percentage of rooms with fixture types and lamp types

Throughout the lighting analysis, the room type "other" is given as a category of room. The Other room type is includes attics, bars, exercise rooms, music rooms, sewing rooms, as well as pool houses.

Lighting Overview

Table 15 presents the average number of fixtures and lamps per home by type of residence. Overall, homes have approximately 49 fixtures and 77 lamps on average.

[2] For a complete list and definition of lamp and fixture types refer to the Appendix.

Type of Residence	Fixtures		Lamps		Sample Size
	Average #	EB	Average #	EB	
Overall	48.94	2.13	77.09	2.72	604
Single Family Unattached (1 story)	42.76	2.88	68.39	3.96	206
Single Family Unattached (2 stories)	52.15	2.94	81.83	3.60	375
Single Family Unattached (3 or more stories)	65.46	11.09	96.85	14.14	15
Single Family Attached	27.45	2.53	45.48	2.29	8

Table 15: Average Number of Fixtures/Lamps by Type of Residence

Table 16 displays the average number of fixtures per home by fixture type. The most common fixture types by a large margin are recessed cans and ceiling mount fixtures, with homes having an average of 17.4 recessed cans and 12.3 ceiling mount fixtures. Also, homes have on average, 7 wall mount fixtures and 3.7 table lamps. Table 16 also tells us that homes average over one ceiling fan with lights.

Fixture Type	Average # of Fixtures (n=604)	EB
All Fixture Types	48.94	2.13
Architectually Integrated	0.37	0.08
Ceiling Fan	1.16	0.12
Ceiling Fixtures	12.32	0.63
Chandelier Hanging	2.63	0.17
Floor Lamp	0.86	0.08
Garage Door Opener	0.97	0.06
Other	0.27	0.11
Recessed Can	17.42	1.50
Recessed Lighting-Other	0.80	0.30
Table lamps	3.74	0.25
Torchiere	0.26	0.05
Track Lighting	0.19	0.06
Under Counter	0.99	0.15
Wall Mount	6.96	0.36

Table 16: Average Number of Fixtures by Fixture Type

Table 17 presents the percentage of all fixtures that are of a certain type. Over 35% of all fixtures are recessed cans, while 25% are ceiling mounts. Additionally, wall mounted fixtures account for about 14%, while table lamps are nearly 8%.

Fixture Type	Percent of Total Fixtures (n=604)	EB
All Fixture Types	**100.0%**	
Architectually Integrated	0.8%	0.2%
Ceiling Fan	2.4%	0.3%
Ceiling Fixtures	25.2%	1.3%
Chandelier Hanging	5.4%	0.3%
Floor Lamp	1.8%	0.2%
Garage Door Opener	2.0%	0.1%
Other	0.6%	0.2%
Recessed Can	35.6%	1.8%
Recessed Lighting Other	1.6%	0.6%
Table Lamps	7.6%	0.6%
Torchiere	0.5%	0.1%
Track Lighting	0.4%	0.1%
Under Counter	2.0%	0.3%
Wall mount	14.2%	0.6%

Table 17: Percentage Fixture Types

Table 18 displays the percentage of homes having each fixture type. Approximately 53% of homes have a ceiling fan. Nearly all homes, 99.5%, have ceiling mounted fixtures. About 94% of homes have recessed cans. Nearly 99% of homes have wall mount fixtures. Almost 92% of all homes are equipped with a ceiling mounted fixture, while over 86% of homes have a table lamp.

Fixture Type	Percent of Homes (n=604)	EB
Architectually Integrated	15.6%	3.1%
Ceiling Fan	52.6%	3.9%
Ceiling Fixtures	99.5%	0.5%
Chandelier Hanging	91.7%	2.1%
Floor Lamp	51.2%	3.9%
Garage Door Opener	72.9%	3.4%
Other	8.9%	2.5%
Recessed Can	94.1%	1.7%
Recessed Lighting Other	25.9%	3.4%
Table Lamps	86.4%	3.0%
Torchiere	18.2%	3.2%
Track Lighting	7.6%	2.1%
Under Counter	37.4%	3.8%
Wall Mount	98.8%	0.9%

Table 18: Percentage of Homes with Fixture Types

Table 19 shows the distribution of the number of fixtures per home. Over one-third of homes have a total of greater than 50 fixtures. Approximately 25% of homes have more than 31-40 fixtures present. No homes have less than 10 fixtures.

Number of Fixtures	Percent of Homes (n=604)	EB
1 to 10	-	-
11 to 20	2.9%	1.4%
21 to 30	18.9%	2.9%
31 to 40	25.1%	3.3%
41 to 50	17.1%	2.8%
>50	36.0%	3.9%

Table 19: Distribution of Number of Fixtures per Home

Table 20 presents the distribution of the number of fixtures per home by residence type.

Type of Residence	1 - 10 Fixtures		11 - 20 Fixtures		21 - 30 Fixtures		31 - 40 Fixtures		41 - 50 Fixtures		> 50 Fixtures		Sample Size
	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	
Overall	-	-	2.9%	1.4%	18.9%	2.9%	25.1%	3.3%	17.1%	2.8%	36.0%	3.9%	604
Single Family Unattached (1 story)	-	-	5.1%	3.2%	27.3%	5.8%	26.8%	5.5%	15.1%	4.6%	25.7%	5.6%	206
Single Family Unattached (2 stories)	-	-	1.6%	1.4%	13.7%	3.1%	24.6%	4.1%	18.9%	3.7%	41.3%	5.2%	375
Single Family Unattached (3 or more stories)	-	-	-	-	-	-	22.9%	23.3%	11.7%	13.3%	65.3%	23.7%	15
Single Family Attached	-	-	12.0%	18.6%	81.3%	21.1%	6.7%	11.0%	-	-	-	-	8

Table 20: Distribution of Number of Fixtures per Home by Residence Type

Table 21 displays the percentage of fixtures containing a CFL by fixture type. Over 9% of fixtures contain a compact fluorescent lamp. Torchieres and floor lamps are most likely to contain CFLs, with about 20% of both torchieres and floor lamps having such a lamp. Approximately 13% of table lamps have a CFL installed, and 10.6% of all recessed can fixtures have CFLs, which is impressive as recessed cans are the most common fixture type.

Fixture Type	Percent Fixtures with CFL	EB	Sample Size (# Homes)
Overall	9.2%	2.6%	604
Architectually Integrated	2.0%	2.3%	88
Ceiling Fan	5.5%	2.2%	339
Chandelier Hanging	6.1%	2.0%	556
Ceiling Fixtures	8.5%	2.3%	601
Floor Lamp	19.9%	5.0%	314
Garage Door Opener	2.8%	1.5%	442
Other	5.4%	5.9%	66
Recessed Can	10.6%	4.8%	569
Recessed Lighting-Other	3.0%	3.3%	135
Table Lamps	12.8%	3.0%	526
Torchiere	20.3%	9.1%	99
Track Lighting	2.6%	3.9%	41
Under Counter	3.7%	2.6%	203
Wall Mount	8.0%	2.5%	596

Table 21: Fixtures Containing Compact Fluorescent Lamps

Table 22 shows the average number of lamps per fixture by fixture type. Chandeliers/Hanging fixtures contain more lamps (3.56 lamps) than any other fixture type. Ceiling fans contain 2.79 lamps on average. Recessed cans, table lamps, and torchieres contain the fewest number of lamps, with each of these fixtures containing approximately one lamp on average.

Fixture Type	Lamps per Fixture		
	Average	EB	Sample Size (# Homes)
Architectually Integrated	1.50	0.21	88
Ceiling Fan	2.79	0.12	339
Ceiling Fixtures	1.73	0.03	601
Chandelier Hanging	3.56	0.17	556
Floor Lamp	1.48	0.09	314
Garage Door Opener	1.35	0.05	442
Recessed Can	1.00	0.00	569
Recessed Lighting-Other	1.05	0.03	135
Table Lamps	1.12	0.02	526
Torchiere	1.09	0.05	99
Track Lighting	2.74	0.50	41
Under Counter	1.57	0.14	203
Wall Mount	2.12	0.06	596

Table 22: Average Number of Lamps per Fixture

Table 23 presents the average number of lamps per home by general lamp type. Overall, homes have 77.09 lamps on average. Incandescent lamps are the most prevalent throughout the Pacific Northwest, with an average home having 61.97 incandescent lamps.

Lamp Type	Average # of Lamps (n = 604)
All Lamp Types	77.09
Compact Fluorescent Total	6.03
Fluorescent Total	3.98
Halogen Total	5.11
Incandescent Total	61.97

Table 23: Average Number of Lamps by Lamp Type

The June 2006 EnergyStar® Consumer Products Program Market Progress Evaluation Report by Kema (E06-156) presents some information on lighting that can be compared to these results. The average number of CFLs purchased per household increased from 6 to 9 CFLs from 2004 to 2005.

Table 24 shows the percentage of all lamps by general lamp type. Over 80% of all lamps are incandescent lamps.

Lamp Type	Percent of Total Lamps (n=604)
Compact Fluorescent Total	7.8%
Fluorescent Total	5.2%
Halogen Total	6.6%
Incandescent Total	80.4%

Table 24: Percentage Lamp Types

Table 25 shows the percentage of homes where a particular lamp type is present. All homes are equipped with at least one incandescent lamp, while almost half have at least one halogen lamp. Fifty-two percent of all homes contain at least one type of CFL. Less than 50% of homes contain fluorescent lamps.

Lamp Type	Percent of Homes (n=604)	EB
Compact Fluorescent Total	52.0%	3.9%
Fluorescent Total	46.4%	3.9%
Halogen Total	53.1%	3.9%
Incandescent Total	99.8%	0.4%

Table 25: Percentages of Homes with Lamp Types

In the EnergyStar® Consumer Products Program MPER referenced above, Kema found that the percent of consumers who have ever purchased a CFL was 58 percent. Over half (57%) of consumers say they will buy CFLs next year.

Location of CFLs – The most common room types to have a CFL are family and living rooms and recreation rooms. About 22% of family rooms and living rooms and 20% of recreation rooms contain a CFL.

Laundry rooms, basements, and closets are less likely to have CFLs, possibly because those rooms are less frequently used. Table 27 summarizes the proportion of rooms with CFLs.

Room	%	EB	Sample Size
Family Room	22.4%	5.9%	278
Living Room	21.5%	3.8%	512
Rec Room	19.4%	8.2%	141
Bedroom-Master	16.2%	2.8%	604
Office	15.2%	3.7%	328
Garage	14.8%	3.3%	543
Bathroom-3	14.4%	7.7%	88
Bedroom-1	13.0%	3.1%	554
Bedroom-2	12.8%	2.9%	473
Porch	12.2%	3.2%	527
Hall	11.9%	2.5%	598
Bedroom-3	11.9%	4.4%	208
Other	11.6%	4.5%	180
Kitchen	11.5%	2.5%	598
Dining Room	10.0%	2.7%	479
Breakfast Nook	9.8%	3.8%	194
Closet	9.2%	2.5%	510
Bathroom-Master	8.7%	2.2%	604
Bedroom-4	8.4%	7.8%	50
Bathroom-2	8.3%	2.9%	355
Laundry Room	8.0%	2.3%	546
Basement	6.3%	7.1%	35
Bathroom-1	6.2%	2.0%	569
Bathroom-4	-	-	1

Table 26: Percent of Rooms with CFL

Table 27 displays the distribution of the number of lamps per home. Over 30% of homes have 41 to 60 lamps. Furthermore, 27% of homes contain 61 to 80 lamps. Nearly 20% have greater than 100 lamps. This finding combined with findings about the number of fixtures per home suggests that most homes are equipped with fixtures containing more than one lamp.

Number of Lamps	Percentage of Homes (n = 604)	EB
1 to 20	-	-
21 to 40	6.8%	2.1%
41 to 60	30.2%	3.4%
61 to 80	27.1%	3.3%
81 to 100	16.9%	3.1%
>100	19.0%	3.3%

Table 27: Distribution of Number of Lamps per Home

Table 28 presents the distribution of the number of lamps per home by residence type. No residence has less than 20 lamps, and less than 7% have less than 41 lamps. More than 40% of all single-family, unattached homes, that were two stories, have 81 or greater lamps. As one would expect, the larger the home, the more lamps there are. Of the 15 single-family, unattached homes, that were three or more stories, 100% have greater than 60 lamps.

Type of Residence	1 to 20 Lamps		21 to 40 Lamps		41 to 60 Lamps		61 to 80 Lamps		81 to 100 Lamps		>100 Lamps		Sample Size
	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	% of Homes	EB	
Overall	-	-	6.8%	2.1%	30.2%	3.4%	27.1%	3.3%	16.9%	3.1%	19.0%	3.3%	604
Single Family Unattached (1 story)	-	-	12.3%	4.6%	37.9%	6.1%	23.7%	5.2%	12.7%	4.4%	13.4%	4.4%	206
Single Family Unattached (2 stories)	-	-	4.0%	1.9%	25.8%	4.1%	28.9%	4.4%	19.8%	4.4%	21.5%	4.6%	375
Single Family Unattached (3 or more stories)	-	-	-	-	-	-	41.8%	23.6%	16.2%	15.7%	42.0%	22.2%	15
Single Family Attached	-	-	-	-	100.0%	-	-	-	-	-	-	-	8

Table 28: Distribution of Number of Lamps per Home by Residence Type

As one would expect, the average number of screw-based fixtures is far greater than that of pin-based fixtures. Lamps with a screw-base accounted for approximately 71 of the average 77, or 92%, lamps found at the average house as seen in Table 29 and Table 30 below. The majority of the pin-based fixtures are MR-16 and quartz tube halogen fixture types, not commonly pin-based CFLs.

n= 604	Average Number of Lamps per Home	EB
Screw Base	71.24	2.38
Pin Base	5.85	0.88

Table 29: Average Number of Lamps per Home by Base Type

n= 604	Percentage of Base Type	EB
Screw Base	92.4%	1.0%
Pin Base	7.6%	1.0%

Table 30: Percentage of Lamps by Base Type

Table 31 displays the percentage of fixtures with screw-based lamps in which CFLs are installed. As recalled from Table 21, the percentage of all fixtures containing CFLs is

9.2%, but when only screw-based fixtures are examined, 8.2% of those fixtures have CFLs installed.

Percent of CFL from all Screw Based Lamps	EB	Sample Size
8.2%	2.1%	604

Table 31: Percentage of Screw-Based Fixtures Containing CFLs

Specific Fixture Overviews

This section presents in-depth overviews for recessed cans, ceiling fans, and torchieres. These fixture types were selected for further analysis because efficient lighting technologies are currently being developed for these fixture types. For each of these fixture types, the distribution of the number of fixtures as well as the percentage of homes containing these fixtures is presented.

Recessed Cans

About 94% of homes have at least one recessed can. Recessed cans account for approximately 36% of all fixtures, and on average, homes contain 17.42 recessed cans. About 11% of all recessed cans contain a CFL.

Table 32 presents the distribution of the number of recessed cans per home. Approximately 6% of homes have no recessed cans present. About 30% have a total of greater than 21 cans, while 23% of homes have between 11-20 cans.

Number of Recessed Cans	Percentage of Homes (n = 604)	EB
0	5.9%	1.7%
1-4	8.7%	2.0%
5-7	19.6%	3.0%
8-10	12.5%	2.4%
11-20	23.2%	3.4%
> 21	30.1%	3.7%

Table 32: Number of Recessed Cans per Home

Table 33 shows the percentage of homes with recessed cans by room type. The most common location for recessed cans is in the kitchen, with more than 88% of homes have recessed cans in the kitchen. The other most common rooms with around 45% of homes containing recessed cans are the master bathroom, family room, hall, living room, porch, and recreation room.

Room	Percentage of Homes	EB	Sample Size
Basement	15.2%	9.2%	35
Bathroom - 1	11.0%	2.4%	569
Bathroom - 2	15.3%	3.8%	355
Bathroom - 3	21.1%	8.8%	88
Bathroom - 4	-	-	1
Master Bathroom	46.2%	3.9%	604
Bedroom - 1	10.5%	2.6%	554
Bedroom - 2	10.0%	2.6%	473
Bedroom - 3	7.7%	3.5%	208
Bedroom - 4	14.8%	9.1%	50
Master Bedroom	23.3%	3.3%	604
Breakfast Nook	17.8%	5.1%	194
Closet	6.1%	2.0%	510
Dining Room	14.8%	3.1%	479
Family Room	45.9%	5.9%	278
Garage	2.4%	1.0%	543
Hall	47.9%	3.9%	598
Kitchen	88.6%	2.8%	598
Laundry Room	9.9%	2.5%	546
Living Room	43.3%	4.3%	512
Office	23.5%	4.4%	328
Other	16.3%	5.6%	180
Porch	47.2%	4.2%	527
Recreation Room	45.8%	8.4%	141
Whole House	94.1%	1.7%	604

Table 33: Percentage of Homes with Recessed Cans by Room Type

Table 34 displays the average number of recessed cans per home in homes that have at least one recessed can. When compared with Table 16, the average number of recessed cans per home increases slightly, from 17.42 to 18.51.

Average Number of Recessed Cans	EB	Sample Size
18.51	1.56	569

Table 34: Average Number of Recessed Cans in Homes with Recessed Cans

As can be seen below in Table 35, the overwhelming majority of recessed can fixtures use screw-based lamps. This accounts for more than 99% of all recessed can fixtures, while pin-based lamps make up the remaining 0.5%.

n=569	Percent	EB
Screw Base	99.5%	0.5%
Pin Base	0.5%	0.5%

Table 35: Percentage of Lamp Base Type for Recessed Can Fixtures

CFLs are installed in slightly nearly 11% of screw-based recessed can fixtures. Table 36 displays the associated error bound and sample size.

Percent of CFL	EB	Sample Size
10.7%	1.9%	2306

Table 36: Percentage of CFLs in Screw-Based Recessed Can Fixtures

Ceiling Fans

Data were only collected and analyzed for ceiling fans that are designed to contain lamps. Over half of homes have at least one ceiling fan. Ceiling fans account for approximately 2% of all fixtures, and on average, homes contain 1.16 ceiling fans. About 5.5% of all ceiling fans contain a CFL.

Table 37 displays the distribution of the number of ceiling fans per home. Less than half of homes do not have any ceiling fans, and about one-fifth of homes have only one ceiling fan. Approximately 4% of homes have five or more ceiling fans.

Number of Ceiling Fans	Percent of Homes (n = 604)	EB
0	47.4%	3.9%
1	22.9%	3.4%
2	13.7%	2.6%
3	7.4%	1.9%
4	4.3%	1.5%
5+	4.4%	1.5%

Table 37: Number of Ceiling Fans per Home

Table 38 presents the percentage of homes with ceiling fans by room type. Around 25%-30% of homes have a ceiling fan in the master bedroom, family room, or living room.

Room	Percentage of Homes	EB	Sample Size
Basement	-	-	35
Bathroom-1	0.3%	0.3%	569
Bathroom-2	-	-	355
Bathroom-3	-	-	88
Bathroom-4	-	-	1
Bathroom-Master	0.6%	0.5%	604
Bedroom-1	10.1%	2.4%	554
Bedroom-2	9.9%	2.6%	473
Bedroom-3	10.9%	4.5%	208
Bedroom-4	7.3%	5.7%	50
Bedroom-Master	32.0%	3.6%	604
Breakfast Nook	4.9%	2.8%	194
Closet	-	-	510
Dining Room	1.6%	1.0%	479
Family Room	24.4%	4.9%	278
Garage	1.3%	1.1%	543
Hall	0.8%	0.6%	598
Kitchen	0.6%	0.6%	598
Laundry Room	0.2%	0.2%	546
Living Room	31.6%	3.8%	512
Office	10.3%	2.9%	328
Other	1.8%	1.7%	180
Porch	1.1%	0.7%	527
Rec Room	13.5%	4.9%	141
Whole House	52.6%	3.9%	604

Table 38: Percentage of Homes with Ceiling Fans by Room Type

Table 39 shows the distribution of the number of lamps per ceiling fan. About 30% of ceiling fans contain four lamps, while less than 2% have 5 lamps. None of the homes surveyed had 6 or more lamps per ceiling fan.

Number of Lamps	Percent of Fans (n = 339 Homes)	EB
1	15.0%	3.3%
2	20.9%	3.9%
3	23.3%	3.8%
4	32.7%	4.9%
5	1.6%	1.0%
6+	-	-

Table 39 : Distribution of Number of Lamps per Ceiling Fan

Table 40 displays the percentage of ceiling fans equipped with each lamp type. Over 73% of ceiling fans have standard incandescent lamps installed, and another 12.6% of ceiling fans are equipped with incandescent decorative bulbs. CFLs were found in 5.7% of fans equipped with lamps.

Lamp Type	Percent of Ceiling Fans (n = 339 Homes)	EB
Compact Fluorescent A Style	0.8%	1.1%
Compact Fluorescent Globe	0.1%	0.1%
Compact Fluorescent Spring	3.5%	1.7%
Compact Fluorescent Unknown	0.2%	0.3%
Compact Fluorescent Mini	0.9%	0.9%
Compact Fluorescent Pin Base	0.2%	0.3%
Compact Fluorescent Total	**5.7%**	**2.2%**
Fluorescent T12	3.5%	3.5%
Fluorescent Total	**3.5%**	**3.5%**
Halogen Other	0.2%	0.3%
Halogen Unknown	0.4%	0.4%
Halogen Total	**0.6%**	**0.5%**
Incandescent Decorative	12.6%	4.5%
Incandescent Flood	0.9%	0.8%
Incandescent Globe	1.9%	1.2%
Incandescent Mini	0.4%	0.4%
Incandescent Other	0.9%	0.7%
Incandescent Standard	73.1%	5.3%
Incandescent Unknown	0.4%	0.4%
Incandescent Total	**90.2%**	**4.0%**

Table 40: Ceiling Fan Lamp Types

Homes that contain ceiling fans contain an average of 2.21 ceiling fans and all but 3.7% of those fans contain screw-based lamps.

Average Number of Fans	EB	Sample Size
2.21	0.16	339

Table 41: Average Number of Ceiling Fans in Homes with Ceiling Fans

(n=339)	Percent of Base Type	EB
Screw Base	96.3%	3.5%
Pin Base	3.7%	3.5%

Table 42: Percentage of Lamp Base Types for Ceiling Fan Fixtures

Table 43 shows the percentage of ceiling fans with screw-based sockets that contain CFLs. Approximately 5.5% of those fixtures contain CFLs.

Percent of CFL	EB	Sample Size
5.7%	2.2%	339

Table 43: Percentage of CFLs in Screw-Based Ceiling Fan Fixtures

Torchieres

About 18% of homes have at least one torchiere. Torchieres account for approximately 0.5% of all fixtures, with an average of 0.26 torchieres per home. About 20% of all torchieres contain a CFL.

Table 44 shows the distribution of the number of torchieres per home. Approximately 12% of homes have one torchiere.

Number of Torchieres	Percent of Homes (n = 604)	EB
0	81.8%	3.2%
1	12.3%	2.8%
2	4.4%	1.6%
3	1.2%	0.8%
4	0.1%	0.2%
5+	0.1%	0.2%

Table 44: Number of Torchieres per Home

Table 45 displays the percentage of homes with at least one torchiere by room type. Over 12% of homes have a torchiere in the family room. Nearly 8% of homes have a torchiere in the living room. No homes have a torchiere in the bathroom, breakfast nook, closet, kitchen, garage, or porch.

Room	Percentage of Homes	EB	Sample Size
Basement	2.8%	4.6%	35
Bathroom-1	-	-	569
Bathroom-2	-	-	355
Bathroom-3	-	-	88
Bathroom-4	-	-	1
Bathroom-Master	-	-	604
Bedroom-1	2.3%	1.2%	554
Bedroom-2	1.4%	0.8%	473
Bedroom-3	1.4%	1.4%	208
Bedroom-4	0.8%	1.3%	50
Bedroom-Master	2.3%	1.1%	604
Breakfast Nook	-	-	194
Closet	-	-	510
Dining Room	0.3%	0.5%	479
Family Room	12.6%	4.7%	278
Garage	-	-	543
Hall	0.5%	0.5%	598
Kitchen	-	-	598
Laundry Room	0.1%	0.2%	546
Living Room	8.7%	2.3%	512
Office	3.4%	1.7%	328
Other	0.9%	1.5%	180
Porch	-	-	527
Rec Room	0.7%	1.2%	141
Whole House	18.2%	3.2%	604

Table 45: Percentage of Homes with Torchieres by Room Type

Table 46 displays the percentage of torchieres equipped with each lamp type. Nearly 38% of torchieres have incandescent lamps installed, and another 32% of torchieres are equipped with halogen tube lamps. Additionally, the percentage of torchieres with compact fluorescent bulbs is slightly greater than 20%.

Lamp Type	Percent of Torchieres (n = 99)	EB
Compact Fluorescent A Style	4.2%	4.6%
Compact Fluorescent Circline	0.9%	1.4%
Compact Fluorescent Spring	13.1%	8.2%
Compact Fluorescent Tubular	1.1%	1.5%
Compact Fluorescent Unknown	0.4%	0.7%
Compact Fluorescent Mini	0.4%	0.7%
Compact Fluorescent Total	**20.3%**	**9.1%**
Fluorescent T5	1.0%	1.6%
Fluorescent Circline	0.9%	1.4%
Fluorescent Other	3.4%	2.6%
Fluorescent Total	**5.3%**	**3.3%**
Halogen Other	1.0%	0.7%
Halogen Parabolic Reflector	0.9%	0.4%
Halogen Quartz Tube	3.4%	8.0%
Halogen Unknown	0.6%	2.4%
Halogen Total	**37.1%**	**8.2%**
Incandescent Flood	0.3%	0.5%
Incandescent Globe	1.7%	1.7%
Incandescent Standard	32.5%	8.5%
Incandescent Unknown	2.8%	3.2%
Incandescent Total	**37.3%**	**8.7%**

Table 46: Torchiere Lamp Types

Fixture Control Types

Table 47 shows the percentage of homes have a given lamp type and lamp control type among all lamps. About 74% of homes are using a standard incandescent lamp controlled manually. Only approximately 6% were incandescent lamps in dimmer controlled switches, while 1% were halogen lamps in a dimmer controlled switch.

Lamp Type	Percent of Lamps by Control Type (n=604)											
	Manual		Dimmer		Motion Detector		Motion Detector with Photocell		Photocell		Timer	
	Percentage	EB	Percentage	EB	Percentage	EB	Percentage	EB	Percentage	EB	Percentage	EB
Compact Fluorescent	7.65%	1.98%	0.10%	0.05%	0.01%	0.01%	0.00%	0.00%	0.04%	0.04%	0.03%	0.03%
Fluorescent Other	0.71%	0.17%	0.02%	0.01%	0.00%	0.00%	-	-	-	-	0.00%	0.00%
Fluorescent T12	2.52%	0.44%	-	-	0.00%	0.01%	-	-	-	-	-	-
Fluorescent T8	1.89%	0.67%	-	-	0.02%	0.03%	-	-	-	-	0.00%	0.00%
Halogen	5.27%	1.16%	1.02%	0.43%	0.04%	0.02%	0.01%	0.01%	-	-	0.01%	0.02%
Incandescent	74.29%	2.63%	5.78%	0.96%	0.12%	0.05%	0.11%	0.07%	0.12%	0.07%	0.24%	0.07%

Table 47: Percent of Lamps by Control Types

Lamp Wattage

Table 48 shows average lamp wattage for each lamp type observed in this study. The highest average wattages were halogen tube lamps and heat lamps. The most common lamp, the standard incandescent, has an average wattage of 64. The most common CFL, the spiral lamp, had an average wattage of 17.

Lamp Type	Average Wattage	EB
Compact Fluorescent A Style	16.7	1.15
Compact Fluorescent Capsule	11.0	0.00
Compact Fluorescent Circline	21.6	2.45
Compact Fluorescent Decorative	18.7	6.15
Compact Fluorescent Flood	18.9	1.93
Compact Fluorescent Globe	12.8	2.37
Compact Fluorescent Spring	17.0	0.76
Compact Fluorescent Tubular	19.2	2.93
Compact Fluorescent Unknown	23.6	2.21
Compact Fluorescent Mini	19.1	0.75
Compact Fluorescent Pin Base	17.4	4.53
Fluorescent T12	44.0	2.68
Fluorescent T4	15.5	5.21
Fluorescent T5	17.7	3.51
Fluorescent T8	31.6	1.35
Fluorescent Circline	30.6	3.32
Fluorescent Other	23.4	8.35
Fluorescent Tube Unknown	27.7	1.53
MR-16 Pin Based Halogen	47.2	5.67
Halogen Other	47.2	7.45
Halogen Parabolic Reflector	72.8	4.72
Halogen Quartz Tube	94.8	24.09
Halogen Unknown	56.1	3.63
Heat Lamp	199.7	15.78
Decorative Incandescent	48.8	1.68
Incandescent Flood	65.9	0.79
Incandescent Globe	54.6	1.24
Incandescent Mini	40.4	2.98
Incandescent Other	57.8	6.46
Incandescent Standard	64.0	0.64
Incandescent Unknown	61.1	11.81

Table 48: Average Lamp Wattage by Lamp Type

Table 49 presents the average wattage per fixture, inclusive of all lamp technology types found in the fixtures, and number of lamps found in the fixture. Chandelier/Hanging lamps were found to have the highest overall wattage (196), followed by ceiling fans (155), and torchieres (151.5). Both chandeliers and ceiling fans commonly have multiple lamps per fixture, explaining the high wattage for these fixtures. Torchieres on the other hand typically have a single lamp, most commonly halogen quartz, which go as high as 500 watts per lamp. Under counter fixture types have the lowest wattage, with an average of 46 watts. These fixtures are more commonly located in kitchens and are usually equipped with fluorescent tubes. Table lamps have the second lowest average wattage.

Fixture Type	Average Fixture Wattage	EB	Sample Size
Architectually Integrated	60.7	9.2	88
Ceiling Fan	155.0	7.4	339
Ceiling Fixtures	97.9	2.6	601
Chandelier Hanging	196.0	9.7	556
Floor Lamp	85.9	6.7	314
Garage Door Opener	83.5	3.7	442
Other	107.5	20.1	66
Recessed Can	60.9	2.4	569
Recessed Lighting-Other	96.2	19.2	135
Table lamps	58.2	1.9	526
Torchiere	151.5	24.5	99
Track Lighting	142.7	24.8	41
Under Counter	45.7	5.7	203
Wall Mount	126.2	5.4	596

Table 49: Average Fixture Wattage

Table 50 looks at the average wattage by room type, when considering all fixtures and lamps within the specific room. These numbers do vary dramatically when considering size of home, type of home, and income. The Hallway tops the list in terms of highest overall wattage by room type, more than likely a result of multiple fixtures. The kitchen is second on the list. The master bathroom, basement and garages top out the top five high wattage rooms. Conversely, on the low end of wattages are laundry rooms and closets. These rooms typically have few fixtures and lamps.

Room	Watts	EB	Sample Size
Basement	376.2	77.4	35
Bathroom - 1	248.2	10.7	569
Bathroom - 2	270.2	15.6	355
Bathroom - 3	239.3	28.7	88
Bathroom- 4	180.0	0.0	1
Master Bathroom	464.3	20.8	604
Bedroom - 1	181.4	8.5	554
Bedroom - 2	177.6	8.6	473
Bedroom - 3	164.8	13.0	208
Bedroom - 4	195.1	29.2	50
Master Bedroom	275.1	14.4	604
Breakfast Nook	213.5	17.7	194
Closet	172.7	11.0	510
Dining Room	329.1	16.1	479
Family Room	319.4	27.4	278
Garage	374.4	22.5	543
Hall	528.9	29.4	598
Kitchen	502.3	27.1	598
Laundry Room	121.2	6.2	546
Living Room	358.5	27.3	512
Office	226.9	17.2	328
Other	258.8	42.1	180
Porch	249.9	21.0	527
Recreation Room	361.1	41.2	141
Whole House	4454.1	154.1	604

Table 50: Average Wattage by Room Type

Table 51 illustrates the lighting wattage for the whole house and hardwired fixtures by home square footage. While these lighting power densities (LPD) are relatively high, roughly equivalent to commercial retail LPDs, it should be noted that over 80% of lamps in this study were incandescent, which drives the LPD up relative to CFLs. Additionally, while these homes have the capability to have LPDs as seen below, it would be a rare that an occupant would power all of the home's lamps simultaneously.

Type of Residence	House LPD		Hardwired LPD	
	W/ft2	EB	W/ft2	EB
Overall	1.89	0.05	1.73	0.04
SF-UN-1S	2.08	0.09	1.87	0.08
SF-UN-2S	1.81	0.06	1.67	0.05
SF-UN-3S+	1.72	0.19	1.59	0.17
Town/Row	2.20	0.24	1.93	0.23

Table 51: Lighting Power Density for Whole House and Hardwired Fixtures

Single-Family Appliances and Building Characteristics

Refrigerator Freezers

The following section describes the refrigerator/freezers found at the surveyed households. In total, 604 households were surveyed. All homes surveyed for this study have at least one refrigerator, 20.5% of all homes have a second, and only 1.6% of all homes have a third refrigerator. For this analysis any refrigerator with a capacity under 8 cubic feet is considered a "compact" refrigerator, while any refrigerator with a capacity of 8 cubic feet and above is referred to as "full-size". The following table summarizes second and third refrigerators by the residence types where they were found.

Type of Residence	Secondary Refrigerator				Third Refrigerator				Sample Size
	Full or Compact		Full Only		Full or Compact		Full Only		
	%	EB	%	EB	%	EB	%	EB	
Overall	20.5%	3.0%	18.9%	2.9%	1.6%	0.8%	1.2%	0.7%	604
Single Family Unattached (1 story)	27.2%	5.7%	25.2%	5.5%	1.7%	1.5%	1.7%	1.5%	206
Single Family Unattached (2 stories)	16.9%	3.6%	15.4%	3.4%	1.5%	1.0%	0.8%	0.7%	375
Single Family Unattached (3 or more stories)	20.7%	17.0%	20.7%	17.0%	4.4%	7.1%	4.4%	7.1%	15
Single Family Attached	-	-	-	-	-	-	-	-	8

Table 52: Percentage of Homes with Second or Third Refrigerator by Type of Residence

Due to the small number of homes with third refrigerators, the following summary information is only based upon the primary and secondary refrigerators. This refrigerator/freezer section of the report first summarizes the analysis conducted on the primary refrigerators, and then summarizes the secondary refrigerators.

The primary and secondary refrigerators are summarized by type, size, age, energy consumption, ENERGY STAR qualifications, and nameplate unit energy consumption (UEC) relative to standards. Because the amount of data for each of the aforementioned characteristics differs, the number of sites in each of the analyses will differ. The data used in the refrigerator analyses are described below.

- Type-The type of each refrigerator was obtained from the site visit.
- Size-The size of the refrigerators, in cubic feet, was first obtained from the efficiency databases (CEC and AHAM) if the model number successfully matched a model in the database. In the event that the models were not matched, the data on the size collected on-site were used.
- Age-The age of the appliance was also obtained from the efficiency databases if a match was made, otherwise the age from the on site visit was used in the analysis.
- Usage (nameplate UEC)-The usage data were obtained exclusively from the efficiency databases.
- ENERGY STAR Qualification-The unit was marked as ENERGY STAR qualified if its nameplate UEC was calculated as 15% above standard for 2001 standards. The 2001 ENERGY STAR standard was 10% above standard for 2001 standards.

Primary Refrigerators

All homes that were visited over the course of this study have a primary refrigerator. The classification of the refrigerators is by size, configuration, and existence of a through the door ice dispenser. Full size refrigerators are categorized as either single or double door. The double door refrigerators are further classified by freezer position: either bottom mounted, top mount, or side-by-side. In the case of the side by side and top mount, a further division is the existence of a through the door ice and water dispenser.

Figure 6 shows the percentage breakdown of primary refrigerators by type. The majority of the primary refrigerators found are the side by side type, accounting for almost 70% of all the primary refrigerators. Top mounted freezer type (Standard, in the figure below) account for over nearly 16% of the primary refrigerators.

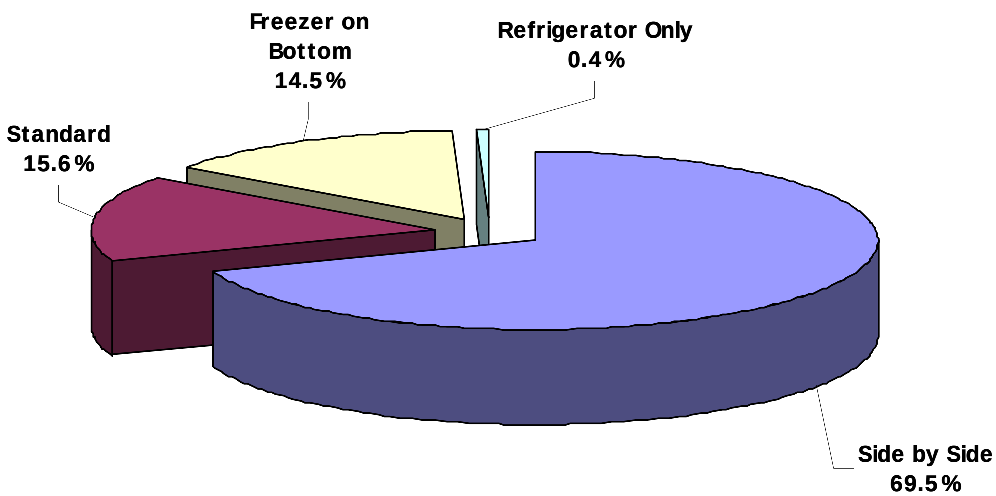

Figure 6: Percentage of Homes with Primary Refrigerator/Freezer by Type

The following abbreviations (common for refrigerators) are used throughout this section to describe the various types of refrigerator and defrost types as found:

- **BF** = Bottom Mounted Freezer (All Automatic)
- **SI =** Side-by-Side with Ice Dispenser (All Automatic)
- **SS** = Side by Side without Ice Dispenser (All Automatic)
- **TF** = Top Mounted Freezer without Ice Dispenser (Partial and Automatic Defrost)
- **SD =** Single Door (Refrigerator Only)

Size

The sizes of refrigerators were obtained from manufacturer data if the unit is matched, or else from survey data if not matched. The following summary of the sizes of the refrigerators summarizes both the matched and unmatched units, or the manufacturer reported and surveyor estimated sizes.

The sample size that is used in the following table that summarizes the average size of the refrigerators is 550. This is the number of full size refrigerators, 8 cubic feet or greater, for which we obtained size data from the efficiency databases. The average manufacturer reported size for all refrigerators obtained from the efficiency databases is 23.7 cubic feet.

Refrigerator Type	Manufacturer Reported Size	EB	Sample Size
All Types	23.7	0.2	550
Freezer On Bottom	22.5	0.5	73
Side By Side	24.1	1.1	13
Side By Side w/Ice Dispenser	24.9	0.2	372
Single Door	19.9	-	1
Top Mounted Freezer	19.8	0.4	91

Table 53: Average Estimated Size by Refrigerator Type

The following table shows the distribution of the sizes of the refrigerators including matched and unmatched units. The largest percentage of the refrigerators, or 67.9%, is within the size range greater than 22.00 cubic feet. Refrigerators with top mounted freezers without ice makers are the only type of refrigerators surveyed that have sizes less than 15 cubic feet of volume.

Size Range (CuFt)	Refrigerator Type											
	All Types (n=604)		Freezer on Bottom (n=81)		Side By Side (n=16)		Side By Side w/Ice Dispenser (n=406)		Single Door (n=3)		Top Mounted Freezer (n=98)	
	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB
≤ 10	-	-	-	-	-	-	-	-	-	-	-	-
11.00 to 14.99	0.3%	0.4%	-	-	-	-	-	-	-	-	1.9%	2.4%
15.00 to 18.99	6.0%	1.6%	4.1%	2.9%	-	-	1.1%	0.8%	-	-	30.3%	8.2%
19.00 to 21.99	25.8%	3.4%	43.9%	9.9%	56.7%	24.3%	13.4%	3.3%	-	-	58.1%	9.2%
> 22.00	67.9%	3.6%	52.0%	10.0%	43.3%	24.3%	85.5%	3.3%	100.0%	-	9.7%	5.5%

Table 54: Percentage of All Refrigerators by Type within Size Ranges- Estimated Sizes

<u>Age</u>

During the on-site survey, surveyors examined the refrigerator nameplate for a manufactured date and residents were asked for the approximate age of their refrigerators. If the resident was unable to provide an age, or the nameplate didn't provide a manufactured date, the surveyor estimated the age of the refrigerators whenever possible. The nameplate manufactured date, resident reported age, and surveyor estimated ages were used for refrigerators when no age data from the matching process were available for the following estimated age analysis.

The sample size of 592 primary refrigerator ages represents all full size primary refrigerator ages obtained in this study. Table 55 shows that the average age of these refrigerators is 2.5 years with an error bound of 0.2 years. The manufacture date range of 2000 through 2006 accounts for more than 90% of all primary refrigerators.

Manufactured Date and Estimated Mfr Date Ranges								Sample Size
Ref Type	**Size Range (CuFt)**	**Avg Mfg Age**	**Ave Mfg Age EB**	**2000 - 2006**	**1995 - 1999**	**1990 - 1994**	**1985 - 1989**	
All Types	Overall	2.5	0.2	90.7%	6.4%	2.8%	0.2%	592
	11.00-14.99	1.3	0.4	100.0%	-	-	-	2
	15.00-18.99	3.8	1.3	78.8%	8.8%	12.4%	-	44
	19.00-21.99	3.6	0.6	79.5%	13.8%	6.5%	0.3%	144
	>22.00	1.9	0.2	95.9%	3.4%	0.6%	0.1%	402
BF	Overall	1.6	0.3	97.7%	1.0%	1.3%	-	80
	15.00-18.99	2.2	1.0	100.0%	-	-	-	6
	19.00-21.99	1.9	0.6	94.9%	2.3%	2.8%	-	37
	>22.00	1.3	0.1	100.0%	-	-	-	37
SI	Overall	5.9	2.6	66.6%	16.6%	13.6%	3.1%	16
	19.00-21.99	8.7	4.2	46.6%	29.3%	18.5%	5.6%	6
	>22.00	2.4	1.6	92.7%	-	7.3%	-	10
SS	Overall	2.4	0.2	91.5%	6.5%	1.9%	0.1%	396
	15.00-18.99	3.1	1.4	81.7%	18.3%	-	-	4
	19.00-21.99	4.4	1.2	66.9%	22.3%	10.8%	-	49
	>22.00	2.0	0.2	95.3%	4.0%	0.6%	0.1%	343
SD	Overall	1.7	0.5	100.0%	-	-	-	3
	>22.00	1.7	0.5	100.0%	-	-	-	3
TF	Overall	3.3	0.6	84.2%	9.4%	6.4%	-	97
	11.00-14.99	1.3	0.4	100.0%	-	-	-	2
	15.00-18.99	4.0	1.6	75.8%	8.8%	15.5%	-	34
	19.00-21.99	3.2	0.7	85.4%	11.5%	3.1%	-	52
	>22.00	1.4	0.3	100.0%	-	-	-	9

Table 55: Average Age and Percentage of Refrigerator Manufacturer Reported and On Site Estimated Ages within Size Ranges

Energy Consumption

The average annual nameplate UEC for refrigerator/freezers was obtained from the model number matches to manufacturer data. A sample of 460 nameplate UECs were obtained for the analysis below. Table 56 shows the average nameplate UEC by type of refrigerator and size range.

The average overall nameplate UEC for all types of refrigerators is 624.9 with an error bound of 10.0. The most efficient units are refrigerators with a single door, which have the lowest nameplate UEC at 424.0, although the sample for this was only one refrigerator. The next most efficient are refrigerators with bottom mounted freezers, which have the average lowest nameplate UEC at 514.1, followed by the top mounted freezers without an ice dispenser that have an average nameplate UEC of 527.9. The tables in the next section of the report that summarize the nameplate UECs relative to standards help to put these numbers into perspective.

Ref Type	Size Range (CuFt)	Average UEC	EB	Sample Size
All Types	Overall	624.9	10.0	460
	11.00-14.99	448.0	-	1
	15.00-18.99	565.9	42.4	37
	19.00-21.99	595.4	23.1	108
	>22.00	641.5	10.7	314
BF	Overall	514.1	9.2	64
	15.00-18.99	567.3	90.0	3
	19.00-21.99	524.2	19.9	29
	>22.00	503.6	2.8	32
SS	Overall	663.9	60.2	13
	19.00-21.99	707.1	67.6	4
	>22.00	612.3	96.9	9
SI	Overall	672.0	9.9	307
	15.00-18.99	609.1	135.2	5
	19.00-21.99	704.6	35.3	38
	>22.00	668.1	9.7	264
SD	Overall	424.0	-	1
	>22.00	424.0	-	1
TF	Overall	527.9	22.5	75
	11.00-14.99	448.0	-	1
	15.00-18.99	558.6	47.8	29
	19.00-21.99	522.0	27.4	37
	>22.00	473.8	22.1	8

Table 56: Average Nameplate UEC by Type of Refrigerator

The bin distribution of unit energy consumption of all successfully matched full size primary refrigerators is shown below in Table 57 grouped by size and type. The nameplate UEC range that makes up the largest percentage of all refrigerators is the range between 550 to 749.9 kWh/year, which covers 62.0% of all types of refrigerators.

Ref Type	Unit Energy Consumption Ranges (kWh/Year)					
	Size Range (CuFt)	350 to 549.9	550 to 749.9	750 to 949.9	950 to 1149.9	1150 to 1349.9
All Types	Overall	28.3%	62.0%	6.9%	2.4%	0.3%
	11.00-14.99	100.0%	-	-	-	-
	15.00-18.99	63.7%	24.1%	12.2%	-	-
	19.00-21.99	51.4%	32.8%	14.1%	0.9%	0.8%
	>22.00	16.4%	76.4%	3.8%	3.2%	0.1%
BF	Overall	90.9%	6.5%	2.6%	-	-
	15.00-18.99	46.6%	53.4%	-	-	-
	19.00-21.99	82.1%	11.9%	6.0%	-	-
	>22.00	100.0%	-	-	-	-
SS	Overall	30.5%	51.7%	11.6%	-	6.2%
	15.00-18.99	-	73.7%	21.2%	-	5.1%
	19.00-21.99	66.9%	25.5%	-	-	7.6%
	>22.00	1.4%	86.7%	8.1%	3.5%	0.2%
SI	Overall	37.3%	32.7%	30.0%	-	-
	15.00-18.99	4.8%	62.6%	29.5%	1.5%	1.6%
	19.00-21.99	0.3%	91.2%	4.6%	3.9%	-
	>22.00	100.0%	-	-	-	-
SD	Overall	100.0%	-	-	-	-
	>22.00	80.8%	13.3%	5.4%	0.5%	-
	Overall	100.0%	-	-	-	-
TF	11.00-14.99	69.5%	20.4%	10.1%	-	-
	15.00-18.99	83.2%	12.0%	3.7%	1.0%	-
	19.00-21.99	100.0%	-	-	-	-

Table 57: Percentage of Primary Refrigerators by Nameplate UEC Ranges and Type within Size Ranges

Additionally, the above groupings of full size primary refrigerators are compared with the 2001 Federal Appliance Standards for annual energy consumption.

Percentage Above/Below 2001 Federal Appliance Standards

The average percentage above or below the 2001 standards for each unit is calculated as follows:

$$\% \text{ Relative to Std} = \frac{\text{2001 Standard (KWh/Yr)} - \text{UEC (KWh/Yr)}}{\text{2001 Standard (KWh/Yr)}}$$

For example, suppose the nameplate annual energy consumption for a refrigerator is 550 KWh/Yr. The 2001 standard consumption for this unit is 500 kWh/Yr. The percentage better or worse than 2001 standards is calculated as follows:

$$\frac{500 - 550}{500} = \frac{-50}{500} = -10\%$$

Thus, the annual energy consumption for this unit is 10% worse than 2001 standards.

Table 58 shows the average percentage above or below the 2001 standard that refrigerators are broken down by type and size. The average percentage above standards for all types of refrigerators is 5.1%. We find that refrigerators with bottom mounted freezers and ice makers, and those with side by side with ice dispensers perform best in comparison to the standards among all refrigerators by averaging 11.8% and 5.9% above standards respectively.

Ref Type	Size Range (CuFt)	Average UEC Relative to 2001 Std	EB	Sample Size
All Types	Overall	5.1%	1.3%	449
	11.00-14.99	15.3%	0.0%	1
	15.00-18.99	-8.8%	9.1%	37
	19.00-21.99	0.2%	3.3%	103
	>22.00	7.7%	1.3%	308
BF	Overall	11.8%	1.8%	59
	15.00-18.99	-1.8%	16.0%	3
	19.00-21.99	8.1%	4.1%	24
	>22.00	14.8%	0.4%	32
SS	Overall	-1.8%	9.7%	13
	19.00-21.99	-8.4%	12.2%	4
	>22.00	6.1%	14.7%	9
SI	Overall	5.9%	1.5%	302
	15.00-18.99	10.0%	16.3%	5
	19.00-21.99	-0.6%	6.0%	38
	>22.00	6.8%	1.4%	259
SD	Overall	0.0%	0.0%	0
	>22.00	0.0%	0.0%	0
TF	Overall	-4.4%	4.7%	75
	11.00-14.99	15.3%	0.0%	1
	15.00-18.99	-13.7%	10.3%	29
	19.00-21.99	-2.4%	5.4%	37
	>22.00	9.5%	3.5%	8

Table 58: Percentage Above/Below 2001 Federal Appliance Standards by Type of Refrigerator

The distribution of the percentages better or worse than 2001 standards for all refrigerators that were successfully matched by size range and type is presented in Table 59.

As can be seen in the table 77.7% of all refrigerators are better than 2001 energy standards for annual energy consumption. Nearly one-fifth of refrigerators (19.5%) have a nameplate UEC of 0.01% to 49.9% worse than 2001 Federal appliance standards for annual energy consumption.

Percentage Comparison to 2001 Federal Appliance Standards									
Ref Type	Size Range (CuFt)	Better		Worse					Sample Size
		10% to 35%	0% to 9%	- 0.01% to -24.9%	- 25% to -49.9%	- 50% to -74.9%	- 75% to -99.9%	- 100% to -124.9%	
All Types	Overall	55.7%	22.0%	13.8%	5.7%	0.6%	0.8%	0.1%	449
	11.00-14.99	100.0%	-	-	-	-	-	-	1
	15.00-18.99	24.6%	41.4%	9.5%	13.6%	3.8%	7.0%	-	37
	19.00-21.99	45.8%	25.3%	16.1%	11.6%	-	0.9%	0.4%	103
	>22.00	62.2%	19.0%	13.5%	2.7%	0.6%	0.1%	-	308
BF	Overall	90.3%	4.7%	2.3%	2.7%	-	-	-	59
	15.00-18.99	46.6%	-	53.4%	-	-	-	-	3
	19.00-21.99	78.6%	12.4%	1.8%	7.2%	-	-	-	24
	>22.00	100.0%	-	-	-	-	-	-	32
SS	Overall	30.5%	40.1%	23.2%	-	-	6.2%	-	13
	19.00-21.99	-	73.7%	21.2%	-	-	5.1%	-	4
	>22.00	66.9%	-	25.5%	-	-	7.6%	-	9
SI	Overall	55.0%	21.1%	16.3%	4.8%	0.6%	0.2%	-	302
	15.00-18.99	52.9%	17.1%	30.0%	-	-	-	-	5
	19.00-21.99	44.8%	19.3%	19.3%	15.0%	-	1.6%	-	38
	>22.00	56.7%	21.4%	15.7%	3.3%	0.7%	-	-	259
SD	Overall	-	-	-	-	-	-	-	0
	>22.00	-	-	-	-	-	-	-	0
TF	Overall	32.0%	38.2%	12.3%	12.6%	1.6%	2.9%	0.5%	75
	11.00-14.99	100.0%	-	-	-	-	-	-	1
	15.00-18.99	18.1%	48.7%	2.6%	17.0%	4.8%	8.7%	-	29
	19.00-21.99	34.0%	31.4%	20.9%	12.8%	-	-	1.0%	37
	>22.00	57.5%	42.5%	-	-	-	-	-	8

Table 59: Percentage of Refrigerators with a Nameplate UEC Better or Worse than 2001 Standards by Percentage Bins and Type within Size Ranges

ENERGY STAR Qualified

To qualify for 2001 ENERGY STAR standards, the annual energy consumption of a refrigerator must be at least 10% less than 2001 Federal Appliance Standards for annual energy consumption. To qualify for 2004 ENERGY STAR standards, the annual energy consumption of a refrigerator must be at least 15% less than 2001 Federal Appliance Standards for annual energy consumption. The following analysis is based on a sample of 449 primary refrigerators for which we have obtained nameplate UEC data.

The distribution of Primary Refrigerator/Freezers that meet ENERGY STAR qualifications grouped by size and type is shown below. These data are not shown by defrost type since the refrigerator data only contained automatic models that met the size requirements of the program. As can be seen in Table 60, the percentage of all refrigerators that meet 2001 ENERGY STAR qualifications is 55.7 % with a 4.6% error bound. The percentage of all refrigerators that meet 2004 ENERGY STAR qualifications is 39.5 % with a 4.4% error bound.

Ref Type	Size Range (CuFt)	2004 Energy Star		2001 Energy Star		Sample Size
		Percentage	EB	Percentage	EB	
All Types	Overall	39.5%	4.4%	55.7%	4.6%	449
	11.00-14.99	100.0%	-	100.0%	-	1
	15.00-18.99	24.6%	12.9%	24.6%	12.9%	37
	19.00-21.99	28.1%	7.8%	45.8%	9.0%	103
	>22.00	45.0%	5.5%	62.2%	5.7%	308
BF	Overall	39.0%	12.0%	90.3%	6.5%	59
	15.00-18.99	46.6%	50.5%	46.6%	50.5%	3
	19.00-21.99	31.8%	16.7%	78.6%	15.0%	24
	>22.00	43.3%	16.7%	100.0%	-	32
SS	Overall	30.5%	23.8%	30.5%	23.8%	13
	19.00-21.99	-	-	-	-	4
	>22.00	66.9%	26.1%	66.9%	26.1%	9
SI	Overall	44.3%	5.5%	55.0%	5.8%	302
	15.00-18.99	52.9%	39.2%	52.9%	39.2%	5
	19.00-21.99	38.7%	14.2%	44.8%	14.6%	38
	>22.00	45.0%	6.0%	56.7%	6.3%	259
SD	Overall	-	-	-	-	0
	>22.00	-	-	-	-	0
TF	Overall	21.8%	8.5%	32.0%	9.8%	75
	11.00-14.99	100.0%	-	100.0%	-	1
	15.00-18.99	18.1%	12.4%	18.1%	12.4%	29
	19.00-21.99	19.9%	11.4%	34.0%	14.1%	37
	>22.00	37.2%	30.6%	57.5%	31.1%	8

Table 60: Percentage of ENERGY STAR Qualified Primary Refrigerators by Type and Size Range

Secondary Refrigerators

Of the 19.5% of homes with second refrigerator/freezers, the majority (55.4%) have top mount freezers (Standard, in the figure below) as their secondary refrigerator type, while 18.0% of homes have side-by-side refrigerators, and 14.4% have half-size or quarter-size models with capacities fewer than 8 cubic feet. A complete breakdown of secondary refrigerator/freezer by type is shown below.

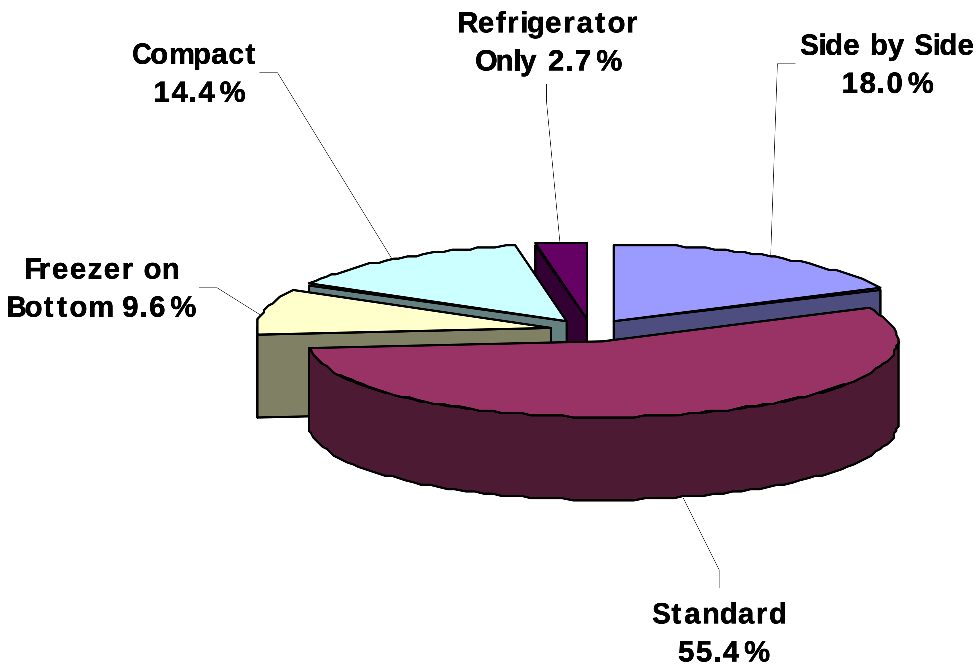

Figure 7: Secondary Refrigerators by Type

Size

The sample size that is used in the following analysis of the secondary refrigerators by size of the unit is 79. Size data for secondary refrigerators were obtained from the manufacturer data and the surveyor estimate.

Table 61 shows the average estimated size of the refrigerators by type. The average of all types of refrigerators is 19.5 cubic feet with an error bound of 0.8 cubic feet. The side-by-side refrigerators with ice dispensers are 24.1 cubic feet on average, the largest of all the types.

Refrigerator Type	Ave Est Size	EB	Sample Size
All Types	19.5	0.8	79
Compact	4.5	1.0	3
Freezer On Bottom	21.3	1.2	10
Side By Side	21.4	2.9	2
Side By Side w/Ice Dispenser	24.1	0.8	16
Single Door	18.6	-	1
Top Mounted Freezer	18.6	0.5	47

Table 61: Average Estimated Size of Secondary Refrigerators by Type

The following table shows the distribution of the sizes of the refrigerators. The largest percentage of the secondary refrigerators surveyed (34.5%) fall in the size range of 19.00 to 21.99 cubic feet

Size Range (CuFt)	All Types (n=124)		Bottom Freezer (BF) (n=11)		Compact (CO) (n=18)		Single Door (SD) (n=8)		Side by Side (SS) (n=17)		Side by Side w/Dispenser (SS) (n=20)		Top Mounted Freezer (TF) (n=67)	
	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB
< 10.99	14.4%	5.6%	-	-	100.0%	-	-	-	-	-	-	-	-	-
11.00 to 14.99	3.6%	3.6%	-	-	-	-	-	-	-	-	-	-	6.5%	6.4%
15.00 to 18.99	29.3%	7.7%	30.0%	24.3%	-	-	-	-	-	-	-	-	47.6%	11.4%
19.00 to 21.99	34.5%	7.6%	53.4%	26.3%	-	-	45.4%	49.8%	79.2%	30.3%	37.1%	19.5%	36.7%	10.6%
> 22.00	18.3%	6.4%	16.6%	19.9%	-	-	54.6%	49.8%	20.8%	30.3%	62.9%	19.5%	9.2%	6.6%

Table 62: Estimated Size Distribution of Secondary Refrigerators by Type

Age

The sample size of 108 secondary refrigerator ages represents all secondary refrigerator age data obtained in this study, from both model number matching and on-site estimation. The average age and error bound along with the distribution of date range by type and size range are presented in the following table. The average age of the refrigerators is 8.1 years with an error bound of 1.2 years.

This is considerably older than the average age of primary refrigerators, which is 2.5 years. The manufacture date range of 2000 through 2006 has the largest percentage, accounting for 46.8% of all secondary refrigerators.

Ref Type	Manufactured Date and Estimated Mfr Date Ranges									Sample Size
	Size Range (CuFt)	Ave Mfg Age	Ave Mfg Age EB	2000 - 2006	1995 - 1999	1990 - 1994	1985 - 1989	1980 - 1984	1979 and Older	
All Types	Overall	8.1	1.2	46.8%	27.0%	13.2%	10.3%	1.3%	1.3%	108
	<=10.99	2.7	1.1	93.0%	7.0%	-	-	-	-	15
	11.00-14.99	3.4	3.3	65.7%	34.3%	-	-	-	-	3
	15.00-18.99	10.4	2.3	31.1%	27.6%	19.4%	17.8%	-	4.1%	31
	19.00-21.99	9.2	1.7	37.6%	33.8%	14.1%	14.4%	-	-	41
	>22.00	7.4	2.8	50.2%	27.6%	14.7%	-	7.5%	-	18
CO	Overall	2.7	1.1	93.0%	7.0%	-	-	-	-	15
	<=10.99	2.7	1.1	93.0%	7.0%	-	-	-	-	15
BF	Overall	11.0	5.1	26.5%	49.1%	9.1%	-	-	15.4%	9
	15.00-18.99	18.1	8.2	-	38.6%	22.9%	-	-	38.6%	3
	19.00-21.99	6.8	3.0	38.8%	61.2%	-	-	-	-	5
	>22.00	1.0	-	100.0%	-	-	-	-	-	1
SS	Overall	6.7	4.4	56.3%	24.7%	-	19.0%	-	-	5
	19.00-21.99	8.2	4.9	44.8%	31.2%	-	24.0%	-	-	4
	>22.00	1.0	-	100.0%	-	-	-	-	-	1
SI	Overall	8.4	1.6	33.4%	40.8%	25.8%	-	-	-	19
	19.00-21.99	8.6	2.8	40.0%	32.3%	27.7%	-	-	-	8
	>22.00	8.3	2.0	29.2%	46.2%	24.6%	-	-	-	11
SD	Overall	2.0	-	100.0%	-	-	-	-	-	1
	19.00-21.99	2.0	-	100.0%	-	-	-	-	-	1
	>22.00	0.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-
TF	Overall	9.0	1.7	41.1%	25.2%	14.3%	17.1%	2.3%	-	59
	11.00-14.99	3.4	3.3	65.7%	34.3%	-	-	-	-	3
	15.00-18.99	9.5	2.2	34.9%	26.3%	18.9%	19.9%	-	-	28
	19.00-21.99	10.3	2.4	33.6%	29.4%	15.1%	21.8%	-	-	23
	>22.00	6.9	7.4	78.0%	-	-	-	22.0%	-	5

Table 63: Average Age and Percentage of Secondary Refrigerator Manufacturer Reported Ages and On Site Estimated Ages by Size Range

Energy Consumption

The average annual nameplate UEC data for refrigerator/freezers is obtained from the model number matches to manufacturer data. A sample of 72 nameplate UECs were obtained for the analysis below. The bin distribution and the average of nameplate annual energy consumption based upon the sample of all successfully matched secondary refrigerators is shown below grouped by type and size.

The average overall nameplate UEC is 711.0 kWh/year with an error bound of 67.9 kWh/year, as compared to the primary refrigerator UEC of 514.1. The largest percentage of refrigerators (37.3%) is within the range from 550 to 749.9 kWh/year.

Ref Type	Size Range (CuFt)	Average UEC	Average UEC EB	150 - 349.9	350 - 549.9	550 - 749.9	750 - 949.9	950 - 1149.9	1150 - 1349.9	1350 - 1549.9	1550 - 1750	Sample Size
				Unit Energy Consumption Ranges								
All Types	Overall	711.0	67.9	2.9%	37.3%	28.8%	8.9%	7.2%	9.6%	3.1%	2.3%	72
	<=10.99	344.9	18.5	53.4%	46.6%	-	-	-	-	-	-	3
	11.00-14.99	620.0	-	-	-	100.0%	-	-	-	-	-	1
	15.00-18.99	685.0	135.9	-	48.9%	27.4%	2.0%	10.0%	7.7%	-	4.0%	21
	19.00-21.99	720.7	82.9	-	34.2%	34.7%	11.1%	6.3%	8.6%	2.4%	2.6%	32
	>22.00	828.8	168.5	-	28.7%	19.7%	16.9%	7.5%	17.5%	9.7%	-	15
CO	Overall	344.9	18.5	53.4%	46.6%	-	-	-	-	-	-	3
	<=10.99	344.9	18.5	53.4%	46.6%	-	-	-	-	-	-	3
BF	Overall	585.3	72.5	-	56.9%	34.1%	-	8.9%	-	-	-	9
	15.00-18.99	547.3	73.4	-	32.2%	67.8%	-	-	-	-	-	2
	19.00-21.99	624.2	120.2	-	52.9%	32.1%	-	15.0%	-	-	-	5
	>22.00	505.0	-	-	100.0%	-	-	nb	-	-	-	2
SS	Overall	1116.4	432.2	-	-	40.3%	-	-	-	59.7%	-	2
	19.00-21.99	1116.4	432.2	-	-	40.3%	-	-	-	59.7%	-	2
	>22.00	-	-	-	-	-	-	-	-	-	-	-
SI	Overall	959.6	144.6	-	-	32.3%	18.8%	8.4%	29.8%	10.8%	-	15
	19.00-21.99	906.8	239.7	-	-	50.3%	-	-	49.7%	-	-	4
	>22.00	973.4	170.3	-	-	27.6%	23.7%	10.5%	24.6%	13.6%	-	11
SD	Overall	1170.4	-	-	-	-	-	-	100.0%	-	-	1
	19.00-21.99	1170.4	-	-	-	-	-	-	100.0%	-	-	1
	>22.00	-	-	-	-	-	-	-	-	-	-	-
TF	Overall	673.0	79.7	-	45.8%	29.2%	8.6%	7.4%	5.3%	-	3.7%	42
	11.00-14.99	620.0	-	-	-	100.0%	-	-	-	-	-	1
	15.00-18.99	698.4	148.8	-	50.5%	23.5%	2.2%	11.0%	8.5%	-	4.4%	19
	19.00-21.99	684.2	94.4	-	37.3%	33.7%	16.1%	5.7%	3.5%	-	3.8%	20
	>22.00	450.6	4.3	-	100.0%	-	-	-	-	-	-	2

Table 64: Percentage of Refrigerators by Nameplate UEC Ranges and Type within Size Ranges

Percentage Above/Below 2001 Federal Appliance Standards

Additionally, the above groupings of secondary refrigerators are compared with the 2001 Federal Appliance Standards for nameplate annual energy consumption, calculated the same as described in the primary refrigerator section.

Table 65 shows that on average, the secondary refrigerators are 35% less efficient than 2001 standards. This is significantly worse than the primary refrigerators that are 5.1% more efficient than standard.

Ref Type	Size Range (CuFt)	Average UEC Relative to 2001 Std	EB	Sample Size
All Types	Overall	-35.2%	12.3%	66
	<=10.99	-	-	0
	11.00-14.99	-40.9%	0.0%	1
	15.00-18.99	-40.2%	29.4%	20
	19.00-21.99	-38.3%	16.0%	30
	>22.00	-25.3%	22.4%	15
CO	Overall	-	-	0
	<=10.99	-	-	0
BF	Overall	-1.7%	13.1%	9
	15.00-18.99	3.6%	10.2%	2
	19.00-21.99	-9.1%	21.8%	5
	>22.00	15.1%	0.1%	2
SS	Overall	-75.9%	75.5%	2
	19.00-21.99	-75.9%	75.5%	2
	>22.00	-	-	0
SI	Overall	-36.8%	22.3%	15
	19.00-21.99	-32.2%	40.2%	4
	>22.00	-37.9%	26.0%	11
SD	Overall	-178.0%	0.0%	1
	19.00-21.99	-178.0%	0.0%	1
	>22.00	0.0%	0.0%	0
TF	Overall	-39.2%	17.4%	39
	11.00-14.99	-40.9%	0.0%	1
	15.00-18.99	-45.3%	32.5%	18
	19.00-21.99	-42.0%	19.7%	18
	>22.00	14.6%	0.9%	2

Table 65: Percentage Comparison to 2001 Federal Appliance Standards By Type of Refrigerator

The distribution of the percentages below the 2001 standards for all full size secondary refrigerators that were successfully matched by size range and type is presented in the table below.

More than 36% of all secondary refrigerators met or exceeded the 2001 standard, while the majority (approximately 38%) have a nameplate UEC of 0.01% to 49.9% worse than 2001 Federal Appliance standards for annual energy consumption.

Size Range (Cu Ft)	Percent Better than 2001 Standards		Percentage Worse than 2001 Standards								Sample Size
	10 to 35%	0 to 9.9%	-0.01% to -	-25% to -49.9%	- 50% to -74.9%	- 75% to -99.9%	-100% to -124.9%	-125% to -149.9%	-150% to -174.9%	-175% to -199.9%	
Overall	21.8%	15.0%	22.9%	15.5%	3.5%	6.0%	6.1%	2.3%	1.1%	4.4%	66
<=10.99	-	-	-	-	-	-	-	-	-	-	0
11.00-14.99	-	-	-	100.0%	-	-	-	-	-	-	1
15.00-18.99	8.1%	33.1%	31.7%	2.6%	2.1%	-	6.7%	3.6%	-	7.9%	20
19.00-21.99	22.2%	9.0%	19.3%	24.8%	-	11.0%	4.2%	2.6%	2.6%	4.5%	30
>22.00	41.0%	4.0%	20.3%	7.5%	12.4%	5.1%	9.7%	-	-	-	15
Overall	-	-	-	-	-	-	-	-	-	-	0
<=10.99	-	-	-	-	-	-	-	-	-	-	0
Overall	49.5%	7.5%	34.1%	-	-	8.9%	-	-	-	-	9
15.00-18.99	32.2%	-	67.8%	-	-	-	-	-	-	-	2
19.00-21.99	40.3%	12.6%	32.1%	-	-	15.0%	-	-	-	-	5
>22.00	100.0%	-	-	-	-	-	-	-	-	-	2
Overall	-	40.3%	-	-	-	-	-	59.7%	-	-	2
19.00-21.99	-	40.3%	-	-	-	-	-	59.7%	-	-	2
>22.00	-	-	-	-	-	-	-	-	-	-	0
Overall	24.1%	4.4%	22.6%	8.4%	13.8%	15.9%	10.8%	-	-	-	15
19.00-21.99	50.3%	-	-	-	-	49.7%	-	-	-	-	4
>22.00	17.3%	5.5%	28.4%	10.5%	17.4%	7.2%	13.6%	-	-	-	11
Overall	-	-	-	-	-	-	-	-	-	100.0%	1
19.00-21.99	-	-	-	-	-	-	-	-	-	100.0%	1
>22.00	-	-	-	-	-	-	-	-	-	-	0
Overall	16.5%	19.4%	21.8%	21.6%	1.0%	2.4%	6.1%	1.7%	1.8%	5.8%	39
11.00-14.99	-	-	-	100.0%	-	-	-	-	-	-	1
15.00-18.99	5.7%	36.5%	28.1%	2.9%	2.3%	-	7.3%	4.0%	-	8.7%	18
19.00-21.99	15.4%	7.6%	20.6%	37.0%	-	5.3%	6.2%	-	3.8%	4.2%	18
>22.00	100.0%	-	-	-	-	-	-	-	-	-	2

Table 66: Percentage range of Secondary Refrigerators with a Nameplate UEC Better or Worse than 2001 Standards by Percentage Bins and Type within Size Ranges

ENERGY STAR Qualified

To qualify for 2001 ENERGY STAR standards, the nameplate annual energy unit consumption of a refrigerator must be at least 10% less than 2001 Federal Appliance Standards for nameplate annual energy consumption. To qualify for 2004 ENERGY STAR standards, the nameplate annual energy consumption of a refrigerator must be at least 15% less than 2001 Federal Appliance Standards for nameplate annual energy consumption. The following analysis is based on a sample of 66 secondary refrigerators for which we have obtained nameplate UEC data.

The distribution of secondary refrigerator/freezers that meet ENERGY STAR qualifications grouped by size and type is shown below. As can be seen in the table the percentage of all secondary refrigerators that meet 2001 ENERGY STAR qualifications is 21.8% with a 9.9% error bound. Additionally, the percentage of secondary refrigerators meeting the 2004 ENERGY STAR qualifications is 15.3% with an error bound of 8.8%.

Ref Type	Size Range (CuFt)	2004 Energy Star Qualified		2001 Energy Star Qualified		Sample Size
		Percentage	EB	Percentage	EB	
All Types	Overall	15.3%	8.8%	21.8%	9.9%	66
	<=10.99	-	-	-	-	0
	11.00-14.99	-	-	-	-	1
	15.00-18.99	8.1%	9.6%	8.1%	9.6%	20
	19.00-21.99	10.3%	11.5%	22.2%	15.3%	30
	>22.00	35.6%	24.2%	41.0%	24.2%	15
CO	Overall	-	-	-	-	0
	<=10.99	-	-	-	-	0
BF	Overall	25.5%	23.1%	49.5%	30.2%	9
	15.00-18.99	32.2%	50.7%	32.2%	50.7%	2
	19.00-21.99	-	-	40.3%	44.2%	5
	>22.00	100.0%	-	100.0%	-	2
SS	Overall	-	-	-	-	2
	19.00-21.99	-	-	-	-	2
	>22.00	-	-	-	-	0
SI	Overall	13.7%	20.3%	24.1%	22.1%	15
	19.00-21.99	-	-	50.3%	45.6%	4
	>22.00	17.3%	24.9%	17.3%	24.9%	11
SD	Overall	-	-	-	-	1
	19.00-21.99	-	-	-	-	1
	>22.00	-	-	-	-	0
TF	Overall	14.5%	11.3%	16.5%	11.6%	39
	11.00-14.99	-	-	-	-	1
	15.00-18.99	5.7%	9.1%	5.7%	9.1%	18
	19.00-21.99	15.4%	16.6%	15.4%	16.6%	18
	>22.00	71.4%	47.4%	100.0%	-	2

Table 67: Percentage of 2001 and 2004 ENERGY STAR Qualified Secondary Refrigerators by Type and Size Range

Water Heaters

The following section summarizes the data on the water heaters that were collected during the on-site visits. As can be seen in Figure 8, the heavy majority of water heaters currently in homes are storage type water heaters. Approximately 79% of all water heaters are of gas storage type, and 13% are of electric storage type.

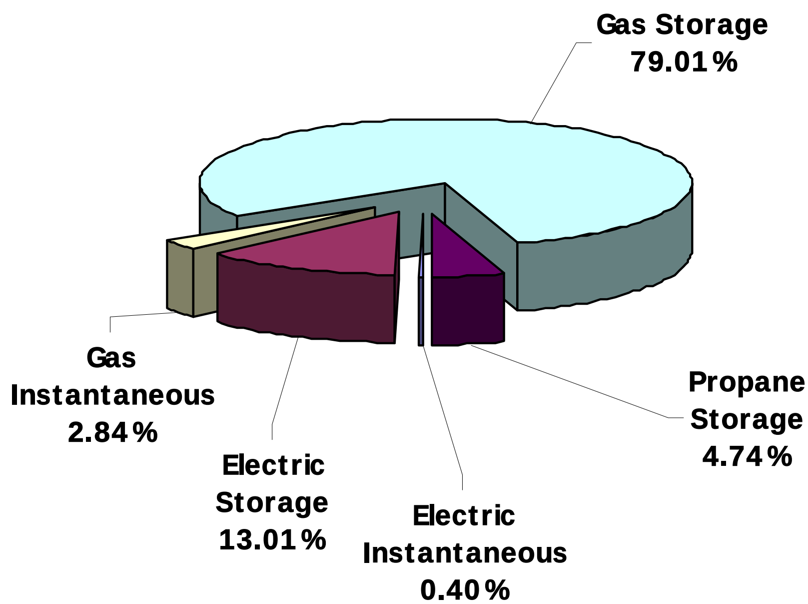

Figure 8: Water Heaters by Type

Fuel Type

Figure 9 shows the breakdown of water heaters by fuel type. The large majority of water heaters are gas, either natural gas or propane, totaling over 86.5% of all water heaters found. About 13.4% of the water heaters are electric.

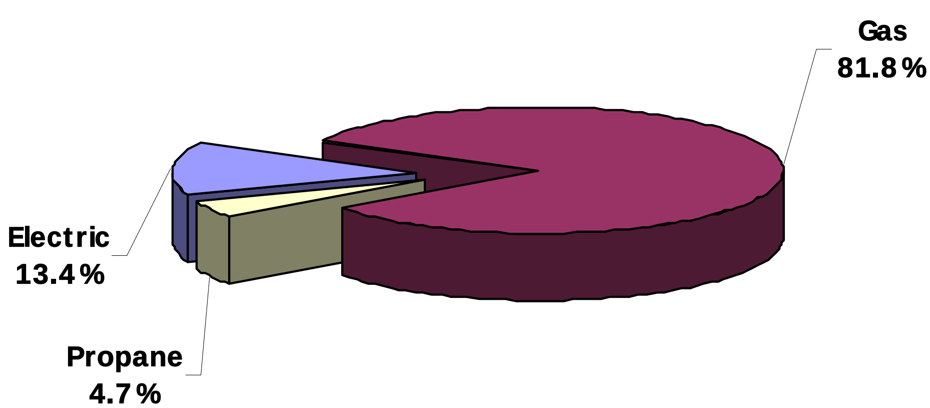

Figure 9: Water Heaters by Fuel Type – 2006

Table 68 and Table 69 compare the percentage of water heaters by fuel type and state for the 2006 study to the 2001 study. The fuel saturations are generally similar across the states with the exception of Montana where the 2006 study found no electric water heaters, and in Oregon where the saturation of electric water heaters surveyed is higher than in 2001.

State	Fuel Choice (%)			n
	Electric	Gas	Propane	
Idaho	6.6%	89.1%	4.3%	179
Montana	0.0%	100.0%	0.0%	18
Oregon	15.5%	81.5%	3.0%	178
Washingon	16.3%	77.3%	6.4%	229

Table 68: Water Heaters by Fuel Type and State – 2006

State	Fuel Choice (%)		
	Electric	Gas	Propane
Idaho	2.6%	92.1%	5.2%
Montana	13.2%	77.4%	9.4%
Oregon	9.1%	90.9%	0.0%
Washingon	14.0%	75.7%	10.3%

Table 69: Water Heaters by Fuel Type and State - 2001

Table 70 shows the average size of the water heaters, overall and for each of the fuel types. The average sizes of the units were obtained from two sources, the first being from the manufacturer if the model number matched a model in the efficiency databases, the second being from the site visit if the model was not matched. The surveyor attempted to obtain the capacity of the water heater from the nameplate information; if no nameplate capacity data were available, the surveyor made an estimate wherever possible.

Fuel	Average Size (Gallons)	EB	Sample Size
All Types	49.1	1.0	600
Electric	57.8	2.9	72
Gas	47.3	1.1	505
Propane	54.0	3.2	23

Table 70: Average Size of Water Heaters by Fuel Type

Table 71 shows the percentage of water heaters in each size range within each fuel type. The sample sizes used to calculate the percentages in each fuel type are also presented in the table below. Notice that the distribution of water heater capacities differs slightly for electric and gas units. A majority of both gas and electric units are in the 50 to 59 gallon range. Additionally, approximately 31.7% of gas units are in the 40-49 gallon range.

Size (Gallons)	Fuel Type							
	All Types (n=600)		Electric (n=72)		Gas (n=505)		Propane (n=23)	
	%	EB	%	EB	%	EB	%	EB
Tankless	3.3%	1.3%	3.0%	2.7%	3.5%	1.6%	-	-
Gallons 40 to 49	26.1%	3.7%	-	-	31.7%	4.3%	3.8%	6.1%
Gallons 50 to 59	56.2%	3.9%	55.0%	10.7%	55.1%	4.3%	78.7%	13.4%
Gallons 60 to 69	4.5%	1.5%	21.0%	9.1%	2.0%	0.9%	-	-
Gallons 70 to 79	7.2%	2.0%	2.8%	4.5%	7.3%	2.2%	17.5%	12.3%
Gallons 80 to 89	2.7%	1.2%	18.2%	7.9%	0.3%	0.4%	-	-

Table 71: Percentage of Water Heaters by Size Range and Fuel Type

Table 72 shows the percentage of total water heaters by fuel type within the size ranges. These percentages were calculated as a proportion relative to the entire set of water heaters, regardless of fuel type. This summary table better displays the actual percentage of the population of water heaters in each size range. The previous table shows that the 50 to 99 gallon size range accounts for 55% of all electric water heaters and Table 72 shows that the same size electric heaters constitute only 7.4% of the entire population. However, the same table also shows the market dominance of 50 to 59 gallon water heaters that account for 56.2% of all water heaters.

Size (Gallons) (n=600)	All Types		Electric		Gas		Propane	
	%	EB	%	EB	%	EB	%	EB
Tankless	3.3%	1.3%	0.4%	0.4%	2.9%	1.3%	-	-
40 to 49 Gallons	26.1%	3.7%	-	-	25.9%	3.7%	0.2%	0.3%
50 to 59 Gallons	56.2%	3.9%	7.4%	2.1%	45.0%	3.8%	3.8%	1.5%
60 to 69 Gallons	4.5%	1.5%	2.8%	1.4%	1.7%	0.7%	-	-
70 to 79 Gallons	7.2%	2.0%	0.4%	0.6%	6.0%	1.8%	0.8%	0.6%
80 to 89 Gallons	2.7%	1.2%	2.5%	1.1%	0.3%	0.3%	-	-

Table 72: Percentage of Water Heaters within each Size Range Among all Water Heaters

Age

Table 73 shows the average age of water heaters by fuel type in each of the size ranges. The ages of the water heaters were obtained during the site visit only. No age information was available in the efficiency databases. The average age of all water heaters for which an age obtained is 1.6 years old. The ages of the electric and gas water heaters are not significantly different.

Size (Gallons)	Fuel Type											
	All Types			Electric			Natural Gas			Propane		
	Average Age	EB	Sample Size	Average Age	EB	Sample Size	Average Age	EB	Sample Size	Average Age	EB	Sample Size
All Sizes	1.6	0.1	603	1.4	0.2	68	1.6	0.1	494	1.6	0.4	23
Tankless	1.3	0.3	18.0	1.4	0.4	4.0	1.2	0.3	14.0	-	-	-
40 to 49	1.8	0.2	158	-	-	-	1.8	0.2	157	1.0	-	1
50 to 59	1.5	0.1	335	1.6	0.2	39	1.5	0.1	279	1.8	0.4	17
60 to 69	1.4	0.2	30	1.4	0.2	12	1.3	0.2	18	-	-	-
70 to 79	1.3	0.3	40	1.0	-	1	1.4	0.3	34	0.8	0.5	5
80 to 89	0.8	0.2	18	0.8	0.3	16	0.5	0.6	2	-	-	-
Size Unknown	1.2	0.3	4	-	-	-	1.2	0.3	4	-	-	-

Table 73: Average Age of Water Heaters by Fuel Type within Size Ranges

Table 74 shows the percentage of water heaters within each fuel type and size range that fall into each of the manufacture date ranges. The first row of data, representing all water heaters, shows the largest percentage was manufactured in the last 3 years, totaling over 92.6% of all the units.

All size/fuel categories with a substantial sample show a similar distribution of age ranges. The largest percentage of water heaters is found in the most recent age range and the percentage decreases with each successive older age range ending with a few percent in the 2000 and older category.

Fuel Type	Size Range (Gallons)	Estimated Manufacture Date 2004-2006	2001-2003	1998-2000	Sample Size
All Types	All Sizes	92.6%	7.3%	0.1%	603
	40 to 49	82.4%	17.6%	-	158
	50 to 59	95.5%	4.2%	0.3%	335
	60 to 69	100.0%	-	-	30
	70 to 79	94.7%	5.3%	-	40
	80 to 89	100.0%	-	-	18
	Tankless	100.0%	-	-	18
	Size Unknown	100.0%	-	-	4
Electric	All Sizes	98.5%	0.5%	1.1%	72
	50 to 59	97.2%	0.8%	2.0%	39
	60 to 69	100.0%	-	-	12
	70 to 79	100.0%	-	-	1
	80 to 89	100.0%	-	-	16
	Tankless	100.0%	-	-	4
Natural Gas	All Sizes	92.0%	8.0%	-	508
	40 to 49	82.3%	17.7%	-	157
	50 to 59	96.4%	3.6%	-	279
	60 to 69	100.0%	-	-	18
	70 to 79	93.6%	6.4%	-	34
	80 to 89	100.0%	-	-	2
	Size Unknown	100.0%	-	-	14
	Tankless	100.0%	-	-	4
Propane	All Sizes	86.0%	14.0%	-	23
	40 to 49	100.0%	-	-	1
	50 to 59	82.2%	17.8%	-	17
	70 to 79	100.0%	-	-	5

Table 74: Percentage of Water Heaters in Purchase Date Ranges by Fuel Type

Energy Factor

Energy factor for water heaters is a measure of efficiency expressed as the ratio defined below, where a higher energy factor equates to a more efficient water heater:

$$\frac{\text{heater supplied energy content of the delivered hot water}}{\text{energy consumed by the water heater}}$$

The average energy factor for the popular 40 gallon gas fired water heater is 0.58, which is slightly below the average of 0.59 from the National Appliance Energy Conservation Act Standards (NAECA), implemented in 2004. However, the average energy factor for gas models of the two most popular sizes (40 and 50 gallon) are above the federal standard.

Energy Factor Comparison			
Size	**Fuel Type**	**Energy Factor Standard**	**Average Energy Factor**
40 Gallons	Gas	0.59	0.58
50 Gallons	Propane	0.53	0.58
50 Gallons	Gas	0.53	0.58
50 Gallons	Electric	0.90	0.91

Table 75: Energy Factor Comparison

Table 76 shows the average energy factor by fuel type within each size range. The energy factor was obtained from the efficiency databases, thus only the models that matched were included in the following summary table. The average energy factor from matched gas units is 0.58 while the average energy factor for all electric units is 0.9.

Size (Gallons)	Fuel Type								
	Electric			Natural Gas			Propane		
	Average Energy Factor	EB	Sample Size	Average Energy Factor	EB	Sample Size	Average Energy Factor	EB	Sample Size
All Sizes	0.90	0.01	25	0.58	0.00	368	0.56	1.8%	16
40 to 49	-	-	-	0.58	0.00	113	-	-	-
50 to 59	0.91	0.01	15	0.58	0.00	222	0.58	0.9%	13
60 to 69	0.87	0.01	4	0.55	0.00	12	-	-	-
70 to 79	0.92	0.00	1	0.53	0.02	17	0.49	1.0%	3
80 to 89	0.87	0.03	5	-	-	-	-	-	-
Tankless	-	-	-	0.83	0.01	4	-	-	-

Table 76: Average Energy Factor by Fuel Type in Size Ranges

Table 77 shows the percentage of water heaters within each fuel type and size range that fall into each of the energy factor ranges. Energy factors of gas water heaters are clustered throughout the range from 0.48 to 0.84, while all electric water heaters fall within the range from 0.84 to 0.95. It is difficult to make any comprehensive comparisons between these data and the 2004 federal standard due to the standard being a function of water heater volume, but a table containing the federal standard is in the Appendix so that comparisons can be made as desired.

Fuel Type	Size Range (Gallons)	Energy Factor																		
		0.48 to 0.519	EB	0.52 to 0.559	EB	0.56 to 0.599	EB	0.60 to 0.639	EB	0.64 to 0.679	EB	0.80 to 0.839	EB	0.84 to 0.879	EB	0.88 to 0.919	EB	0.92 to 0.959	EB	Sample Size
Electric	All Sizes	-	-	-	-	-	-	-	-	-	-	-	-	33.2%	15.9%	31.0%	16.4%	35.8%	18.3%	25
	Tankless	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	50 to 59	-	-	-	-	-	-	-	-	-	-	-	-	22.1%	17.7%	35.3%	22.0%	42.6%	24.1%	15
	60 to 69	-	-	-	-	-	-	-	-	-	-	-	-	48.1%	41.4%	51.9%	41.4%	-	-	4
	70 to 79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0%	-	1
	80 to 89	-	-	-	-	-	-	-	-	-	-	-	-	79.8%	29.6%	-	-	20.2%	29.6%	5
Gas	All Sizes	2.2%	1.3%	15.5%	3.6%	69.8%	4.6%	8.8%	2.9%	2.1%	1.5%	1.1%	1.1%	0.5%	0.7%	-	-	-	-	368
	Tankless	-	-	-	-	-	-	-	-	-	-	64.0%	40.9%	36.0%	40.9%	-	-	-	-	4
	40 to 49	-	-	6.9%	4.4%	81.9%	7.2%	10.6%	6.0%	-	-	0.5%	0.9%	-	-	-	-	-	-	113
	50 to 59	-	-	16.6%	4.9%	72.5%	5.7%	8.2%	3.4%	2.7%	2.2%	-	-	-	-	-	-	-	-	222
	60 to 69	-	-	100.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
	70 to 79	49.2%	21.4%	30.5%	19.9%	-	-	9.0%	13.9%	11.3%	13.7%	-	-	-	-	-	-	-	-	17
	80 to 89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Propane	All Sizes	14.7%	13.3%	14.7%	15.6%	62.7%	20.5%	8.0%	12.4%	-	-	-	-	-	-	-	-	-	-	16
	40 to 49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	50 to 59	-	-	17.2%	18.1%	73.5%	21.3%	9.3%	14.5%	-	-	-	-	-	-	-	-	-	-	13
	70 to 79	100.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3

Table 77: Percentage of Water Heaters in Energy Factor Ranges by Fuel Type and Size

Table 78 shows the percentage of all water heaters broken down by whether the tank was wrapped with insulation or unwrapped. The unknown category contains tanks that were unobservable. Approximately 97.6% of the observed water heaters were unwrapped.

Fuel Type	Size Range (Gallons)	Tank Wrapped		Tank Not Wrapped		Sample Size
		%	EB	%	EB	
All Types	Overall	2.4%	1.2%	97.6%	1.2%	604
	Tankless	-	-	100.0%	-	18
	40 to 49	1.5%	1.5%	98.5%	1.5%	158
	50 to 59	1.2%	1.0%	98.8%	1.0%	336
	60 to 69	8.5%	9.5%	91.5%	9.5%	30
	70 to 79	3.5%	5.7%	96.5%	5.7%	40
	80 to 89	15.4%	22.1%	84.6%	22.1%	18
	Size Unknown	36.8%	45.4%	63.2%	45.4%	4

Table 78: Percentage of Water Heaters that were Wrapped and Unwrapped

Clothes Washers

This section describes the clothes washer data. The model numbers collected on the washers were linked with the CEC database in order to obtain the energy factor. There were no manufacture date data, thus all the age data presented in this section are customer reported dates from the on site survey.

Approximately 99.77% of all homes have a clothes washing machine (all but one home).

Type of Residence	%	EB	Sample Size
Overall	99.8%	0.4%	604
Single Family Unattached (1 story)	99.4%	1.0%	206
Single Family Unattached (2 stories)	100.0%	-	375
Single Family Unattached (3 or more stories)	100.0%	-	15
Single Family Attached	100.0%	-	8

Table 79: Percentage of Homes with Clothes Washers by Type of Residence

Table 80 shows the distribution of the 603 clothes washers found on site, presented by type of washer and type of residence. Nearly 36% of all washers found were horizontal-axis washing machines. The largest percentage of homes with horizontal-axis washers occurred in single-family three or more story houses. Approximately 51% of all homes of that type with washers have horizontal-axis washers, though it should be noted that the sample size is quite small to represent all homes with three or more floors. The second largest percentage was around 39% and was found in the 2 story houses.

Type of Residence	Horizontal Axis		Standard		Stacked		Unknown		Sample Size
	%	EB	%	EB	%	EB	%	EB	
Overall	35.6%	3.8%	59.7%	3.8%	3.3%	1.3%	1.4%	0.8%	603
Single Family Unattached (1 story)	28.7%	5.7%	66.6%	6.0%	4.5%	2.5%	0.2%	0.3%	205
Single Family Unattached (2 stories)	39.3%	5.0%	56.1%	5.1%	2.4%	1.5%	2.1%	1.3%	375
Single Family Unattached (3 or more stories)	50.7%	23.1%	42.2%	23.4%	7.1%	11.3%	-	-	15
Single Family Attached	19.9%	28.1%	80.1%	28.1%	-	-	-	-	8

Table 80: Distribution of Clothes Washers by Type of Washer and by Type of Residence

The sample size of washers with age information was 563 washers. Again, the data on the year of manufacture of the washing machine is the year that the customer reported. The washing machine was excluded from this part of the analysis if the customer was not aware of the age of the machine. As can be seen from the table below, most of the washers (84.6%) in the data were manufactured between 2000 and 2006. Among the remaining washers, approximately 10% were manufactured between 1995 and 1999. The average overall self-reported age of clothes washers is 3.5 years old.

Manufacture Date Range	% (n=563)	EB
2000-2006	84.6%	2.8%
1995-1999	10.1%	2.5%
1990-1994	3.5%	1.3%
1985-1989	1.0%	0.6%
1980-1984	0.4%	0.5%
1979 and older	0.4%	0.5%

Table 81: Distribution of Manufactured Date of Clothes Washers

In 2004 federal standards switched from rating clothes washer efficiencies from Energy Factor (EF) units to Modified Energy Factor (MEF) units. The change was made due to differences in the amount of water extracted from the clothing between different models. The MEF accounts for these differences, which have an impact on the energy consumption of the clothes dryer.

Modified Energy Factor for clothes washers is a ratio of cubic feet per kWh per cycle. The current federal efficiency standards for clothes washers, effective in 2004, set a minimum energy factor of 1.04. The minimum ENERGY STAR qualifying MEF is 1.42 for all clothes washers. The average MEF of each of the types of clothes washers, based upon the sample of clothes washers that were successfully linked with the efficiency database, meets the 2004 minimum standard energy factor. Additionally, it is apparent that horizontal axis washers, which easily achieved ENERGY STAR qualifying levels on average, perform significantly better than standard units.

Type of Washer	2004 MEF Minimum Standard	Energy Star Qualifying MEF	Average Modified Energy Factor	EB	Sample Size
H-Axis	1.04	1.42	1.84	0.04	118
Stacked H-Axis	1.04	1.42	1.79	0.11	11
Standard	1.04	1.42	1.49	0.09	56

Table 82: Average Modified Energy Factor and Comparative Standards

The following table summarizes the modified energy factor distribution relative to efficiency standards. It shows that all washers exceed the minimum federal requirements, and 99.6% of horizontal axis washers exceed ENERGY STAR minimum requirements. All Stacked horizontal axis washers exceed ENERGY STAR minimum requirements. Surprisingly, even 59.3% of standard washers exceed the ENERGY STAR minimum requirement. Overall, almost 90% of all washers meet or exceed the ENERGY STAR threshold.

Type of Washer	Modified Energy Factor				Sample Size
	< 1.04	1.04 to 1.42	1.43 to 1.8	> 1.8	
All Washers	-	11.2%	50.8%	38.0%	185
H-Axis	-	0.4%	53.1%	46.6%	118
Stacked H-Axis	-	0.0%	47.9%	52.1%	11
Standard	-	40.7%	46.1%	13.2%	56

Table 83: Modified Energy Factor Distribution Relative to Standards

NEEA is not far from achieving their market share goal for ultra-high-efficiency (UHE; modified energy factor >1.8) clothes washers of at least 50 percent of all ENERGY STAR clothes washers by 2007.

Clothes Dryers

The following section describes the clothes dryers found during the on site surveys. Data on clothes dryers were very limited in the CEC database. This section contains information on the percentage of homes with dryers, the breakdown of the fuel types, age of the dryers obtained by the surveyors during the site visits, average energy factor, and presence of a moisture sensor.

Approximately 99% of all sites that were visited have a dryer. Table 84 shows the breakdown of the percentage of homes with dryers by residence type. The error bound and sample size for each type of residence is also displayed in the table.

Type of Residence	Percentage with Dryer	EB	Sample Size
Overall	99.7%	0.4%	604
Single Family Unattached (1 story)	99.2%	1.1%	206
Single Family Unattached (2 stories)	100.0%	-	375
Single Family Unattached (3 or more stories)	100.0%	-	15
Single Family Attached	100.0%	-	8

Table 84: Percentage of Homes with Dryers by Type of Residence

Figure 10 shows the breakdown of fuel types among all dryers found during the on site visits. A total of 604 homes in the sample have dryers. The majority of homes used electric dryers, while about 10% used gas dryers.

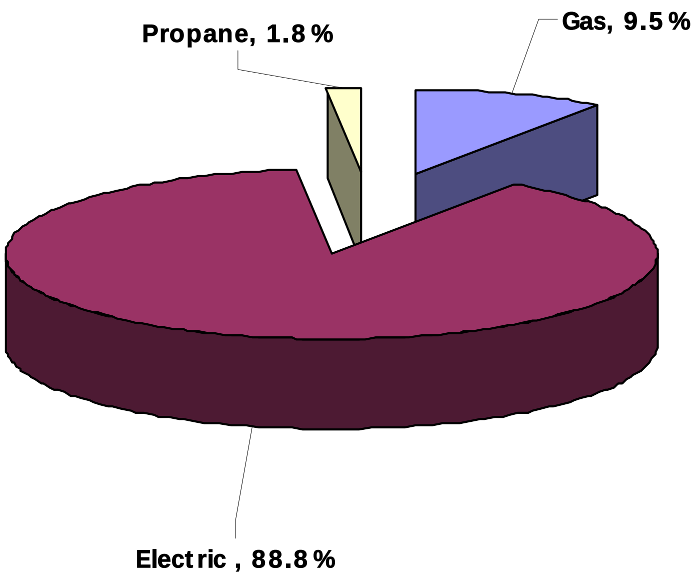

Figure 10: Percentage of Dryers by Fuel Type

The data on the age of the dryers were obtained from either the owner of the house or the surveyor estimation of the age. A total of 583 dryers in the sample have an estimated age. The average weighted age of the dryers is 3.8 years old. Table 85 shows the distribution of the estimated manufacture date for the dryers. The largest percentage of dryers is between 0 to 6 years old. However, 10% of all dryers are between 7 and 11 years old.

Manufacture Date Range	Percentage (n=583)	EB
2000-2006	82.9%	2.9%
1995-1999	10.0%	2.3%
1990-1994	4.6%	1.5%
1985-1989	1.3%	0.9%
1980-1984	0.7%	0.8%
1979 and older	0.5%	0.5%

Table 85: Distribution of Estimated Manufacture Date of Dryers

As the databases containing efficiency data for dryers are not extensive, only 49 energy factors were obtained from matching model numbers. The reader should understand that the energy factors presented are based upon limited data and may be biased towards newer models that were entered into the databases. The average energy factor was 3.06 with an error bound of 0.03.

Average Energy Factor	EB	Sample Size
3.07	0.02	49

Table 86: Average Dryer Energy Factor

Moisture sensors detect the amount of moisture in the load of laundry, and terminate the cycle prematurely if the moisture content reaches a certain moisture threshold. Machines with this option save energy and wear, as it prevents over-drying. Table 87 illustrates that the feature was observed in over half of the dryers found in new homes.

(n=604)	Presence of Moisture Sensor	
	Percentage	EB
Yes	50.6%	3.9%
No	49.4%	3.9%

Table 87: Dryers with Moisture Sensors

Dishwashers

The following section summarizes the 603 dishwashers found during the site visit. The data were merged with CEC database to obtain the energy factor for the model. This section contains information on the percentage of homes with dishwashers, the age of the dishwasher obtained by the surveyor during the site visit, and the energy factor from the CEC database.

Table 88 shows the percentage of homes with dishwashers by type of home. Approximately 99.9% of all homes have a dishwasher.

Type of Residence	Percentage with Dishwashers	EB	Sample Size
Overall	99.9%	0.2%	604
Single Family Unattached (1 story)	100.0%	-	206
Single Family Unattached (2 stories)	99.8%	0.4%	375
Single Family Unattached (3 or more stories)	100.0%	-	15
Single Family Attached	100.0%	-	8

Table 88: Percentage of Homes with Dishwasher by Type of Residence

Based on the subset of 603 dishwashers for which age information was found, 99% of the dishwashers were built in 2004-2006.

Manufacture Date Range	Percentage (n=603)	EB
2004-2006	99.0%	0.7%
2001-2003	0.9%	0.7%
1998-2000	0.1%	0.2%

Table 89: Distribution of Manufacture Date of Dishwashers

Energy factor for dishwashers is defined as loads per kWh. The average energy factor for all dishwashers that were matched to the CEC database is 0.535. Table 90 displays the average energy factor compared to the current federal minimum standard, enacted in 1994 (n=176). Overall, only 36% of the dishwasher model numbers were successfully matched. There should not be any systematic bias in the efficiency of the units matched, but the reader should be aware of the low match rate.

Dishwasher Energy Factor		
Current Federal Standards	Minimum Energy Star Qualification	Average Energy Factor
0.46	0.58	0.536

Table 90: Comparison of Energy Factor with Federal Standards

The distribution of dishwasher energy factors is found in Table 91. The highest percentage of dishwashers with energy factors falls within the range of 0.460 to 0.579, containing 70% of the dishwashers. This energy factor range encompasses all dishwashers that met 1994 standards but were below the current ENERGY STAR minimum. The range of 0.580 to 0.775 accounts for all dishwashers that met or exceeded the ENERGY STAR minimum qualifying energy factor of 0.58. The total percentage of dishwashers meeting 1994 federal standards is 99.5%. The sample size for the distribution of the energy factors is 149, which is the total number of dishwashers in single-family residences that we were able to match with the CEC database.

Energy Factor	Percentage	EB
0.275 - 0.459	0.5%	0.7%
0.460 - 0.579	68.9%	6.3%
0.580 - 0.775	30.7%	6.3%

Table 91: Distribution of Energy Factor of Dishwashers

Cooling Equipment

This section presents the summary analysis of the data on primary cooling equipment found at the 375 sites that had air conditioning. The air conditioner model numbers were linked with efficiency databases from the ARI, CEC, Carrier Bluebook, and FTC in order to obtain manufacture date, capacity, seasonal energy efficiency ratio (SEER), and energy efficiency ratio (EER).

The primary cooling equipment identified during this study was of five distinct types

- Packaged System Air Conditioning - These units have the air-conditioning cycle components, the condenser, compressor, evaporator (cooling) coil and air handler fan, combined into one piece of equipment or "package". The equipment can be mounted on the roof or the side of a residence depending on the duct location.
- Split System Air Conditioning - These units are the typical residential air-conditioner with a "split" between an indoor and outdoor piece of equipment. These pieces include a remote condenser and compressor located outside the home and commonly referred to as the outdoor or condensing unit. The indoor unit is typically in the same location as the furnace and houses the evaporator coil and air handler fan.
- Split System Heat Pumps - These units are similar to Split System A/Cs, but are configured to operate in both a normal and reverse refrigeration cycle. This allows the heat pump to provide cool air in the summer and warm air in the winter.
- Packaged Terminal Air Conditioning (PTAC) - These systems are commonly referred to as window units, room A/Cs, or wall units. They are package units because they have all components located in the same piece of equipment, but have a lower range of available cooling capacity. This category includes packaged terminal heat pumps.
- Portable- Stand Alone Units - These systems are sometimes called spot coolers and are similar to PTACs, but they are not mounted in a fixed location.

The distribution of these cooling equipment types is shown below in Table 92.

System Type (n=604)		% of Primary Cooling Types	EB
None		42.0%	3.8%
Central	Heat Pump	7.8%	2.2%
	Packaged System A/C	3.1%	1.4%
	Split System A/C	46.1%	3.9%
Space	Portable- Stand Alone	0.2%	0.2%
	PTAC	0.7%	0.7%

Table 92: Distribution of Cooling System Types

In the 2001 study, all states but Idaho had an average cooling equipment saturation of about 20%. Idaho had a significantly higher penetration, with nearly all homes in Boise with AC, and non-Boise areas at about 30%, resulting in a total cooling saturation of over 70% in Idaho. Table 93 presents the 2006 study results. The penetration of AC systems has increased in all states.

State	Have AC	EB	n
Idaho	86.5%	5.9%	179
Montana	61.4%	18.8%	18
Oregon	65.4%	6.8%	178
Washingon	41.4%	6.3%	229

Table 93: Presence of AC System – 2006

The analysis of cooling equipment is presented in this section. We will include heat pumps in this analysis and consider heat pumps the same as air conditioners, as the cooling portion of a heat pump is very similar in terms of energy use to a standard A/C.

From our analysis of the surveyed residences, 42% with a 3.8% error bound of homes have no cooling equipment in place. The remaining homes have one or more cooling equipments present. Of the homes that have primary cooling equipment, the distribution of central systems versus space cooling units is shown below.

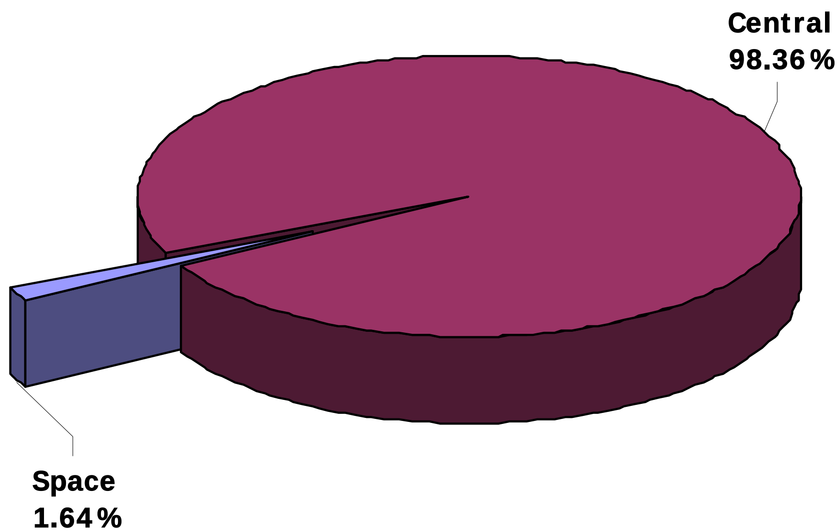

Figure 11-The Distribution of Primary Cooling Systems

Cooling equipment was classified into five types; heat pump, packaged system A/C, and Split System AC, all classified as central systems, and window units, and portable considered space units. The data show that the majority of systems are split A/C which corresponds to common building practices. The second most predominant systems were Heat Pumps.

Equipment Type	Central (n=370)		Space (n=5)	
	% of System Class	EB	% of System Class	EB
Heat Pump	13.7%	3.7%	-	-
Packaged System AC	5.5%	2.4%	-	-
Split System A/C	80.8%	4.2%	-	-
PTAC	-	-	78.0%	25.6%
Portable	-	-	22.0%	25.6%

Table 94: Breakdown of Classes of Primary Cooling Systems by Equipment Type

Table 95 below shows the average estimated age of the primary system found at a residence. The estimated ages were obtained from a combination of dates that were gathered from the manufacturer nameplate and the surveyor estimates during the on site visit. The sample size of 375 (summing central and space units) represents all sites that were found with some type of cooling equipment and age estimate. The average central air conditioning system type is 1.45 years old, and the average space air conditioning system is 1.5 years old. As would be expected, the air conditioners are new and not being recycled from older homes.

Air Conditioning System Type		Primary Cooling System Estimated Age	EB	Sample Size
Central	All Types	1.45	0.07	370
	Heat Pump	1.55	0.16	40
	Packaged System A/C	1.56	0.44	18
	Split System A/C	1.43	0.08	312
Space	All Types	1.52	0.39	5
	Portable- Stand Alone	1.00	-	2
	PTAC	1.66	0.45	3

Table 95 Average Age of Primary Cooling Equipment

Table 96 shows the percentage distribution for each type of cooling system by age or year manufactured. Most (approximately 95%) of the primary central and space type air conditioners were manufactured in 2004 or 2005.

Age	Central								Space			
	All Types		Heat Pump		Packaged		Split System		Portable- Stand		PTAC	
	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB
2006	2.7%	1.5%	3.7%	4.3%	4.3%	7.0%	2.5%	1.6%	-	-	-	-
2005	53.7%	5.3%	39.2%	14.2%	55.6%	22.5%	56.0%	6.0%	100%	-	33.9%	45.0%
2004	41.3%	5.4%	55.8%	14.5%	29.0%	21.4%	39.7%	6.1%	-	-	66.1%	45.0%
2003	1.3%	1.0%	1.3%	2.2%	1.9%	3.2%	1.3%	1.2%	-	-	-	-

Table 96: Age Range Distribution of Cooling System by Types

Table 97 below shows bin distributions of capacities for cooling system types. The capacities were obtained from a combination of manufacturer information and the surveyor estimates during the on site visit. The sample size of 354 represents all cooling equipment for which capacity data was obtained. All central air conditioning capacities were found to be between 2.0 and 5.0 tons. The largest percentage bin of combined central air conditioning types is 26.8% found in the 3 to 3.49 ton range. The largest percentage bin of space air conditioning type window/wall units (PTAC) is 51.3% and falls in the 1.0 to 1.49 ton range.

Ton Range	Central								Space			
	All Central (n=354)		Heat Pump (n=40)		Packaged System A/C (n=17)		Split System A/C (n=297)		Portable- Stand Alone (n=2)		PTAC (n=2)	
	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB
0.5-0.99	-	-	-	-	-	-	-	-	100%	-	48.7%	58.0%
1.0-1.49	-	-	-	-	-	-	-	-	-	-	51.3%	58.0%
1.5-1.99	-	-	-	-	-	-	-	-	-	-	-	-
2.0-2.49	10.2%	3.0%	7.7%	7.2%	13.8%	15.7%	10.4%	3.4%	-	-	-	-
2.5-2.99	19.6%	4.0%	17.9%	10.9%	22.9%	19.8%	19.7%	4.4%	-	-	-	-
3.0-3.49	26.8%	5.0%	28.9%	13.6%	15.3%	15.3%	27.2%	5.6%	-	-	-	-
3.5-3.99	14.4%	3.6%	11.0%	9.7%	22.5%	20.6%	14.4%	3.9%	-	-	-	-
4.0-4.49	19.9%	4.8%	23.9%	13.1%	13.8%	15.1%	19.6%	5.3%	-	-	-	-
4.5-5.00	9.1%	2.8%	10.6%	7.7%	11.8%	12.7%	8.6%	3.1%	-	-	-	-

Table 97: Size Distribution of Cooling Systems by Type

Table 98 shows the percentage of cooling systems by type and capacity within age ranges. For example, from the table we can identify that 53.7% of all types of central cooling units were built in 2005.

Central System Type	Ton Range	Age 2006		Age 2005		Age 2004		Age 2003		Sample Size
		%	EB	%	EB	%	EB	%	EB	
All Types	All Ranges	2.7%	1.4%	53.6%	5.3%	41.5%	5.4%	1.3%	1.0%	375
	2.0 to 2.49	9.5%	9.0%	38.5%	14.4%	50.6%	15.5%	1.3%	2.2%	36
	2.5 to 2.9	3.5%	4.1%	52.8%	11.1%	43.0%	11.2%	0.7%	1.1%	75
	3.0 to 3.49	0.9%	1.5%	51.5%	11.2%	43.5%	11.5%	2.1%	2.8%	90
	3.5 to 3.9	-	-	64.4%	13.4%	34.3%	13.4%	1.3%	2.2%	51
	4.0 to 4.49	2.3%	2.7%	45.7%	13.3%	48.0%	14.0%	1.7%	2.8%	63
	4.5 to 5	2.7%	4.4%	76.7%	13.4%	20.6%	13.0%	-	-	39
	Unknown	4.6%	7.4%	62.4%	21.3%	33.0%	21.2%	-	-	17
Heat Pump	All Ranges	3.7%	4.3%	39.2%	14.2%	55.8%	14.5%	1.3%	2.2%	40
	2.0 to 2.49	24.0%	36.6%	-	-	76.0%	36.6%	-	-	3
	2.5 to 2.9	10.4%	16.6%	30.0%	30.4%	59.6%	32.1%	-	-	7
	3.0 to 3.49	-	-	65.1%	27.8%	34.9%	27.8%	-	-	11
	3.5 to 3.9	-	-	-	-	87.8%	20.8%	12.2%	20.8%	4
	4.0 to 4.49	-	-	43.9%	31.5%	56.1%	31.5%	-	-	9
	4.5 to 5	-	-	42.3%	35.8%	57.7%	35.8%	-	-	6
Packaged System A/C	All Ranges	4.3%	7.0%	55.6%	22.5%	29.0%	21.4%	1.9%	3.2%	18
	2.0 to 2.49	32.0%	50.5%	-	-	68.0%	50.5%	-	-	2
	2.5 to 2.9	-	-	20.4%	32.8%	79.6%	32.8%	-	-	3
	3.0 to 3.49	-	-	25.9%	34.5%	-	-	12.9%	22.8%	4
	3.5 to 3.9	-	-	91.2%	16.0%	8.8%	16.0%	-	-	3
	4.0 to 4.49	-	-	100%	-	-	-	-	-	2
	4.5 to 5	-	-	100%	-	-	-	-	-	3
	Unknown	-	-	100%	-	-	-	-	-	1
Split System A/C	All Ranges	2.5%	1.6%	56.0%	6.0%	39.7%	6.1%	1.3%	1.2%	312
	2.0 to 2.49	5.5%	8.7%	47.2%	16.7%	45.6%	17.2%	1.6%	2.7%	31
	2.5 to 2.9	2.6%	4.3%	59.2%	12.0%	37.3%	11.9%	0.9%	1.4%	65
	3.0 to 3.49	1.1%	1.9%	49.9%	12.4%	46.8%	12.7%	2.1%	3.4%	75
	3.5 to 3.9	-	-	70.2%	14.2%	29.8%	14.2%	-	-	44
	4.0 to 4.49	2.9%	3.4%	43.3%	14.7%	48.6%	15.9%	2.2%	3.6%	52
	4.5 to 5	3.6%	5.8%	82.0%	13.5%	14.5%	12.6%	-	-	30
	Unknown	5.1%	8.3%	57.9%	22.7%	36.9%	22.7%	-	-	15

Table 98: Size Distributions by Age Range for Central System Types

Seasonal energy efficiency ratio (SEER) is a measure of air conditioning efficiency given in kBtu of cooling delivered per kWh of electrical energy consumed. The SEER data for this analysis were obtained strictly from the manufacturer data of matched model numbers. The sample of size of 310 represents all of the cooling systems that were successfully matched with manufacturer data.

The distribution of SEER range by cooling system type is shown below in Table 99. The greatest amount of combined central system air conditioners are in the 10 to 10.99 SEER range accounting for 81.8% of central systems with a 4.2% error bound. As these homes were permitted before 2006, the 10 to 10.99 SEER range met the national standard of that time, though it should be noted that the current national standard has increased to 13 SEER. The ENERGY STAR threshold has increased to 14 SEER.

Efficiency Range	All Central Types (n=310)		Heat Pump (n=16)		Packaged System A/C (n=14)		Split System A/C (n=280)	
	%	EB	%	EB	%	EB	%	EB
14 or Higher SEER	2.5%	1.5%	-	-	-	-	2.8%	1.7%
13 - 13.99 SEER	2.8%	1.5%	19.5%	15.3%	-	-	2.0%	1.4%
12 - 12.99 SEER	8.9%	3.1%	41.0%	24.3%	5.5%	9.0%	7.2%	2.9%
11 - 11.99 SEER	2.6%	1.8%	-	-	-	-	2.9%	2.0%
10 - 10.99 SEER	82.0%	4.2%	39.5%	23.2%	94.5%	9.0%	83.6%	4.2%
9 to 9.99 SEER	1.3%	1.2%	-	-	-	-	1.4%	1.4%

Table 99: Distribution of Cooling Systems by SEER ranges and Cooling System Type

The distribution of average SEER values across the system capacity ranges is shown in Table 100. The average SEER for capacity range can be observed in this table. For split system units in the range of 3.0 to 3.49 tons, the most saturated capacity range, the average system efficiency is 10.3 with an error bound of 0.1. The most efficient units are heat pumps in the 4.5 to 4.99 range with an efficiency of 12.6.

System Type	Ton Range	Average Efficiency	EB	Sample Size
All Central	2.0 to 2.49	10.1	0.1	35
	2.5 to 2.9	10.2	0.1	66
	3.0 to 3.49	10.4	0.2	76
	3.5 to 3.9	10.5	0.3	46
	4.0 to 4.49	11.0	0.4	50
	4.5 to 5	10.5	0.2	34
Heat Pump	2.0 to 2.49	10.0	-	3
	2.5 to 2.9	12.1	1.8	3
	3.0 to 3.49	12.4	0.5	4
	3.5 to 3.9	10.0	0.0	1
	4.0 to 4.49	12.2	0.5	2
	4.5 to 5	12.6	0.4	3
Packaged System A/C	2.0 to 2.49	10.0	-	2
	2.5 to 2.9	10.4	0.7	3
	3.0 to 3.49	10.1	0.1	3
	3.5 to 3.9	10.1	0.0	2
	4.0 to 4.49	10.3	0.3	2
	4.5 to 5	10.1	0.1	2
Split System A/C	2.0 to 2.49	10.1	0.1	30
	2.5 to 2.9	10.1	0.1	60
	3.0 to 3.49	10.3	0.1	69
	3.5 to 3.9	10.6	0.3	43
	4.0 to 4.49	10.9	0.4	46
	4.5 to 5	10.3	0.2	29

Table 100: Cooling Systems by Type, Tonnage Range, and Average Efficiency (SEER)

As mentioned above, the current minimum efficiency standard for split-system air conditioners, packaged air conditioners, and heat pumps is a SEER of 13.0. The minimum qualifying ENERGY STAR SEER is 14.0 for split-system and packaged air conditioners and heat pumps. Table 101 shows the average SEER compared with current and previous standards. The average SEER for all of the system types listed below exceed the previous federal standard (which was current when the homes were permitted), but fall short of the 2006 standard and ENERGY STAR minimum.

SEER					
Type of System	**Previous Minimum Federal Standard**	**2006 Minimum Federal Standard**	**Minimum Energy Star Standard**	**Average SEER**	**Sample Size**
Heat Pump	9.7	13	14	11.74	16
Packaged System A/C	9.7	13	14	10.19	14
Split System A/C	10	13	14	10.46	277

Table 101: Average SEER Standard Comparison

Heating Equipment

This section presents the summary analysis of the primary heating systems found during the site visits. The heating systems were linked with efficiency databases from the CEC and the Carrier Bluebook in order to obtain manufacture date, input, output, capacity, and annual fuel utilization efficiency (AFUE, expressed as a percentage). The efficiency of gas units is shown in AFUE, and no distribution of electric unit efficiencies is given due to the fact that all electric units are assumed to be 100% efficient. Heat pumps are included in the next several tables due to the fact that the heat pump may be the only heating system at the home. They are excluded from the efficiency tables due to low efficiency matching rates.

Table 102 shows the percentage of homes that have one or more heating system. An almost equal amount of homes had either one or two heating systems, with approximately 44% of homes having one or two systems. For the homes with more than one heating system, the surveyor determined which system was primary and noted it accordingly.

Number of Heating Systems	**% of Homes (n=604)**	**EB**
1	43.9%	3.8%
2	44.4%	3.9%
3	8.8%	2.7%
4	0.8%	0.6%
5 or more	2.1%	1.1%

Table 102: Percentage of Homes with Heating System

Table 103 shows the primary heating system type among all houses with heating system types. The majority of all primary heating systems were found to be forced air furnaces, totaling just over four-fifths of the population of primary heating systems. Space units used as the primary heating system were far less common than central units.

	System Type (n=604)	% of Primary Heating Types	EB
Central	Forced Air Furnace	85.2%	2.8%
	Heat pump w/Electric Supp	7.2%	2.1%
	Heat pump w/out Elec Supp	1.2%	1.0%
	Hydronic System	1.7%	1.0%
Space	Baseboards	1.0%	0.7%
	Fireplace	0.7%	0.6%
	Floor	0.5%	0.5%
	Pellet Stove	0.1%	0.1%
	Wall Unit	2.6%	1.2%

Table 103: Percentage of Primary Heating Types by Type of System

Table 104 shows the percentage of heating systems by fuel type and system type. These fuel types were taken from the surveyor information. Among all the system types found, the vast majority consumed natural gas. Only 13.3% of all primary heating systems consumed electricity. Interestingly, among all forced air furnaces, 93.1% consumed natural gas.

System Type		Fuel Type								Sample Size
		Gas		Electricity		Pellets		Propane		
		%	EB	%	EB	%	EB	%	EB	
All Types		82.4%	3.0%	13.3%	2.7%	0.1%	0.1%	4.3%	1.5%	604
Central	All Central	85.4%	2.9%	10.2%	2.5%	-	-	4.5%	1.6%	577
	Forced Air Furnace	93.1%	2.0%	2.2%	1.2%	-	-	4.7%	1.7%	526
	Heat pump w/Electric Supp	-	-	100.0%	-	-	-	-	-	37
	Heat pump w/o Supplemental	49.6%	41.2%	50.4%	41.2%	-	-	-	-	6
	Hydronic System	84.0%	23.7%	-	-	-	-	16.0%	23.7%	8
Space	All Space	23.4%	14.8%	75.1%	14.9%	1.5%	2.5%	-	-	27
	Baseboards	-	-	100.0%	-	-	-	-	-	6
	Fireplace	100.0%	-	-	-	-	-	-	-	4
	Floor	51.2%	58.0%	48.8%	58.0%	-	-	-	-	2
	Pellet Stove	-	-	-	-	100.0%	-	-	-	1
	Wall Unit	8.7%	13.6%	91.3%	13.6%	-	-	-	-	14

Table 104: Percentage of Heating Systems by Fuel Type within Type of Heating System

Table 105 shows the percentage of heating systems by fuel type by state. The percentage of gas heat was lowest in Oregon and Washington.

State	Gas		Electricity		Pellets		Propane		n
	%	EB	%	EB	%	EB	%	EB	
ID	90%	5%	3%	3%	0.4%	0.6%	6%	4%	179
MT	100%	-	-	-	-	-	-	-	18
OR	82%	6%	17%	6%	-	-	0.5%	0.8%	178
WA	77%	5%	16%	4%	-	-	6%	3%	229
Overall	82%	3%	13%	3%	0.1%	0.1%	4%	2%	604

Table 105: Percentage of Heating Systems by Fuel Type by State - 2006

Table 106 shows the percentage of floor area by fuel type by state from the 2001 study. In 2001, the Washington market was found to have the lowest saturation of gas heating as shown below. When comparing 2006 to 2001 findings, the Idaho fuel saturations have stayed relatively stable. In 2006, all the Montana homes were heated with gas, but in 2001 82% of the floor area was heated by gas. However, recall that there were few sample points in Montana in 2006. The electric heating saturation has increased slightly in Oregon, going from 6% to 17% with an error bound of 6% in 2006. The electric heating saturation has decreased slightly in Washington, from 21% to 16%, and gas saturation has increased from 68% to 77%.

State	Fuel Type (Percent of Floor area)				
	Gas	Electric		Propane	Other
		Resistance	H.P.		
Idaho	87.8	5.7	0.9	5.7	0.0
Montana	82.0	6.5	1.8	9.3	0.4
Oregon (1999)	90.3	0.8	4.7	0.0	4.2
Oregon (1994)	72.0	23.6	3.0	0.0	1.4
Washington	67.6	6.5	14.6	10.1	1.3

Table 106: Percentage of Floor Area by Fuel Type by State - 2001

Table 107 shows the average estimated age of each type of heating system, and the percentage of each type of heating systems in various manufacture date ranges. As explained previously, the estimated ages were obtained from a combination of the dates that were obtained from the manufacturer information and the surveyor estimates during the on site visit. On average, forced air furnaces were 1.5 years old.

System Type		Manufactured Date and Estimated Manufactured Date Ranges										Sample Size
		Avg Mfr Age	Ave Mfr EB	2006		2005		2004		2003		
				%	EB	%	EB	%	EB	%	EB	
All Types		1.50	0.06	2.7%	1.1%	51.1%	3.9%	42.0%	3.9%	3.1%	1.3%	604
Central	All Central	1.52	0.06	2.5%	1.1%	50.5%	4.0%	42.5%	4.0%	3.2%	1.3%	577
Central	Forced Air Furnace	1.53	0.07	2.2%	1.0%	50.8%	4.2%	42.0%	4.2%	3.6%	1.5%	526
Central	Heat pump w/Electric Supplement	1.51	0.16	2.0%	3.3%	44.6%	14.9%	53.4%	15.0%	0.0%	0.0%	37
Central	Heat pump w/no Supplemental Heat	1.57	0.41	-	-	43.4%	40.7%	56.6%	40.7%	-	-	6
Central	Hydronic System	0.86	0.30	22.8%	25.1%	68.7%	27.0%	8.5%	13.7%	0.0%	0.0%	8
Space	All Space	1.27	0.20	5.7%	9.0%	61.2%	17.0%	33.1%	16.3%	0.0%	0.0%	27
Space	Baseboards	1.41	0.36	-	-	59.3%	36.5%	40.7%	36.5%	-	-	6
Space	Fireplace	1.50	0.47	-	-	49.8%	46.6%	50.2%	46.6%	-	-	4
Space	Floor	1.51	0.58	-	-	48.8%	58.0%	51.2%	58.0%	-	-	2
Space	Pellet Stove	2.00	0.00	-	-	-	-	100.0%	-	-	-	1
Space	Wall Unit	1.10	0.28	10.6%	16.3%	68.9%	22.6%	20.5%	19.3%	0.0%	0.0%	14

Table 107: Average Estimated Age and Percentage of Heating System by Type within Age Ranges

Table 108 shows the percentage of all furnaces by fuel type and capacity range. The capacity of the furnaces was obtained from manufacturer information if the model number linked to one of the databases. The on site estimation of the capacity of the furnaces was used if the model number did not link with the database. Nearly one-quarter of all units were gas units between 55 to 69.99 kBtu. The second largest percentage of furnaces was gas units between 70 and 84.99 kBtu.

	Capacity Ranges (n = 501)	% of Furnaces with Capacity	EB
Gas (kBtuh)	24 to 39.99	9.4%	2.4%
	40 to 54.99	17.5%	3.0%
	55 to 69.99	27.5%	4.0%
	70 to 84.99	25.5%	3.6%
	85 to 99.99	11.0%	3.2%
	100 to 114.99	5.1%	1.8%
	115 to 129.99	0.4%	0.5%
	> 129.99	0.5%	0.6%
Electric (kW)	1 to 2.99	2.2%	1.2%
	3 to 4.99	-	-
	5 to 6.99	-	-
	7 to 8.99	-	-
	9 or Greater	0.9%	0.8%

Table 108: Percentage of All Furnaces with Capacity by Fuel Type within Capacity Ranges

Table 109 shows the percentage distribution for the output capacities of the heat pumps in Pacific Northwest. The highest percentage falls within the 30 – 39.9 kBtuh range, at 45%.

Output Range (n=31)	Percent	EB
20 - 29.9	23.3%	13.5%
30 - 39.9	45.1%	16.8%
40 - 49.9	23.1%	14.6%
50 - 59.9	8.5%	8.1%

Table 109: Heat Pump Output Bins

Table 110 shows the average AFUE by system type. Only the units that matched with one of the efficiency databases were included in the analysis below. The average AFUE for central systems is 82.83.

System Type	All Types	Central		
		All Central	Forced Air Furnace	Hydronic System
Average AFUE	83.30	83.30	83.22	86.77
Error Bound	0.5	0.5	0.5	3.2
Sample Size	483	483	478	5

Table 110: Average AFUE by System Type

There is a noticeable trend toward higher efficiency heating units from the 2001 study to the 2006 study. Across all states, the average Annual Fuel Utilization Efficiency (AFUE) increased one to two percent and the percent of new homes with heating systems with an AFUE of 90 or higher drastically increased in all Pacific Northwest states. As shown in Table 111, Oregon had the largest increase of high efficiency heating systems, jumping from 1.2% in the 2001 study to 24.9% in the 2006 study.

State	2001 Study			2006 Study		
	Average AFUE	>90 AFUE	Sample Size	Average AFUE	>90 AFUE	Sample Size
Idaho	82.0	16.4%	73	84.6	33.8%	164
Montana	83.3	25.0%	36	85.4	41.0%	17
Oregon	81.8	1.2%	31	83.4	24.9%	135
Washington	80.5	6.2%	109	82.2	15.1%	181

Table 111: Comparison of Average Heating System AFUE and Percentage of Homes with High Efficiency Heating Systems

Table 112 shows the percentage of heating systems with an AFUE by type and AFUE range. The large majority of the forced air furnaces have an AFUE between 78 and 84.99.

AFUE Range	Central					
	All Central (n=497)		Forced Air Furnace (n=492)		Hydronic System (n=5)	
	%	EB	%	EB	%	EB
Below 78	-	-	-	-	-	-
78 - 84.99	76.7%	3.5%	76.8%	3.6%	68.8%	33.3%
85 - 89.99	-	-	-	-	-	-
90 - 96	23.3%	3.5%	23.2%	3.6%	31.2%	33.3%

Table 112: Percentage of Heating Systems by Type within AFUE Ranges

Table 113 shows the overall average AFUE for gas fired forced air furnaces compared with standards. On average, the forced air furnaces meet 1992 minimum standards, but fall short of ENERGY STAR qualifying standards. This standard is currently in the rulemaking process. The original and still current standard comes from EPACT-1992. The latest EPACT-2005 did not directly address furnaces but put a final action date of 9/2007 to set the new furnace standard. The proposed new standard (October 2006) sets weatherized homes minimum AFUE to 83, mobile homes and non-weatherized homes to 80[3].

[3]http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/furnaces_boilers/fb_nopr_100606.pdf

Annual Fuel Utilization Efficiency			
Type	**Minimum Federal Standard**	**Minimum Energy Star Standard**	**Average AFUE**
Gas Fired Forced Air Furnace	78	90	83.22

Table 113: Average AFUE Standard Comparison

Table 114 shows the distribution of gas forced air furnace AFUE. None of the furnaces fall below the current federal minimum standard of 78 AFUE.

AFUE Range				
Type	**72 to 77.88**	**78 to 84.99**	**90 to 96**	**Sample Size**
Gas Forced Air Furnace	-	76.8%	23.2%	492

Table 114: AFUE Bin Distribution

As in the cooling section, heat pumps were affected by a change in the Federal Regulations concerning the minimum Heating Seasonal Performance Factor (HSPF). Heat pumps manufactured between January 1, 1992 and January 23, 2006 were required to meet a minimum HSPF of 6.8. After January 23, 2006, the minimum HSPF rose to 7.7. The current Energy Star threshold is 8.2 HSPF.

Given the standards above, the average HSPF from this study, as presented in Table 115, meets the current federal minimum and surpasses the previous standard. The average capacity was just under 40 kBtuh.

(n=31)	Heating Seasonal Performance Factor	Average Output (kBtuh)
Average	7.7	39.8
EB	0.2	2.9

Table 115: Heat Pump Average HSPF and Output

Table 116 shows the bin distribution of heat pump HSPF. Over half (54.9%) fell between the previous federal standard of 6.8 and the current standard of 7.7, while approximate 30% surpass the current federal standard but fall short of the Energy Star minimum HSPF. Sixteen percent meet or surpass the current Energy Star standard for split heat pumps.

HSPF Range (n=31)	Percent	EB
6.8 - 7.69	54.9%	16.8%
7.69 - 8.19	29.0%	15.4%
8.2 or Greater	16.1%	13.1%

Table 116: Heat Pump HSPF Bins

Thermostats

Table 117 shows the percentage of homes by the type of thermostat within each home. The large majority of homes (91%) have digital thermostats.

Type	% of Homes (n=602)
Mechanical Thermostat	8.7%
Digital Thermostat	90.6%
Hybrid Thermostat	0.7%

Table 117: Percent of Homes by Type of Thermostat

Pool and Spa

The following section describes the pools and spas found at the residences. Information on the fuel type and the presence of a pool or spa was recorded during the site visit.

Pool

Approximately 2% of sites visited had a below ground swimming pool of some sort. The following figure shows the percentage of these residences broken down by heating fuel type. It can be seen that the predominant fuel type is natural gas, which is used to heat approximately one-third of the total pools. However, over 43% of pools are not heated.

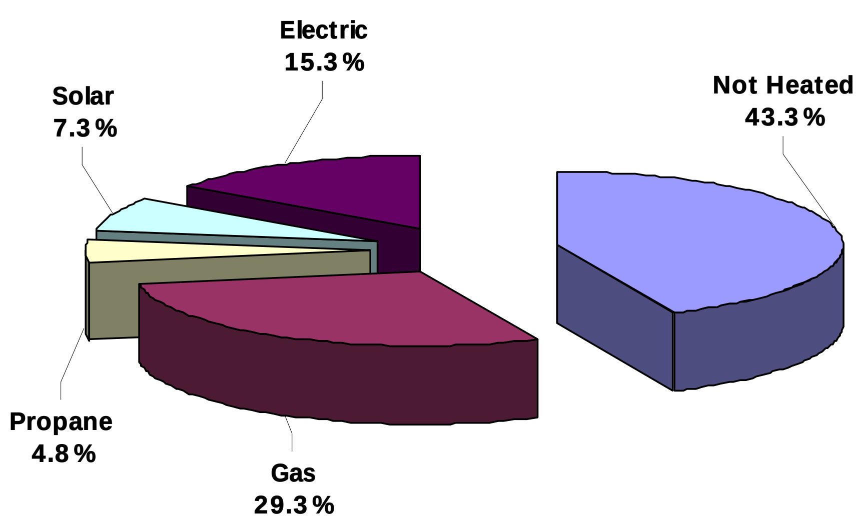

Figure 12: Percentage of Residences with Pool by Fuel Type

Spa

Eight percent of homes in the region have a spa. The large majority of spas are heated with electricity. Table 118 outlines the percentage of various fuel types for sites that had spas.

Spa Fuel Type	Percentage (n=48)	EB
Gas	3.2%	3.7%
Electric	96.8%	3.7%

Table 118: Percentage of Spas by Fuel Type

Consumer Electronics

RLW surveyors were asked to record the number of plug loads in each residence by type. The table below shows the average number of each plug load found in each surveyed home. There are on average 2.6 televisions per home, compared to only 1.6 computers per home.

Consumer Appliances	Average Number (n=599)	EB
Television	2.6	0.1
Video Cassette Recorder	2.3	0.1
Camera Charger	0.7	0.1
Computers	1.6	0.1
Gaming Console	0.5	0.1
Fax Machine	0.3	0.0
Printer	1.1	0.0
Personal Digital Assistant	0.3	0.1
MP3 Player	0.8	0.1
Cell Phone Charger	1.6	0.1
Aquariums	0.8	0.1
Answering Machine	0.7	0.0
Stereos	1.2	0.1
Cordless Phone	2.0	0.1

Table 119: Average Number of Each Plug Load

Large Appliances

Information on other major end uses in the home was gathered. Table 120 presents the percentage of homes that had each of the large appliances surveyed.

Large Appliances	% of Homes (n=604)	EB
Has Attic Fan	12.6%	2.5%
Has Well	11.4%	2.5%
Has Driveway Coil	0.1%	0.2%
Has Crank Case Heater	1.9%	1.0%
Has Photovoltaic System	0.5%	0.4%
Has Welding Equipment	5.5%	1.9%
Has Shop Equipment	16.7%	3.3%
Has Air Cleaner	11.4%	2.4%

Table 120: Percent of Homes with Large Appliances

Building Envelope Components

The following section discuses the findings for building envelope components as observed by the survey. Comparisons to the 2001 study are made where available, while a more detailed comparison of building code standards and compliance for envelope components is presented in the following section titled Building Heat Loss Performance.

Windows

The following section describes the window types at the residences. Information on the type of window frame and the number of panes in each window was recorded during the site visit. If the customer reported that there were multiple types of frames or panes in their home, the predominant window type was observed and recorded. A low-e detector was used on-site to determine the presence of a low-emissivity coating applied by the manufacturer.

Figure 13 shows the breakdown of predominant window frame types among all homes. The majority of window frame types found in homes are non-metal, constituting more than 99% of the glass area in homes.

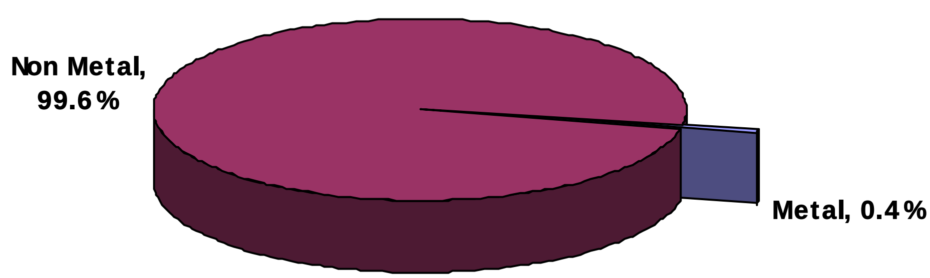

Figure 13: Percentage of Glass Area by Window Frame Type

Table 121 shows the breakdown of homes by predominant window frame type and type of panes by type of residence. 99.6% of all the glass area in homes is non metal, double paned windows. On average, approximately 0.4% of all glass area is metal, double paned windows. None of the homes in the sample have single paned windows.

Type of Residence	Window and Pane Type				
	Metal Double		Non Metal Double		Sample Size
	%	EB	%	EB	
Overall	0.4%	0.4%	99.6%	0.4%	602
Single Family Unattached (1 story)	0.8%	0.8%	99.2%	0.8%	206
Single Family Unattached (2 stories)	0.2%	0.4%	99.8%	0.4%	374
Single Family Unattached (3 or more stories)	-	-	100.0%	-	14
Single Family Attached	-	-	100.0%	-	8

Table 121: Percentage of Homes by Predominant Type of Glass Area by Frame Type and Panes Type by Type of Residence

The finding that window frame types are largely non-metal in all states in the region is similar to the 2001 study findings.

State	Window Frame Type				
	2001 Study			2006 Study	
	Non-Metal	Metal	Other	Non-Metal	Metal
Idaho	94.2%	0.7%	5.1%	99.3%	0.7%
Montana	93.0%	5.7%	1.3%	100.0%	0.0%
Oregon	99.9%	0.0%	0.1%	99.0%	1.0%
Washington	95.9%	2.5%	1.6%	100.0%	0.0%

Table 122: Comparison of Window Frame Types

Table 123 shows the percentage of glass area in homes by glazing characteristics and type of residence. Low-e glazing constitutes 88.6% of the overall window glazing. Non low-e glazing constitutes the remaining 11.4% of glazing area.

Type of Residence	Window Glazing Characteristics				
	Low E Glazing		Not Low E Glazing		Sample Size
	%	EB	%	EB	
Overall	88.6%	2.3%	11.4%	2.3%	598
Single Family Unattached (1 story)	88.7%	3.5%	11.3%	3.5%	204
Single Family Unattached (2 stories)	87.8%	3.2%	12.2%	3.2%	372
Single Family Unattached (3 or more stories)	100.0%	-	-	-	14
Single Family Attached	90.5%	15.5%	9.5%	15.5%	8

Table 123: Percentage of Glass Area by Glazing Type and Type of Residence

Table 124 shows that the use of low-e glazing in windows has, on the whole, increased from 73% to 88.6% of glass area between the two studies, most notably in Idaho and Washington, where the percent of new home glass area that is low-e more than doubled. The change in Washington is apparently due to the strengthening of the standard Washington State Energy Code (WSEC) on glazing U-value, a decrease from 0.65 to 0.40, which practically requires low-e windows. The specific code criteria by state are presented in the following section (Building Heat Loss Performance). The change in Idaho may be due to more stringent code as well as market influences since DOE and LBNL have pushed for higher market penetration of low-e windows. The U-values to meet code compliance in all other states practically requires non-metal frames and low-e coatings, which may affect the overall Northwest window market.

State	2001 Study	2006 Study
Idaho	30.4%	73.2%
Montana	83.5%	97.4%
Oregon	96.0%	88.0%
Washington	38.8%	93.3%
Overall	73.0%	88.6%

Table 124: Comparison of Homes with Low-E Glazing

Table 125 presents window performance data, which is characterized by a total window U-value and a total window area (expressed as a percent of total floor area). The actual U-value was not measured on-site, rather an average U-value was obtained using the frame type, number of panes and glazing observed. Table 125 summarizes window performance as best observed during the on-site visits in the four states in the 2006 study, while Table 126 displays the results of the 2001 study. The average glazing as a percentage of floor area was slightly lower than the 2001 findings for all states. The state codes identified and changes to the codes since the 2001 study are discussed in more detail in the following section (Building Heat Loss Performance). Note that an addendum to the Montana code specifies window U-values to be a maximum of 0.35. The IECC prescriptive code that applies to both MT and ID has variation in maximum U-value by climate zone and glazing area. The code U-value for ID is an average, while all other states' code value are the prescriptive value for the entire state.

State	Sample		Code	
	U-Value	% of Floor Area	U-Value	% of Floor Area
ID	0.393	12.3%	0.481	varies
MT	0.355	12.0%	0.350	varies
OR	0.372	14.4%	0.400	NA
WA	0.362	13.7%	0.400	15%, opt II
Overall	0.370	13.6%	0.412	NA

Table 125: Window Performance – Average U-Values, 2006 Study

State	Sample		Code	
	U-Value	% of Floor Area	U-Value	% of Floor Area
ID	0.474	12.7%	0.500	17.0%
MT	0.402	13.1%	0.500	NA
OR	0.371	15.2%	0.400	NA
WA	0.460	14.8%	0.650	15.0%

Table 126: Window Performance– Average U-Values, 2001 Study

Table 127 shows the percentage of sites within each U-value bin. The majority of the sites have windows with U-values less than 0.4. None of the sites in the sample had an average U-value less than 0.35.

State	U-Value > 0.4		U-Value <= 0.4	
	%	EB	%	EB
ID	30%	14%	70%	14%
MT	0%	0%	100%	0%
OR	15%	6%	85%	6%
WA	15%	11%	85%	11%
Overall	16%	6%	84%	6%

Table 127: U-Value Bins, 2006 Study

Wall Construction

Figure 14 shows the breakdown of all homes by wall construction type. The large majority of homes were constructed using 2 x 6s, totaling over 78.9% of all homes.

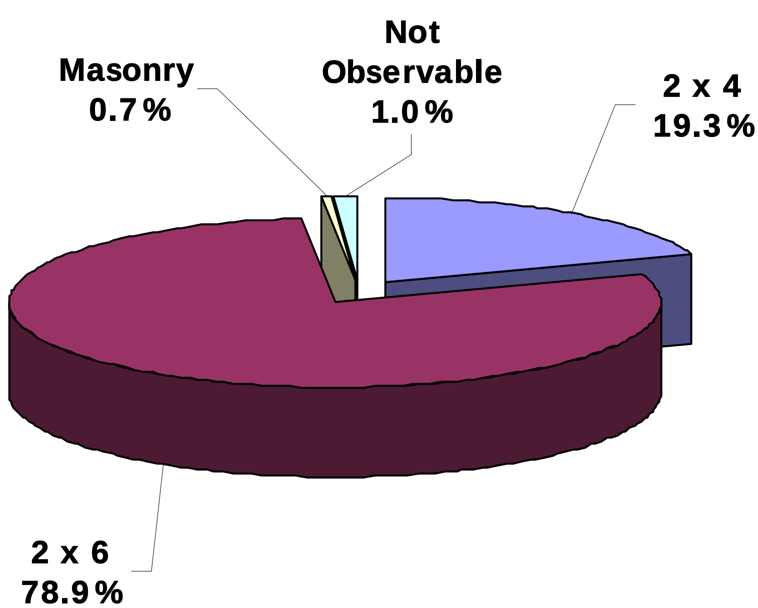

Figure 14: Percentage of Homes by Wall Construction Type

Figure 15 and Figure 16 compare the trends in wall framing types between the 2001 and the 2006 study. It appears that the percentage of 2x4 framing has decreased in Washington, stayed constant in Oregon, and increased slightly in Montana and Idaho relative to 2x6 construction. However, note that these data do not allow for direct comparison because the 2006 study collected and analyzed the framing type after the home was occupied, and therefore assigned a predominant framing type to the home, while the 2001 study characterized the wall area by framing type.

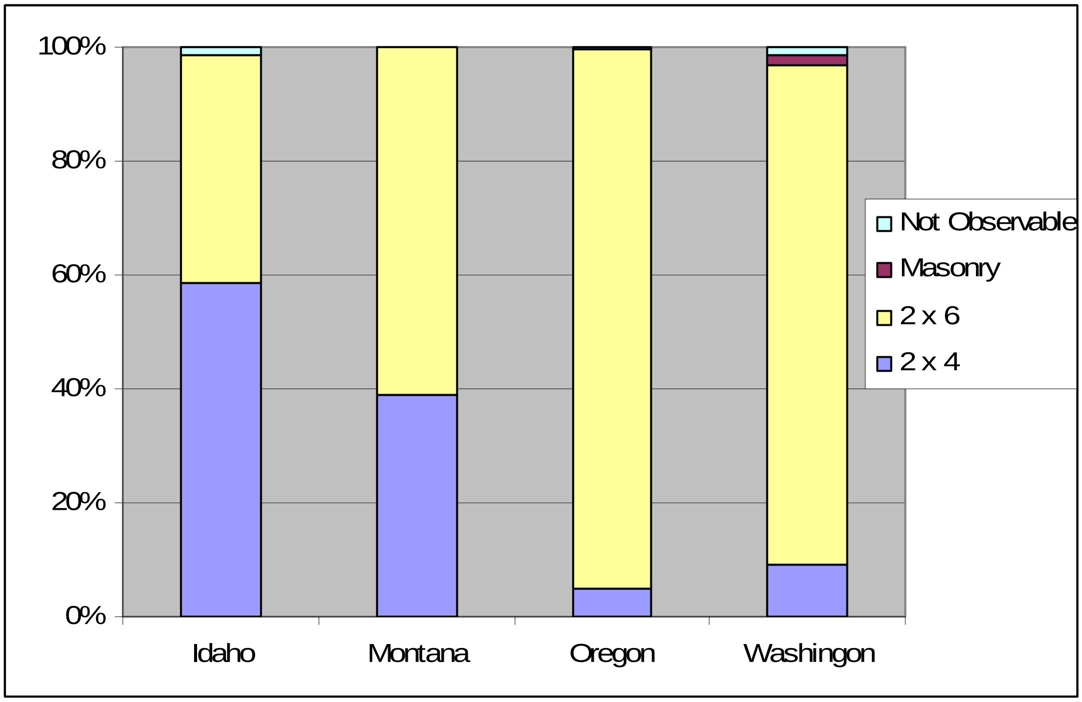

Figure 15: Wall Framing Types by State (% of homes) - 2006

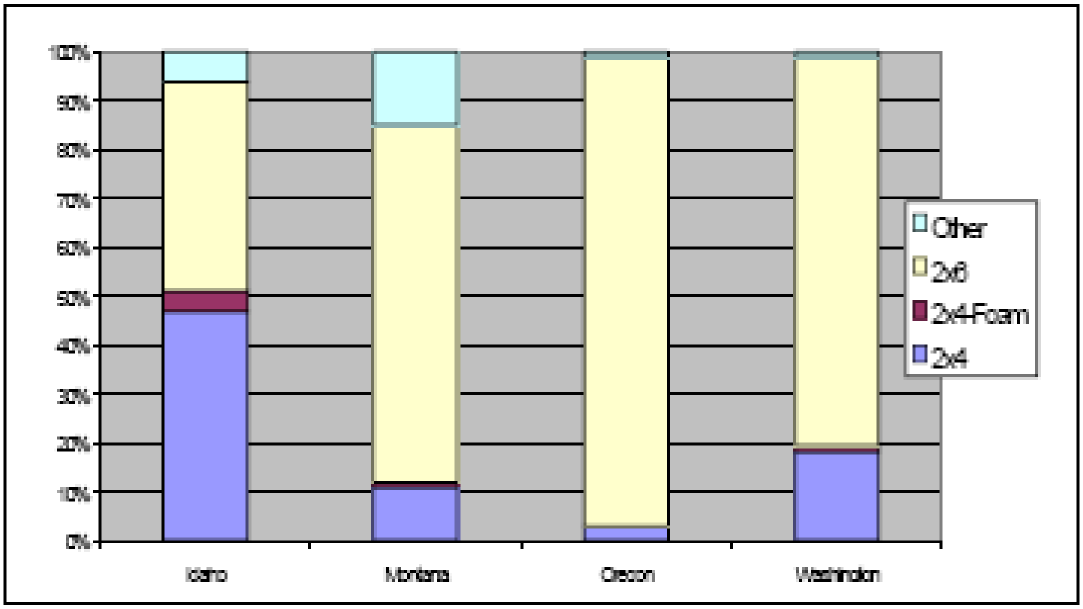

Figure 16: Wall Framing Types by State (% of wall area) - 2001

Insulation

The following section describes the insulation in walls, floors, and attics. Along with insulation level, the surface area of each insulated component was measured at each site. The insulation in raised floors and attics was often directly observable in occupied homes, while wall and slab edge insulation typically were not observable. Unobservable insulation levels were determined based on framing size and any documentation available on-site. In the absence of any data the code values for the site location were assigned to these building envelope components. These data were collected with some additional difficulty during the site visits. Difficulty arose when the attic was inaccessible due to the fact that access was blocked by furniture, the homeowner denied the surveyor access, etc. When the attic was accessible and there was batt insulation, in some cases the R-value was not observable, then the surveyor estimated the thickness of the insulation, which was then converted into R value.

Attic

The average R-value among all homes with an estimated or verified R-value for attic insulation is 38.1 with an error bound of 0.2.

Table 128 shows the average R-value and the percentage of homes with R-values in ranges by type of residence. The largest percent of homes are in the range between R-38 to R-41.99, totaling 91.7% of the homes with an R-value. All homes have attic insulation.

In the event that the surveyor was only able to record the inches of the batt insulation, the California Energy Commission (CEC) residential Title-24 manual was referenced in order to translate the inches into R-value. In the event that the surveyor was only able to record the inches of the blown in insulation, the number of inches was multiplied by 3.5 to arrive at the R-value. The overall attic R-value was calculated as the sum of the R-values for blown-in and batt insulation.

Type of Residence	Average R Value	Average R Value EB	R11 to R18.99		R19 to R21.99		R30 to R37.99		R38 to R41.99		Greater Than R42		Sample Size
			%	EB	%	EB	%	EB	%	EB	%	EB	
Overall	38.1	0.2	0.2%	0.4%	0.3%	0.5%	2.6%	1.2%	91.7%	2.0%	5.2%	1.6%	579
Single Family Unattached (1 story)	38.5	0.3	-	-	-	-	-	-	94.7%	2.6%	5.3%	2.6%	198
Single Family Unattached (2 stories)	37.9	0.3	0.4%	0.6%	0.5%	0.8%	3.9%	1.9%	90.4%	2.8%	4.7%	2.0%	360
Single Family Unattached (3 or more stories)	39.1	1.3	-	-	-	-	-	-	89.9%	13.1%	10.1%	13.1%	13
Single Family Attached	37.6	3.2	-	-	-	-	19.9%	28.1%	68.1%	30.0%	12.0%	18.6%	8

Table 128: Average R-Value and Percentage of Homes with Attic R-Values within R-Value Bins

Table 129 and Table 130 present the average R-values for attic insulation for the 2001 and 2006 studies. The 2006 study did not distinguish between scissors and vault, therefore these results are not directly comparable, but generally it can be seen that the averages did not change a lot.

State	Average R-Value	EB	n
Idaho	37.8	0.6	173
Montana	39.4	1.5	17
Oregon	38.1	0.5	178
Washingon	38.2	0.3	211

Table 129: Attic Insulation Values by State - 2006[4]

	Ceiling Type					
	Attic		Scissors		Vault	
State	%	R	%	R	%	R
Idaho	52.6%	38.0	40.8%	37.5	6.6%	28.9
Montana	57.1%	39.3	29.5%	39.3	13.3%	35.3
Oregon	61.3%	40.6	27.0%	38.0	11.7%	33.2
Washingon	59.7%	33.2	22.7%	32.2	17.6%	30.2

Table 130: Ceiling Values by State - 2001

Walls

The percentage of insulated homes with different insulation levels are presented in the table below. Among those homes where it was possible to observe the percentage of the walls that were insulated, the percentage of homes with R21 is 51.4%.

[4] The distinction between scissors and vault was not made in the 2006 study design.

Construction Type	Insulation Level												Sample Size
	None		R 11		R 13		R 15		R 19		R 21		
	%	EB	%	EB	%	EB	%	EB	%	EB	%	EB	
All Types	0.3%	0.5%	0.8%	0.8%	16.3%	2.6%	2.7%	1.5%	28.4%	3.9%	51.4%	4.3%	485
2 X 4	-	-	2.4%	2.7%	76.3%	8.0%	6.5%	5.2%	13.0%	6.3%	1.8%	2.9%	147
2 X 6	-	-	0.4%	0.7%	1.0%	0.9%	1.8%	1.4%	32.9%	4.7%	63.8%	4.8%	333
Masonry	34.9%	45.7%	-	-	-	-	-	-	-	-	65.1%	45.7%	3
Unknown	-	-	-	-	-	-	-	-	-	-	100.0%	-	2

Table 131: Percentage of Homes by Wall Construction Type by Insulation Level

Floor

The following table displays the percentage of homes for which an R-value was obtained for the floor insulation. Sixteen percent of all homes are slab on grade and 84% are raised floors. About 1% of the homes with raised floors have no floor insulation. Slab on grade floors are typically 4-inch thick slabs of concrete on which the homes are constructed. Raised floors are suspended from foundation stem walls.

Floor R-Value (n=604)	Percentage of Homes with R-Value					Error Bounds				
	ID	MT	OR	WA	Overall	ID	MT	OR	WA	Overall
No Insulation	0.9%	17%	-	-	0.9%	1%	15%	-	-	1%
R13	3%	-	-	-	0.7%	2%	-	-	-	0.4%
R19	54%	-	16%	14%	22%	7%	-	5%	4%	3%
R21	-	-	1%	3%	2%	-	-	1%	4%	2%
R25	-	-	35%	7%	13%	-	-	7%	3%	2%
R30	7%	-	37%	42%	32%	5%	-	7%	6%	4%
Slab	29%	45%	4%	15%	16%	7%	19%	3%	4%	3%
Unknown	6%	38%	6%	19%	14%	4%	19%	3%	5%	3%

Table 132: Percentage of Homes with Floor R-Values

Table 133 shows the percentage of homes with basements. Over 87% of homes do not have basements.

Basement (n=604)	Percent of Homes with Basement Type					Error Bound				
	ID	MO	OR	WA	Overall	ID	MO	OR	WA	Overall
None	16.9%	2.7%	24.7%	42.8%	87.2%	2.4%	1.3%	3.3%	3.9%	2.7%
Finished, Conditioned	1.5%	0.5%	1.2%	3.1%	6.3%	1.0%	0.6%	0.6%	1.3%	1.8%
Finished, Unconditioned	0.3%	-	-	0.7%	0.9%	0.4%	-	-	0.7%	0.8%
Unfinished, Conditioned	1.0%	0.8%	0.7%	1.0%	3.4%	0.8%	0.7%	0.8%	0.8%	1.6%
Unfinished, Unconditioned	0.4%	0.5%	1.0%	0.2%	2.1%	0.5%	0.6%	0.9%	0.3%	1.2%

Table 133: Percent of Homes with Basement Type

Insulation Performance

This section presents an analysis that compares the current assembly U-values to those found in the 2001 baseline study. The 2001 study focused on the envelope characteristics, as well as heating, cooling, and water heating equipment obtained from building plans, with a limited amount of appliance efficiency or lighting data presented.

For the 2006 study NEEA decided to look more comprehensively at appliances and lighting. To obtain an accurate picture of appliance and lighting saturation, the homes needed to be audited after they were fully occupied, which made it more difficult to obtain accurate envelope data.

In some instances, the surveyors had to make assumptions about the levels of insulation, whereas in the previous study, the insulation and code values were on the plans that the contractors obtained.

Therefore, these tables contain RLW's best estimates of the insulation levels in homes, however it must be acknowledged that if the study's primary goal were to obtain the most accurate envelope characteristics information available, then the study would have been performed on unoccupied, non-finished homes.

Assembly U-Values

The on-site surveyors collected data on frame types and insulation levels of individual building components during the site visits. These components were examined independently and the U-values for each assembly are presented below. Because of the variations in code, code enforcement, building standards, and market conditions, the states vary on many components associated with energy efficiency. For all states, RLW compared building component heat loss performance to the energy code reference prescriptive compliance path, or base path, associated with each home's location.

Building component insulation levels were collected onsite in terms of R-value. In order to compute heat loss rates, RLW used the R-value to U-value conversions found in Chapter 10 of the 2004 Washington State Energy Code. There is wide variation of assembly U-values with the same cavity insulation level (R-value). RLW chose the representative assemblies based on the table of R-value and U-value Washington State Energy Code, which specifies both U-value and R-value for most building components.

Table 134 summarizes the U-values associated with the opaque components of the residential buildings in the 2006 sample. Average U-values in all states exceeded code in walls. Floor U-values did not meet the minimum code requirements in all states, with the exception of Oregon. Window U-values were better than code in all states but Montana.

Table 135 shows the results from the 2001 study, in which Oregon was the only state to exceed code for walls, Washington was the only state to surpass code in floor, all but Washington met code for ceiling, and again all but Montana was better than code for windows.

There has been a lot of discussion regarding some increases in code when comparing Table 134 to Table 135. We utilized the most current energy codes for each state. Below is some discussion about the code values that are presented in Table 134.

Compliance method:

Because RLW did not obtain building plans for the homes, we were not aware which compliance method was used for the home: Prescriptive or whole building alternates to the prescriptive approach. Under a non-prescriptive run, builders can trade off envelope efficiency for increased heating, cooling, or water heating efficiency. In addition, plan details of the construction assemblies used at each site such as stud spacing, additional rigid insulation, and alternative building materials have an impact on U-value assignments. The prescriptive code varies by state depending on glazing % of floor area, climate zone, wall construction type, and occupancy type. Without knowing the exact code that was used to gain compliance for the residence, the code values presented in this report are best approximations of the actual code values.

Floor:

The sample and code values presented in Table 134 are for raised floors only, which comprised 84% of floors in the study.

Ceiling:

The 2001 study reported a ceiling code U-value of 0.026 for every state. Since 2001 the code for ceiling insulation has increased in all four states.

The 2004 Washington State Energy Code (WSEC) calls for a U-value of 0.031 for dropped ceilings and 0.034 for vaulted ceilings for the entire state under the prescriptive requirements.

The 2005 Oregon Residential Energy Code calls for a U-value of 0.031 under Path 1 of the prescriptive code.

The 2003 International Energy Conservation Code used for Montana requires a U-value of 0.026 representing a "nominal" insulation value of R-49 or R-38 with a standard framed ceiling of R-38 with advanced framing.

State Code References:

State	Code Used	Notes
Idaho	2003 International Energy Conservation Code (IECC), no state amendments	In 2003, Idaho began using IECC as their building code. Prior to that, Idaho used the Idaho Building Code Act that was not strictly enforced (used for the 2001)
Montana	2003 IECC	Montana amendments
Oregon	March 2005 Oregon Residential Energy Code, Table N1104.1(1) Base Path 1 (The code U-values have been at or very close to the current values since 1992)	The residential energy code provides a Base Path (Path 1) for code compliance that is used for the majority of new construction. All new buildings are required to be built in compliance with the Base Path or one of the nine other "Prescriptive Paths." Paths 2-8 provide design flexibility and are generally energy-equivalent to the Base Path. Path 9 allows for log home construction. Path 10 allows for 2x4 exterior wall
Washington	2004 Washington State Energy Code Second Edition, and the Energy Code Builder's Field Guide	The current edition of the WSEC was adopted effective July 1, 2004.

All homes in the study were permitted in 2004 or later. Recall that the actual compliance documentation was not reviewed for these homes. Specific permit dates for each home were not collected. The codes referenced are the most recent revisions and most likely code applicable to most sites in each state, however some of the sites are likely to have complied under old code and this should be taken into consideration by the reader.

State	Wall		Floor		Ceiling		Window		Sample Size
	Sample	Code	Sample	Code	Sample	Code	Sample	Code	
ID	0.072	0.060	0.040	0.037	0.030	0.026	0.393	0.481	170
MT	0.069	0.059	-	-	0.030	0.027	0.355	0.350	14
OR	0.062	0.060	0.033	0.034	0.032	0.031	0.372	0.400	173
WA	0.062	0.059	0.032	0.029	0.031	0.031	0.362	0.400	225
Overall	0.064	0.059	0.034	0.032	0.031	0.030	0.370	0.412	582

Table 134: U-Value Comparison of Components (Btu/hr-F-ft2), 2006 Study[5]

State	Wall		Floor		Ceiling		Window	
	Sample	Code	Sample	Code	Sample	Code	Sample	Code
ID	0.071	0.062	0.054	0.038	0.026	0.026	0.474	0.495
MT	0.063	0.062	0.065	0.038	0.026	0.026	0.402	0.400
OR	0.059	0.061	0.033	0.032	0.026	0.026	0.371	0.433
WA	0.065	0.062	0.039	0.041	0.030	0.026	0.460	0.640

Table 135: U-Value Comparison of Components (Btu/hr-F-ft2), 2001 Study

State	Wall		Floor		Ceiling		Window		Sample Size
	Sample	Code	Sample	Code	Sample	Code	Sample	Code	
ID	0.003	0.000	0.001	0.000	0.000	0.000	0.010	0.006	170
MT	0.009	0.001	-	-	0.001	0.000	0.009	0.000	14
OR	0.001	0.000	0.001	0.000	0.001	0.000	0.008	0.000	173
WA	0.002	0.001	0.001	0.000	0.000	0.000	0.005	0.000	225
Overall	0.001	0.000	0.001	0.000	0.000	0.000	0.004	0.002	582

Table 136: Error Bounds of U-Values, 2006 Study

Building Heat Loss Performance

Overall building heat loss rates were developed from the building characteristics data and assembly areas, and were normalized by conditioned floor area of the home. Code heat loss rates were developed by applying the most recent versions of the residential code values to the sample homes. Each state's residential building code was used to determine each home's compliance or non-compliance. The overall heat loss rates were calculated using Washington State Energy Code, Chapter 5, Equation 3, which can be found in Appendix A. The basic formula is shown below:

[5] The cells highlighted in gray are the assemblies where RLW estimated that the average U-values did not meet code.

$$UA_{total} = \sum_{n=1}^{x} U_n A_n$$

Where U is the U-value for each independent component and A is the associated area. X is the number of opaque and glazed building components including windows, floors, ceilings, walls, doors and slab. The measured component areas were used for both the code UA and site UA, so that the only variable was the component U value.[6]

The overall heat loss rates reported in the previous study included heat loss due to air infiltration. This factor in the 2001 study was assigned based on the *Super Good Cents Heat Loss Reference*[7]. Since our study included performance testing, the heat loss due to measured air infiltration was added to the overall heat loss for each site. The atmospheric conditions, heat capacity-density product of dry air, were based on the Conservation and Renewables Residential Specifications from the Bonneville Power Authority (October 1, 2002). This document assigns a heat capacity-density product to the three heating zones of the Regional Technical Forum because the average elevation above sea level varies across the Northwest affecting the density of dry air. Heat loss due to infiltration is calculated using the following equation:

$$UA_{\inf il} = ACH * V * HCP$$

Where ACH is the measured infiltration rate, V is the measured conditioned volume, and HCP is the heat capacity-density product for the appropriate elevation.

Similar to the previous section, results are presented as comparisons between this study and the 2001 study. The average overall building heat loss rates and the code reference can be seen in Table 137 and Table 138. The differences in methodologies between the two studies are most apparent in this comparison. RLW did not obtain building plans for the homes, and therefore was unaware which compliance method was used for the home. As mentioned previously, RLW did not always have access to accurate construction R-values onsite in completed homes compared to the details available on plans in terms of cavity and framing characteristics for envelope assemblies. This fundamental difference in data collection methodology may lead to larger or smaller than actual discrepancies between the two studies. Also, the overall heat loss (UA/sf) decreased in all states but Oregon, where it is very similar to 2001.

The decrease in overall heat loss rates per square foot is likely due to a number of factors, the most significant of which is the improved window U-values. Another factor is the heat loss due to infiltration. Measured infiltration in these homes was fairly low resulting in a low UA_{infil}. Another possible contributor to the lower normalized heat loss rate is the high percentage of multi-story buildings in the sample. In the current study, just under two-thirds of the homes are multiple-story dwellings. The distribution of multi-story dwellings is not presented in the 2001 report. A multi-story home has less heat loss surface per square foot of floor area than a single-story home.

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[6] For slab-on-grade and below grade slabs the measured perimeter and appropriate F-factor were used following the WSEC method

[7] Davis, B. ; Baylon, D. ; Kennedy, M. **Super good cents heat loss reference.** Research Org: Ecotope, Inc., Seattle, WA (USA); Sponsoring Org: DOE;USDOE, Washington, DC (USA); 1991 Feb 01

RLW has not included a % pass rate for this study since we did not collect building plans for each site and therefore do not know the exact pass fail rate for the homes.

State	Overall Heat Loss		Sample Size
	Buildings	Code	
ID	0.223	0.224	39
MT	0.217	0.197	4
OR	0.228	0.230	114
WA	0.209	0.211	88
Overall	0.219	0.221	245

Table 137: Overall Heat Loss Rates by State (UA/ft^2), 2006 Study

State	Overall Heat Loss		
	Buildings	Code	% Pass
ID	0.267	0.261	52%
MT	0.245	0.251	87%
OR	0.220	0.230	100%
WA	0.242	0.264	94%

Table 138: Overall Heat Loss Rates by State (UA/ft^2), 2001 Study

Single-Family Test Data Analysis

This chapter of the report summarizes the 264 single-family functional tests that were performed in 2005-06 as part of the Residential New Construction Characteristics and Practices Study.

RLW originally planned to perform testing at 25% of the 400 single-family home audits as part of the NEEA contract, for a total of 100 single-family "enhanced" sites. Energy Trust of Oregon, Tacoma Power, and Idaho Power provided additional funding to increase the total number of enhanced sites to 264. Regional weights were used to weight the sites summarized in this chapter.

Methodology

Sample Size

Infiltration tests were performed on all 264 homes and system airflow and duct leakage tests were performed wherever these tests were applicable and feasible. Table 139 shows the sample sizes used in the system airflow and duct leakage analyses. System airflow and duct leakage tests can not be performed on zonal systems. For the system airflow analyses, the systems where output capacity could not be determined were excluded from the analysis. Most airflow tests were not performed because of filter issues: blocked filter access, irregular size, etc. There were a variety of reasons for not conducting the leakage tests including malfunctioning duct systems, no access to a return register, or the occupant would not allow technician to complete test.

Test Type	n
Total Number of SF Test Sites	**264**
System Airflow by System Type	**198**
Excluded:	**66**
Zonal systems	10
Output capacity unknown	41
No airflow data	15
System Airflow by Cooling Capacity	**135**
Excluded:	**129**
Zonal systems	2
No cooling system	113
No cooling capacity	8
No airflow data	6
Duct Leakage	**225**
Excluded:	**39**
Flow exponent	11
Zonal systems	9
No leakage data	4
No airflow data	15

Table 139: Sample Sizes for Functional Test Analyses

Infiltration Testing

Infiltration was measured using The Energy Conservatory's Minneapolis Blower Door™ in conjunction with a differential pressure gauge. The Minneapolis Blower Door™ is a fan, curtain and frame assembly that is temporarily sealed into an exterior doorway. The blower door was positioned in the frame and the fan speed was adjusted to maintain a pressure difference of 50 Pascals (Pa) (~0.2 inches of water column) between the inside of the home and outside air pressure. By measuring the airflow that is required to maintain 50 Pa, the air tightness of the house can be assessed. The technician recorded the house pressure, the fan pressure, and volumetric airflow (CFM50) through the blower door fan to maintain 50 Pa. For quality assurance purposes, the same test was performed at 25 Pa and the corresponding values were used to compute a flow exponent that was used to screen outlying infiltration values. This test procedure followed the guidelines for performance testing developed by the Regional Technical Forum (RTF), which are also referenced as Performance Tested Comfort Systems (PTCS). The Energy Star Homes Northwest program utilizes similar performance test procedures.

Airflow Testing

The team used the TrueFlow® Air Handler Flow Meter in conjunction with the DG-3 or DG-700 gauges to measure the airflow of ducted heating systems.

Before installing the orifice plate, a pressure probe was placed just downstream of the supply fan, and the heating system was turned on to operational fan flow to determine the standard operating pressure. Next, the air filter was removed from its position, and the TrueFlow® meter was inserted in the filter's place. Once the metering plate was in place, the heating system fan was again turned on to operational supply fan flow and volumetric flow rate through the system was measured with the pressure gauge. Finally the system flow rate was normalized to operational conditions by taking into account the standard operating pressure of the system.

Duct Leakage Testing

The duct leakage test was conducted to measure the duct leakage rate to the outside of the thermal envelope of the home. The test utilized both the Minneapolis Duct Blaster® and the Minneapolis Blower Door® tools. Total duct leakage, which includes leakage inside the envelope of the home, was not tested.

First, the Minneapolis Blower Door® tool was installed at an exterior door way. The Duct Blaster® was then installed at the least restrictive return register. The portion of the return register that was not covered by the Duct Blaster® was sealed with tape, as were all other supply and return registers in the home.

The house was then pressurized to 50 Pa with the Blower Door®. The duct system was then pressurized to match the pressure of the house. By pressurizing the house and the ducts to the same pressure, the test measures leakage to the outside of the envelope only. The required airflow to maintain equal pressure in the duct system, CFM50, was recorded for each home. The home and duct pressures were both reduced to 25 Pa and the corresponding values were recorded well. The flow exponent equation was then used to determine the validity of the test by comparing the CFM50 and CFM25 results. Systems with results falling outside of the expected flow exponent range of 0.50 to 0.75

were retested up to two additional times. All sites with flow exponents that were outside of the acceptable range, even after the additional tests, were excluded from the analysis. The flow exponent equation is shown below.

$$n = \text{flow exponent} = \ln(Q50/Q25)/\ln(P50/P25), \text{ where}$$

Q50=the cubic feet per minute as measured at the duct blaster while the house is pressurized to 50 Pa
Q25=the cubic feet per minute as measured at the duct blaster while the house is pressurized to 25 Pa
P50=50 Pa
P25=25 Pa

This test procedure followed the guidelines for performance testing developed by the Regional Technical Forum (RTF), which are also referenced as Performance Tested Comfort Systems (PTCS)[8].

Results

Infiltration

The flow rate to maintain a depressurization of 50 Pa in the house was measured in cubic feet per minute (CFM50) and was then converted to air changes per hour at that pressure (ACH50) and natural air changes per hour at atmospheric pressures (ACH). This conversion was done in order to facilitate a comparison to standard infiltration measurements; the equations used can be seen below.

$$ACH50 = 60 \times CFM50 \;/\; \text{Volume of House in Cubic Feet}$$

The following two equations were taken directly from the product manual for the Minneapolis Blower Door®[9]:

$$Q = L \times ((A \times T) + (B \times V2))^{1/2}, \text{ where}$$

Q = airflow rate in cubic feet per minute (CFM)
L = Effective Leakage Area (ELA) in square inches
A = Stack Coefficient
T = Design indoor-outdoor temperature difference (F)
B = Wind Coefficient
V = Design wind speed

$$ACH = (Q \times 60) \;/\; \text{Volume of House in Cubic Feet}$$

Information for determining the proper Effective Leakage Area, Stack Coefficient, and Wind Coefficient can be found within tables in the Minneapolis Blower Door® manual, Appendix F. Design indoor-outdoor temperature difference (F) and Design wind speed

[8] The Energy Star Homes Northwest program utilizes these same performance test procedures.

[9] The Energy Conservatory, Minneapolis Blower Door™ Operation Manual for Model 3 and Model 4 Systems, Appendix F, http://www.energyconservatory.com

were determined by referencing the closest city to the test home in the 2001 ASHRAE Fundamentals handbook[10].

The qualifying infiltration rate for the Energy Star Homes Program in the Northwest is < 7 ACH50 for homes heated with gas furnaces/heat pumps and < 2.5 ACH50 for homes with zonal electric/propane/oil systems.

The homes in this study had an average ACH50 of 5.6 for central gas furnaces and heat pumps, less than the Energy Star Homes Program threshold. This finding suggests that new homes with central gas furnaces and heat pumps are being built slightly tighter than ESH requires. There were too few zonal systems in our data to compute an average ACH50.

Table 140 presents the measured ACH50 values along with the results of two models used to determine ACH at atmospheric pressure. The calculation methodology presented previously in this section is based on the LBNL model of infiltration[11]. NEEA recommended the use of the "ACH50 divided by 20" model based on the only previous large scale infiltration testing in the Northwest as part of the NORIS[12] study. RLW believes that each model is an approximation and the ACH50 test data should be compared to previous and future studies.

System Type	State	ACH		ACH50		ACH50 divided by 20		n
		Average	EB	Average	EB	Average	EB	
Central Systems	ID	0.39	0.04	4.9	0.4	0.24	0.02	44
	MT	0.47	0.28	5.8	2.6	0.29	0.13	4
	OR	0.50	0.06	6.6	0.7	0.33	0.04	113
	WA	0.41	0.02	5.3	0.3	0.26	0.02	83
	Overall	**0.44**	**0.03**	**5.6**	**0.3**	**0.28**	**0.02**	**244**

Table 140: Average Infiltration by State and System Type

Table 141 summarizes the recommended mechanical ventilation requirement for different building leakage classes[13]. The need for mechanical ventilation depends on climate, but primarily depends on building tightness. The results suggest that many new homes would fall in the category of needing some additional mechanical ventilation. However, it is important to point out that 1) This is an indoor air quality (IAQ) issue, not an energy efficiency issue, 2) Washington State code already requires whole house ventilation in new homes, 3) while homes are significantly tighter than the 1980's NORIS sample (ACH50 Mean 9.3 versus 2006 NRCC of 5.6), they are also significantly larger (2355 ft2 versus 1844 ft2) with median occupancy (2.4 persons/house versus 3.4) resulting in lower concentrations of occupant-generated pollutants (NOx, CO2, VOCs,

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[10] American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., 2001 ASHRAE® Handbook Fundamentals, Chapter 27.

[11] 1997 ASHRAE Fundamentals Handbook, Section 25.34.

[12] Palmiter, L. and Brown, I. Nortwest Residential Infiltration Study: Analysis and Results. August 15, 1989. Ecotope Inc. for the Washington State Energy Office

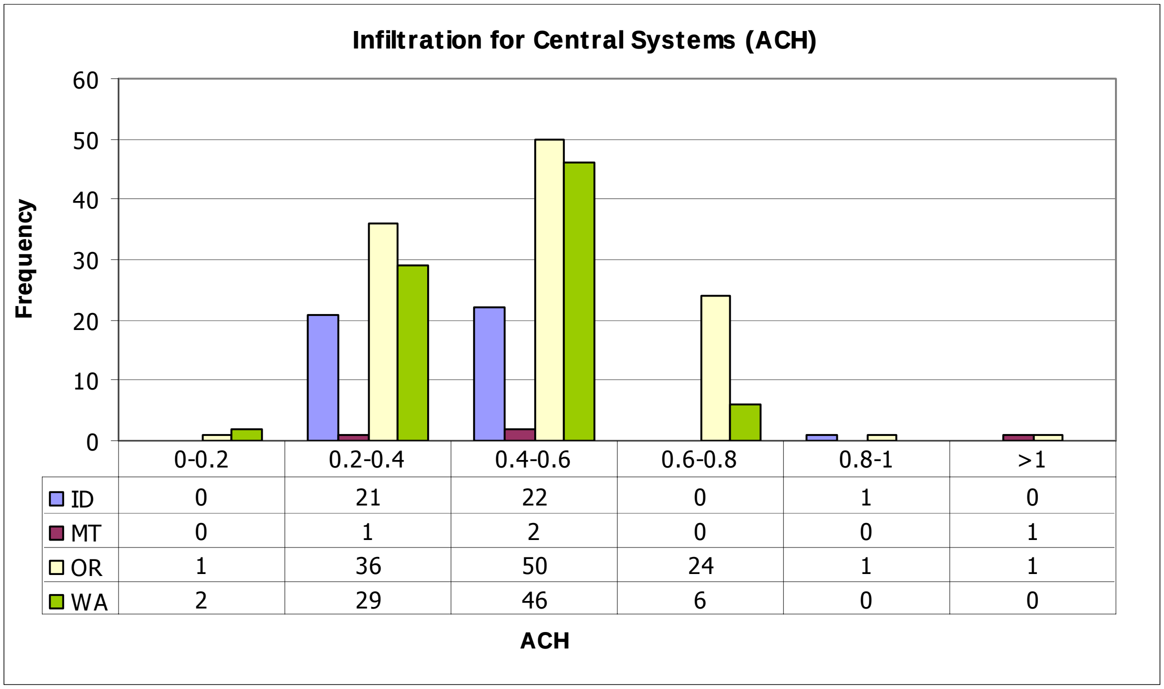
[13] Sherman, Max, LBL # 35173, The Use of Blower Door Data, http://epb.lbl.gov/blowerdoor/BlowerDoor.pdf

moisture). In conclusion, just because these homes average 5.6 ACH50 does not mean that they will necessarily experience IAQ problems.

LEAKAGE CLASS	Typical ACH50	Ventilation Requirement
A	1	Full
B	2	Yes
C	3	Yes
D	5	Some
E	7	Likely
F	10	Possible
G	14	Unlikely
H	20	None
I	27	Buildings in this range may be too loose and should be tightened
J	27+	

Table 141: Typical Ventilation Requirements by Leakage Class

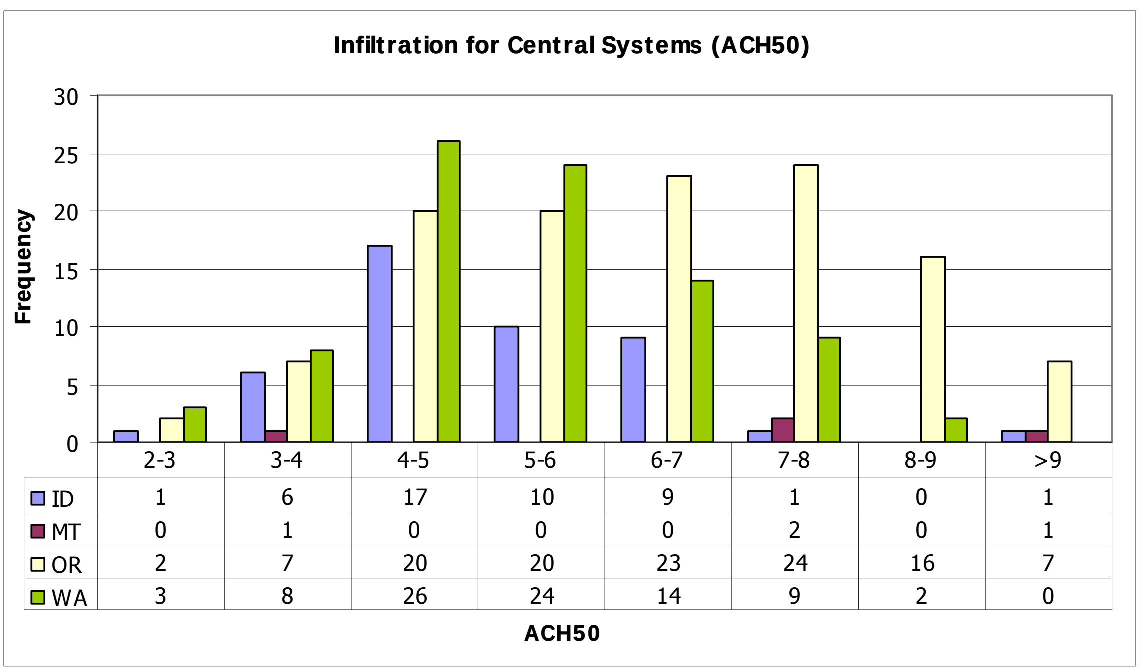
Figure 17 shows the frequency distribution of ACH by state for homes with central systems.



	0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1	>1
ID	0	21	22	0	1	0
MT	0	1	2	0	0	1
OR	1	36	50	24	1	1
WA	2	29	46	6	0	0

Figure 17: Frequency Distribution of ACH for Central Systems

Figure 18 shows the frequency distribution of ACH50 by state for homes with central systems. Oregon has higher infiltration rates than the other states. There were no apparent deficiencies in the construction of these homes and none of the other data collected suggest that Oregon homes would have higher infiltration, with the exception that there were more raised floors in Oregon relative to the rest of the region.



	2-3	3-4	4-5	5-6	6-7	7-8	8-9	>9
ID	1	6	17	10	9	1	0	1
MT	0	1	0	0	0	2	0	1
OR	2	7	20	20	23	24	16	7
WA	3	8	26	24	14	9	2	0

Figure 18: Frequency Distribution of ACH50 for Central Systems

System Airflow

Two analyses were performed on the airflow data: one summarizes system airflow relative to heating output capacity for forced air furnaces, and the second summarizes airflow per ton of cooling capacity for systems that had mechanical cooling installed.

The average overall fan airflow relative to system capacity for furnaces was found to be 15 CFM/kBTU of system *output.* The two heat pumps in the airflow test sample were dropped from the analysis. The 2001 California Residential Title-24 Manual uses 21.7 CFM/kBTU as a rule of thumb for default values for heating system airflow. The average system airflow that we measured in the four state region indicates that either the system ducts are undersized, or the fans are undersized or underperforming.

Of the original 264 test sites in the sample, 10 were zonal systems and therefore no airflow test could be conducted. Forty-one of the participant heating systems do not have an identifiable output capacity. There were 15 sites where airflow tests were not able to be performed due primarily to filter access obstruction that prevented installation of the orifice plate.

System Type	State	Airflow (CFM / kBTU Output)		n
		Average	EB	
Forced Air Furnace	ID	14.0	0.9	36
	MT	15.2	3.2	4
	OR	13.6	1.1	87
	WA	16.2	1.5	69
	Overall	**14.9**	**0.7**	**196**

Table 142: Average System Airflow per kBTU

Figure 19 shows the frequency distribution of the measured system airflow by state for forced air furnaces.

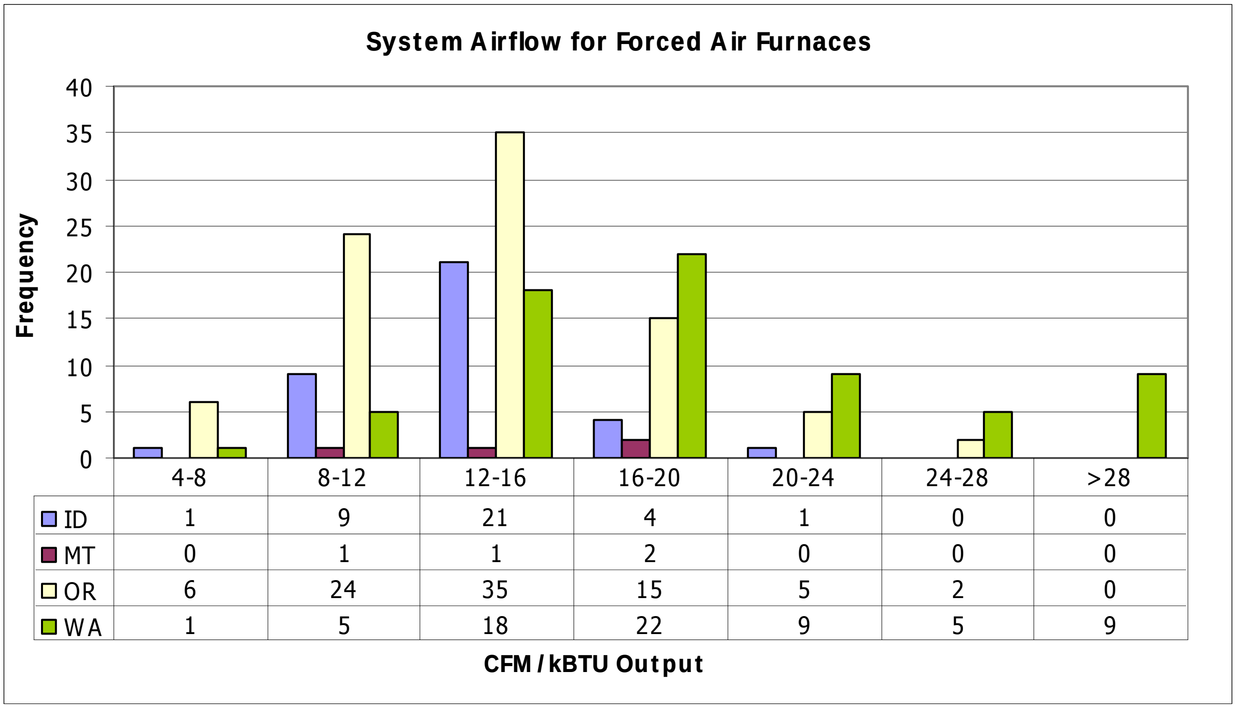


Figure 19: Frequency Distribution of System Airflow

The average measured fan airflow normalized to cooling capacity is 294 CFM/ton for the region. These averages are lower than nominal system design airflow of 400 CFM/ton, although this metric does not include air distribution system leakage that would decrease the airflow measured by in-situ performance testing.

State	Airflow (CFM / ton)		n
	Average	EB	
ID	299	24	42
MT	281	91	2
OR	292	14	66
WA	291	27	25
Overall	**294**	**13**	**135**

Table 143: Average System Airflow per Ton of Cooling

Unfortunately there are no comparable large scale studies of residential HVAC airflow testing. To better understand why measured airflow is less than design flow we examined the possible differences between our in-situ tests and manufacturer's laboratory tests.

1. The measured average may have been affected by the airflow measurement test conditions which were taken in the heating mode. In systems with two fan speeds, the heating fan speed is the lower of the two, while the cooling fan speed uses the higher fan speed setting.
2. The measured airflow may have been affected by airflow bypassing the flow grid orifice plate during measurement. Two situations that would result in plate

bypass are leaky air handler cabinets[14] when the plate was installed at the air handler and leaky return systems when the plate was installed at the return registers are

[14] Withers, Charles Air Handlers: An Appliance of Airtight Defiance? 2006 ACEEE Summer Study on Energy Efficiency in Buildings. Day 1 Panel 1, Second Session. Work funded by the Florida Solar Energy Center

Duct Leakage

The duct leakage testing was performed on 225 sites. The leakage was analyzed in relation to the presence of a basement. Duct leakage to outside the thermal envelope of the home is given as both a percentage of system fan flow and floor area. The overall average that RLW measured for the region is 21% of total measured airflow, which is actually a ratio of duct leakage at 25 PA relative to measured system airflow. Most homes tested did not have a basement. All basements tested were conditioned.

Table 144 presents the average duct leakage (CFM25) as a percentage of measured system airflow by state and basement type. Note that these metrics are relative to measured system airflow, and not a design airflow based upon system capacity, therefore the percentages are higher than what would be calculated if the assumed airflow, typically 21.7 CFM/kBtu of heating capacity or 400 CFM/ton of cooling capacity, were used in the calculation. The alternative duct leakage percentages based on system design airflow (nominal) are presented in Table 145. Recall from the previous system airflow section that the measured airflows are approximately 75% of the nominal airflow. The overall average duct leakage as a percentage of nominal airflow is 15%, or 72% of the duct leakage percentage relative to measured airflow.

Basement Type	State	% Leakage		n
		Average	EB	
None	ID	24%	3%	37
	MT	20%	13%	3
	OR	22%	4%	91
	WA	21%	2%	67
	Overall	**22%**	**2%**	**198**
Conditioned	ID	7%	3%	3
	OR	13%	7%	8
	WA	15%	10%	4
	Overall	**11%**	**4%**	**15**
Overall	ID	20%	4%	40
	MT	20%	13%	3
	OR	21%	4%	99
	WA	21%	2%	71
	Overall	**21%**	**2%**	**213**

Table 144: Average Duct Leakage (CFM25) as % of *Measured* System Airflow

Basement Type	State	% Leakage		n
		Average	EB	
None	ID	14%	2%	31
	MT	12%	5%	3
	OR	15%	3%	68
	WA	17%	2%	61
	Overall	**15%**	**1%**	**163**
Conditioned	ID	5%	4%	2
	OR	7%	4%	6
	WA	17%	5%	3
	Overall	**8%**	**4%**	**11**
Overall	ID	13%	2%	33
	MT	12%	5%	3
	OR	14%	3%	74
	WA	17%	2%	64
	Overall	**15%**	**1%**	**174**

Table 145: Average Duct Leakage (CFM25) as % of *Nominal* System Airflow

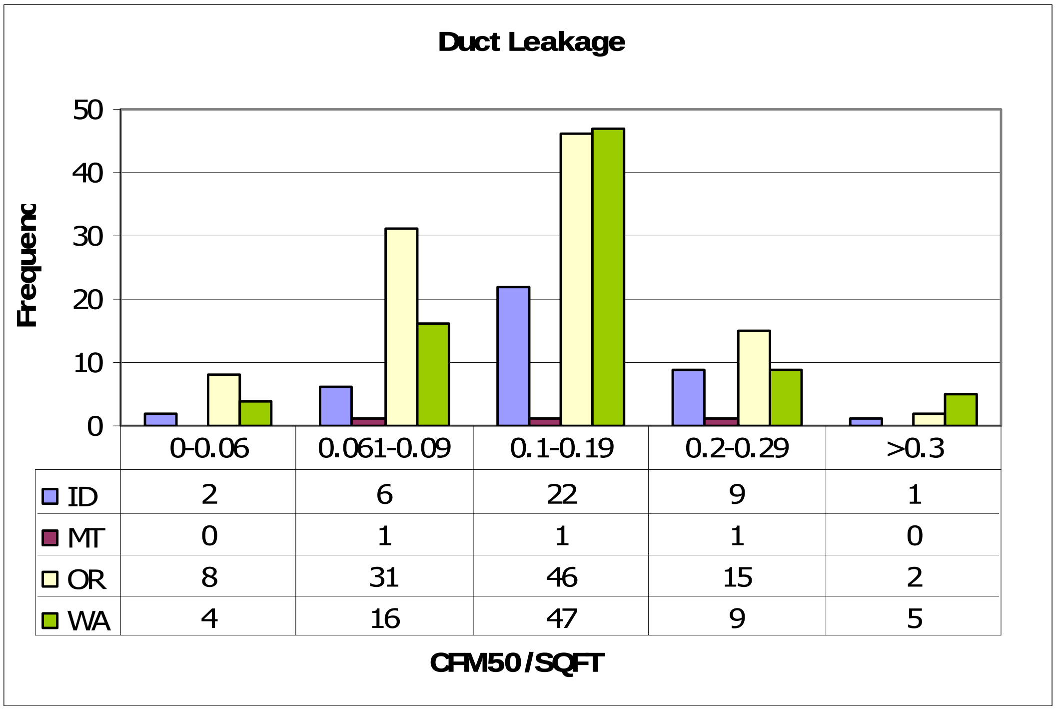
Table 146 presents the average duct leakage relative to conditioned floor area square footage. These results are significantly higher than the Energy Star Northwest Home duct leakage test requirement of 0.06 CFM50 per square foot of floor area, using the same performance test procedures[15]. This may be due to a number of different factors including the prevalence of wall plenums used as returns, the underutilization of mastic as a duct sealant, and other installation deficiencies.

Basement Type	State	CFM50/sqft		n
		Average	EB	
None	ID	0.16	0.02	37
	MT	0.15	0.05	3
	OR	0.15	0.03	93
	WA	0.14	0.01	76
	Overall	**0.15**	**0.01**	**209**
Conditioned	ID	0.06	0.02	3
	OR	0.05	0.02	9
	WA	0.09	0.09	4
	Overall	**0.06**	**0.02**	**16**
Overall	ID	0.14	0.03	40
	MT	0.15	0.05	3
	OR	0.13	0.03	102
	WA	0.14	0.01	80
	Overall	**0.14**	**0.01**	**225**

Table 146: Average Duct Leakage (CFM50) per Square Foot

[15] Performance Tested Comfort Systems (PTCS), October 2003, Total Duct Leakage Test Standard: For certification, the measured CFM50 must not exceed 0.06 CFM50 x floor area served by the system (in square feet) or 75 CFM50, whichever is greater.

Figure 20 shows the frequency distribution of the measured duct leakage per square foot by state for all homes. Recall that the Energy Star Northwest Home duct leakage test requirement is 0.06 CFM50 per square foot of floor area, as broken out in the following chart.



	0-0.06	0.061-0.09	0.1-0.19	0.2-0.29	>0.3
ID	2	6	22	9	1
MT	0	1	1	1	0
OR	8	31	46	15	2
WA	4	16	47	9	5

Figure 20: Frequency Distribution of Duct Leakage for All Homes

This concludes the Residential New Construction Baseline Study Report. A final study appendix is also available that contains more detailed information on how the data analyses were performed and describes the final study datasets.