EVERGREEN ECONOMICS

Baseline Energy Appliance, Equipment and Building Characteristics Study Report

Prepared for the State of Hawaii Public Utilities Commission

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*Note: Appendices A-H are included in a separate document.

1 Executive Summary

This report presents the findings of the Baseline Energy Appliance, Equipment and Building Characteristics Study for Energy Use in the Hawaiian Electric Companies' Service territories ("Baseline Study").[1] Energy efficiency programs in the Hawaiian Electric Companies' service territories are offered under the auspices of the State of Hawaii Public Utilities Commission (PUC), funded by a Public Benefits Fee (PBF) and administered by a Public Benefits Fee Administrator (PBFA) as "Hawaii Energy." [2,3]

1.1 Study Objectives

This study presents the results of research conducted on behalf of the State of Hawaii PUC to assess key characteristics of buildings, appliances and equipment that use electricity in the Hawaiian Electric Companies' service territories providing a "baseline" from which to assess changes in the buildings, equipment, appliance, and use patterns over time. Study results will inform the planning of future energy efficiency programs and support a statewide energy efficiency potential study currently underway via the PUC. The baseline data contained in this report will be used to enhance or update PBF-funded energy efficiency programs and for planning other energy-related programs and policies in the state. These baseline data will serve as a reference point to monitor the effectiveness of program efforts or track progress toward energy efficiency and related goals. Finally, these baseline data may also be used by the Hawaiian Electric Companies for electricity load planning.

The following report provides a comprehensive characterization of the buildings, appliance and equipment holdings (including efficiency levels), and occupancy as they relate to electricity consumption across customers within all sizes and segments of the Hawaiian Electric Companies' service territories.

1.2 Study Approach

Data and findings presented in this report are based on a combination of comprehensive and in-depth data collection efforts. These data collection efforts include nearly 900 on-site surveys and almost as many mail surveys. Table 1, shown on the next page, provides an

[1] Hawaiian Electric Companies include Hawaiian Electric and its subsidiaries, Maui Electric Company and Hawaii Electric

[2] Science Applications International Corporation (SAIC) has been under contract to the Hawaii PUC as the PBFA since 2009, and as such administers the Hawaii Energy Conservation and Efficiency Programs (or "Hawaii Energy" Programs www.hawaiienergy.com).

[3] Note that the Kauai Island Utility Cooperative (KIUC), which provides electricity on Kauai, does not participate in the PBF. This baseline study was funded with PBF dollars, and therefore covers the Hawaiian Electric Companies' service territories but excludes Kauai.

overview of the survey efforts, including the number completed by sector, county[4] and survey mode. Data collection was completed over a one-year period beginning July of 2012.

Table 1 – Overview of Baseline Study Survey Completes by Sector, County and Mode

County	Number of Completed Surveys				
	Total	Residential On-site	Small and Medium Business Mail	Small and Medium Business On-site	Large Business On-site[2]
Oahu	1,041	249	488	276	28
Maui[1]	334	81	165	76	12
Hawaii	389	75	227	74	13
Total	1,764	405	880	426	53

[1] The mail survey included all three inhabited islands within Maui County (Maui, Lanai and Molokai islands), while the on-site surveys were conducted only on the island of Maui, which according to the 2010 U.S. Census accounts for 92 percent of Maui County's residents.

[2] The definition of a "large business" is based on the Hawaiian Electric Companies rate code that signified a large customer or business that had a dedicated Hawaiian Electric Company account manager.

1.3 Findings

This section provides key baseline findings for the residential and business sectors.

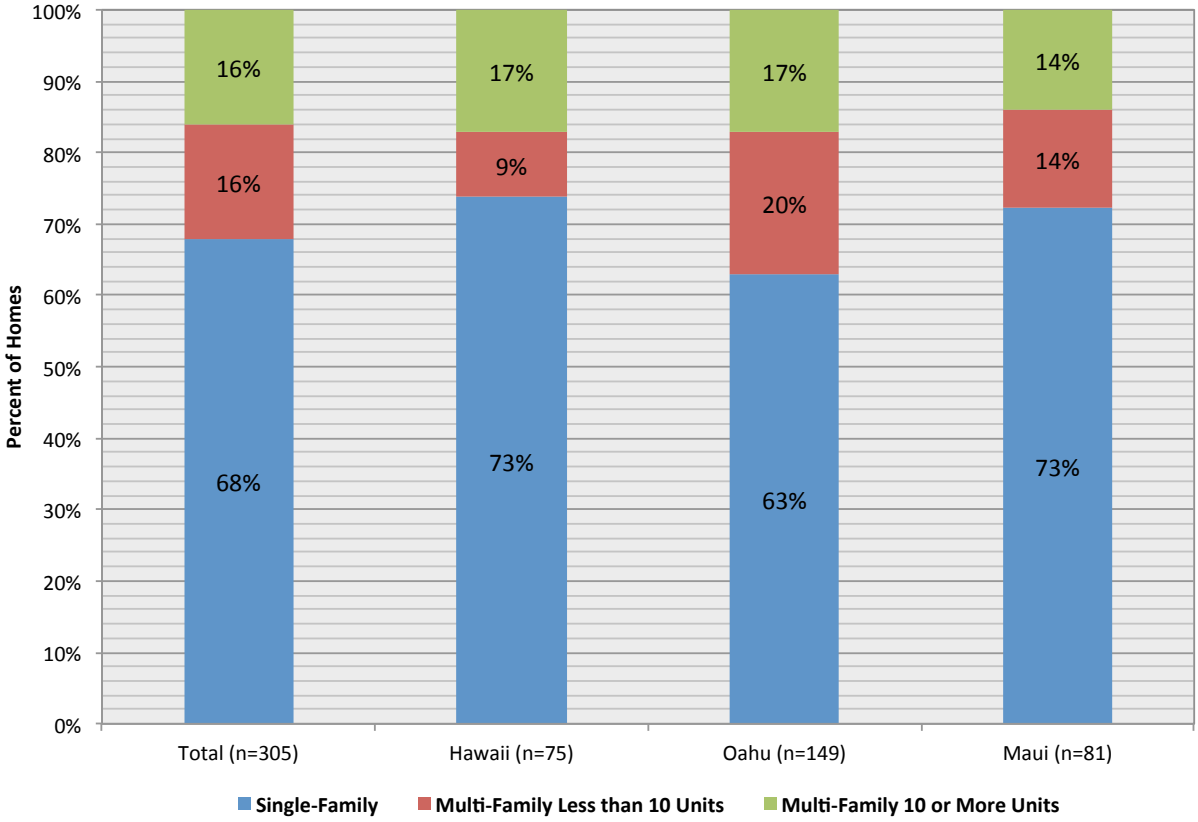
1.3.1 Residential Sector

In Section 4, we present selected results from the residential on-site surveys, with comprehensive results provided in Appendix C. We selected a few exhibits to include in this summary that highlight the findings.

First, we present the breakdown of single-family versus multi-family by county, and for multi-family, broken out by the number of units in the building. All of the rest of the charts in this summary present the observed on-site survey data for the following segments: Total, Hawaii, Oahu, Maui, Single-Family, and Multi-Family. As shown in Figure 1 on the next page, our on-site survey results are weighted to the population such that 68 percent of homes are single-family and 32 percent are multi-family, with an equal split between buildings less than 10 units and 10 units or more.

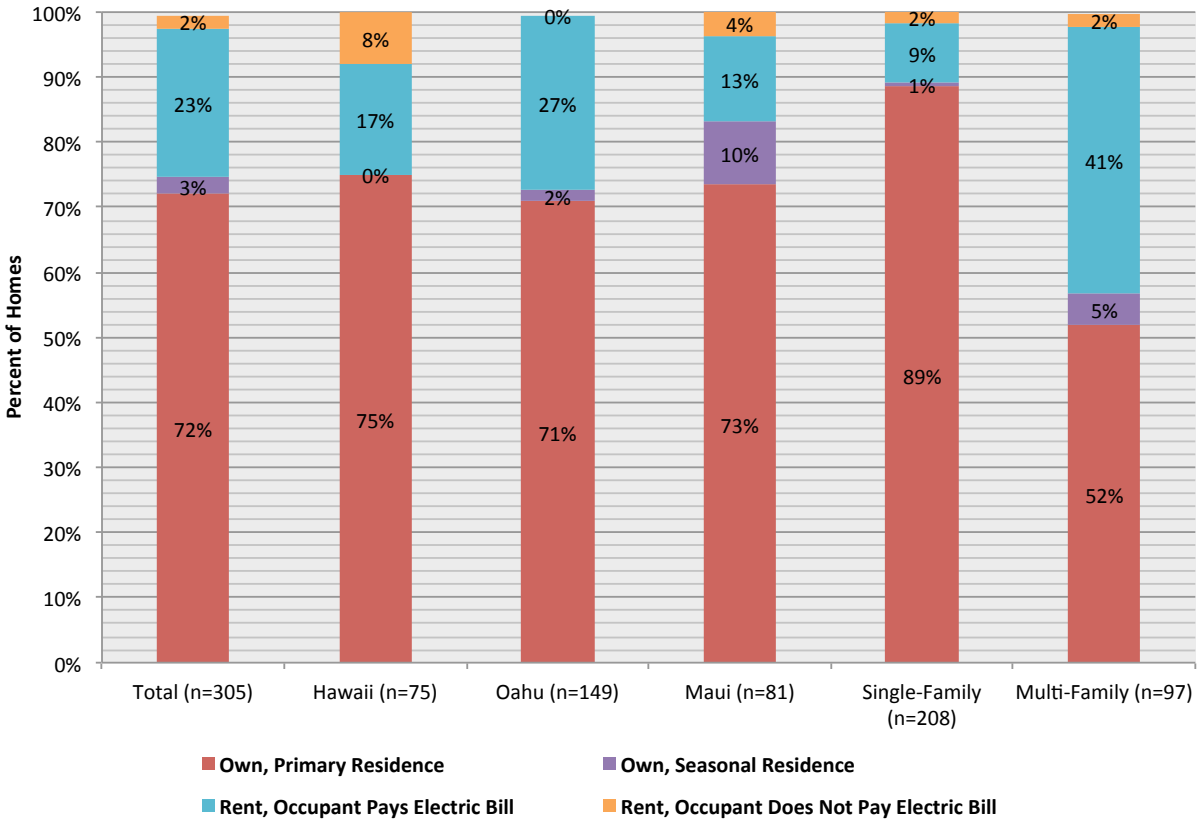
[4] Three inhabited islands (Maui, Molokai and Lanai) comprise Maui County; we use the term "county" to refer to all three islands in order to distinguish between Maui island and Maui County (which this study is intended to represent). Elsewhere in the report, we use the term "Oahu" or "Oahu County"; we should technically refer to Oahu as "City and County of Honolulu" when presenting results by county, but we chose to use 'Oahu' when referring to the county to make it clear we are referring to the entire island rather than just the city of Honolulu.

Figure 1 – Home Type by County



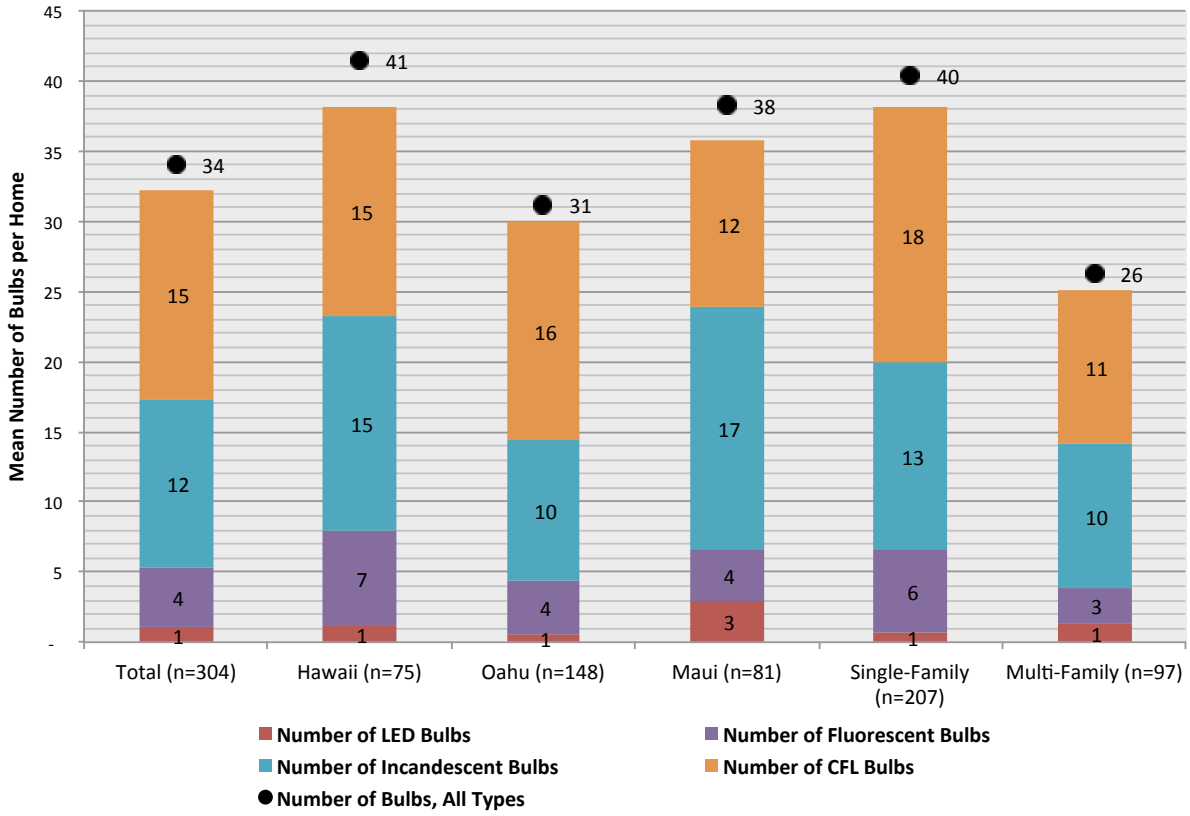
Next, we highlight results from the household questionnaire that auditors gave to residents of surveyed homes. As shown in Figure 2, 75 percent of households are owner occupied, and a small percentage (about 3%) of owner-occupied homes are not a primary home and are used only seasonally. The remainder is renter occupied, with most renters directly paying their own electricity bill.

Figure 2 – Homes by Ownership, Occupancy and Electricity Bill Payment, and by County and Home Type



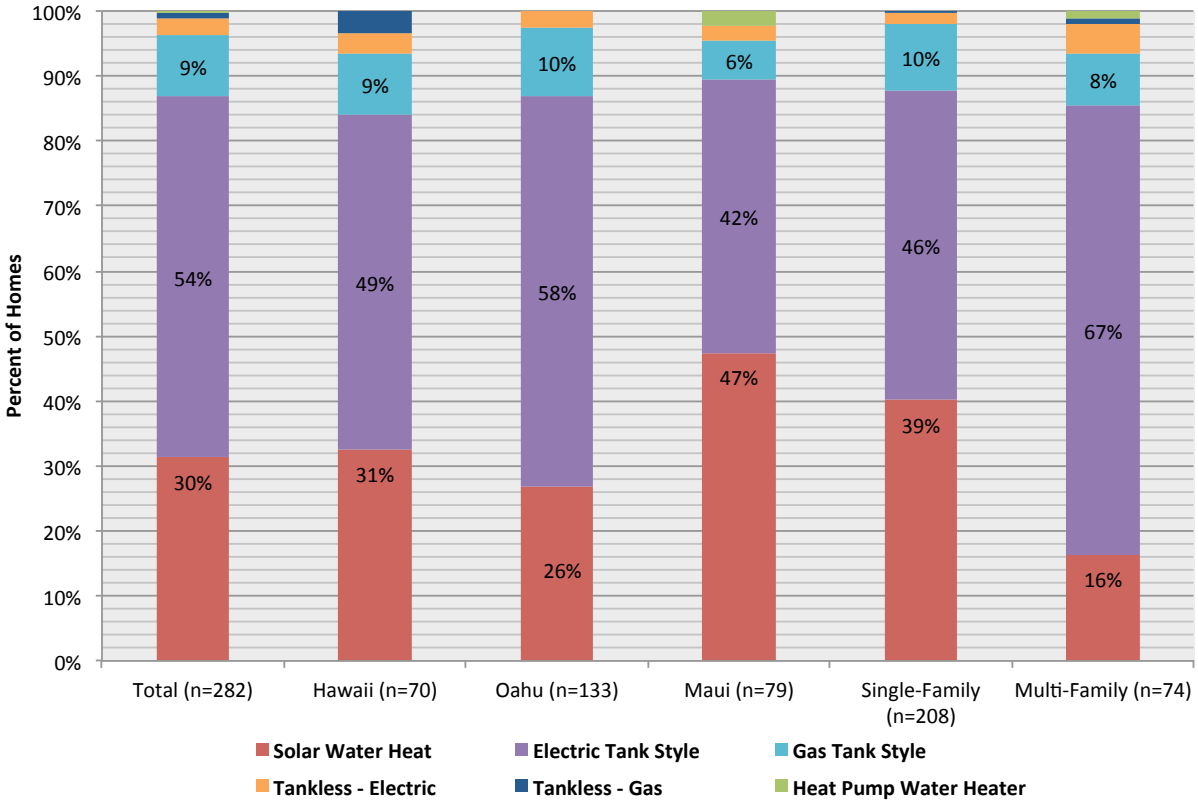
On the next page, Figure 3 presents a subset of lighting results based on the bulb inventory collected by auditors as part of the on-site survey effort. As shown, the mean number of installed bulbs per home is 34. There is an average of one light-emitting diode, four fluorescent bulbs, 12 incandescent bulbs and 15 compact fluorescent lamps per home.

Figure 3 – Mean Number of Installed Bulbs per Home by Type, and by County and Home Type



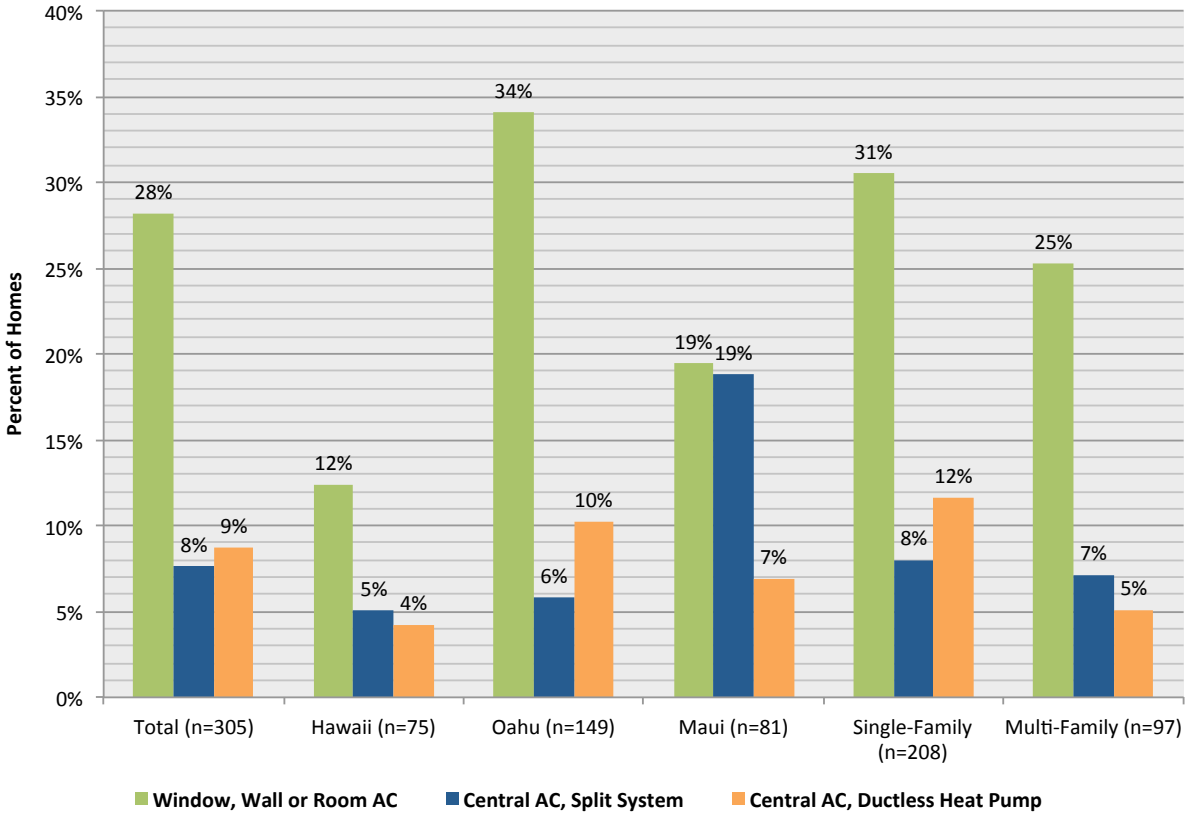
The following exhibit highlights data we collected on water heating equipment. Figure 4 shows the share of different types of water heating equipment and fuel sources by county and home type. As shown, 30 percent of water heaters are solar, with a higher percentage of solar water heaters on Maui and in single-family homes.

Figure 4 – Water Heating Type and Fuel Source, by County and Home Type



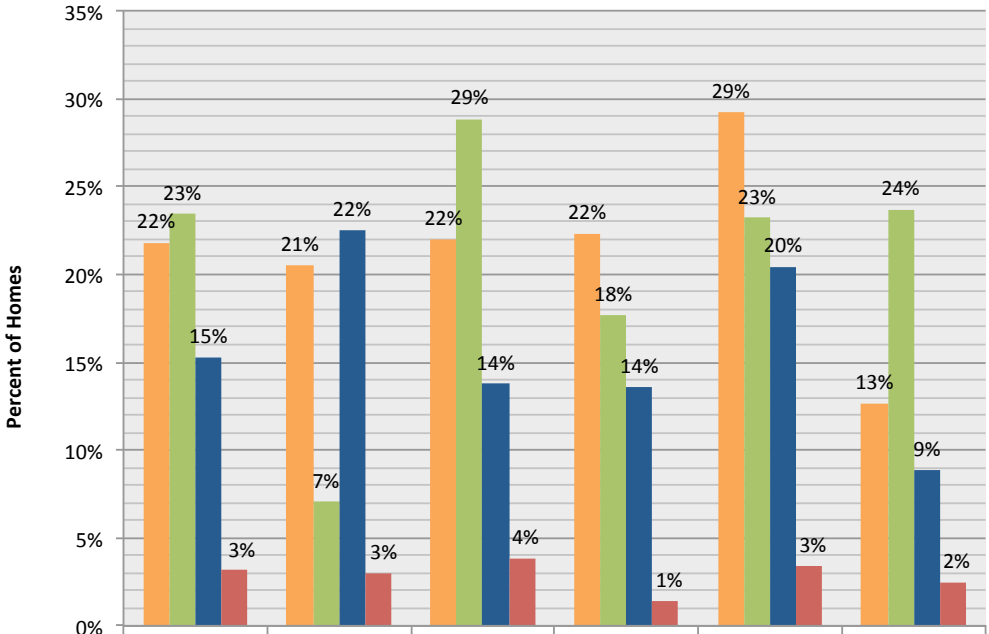
The next exhibit in this summary highlights results based on our observations of space cooling equipment. Figure 5 shows the percent of homes with space cooling appliances by county and home type. Window, wall or room air conditioners are the most commonly held type of cooling equipment (28% of homes). Eight percent of homes use split-system central air conditioning, with many more homes on Maui using this type of cooling equipment. As shown in Section 4, newer homes are much more likely to have split-system central air conditioning.

Figure 5 – Percent of Homes with Space Cooling Appliances, by County and Home Type



The final exhibit in this summary presents key features of the refrigerator and freezer holdings. As shown in Figure 6, 22 percent of homes have two or more refrigerators, and 15 percent of homes have a stand-alone freezer. The fraction of refrigerators that have an Energy Star rating, based on the sample of refrigerators that we were able to confirm, is 23 percent, and for stand-alone freezers, only three percent.

Figure 6 – Refrigerator and Stand-Alone Freezer Holdings and Efficiency, by County and Home Type



	Total (n=305)	Hawaii (n=75)	Oahu (n=149)	Maui (n=81)	Single-Family (n=208)	Multi-Family (n=97)
More than 1 Fridge	22%	21%	22%	22%	29%	13%
Energy Star Fridge (1 or More)	23%	7%	29%	18%	23%	24%
Stand Alone Freezer (1 or More)	15%	22%	14%	14%	20%	9%
Energy Star Freezer (1 or More)	3%	3%	4%	1%	3%	2%

1.3.2 Business Sector

In Section 5, we present selected results from the business and mail on-site surveys, with comprehensive results provided in Appendix C. We selected a few exhibits to include in this summary that highlight the findings. We note the source of each exhibit, indicating whether the results are based on the on-site and mail surveys or just the on-site surveys.

First, we present the breakdown of buildings by size – by business type and overall for small-medium customers in the combined mail and on-site samples, and overall for large/assigned accounts. As shown in Table 2, large/assigned account buildings are, on average, roughly one hundred times larger than those in the small-medium group. Within the small-medium group, the warehouse, education and amusement sectors all have fewer buildings under 5,000 square feet than other segments (the difference is not statistically significant for lodging.)

Table 2 – Building Square Footage – Business Sector

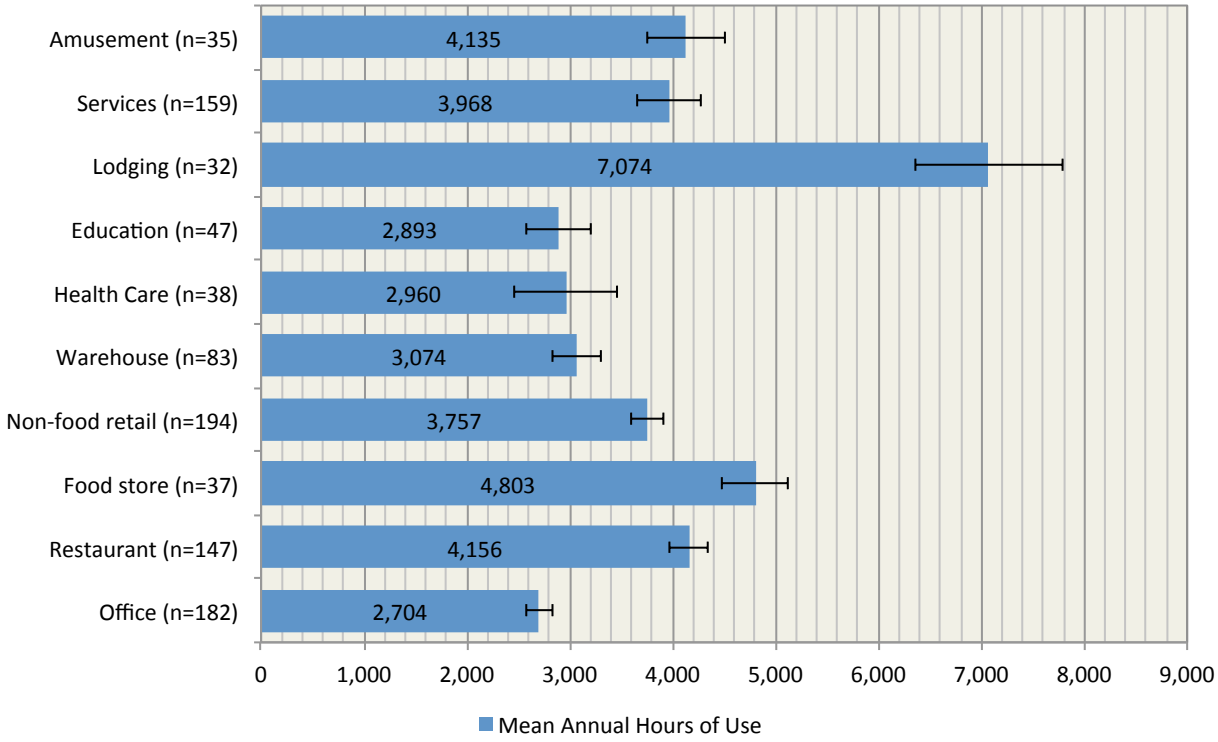
Square Feet	Small-Medium n = 1,037	Large n = 42
Less than 1K Square Feet	19%	0%
1K to 5K Square Feet	46%	12%
5K to 10K Square Feet	14%	9%
10K to 25K Square Feet	11%	12%
25K to 50K Square Feet	5%	2%
50K to 100K Square Feet	2%	23%
100K to 200K Square Feet	1%	27%
200K to 500 Square Feet	1%	4%
Greater than 500K Square Feet	0%	12%
Mean	12,246 sq. ft.	1,223,294 sq. ft.

Source: Mail and On-site Surveys

Differences between small-medium and large buildings are not as pronounced for building age, with a mean age of 34.9 years for small-medium and 31 years for large/assigned account buildings – not a statistically significant difference.

Another characteristic where the large/assigned buildings sample differs from the small and medium group is annual hours of operation. On average, buildings in the large sample reported being open 5,592 hours, compared to 3,521 for the small-medium group, a statistically significant difference. As indicated by the results in Figure 7 showing hours of operation by business type for small-medium businesses, the highest, lodging (7,074), averages about 2.5 times the hours of offices (2,704). No other business type averages more than 5,000 annual hours of operation. Note that the lines and end points show the 90 percent confidence intervals around the means, so that statistically significant differences can be seen.

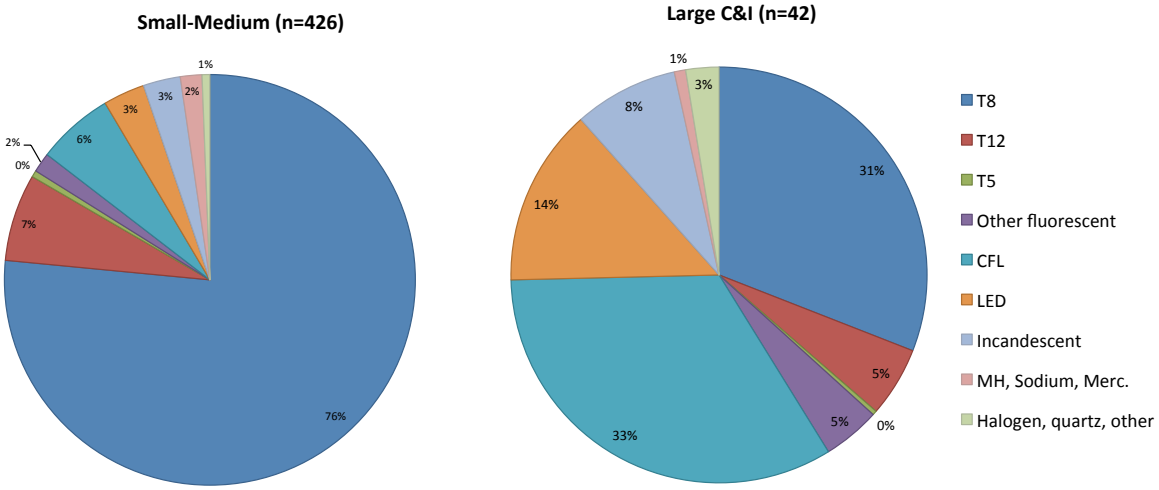
Figure 7 – Small-Medium Business Annual Hours of Operation, by Business Type



Source: Mail and On-site Surveys

Next, we present information on the distribution of lighting technologies, focusing on the relative share of various lighting types as a percentage of the overall population of lamps, presented in Figure 8. While T8s account for the overwhelming majority of lighting installed in small-medium buildings, CFL lamps account for the largest share (one-third) of the lamps at the sampled large/assigned account sites, followed closely by T8s (31%). Overall, T12s represent less than five percent of the lamps noted at large/assigned account sites and seven percent at the small-medium sites.

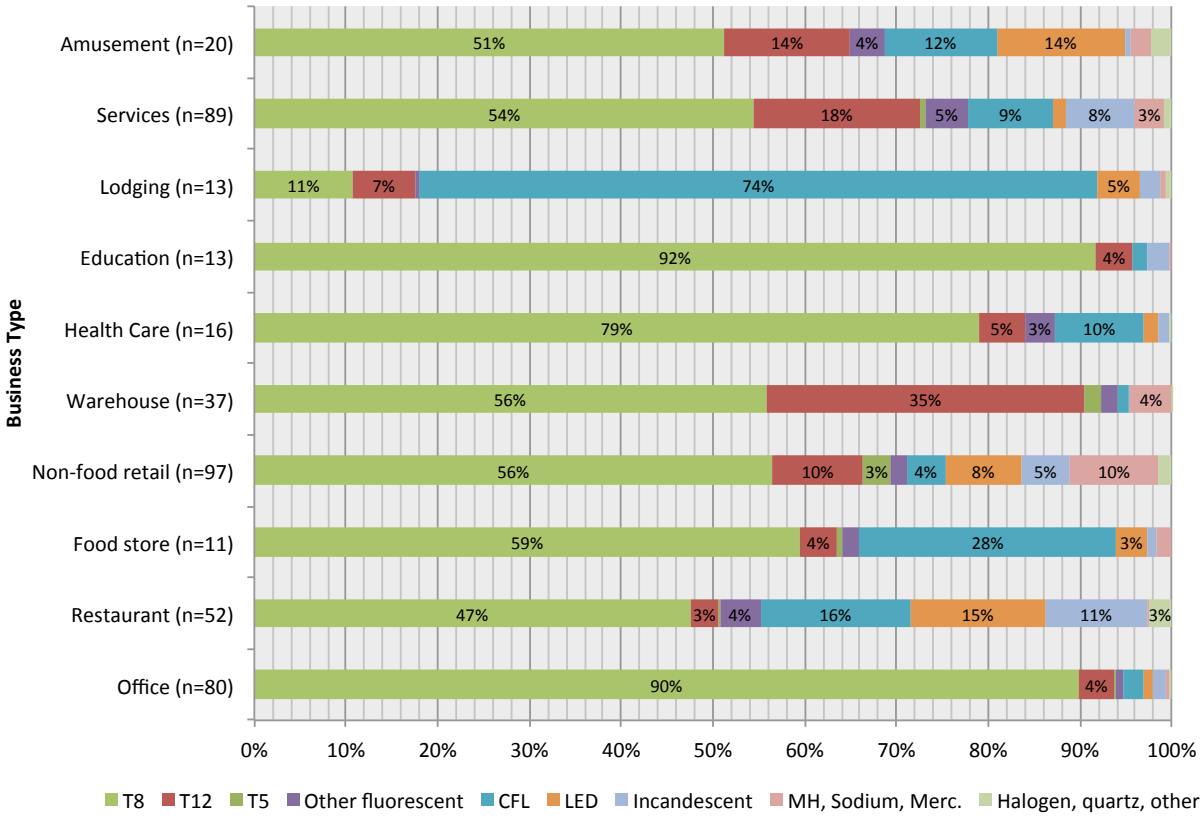
Figure 8 – Population of Lighting Technologies, by Lamp Type



Source: Mail and On-site Surveys

Figure 9 presents the distribution of lighting technologies across business types based on the small-medium on-site surveys, and shows that the share of T8 and T5 lamps is highest in the office and education sectors, while warehouses have the greatest percentage of T12 lamps (35%), indicating that there may still be opportunities to encourage upgrades to more efficient linear fluorescents in this sector. Another sector with potential is services, which still shows a relatively high proportion of T12s (18%) and incandescent bulbs (8%).

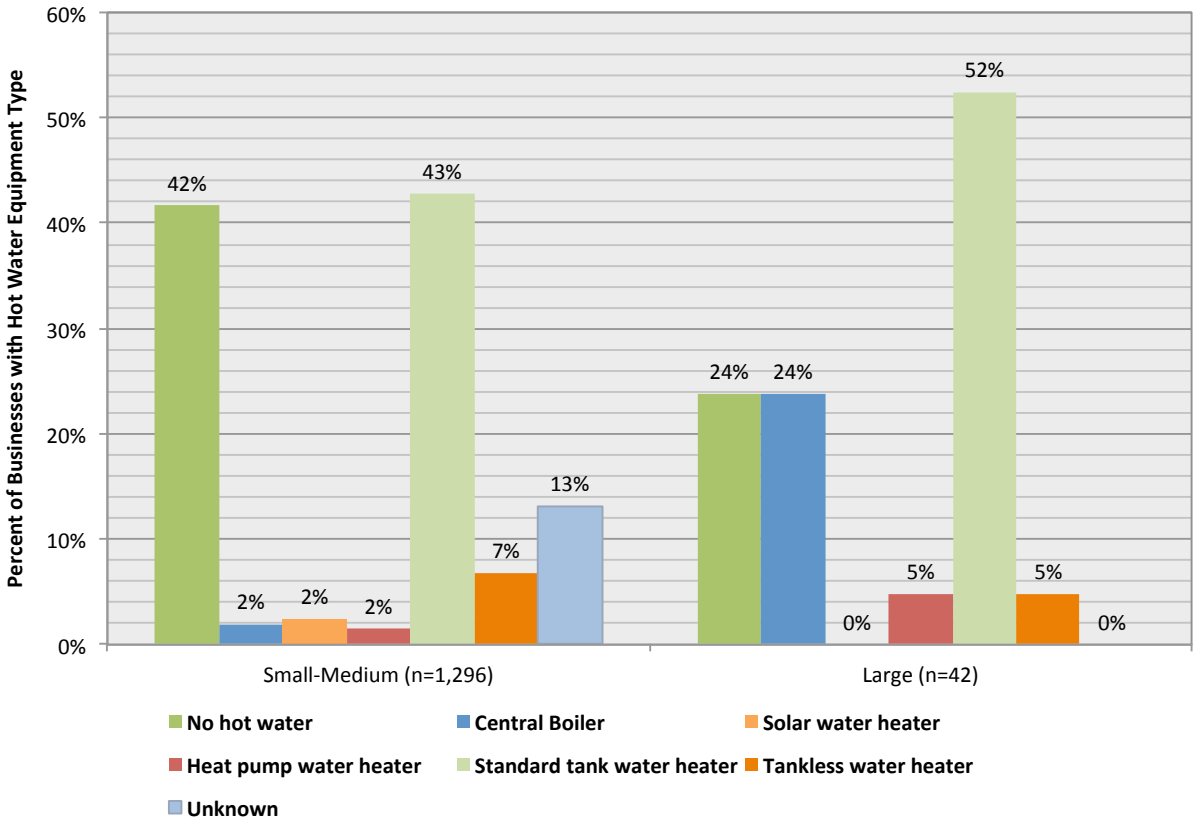
Figure 9 – Distribution of Lighting Technologies, by Small-Medium Business Type



Source: Mail and On-site Surveys

Our next set of results analyzing hot water heating equipment at business buildings, summarized in Figure 10, shows that 24 percent of large buildings have no hot water, compared to 42 percent of small-medium sites – a statistically significant difference. Standard tank type water heaters are most common (52% of large and 42% of small-medium buildings), while 24 percent of large and two percent of small-medium sites have boilers. Average capacity per unit observed at the large sites is 1,456 gallons for the boilers and 450 gallons for tank style heaters, significantly larger than the small-medium averages of 237 gallons for boilers and 72 gallons for standard tank systems.

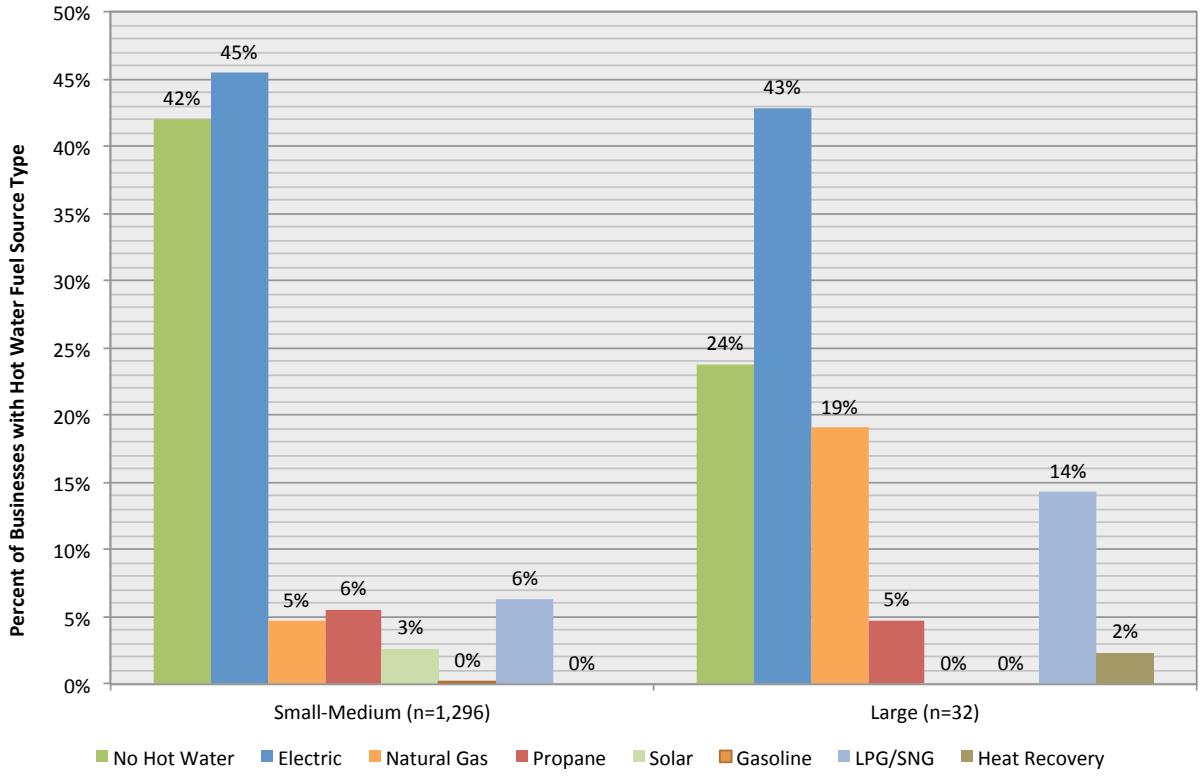
Figure 10 – Business Hot Water Heating Equipment



Source: Mail and On-site Surveys

Hot water fuel sources, shown in Figure 11, illustrate that electricity is by far the most common hot water fuel source. Solar hot water is found at two percent of small-medium buildings, and at none of the 52 large/assigned account buildings, indicating that more work needs to be done to encourage adoption of solar water heating technology among this group of generally knowledgeable customers.

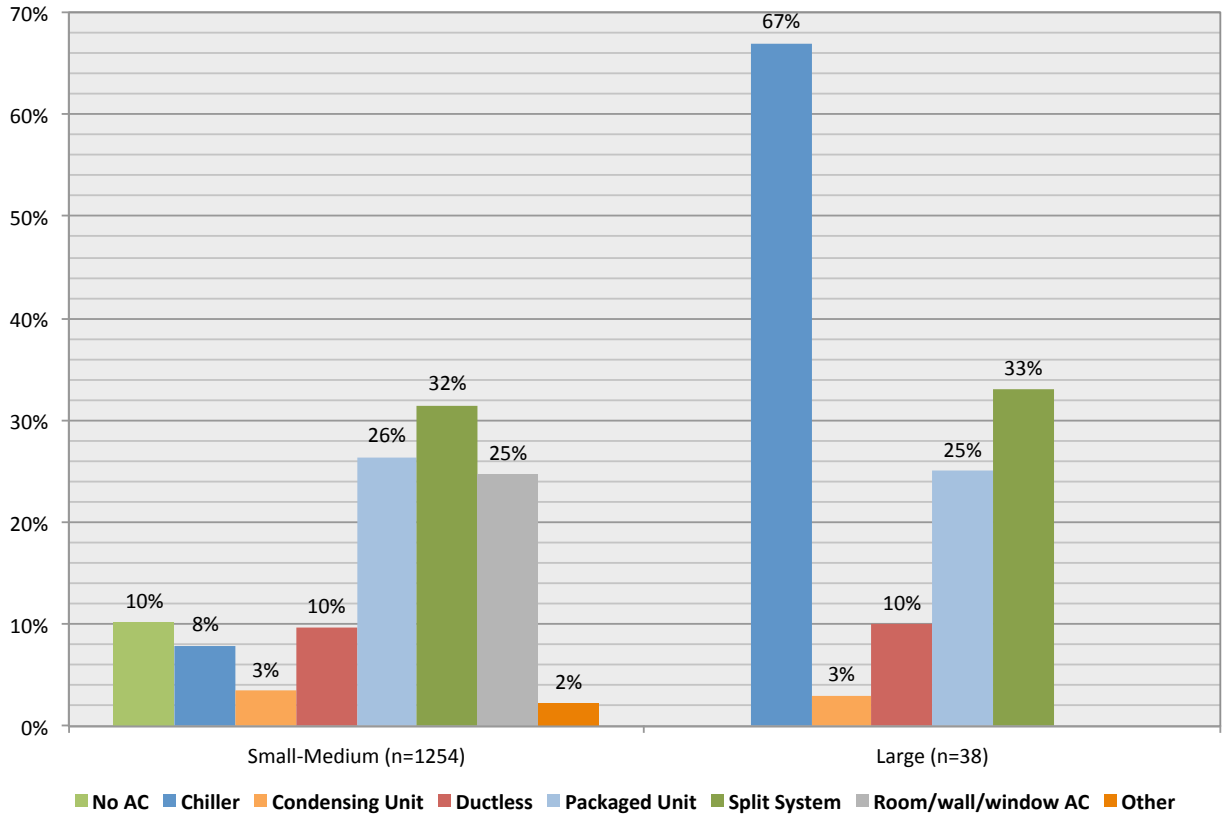
Figure 11 – Business Hot Water Heating Fuel Source



Source: Mail and On-site Surveys

While fully one-third of small-medium facilities have no air conditioning equipment, all of the large facilities cool at least part of their space, with two-thirds using chillers and one-third employing split systems, as shown in Figure 12. Over half of all facilities in both categories cool 100 percent of their facility.

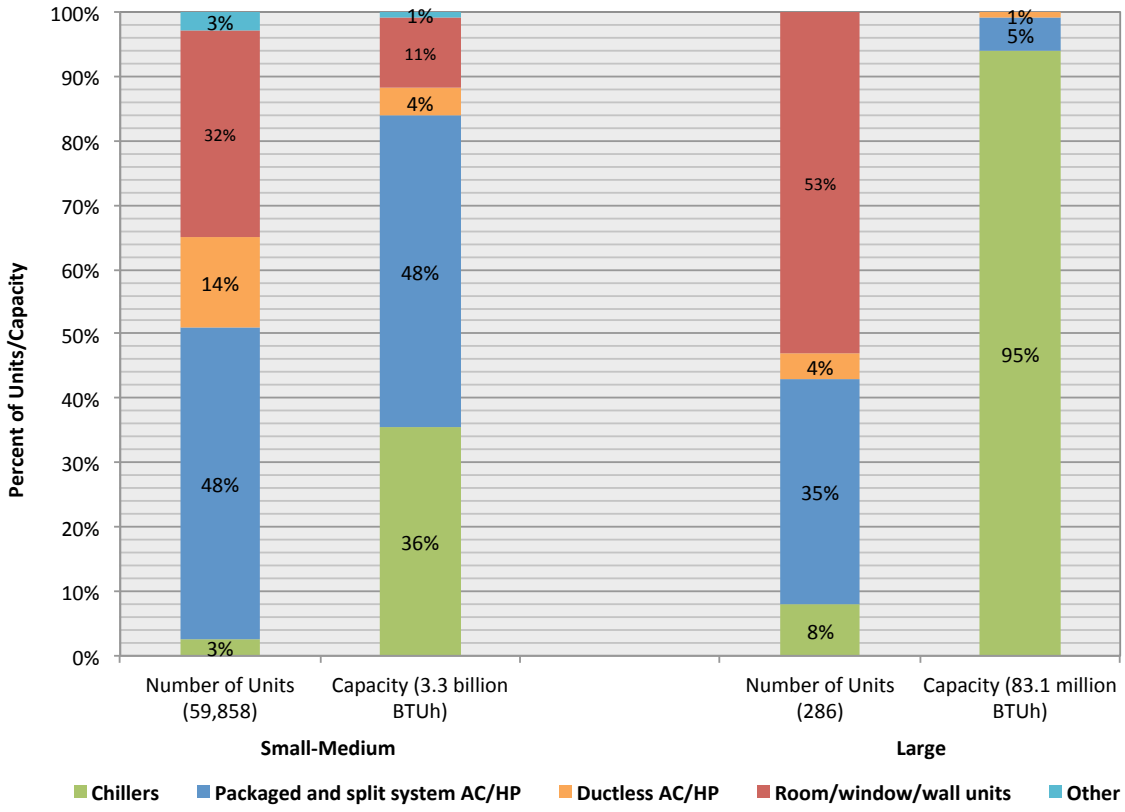
Figure 12 – Business Cooling Equipment Types



Source: Mail and On-site Surveys

Using capacity data collected during the on-site audits, the average capacity for each type of cooling system was applied to the population of that system type to estimate the percentage breakdown of cooling capacity compared to the percentage breakdown of the number of units. Results, presented in Figure 13, indicate that while chillers make up less than two percent of the equipment at small-medium buildings and nine percent of units at large/assigned account buildings, they represent more than a third of cooling capacity for small-medium buildings and almost 95 percent of capacity for large/assigned account sites.

Figure 13 – Business Cooling Equipment Numbers and Capacity



Source: Mail and On-site Surveys

In a state where tourism and service industries play a very important role, it is not surprising that many businesses use traditionally "residential" measures such as washers, dryers and dishwashers. As shown in Table 3, among small-medium buildings, 25 percent of buildings have at least one washer on site, and 22 percent have dryers, which include both residential and commercial sized units. For large/assigned account sites, washers are found at 31 percent of sites, dryers at 28 percent of sites, and dishwashers at 21 percent of sites, although some of these have hundreds of units in place.

Table 3 – Appliances: Penetration and Average per Site

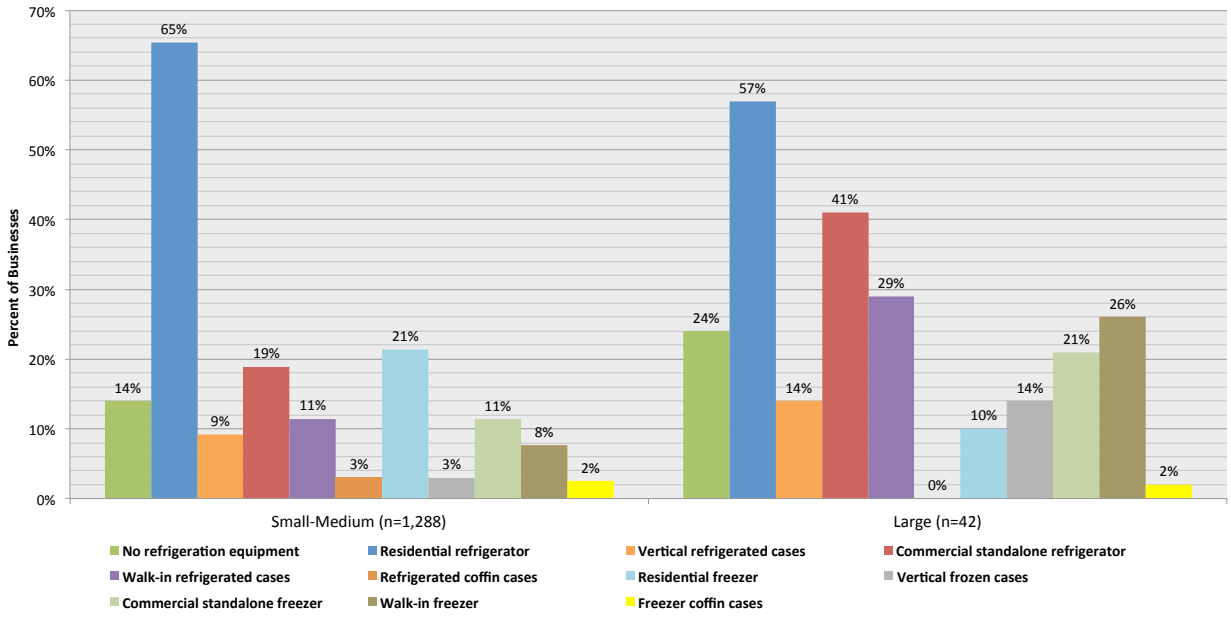
Appliance Type	Small-Med (n=941)		Large (n=42)	
	%	Avg./site	%	Avg./site
Dishwashers	10%	1.3	21%	117.4
Washers	25%	3.3	31%	83.9
Dryers	22%	3.4	28%	84.5

Source: Mail and On-site Surveys

The hospitality and tourism industries also influence the presence of cooking and refrigeration equipment. As shown in Figure 14, 86 percent of the buildings in the small-medium mail and on-site samples have some kind of refrigeration equipment, most often residential refrigerators. Residential freezers and higher capacity commercial standalone refrigerators and freezers are the next most common measures, while fewer small-medium sites have centralized refrigeration systems associated with vertical and coffin cases and walk-in coolers/freezers.

At large/assigned account sites, upright residential refrigerators were noted at 57 percent of sites, with an average of more than 200 units per site because several large hotels were included in the sample. Among commercial refrigeration equipment types, the most common are standalone refrigerators and walk-in refrigerated cases.

Figure 14 – Business Refrigeration Equipment



Source: Mail and On-site Surveys

Cooking equipment also has a high penetration rate among business sites across the state, with some kind of cooking equipment found at more than half of small-medium buildings and over two-thirds of large sites. Table 4 shows that microwave ovens are found at 49 percent of small-medium sites (average of 1.4 units per site) and 43 percent of larges sites (average of 95 units.) Conventional ovens and ranges also have relatively high market penetration among small-medium and especially large businesses.

Table 4 – Business Cooking Equipment

Equipment Type	Small-Med (n=862)		Large (n=42)	
	%	Avg./site	%	Avg./site
Oven/range/stove	26%	2.0	52%	87.4
Broiler/fryer/griddle	13%	1.4	43%	4.4
Microwave	49%	1.4	43%	95.0

Source: Mail and On-site Surveys

As shown in Table 5, relatively fewer businesses have motors, pumps and compressors, with large/assigned account sites having both a higher penetration of these measures and more units per site.

Table 5 – Business Motors, Pumps and Compressors

Equipment Type	Small-Med (n=426)		Large (n=42)	
	%	Avg./site	%	Avg./site
Motors	6%	9.3	33%	18.5
VFD motors	2%	4.2	12%	10.0
Compressor	22%	1.6	38%	1.6
Pool/spa pumps	20%	1.7	45%	4.7
Other pumps	20%	2.5	19%	4.1

Source: Mail and On-site Surveys

Finally, electronics and related equipment are common at both small-medium and large business facilities, as shown in Table 6. The large number of televisions per site for the large/assigned account sample again reflects the inclusion of a number of large hotels in the businesses visited.

Table 6 – Business Electronics and Miscellaneous Equipment

Equipment Type	Small-Med (n=426)		Large (n=42)	
	%	Avg./site	%	Avg./site
Computer	77%	11.6	71%	47.0
Copier/scanner/printer	80%	4.5	64%	12.7
Televisions	68%	6.1	40%	182

Source: Mail and On-site Surveys

2 Introduction

This report presents the findings of the Baseline Energy Appliance, Equipment and Building Characteristics Study for Energy Use in the Hawaiian Electric Companies' Service Territories ("Baseline Study").[5] The study was administered by the State of Hawaii Public Utilities Commission (PUC) and funded by ratepayers in the Hawaiian Electric Companies' service territories via a Public Benefits Fee (PBF).[6,7] The PBF is intended to promote the development of programs and services that increase energy efficiency, reduce electricity consumption and demand, and ultimately decrease Hawaii's dependence on imported fossil fuels.

2.1 Background

This study, in conjunction with other research conducted by Hawaiian Electric Company and Kauai Island Utility Cooperative (KIUC), represents a coordinated effort on the part of the PUC to document key characteristics of the state's building stock, appliance and equipment holdings, efficiency levels, occupancy, and usage patterns as they relate to electricity consumption across the state.

Baseline data presented here serve a number of functions. They provide the PUC and the PFBA with foundational material to conduct a study of the state's energy efficiency potential, which in turn will provide input for the PBFA to plan cost-effective energy efficiency programs for the future. These data may also serve as a reference point for tracking changes in key energy efficiency characteristics over time and can be used to measure the effectiveness of programs and progress toward energy efficiency and other statewide energy goals. Finally, these study results may be useful to the Hawaiian Electric Companies for electricity load planning.

This study complements a number of related and ongoing efforts. Every second year, on even numbered years, Hawaiian Electric Company sponsors a Residential Appliance Saturation Survey (RASS). The RASS uses a high-volume mail survey to collect home and appliance characteristics from a representative sample of residential customers throughout the Hawaiian Electric Companies' service territories. (The Hawaiian Electric Companies have collected similar data (via mail and onsite surveys) from their non-residential

[5] Hawaiian Electric Companies include Hawaiian Electric and its subsidiaries, Maui Electric Company and Hawaii Electric Light Company, which provide service electric service to Oahu, Maui and Hawaii Counties, respectively.

[6] Science Applications International Corporation (SAIC) has been under contract to the Hawaii PUC as the PBFA Administrator (PBFA) since 2009, and as such administers the Hawaii Energy Conservation and Efficiency Programs (or "Hawaii Energy" Programs www.hawaiienergy.com).

[7] Note that the Kauai Island Utility Cooperative (KIUC), which provides electricity on Kauai, does not participate in the PBF. This baseline study was funded with PBF dollars, and therefore covers the Hawaiian Electric Companies' service territories but excludes Kauai.

customers, but less frequently. The most recent Commercial End-Use Survey was conducted in 1994.)

The Baseline Study described in this report complements the Hawaiian Electric Companies' RASS with an on-site survey effort for the residential sector that relies on trained auditors to directly observe equipment and efficiency characteristics. In addition, both mail and onsite data were collected from non-residential customers to provide a current baseline assessment. As some of the sites were extremely large and complex, on-site visits did not make sense for two of the largest customers: the Board of Water/Sewers (BoWS), and the four branches of the military that have bases in the state. Instead of conducting site visits, the evaluation team completed case studies for these customers to provide some meaningful data and metrics (see Section 6 for case study results).

An evaluation team, led by Evergreen Economics and including Michaels Energy and Dr. Phil Willems, conducted this baseline research over a period extending from early 2012 through mid-2013.

Table 7 on the next page provides an overview of the state's 2012-2013 baseline data collection efforts that will be used in an energy efficiency potential study being conducted via the PUC. The shaded cells indicate the components of this overall process that were conducted in the research effort described in this report, and upon which the remainder of this document is focused.

Table 7 – Overview of the State's 2012-2013 Baseline Data Collection Efforts

Study Sponsor/ Geographic Area	Customer Sector / Survey Mode				
	Residential		Small and Medium Business		Large Business[3]
	Self-Administered/ Mail	Observed/ On-site	Self-Administered / Mail	Observed/ On-site	Observed/ On-site
Hawaiian Electric Companies Service Territories					
PUC (Oahu[1], Maui[2] and Hawaii Counties)		405 Completed (Single-Family: 208 Multi-Family: 97 Military housing: 100) Included a household questionnaire	5,000 Mailed 880 Returned	426 Completed	52 Completed Plus case studies of water/waste water and military sectors
Hawaiian Electric Companies (Oahu, Maui and Hawaii Counties)	10,264 Mailed 4,954 Returned (Single-Family: 3,742 Multi-Family: 1,212)				
	Residential		**Small, Medium and Large Business**		
KIUC Service Territories					
KIUC (Kauai County)	Telephone survey data		Analysis of existing databases		

Note: The shaded cells indicate the components of this overall process that were conducted in the research effort described in this report, and upon which the remainder of this document is focused.

[1] When discussing results by County, we use the term "Oahu" or "Oahu County"; we should technically refer to Oahu as "City and County of Honolulu" when presenting results by county, but we chose to use 'Oahu' when referring to the county to make it clear we are referring to the entire island rather than just the city of Honolulu.

[2] The mail survey included all three inhabited islands within Maui County (Maui, Lanai and Molokai islands), while the on-site surveys were conducted only on the island of Maui.

[3] The definition of a "large business" is based on the Hawaiian Electric Company rate code that signified a large customer or businesses that had a dedicated Hawaiian Electric Company account manager. For purposes of this research, military facilities, and public infrastructure (e.g., water treatment) are considered in the "Large Business" category.

2.2 Population and Electricity Consumption Overview

Given Hawaii's distinct climate, economy and dependence on fossil fuels,[8] it is useful to begin with a view of its electricity consumption in relation the rest of the U.S. Information

[8] For a discussion of these contextual factors, refer to Evergreen Economics. *Evaluation of the Hawaii Energy Conservation and Efficiency Programs Program Year 2011*. (Honolulu, HI: Hawaii Public Utilities Commission, June 2013). http://www.hawaiienergy.com/125/evaluation-measurement-verification-em-v.

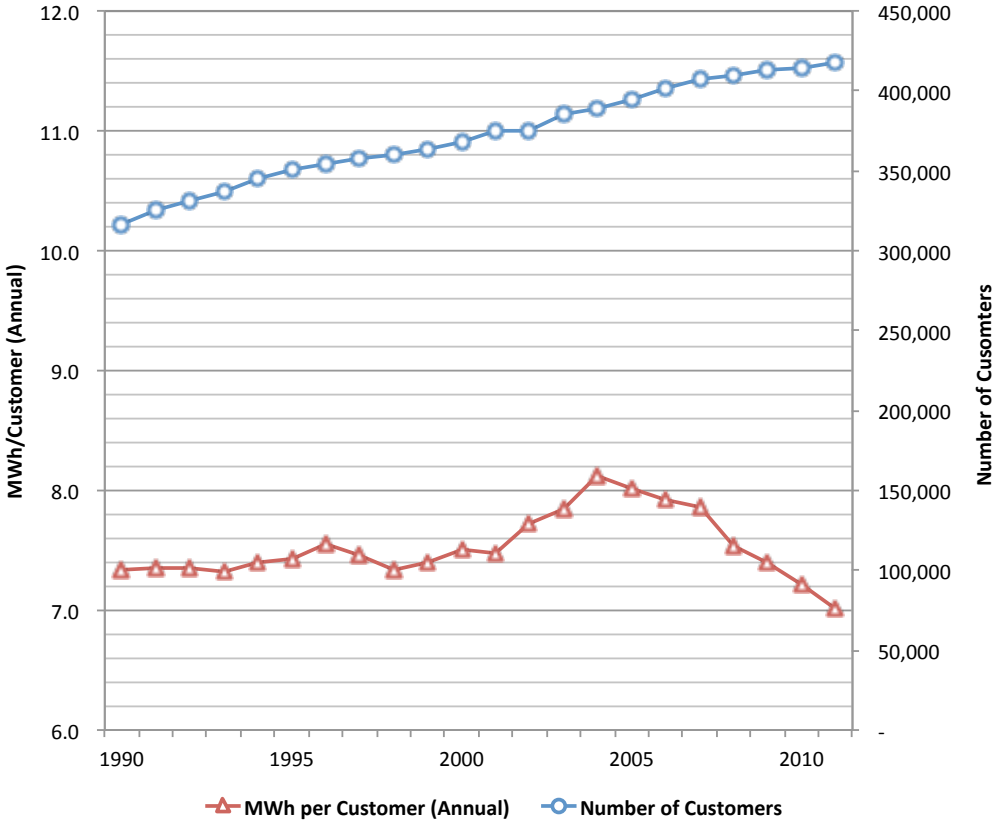
is also provided for California as another point of reference. The climate in California is distinct in important ways from that of Hawaii, so the energy demands are not directly comparable. However, it serves as another point of interest as it is a state with advanced energy efficiency programs and policies and relatively mild climate. This is intended to provide background on how and why Hawaii's energy efficiency efforts are unique as compared to other states and the attendant effects on efficiency potential.

The following charts show the breakdown of annual electricity consumption of residential and business customers in Hawaii, as compared to those in the U.S. as a whole and in California. According to the Energy Information Administration, in 2010 Hawaii imported 94 percent of its energy and had the highest electricity prices in the U.S. yet had the third lowest per capita energy use in the nation likely due to its mild tropical climate.

2.2.1 Residential Sector

This section contains population and electricity consumption statistics for the residential sector. Figure 15 shows the change in electricity usage per residential customer and the number of residential customers for the state of Hawaii.

Figure 15 – Annual Residential Customer Energy Use: 1990 - 2011 – Hawaii



Source: U.S. Energy Information Administration[9]

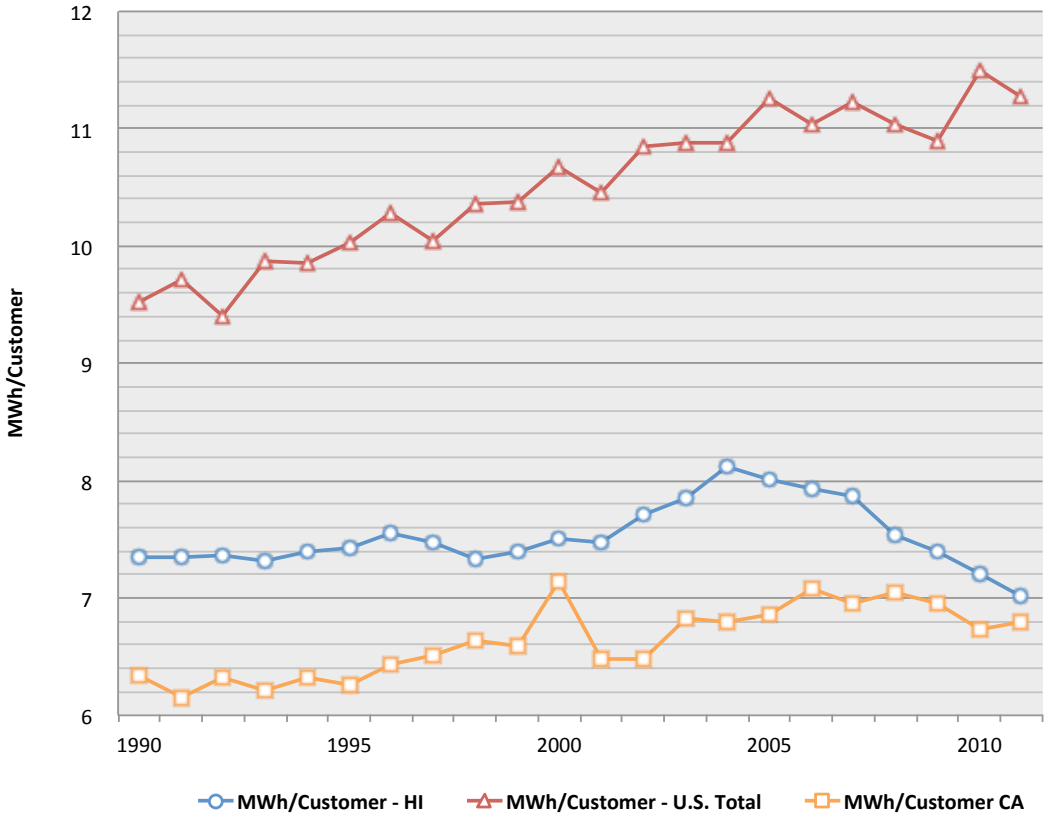
Figure 16 on the next page compares the trend in residential per capita energy usage for Hawaii as compared to the U.S. and California. California was an early leader in the provision of rebate programs in electric demand side management (DSM), integrated resource planning and leveraging public benefits charges. Early forms of DSM programs emerged in the late 1970s, but gained traction with the introduction of rebate programs in the 1980s.[10] As shown in Figure 16 below, during the 1990s the difference between Hawaii and California in per-capita energy use was about one MWh per customer per year. Hawaii began implementing its DSM portfolio in the mid 1990s, and the results are evident in a downward trend in per capita use since a peak in 2004, despite rising trends in the U.S. overall, and, though by a smaller degree, also in California. The decline in Hawaii is likely

[9] U.S. Energy Information Agency State Historical Tables for 2011, Released: October 1, 2012. http://www.eia.gov/state/

[10] Alliance Commission on National Energy Efficiency Policy, The History of Energy Productivity, January 2013, http://www.ase.org/sites/ase.org/files/resources/Media%20browser/ee_commission_history_report_2-1-13.pdf

due to a combination of factors that include the recession, energy efficiency programs and increased use of renewable energy.

Figure 16 – Residential Customer Energy Use: 1990 – 2011 - U.S. Total, Hawaii and California



Source: U.S. Energy Information Administration[11]

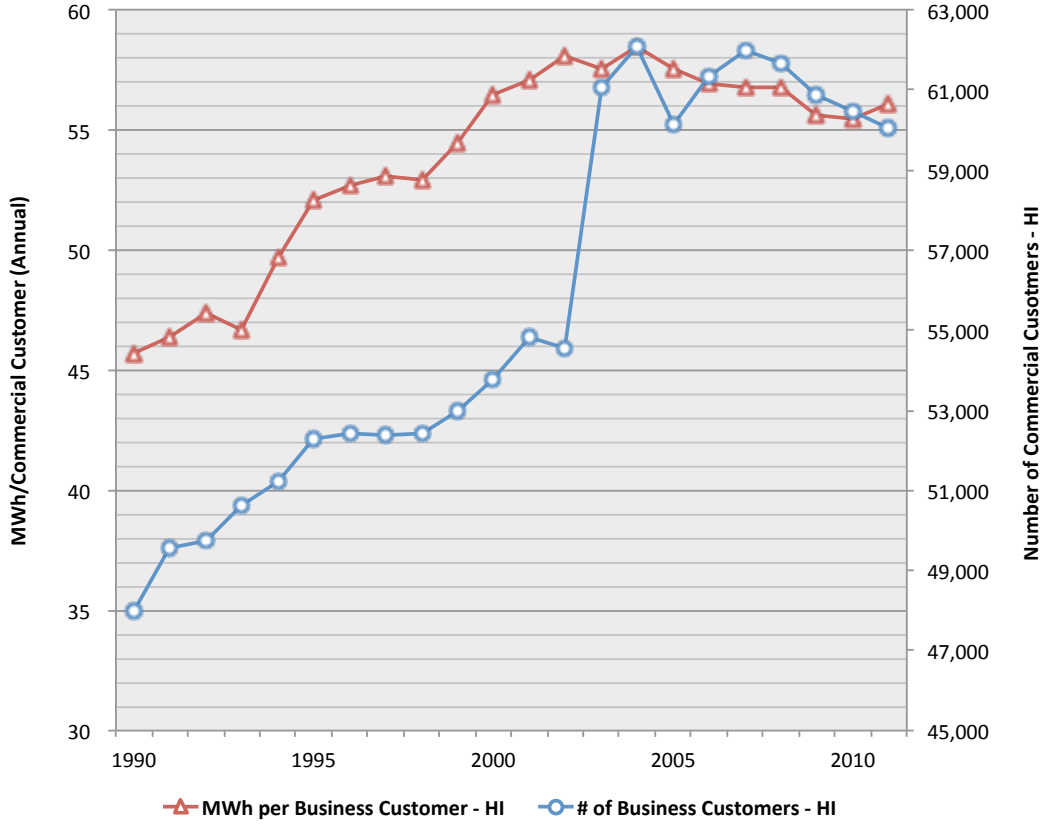
A detailed discussion of the findings from our study of the Hawaiian Electric Companies' residential customers and their energy use can be found in Section 4.

2.2.2 Business Sector

This section contains business sector population and energy consumption statistics. Figure 17 shows the change in electricity usage per business customer and the number of business customers for the state of Hawaii.

[11] U.S. Energy Information Agency State Historical Tables for 2011, Released: October 1, 2012. http://www.eia.gov/state/

Figure 17 – Annual Business Customer Energy Use: 1990 - 2011 – Hawaii[1]



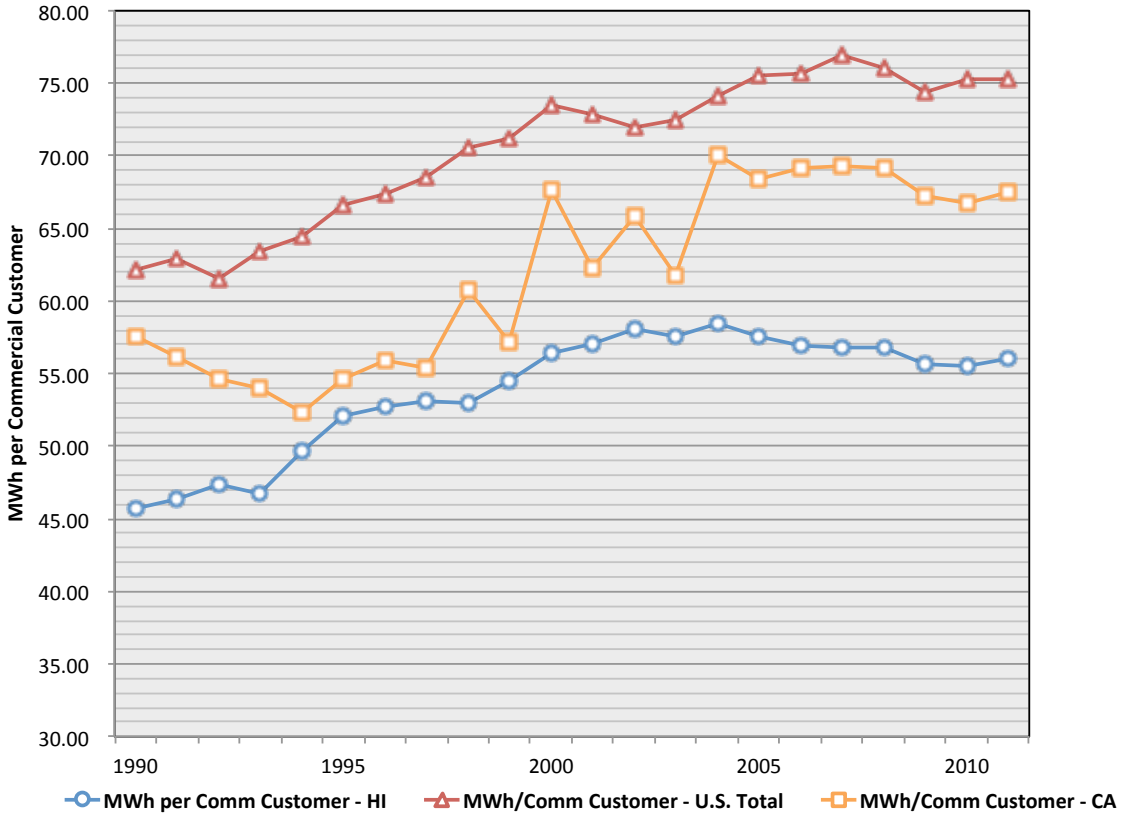
Source: U.S. Energy Information Administration[12]

[1]In 2003, EIA revised the survey to separate the transportation sales and reassign the other activities to the commercial and industrial sectors as appropriate. The "other" sector activities included public street and highway lighting, sales to public authorities, sales to railroads and railways, interdepartmental sales, and agricultural irrigations

Figure 18 below compares the trend in business per capita energy usage for Hawaii as compared to the U.S. and California. Hawaii electricity use per business mirrors the residential customer trend of declining since a peak in 2004, compared to California and the U.S. as a whole.

[12] *Ibid.*

Figure 18 – Business Customer Energy Use: 1990 – 2011 - U.S. Total, Hawaii and California



Source: U.S. Energy Information Administration[13]

A detailed discussion of the findings from our study of the Hawaiian Electric Companies' business customers and their energy use can be found in Section 5.

2.3 Organization of Report

The remainder of this report contains the following sections:

- Section 3 – Study Methods
- Section 4 – Residential Customer On-site Survey Results
- Section 5 – Business Customer Mail and On-site Survey Results
- Section 6 – Hawaii Large C&I Case Study Report
- Appendices:
    - Appendix A – Research Instruments

[13] *Ibid.*

- Appendix B – Sampling Detail
- Appendices C – G – Tabular Survey Results

3 Study Methods

This section provides an overview of the methods used to conduct the baseline study. For a more detailed discussion, the reader is referred to Appendix A – Research Instruments, Appendix B – Sampling Detail and Appendices C through G – Tabular Survey Results.

3.1 Overview

As described in the previous section, the Evergreen Economics team employed a combination of survey modes to collect data for this study. Each modality has strengths and weaknesses. The mail survey provides a larger sample size and may be relied upon for basic descriptive information about business customers, their facilities and equipment. The on-site survey draws on a smaller sample but contains more detailed records of electricity-using equipment and more reliable data on facility characteristics and conditions based on auditor observation and discussions with facility staff.

Mail surveys are attractive because as they are relatively inexpensive to conduct, it is possible to collect a large number of sample points. However, since respondents are answering questions about their own homes and businesses, the questions about building, appliance and equipment characteristics must be limited to the kind of information that reasonable but untrained respondents can provide. The on-site survey mode is often more reliable, since trained auditors examine and report on building, appliance and equipment characteristics. Trained auditors can also observe and provide details (e.g., the efficiency level of the equipment) that cannot be reliably gathered via mail surveys. However, onsite surveys are also costly relative to mail surveys, thus yielding fewer sample points for a given research budget.

This study employed both mail and onsite techniques. The mail surveys provided an opportunity for broad coverage of many homes and businesses while the onsite surveys enabled trained auditors to collect more detailed information for a smaller number of sites.

Finally, two complicated subcategories – military facilities and water treatment – were addressed using a "case study" approach based on interviews and data analysis.

For the residential sector, trained auditors visited a sample of homes. The onsite effort conducted as part of this Baseline Study complemented the Residential Appliance Saturation Survey (RASS) mail survey conducted in 2012 by the Hawaiian Electric Companies. For the business sector, both modalities were conducted as part of the Baseline Study efforts described in this report. For some sites, customers provided basic information via a mail survey; for other sites, trained auditors visited facilities in person to collect more detailed information available through their 'on-site' observations. Both the mail and the on-site survey samples were drawn from the same sample frame. Due to unforeseen elements related to timing of the data collection, there is a small overlap between the two efforts with regard to small and medium business customers (20 surveys).

Table 8 provides an overview of the number of surveys completed by sector, county and survey mode. The residential and small and medium business customer on-site surveys were conducted during the period October 8, 2012 through April 9, 2013. The small and medium business customer mail surveys were mailed out on January 15, 2013, and the final returned surveys came in on April 2, 2013. The large business customer on-site surveys were conducted during the period April 1, 2013 through June 14, 2013. More detail on our study methods is found in Section 3.

Table 8 – Overview of Baseline Study Survey Completes by Sector, County and Mode

County	Number of Completed Surveys				
	Total	Residential On-site	Small and Medium Business Mail	Small and Medium Business On-site	Large Business[2] On-site
Oahu	1,041	249	488	276	28
Maui[1]	334	81	165	76	12
Hawaii	389	75	227	74	13
Total	1,764	405	880	426	53

[1] The mail survey included all three inhabited islands within Maui County (Maui, Lanai and Molokai islands), while the on-site surveys were conducted only on the island of Maui, which according to the 2010 U.S. Census accounts for 92 percent of Maui County's residents.

[2] The definition of a "large business" is based on the Hawaiian Electric Companies rate code that signified a large customer or businesses that had a dedicated Hawaiian Electric Company account manager.

3.2 Residential Sector

This section provides the methods used for gathering baseline information for the residential sector.

3.2.1 Residential Customers – On-site Survey

The Evergreen Economics team conducted a total of 405 on-site surveys with residential customers, including 100 military housing units (which are only located in Oahu County).

Table 9 presents the sample allocation (target of 400 surveys), while Table 10 shows the completed surveys (405 completes) by county and home type. (This on-site survey effort complements the residential mail survey that was conducted by the Hawaiian Electric Companies as a separate research effort; see Table 7.)

Table 9 – Residential Sample Allocation

County	Sample Allocation			
	Total	Military	Non-military	
			Single-Family	Multi-Family
Oahu	245	100	100	45
Maui	80	0	60	20
Hawaii	75	0	55	20
Total	400	100	215	85

Table 10 – Residential Customer On-site Survey Completes

County	Number of Completed Surveys				
	Total	Military		Non-military	
		Single-Family	Multi-Family	Single-Family	Multi-Family
Oahu	249	24	76	94	55
Maui[1]	81	0	0	59	22
Hawaii	75	0	0	55	20
Total	405	24	76	208	97

[1] The on-site surveys were conducted only on the island of Maui, which according to the 2010 U.S. Census accounts for 92 percent of Maui County's residents.

Trained auditors from Michaels Energy and Pacific SBS conducted the on-site surveys during the period October 8, 2012 through April 9, 2013. Each survey lasted about two hours, covering interior and exterior electric end-uses such as lighting, water heating, cooling and home electronics, and collecting descriptions of the home including square footage of the living space. The auditors also gave the resident a household questionnaire that asked for information about the household such as income. The completed questionnaire was collected at the end of each on-site visit, at which time the resident was also given a $25 incentive by the auditor in appreciation for their time.

Michaels Energy conducted quality control on individual site information, and Evergreen Economics analysts conducted additional quality control and data cleaning using SPSS statistical software. We developed sample weights for each surveyed home that are based on the ratio of survey completes to the total population in each stratum.

3.3 Business Sector

This section provides the methods used for gathering baseline information for the business sector.

3.3.1 Small and Medium Business Customers – Mail Survey

The Evergreen Economics team mailed out a total of 5,000 small-medium business customer end-use surveys on January 15, 2013. A $2 bill was included with each survey as an incentive to boost the initial response. We received a total of 880 valid and complete mail responses by April 2, 2013. SMS Research printed the materials, conducted the mailing and scanned the surveys. Due to a low initial response of 587 surveys (12%) by February 12, 2013, we followed up with phone surveys and a second mailed survey (without incentive) to customers who did not initially respond. The follow-up effort was successful, boosting the response from an initial 12 percent to the final 18 percent on April 2, 2013.

Table 11 presents the sample allocation, while Table 12 shows the number of completed surveys returned by county and business type.

Table 11 – Small and Medium Business Sample Frame for Mail Survey

Business Type	Sample Allocation			
	Total	County		
		Oahu	Hawaii	Maui
Amusement	290	130	80	80
Cold Storage	40	15	10	15
Education	450	255	110	85
Health	150	70	45	35
Hotels	85	45	15	25
Office Buildings	925	600	160	165
Restaurants	825	540	140	145
Retail - Food	285	165	60	60
Retail - Nonfood	1,040	600	220	220
Services	690	440	120	130
Wholesale	220	140	40	40
Total	5,000	3,000	1,000	1,000

Table 12 – Business Customer Small-Medium Mail Survey Completes

Business Type	Number of Completed Surveys			
	Total	County		
		Oahu	Hawaii	Maui[1]
Amusement	31	16	7	8
Cold Storage	7	5	2	0
Education	59	32	20	7
Health	50	28	12	10
Hotel	22	13	3	6
Office Buildings	189	101	58	30
Restaurant	122	74	23	25
Retail-Food	40	24	10	6
Retail-Nonfood	147	68	43	36
Services	126	75	29	22
Wholesale	87	52	20	15
Total	880	488	227	165

[1] The mail surveys were conducted across Maui County, including the other inhabited islands in the county, Molokai and Lanai.

3.3.2 Business Customer On-site Surveys

The Evergreen Economics team conducted the business customer on-site surveys in two waves. The first wave, which included the small and medium business customer surveys, was deployed in conjunction with the residential on-site surveys. Once these were complete, the team conducted a second wave of large business customer on-site surveys. For all categories of business customers, the sample frame is constructed by "establishment," where an establishment represents the business operations of one customer at one contiguous site. Business customers were not offered incentives for completing on-site surveys.

3.3.2.1 Small and Medium Business Customers

The Evergreen Economics team conducted a total of 426 on-site surveys with small and medium business customers. Table 13 presents the sample allocation (target of 417 surveys), while Table 14 shows the completed surveys (426 completes) by county and business type.

Table 13 – Small and Medium Business Modified Proportional Sample Allocation for On-site Survey – Number of Establishments

Business Type	Sample Allocation			
	Total	County		
		Oahu	Hawaii	Maui
Amusement	30	20	6	4
Cold Storage	7	4	1	2
Education	34	17	10	7
Health	20	8	7	5
Hotels	20	9	6	5
Office Buildings	72	50	10	12
Restaurants	59	45	7	7
Retail - Food	29	20	4	5
Retail - Nonfood	71	45	13	13
Services	49	30	8	11
Wholesale	26	19	3	4
Total	417	267	75	75

Table 14 – Small and Medium Business Customer On-Site Survey Completes

Business Type	Number of Completed Surveys			
	Total	County		
		Oahu	Hawaii	Maui[1]
Amusement	20	13	3	4
Cold Storage	2	-	2	-
Education	13	9	3	1
Health	14	4	8	2
Hotel	13	3	3	7
Office Buildings	80	49	16	15
Restaurant	52	35	9	8
Retail-Food	11	5	2	4
Retail-Nonfood	97	75	10	12
Services	89	57	13	19
Wholesale	35	26	5	4
Total	426	276	74	76

[1]The on-site surveys were conducted only on the island of Maui, which according to Hawaiian Electric Companies' billing data accounts for 92 percent of Maui County's businesses.

Trained auditors from Michaels Energy and Pacific SBS conducted the surveys during the period October 10, 2012 through March 4, 2013. Each survey lasted between two and four

hours, covering interior and exterior electric end-uses such as lighting, water heating, cooling, refrigeration and motors and pumps, and collecting descriptions of the business including square footage and number of employees at the site.

Michaels Energy conducted quality control on individual site information, and Evergreen Economics analysts conducted additional quality control and data cleaning using SPSS statistical software. We developed sample weights for each surveyed business that are based on the ratio of annual kWh of the survey completes to the total population annual kWh in each stratum.

3.3.2.2 Large Business Customers

The Evergreen Economics team conducted a total of 52 on-site surveys with large businesses, the definition of which is based on either the Hawaiian Electric Companies' rate code that signified a large customer or that had a dedicated Hawaiian Electric Companies account manager. Table 15 presents the sample allocation for this on-site effort (target of 90 surveys) and Table 16 on the next page shows the completed surveys by county and business type.

Table 15 – Large Business Sample Frame and Allocation[14]

Business Type	Sites	Percent of Total kWh	Sample Allocation
Air Transportation	119	2%	1
Amusement	1,586	3%	3
Board of Water/Sewers	614	5%	Case study
Education	1,496	6%	5
Health	462	5%	6
Hotel	323	11%	15
Other - housing projects	8,202	8%	15
Military	46	14%	Case study
Office Buildings	8,477	11%	10
Retail-Food	921	5%	6
Retail-Nonfood	6,289	10%	8
Services	2,081	3%	5
Warehouse[1]	2,280	5%	16
Total	32,896	88%	90

[1] Warehouse includes Food Processing, Manufacturing, and Wholesale.

[14] Legend: Percent of total kWh = the percent of total kWh that sector represents from the large business population (the sample frame represents 88 percent of the large business population); sample allocation = the number of sites we will target by sector (total of 90 sites and 2 case studies).

Table 16 – Large Business Customer On-Site Survey Completes

Business Type	Number of Completed Surveys			
	Total	County		
		Oahu	Hawaii	Maui[1]
Air Transportation	0			
Amusement	3	3		
Board of Water/Sewers	0			
Education	1	1		
Health	4	4		
Hotel	13	4	5	4
Other - housing projects	10	3	3	4
Military	0			
Office Buildings	6	4	1	1
Retail-Food	2		1	1
Retail-Nonfood	7	4	1	2
Services	1		1	
Warehouse[2]	5	4	1	
Total	52	27	13	12

[1] The on-site surveys were conducted only on the island of Maui, which according to Hawaiian Electric Company billing data accounts for 100 percent of Maui County's large or managed accounts.
[2]Warehouse includes Food Processing, Manufacturing, and Wholesale.

Trained auditors from Michaels Energy and Pacific SBS conducted the surveys during the period of April 1, 2013 through June 14, 2013. The survey instrument was adapted from the small and medium business customer effort, covering interior and exterior electric end-uses such as lighting, water heating, cooling, refrigeration and motors and pumps, and collecting descriptions of the business including square footage, hours of operation and number of employees at the site. On average, site visits lasted six hours each.

The Evergreen Economics team used a case study approach for two sectors, military installations and water treatment, due to their complex nature and the difficulty of obtaining access to a representative sample of sites. We conducted in-depth interviews and analyzed Hawaiian Electric Companies' billing data to provide a characterization of the energy consumption and likely remaining energy potential for the wastewater sector and the four branches of military that have bases in the state.

Michaels Energy conducted quality control on individual site information, and Evergreen Economics analysts conducted additional quality control and data cleaning using SPSS statistical software. We developed sample weights for each surveyed business that are based on the ratio of annual kWh of the survey completes to the total population annual kWh in each stratum.

4 Residential On-site Survey Results

This section presents selected results from the residential on-site surveys, including both military and non-military housing. Please see Appendices C and D for a more comprehensive set of results for the non-military and military residential sectors.

4.1 Introduction

This subsection presents selected descriptive information on residential customers in the Hawaiian Electric Companies' service territories, which includes the counties of Oahu, Maui and Hawaii. As described below, a number of sources are used to construct key characteristics of the residential 'sample frame' or full population, in order to best represent all the residential segments and to summarize both housing units and electricity consumption.

Table 17 below is based on a report prepared by SMS Research[15]. The data show the majority of the Hawaiian Electric Companies' residents (57%) live in single-family detached non-military homes. In comparison, RASS results reflect that a somewhat greater proportion of non-military dwelling units are single-family detached, 69 percent. There are an estimated 14,737 military homes, all located in Oahu County according to this source. Note that anecdotally we are aware of other military housing on other islands, but it is fairly minor and not a housing complex or barracks like the buildings found on Oahu.

Table 17 – Housing Summary by Type (2010)

County	Total Housing Units	Single-Family	Condo	Apartment	Military	Student	Co-op
Oahu	329,724	165,440	100,438	43,424	14,737	3,408	2,277
Maui	65,724	41,723	20,135	3,702	-	164	-
Hawaii	77,424	60,658	12,080	3,867	-	819	-
Total	472,872	267,821	132,653	50,993	14,737	4,391	2,277

Source: Hawaii Housing Planning Study, 2011

The next exhibit breaks out residential housing by individual structure (e.g., a multi-family building with 100 units is counted as one structure). Based on Census data and American Community Survey sample data (summarized in Table 18 on the next page), 61 percent of Hawaiian Electric Companies' residential housing structures are single-family homes. 20 percent are multi-family structures with 20 or more units. Note that there is a

[15] *Hawaii Housing Planning Study, 2011 – Inventory Report*. Prepared by SMS Research and Marketing Services Inc. for Department of Hawaiian Home Lands, Department of Human Services, Hawaii Housing Finance and Development Corporation and the counties of Oahu, Maui, Hawaii and Kauai.

discrepancy in the number of housing units versus housing structures as a result of presenting data from two different sources. The RASS results indicate a smaller proportion of dwelling units are multi-family, 31 percent. While Census data serves as the primary resource for constructing the sample frame, it does not provide a breakout for residential housing by military versus non-military. The SMS Research data provide this missing link and were used to complete the military population sample frame

Table 18 – Housing Summary by Units in Structure

County	Total Housing Structures	Single-Family		Multi-Family				
		1-unit, detached	1-unit, attached	2 units	3 or 4 units	5 to 9 units	10 to 19 units	20 or more units
Oahu	336,644	158,134	30,426	9,051	17,598	22,693	16,261	82,481
Maui	70,510	39,504	3,580	4,733	3,234	5,304	3,830	10,325
Hawaii	82,049	63,439	2,906	1,538	2,286	2,879	2,774	6,227
Total	489,203	261,077	36,912	5,322	23,118	30,876	22,865	99,033

Source: U.S. Census Bureau, 2010 American Community Survey

Table 19 below shows the total electricity consumption[16] for the Hawaiian Electric Companies' residential population by county and within Maui County, by island. Data provided by the Hawaiian Electric Companies was the only source for a breakdown of residential customers within Maui County by island. Note that the tables shown in this subsection include all residents in Maui County, while the on-site surveys were conducted only on the island of Maui (approximately 92% of residents in Maui County live on the island of Maui.) We assume the characteristics of households on the island of Maui are similar to those found on the other Maui County islands.

The mean annual electricity consumption among non-military residential customers is 7,048 kWh per year. According to Forest City, one of two military housing developers, total residential military electricity consumption is about 169,200,000 kWh per year, and mean annual electricity consumption is estimated at 12,000 kWh per year.

[16] The Evergreen Economics team obtained Hawaiian Electric Companies' billing data from the PBFA during the course of the Program Year 2011 evaluation.

Table 19 – Energy Usage (kWh) for Residential Customers

County	Island	Residential		Residential-Military	
		Number of Accounts	Mean Annual kWh Usage	Number of Homes	Mean Annual kWh Usage
Oahu					
	Oahu	257,997	7,128	16,500	12,000
Maui					
	Maui	53,111	7,557	0	N/A
	Molokai	2,567	4,687	0	N/A
	Lanai	1,372	5,458	0	N/A
Hawaii					
	Hawaii	66,682	6,458	0	N/A

Source of non-military estimates: Hawaiian Electric Companies' billing data
Source of military estimates: interview with Forest City, one of two developers of military housing

The remainder of this section presents results from the residential on-site survey and household questionnaire. The on-site survey findings in this section offer some technical detail that cannot be collected via a mail or telephone survey with customers. In particular, information such as equipment efficiency ratings and capacity information can only be consistently and reliably collected by trained field staff performing on-site inspection, as was done for the baseline survey. Thus, some measurements presented here have not been measured before and will not have a RASS or Census result available for comparison.

The next eight subsections present results for the non-military sector (including both single and multi-family homes); the ninth subsection presents results for military housing.

- Home Characteristics
- Household Characteristics
- Lighting
- Water Heating
- Space Cooling
- Appliances
- Envelope
- Electronics
- Military Housing

The non-military results are generally presented by county[17] and home type (i.e. single-family versus multi-family), as well as for the total sample. Throughout this section, we

[17] As described above, our on-site surveys excluded two of the three inhabited islands in Maui County, Lanai and Molokai, but we assume that the results for the island of Maui (where 92 percent of the county's residents live) represent Maui County.

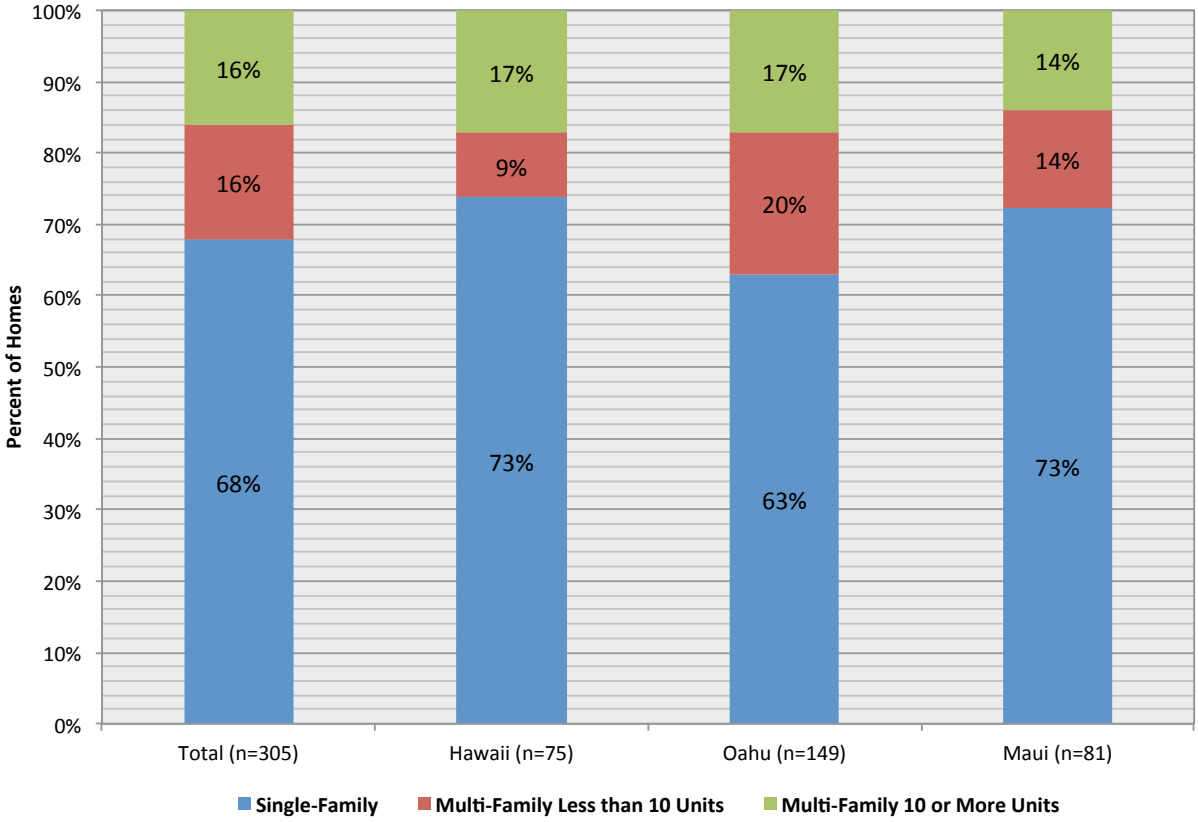
include the sample size, which unless noted is the number of homes where we collected usable data. We distinguish between "homes" for reporting of equipment and "households" for reporting about the members of the household. We referred to the approximate sampling error estimates (shown in Table 7 of Appendix B – Sampling Detail) when developing this section. We generally describe differences across segments that are statistically significant (not noted), or indicate that a difference that is being described is not statistically significant (noted in the text) at the 90 percent level of confidence.

4.2 Home Characteristics

In this subsection, we present information about Oahu, Maui and Hawaii homes (excluding military housing), including vintage, type (single versus multi-family) and size. We also report on the use of fuel sources including natural gas, propane and solar photovoltaic (PV).

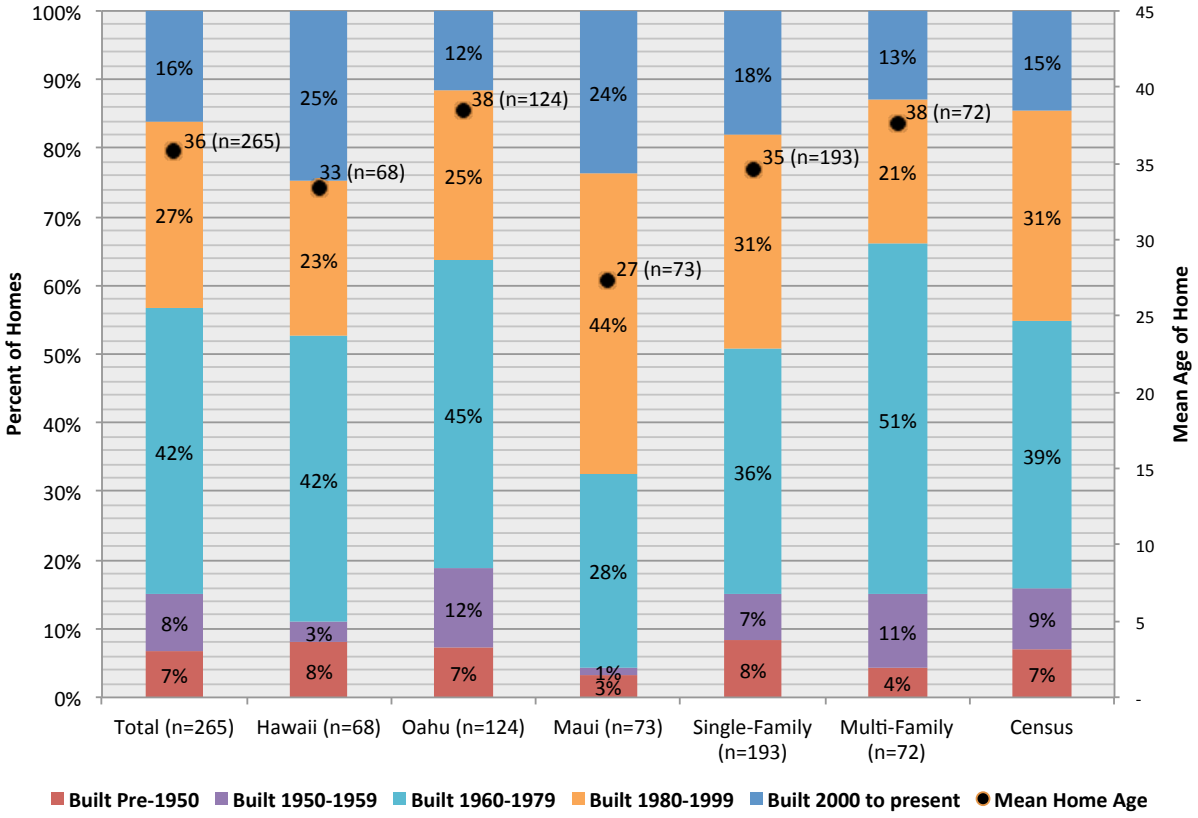
First, we present the breakdown of single-family versus multi-family by county, and for multi-family, broken out by the number of units in the building. All of the rest of the charts in this subsection present the observed on-site survey data for the following segments: Total, Hawaii, Oahu, Maui, Single-Family, and Multi-Family. As shown in Figure 19, our on-site survey results are weighted to the population such that 68 percent of homes are single-family, and 32 percent are multi-family with an equal split between buildings less than 10 units and 10 units or more. There are slightly more single-family homes in our weighted sample on Hawaii and Maui, but this difference is not statistically significant. These proportions are similar to those indicated by the recent Hawaiian Electric Companies-sponsored Residential Appliance Saturation Survey (RASS). The RASS results indicate 69 percent are single-family overall, and there is a higher proportion in Hawaii (83%) and Maui (71%) than Oahu (64%).

Figure 19 – Home Type by County



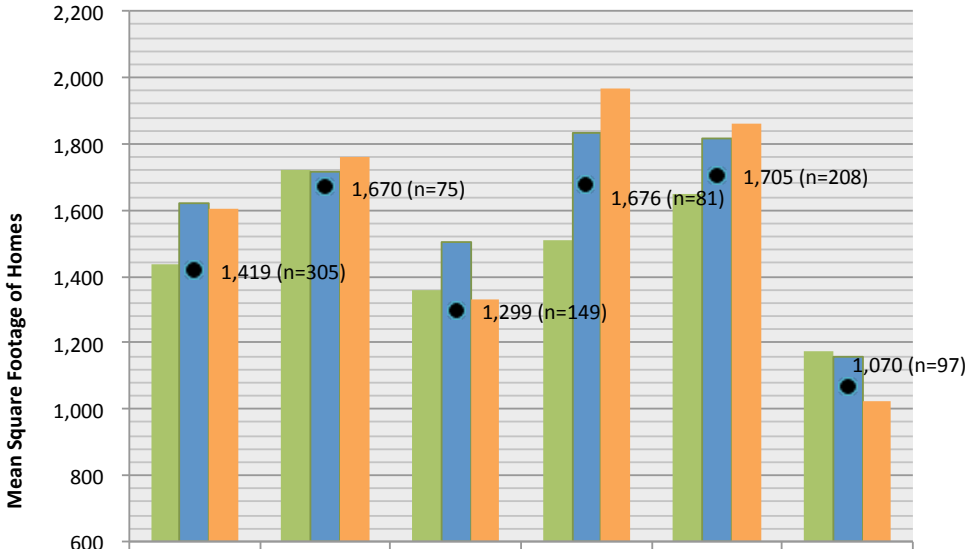
As shown in Figure 20, baseline survey data indicate the mean age of homes is 36 years, corresponding to a construction date of 1977. This finding is fairly consistent with RASS, which reports a mean residence age of 31 years (build date of 1981). Baseline Survey results indicate well over half of all homes (56%) were built before 1980, and most of these older homes were built between 1970 and 1989 (75%). Maui is somewhat different from the others, with a greater percentage (66%) of post-1980 construction. Hawaii is also a bit different, with one of the highest rates of very recent construction (25%) but one of the lowest for the 1980 through 1999 period. RASS results show mean age of residences to be lower in Hawaii (28 years) and Maui (27 years) relative to Oahu (34). As shown in the figure below, these trends are repeated in Baseline Survey results, with Hawaii (33 years) and Maui (27 years) showing a lower mean age than Oahu (38 years).

Figure 20 – Home Vintage, by County and Home Type



As shown in Figure 21 on the next page, single-family homes are generally trending larger over time, while multi-family homes remain quite stable in size over time. Single-Family homes built post-2000 register a mean size of just under 1,900 square feet, up from approximately 1,650 for homes built pre-1979. The mean size of multi-family homes is stable over the pre-1999 categories showing a decline in mean size of just 17 square feet up to 1999; mean square feet for homes built in 2000 or later is lower again by 133 square feet, coming in at 1,024 square feet per home. Overall, these results are consistent with RASS. Baseline Survey data yield a mean square footage of 1,419 square feet versus the RASS result of 1,541 square feet.

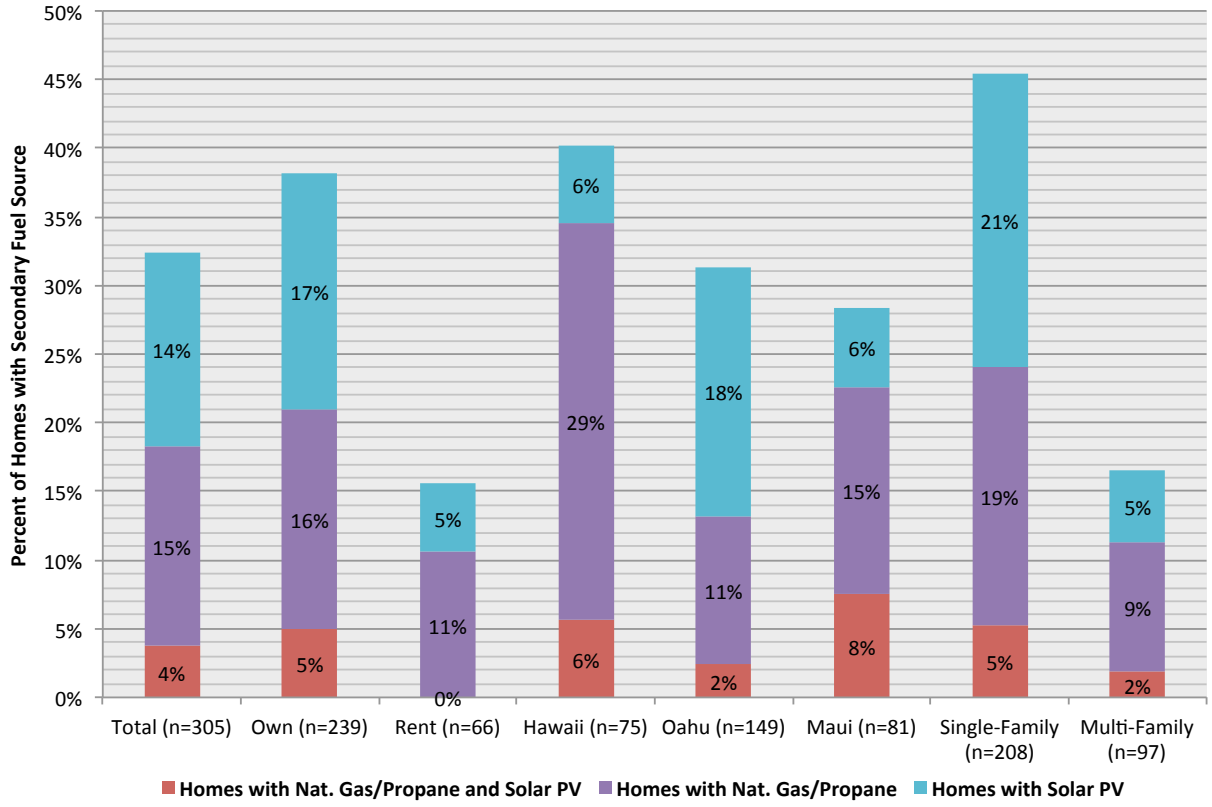
Figure 21 – Mean Home Size, Total and by Home Vintage, and by County and Home Type



	Total (n=265)	Hawaii (n=68)	Oahu (n=124)	Maui (n=73)	Single-Family (n=193)	Multi-Family (n=72)
Mean Square Footage of Homes Built Pre-1979	1,436	1,719	1,359	1,507	1,650	1,174
Mean Square Footage of Homes Built 1980-1999	1,620	1,715	1,504	1,833	1,816	1,157
Mean Square Footage of Homes Built 2000-Present	1,604	1,761	1,329	1,968	1,863	1,024
Mean Square Footage of Homes	1,419	1,670	1,299	1,676	1,705	1,070

Overall, survey data indicate that 68 percent of homes are fueled by electricity only, and 32 percent have access to a secondary fuel source, as shown in Figure 22. Most homes with a secondary fuel source – about 60 percent – have solar PV systems. About one-fifth (21%) of homes with solar also use natural gas or propane fuel in their home. Not surprisingly, secondary fuels are much more common among single-family homes than multi-family homes (45% versus 17%), and much more common among homes occupied by owners versus renters (39% versus 16%).

Figure 22 – Secondary Fuel Sources, by County and Home Type

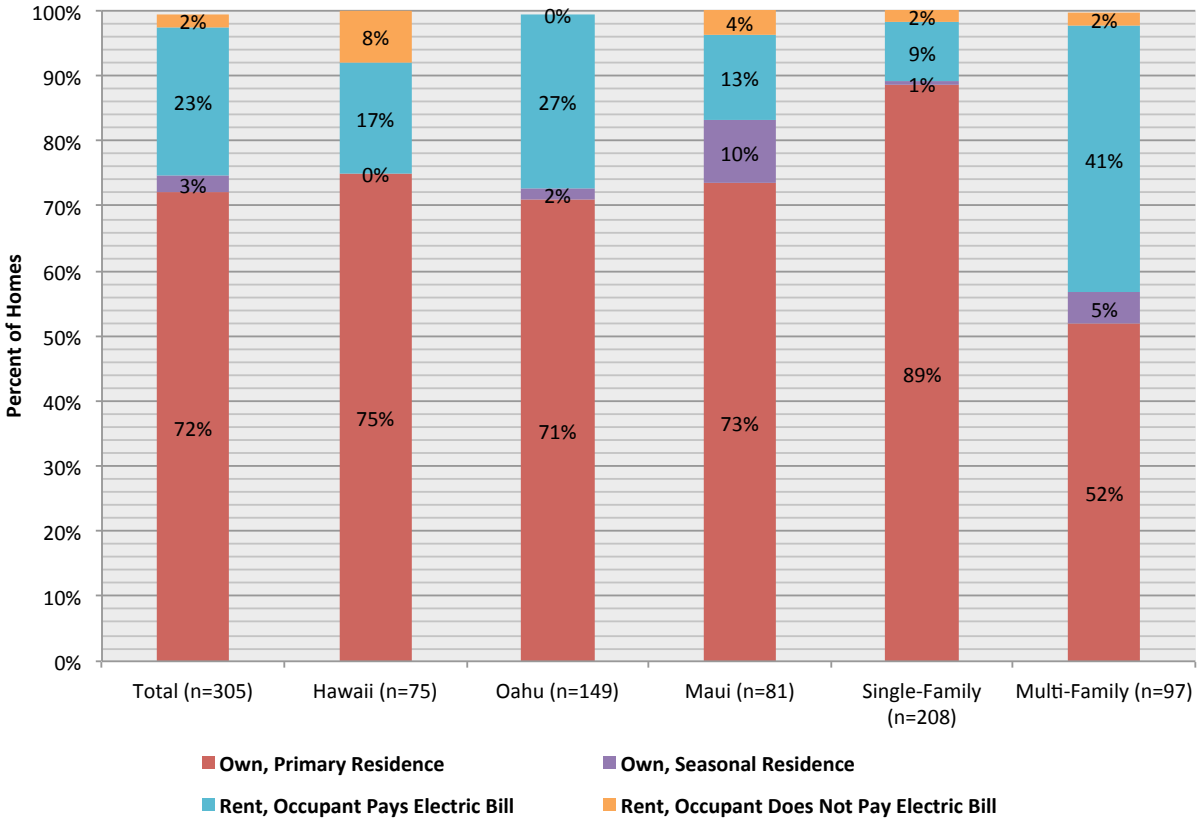


4.3 Household Characteristics

This subsection presents results on the household, including home ownership status, seasonal occupancy, composition (e.g., presence of children and seniors), income, number of occupants, and opinions on the importance of saving energy and lowering energy bills. These data were obtained from the household questionnaire that auditors gave to study respondents. Most of the following charts present the observed on-site survey data for the same segments shown in the previous section, with one exception that presents results by income categories.

As shown in Figure 23, the majority of households (75%) are owner occupied. This result is somewhat lower than found in the RASS data (81%) but higher than 2011 Census (57%). A small percentage (about 3%) of owner-occupied homes are not a primary home and are used only seasonally. Due to survey implementation methods (the restriction of on-site surveys to occupied homes), this estimate may be biased downward somewhat. However, the estimate aligns with the 2011 Census, which showed a homeowner vacancy rate of 2.2 percent among owner-occupied homes.

Figure 23 – Homes by Ownership, Occupancy and Electricity Bill Payment, and by County and Home Type



As shown in Figure 24 below, about 10 percent of homes include a disabled member whose care requires electrically-powered equipment. The frequency is higher among multi-family homes than single-family (10% versus 9%) and higher in Hawaii (12%) than Oahu (10%) or Maui (8%). About 20 percent of all homes include a member under the age of 18, and 45 percent include a member over the age of 65. Single-Family homes are more likely to include children and less likely to include elderly members. While Hawaii County is similar in these respects to the multi-family segment, it has the lowest percent of multi-family dwellings across the three counties. Maui has lower rates of both children and elderly, indicating higher relative percentage of households composed of members between 18 and 64.

Figure 24 – Households with Disabled, Children and Elderly, by County and Home Type

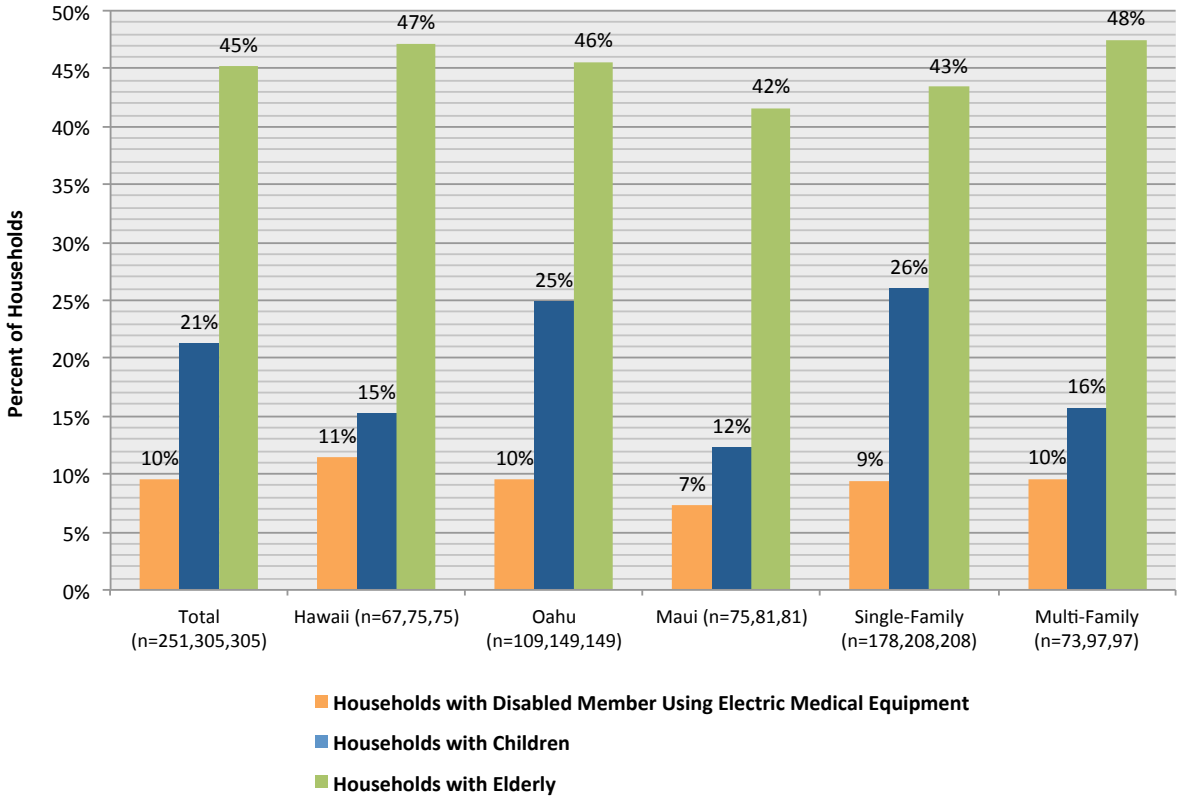
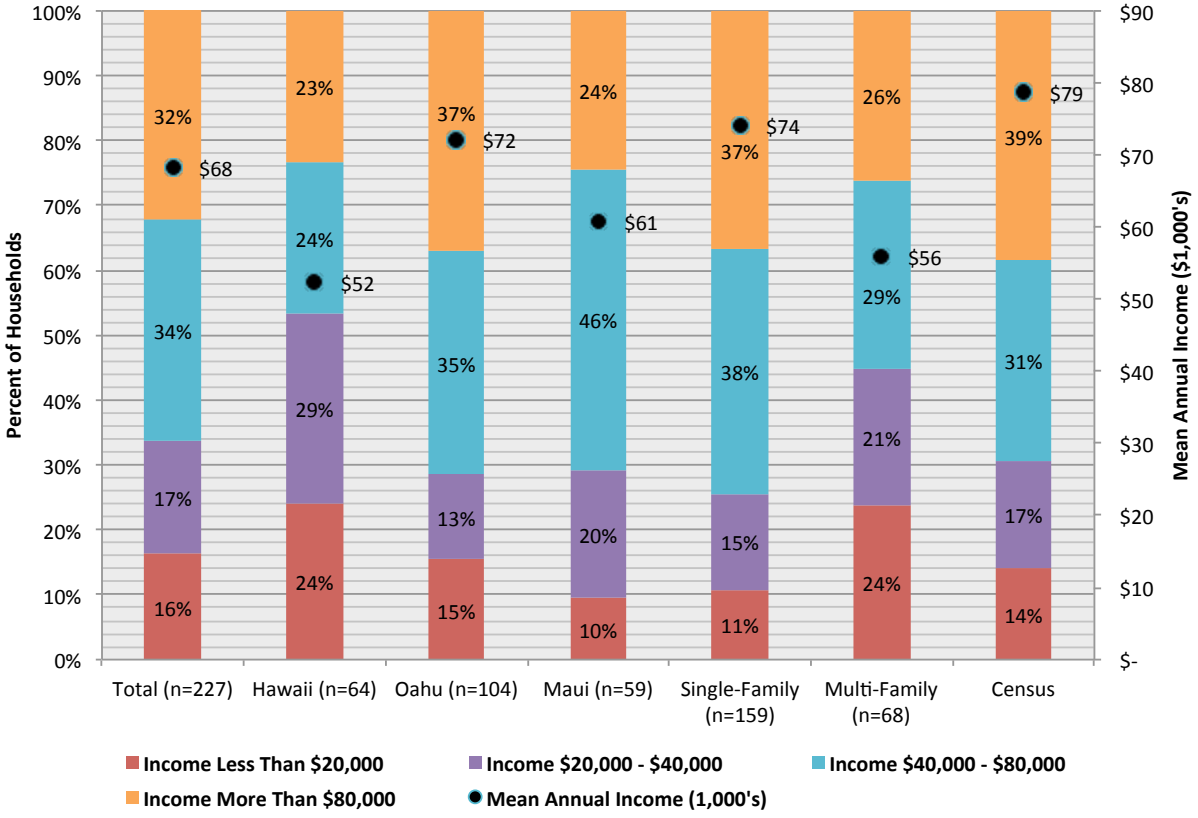


Figure 25 on the next page shows the percentage of households within each annual income category, as well as the mean annual income, by county and home type. Overall, the data show a fairly even split of households between those over $80,000 per year, those with incomes between $40,000 and $80,000, and those with income below $40,000 (at 32%, 34%, and 33%, respectively). Across the counties, mean income is lower in Hawaii ($52,000) than in either Maui ($61,000) or Oahu ($72,000). Household income is also notably lower among households in multi-family than single-family homes ($56,000 versus $74,000, respectively). Baseline Survey results yield a mean annual income $11,000 less than Census and $12,000 less than RASS. However, Baseline data was collected via categories not specific income figures, perhaps sheering off the upper tail of the distribution. Also, Census shows a median income of $61,000, and Baseline data have a median in the $60,000-$80,000 range, demonstrating some consistency between the distributions. (RASS does not report a median figure.)

Figure 25 – Household Income, by County and Home Type



The householder questionnaire posed questions related to the perceived importance of preserving the environment and the importance of saving money on energy bills. The questions were stated as follows:

- *"How important is it for your household to use less energy in order to help preserve the environment?"*
- *"How important is it for your household to use less energy in order to reduce your energy bills?"*

Respondents were asked to select from importance ratings ranging from "Extremely important" to "Not at all important". Figure 26 on the next page shows that just under half (48%) of householders report it was "extremely important" to reduce energy bills, while somewhat fewer (36%) report it was extremely important to preserve the environment. The County of Hawaii stands out with the highest rating of energy issues' importance, on both environment (53%) and lowering bills (65%).

Figure 26 – Importance of Saving Energy and Lowering Bills, by County and Home Type

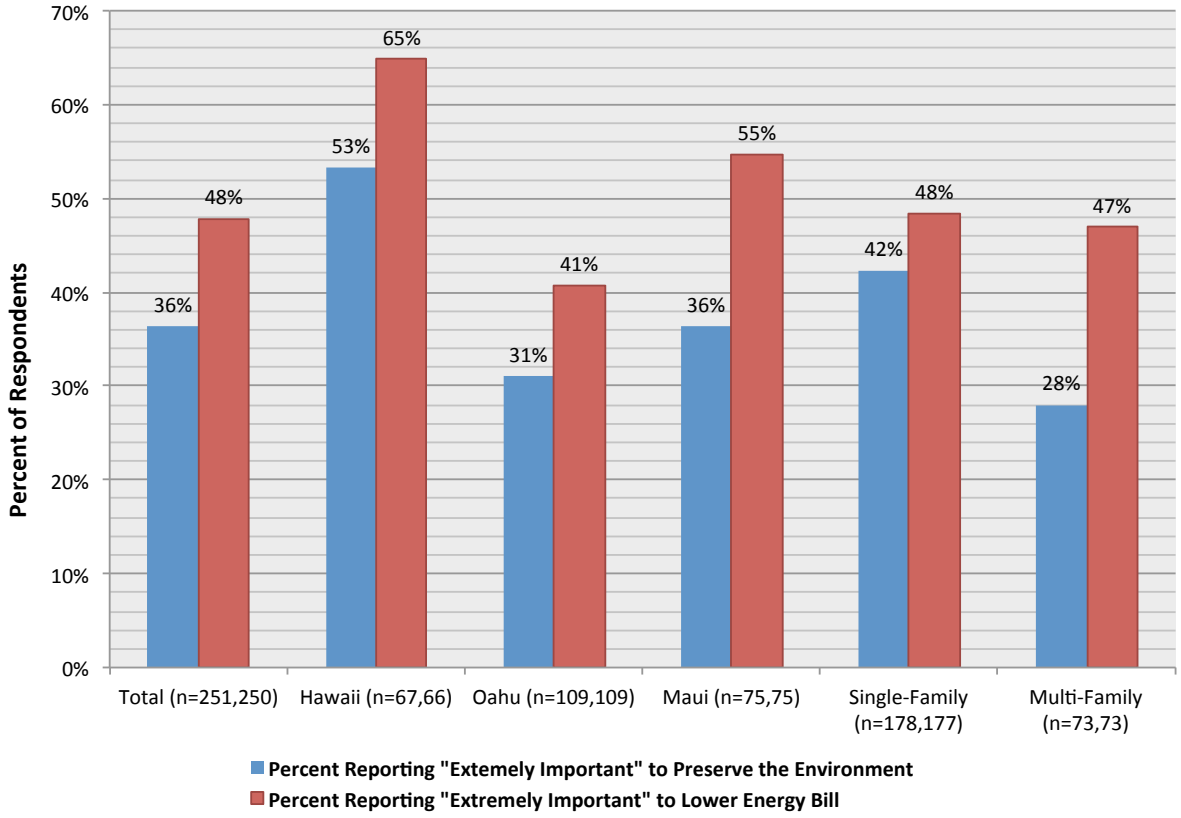


Figure 27 on the next page highlights differences in priorities related to energy costs and the environment. For household income levels below $100,000, income is inversely related to the likelihood of providing the highest importance rating for both saving energy for the environment as well as for lowering bills. The highest income category ($100,000+) shows a small jump upward relative to the $80,000-$100,000 category but remains lower than the below $80,000 categories. Not surprisingly, since lower-income households are more likely to rent their homes, more renters attribute the highest importance rating to both saving energy for the environment (40% versus 35%) and reducing bills (54% versus 46%).

Figure 27 – Importance of Saving Energy and Lowering Bills by Ownership and Income, and by County and Home Type

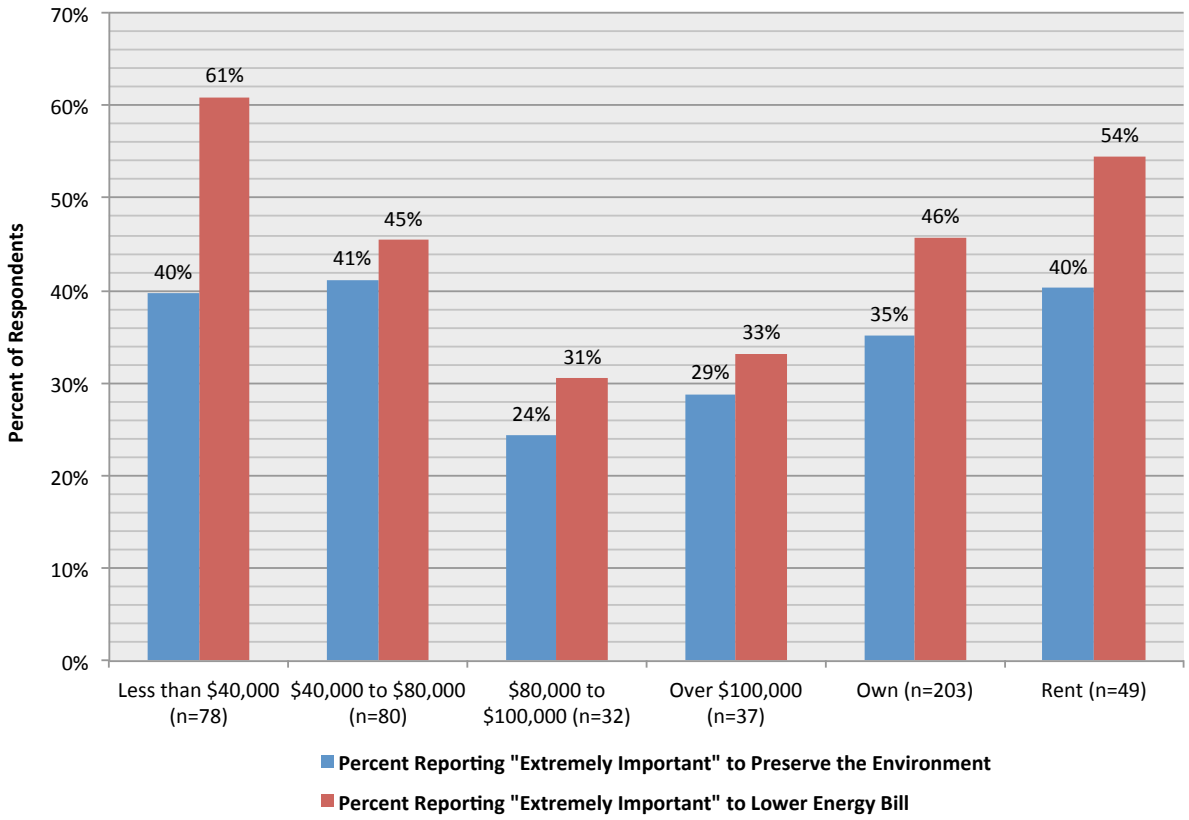


Figure 28 on the next page shows the mean annual occupancy by age group for each county and for single-family and multi-family homes (note that the legend reads left to right and then wraps to the next line, not top to bottom). Overall, the mean occupancy per home is just under 3 persons and the mean age of occupants is 42. Mean occupancy is consistent with Census (3 persons) and RASS (3.1 persons). Mean age of occupants is lower than RASS (49 years). However, Baseline data was collected via categories, not specific figures, which may truncate the higher tail of the distribution. The 2010 American Community Survey[18] reports a median age of 39 years, which is consistent with our Baseline data where the median is in the 36 to 50 year age range.

Baseline Data show the County of Hawaii has the lowest mean occupancy (2.0) and the highest mean householder age (52), with over 41 percent of all occupants over the age of

[18] U.S. Census Bureau; American Community Survey, 2010 American Community Survey 1-Year Estimates, Table DP1 Profile of General Population and Housing Characteristics: 2010, 2010 Demographic Profile Data <http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1>

65. Oahu has a greater percentage of occupants under the age of 35 – 44 percent versus 20 to 25 percent for Hawaii and Maui. At 25 percent of all occupants, Oahu has more than double the percentage of those between the ages of 19 and 35 than Hawaii (11%) or Maui (7%). Maui has the highest rate of occupancy of those between the ages of 36 and 64 – at 49 percent, with Oahu and Maui closer to one-third (34% and 35% respectively).

Figure 28 – Mean Household Occupancy by Age Groups, and by County and Home Type

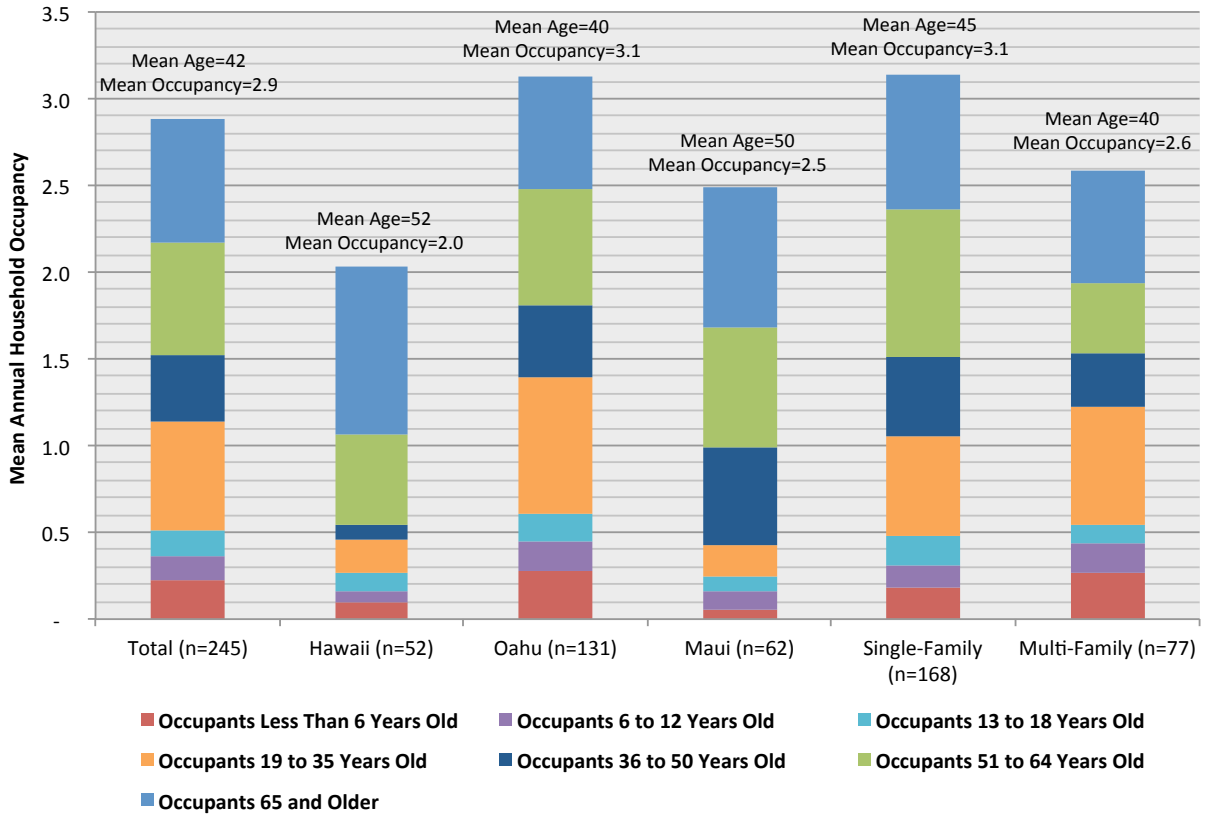
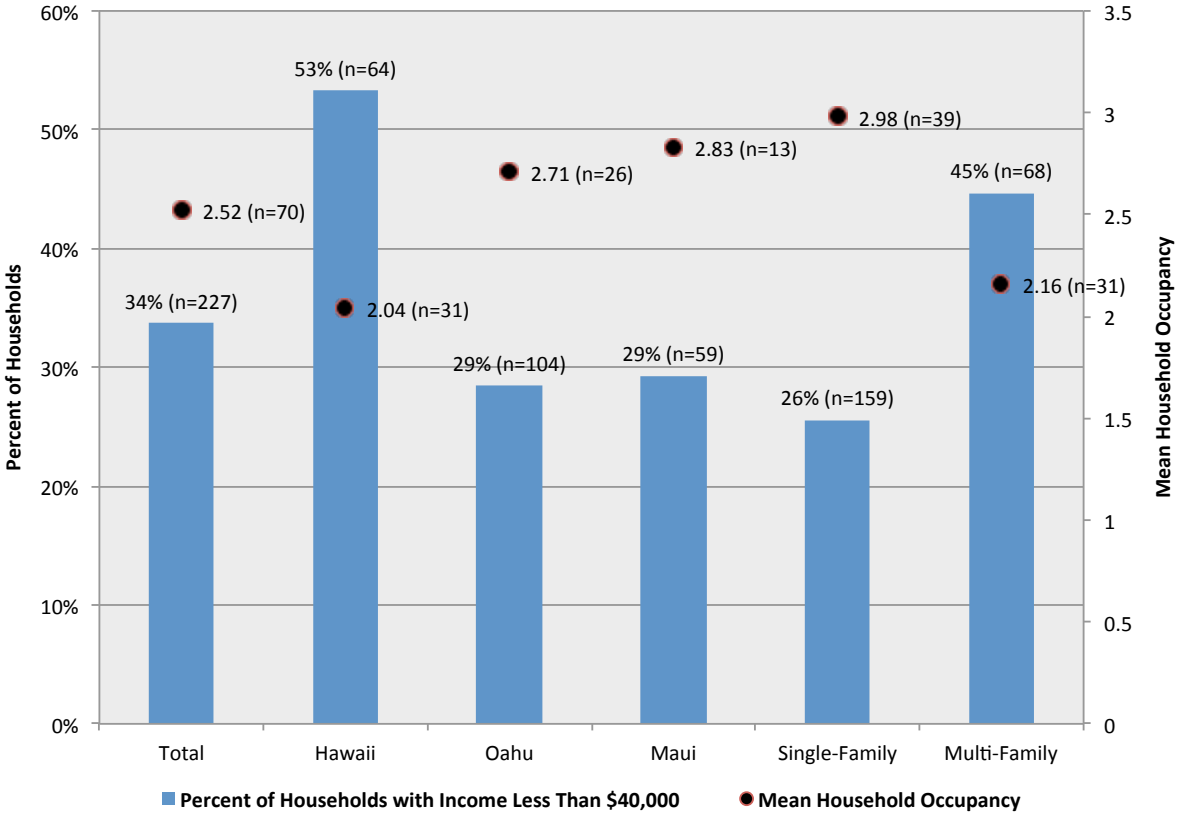


Figure 29 on the next page presents the percentage of households that have annual income less than $40,000 and the mean occupancy for those households, by county and home type. The data show that Hawaii County has by far the largest percentage of lower-income households, and has a relatively low mean occupancy at 2.0 people per household. Oahu and Maui are similar in their rates of lower-income households (29% each) and mean occupancy, at a little less than three persons per home.

Figure 29 – Lower-Income Households and Occupancy, by County and Home Type



4.4 Lighting

This next subsection presents results on the inventory that auditors took of light bulbs being used in the study sample. First, we report on the mean number of bulbs per home, broken out by bulb type. Next, we provide a more detailed breakdown of bulbs by room type. Then we look at the frequency that homes are making use of efficient lighting technologies, including compact fluorescent lamps (CFLs), LEDs, dimmers and occupancy sensors. There are a total of four charts in this subsection, the first and third are broken out by the same segments that are used throughout this residential section. The second chart is broken out by room type and county, and the fourth chart is broken out by home ownership and income.

Figure 30 depicts the distribution of installed bulbs by type and the total number of installed bulbs per home by county and home type. Overall, the mean number of installed bulbs per home is 34. Oahu has a somewhat lower mean, at 31, relative to Maui (38) and Hawaii (41). The mean multi-family home holds about 65 percent of the bulbs present in single-family homes.

Across the counties, Oahu has the largest percentage of CFL bulbs (50%) and the lowest percentage of incandescent bulbs (32%). Maui has the lowest percentage of CFL bulbs (31%) and the highest percentage of incandescent bulbs (45%). Maui also has the highest percentage of LEDs, at eight percent, while Oahu and Hawaii have only two and three percent LEDs, respectively.

In comparison to RASS, the number of incandescent bulbs per home found in the Baseline Survey is slightly lower (12 versus 14) while the number of CFL bulbs is higher (15 versus 9); the mean number of fluorescent bulbs is the same across the two studies (4).

The Baseline Study shows no statistically significant difference in the holdings of CFLs between single-family and multi-family homes.

Figure 30 – Mean Number of Installed Bulbs per Home by Type, and by County and Home Type

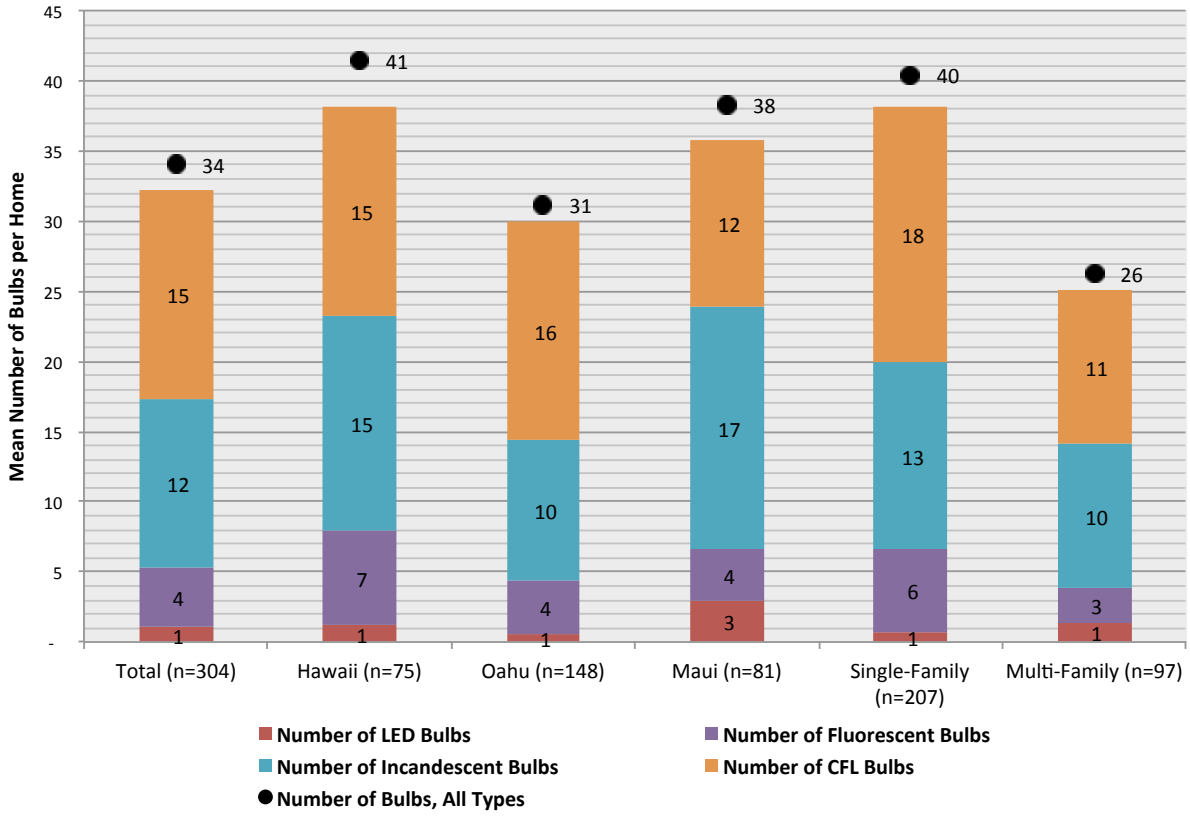
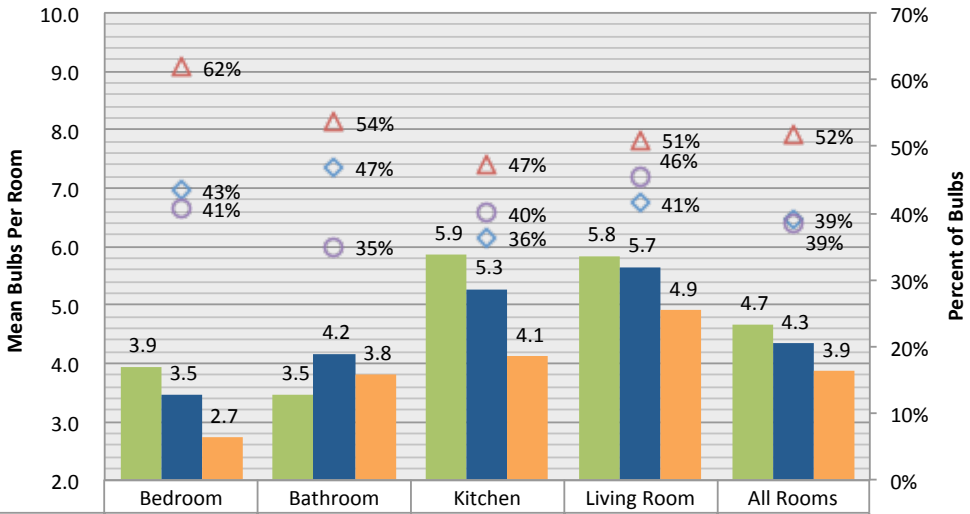


Figure 31 on the next page shows the mean number of bulbs installed by room type, and the share of those bulbs that are efficient (LED or CFL) for each county. Kitchens and living rooms have somewhat more bulbs than do bedrooms and bathrooms. This is particularly true in Hawaii and Maui where kitchen and living room lights outnumber bedroom/bathroom lights by about three to two. In Oahu, bathrooms are more like

kitchens, at about four bulbs per room; bedrooms have the lowest mean count at 2.7; and living rooms have the highest at 4.9.

The share of efficient bulbs for each county does not vary substantially by room type. For the most part, bathrooms and bedrooms have a higher share of efficient lighting than do kitchens and living rooms. Maui is an exception in that homes have a lower share of efficient bulbs in bathrooms. Both Hawaii and Maui have relatively lower shares of efficient lighting in kitchens.

Figure 31 – Mean Number of Installed Bulbs by Room Type and Efficiency, and by County



	Bedroom	Bathroom	Kitchen	Living Room	All Rooms
Hawaii Bulbs per Room	3.9	3.5	5.9	5.8	4.7
Maui Bulbs per Room	3.5	4.2	5.3	5.7	4.3
Oahu Bulbs per Room	2.7	3.8	4.1	4.9	3.9
Hawaii n	834	595	429	404	745
Maui n	775	752	452	473	751
Oahu n	2,148	2,332	1,120	1,196	1,672
Hawaii Percent of Bulbs CFL/LED	43%	47%	36%	41%	39%
Maui Percent of Bulbs CFL/LED	41%	35%	40%	46%	39%
Oahu Percent of Bulbs CFL/LED	62%	54%	47%	51%	52%

Figure 32 shows the percent of homes with efficient lighting technologies by county and home type. The figure shows the share of homes with at least one CFL bulb, LED bulb, dimmer and occupancy sensor. Nearly one-third of Maui homes have at least one LED, while no more than 10 percent of the homes in other counties have at least one LED. More than 10 percent of homes in Maui and Hawaii have no CFLs present, while only five percent of homes on Oahu have no CFLs. The presence of at least one occupancy sensor registers at three to four percent of homes across the board. The presence of dimmers is more variable

– ranging from 16 percent in Maui to just two percent in Hawaii. Note that most CFLs are not compatible with dimmers.

Figure 32 – Percent of Homes With Efficient Lighting Technologies Present, by County and Home Type

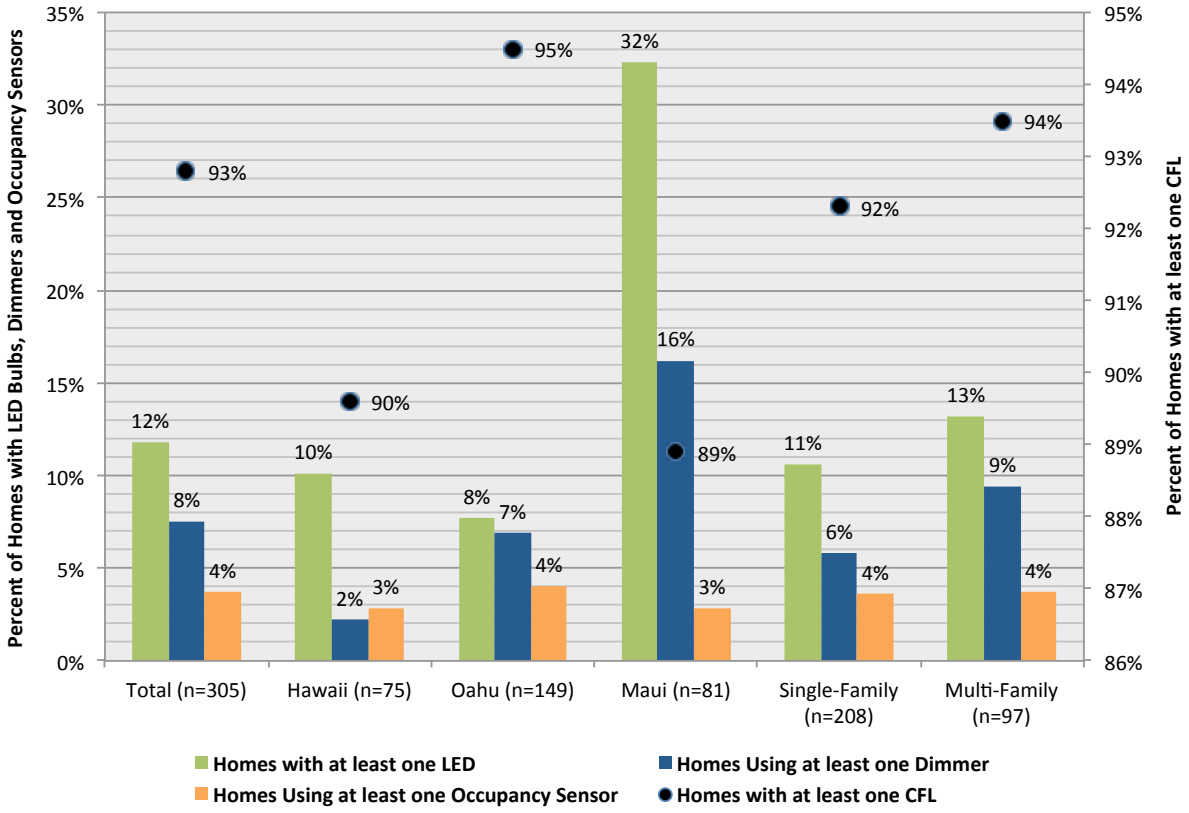
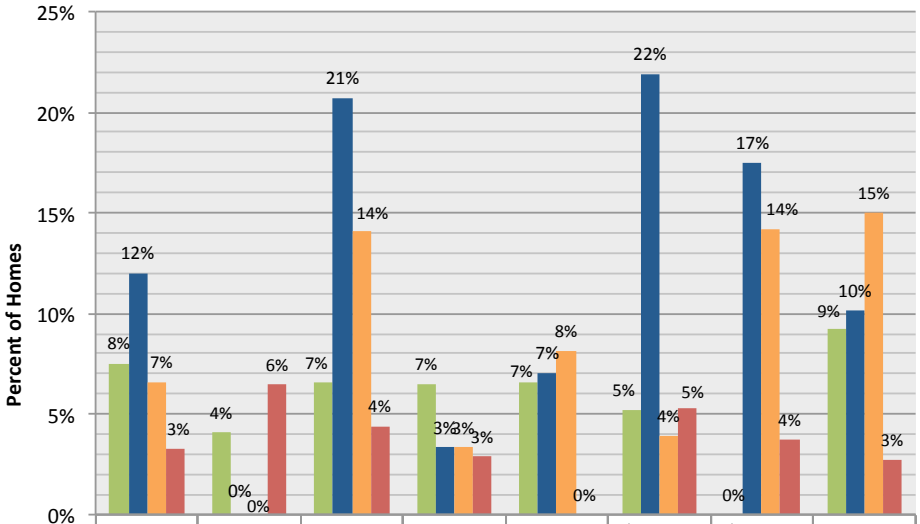


Figure 33 is similar to Figure 32, except that it shows the percent of homes with efficient lighting technologies by income and home type, and home type is further broken down by ownership. Dimmers are more common in higher-income homes and homes that are owner occupied. These same groups are also the most likely not to have CFLs present in the home, though the percentage is relatively small, at less than 10 percent of homes. LEDs appear not to be strongly correlated with income, but they are more prevalent in owner-occupied homes than rentals. Occupancy sensors have small and similar penetration across the segments examined here, between three and six percent. None of these results are statistically significant, so these are general trends we observed.

Figure 33 – Percent of Homes With Efficient Lighting Technologies Present, by Home Ownership and Income



	Own (n=185)	Rent (n=22)	Own (n=53)	Rent (n=44)	Less than $40,000 (n=78)	$40,000 to $80,000 (n=80)	$80,000 to $100,000 (n=32)	Over $100,000 (n=35)
	Single-Family		Multi-Family		Households by Income			
Homes without at least one CFL	8%	4%	7%	7%	7%	5%	0%	9%
Homes with at least one LED	12%	0%	21%	3%	7%	22%	17%	10%
Homes Using at least one Dimmer	7%	0%	14%	3%	8%	4%	14%	15%
Homes Using at least one Occupancy Sensor	3%	6%	4%	3%	0%	5%	4%	3%

4.5 Water Heating

The next set of exhibits focuses on characteristics we observed regarding water-heating equipment. First, we present results on the type and fuel by county and home type segments. Next, we show solar water heating by home vintage, income and home ownership. The last chart in this subsection focuses only on single-family homes and shows the trend in tank volume by home vintage.

Figure 34 on the next page shows the share of different types of water heating equipment and fuel sources by county and home type (note that the legend reads left to right, not top to bottom). The figure also shows the percent of homes with shared systems, i.e. multi-family homes with central water heating serving multiple dwelling units. The water heating technologies shown in the stacked bar exclude shared systems.

Electric tank-style water heaters make up over half (54%) of all homes' water heating appliances – a result consistent with RASS (55%). The share of these more traditional style water heaters is higher for multi-family homes than single-family (67% versus 46%, respectively). For the most part, tank-style water heaters powered with gas are present in between eight and 10 percent of homes; Maui is an exception to this at about six percent

(though this difference is not statistically significant). Solar water heating is present in 30 percent of all homes; there are substantially fewer within multi-family (16%) and more in Maui County (47%). RASS reports a lower percent of homes with solar water heating (23%) but are consistent with Baseline data in reporting higher value for Maui (31%) and lower values for multi-family residences (3% to 5%).

Figure 34 – Water Heating Type and Fuel Source, by County and Home Type

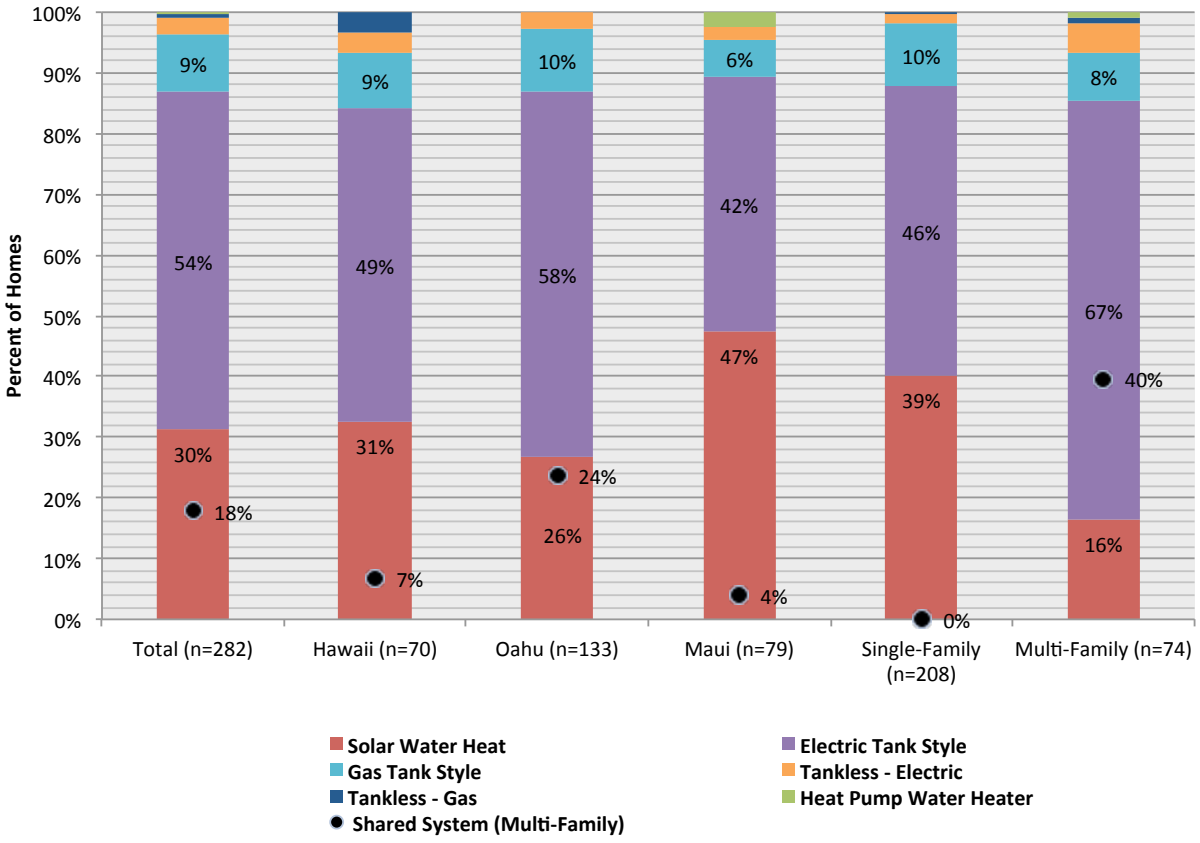


Figure 35 below shows the percent of homes with solar water heating by home vintage, income level and home ownership. Solar water heating is clearly correlated to home vintage with an upward trend in solar systems starting at 28 percent of pre-1959 homes, to nearly 50 percent of homes built after 2000. Legislation was introduced in 2010 that requires all new single-family homes to have solar water heating. While this may further affect change going forward, it does not explain the changes illustrated here as housing starts in 2011 and 2012 were small, totaling 1.3 percent across all residential home types.[19]

[19] http://www.census.gov/construction/bps/stateannual.html

Renters and lower-income homes (with annual income less than $40,000) are much less likely than owner/other income group counterparts to have solar water heating. However, with the exception of the lowest income group category, income does not appear to be correlated with solar system adoption, as percent of homes does not vary notably across the other, higher-income groups.

Figure 35 – Homes With Solar Water Heating, by Home Vintage, Income and Home Ownership

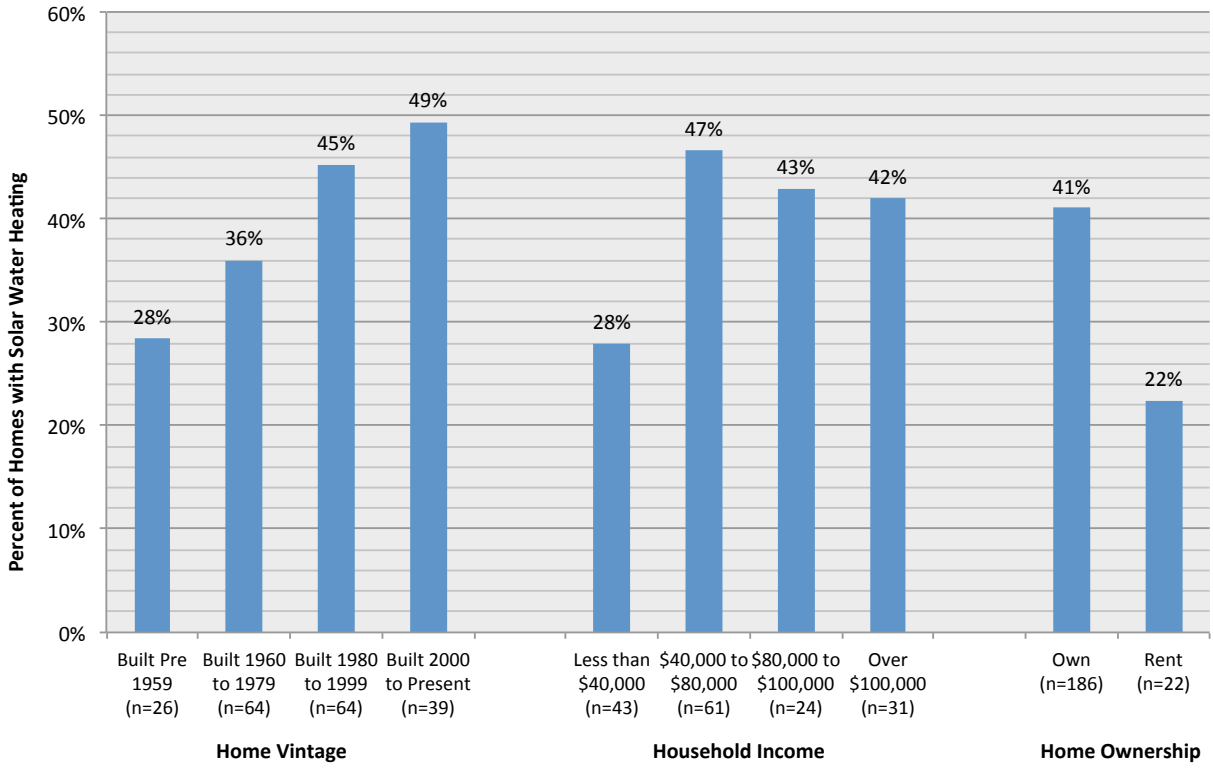
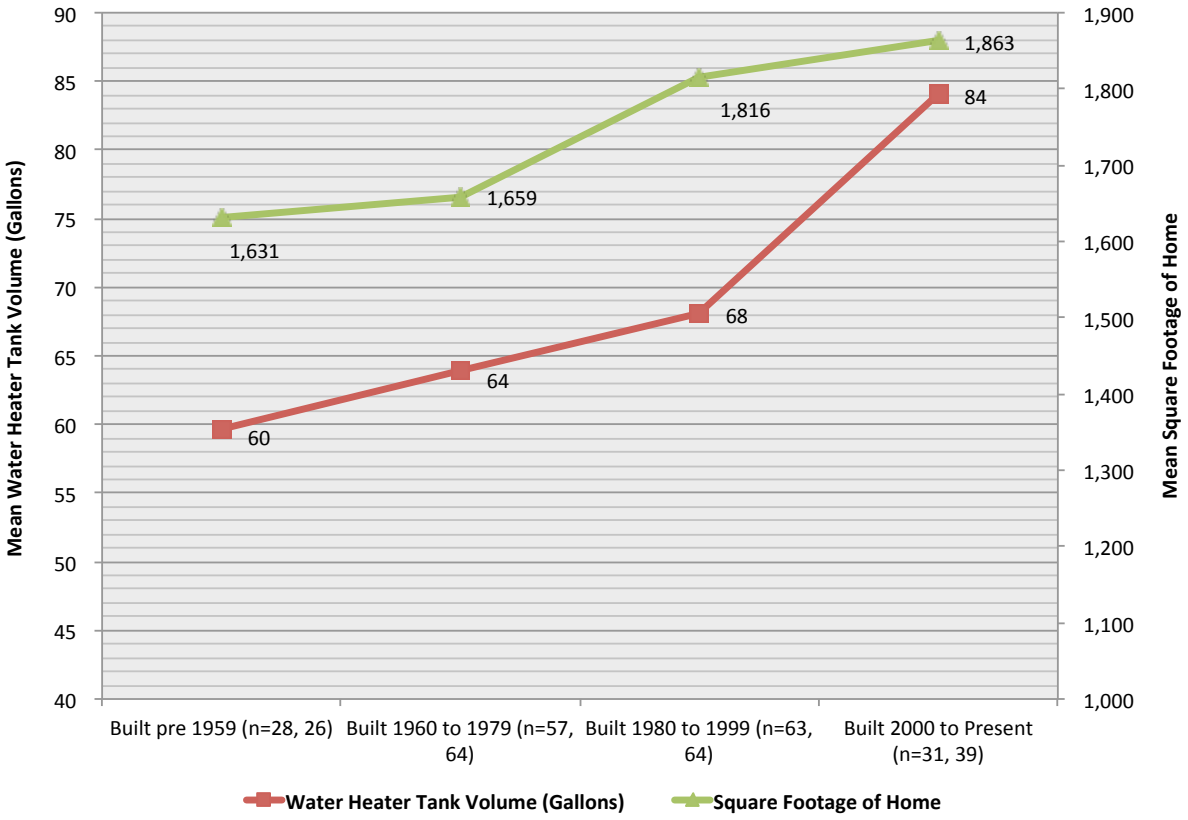


Figure 36 illustrates the change in mean water heater tank volume for single-family homes across home vintage categories. The figure shows a clear and substantial rise in volume over time, from 60 gallons for homes built before 1959, to a mean that is 40 percent higher at 84 gallons for homes built after the year 2000. Some of the increase in water heater size can be explained by the increase in home square footage (also shown in Figure 21). Water heater tank volume per square foot has risen over time, from a mean of 37 gallons per 1,000 square feet for homes built before 1959 to 45 gallons per 1,000 square feet for homes built after the year 2000.

Figure 36 – Mean Water Heating Tank Volume by Home Vintage, for Single Family Homes



4.6 Space Cooling

This subsection presents results based on our observations of space cooling equipment. First, we present the presence of space cooling by type by county and home type, by home ownership and income, and by home vintage. Then we present space cooling usage patterns and mean efficiency by equipment type. Next, we present the mean age of space cooling by equipment type and by county and home type. Finally, we present information about fans that we observed by county and home type.

Figure 37 shows the percent of homes with space cooling appliances by county and home type. Unitary systems – i.e., window, wall or room air conditioners – are the most commonly held type of cooling equipment; 28 percent of homes have this type of cooling equipment present. Central systems including split systems and ductless heat pumps are present in 17 percent of homes. Maui County has three or four times as many homes with split systems than in Hawaii or Oahu Counties. Ductless heat pumps are more frequently found in single-family homes and homes on Oahu, though this result is not statistically significant. Overall, Baseline data indicate 41 percent of homes have an air conditioner of some kind, which is somewhat lower than the RASS result of 47 percent. At the technology

specific level, baseline data yield a comparable value for room AC (28% versus 30%, respectively) and a lower value for split systems (8% versus 14%).

Figure 37 – Percent of Homes with Space Cooling Appliances, by County and Home Type

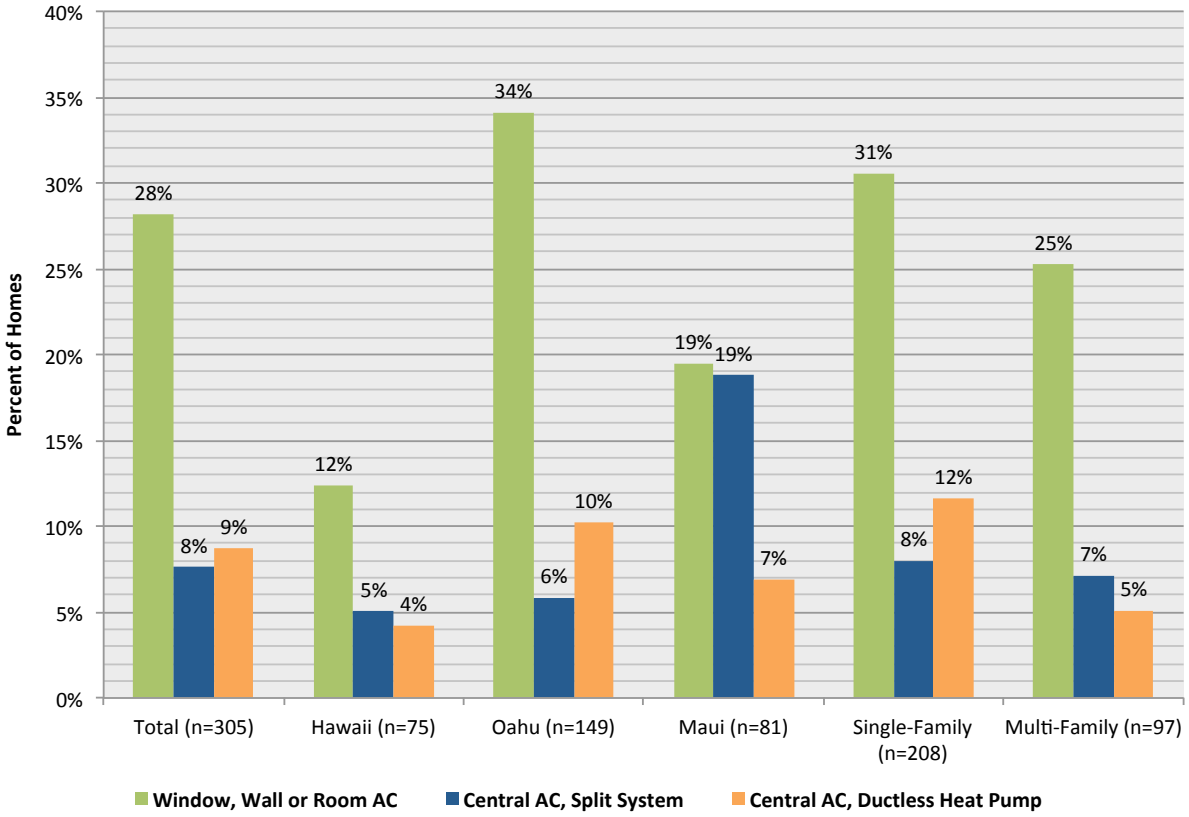


Figure 38 shows the percent of homes with cooling appliances by household income and home ownership. Percent of homes with cooling equipment is correlated to income. Lower-income homes have substantially less cooling equipment than higher-income homes. Homes in moderate-to-high income categories ($40,000 to $100,000) are most likely to have unitary systems (window, wall or room air conditioning) (34%). They are also more likely to have ductless heat pump cooling (8%) than split systems (3%), but this result is not statistically significant.

Figure 38 – Percent of Homes with Space Cooling Appliances, by Home Ownership and Income

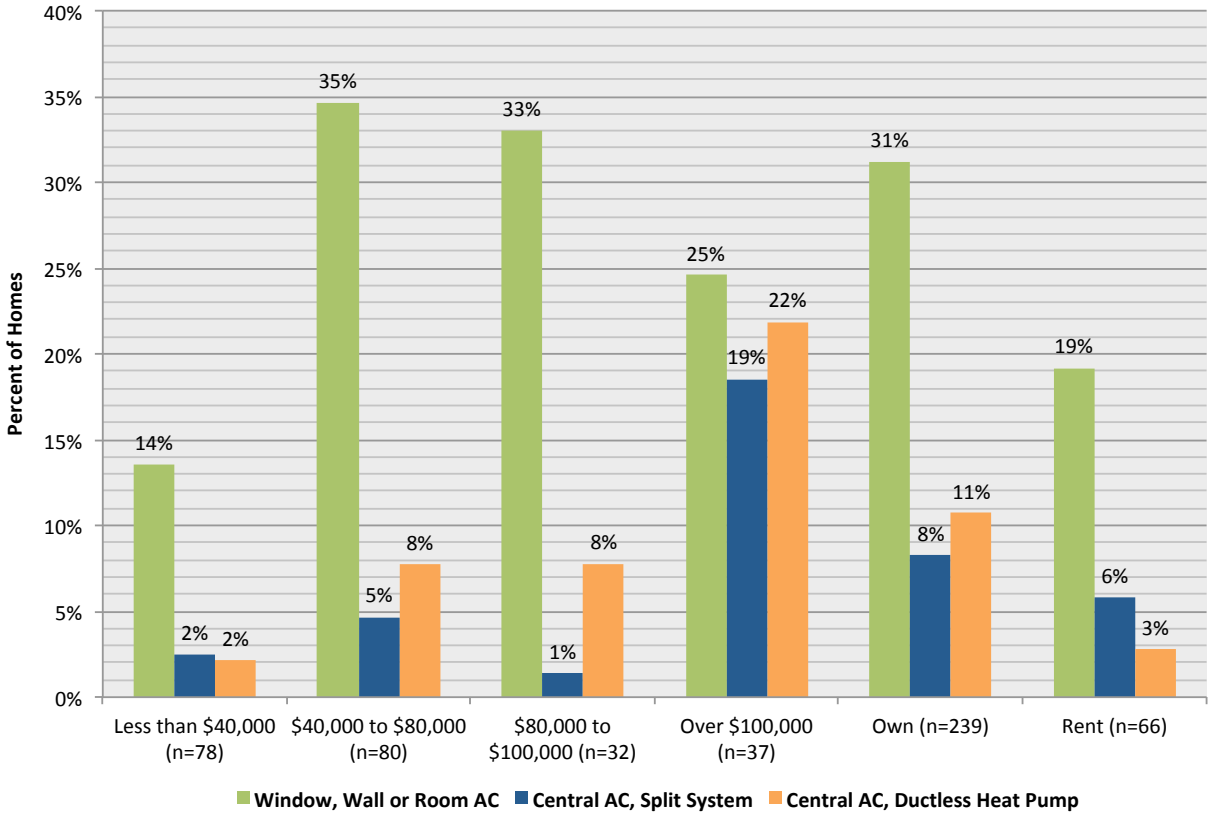


Figure 39 shows the percent of homes with cooling appliances by home vintage. The figure shows that newer homes are notably more likely to include split systems; the trend is stark, with fewer than eight percent of homes built with split systems prior to 2000, versus nearly one-third of post-2000 vintage homes.

Figure 39 – Percent of Homes with Space Cooling Appliances, by Home Vintage

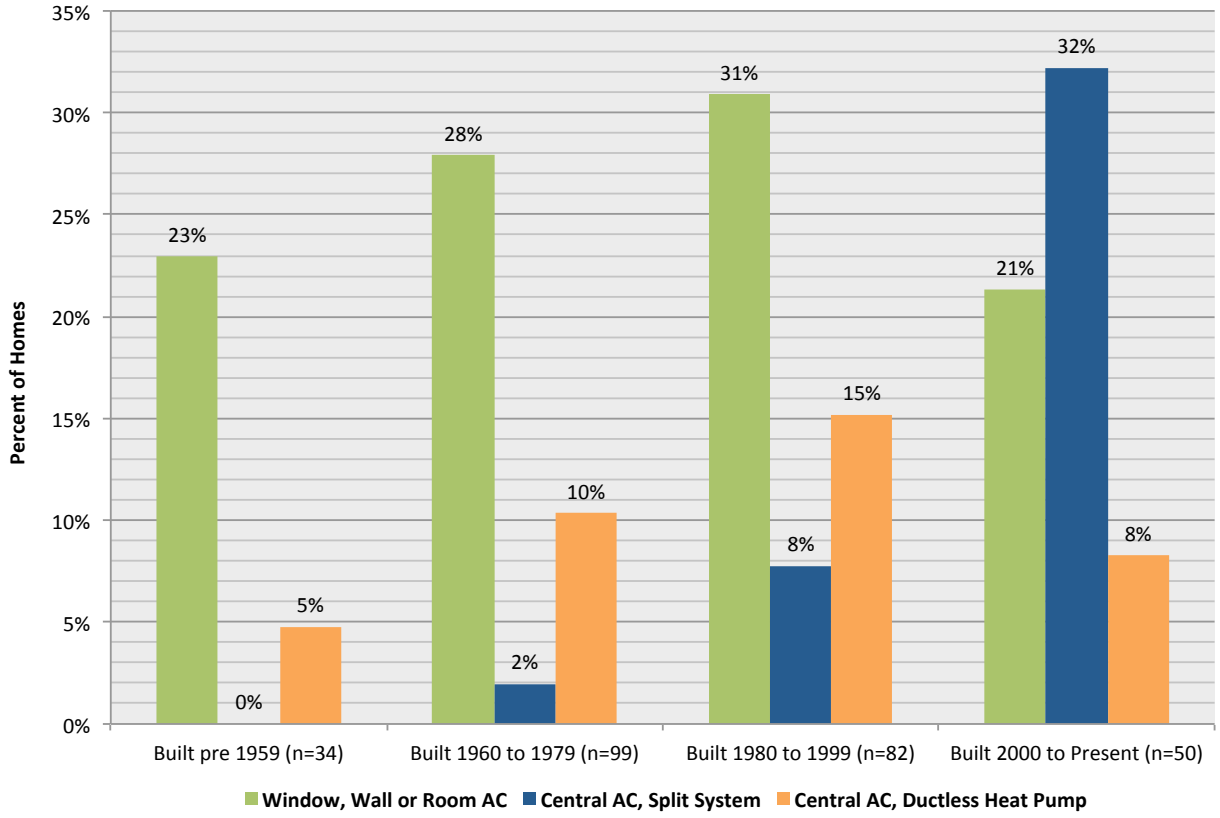
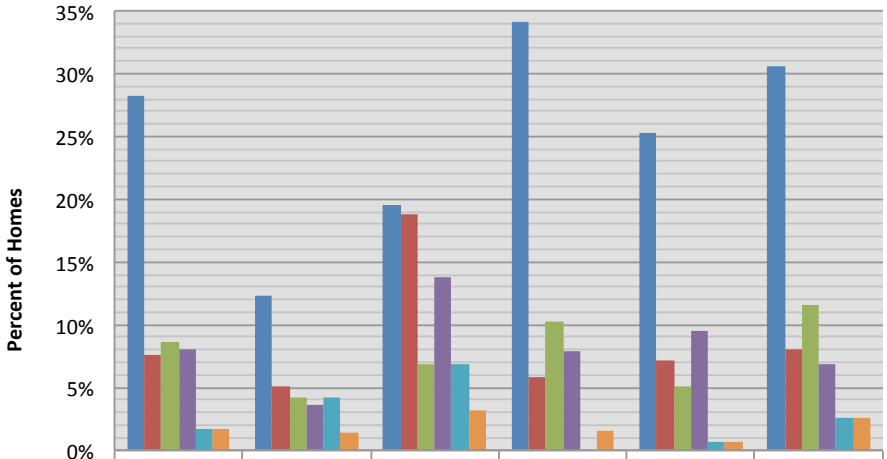


Figure 40 shows the same percent of homes with space cooling appliances by county and home type as shown in Figure 37. The first column in each category shows the percent of homes with unitary systems (window, wall or room air conditioning); overlaid is the percent of unitary systems that are never or rarely used based on customer self-report. The difference between the two values is the percent of unitary systems that are used regularly. (For the total column, 28 percent of homes have a unitary system, 20 percent have one and use it regularly and the remaining 8 percent have one but rarely or never use it.)

The data indicate that just over 70 percent of homes with unitary systems use the equipment regularly, while just under 30 percent report using their air conditioning equipment 'rarely' or 'never'. Split system and ductless heat pumps have slightly higher (but not statistically significant) rates of regular use, at 75 and 78 percent, respectively. Not surprisingly, ductless heat pumps have a higher utilization rate than other equipment types as they have been on the market for a shorter period. Maui County reports relatively low utilization of unitary systems, with fewer than one in four homes reporting regular usage. Hawaii has notably low utilization of split systems, with regular usage reported by just about one in five homes that have the equipment installed.

Figure 40 – Space Cooling Usage Patterns by Equipment Type, and by County and Home Type



	Total (n=305)	Hawaii (n=75)	Maui (n=81)	Oahu (n=149)	Multi-Family (n=97)	Single Family (n=208)
Homes With Window, Wall or Room AC	28%	12%	19%	34%	25%	31%
Homes With Central AC, Split System	8%	5%	19%	6%	7%	8%
Homes With Ductless Heat Pump AC	9%	4%	7%	10%	5%	12%
Rarely/Never Used Window, Wall or Room AC (n=80)	8%	4%	14%	8%	10%	7%
Rarely/Never Used Central AC Split System (n=28)	2%	4%	7%	0%	1%	3%
Rarely/Never Used Ductless Heat Pump AC (n=26)	2%	1%	3%	2%	1%	3%

Figure 41 presents the mean EER, or "Energy Efficiency Rating" as well as the mean SEER, or "Seasonal Energy Efficiency Rating", for the cooling equipment that was observed on-site. Unitary systems (window, wall or room air conditioning) typically have an EER rating of about 10, though a small number that received a SEER rating had a much higher efficiency at 14 SEER. The mean SEER rating of split systems is based on a small sample (14), but indicates efficiency levels well below current standards, at less than 12 SEER. The most commonly used cooling system, the unitary systems, have a mean EER rating of 10.2. Due to the small sample sizes (which are the number of units observed, shown in the figure on the next page), none of these differences are statistically significant, but they are suggestive of underlying trends that may be present.

Figure 41 – Mean Efficiency by Equipment Type

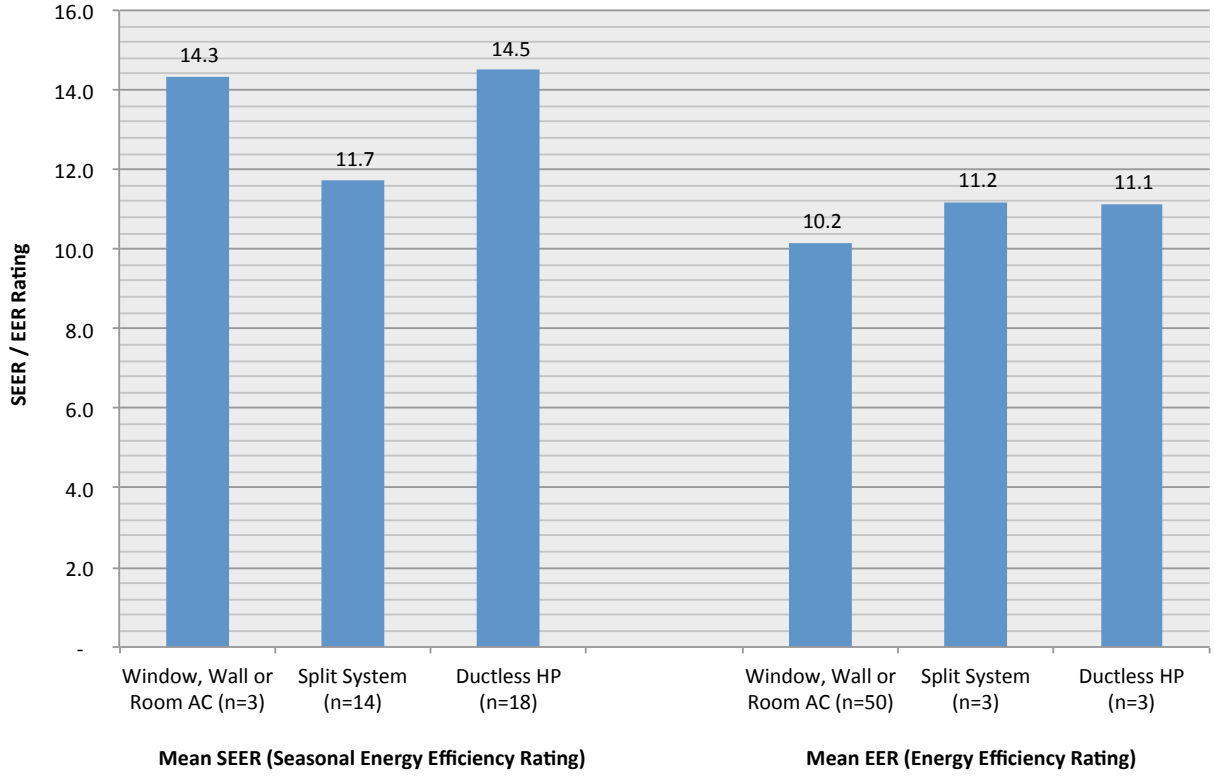
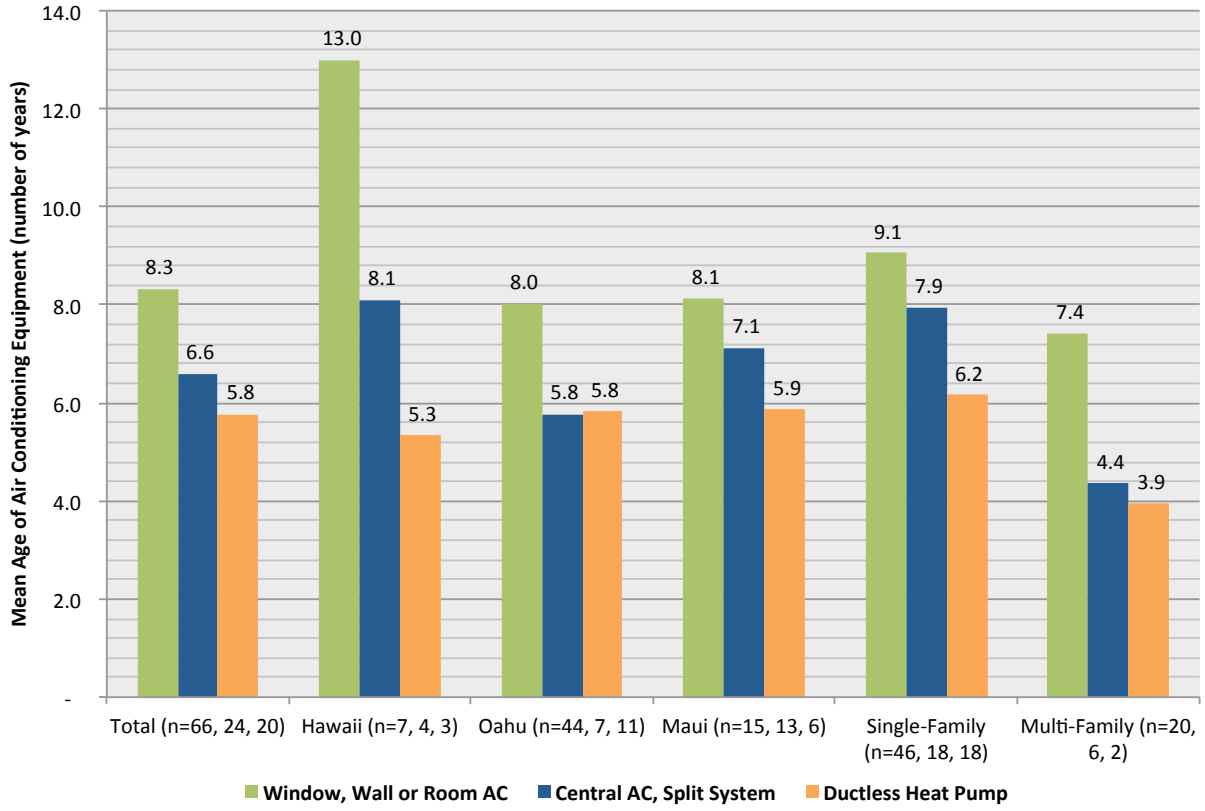


Figure 42 shows the mean age of cooling equipment, by county and home type. Over all segments, the mean age of unitary systems (window, wall or room air conditioning) is the greatest, at eight years. This result is fairly consistent with RASS, where the mean age of room AC equipment is seven years. Split systems and ductless heat pumps are typically newer, registering a mean age of 6.6 and 5.8 years, respectively. Unitary systems in single-family homes and in the County of Hawaii are older than the typical unit, at nine and 13 years, respectively. Similarly to what was noted for the prior exhibit, due to the small sample sizes (which are the number of units observed, shown in the figure on the next page), none of these differences are statistically significant, but they are suggestive of underlying trends that may be present.

Figure 42 – Mean Age of Cooling Appliances by Equipment Type, and by County and Home Type



The mean number of fans in use per home by type and the percentage of fans in use that are Energy Star[20] rated are shown in Figure 43. Overall, the mean holdings are just under two fans per home, and almost 90 percent of those (or 1.6 fans per home) are ceiling fans. Homes in Maui County have 36 percent more fans per home than the overall mean, at 2.6 fans per home. The percent of fans that are Energy Star rated is just under 20 percent overall. The share of fans that is Energy Star rated is notably higher among multi-family homes versus single-family (26% versus 14%, respectively). Data indicate that 38 percent of homes had no fans in operation at the time of the survey. On-site surveys were conducted during the period July 9, 2012 through April 9, 2013.

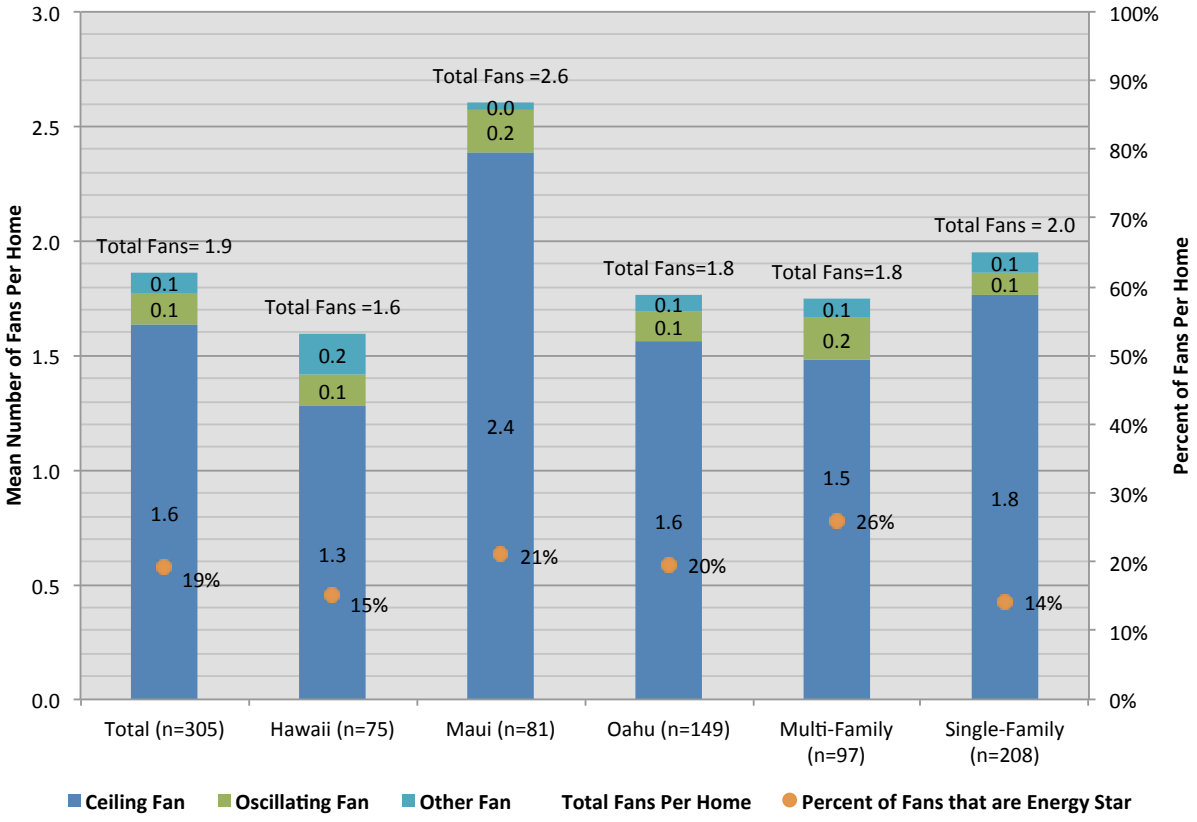
The RASS study reports a higher number of fans per home versus the on-site data reported here, particularly for portable and other fans. The RASS, based on self-reported mail survey data, reports a mean number of ceiling fans per home that ranges from 2.2 (for Oahu) to 2.8

[20] Energy Star is a U.S. Environmental Protection Agency voluntary program that helps businesses and individuals save money and protect our climate through superior energy efficiency. See www.energystar.gov.

(for Maui) per home – and overall total fans (ceiling and other) of between 3.8 and 4.4 fans per home. Based on Census data reports that indicate a mean number of rooms per home of 5.0, the RASS results imply that approximately one out of every two rooms has a ceiling fan, and about four out of five have a fan of some kind.

The data reflected here are a count of all appliances that were plugged-in, and thereby assumed to be generally in use at the time of the survey. The number of fans in closets or on shelves and not plugged in were not counted in our effort. However, these are likely to be reported by RASS mail-survey respondents who may report all of their holdings, even those in a closet or storage at the time of the survey.

Figure 43 – Space Cooling Fans in-use by Type and Efficiency, and by County and Home Type



4.7 Appliances

This subsection describes appliances that we observed, including the frequency of homes with appliances, and their age and efficiency levels for a subset of appliances where we could confirm those attributes. Most of the charts break out results by the county and home type segments that we use throughout this residential section, with one chart (other

appliances) by type of appliance, and a refrigerator and stand-alone freezer chart that shows results by home ownership and income.

Figure 44 summarizes laundry equipment holdings and usage patterns. The figure shows the portion of homes with washers and dryers, equipment age distributions, efficiency rating (reflected as "Energy Star" rating) and self-reported typical load frequency. The figure shows that 83 percent of homes have a clothes washer and 62 percent of the washers are more than five years old. The population of clothes dryers is slightly older than washers, with 66 percent registering at more than five years old. These results contrast with RASS, which reports 90 percent of homes have a washer[21] and 72 percent have a dryer. RASS reports a younger stock of laundry equipment as well, with mean washer and dryer ages of 5.8 and 6.3 respectively. RASS is consistent with Baseline in reporting an older stock of dryers.

Baseline data indicate that about twice as many homes have standard efficiency washers than have Energy Star-rated washers (56% versus 27%, respectively). Note that dryers do not yet have an Energy Star standard. Single-family homes do 1.5 more loads of laundry per week on average (5.5 versus 4.0, respectively), and are twice as likely to exceed seven loads of laundry per week (20%) than multi-family households (10%).

[21] It is possible that some homes with shared equipment report having a washer in response to RASS questionnaire, while Baseline data reflect equipment present only on the premise itself, not in common areas.

Figure 44 – Laundry Equipment and Percent of Homes Holding Appliance, Frequency of Use and Age

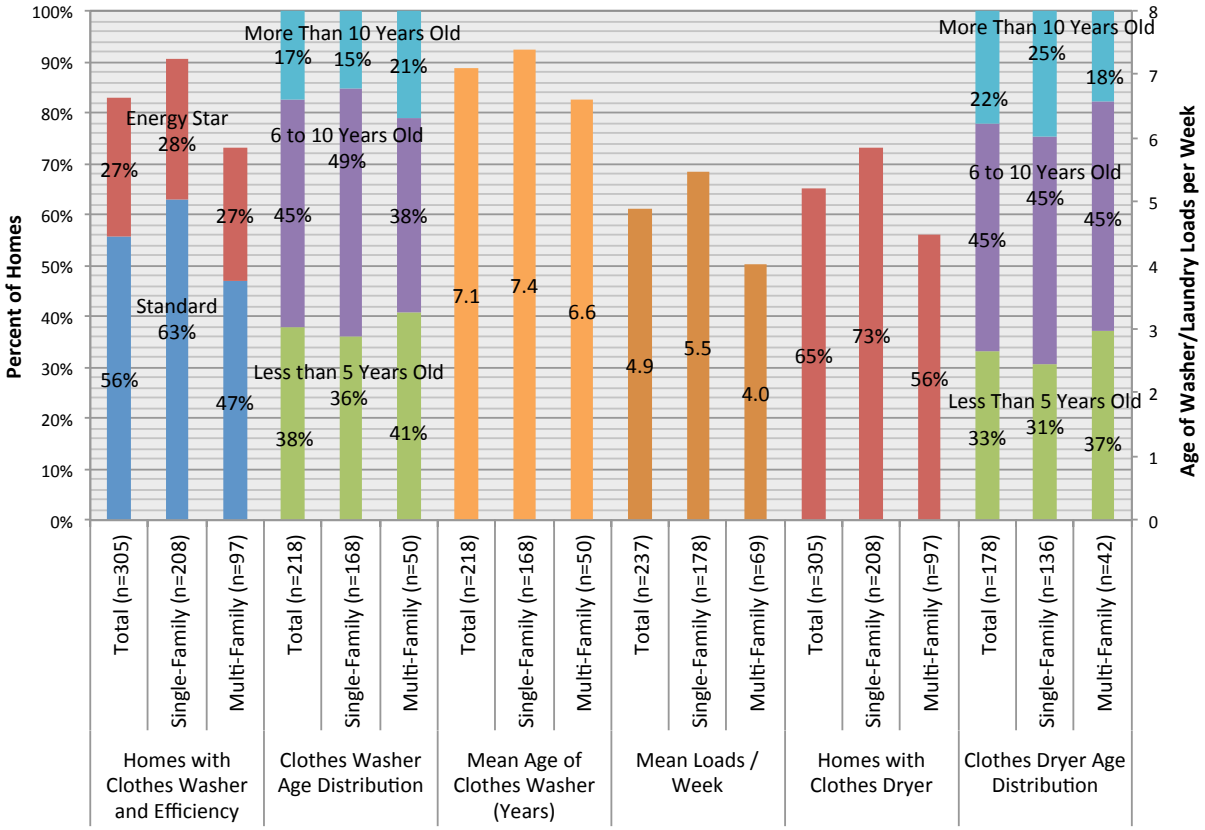
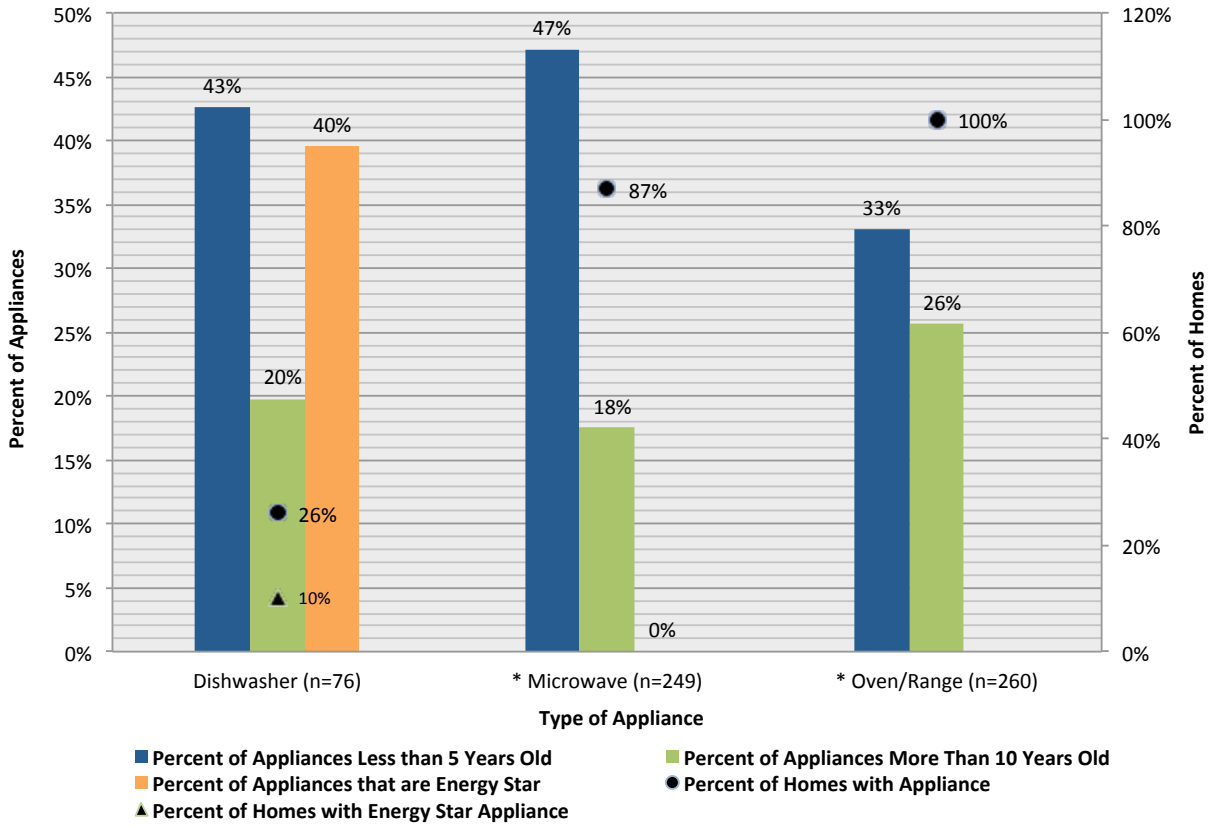


Figure 45 presents the mean age and Energy Star rating for kitchen appliances (refrigerators and stand-alone freezer results which are presented after this chart). The figure also shows the percent of homes where the appliance is present and indicates those that are Energy Star rated where an Energy Star standard exists (the legend goes left to right, not top to bottom). The circular marker indicates the frequency of homes that hold the appliance and the triangular marker the percent of homes with an Energy Star rated appliance, where there is an Energy Star standard (both of these data correspond to the right axis).

The columnar data, which correspond to the left axis, show the percent of appliances that are less than five years old, more than 10 years old, and that are Energy Star.

Penetration of Energy Star-rated appliances is 40 percent among dishwashers, a result that is very consistent with RASS, which shows 41 percent. Baseline data and RASS are also consistent in estimates of the percentage of homes with microwaves (87% versus 90%, respectively). Microwaves are most likely to be less than five years old, with nearly half of appliances in this age range. Ovens/ranges are most likely to be more than 10 years old, at 26 percent.

Figure 45 – Kitchen Appliances (Excluding Refrigerators and Stand-Alone Freezers), and Percent of Homes Holding Appliance, Energy Star Rating and Age



The n's for this figure reflect appliances where we could determine age.

Figure 46 presents key features of the refrigerator and freezer holdings. The figure shows the percent of homes with multiple refrigerators, stand-alone freezers and the percent of homes with Energy Star-rated equipment. Data indicate almost 30 percent of single-family homes have more than one refrigerator, and 20 percent own a stand-alone freezer. Multi-Family homes are half as likely to hold multiple refrigerators or freezers.

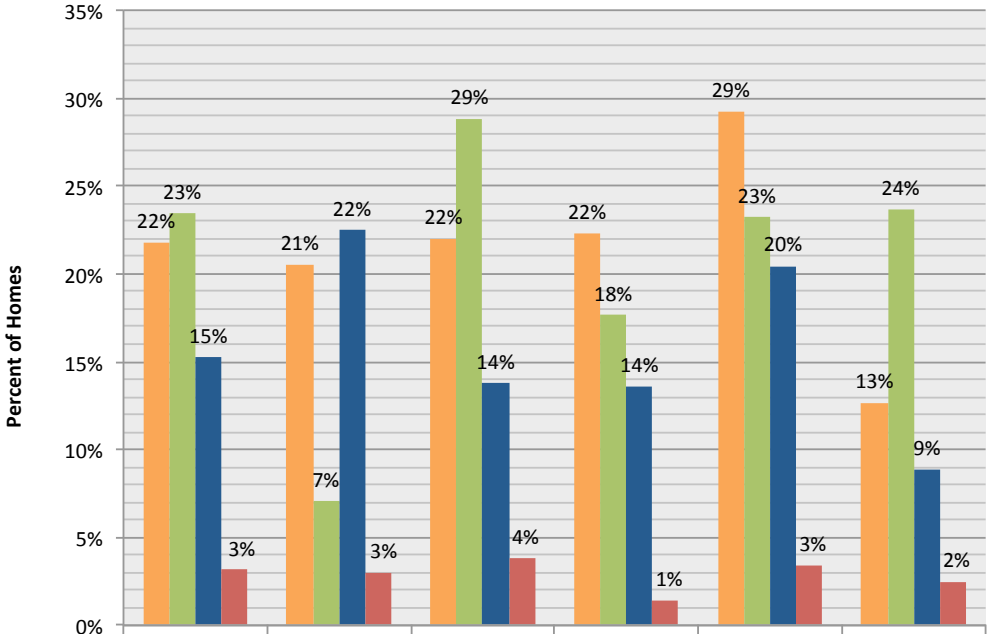
The propensity to hold more than one refrigerator does not vary notably across the counties; however, stand-alone freezers are more common in Hawaii County (22%) than Maui or Oahu (14% each) – though this difference is not statistically significant.

Energy Star refrigerators are about equally common in single-family and multi-family homes, where just under one-quarter of homes have an Energy Star refrigerator. Again, the counties differ notably. A much smaller percent of homes in Hawaii County have an Energy Star refrigerator (7%) versus Maui (18%) and Oahu (29%).

Energy Star stand-alone freezers are present in small percentages of the population, ranging from a low of one percent in Maui to a high of four percent in Oahu. The percent of homes holding stand-alone freezers that are Energy Star rated is similar to refrigerators, at

20 and 23 percent, respectively. However, there are notable differences by county. Maui has a low rate of homes holding freezers that are Energy Star rated, at just seven percent. Hawaii also has a low rate of homes holding freezers that are Energy Star rated, at 14 percent.

Figure 46 – Refrigerator and Stand-Alone Freezer Holdings and Efficiency, by County and Home Type



	Total (n=305)	Hawaii (n=75)	Oahu (n=149)	Maui (n=81)	Single-Family (n=208)	Multi-Family (n=97)
More than 1 Fridge	22%	21%	22%	22%	29%	13%
Energy Star Fridge (1 or More)	23%	7%	29%	18%	23%	24%
Stand Alone Freezer (1 or More)	15%	22%	14%	14%	20%	9%
Energy Star Freezer (1 or More)	3%	3%	4%	1%	3%	2%

The results for fridge and freezer holdings discussed above contrast rather sharply with those of RASS. Overall, RASS data reflect a greater portion of homes with a second fridge and more homes with stand alone freezers. The RASS data indicate 36 percent of homes have a second fridge, versus 22 percent of homes in the Baseline Survey. RASS data indicate 25 percent of homes have a freezer versus 15 percent in the Baseline Survey. The RASS results vary substantially by home type. A closer look at the data shows the discrepancies in overall results are driven by the single-family sector. Table 20 below compares results of the two studies by home type. The comparison shows Baseline and RASS have relatively consistent results in the multi-family sector but not in the single-family sector. RASS data indicate that 50 percent have a second fridge and 30 percent have a stand alone freezer.

These two facts together imply that between about 50 and 80 percent of single-family homes own at least one of these two appliances.

Table 20 – Fridges and Freezers – Comparison of RASS to On-Site Data

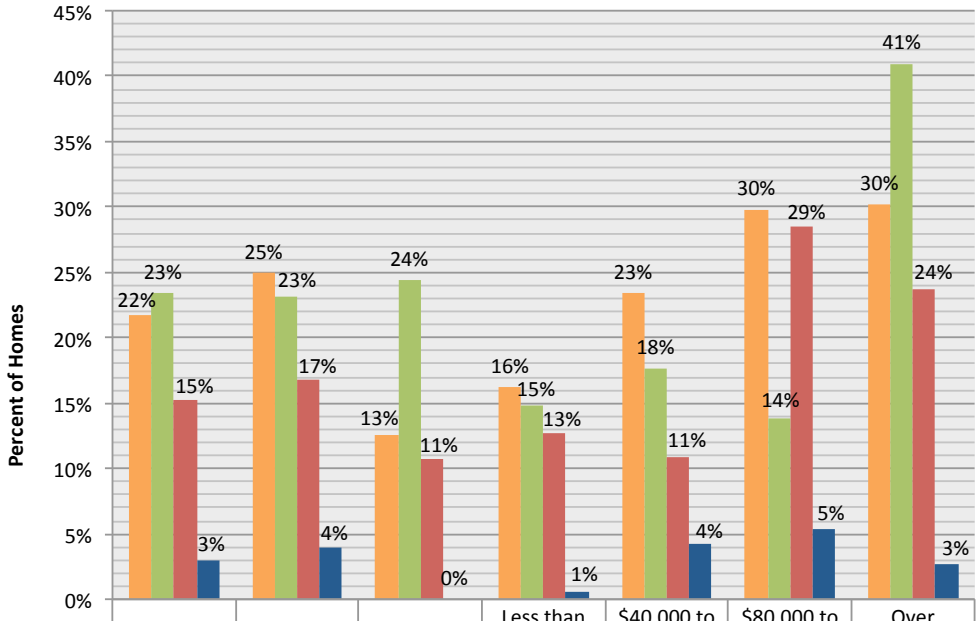
Home Type	Multi-Family		Single-Family	
	Baseline (n=97)	RASS (1,342)	Baseline (n=208)	RASS (n=3,599)
Homes with 2 or More Fridges	13%	12%	29%	49%
Homes with Stand Alone Freezer	9%	11%	20%	32%

Figure 47 on the next page shows key characteristics of refrigerator and stand-alone freezer holdings by home ownership and income level. The propensity to hold more than one refrigerator is almost twice as high for homeowners versus renters (25% versus 13%, respectively). Similarly, having more than one refrigerator is more common (but not statistically significant) in higher income groups, where it is about 30 percent, versus 16 percent among households earning $40,000 or less in annual income. Energy Star refrigerators are about equally likely to be held by owners as they are by renters. With the exception of the highest income group, all other income groups are not substantially different in their propensity to hold Energy Star refrigerators. The highest income group (annual income over $100,000) has the highest rate of Energy Star refrigerator holdings, at 41 percent.

More owners than renters have stand-alone freezers (17% versus 11%, respectively), and households with incomes of $80,000 or more per year are about twice as likely as those with lower incomes to own a stand-alone freezer (24% to 29% for higher incomes and 11% to 13% for lower incomes). These differences are not significantly different, but may suggest underlying trends.

Energy Star stand-alone freezers have a very low penetration among renters and those in the lowest income group, where they are present in eight percent or fewer households that have a freezer.

Figure 47 – Refrigerator and Stand-Alone Freezer Holdings and Efficiency, by Home Ownership and Income



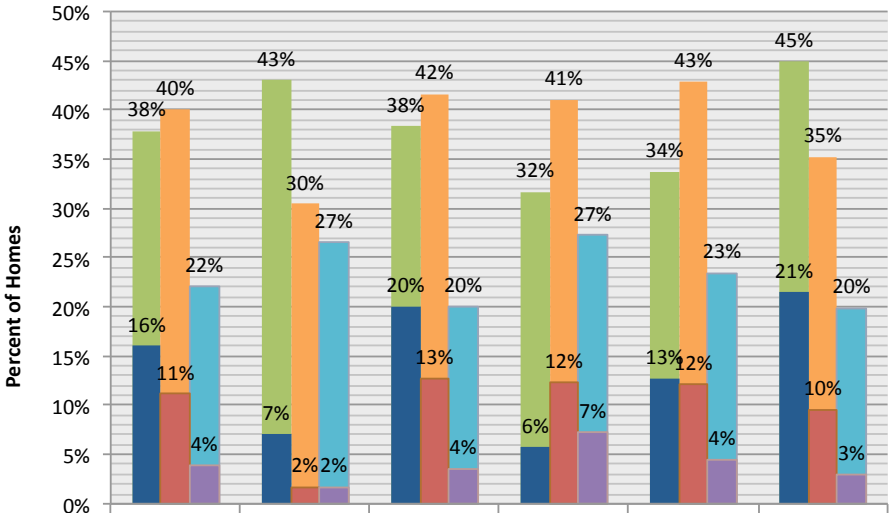
	Total (n=305)	Own (n=239)	Rent (n=66)	Less than $40,000 (n=78)	$40,000 to $80,000 (n=80)	$80,000 to $100,000 (n=32)	Over $100,000 (n=37)
More than 1 Fridge	22%	25%	13%	16%	23%	30%	30%
Energy Star Fridge (1 or More)	23%	23%	24%	15%	18%	14%	41%
Stand Alone Freezer (1 or More)	15%	17%	11%	13%	11%	29%	24%
Energy Star Freezer (1 or More)	3%	4%	0%	1%	4%	5%	3%

Figure 48 shows the age and Energy Star distribution of refrigerators by county and home type. Overall, a little more than 20 percent of refrigerators are more than 10 years old; those that are less than 10 years old are roughly split between one to five years and six to 10 years old categories (38% and 40% respectively). Energy Star-rated refrigerators make up a greater percentage of newer refrigerators; 42 percent of refrigerators one to five years old are Energy Star-rated versus 28 percent of those between six and 10 years old.

There are differences in patterns and Energy Star penetration across the counties. As was shown in previous exhibits and described in the text above, Oahu has a higher percent of homes with Energy Star refrigerators than the other two counties. For Oahu and Hawaii Counties, the share of Energy Star-rated refrigerators increases for newer equipment, indicating an increasing market share over time. Still, even among the newest refrigerators, 16 percent of those in Hawaii County are Energy Star rated versus more than half (52%) in Oahu County. In Maui County, Energy Star share goes down instead of up over the age range, at 30 percent for refrigerators six to 10 years old and 18 percent for those one to five years old.

There are also differences in the refrigerator age and Energy Star distributions across home types. Multi-Family homes have more refrigerators under five years old compared to single-family (45% versus 34%, respectively) and a sharply increasing share of Energy Star models, moving from 27 percent for six to 10 year old equipment to 48 percent of newer models. Single-Family homes are more likely to own a refrigerator in the six to 10 year old ranges than multi-family (43% versus 35%, respectively, though this difference is not statistically significant). The share of Energy Star penetration in the six to 10 year old range is similar in single and multi-family sectors (28% versus 27%, respectively) but diverges in newer models, where single-family registers 38 percent Energy Star, a 10 percentage gap relative to multi-family. Though it is not shown in the table, the mean age of refrigerators is 7.6 years, one year older than RASS reports, 6.6 years.

Figure 48 – Refrigerators by Age and Energy Star Rating, by County and Home Type



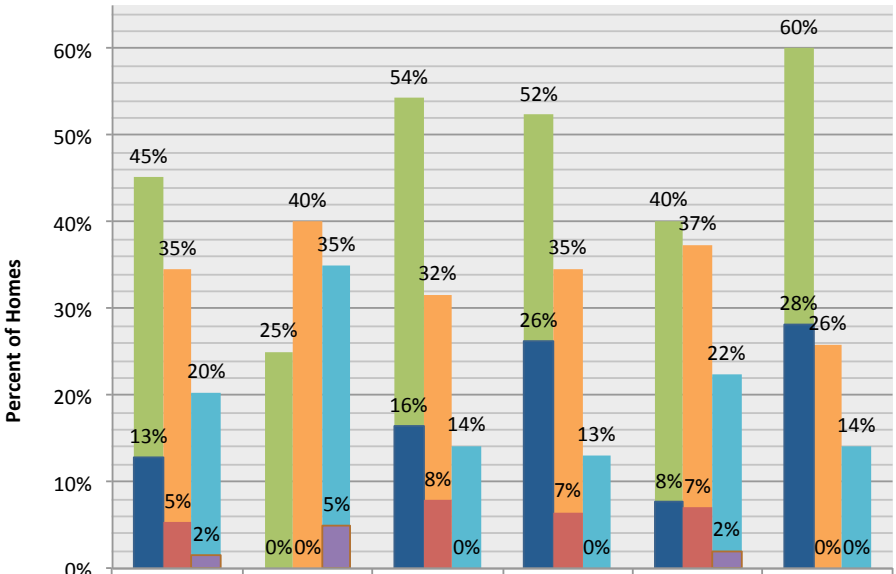
	Total (n=311)	Hawaii (n=58)	Oahu (n=161)	Maui (n=92)	Single-Family (n=237)	Multi-Family (n=74)
Less than 5 Years Old, All Fridges	38%	43%	38%	32%	34%	45%
6 to 10 Years Old, All Fridges	40%	30%	42%	41%	43%	35%
More than 10 Years Old, All Fridges	22%	27%	20%	27%	23%	20%
Less than 5 Years Old, Energy Star Fridges	16%	7%	20%	6%	13%	21%
6 to 10 Years Old, Energy Star Fridges	11%	2%	13%	12%	12%	10%
More than 10 Years Old, Energy Star Fridges	4%	2%	4%	7%	4%	3%

Figure 49 is similar to Figure 48; it shows the age and Energy Star distribution by county and homes type for stand-alone freezers instead of refrigerators. There is a pronounced difference in the age distribution of freezers across the counties, with more potential for improved efficiency in Hawaii County than Maui or Oahu. In Hawaii County more than one-third of all freezers are in the 'more than 10 years old' category, while Maui and Oahu are

similar, at 13 and 14 percent, respectively. Further, on-site surveyors found no Energy Star freezers under 10 years old in Hawaii County sampled sites, while more than half of the newest freezers observed in Maui and 30 percent of those in Oahu are Energy Star rated. Hawaii County also has the highest proportion of homes holding a second freezer, 22 percent versus 14 to 15 percent for Maui and Oahu. Although the freezer results contrast with RASS, it is worth mentioning that RASS data also indicate more homes with freezers in Hawaii County (35%) than Maui (26%) and Oahu (22%).[22]

There are notable differences across the home type categories as well. Stand-alone freezers in the multi-family sector are much more likely to be less than five years old, at 60 percent of all freezers, versus 40 percent of freezers in the single-family sector. While nearly one in two of the freezers under five years old in the multi-family sector are Energy Star rated, one in five meet the efficiency standard in the single-family sector.

Figure 49 – Stand-Alone Freezer by Age and Energy Star Rating, and by County and Home Type



	Total (n=311)	Hawaii (n=58)	Oahu (n=161)	Maui (n=92)	Single-Family (n=237)	Multi-Family (n=74)
Less than 5 Years Old, All Freezers	45%	25%	54%	52%	40%	60%
6 to 10 Years Old, All Freezers	35%	40%	32%	35%	37%	26%
More than 10 Years Old, All Freezers	20%	35%	14%	13%	22%	14%
Less than 5 Years Old, Energy Star Freezers	13%	0%	16%	26%	8%	28%
6 to 10 Years Old, Energy Star Freezers	5%	0%	8%	7%	7%	0%
More than 10 Years Old, Energy Star Freezers	2%	5%	0%	0%	2%	0%

[22] Data reflecting the age of stand-alone freezers is not available in RASS results.

4.8 Envelope

The following charts present results on windows, doors and roofs that we observed. The results are all shown by county and home type.

Figure 50 shows the percent of homes with efficient window and door measures present. That is, the figure presents the percent of homes with at least one window or door with the specified efficient measure. Tinted windows and double-paned windows are the most common efficient measures, at 21 and 20 percent of all sampled homes, respectively. The portion of homes with tinted windows is confirmed by RASS results (18%). Tinted windows and insulated door measures are much more common in Maui County, where about one in three homes have either tinted or double-paned windows. Among the three counties, Oahu has the lowest penetration of these window measures, at 16 percent of homes. Adoption of both double-paned and tinted windows does not appear related to home type; single-family and multi-family segments have similar penetration of these measures.

Insulated doors and triple-paned windows are less common than double-paned and tinted windows. Just five percent of homes have insulated doors and four percent have triple-paned windows. The County of Hawaii stands out in its percent of homes with insulated doors, at nearly double the overall mean, nine percent, though this difference is not statistically significant.

Figure 50 – Percent of Homes with Efficient Window and Door Measures, by County and Home Type

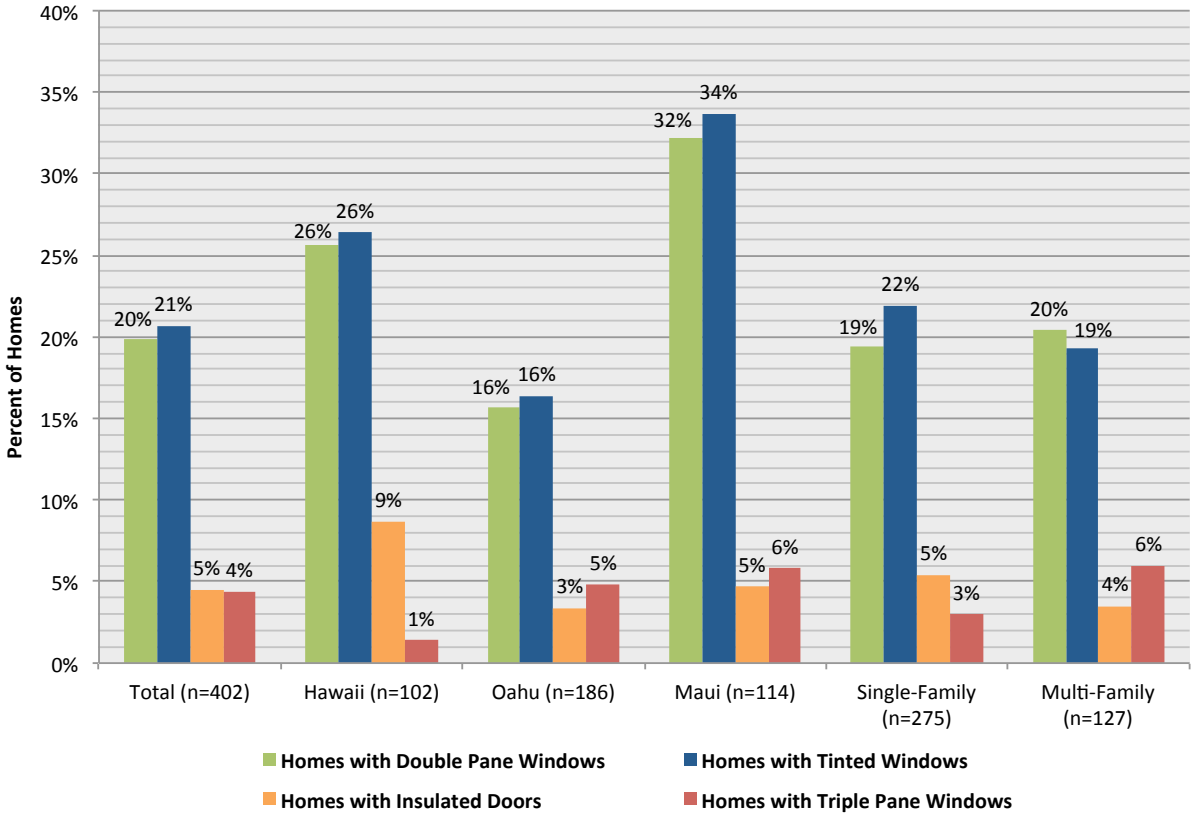


Figure 51 shows the distribution of efficient and standard window square footage by county and home type. The figure shows the percent of window square feet that are single, double and triple-paned, as well as those that are Jalousie windows or other types of windows. Tinting may accompany most types of windows, including single, double and triple paned. The percent of window square feet that are tinted are shown in a separate column.

Data show that 36 mean window square feet are double or triple-paned windows; the vast majority of that is double paned (34 of 36 mean square feet). Looking across the counties, double-paned windows are more common in Hawaii and Maui (55 and 54 mean square feet) than in Oahu (25 mean square feet). There is no difference in the percentage of window square feet that are double paned across single-family and multi-family sectors, with both at the overall mean, 15 percent.

Tinted windows make up about a mean of 16 percent of window square footage. This percent is fairly consistent over county and home type segments, though it is somewhat more common in Maui (22%) and less common in Oahu (14%) – this difference is not statistically significant.

Figure 51 – Mean Home Window Square Footage by Window Type and Tinting, by County and Home Type

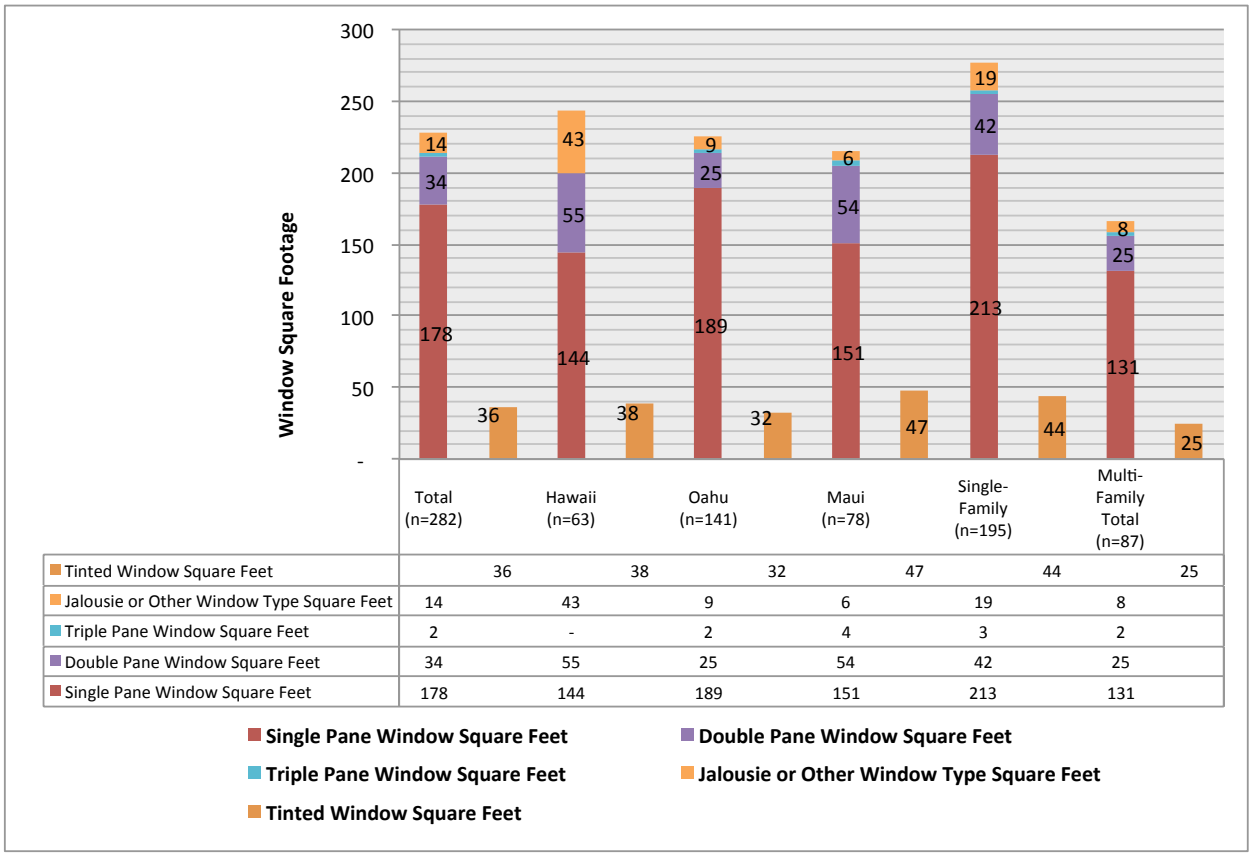
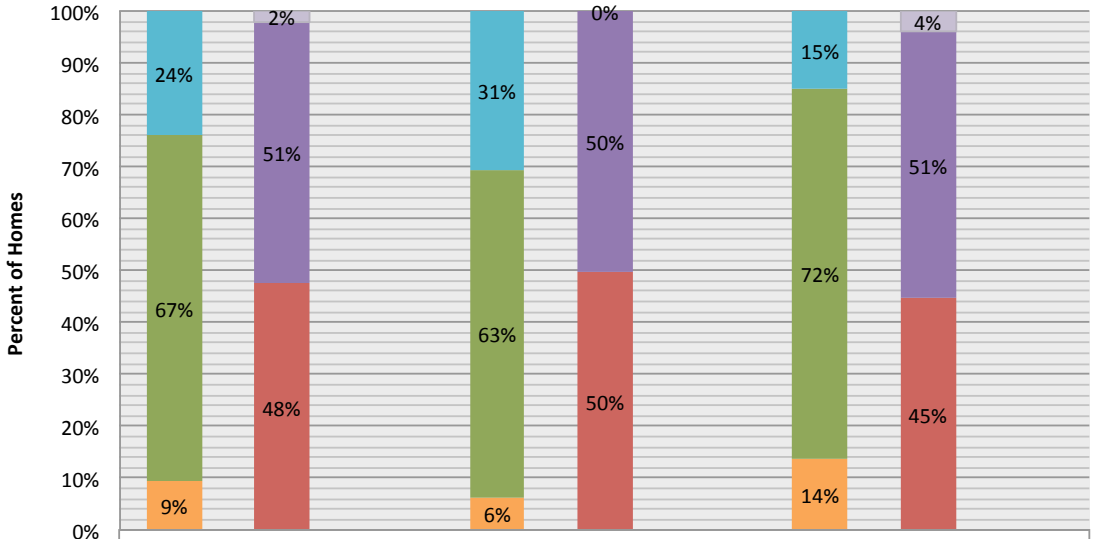


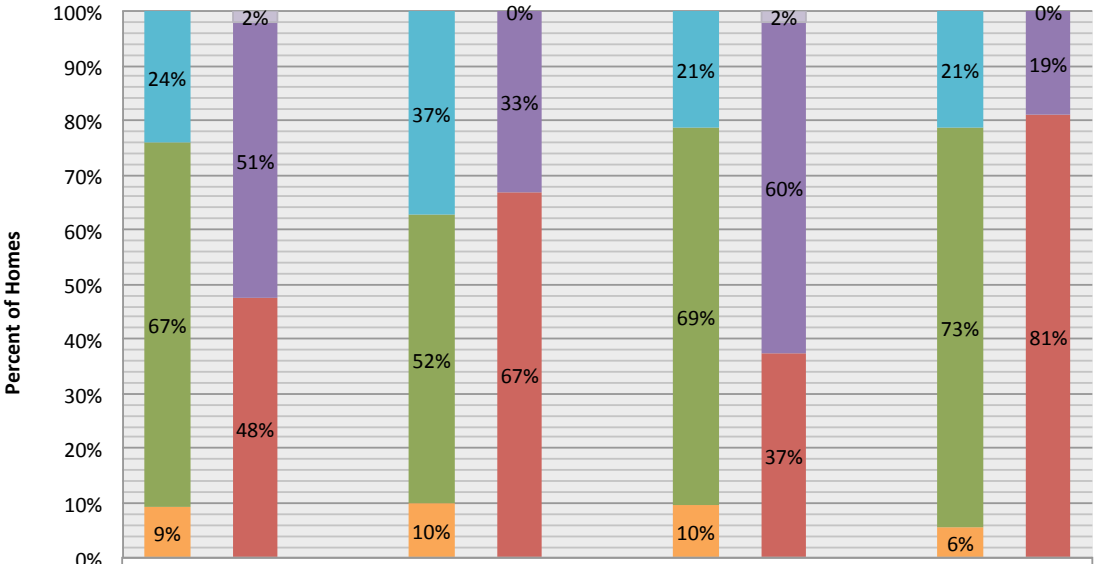
Figure 52 and Figure 53 show the distribution of roof condition and color. Overall, about half of homes have a roof in good condition and about half of homes have a roof in moderate condition. Two percent of homes were observed with a roof in poor condition. Across the counties, there are more roofs in good condition in Maui (81%) and Hawaii (67%) versus Oahu (37%). Roofs in poor condition are concentrated in multi-family dwellings in Oahu County, where they make up three to four percent of homes. No roofs in poor condition were recorded for single-family homes or homes in Maui or Hawaii counties.

Figure 52 – Home Roof Color and Roof Condition, by Home Type



	Total (n=239)	Single-Family (n=171)	Multi-Family (n=68)
Condition Poor	2%	0%	4%
Condition Moderate	51%	50%	51%
Condition Good	48%	50%	45%
Color Dark	24%	31%	15%
Color Medium	67%	63%	72%
Color White	9%	6%	14%

Figure 53 – Home Roof Color and Roof Condition, by County



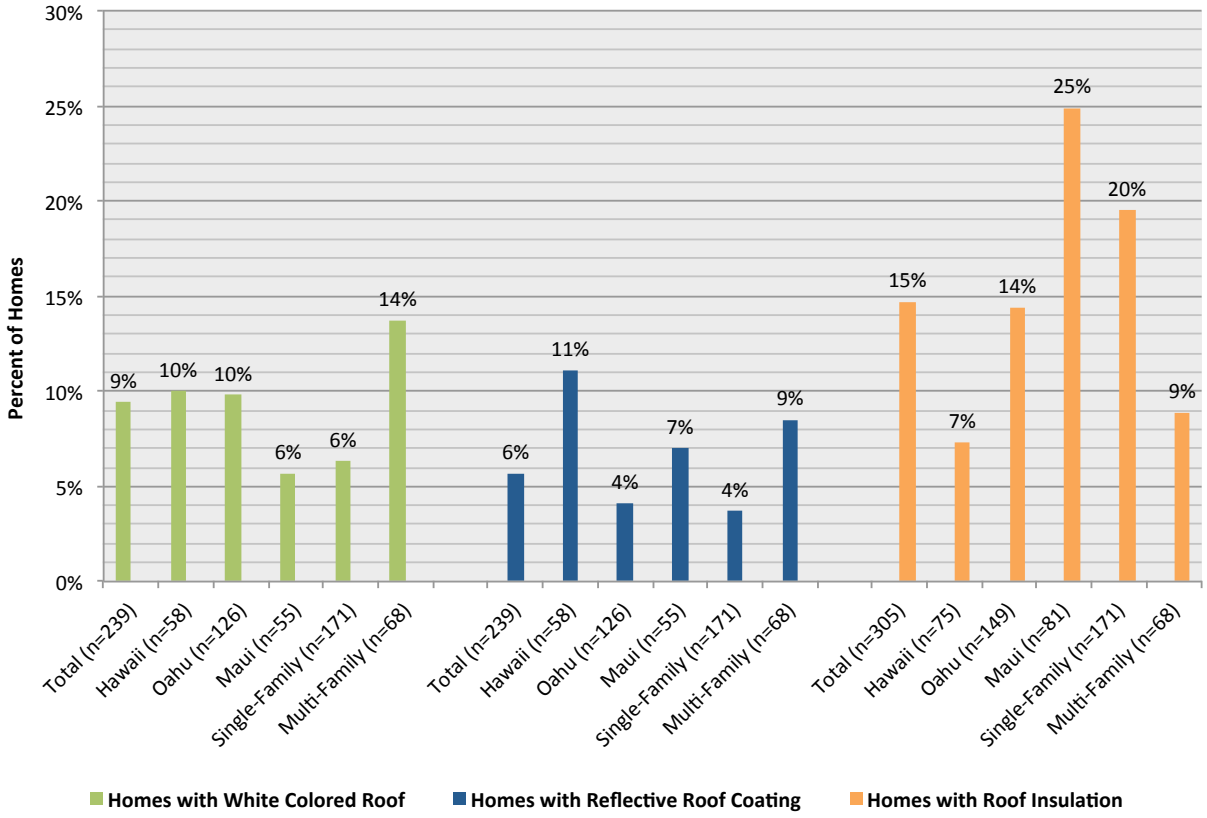
	Total (n=239)	Hawaii (n=58)	Oahu (n=126)	Maui (n=55)
Condition Poor	2%	0%	2%	0%
Condition Moderate	51%	33%	60%	19%
Condition Good	48%	67%	37%	81%
Color Dark	24%	37%	21%	21%
Color Medium	67%	52%	69%	73%
Color White	9%	10%	10%	6%

Figure 54 presents the percent of homes with efficient roof measures: white colored roof, reflective roof coating and roof insulation. The figure shows that roof insulation is the most common of the three roof measures, at 15 percent of homes overall[23], versus nine percent with white colored roofs and six percent for reflective roof coating. Comparisons across county and home type show roof insulation is most common in Maui (25%) and in single-family homes (20%), and is least common in Hawaii (7%). Other trends that we observed, but which were not found to be statistically significant, are:

- White-colored roofs are most common in multi-family homes (14%) and are less often found in Maui (6%) and in single-family homes (6%).
- A reflective roof is more common in Hawaii County (11%) than either white colored roofs (10%) or roof insulation (7%).
- Reflective coatings are more common in multi-family homes (9%) versus single-family homes (4%).

[23] RASS results indicate 21 percent of homes have ceiling insulation.

Figure 54 – Percent of Homes with Efficient Roof Measures, by County and Home Type



4.9 Electronics

The final set of results for the non-military residential sector is for home electronics. We present two charts, the first focusing on televisions we observed and the second on home theatre and office equipment. Both sets of results are presented by county and home type.

Flat screen televisions vary widely in their energy consumption (for a given size). For a given screen size, CRT sets typically use more energy than LED sets and less than similarly sized plasma sets. CRT sets are generally smaller and as flat screen televisions have become more affordable and commonplace, the mean size of televisions has also grown. In the mid 1990s, the typical American television purchase was a 30 inch CRT (picture tube) which drew about 115 watts when on. In the 2000's the typical purchase was a 40 to 50 inch flat screen LCD and Plasma sets that consumed as much as 75 percent to 300 percent more

electricity per unit[24] than the older CRT sets. However, these technologies have continued to evolve and a typical 2013 LED 50 inch model uses 100 watts; 2013 model LCD sets remain under about 125 watts. At the same time, plasma sets remain substantially higher energy users; a typical 50 inch 2013 model will draw about 300 watts.[25]

The older style CRT sets are still present in just under one-third of homes. Figure 55 shows the mean number and type of television sets in use per home, by county and home type. The figure shows the percent of homes with at least one television (94% overall) and with two or more televisions (51% overall). The County of Hawaii is most likely to have no television sets (8% of homes, though not statistically significant) and most likely to have a CRT set (40%). Not surprisingly, single-family homes have more sets per home, at 2.2 versus 1.6 for multi-family homes.

Data were collected slightly differently for the RASS than the Baseline Study. The RASS findings indicate the mean number of color televisions with screen size of less than 37 inches is 1.5 sets per home. In addition, 53 percent of homes have one or more large televisions (greater than 37 inches). Together, these results indicate a mean value of approximately 2.0 television sets per home or more – which is generally consistent with the baseline data presented below.

[24] U.S. News and World Report, 2007, http://money.usnews.com/money/articles/2007/12/06/your-new-plasma-tv-may-be-an-energy-hog

[25] http://www.rtings.com/info/lcd-vs-led-vs-plasma/power-consumption-and-electricity-cost

Figure 55 – Number and Type of Television Set per Home, by County and Home Type

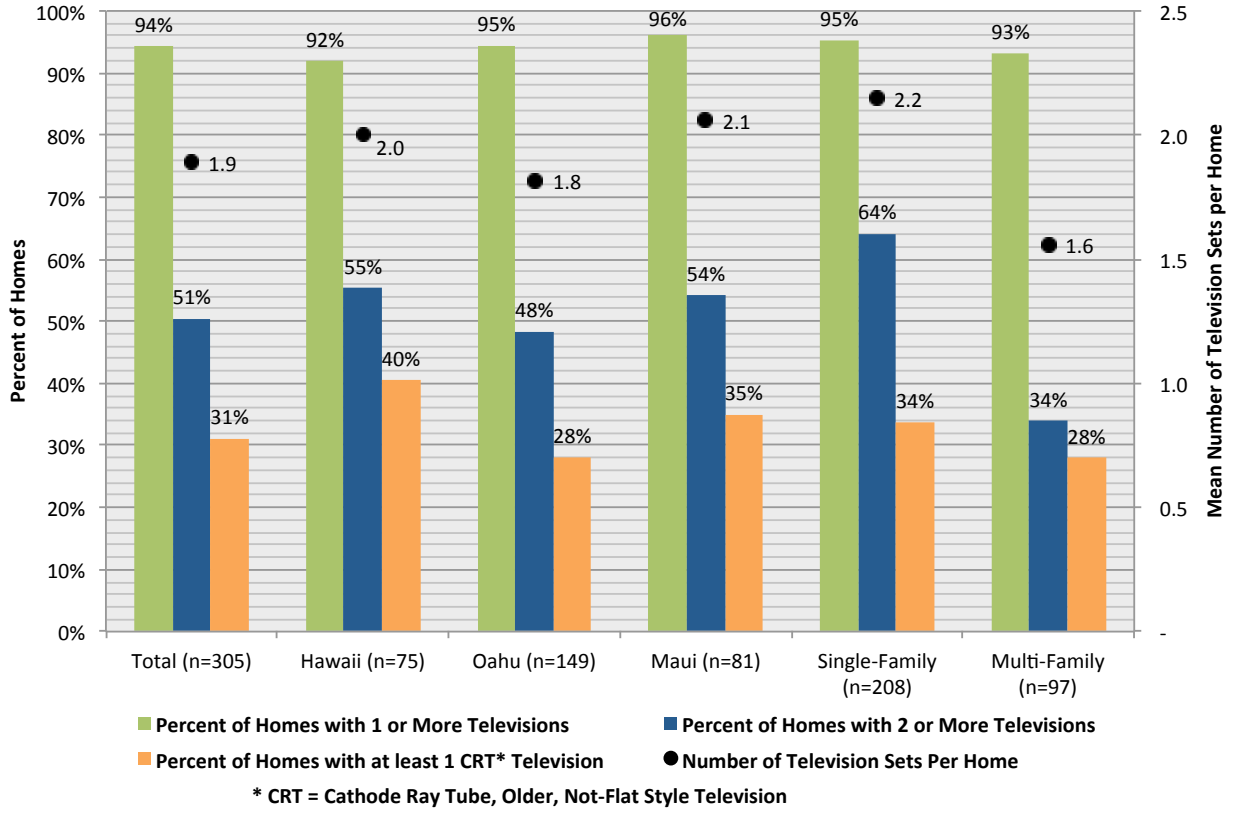
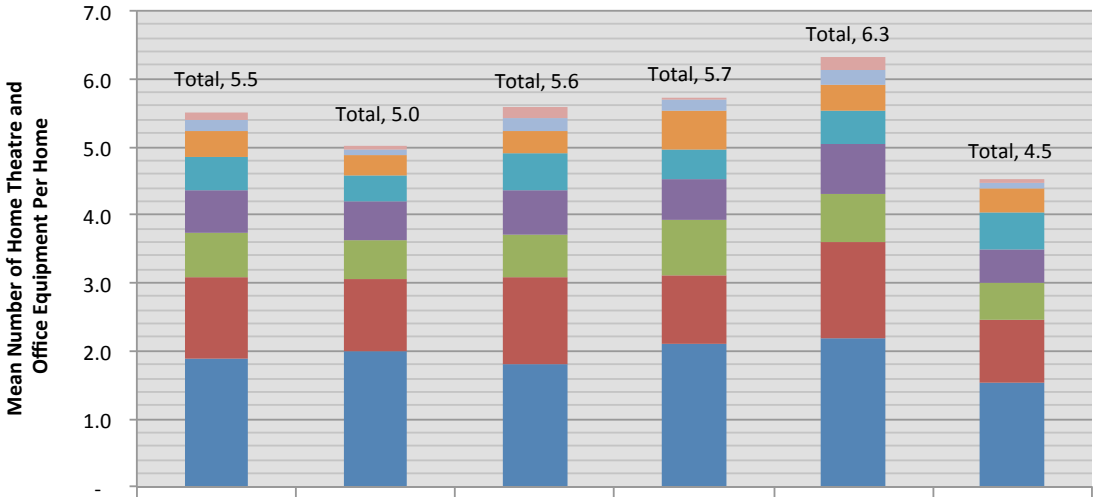


Figure 56 on the next page shows the mean number of home theatre and home office equipment found in use (i.e. plugged in) statewide and for county and home type segments. Equipment types logged in these data include televisions, satellite boxes, audio/visual receivers, DVD/CD and Blu-Ray players, game consoles, printers, scanners, fax machines, computers and monitors. The data indicate there is a mean of 5.5 units of such electronic equipment per home, the most common of which is televisions (1.9), followed by computers (1.2). Single-Family homes have 40 percent more electronic devices than do multi-family homes (6.3 and 4.5, respectively).

Figure 56 – Mean Number and Type of Home Theatre and Office Equipment per Home, by County and Home Type



	Total (n=305)	Hawaii (n=75)	Oahu (n=149)	Maui (n=81)	Single-Family (n=208)	Multi-Family (n=97)
Monitor	0.1	0.1	0.2	0.0	0.2	0.0
Game Console	0.2	0.1	0.2	0.2	0.2	0.1
DVD/CD Player	0.4	0.3	0.3	0.6	0.4	0.3
Other	0.5	0.4	0.6	0.4	0.5	0.5
Printer/Fax/Scanner	0.6	0.6	0.6	0.6	0.7	0.5
Satellite Box/Receiver	0.6	0.6	0.6	0.8	0.7	0.6
Computer	1.2	1.1	1.3	1.0	1.4	0.9
Television	1.9	2.0	1.8	2.1	2.2	1.5

4.10 Military Housing

This section presents the Baseline Study findings for the military housing sector. This section summarizes data collected describing structural characteristics and equipment holdings of homes occupied by military personnel and their families in Oahu County. As discussed previously, we surveyed 100 military homes in support of the findings presented here. There are smaller installations of military housing on other islands, but the vast majority of military housing is located on Oahu.

There are two housing development companies that contract with the military to build, manage and maintain the military housing on Oahu: Forest City and Lend Lease.[26] We contacted both of these companies to assist us with developing our Baseline Study sample

[26] The military branches used to own and operate the housing properties, but over the last decade, they transferred ownership and management via 50-year agreements.

and to coordinate recruitment of customers for site visits. Military personnel lease their homes from Forest City and Lend Lease.[27]

There are approximately 16,500 military homes on Oahu, with each company managing about half. All homes are owned by the military establishment and rented to personnel and their families. Most homes are duplex, triplex or other single-family attached, (i.e. multi-family) structures. Our sample of military homes is 76 percent multi-family and 24 percent single-family detached homes. We did not stratify by home type, so we expect that this distribution is close to the actual distribution in military housing.

Until recently, the military branches (e.g., Navy) paid for occupants' electricity bills. Both housing developers have recently instituted a type of sub-metering, where occupants receive an electricity bill that is compared to usage of other homes in their neighborhood. If their bill exceeds their neighbors' by more than 10 percent, they pay for the additional usage above the 10 percent threshold. Conversely, if their bill is less than their neighbors' by 10 percent or more, they receive a credit for the amount of their usage below the 10 percent threshold.[28]

The military branches determine the extent to which housing is built with energy efficient standards and appliances through its agreements with the housing developers. As explained in more detail in Section 6, the military has begun to respond to the Energy Independence and Security Act (EISA),[29] which contains provisions for the Department of Defense to reduce its electricity consumption by 30 percent by 2025 over 2005 levels and 25 percent of the energy consumed shall be from renewable energy sources.

The military housing stock consists of newer construction compared to the civilian housing stock, though the housing developments were initially constructed in the 1940s through 1960s to coincide with the state's military base installations. Forest City shared information with us about the vintage of the housing stock it manages.

- 250 homes are "historic" – original homes dating from the 1940s and 50s.
- 400 homes are from the 1960s and 1970s.
- The remainder was built since 1980, including around 3,000 homes that were built between 2004 and the present, which replaced older homes that were demolished.

During tenant turnover, the housing developers will also make basic energy efficiency upgrades, including installing CFLs and energy efficient appliances.

Military homes are built to relatively consistent specifications; home characteristics do not vary as much as they typically do among civilian housing. While the details are more

[27] Technically, military housing may be leased by civilians, but this happens very rarely.

[28] The top and bottom 5 percent of homes and homes that are not occupied are omitted from the neighborhood comparison.

[29] Public Law 110-140 110th Congress.

complex and are described carefully throughout this section, the following is a high level description of a "typical" military home that is based on baseline survey results.

- A military home is equipped with central air conditioning, energy efficient appliances and compact fluorescent lighting.
- A military home includes a single refrigerator, a clothes washer and dryer, two televisions, a stove and microwave oven.
- A military home does not include a dishwasher, a second refrigerator or a stand-alone freezer.
- Appliances and air conditioning equipment are mostly energy efficient.
- More than half the homes have solar PV systems. Very few have natural gas or propane.
- Almost half have solar thermal water heating; the remainder have electric tank-style water heat.
- Envelope characteristics are similar to civilian homes, with about one in five homes including any tinted or double pane windows, and less than 5 percent have insulated doors.
- Roofing is typically flat finish and medium to dark in color and in good condition. Little to no reflective or white roofing is present. Wall and roof insulation are relatively uncommon (similar to civilian homes).

Military homes are distinct from civilian in terms of their demographics, household characteristics and attitudes toward energy conservation. In general, the following characteristics distinguish military households from civilian in demographic and attitudinal characteristics.

- Military homes have more occupants on average (approximately four versus three in civilian homes), and substantially more children than in civilian homes (almost two per home versus only one child for every two homes in the civilian sector).
- Military homes have almost no seniors per home (occupants over the age of 65) while almost half of civilian homes do.
- Income is less varied than the civilian sector – i.e. there are smaller portions in the upper and lower income ranges, and more in the middle. Military households have a somewhat lower mean annual income versus civilian (20% lower).
- Military householders are more concerned with energy efficiency than their civilian counterparts. Nearly three out of four respondents rated energy bill reduction as "extremely important" versus about one in two civilian respondents; they also express higher levels of concern for the environment than civilian respondents, with almost one in two rating the issue "extremely important", a rate exceeding that found in the civilian sector (36%).

Forest City shared the results of recent studies (in which it participated) that were conducted in Hawaii to understand residential energy consumption and efficiency measure

performance in military housing. One of these studies, the "UH Watt Watcher: Energy Consumption Data Analysis[30]" is a multi-phase project. The Phase I Final Report (February 2012) offers the following key finding:

> *"The single most compelling observation resulting from this data is the dominance of the air conditioning load in the overall energy consumption. On average, air conditioning accounts for 44% of the energy consumption in the monitored homes and can reach 69% of the monthly consumption."*

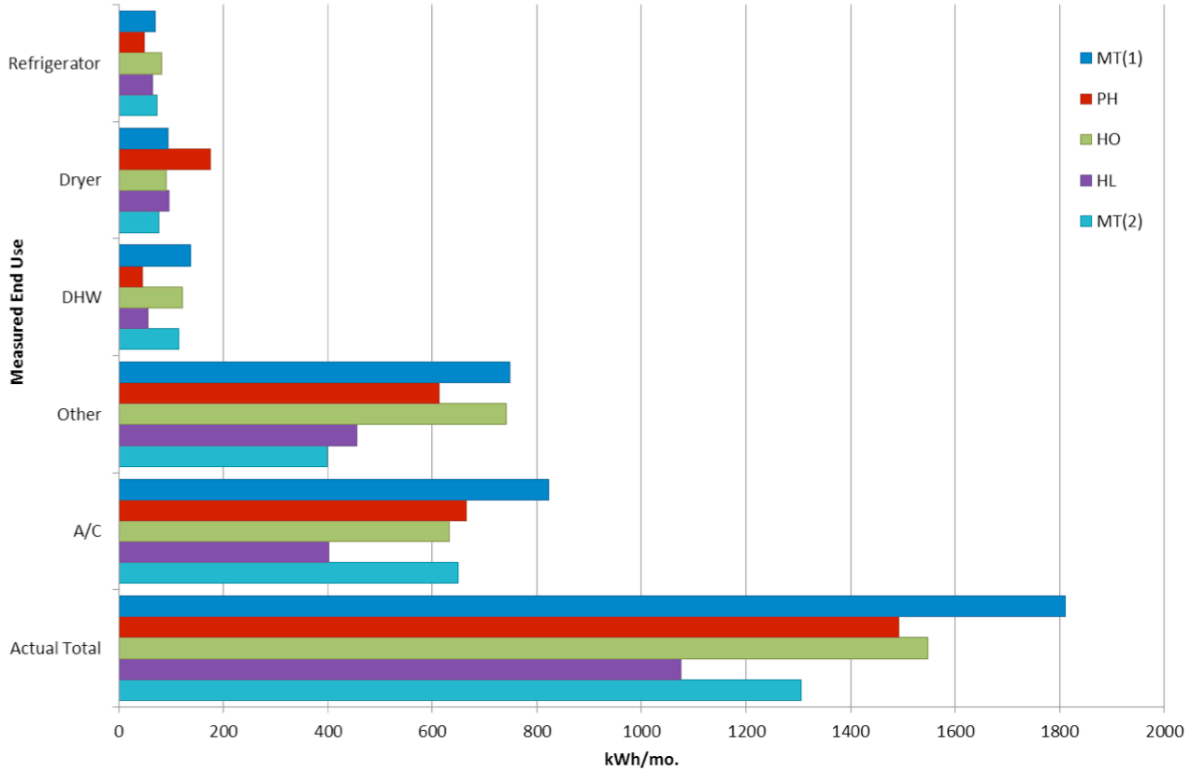
The Phase II Report showed that by replacing the air conditioning equipment, sealing the ducts, and making other slight adjustments to the building envelope, the cooling load could be reduced by almost one-third.[31]

The Energy Consumption Study involved metering appliance energy consumption for a sample of 28 homes. The metering was in place for varying time-periods that lasted typically about one month. The timing of the metering varied by neighborhood, ranging from an earliest start date of October 2010 to a latest end date of April 2011. Most of the metering – three of the five neighborhoods in the sample – took place in the winter months December through February. The metering results presented in the report are shown in Figure 57 below and illustrate the influence of AC on usage.

[30] "UH Watt Watcher: Energy Consumption Data Analysis Phase I Final Report", February 10, 2011, (page 2) Prepared for Forest City Military Communities Hawaii. Prepared By UH Watt Watcher Team, A Multi-Departmental Collaboration between Hawaii Natural Energy Institute, University of Hawaii: School of Architecture Sea Grant Program And Department of Information and Computer Sciences Department of Economics, Botany Department, College of Engineering.

[31] UH Watt Watcher Energy Consumption Data Analysis Phase II Final Report: Air Conditioning Retrofit Study, June 20, 2012, Prepared for Forest City Military Communities Hawaii. Prepared By UH Watt Watcher Team Hawaii Natural Energy Institute School of Architecture, Sea Grant Program.

Figure 57 – Comparison of Measured End Uses by Neighborhood

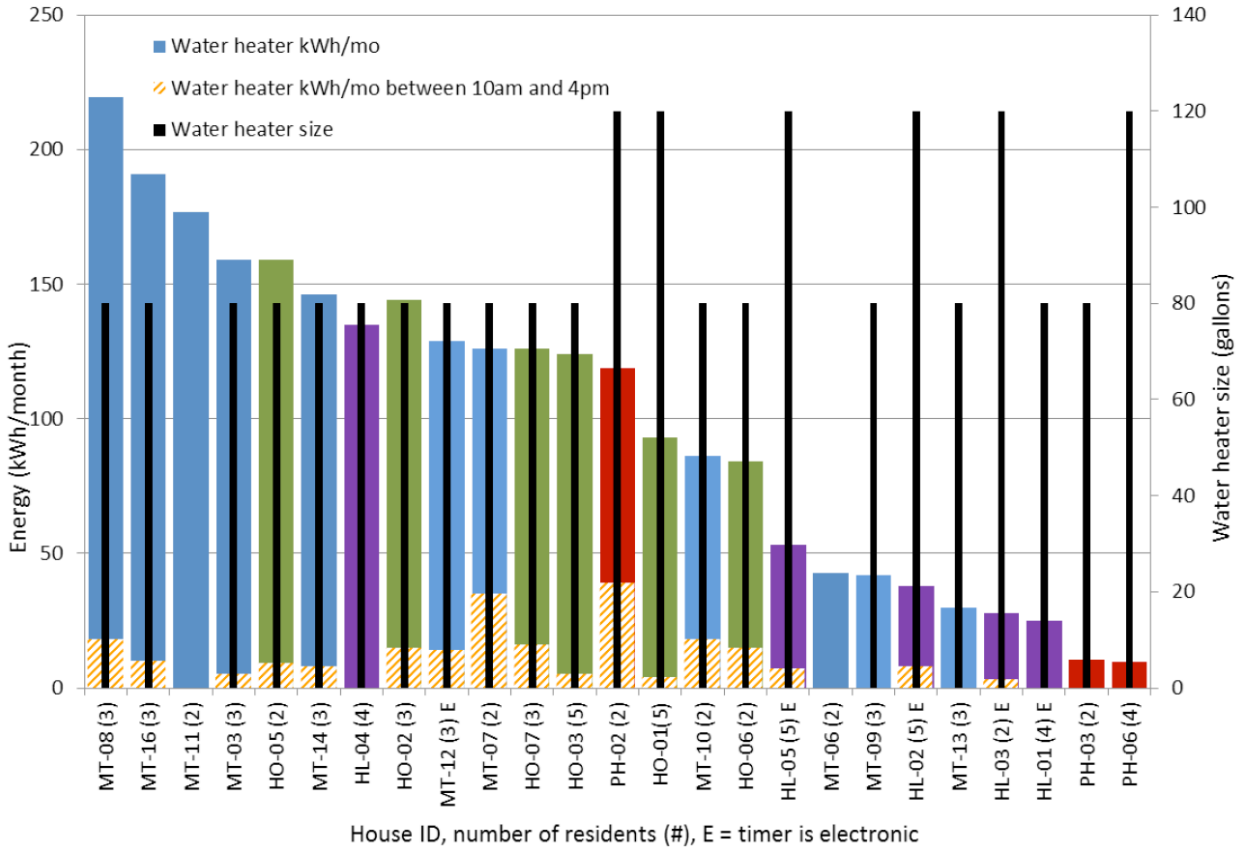


Source: UH Watt Watcher: Energy Consumption Data Analysis Phase I Final Report, Page 4

Another interesting finding from the Phase II Report worth repeating here relates to the performance of water heaters. All 28 homes in the sample were equipped with direct solar water heaters and an electric backup heater. The systems were designed such that the electric system would function after 4pm and before 10am, while the solar water heater would run during the day, from 10am to 4pm. However, the study found the majority of systems were not functioning to specifications. The timer was not functioning on some, the solar system was not functioning on others, and there were problems with the solar pumps as well; one-third of the monitored systems showed no activity from the solar pump whatsoever during the monitored period.

Figure 58 below is an excerpt from the report that shows the measured energy consumption for water heating per house (house ID). The figure indicates a shared neighborhood (color coded bar), energy consumed between 10am and 4pm when the solar system is designed to be operational (orange striped portion of bar), number of residents in home (# after ID), if the timer is electronic (E after the ID), and the size of the water heater (black bar). The consumption varies from 10 to 219 kWh/month.

Figure 58 – Energy for Water Heating, Water Heater Size Number of Residents in Home



Source: UH Watt Watchers: Energy Consumption Data Analysis, Phase I Final Report, Page 20

The two military builders supported our effort by providing data on the housing stock as well as assisting in recruiting participants for the survey. Forest City provided a detailed database on the nearly 7,000 military homes it built and manages, representing nearly half of the military housing stock in Oahu County. The data included size, home type, year of construction, the number of bedrooms and more. Figure 59 below summarizes the data provided on these military homes. The data show a mean home size of 1,478 square feet, a mean age of 13.1 years, and that over half the homes (56%) are duplexes (i.e., two homes per building).

Figure 59 – Forest City Housing Data: Home Size, Home Type

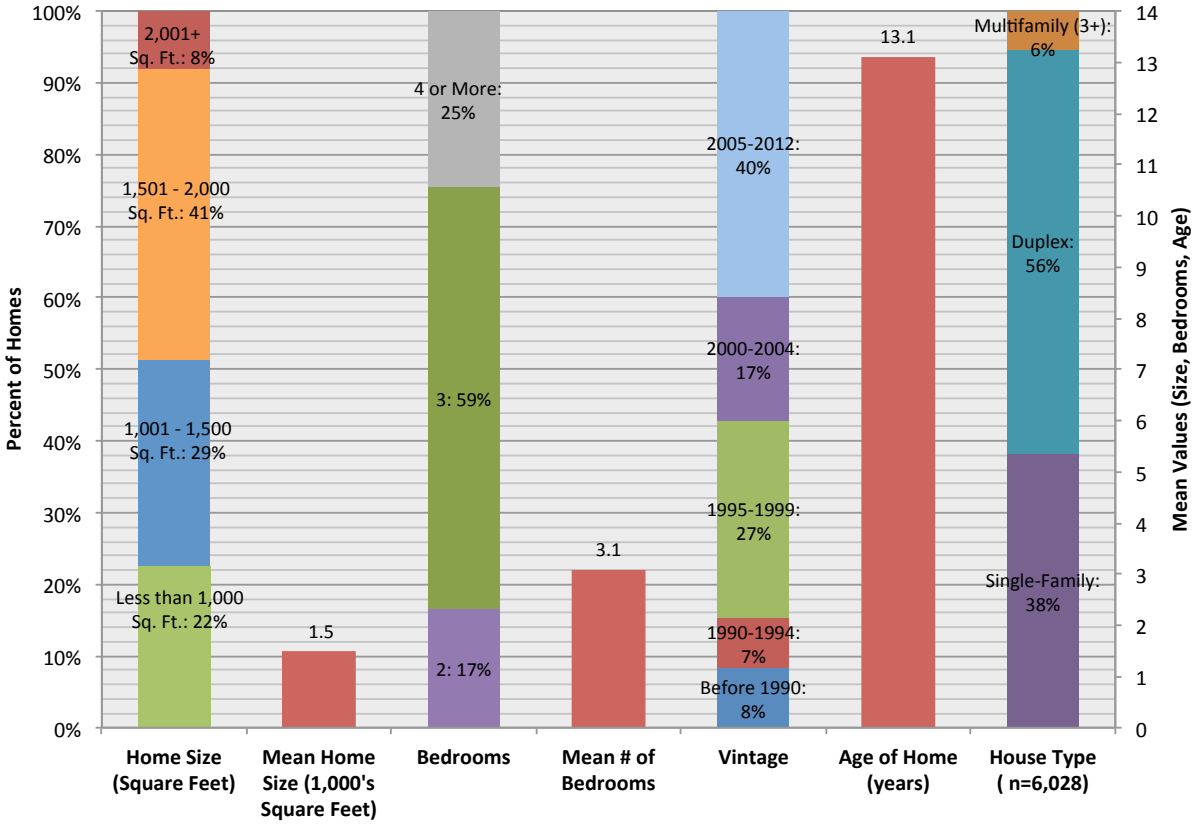


Figure 60 below is also based on the database provided by Forest City. The figure shows the mean home size by vintage. The data indicate a recent upward trend in home size for this builder. Mean size is stable at approximately 1,000 square feet per home through 2004; there is a jump to 1,800 feet for homes built more recently. These data reflect only Forest City and may not be reflective of Lend Lease homes. We offer the information anyway because the Baseline Survey was unable to gather vintage information for more than a small number of cases, as occupants were often unaware of the year their home was built.

Figure 60 – Forest City Housing Data: Mean Home Size by Vintage Category

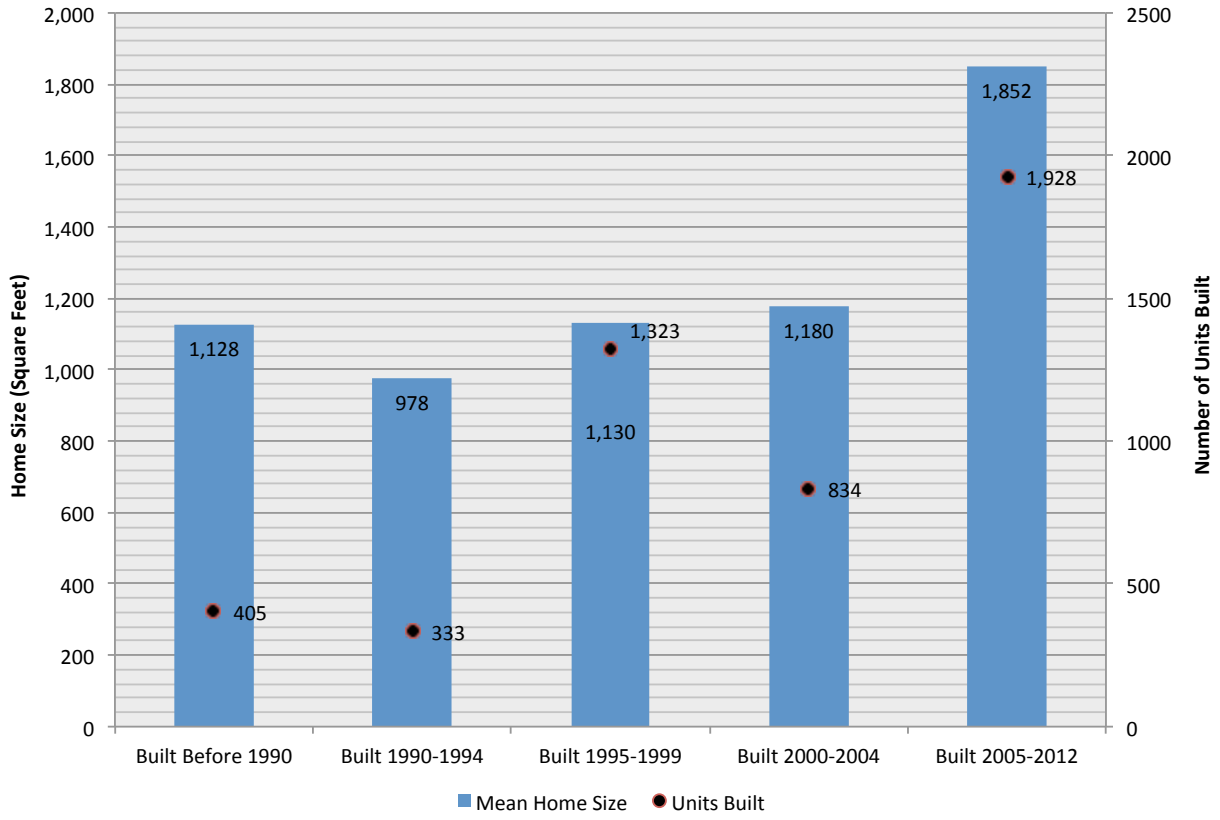


Figure 61 below summarizes Baseline Survey results showing military and civilian home type and home vintage distribution. Both RASS and our Baseline Survey data indicate that the military housing stock is substantially newer than the civilian stock. While the sample size of the Baseline Survey is small for this metric (32 points), the mean age of military homes is consistent with the Forest City data presented previously, at 13 years. In contrast, Baseline Survey results indicate civilian homes have a mean age of 36 years and RASS reports a mean age of 49 years. Within the civilian sector, baseline data show the mean age of multi-family homes comparable to single-family (three year difference). In the military Baseline sample, multi-family homes are newer as reflected in a mean age of eight years versus 20 years for military single-family homes. It is important to note the number of data points collected for the age of homes within the military sector is small, due to a large portion of occupants being unaware of the year their home was built.

Figure 61 – Home Vintage: Military Versus Civilian by Home Type

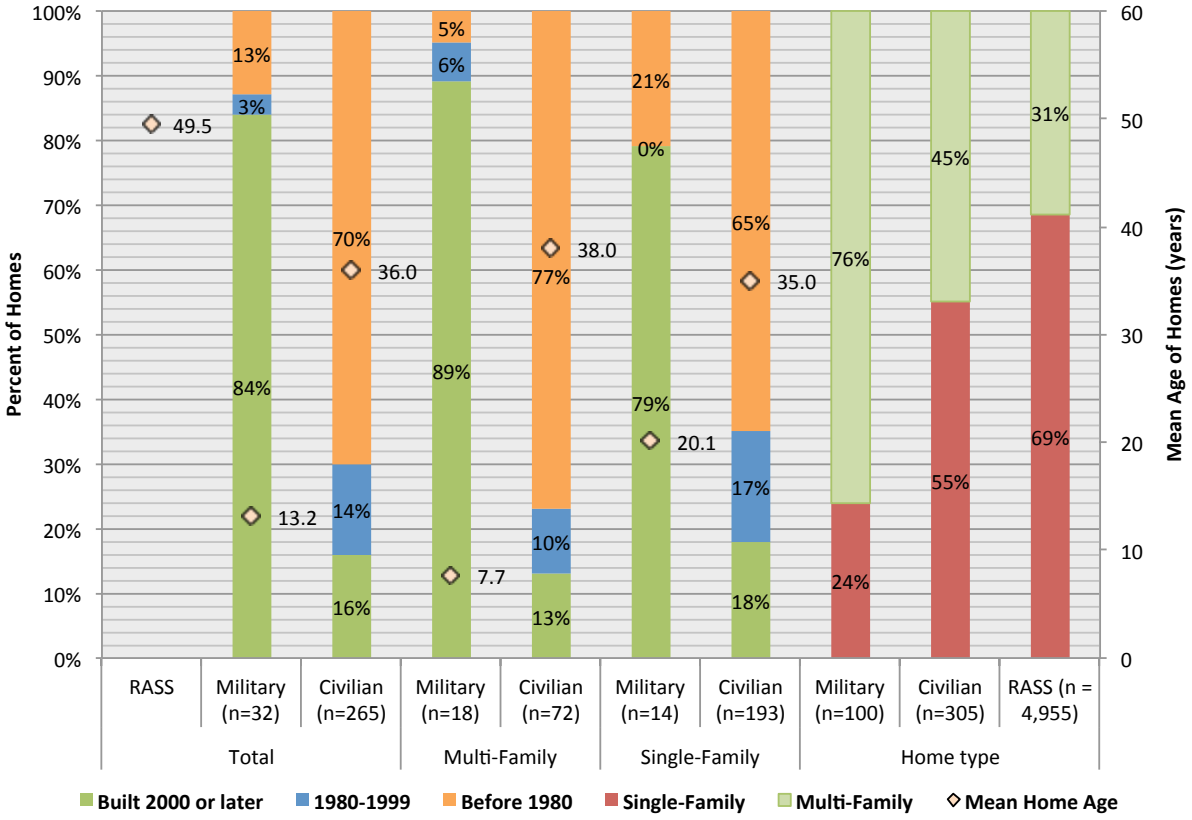


Figure 62 below summarizes home square footage data for the military and civilian sectors by home type, as well as the RASS results. The figure shows that the mean military home is notably smaller than the mean civilian home (1,260 square feet versus 1,560,[32] respectively). However, the population of military homes appears more uniform in size, with just over 80 percent of homes registering in the mid-range, between 1,000 and 2,500 square feet, versus just over half of civilian homes. RASS findings show just over 1,500 square feet on average, a small increase relative to the Baseline Survey results. These findings are fairly consistent with the Forest City data that showed a mean size of just less than 1,500 square feet and indicate 70 percent of military homes it built are between 1,000 and 2,000 square feet.

[32] Baseline results presented here reflect sites where both home age and home size information were valid. The mean size over all civilian homes surveyed with valid size information is 1,419 (n=305), 12 percent smaller than the mean military home.

Figure 62 – Home Size Distribution: Military versus Civilian

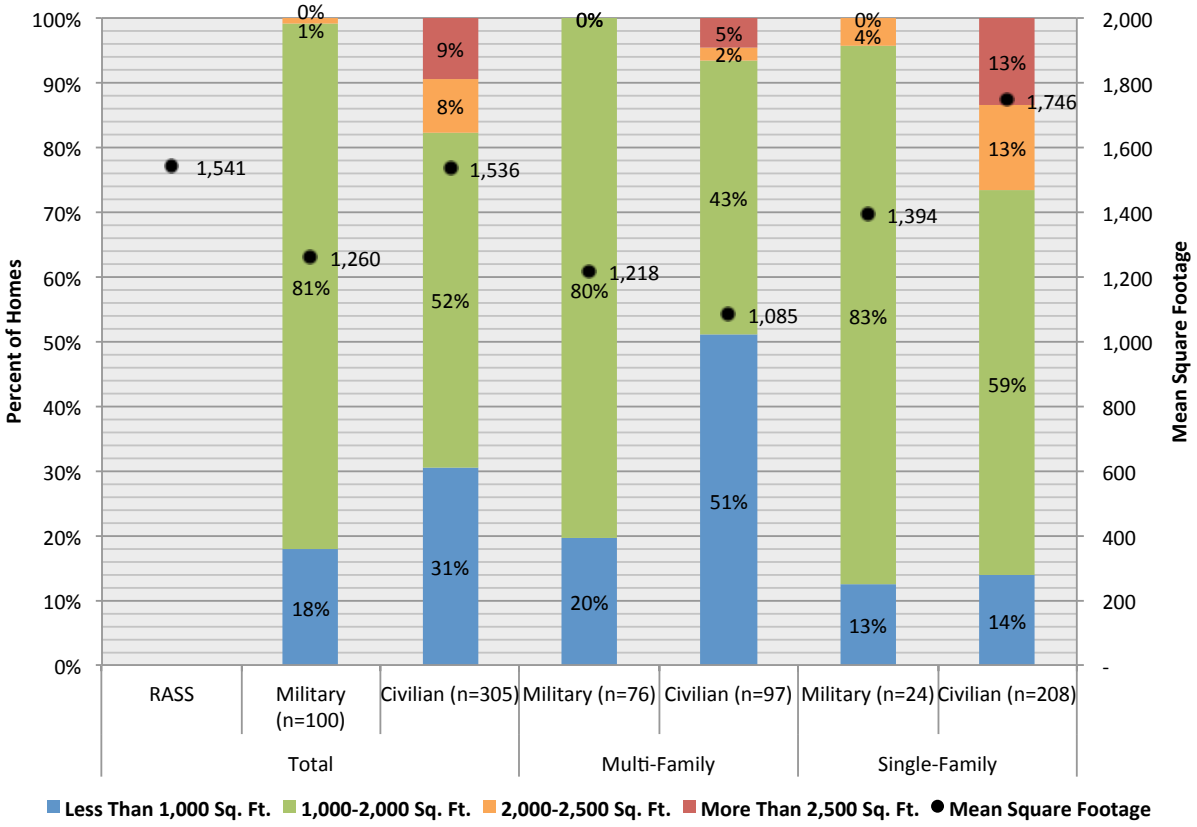


Figure 63 below reflects greater use of secondary fuel sources within the military sector versus civilian; in particular the use of solar PV is notably higher in the military sector. Just over half (53%) of military homes have solar PV systems versus just 18 percent of civilian homes. While the use of secondary fuels is higher in the military sector, this is limited to solar PV. The use of natural gas or propane is scarce among military homes (at 5%), and lower than civilian rates; almost one in five civilian homes use a gas fuel source. Secondary fuels are more common among single-family than multi-family homes in both military and civilian sectors. However, this difference is less pronounced in the military sector (52% versus 62%, respectively) than in the civilian (17% versus 47%), though this result is not statistically significant within the military sector.

Figure 63 – Secondary Fuel Sources, Military Compared to Civilian

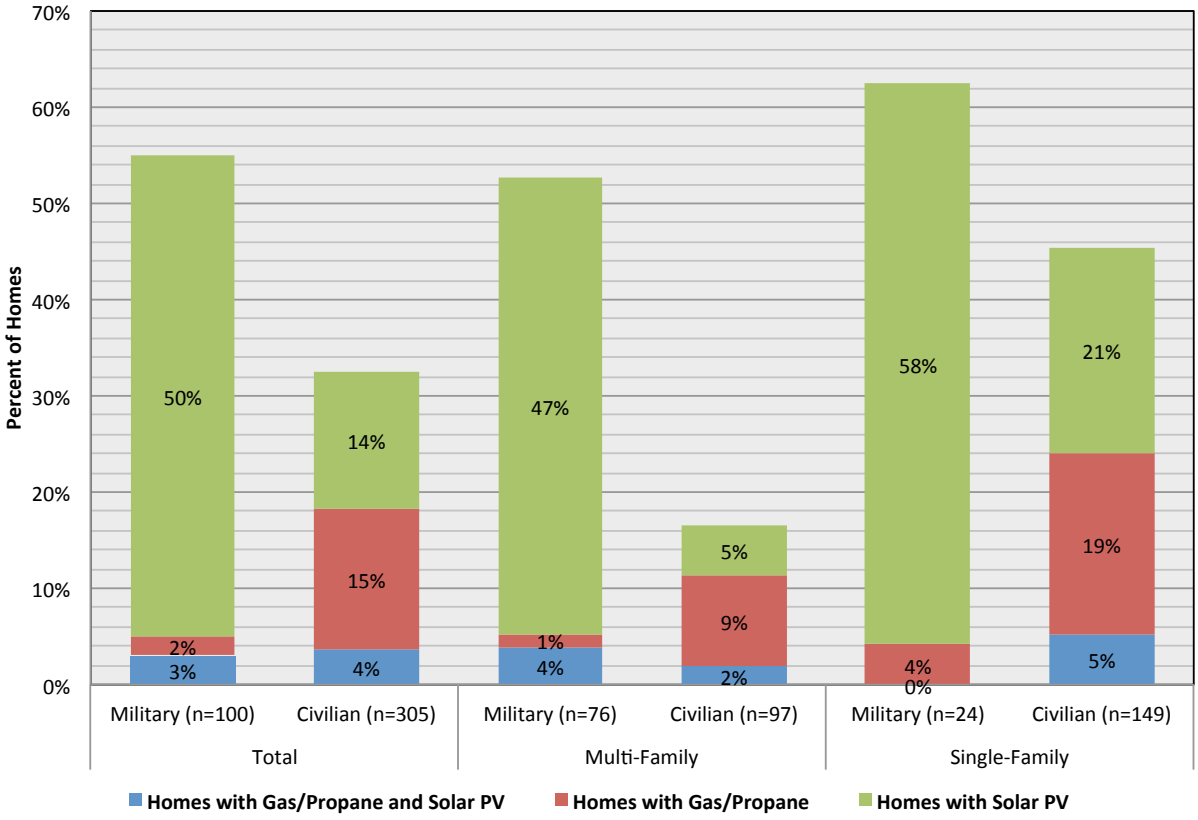
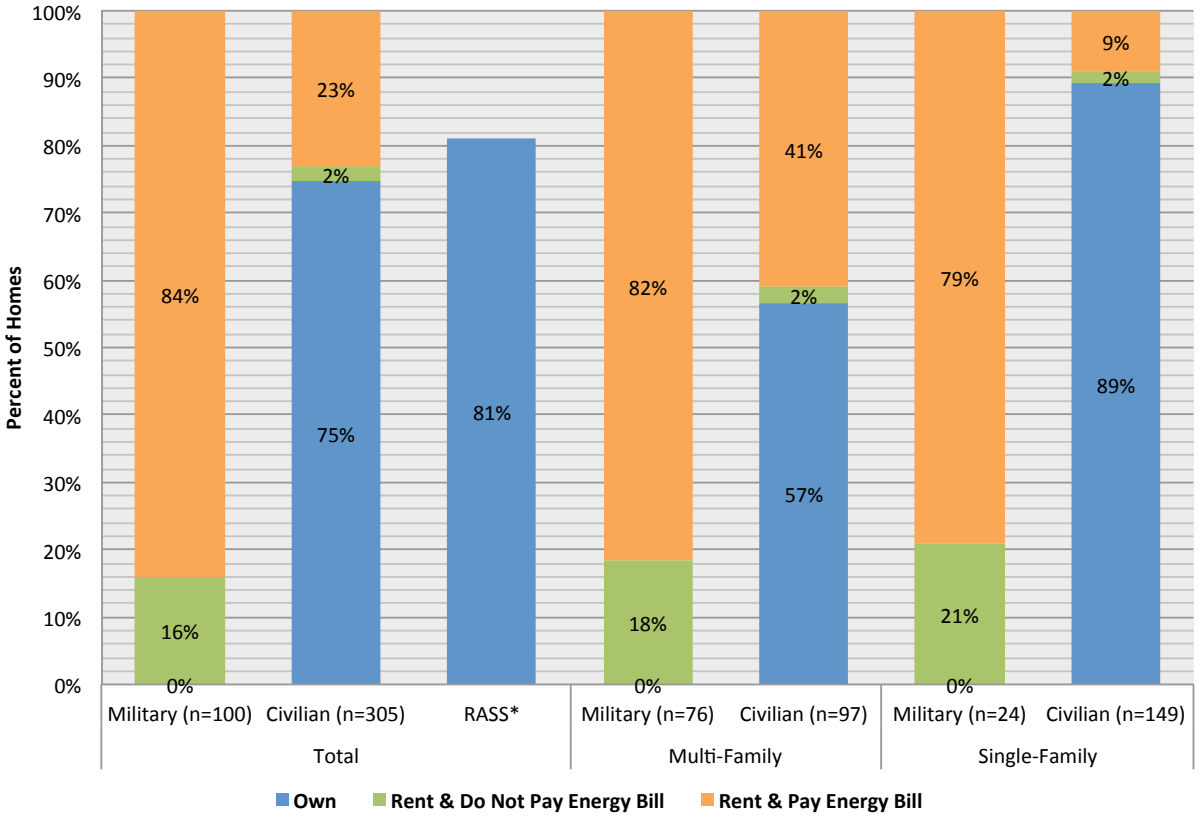


Figure 64 below presents the rate of military homes ownership and utility bill payment by home type and shows civilian rates for comparison. As shown in the figure, military homes are not owner occupied (per military policy). More occupants are relieved of utility bill payment in the military sector versus civilian (16% versus 2%, respectively); most say that they do pay their own utility bill (84%). As explained previously, all military housing occupants receive a bill, but only a small fraction actually pay anything unless their usage exceeds their neighbors' by more than 10 percent.[33]

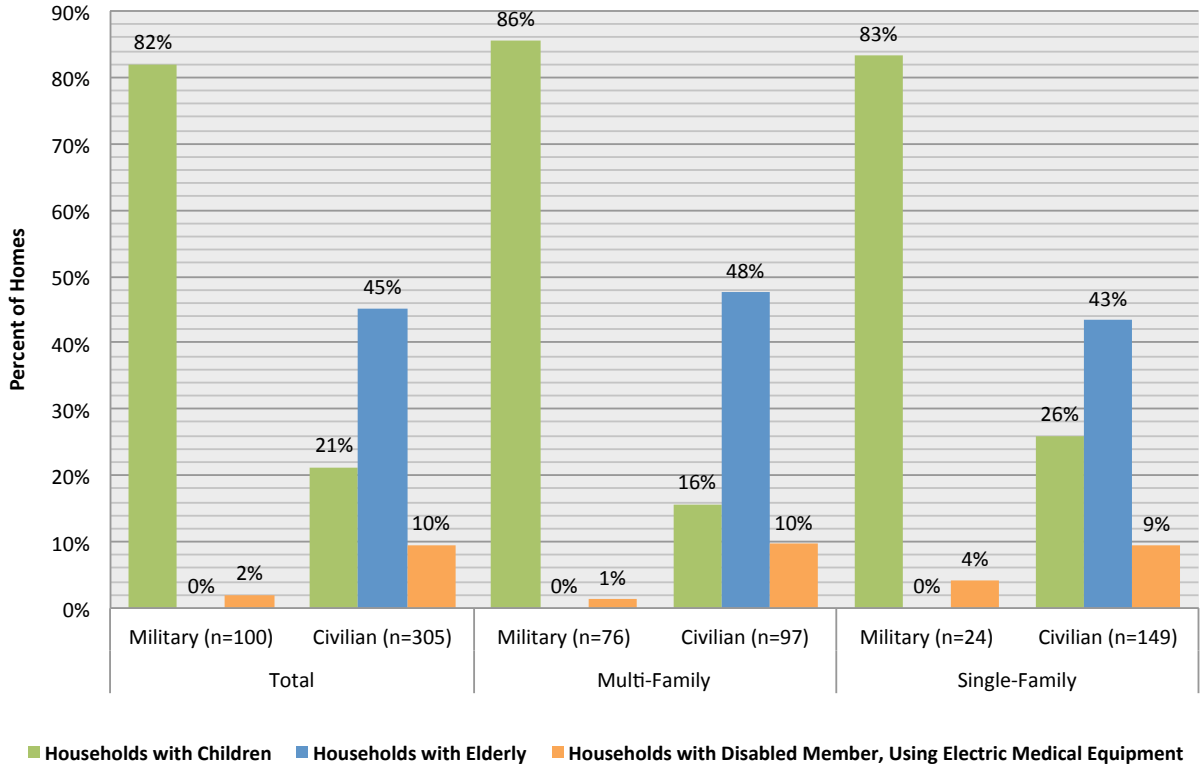
[33] There was probably some confusion about the question, since all military housing occupants should receive a bill, but only a small fraction are required to pay it. There could be a timing issue, where we conducted surveys with occupants that had not yet participated in the sub-metering program.

Figure 64 – Home Ownership and Utility Bill Payment: Military versus Civilian by Home Type



As shown in Figure 65 below, there is a clear demographic distinction between the military and civilian sectors. Military homes are four times more likely to include at least one child (82% versus 21%, respectively). Survey results also show they include very few elderly household members (at an estimated 0%). In contrast, nearly one in two civilian homes (45%) include an occupant over the age of 65. Household members with a disability are more common among civilian homes than in military homes (at 10% versus 2%, respectively), though fairly uncommon in both sectors.

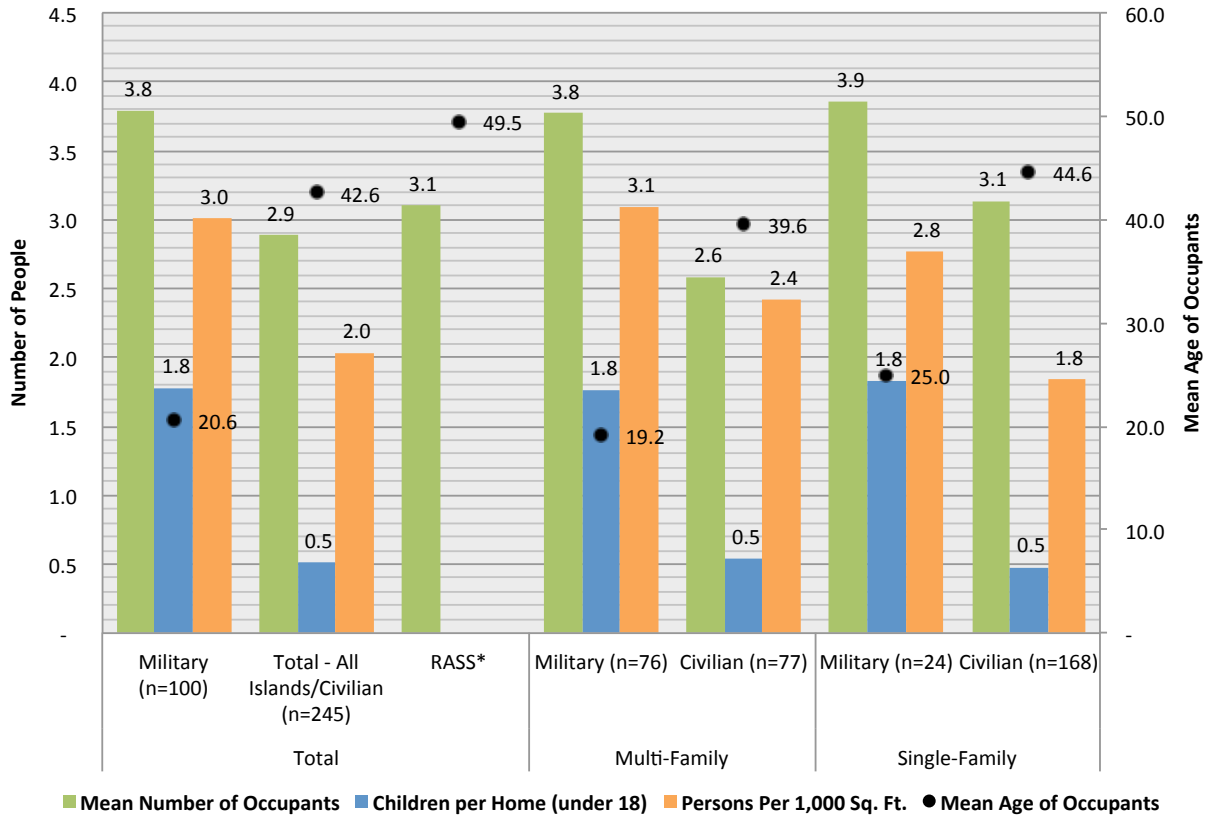
Figure 65 – Household Membership: Military versus Civilian by Home Type*



*The 0% figures to the right of the green bars representing military households with children reflect that elderly persons were recorded as members of military households.

Figure 66 below further illustrates the demographic distinctions between the military and civilian housing sectors. Military homes generally have a larger number of occupants (3.8 versus 2.9), despite being of similar size relative to civilian. This is underscored by the difference in the mean number of occupants per 1,000 square feet of living space, a figure that is 3.0 for military homes and 2.0 for civilian homes. Despite having a higher mean occupancy, military homes typically have fewer adults per home than civilian homes (with a mean of 2.0 versus 2.4 occupants over age 18). Greater mean occupancy in the military sector is driven by the number of children in military homes (mean of 1.8 for military versus 0.5 for civilian). The lower numbers of elderly (as shown above in Figure 65) and the greater numbers of children are reflected in a stark difference in the mean age of occupants, at just 21 for military versus 43 for our baseline survey and an even higher result from RASS, nearly 50.

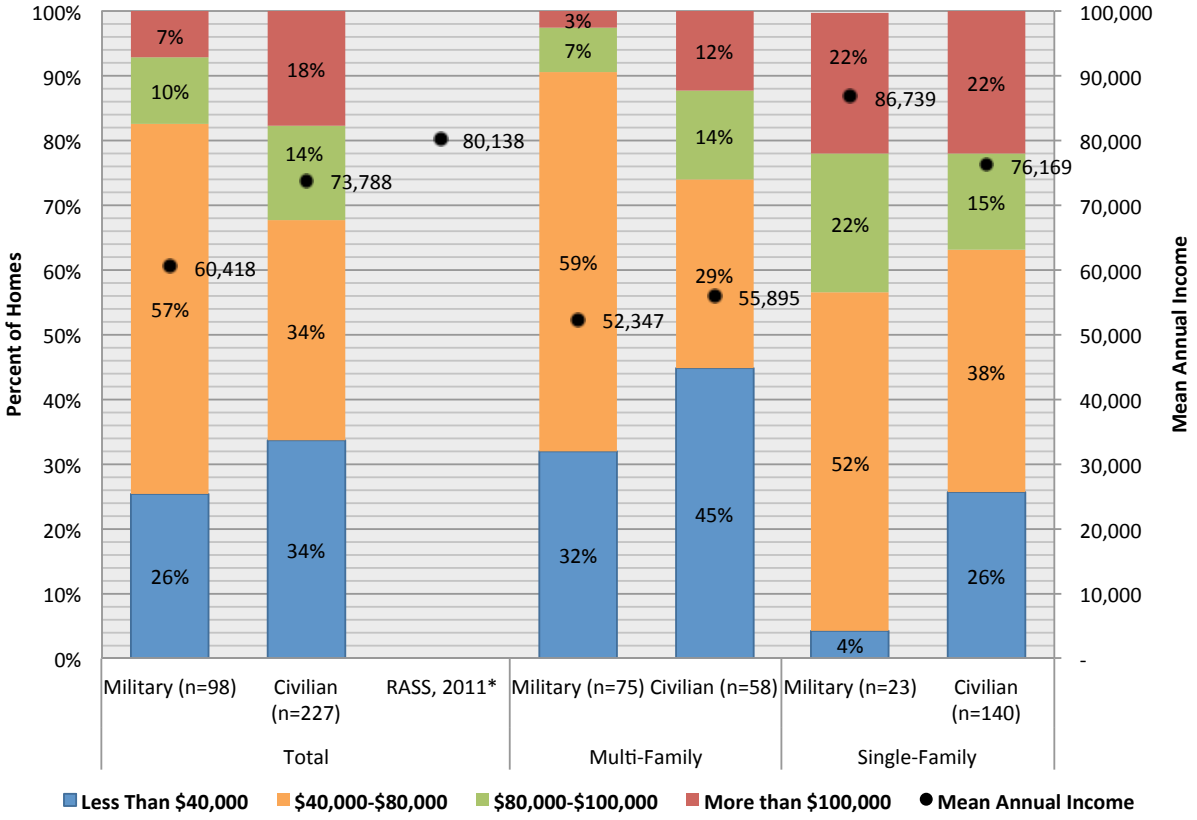
Figure 66 – Household Occupancy Characteristics: Military versus Civilian and RASS by House Type



*The RASS did not have aligned information available for all characteristics

Figure 67 below shows the portion of households within each annual income category, as well as the mean annual income, for the military and civilian sectors by home type. Mean income is more than 20 percent lower among military households, at about $60,400 per year versus $73,800 among civilian households. Income is more uniform within the military sector, where just 33 percent of households earn less than $40,000 or more than $100,000. Among civilian households, just over half fall within these upper and lower ranges. Baseline survey data show that this relative uniformity of income levels does not hold true for the single-family sector. Despite having a more uniform distribution overall, the difference between the multi-family and single-family sector is more pronounced (though not statistically significant) among military households, with the mean income of a multi-family homes registering at 60 percent of the mean single-family household income, while in the civilian sector it registers at 74 percent. Again, bear in mind that our military sector sample of single-family homes is relatively small, at 24 points.

Figure 67 – Household Income: Military versus Civilian and RASS by House Type



*The RASS did not have aligned information available for these categories

As described in the previous section detailing results for the civilian sector, the householder self-administered survey posed questions related to the perceived importance of preserving the environment and the importance of saving money on energy bills. For convenience, the text of these two questions is restated below:

- *"How important is it for your household to use less energy in order to help preserve the environment?"*
- *"How important is it for your household to use less energy in order to reduce your energy bills?"*

Respondents were asked to select from importance ratings ranging from "Extremely Important" to "Not at all important". Figure 68 below reveals a marked contrast between the military and civilian responses. Military respondents express greater concern for energy issues related to both the environment and to costs, with a particular emphasis on concern for costs. Several differences between the military and civilian sectors particularly stand out. Nearly half (48%) of military respondents indicate that preserving the environment is extremely important and nearly three out of four (73%) indicate that reducing energy costs is an extremely important issue. These figures are notably higher

than those of the civilian sector (though the difference is not statistically significant for preserving the environment), where 36 percent and 48 percent indicate similar energy concerns for the environment and for costs, respectively. Another notable difference between military and civilian response patterns is the *relatively* greater concern expressed in the military sector for the cost of energy as compared with preservation of the environment. Among military respondents, 48 percent indicate the former and 73 percent the latter, a difference of 25 percentage points. Among civilian respondents, these figures are 36 and 48 percent, a difference of just 12 percentage points. Finally, notice that there is a marked (yet not statistically significant) difference within the civilian sector in concern for the environment by home type with more single-family respondents indicating concern (28% for multi-family versus 42% for single-family). Military response patterns with regard to the environment are stable across home-type (47% versus 50%, respectively).

Figure 68 – Attitudes Toward Energy and the Environment

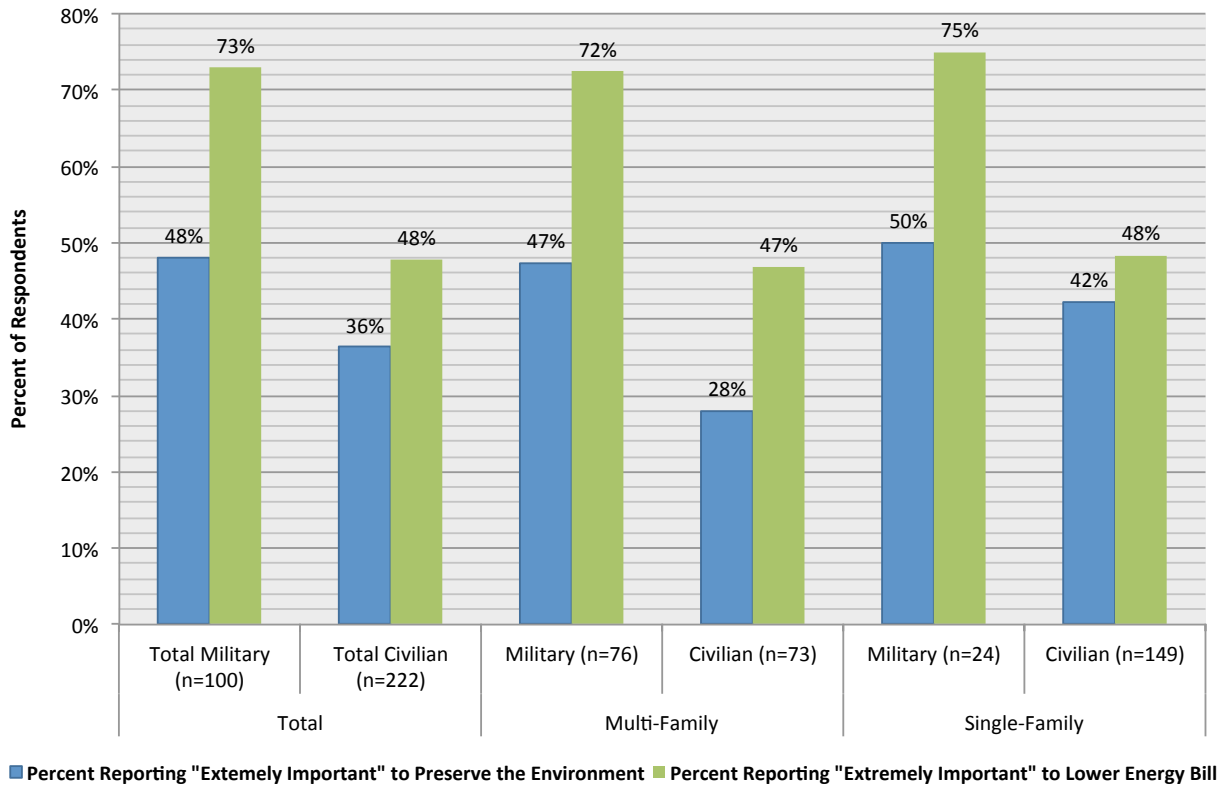
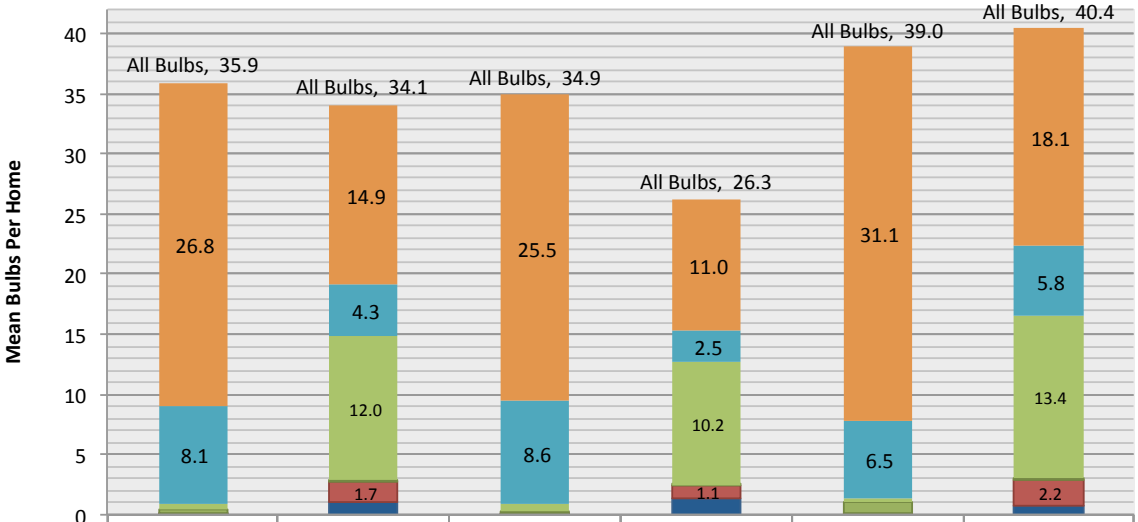


Figure 69 depicts the distribution of installed bulbs by type and the total number of installed bulbs per home for the military and civilian sectors by home type. Overall, the mean number of installed bulbs per home is on par with the civilian sector at 36 versus 34 bulbs per home. However, unlike civilian homes that continue to hold a measurable

number of incandescents (a mean of 12 per home or 35% of total mean bulbs), military homes have very nearly no incandescents at all, at a measured percent of less than 0.5%.

Figure 69 – Lighting: Military versus Civilian by Home Type



	Total		Multi-Family		Single-Family	
	Military	Civilian	Military	Civilian	Military	Civilian
CFL	26.8	14.9	25.5	11.0	31.1	18.1
Fluorescent	8.1	4.3	8.6	2.5	6.5	5.8
Incandescent	0.5	12.0	0.6	10.2	0.3	13.4
Mean Other	0.4	0.1	0.2	0.0	0.9	0.2
Halogen	0.1	1.7	0.1	1.1	0.1	2.2
LED	0.0	1.0	0.0	1.4	-	0.8
All Bulbs	35.9	34.1	34.9	26.3	39.0	40.4

As shown in Figure 70 below, baseline survey results show that solar systems account for over half of military homes' water heating equipment. Comparisons across home type show solar systems are fairly equivalently prevalent across home type within the military sector. A comparison of military to civilian sector results reveals marked differences. Within the civilian sector, the rate of solar water heating systems is less than half that of military (18% versus 52% respectively). This result reflects the fact that there is a larger fraction of newer homes in the military sector, which typically have solar water heaters, per the law that was introduced in 2010 that requires all new single-family homes built in the state to have solar water heating.

Electric tank-style water heaters make up over half (54%) of all homes' water heating appliances. The share of these more traditional style water heaters is higher, but the difference is not statistically significant, for multi-family homes than single-family (67% versus 46%, respectively). While in civilian homes tankless and tank-style gas water heaters make up about 10 percent of systems, military homes have only solar and electric tank-style systems.

Figure 70 – Water Heating Equipment: Military versus Civilian by House Type

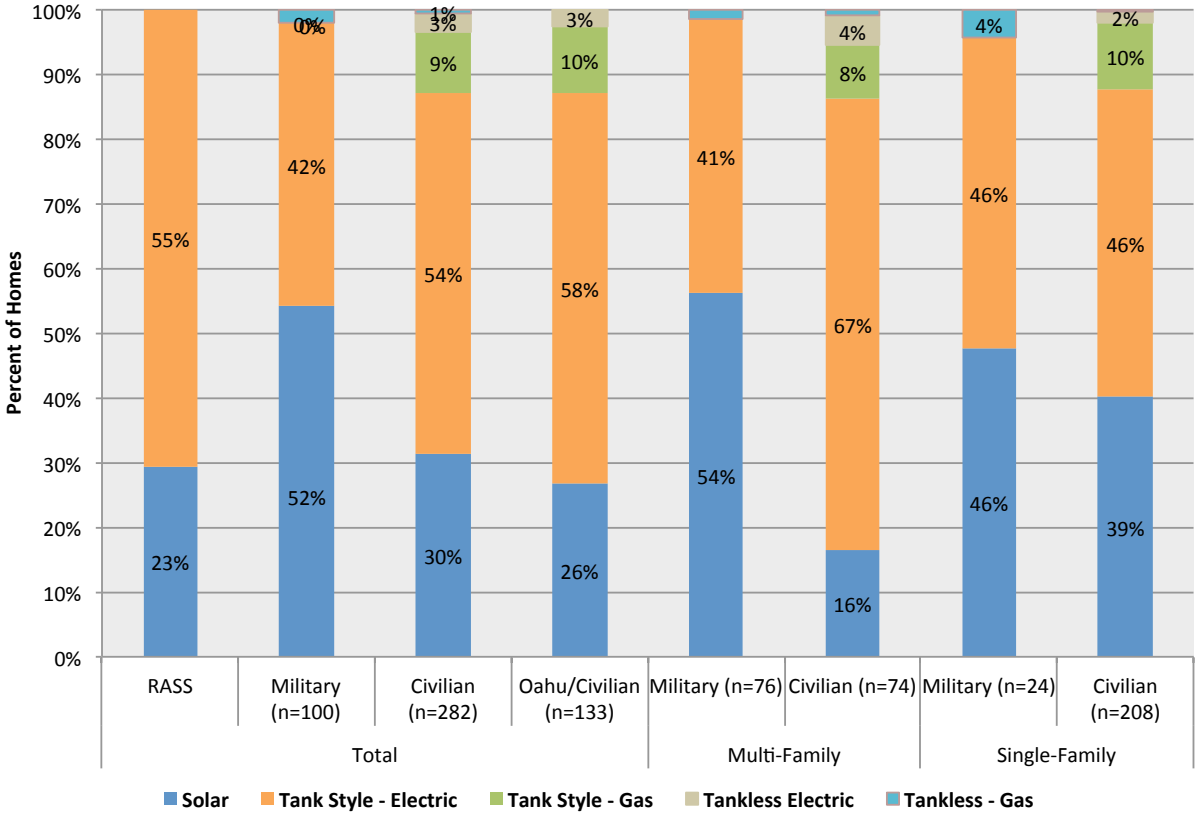
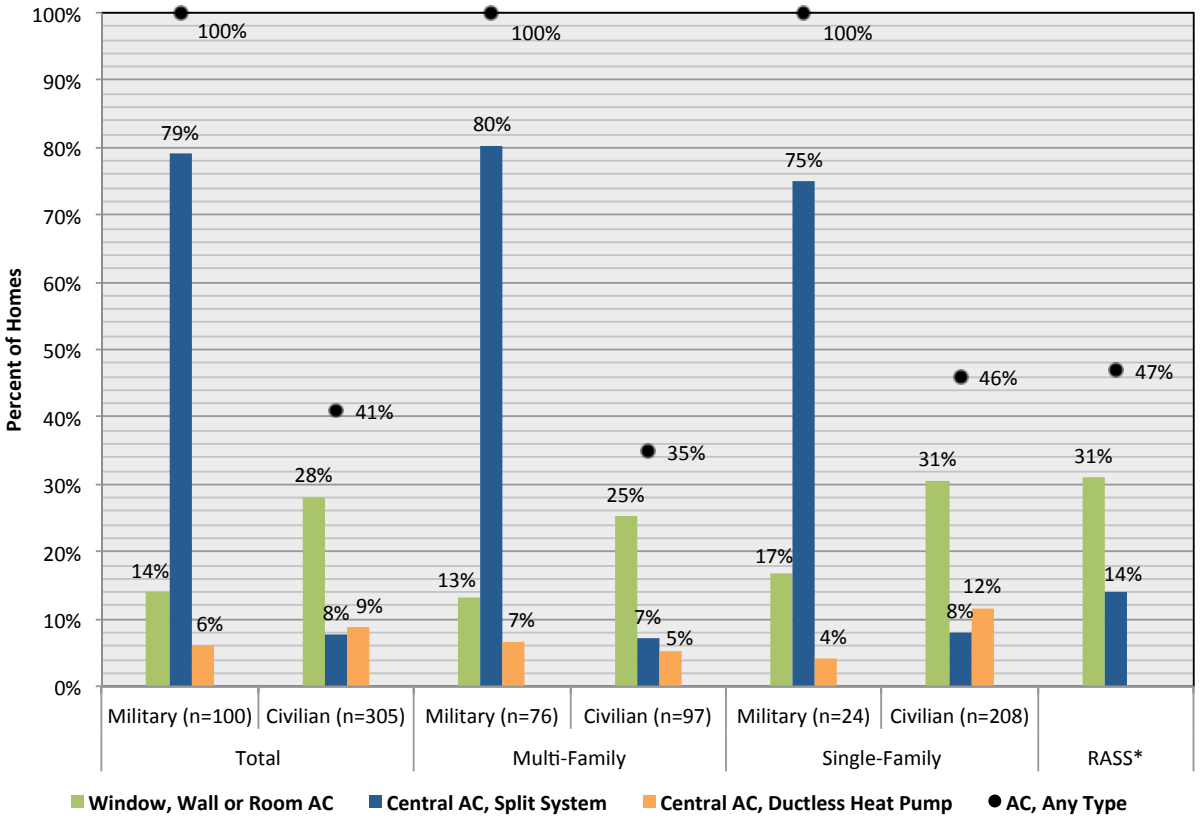


Figure 71 shows the percent of homes with space cooling appliances for military and civilian sectors by home type. The military sector is quite a bit different from the civilian sector in the propensity and types of air conditioning equipment. In the civilian sector, well over half of all homes (59%) have no air conditioning at all, and among civilian homes that do have air conditioning, more than six out of 10 (62%) have unitary systems (i.e. window, wall or room air conditioners). In contrast, *all* the military housing units sampled for the baseline survey had air conditioning equipment. Furthermore, the most common type of air conditioning equipment in military homes is central/split system equipment, which is present in about 80 percent of military homes. We are uncertain why all military homes have air conditioning, with most of that being central. Newer civilian homes are more likely to include air conditioning, typically central, due to trends in customer demand and builder specifications, and also building code changes that require fewer windows. We have heard anecdotally that the military provides air conditioning for military families since they are typically used to having cooling in their mainland homes, to keep the families comfortable and reduce complaints.

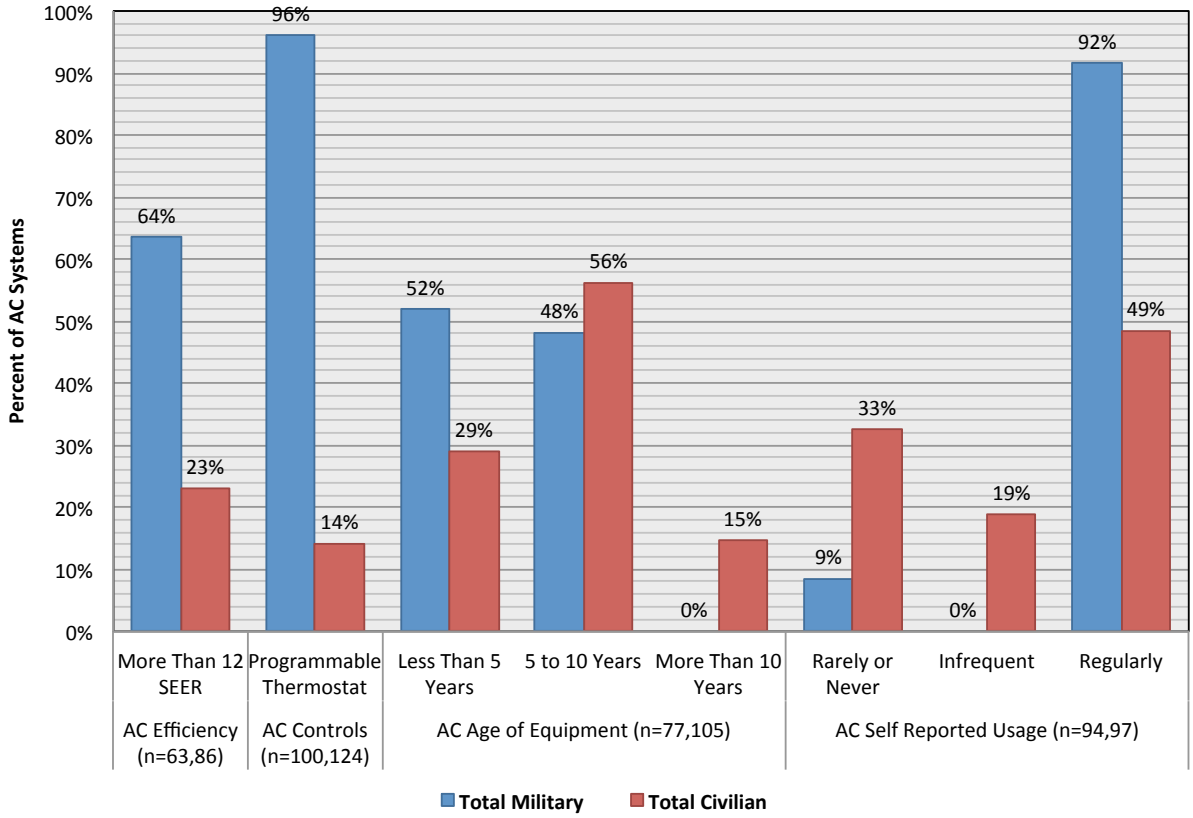
Figure 71 – Homes with Space Cooling Appliances: Military versus Civilian by House Type



*The RASS did not have aligned information available for all categories

Figure 72 below presents efficiency, age and usage pattern details related to the air conditioning equipment present in military homes. The figure also provides similar data for the civilian sector as a comparison. Consistent with the later vintage of military homes, the AC equipment is younger and generally more efficient; it is also used more regularly than the equipment in civilian homes. Nearly all the systems in military homes are equipped with a programmable thermostat and 64 percent had a SEER rating of 12 or higher. In contrast, both programmable thermostats and 12+ SEER ratings are relatively scarce among air conditioned homes in the civilian sector (14% and 23%, respectively). Furthermore, the equipment usage patterns of military and civilian households differ markedly. A very large majority (92%) of military households report using their air conditioning equipment regularly. In the civilian sector, just under half of households with air conditioning report using the equipment regularly and one-third report not using it at all. We speculate that military families may be home more often than civilian home occupants due to the higher rate of young children present in military households, and may be accustomed to using air conditioning in their mainland homes.

Figure 72 – Air Conditioning Equipment Details and Usage



In addition to a greater prevalence of central air conditioning, military homes are also equipped with many more fans than are civilian homes. In particular, as shown in Figure 73, military homes are equipped with substantially more ceiling fans than civilian homes; they register a mean of 4.1 ceiling fans per home, more than double that recorded by the baseline survey in the civilian sector (1.6) as well as self-reported via the RASS survey (2.5). A closer look at the distribution of fans in the military sector indicate that most of the fans are located in bedrooms (61%), living rooms (20%) and dining rooms (11%). In fact, all of the military homes built with ceiling fans include a ceiling fan in the living room.

Figure 73 – Space Cooling Fans in-use by Type and Efficiency

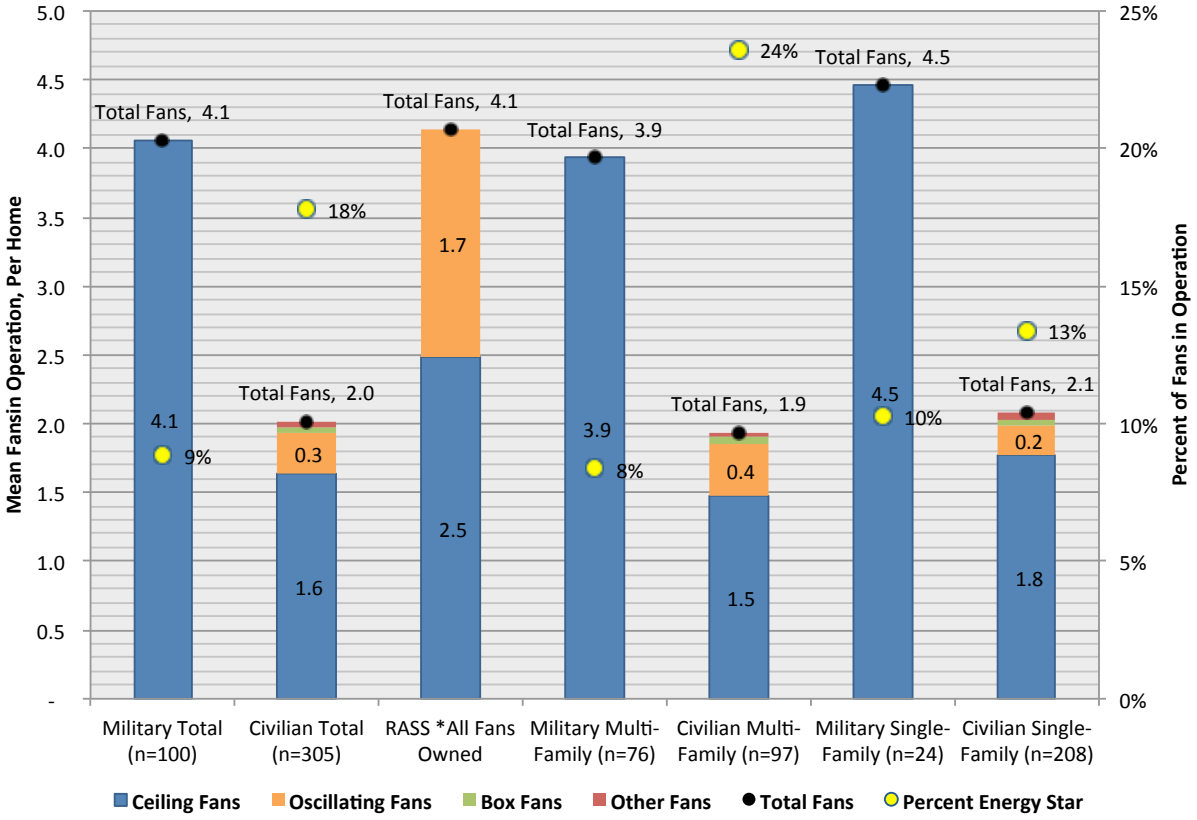
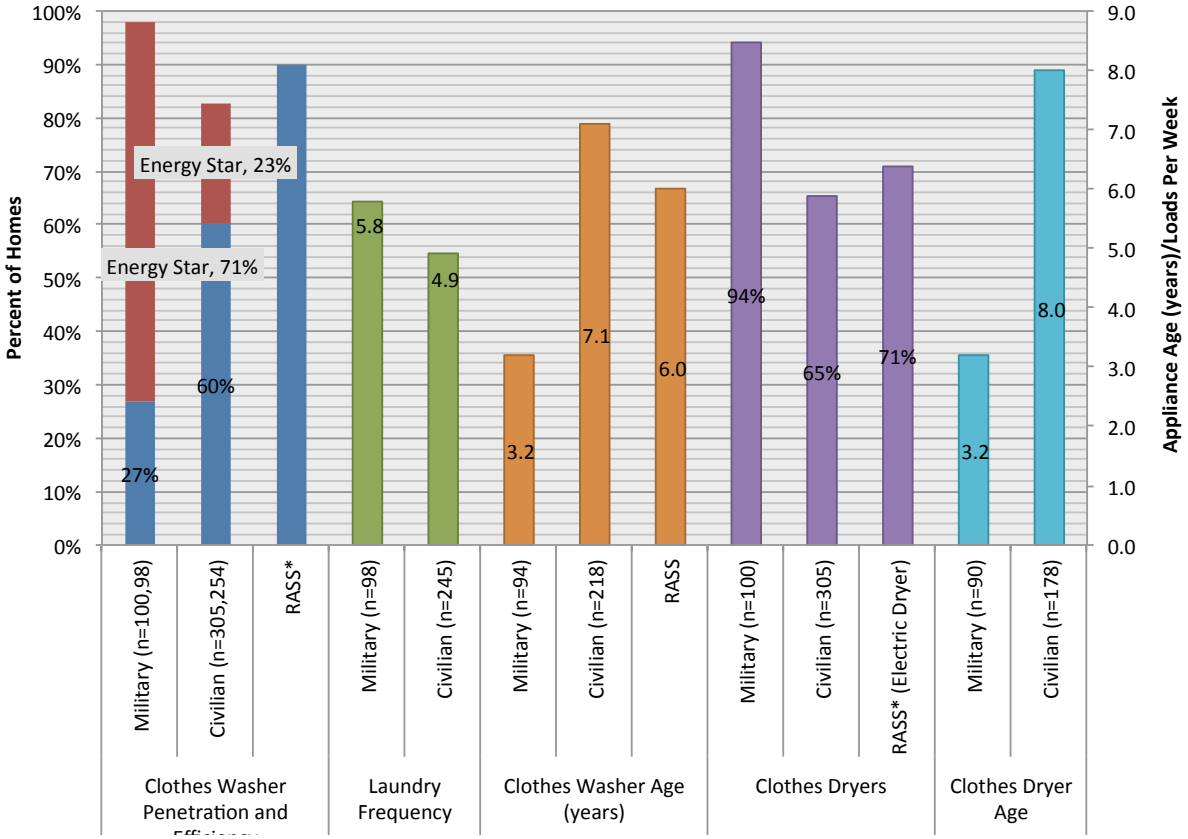


Figure 74 summarizes data collected reflecting laundry equipment and usage patterns for the military sector; the civilian sector is shown for comparison. Similar to the air conditioning findings, the military sector again has more equipment, newer equipment and more efficient equipment than the civilian sector, and again they use their appliances more regularly than do households in the civilian sector, with a mean of nearly one additional load per week (likely attributable to the larger households). Nearly all the military homes surveyed have clothes washers (98%) and dryers (94%), while a good portion of the civilian sector do not have a washer (17%) and more than one-third (35%) do not have a dryer. The laundry equipment in military homes is mostly newer (mean age of 3.2 years) and efficient (almost three out of four washers have an Energy Star rating). Civilian laundry equipment is older (mean age of seven or eight years) and less efficient (28% of washers have an Energy Star rating).

Figure 74 – Laundry Appliance Saturation, Efficiency and Usage



*RASS does not collect Energy Star rating data

Figure 75 below presents key features of the refrigerator and freezer holdings in the military and civilian sectors, for the totals and by home type. The figure shows the percent of homes with multiple refrigerators, stand-alone freezers and the percent of homes with Energy Star rated equipment. Unlike air conditioning and laundry equipment, military homes have somewhat less refrigeration equipment than do civilian homes. Data indicate that secondary refrigerators are relatively scarce (in 6% of homes) and less common than in civilian homes (in 22% of civilian homes). However, military and civilian sectors are nearly on par with respect to their stand-alone freezer holdings, at 12 versus 15 percent, respectively. There are other notable differences between military and civilian sector refrigeration equipment. In the civilian sector, second fridges and stand-alone freezers are much more common in single-family homes than multi-family homes (more than twice the likelihood of each). In contrast, military multi-family homes are more likely than single-family homes to have stand-alone freezers (13% versus 8%, respectively, but this difference is not statistically significant) and nearly as likely to have second refrigerators (5% versus 8%). Consistent with other equipment holdings, data show military sector refrigeration equipment is newer and more efficient than civilian holdings. Mean age of

refrigerators is 2.2 years younger (5.4 versus 7.6 years) and more than three times more likely to have an Energy Star rating.

Figure 75 – Fridge and Freezer Equipment Holding

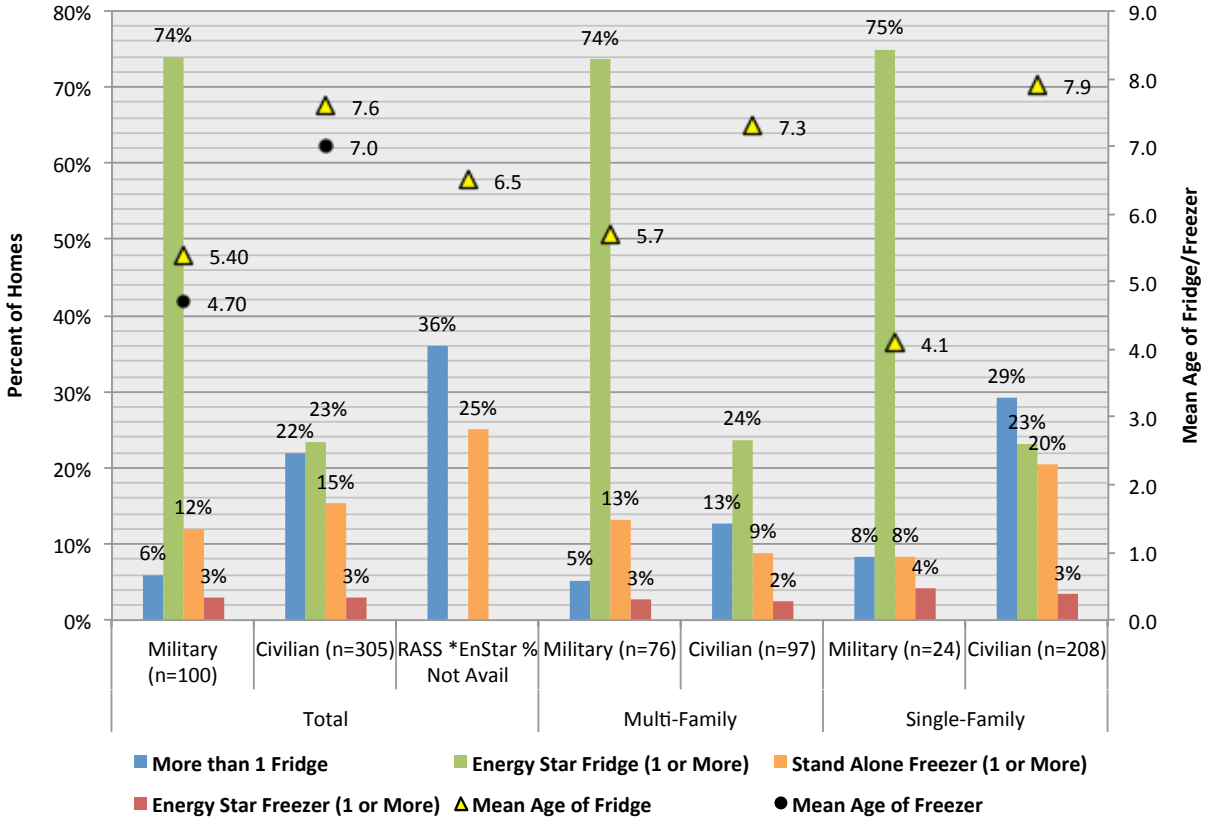
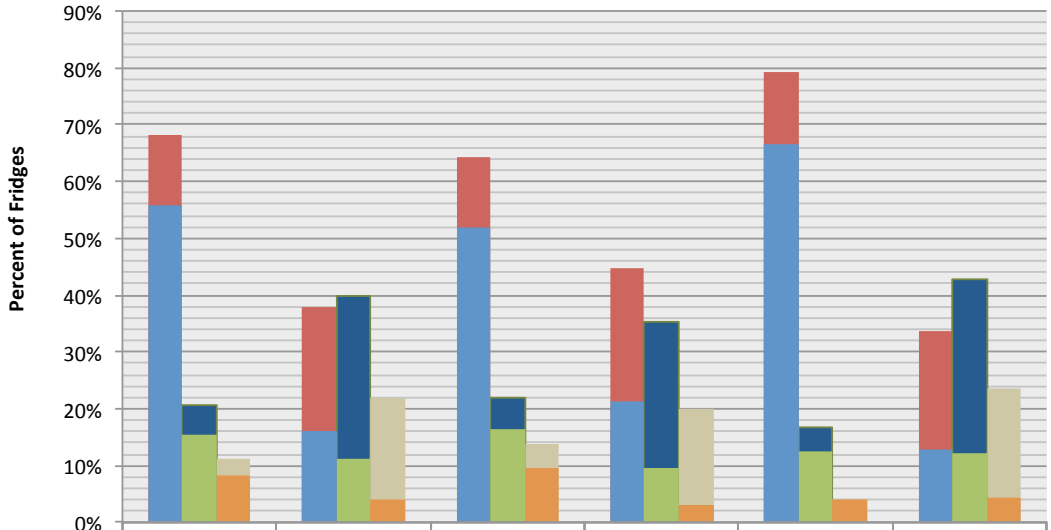


Figure 76 shows the age and Energy Star distribution of refrigerators within the military and civilian sectors and by sector and home type. Almost seven out of 10 refrigerators in the military sector are less than five years old and 82 percent of these are Energy Star rated. The civilian sector has twice the portion of fridges six to 10 years old (40% versus 21%, respectively) and also twice the portion of fridges in the 10+ years old category (22% versus 11%, respectively). The civilian population reflects an increased tendency to purchase efficient refrigerators over time, with Energy Star making up 42 percent of refrigerators less than five years old and 18 percent of refrigerators over 10 years old. In contrast, within the military sector the portion of refrigerators that are Energy Star rated is more stable over time, at 82 percent of refrigerators less then five years old and 73 percent of refrigerators more than 10 years old.

Figure 76 – Fridge Detail: Age and Efficiency Characteristics



	Total		Multi-Family		Single Family	
	Military (n=93)	Civilian (n=223)	Military (n=70)	Civilian (n=63)	Military (n=22)	Single-Family (n=160)
< 5 Yrs Old All Fridges	68%	38%	64%	45%	79%	34%
6 - 10 Yrs Old All Fridges	21%	40%	22%	35%	17%	43%
> 10 Yrs Old All Fridges	11%	22%	14%	20%	4%	23%
< 5 Yrs Old Energy Star	56%	16%	52%	21%	67%	13%
6 - 10 Yrs Old Energy Star	15%	11%	16%	10%	13%	12%
> 10 Yrs Old Energy Star	8%	4%	10%	3%	4%	4%

Figure 77 below presents a summary of age and Energy Star ratings for kitchen appliances in the military and civilian sectors. The data show details for dishwashers and microwaves. The figure shows military homes are unlikely to have dishwashers, and unlike many other household appliance types, military homes are even less likely than civilian homes to have a dishwasher. In fact, military homes are half as likely to own a dishwasher than civilian homes, at 12 percent versus 26 percent, respectively. RASS results show a higher saturation of dishwashers than the baseline survey, at 41 percent.

Among military homes that do own a dishwasher, almost 60 percent are less than five years old and none are more than 10 years old. In contrast, almost 60 percent of dishwashers in the civilian sector are more than five years old. However, due to the small sample size of military homes with dishwashers, this result is not statistically significant.

Data reflecting the presence of microwave ovens shows little difference between military and civilian sectors, at 91 percent versus 87 percent, respectively. RASS data further validate these figures, with 90 percent of homes reporting the presence of a microwave. While the propensities show little difference, microwaves are much newer within the military sector, with a mean age of 3.8 years versus 7.3 in the civilian sector, likely reflecting the newer housing stock.

Figure 77 – Kitchen Appliance Holdings: Military versus Civilian and RASS

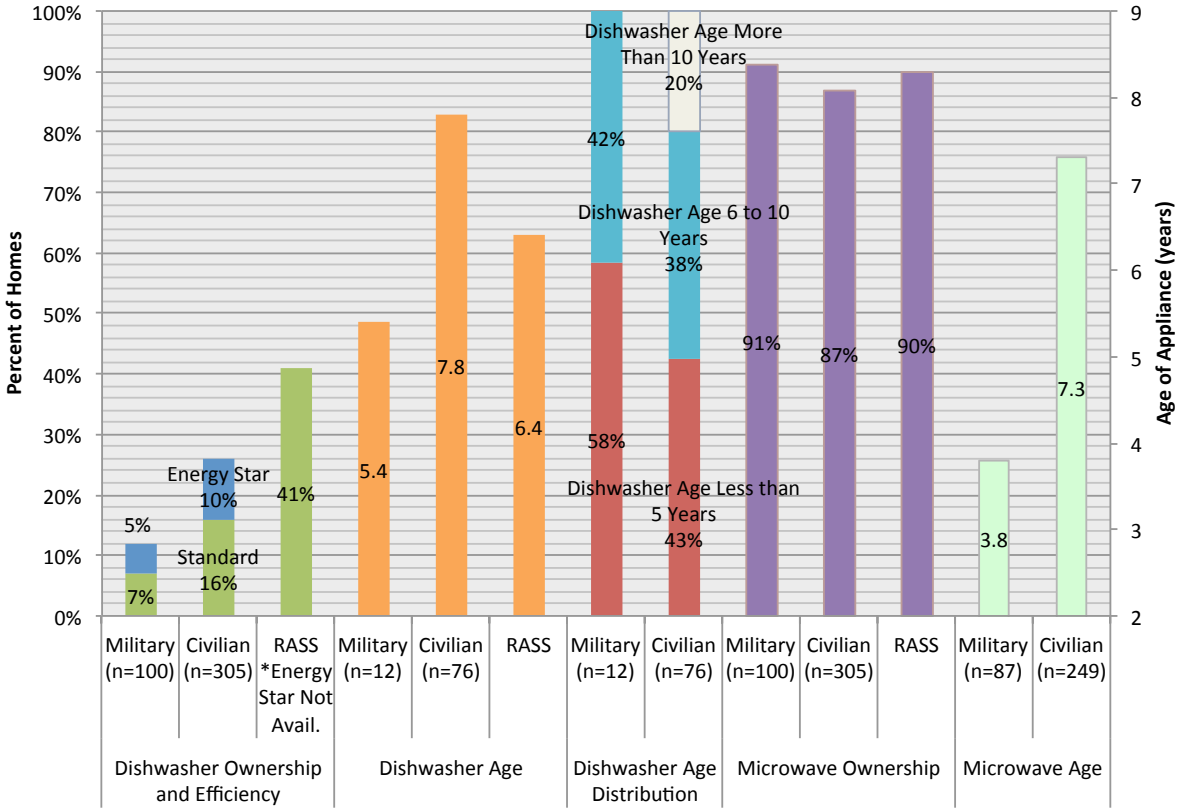
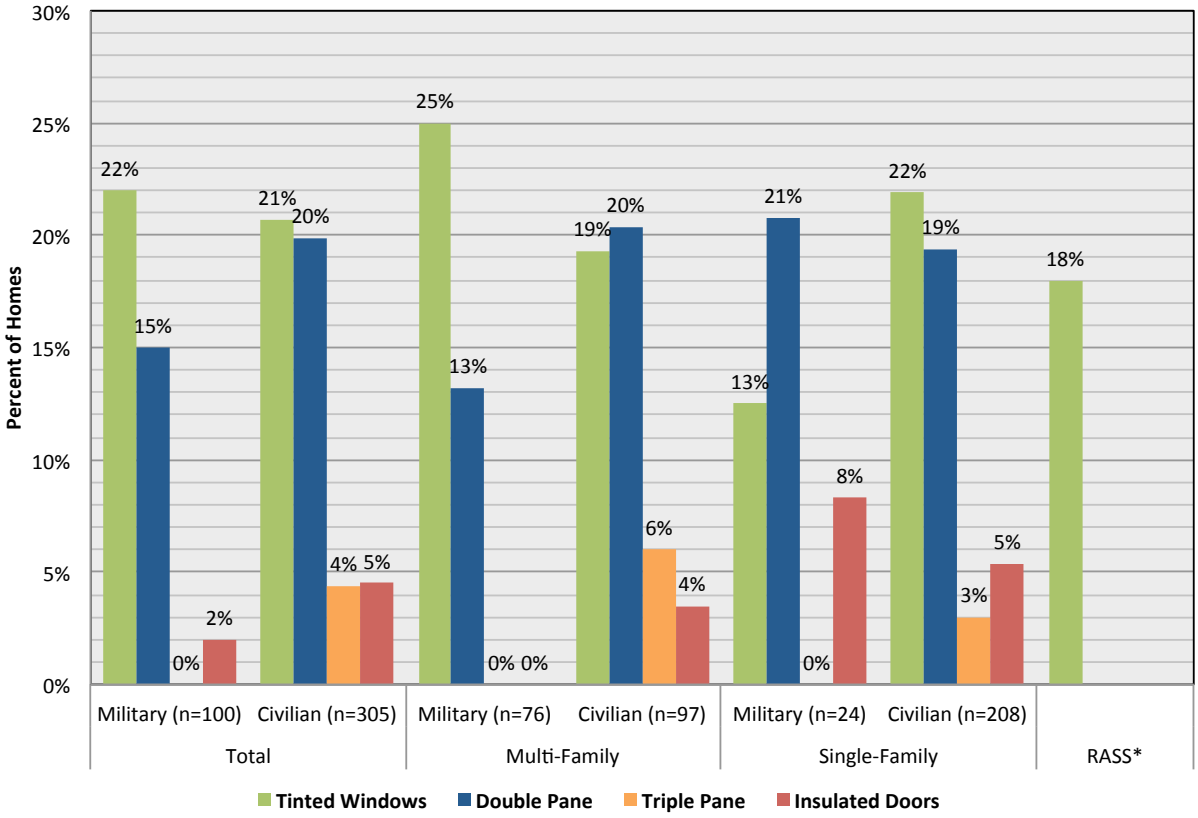


Figure 78 below shows the percent of homes with efficient window and door measures present. That is, the figure presents the percent of homes with *at least one* window or door with the specified efficient measure. Efficient window and door measures are similarly prevalent in military and civilian sectors. In both sectors, tinted windows and double-paned windows are the most common efficiency measures. Military homes are similar to civilian homes in their propensity to have tinted windows (22% versus 21%, respectively) and somewhat less likely to have double-paned windows (15% versus 20%, respectively, but this difference is not statistically significant). Triple-paned windows and insulated doors are virtually non-existent in the military sector, though they are present in four to five percent of civilian homes.

Figure 78 – Window and Door Efficiency Measures: Military versus Civilian and RASS by House Type



*The RASS did not have aligned information available for all categories

Figure 79 below shows the distribution of roof condition and color, as well as the presence of wall and roof insulation. Despite the greater prevalence of central air conditioning, there is little difference between military and civilian sectors with respect to the presence of insulation. Both wall and roof insulation is uncommon in both military and civilian homes; estimates show between 11 percent and 15 percent of homes include these features. White roofs and reflective roofs are uncommon in the civilian sector (6% to 9%) and absent from the set of sampled homes in the military sector. Consistent with their later vintage, military home roofs are generally in better condition than civilian home roofs, with 77 percent in 'good' condition versus 48 percent of civilian roofs.

Figure 79 – Home Roof Color Characteristics: Color, Finish and Condition

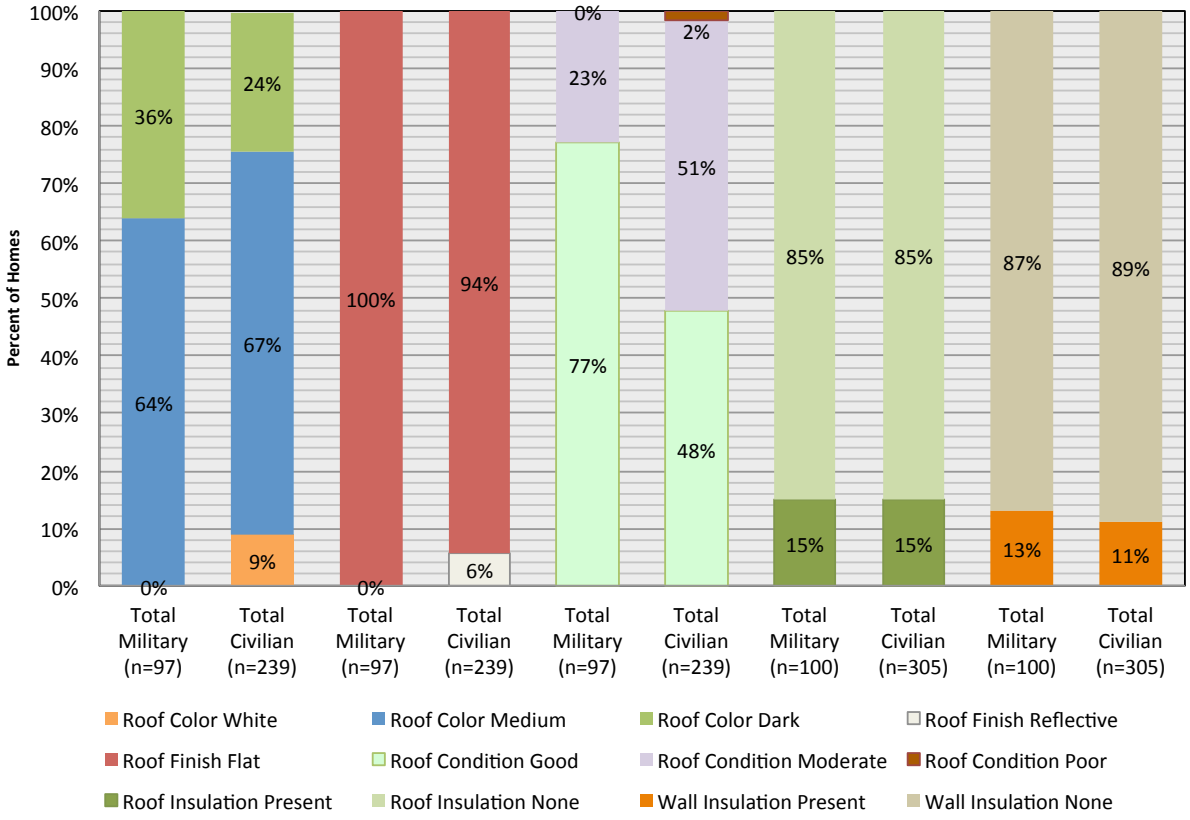
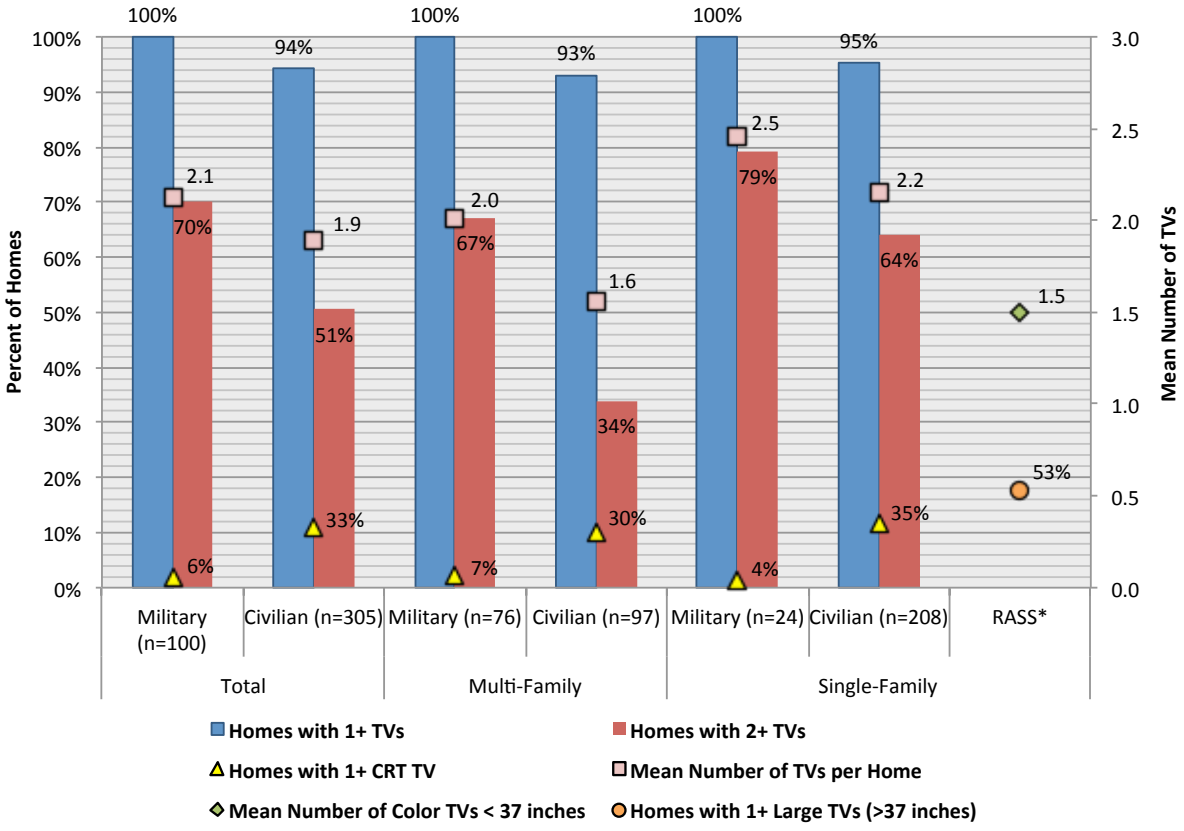


Figure 80 shows the number and type of television sets in use per home in the military sector by home type; similar civilian statistics are shown for comparison. Televisions have high saturation rates for both military and civilian sectors, though marginally higher among military homes. While nearly all homes in the civilian sector have at least one television, all military homes in our baseline sample have at least one television. A more differentiating statistic is the portion of homes with a second television; seven of 10 homes in the military sector have two or more televisions versus just under half of civilian homes. While this statistic seems almost stark, consider the similarity across sectors in the mean number of television sets per home. These data underscore the homogeneity of military homes. Overall, the mean number of television sets per home is fairly equivalent across military and civilian sectors, at 1.9 versus 2.1 sets per home. At the same time, the percent of homes with two or more sets is markedly different. This indicates that a civilian home with two or more sets is actually likely to have three or even four sets per home, while military homes with multiple sets are more likely to have just two.

Flat screen televisions vary widely in their energy consumption (for a given size). For a given screen size, CRT sets typically use more energy than LED sets and less than similarly sized plasma sets. CRT sets are generally smaller and as flat screen televisions have become more affordable and commonplace, the mean size of televisions has also grown, yielding

higher per unit energy consumption for plasma sets and most flat screen sets purchased through the late 2000s. The older style CRT sets are still present in just under one-third of civilian homes, but just 6 percent of military homes.

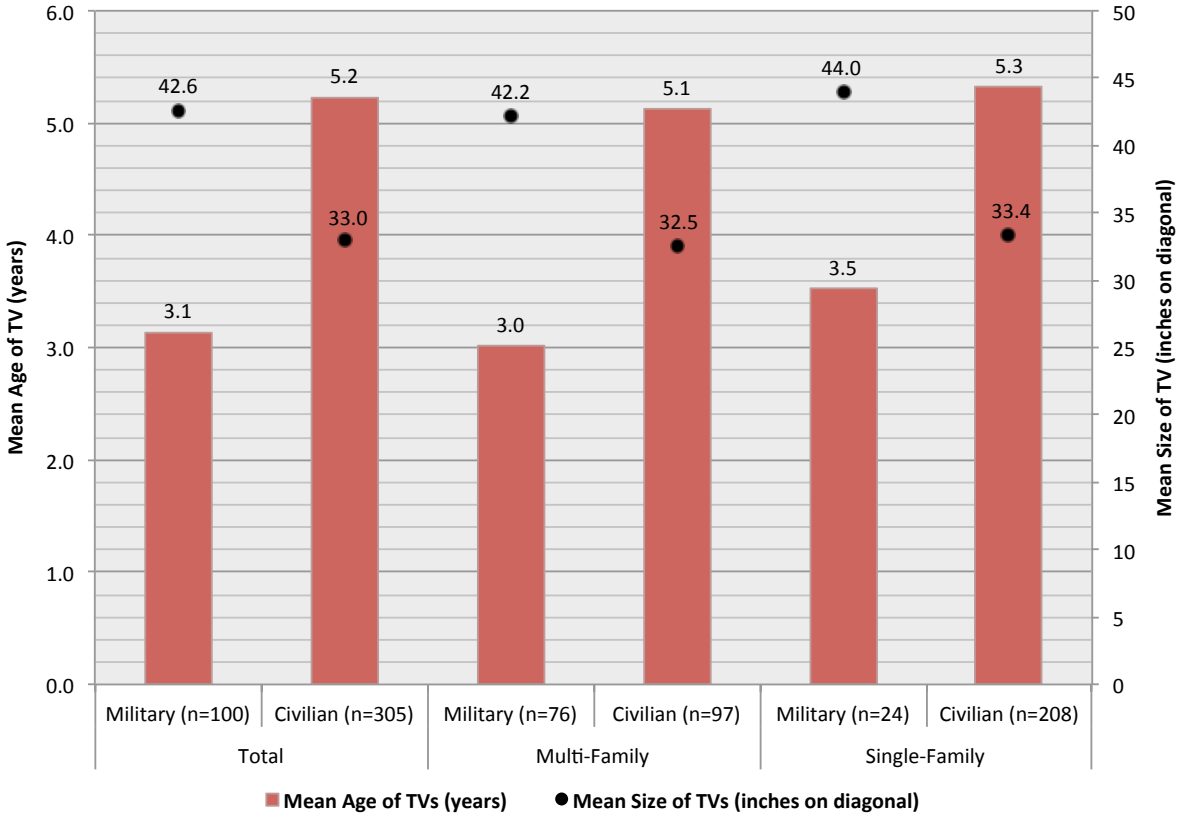
Figure 80 – Television Equipment Holdings: Military versus Civilian and RASS by House Type



*The RASS did not have aligned information available for all categories

As shown in Figure 81 below, television sets are newer and larger in the military sector when compared with televisions in the civilian sector. Consistent with a lower prevalence of CRT sets and a mean vintage two years younger than civilian sets, the mean television set size in the military sector is almost 10 inches greater than in the civilian sector.

Figure 81 – Television Age and Size Characteristics: Military versus Civilian by House Type



5 Business Mail and On-site Survey Results

This section presents selected results from the business on-site and mail surveys, including both small-medium and large business customers. Please see Appendices E-G for a more comprehensive set of results for the small-medium mail, small-medium on-site and large on-site surveys.

5.1 Introduction

This subsection presents selected descriptive information on business customers in the Hawaiian Electric Companies' service territories, which includes the counties of Oahu, Maui and Hawaii. As described below, a number of sources are used to construct key characteristics of the business 'sample frame' or full population, in order to best represent all the business segments and to summarize both building and business characteristics and electricity consumption.

Table 21 below is based on data from the U.S. Census Bureau's Survey of Current Business. Note that the Census data is unlikely to match that maintained by the Hawaiian Electric Companies, since the utilities' definition of businesses includes the many local, state and federal government buildings that have electric accounts, which are excluded from the Census data. The number of businesses shown below in the Census data is in fact about 40 percent less than the 55,000 non-residential customers served by the Hawaiian Electric Companies. Despite this discrepancy, however, the Census data provide an overview of the types of businesses in Hawaii, highlighting the relative importance of restaurants, retail and services in the overall economy.

Table 21 – Business Summary by Type (2010)

Segment	Total	Hawaii	Maui	Oahu
Office	3,338	429	464	2,445
Restaurant	2,989	361	408	2,220
Food and Non-food Retail	4,332	675	778	2,879
Warehouse	2,377	332	276	1,769
Health Care	3,337	460	390	2,487
Education	470	59	65	346
Lodging	249	61	88	100
Services	8,557	992	1,173	6,392
Amusement	446	81	116	249
Other	3,324	516	556	2,252
Total	29,419	3,966	4,314	21,139

Source: U.S. Census, County Business Patterns, 2011

The remainder of this section presents results from the on-site and mail surveys of small and medium-sized businesses. The next nine subsections present results for the business sector; the tenth subsection presents results for business customers receiving service under a large or assigned account rate, and the eleventh subsection presents results for multi-family common areas.

- Building Characteristics (size, vintage)
- Business Characteristics (employees, hours of operation, own vs. rent)
- Lighting
- Water Heating
- Space Cooling
- Appliances
- Refrigeration and Cooking Equipment
- Motors, Compressors and Pumps
- Computers, Electronics and Miscellaneous
- Large and Assigned Accounts
- Multi-Family Common Area

Whenever appropriate, results are presented by island/county[34] and business/building type, as well as for the total sample. Throughout this section we include the sample size, which unless noted is the number of business sites where we collected usable data on the variable in question. We distinguish between "buildings or sites" for reporting of equipment and "businesses" for reporting about operating characteristics and attitudes toward energy efficiency or management. We referred to the approximate sampling error estimates (shown in Table 16 of Appendix B – Sampling Detail) when developing this section. We generally describe differences across segments that are statistically significant at the 90 percent confidence level (not noted), or indicate that a difference that is being described is not statistically significant (noted in the text).

5.2 Building Characteristics

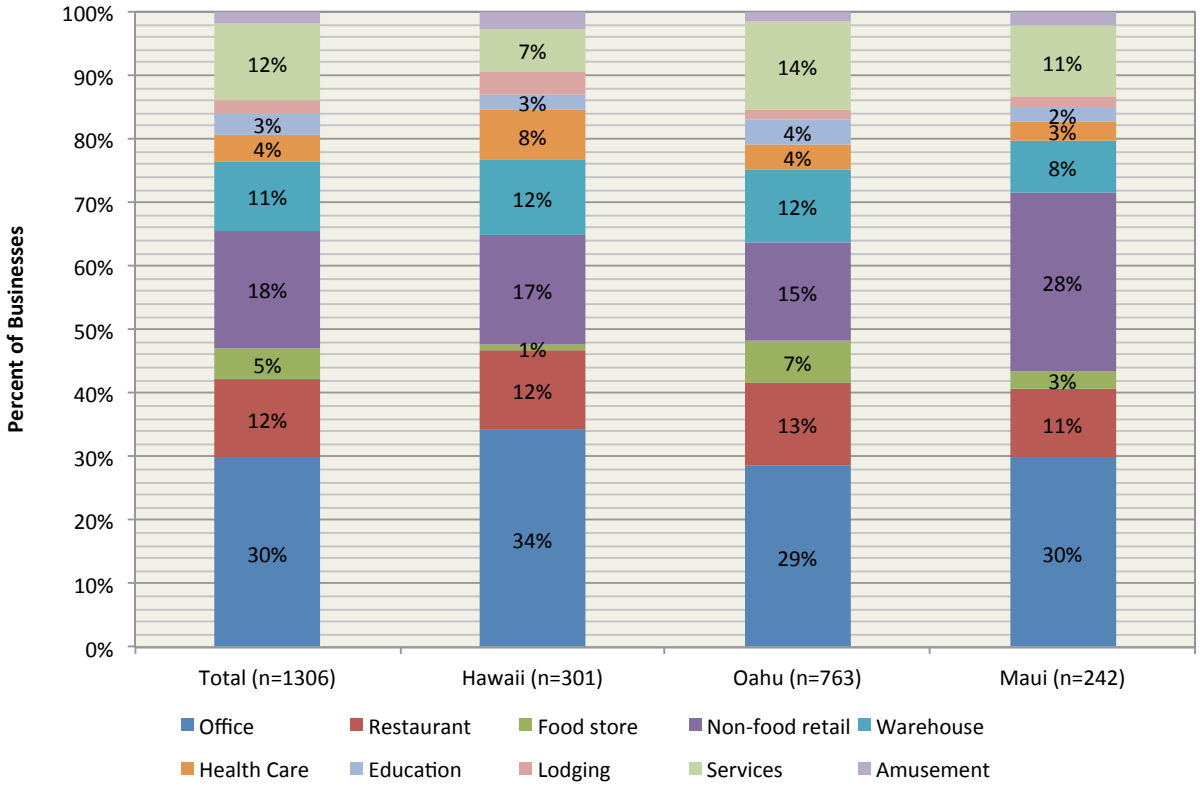
In this subsection, we present information about Hawaii, Maui and Oahu businesses and about buildings in the different business categories, including age, size and business sector or type.

We present results broken down first by island/county, and then by business type. When appropriate, results from the small-medium on-site surveys and the small-medium mail surveys are combined. In some cases, however, we relied only on the detailed information collected by trained engineers.

[34] As described above, our on-site surveys excluded two of the three inhabited islands in Maui County, Lanai and Molokai, but we assume that the results for the island of Maui represent Maui County.

As shown in Figure 87 on the next page, our weighted, combined on-site and mail survey results show that offices are the most prevalent business type overall (30%) and in all three counties, while non-food retail stores are the second most common overall (18%) and in each of the three counties. Maui has a significantly higher percentage of non-food retail buildings (28%) than the other counties. Among other building types, Hawaii has more health care and fewer services establishments, while Oahu has a higher percentage of food stores than the other counties.

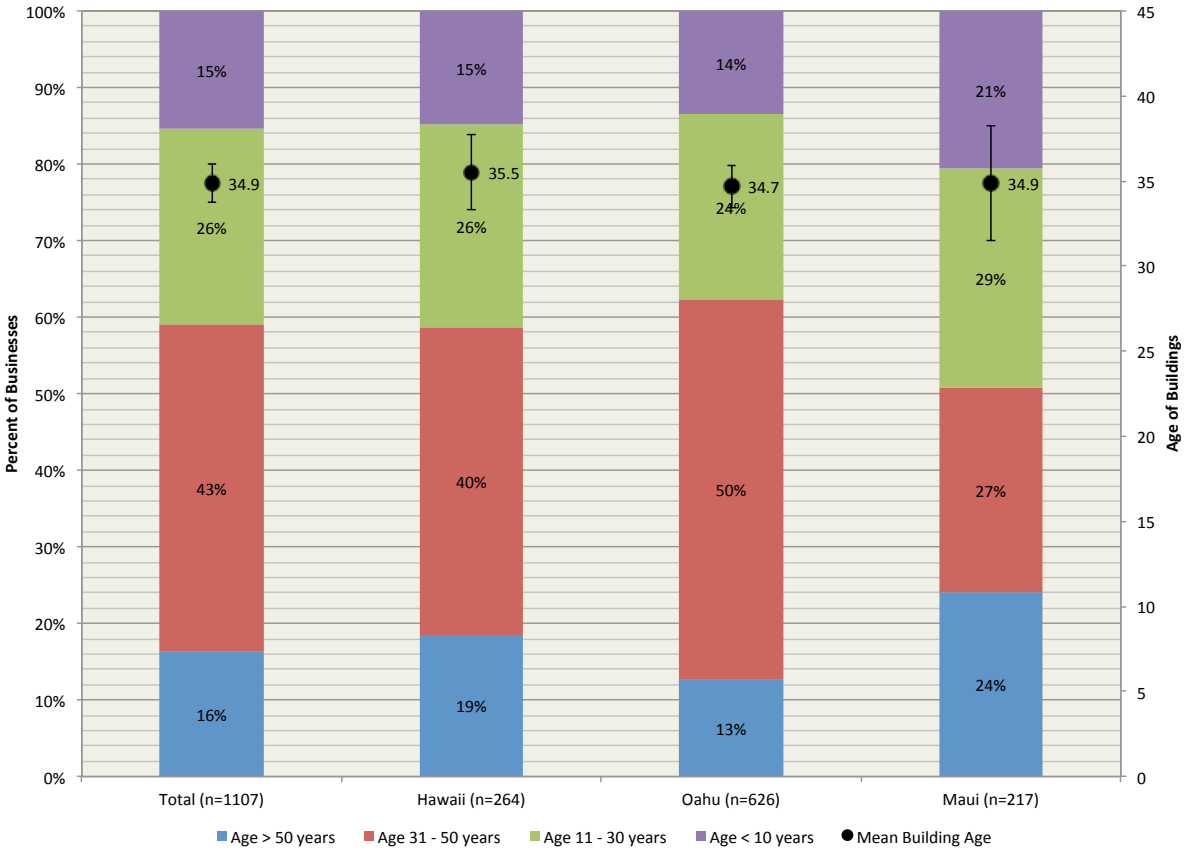
Figure 82 – Business Type by County



Source: Mail and On-site Surveys

As shown in Figure 83, the combined mail and on-site baseline survey data indicate the mean age of business buildings is 35 years, corresponding to a construction date of 1978. Mean ages of buildings were not significantly different across counties. Overall, almost 60 percent of all buildings were constructed more than 30 years ago, before energy efficiency became a significant influence in building design, and most (41%) of these older buildings date from between 1963 and 1982. Maui is somewhat different from the others, having both the highest percentage of buildings over 50 years old (24%) and the highest percentage of buildings 30 years old or newer (50%). About half the buildings on Oahu are 31-50 years old.

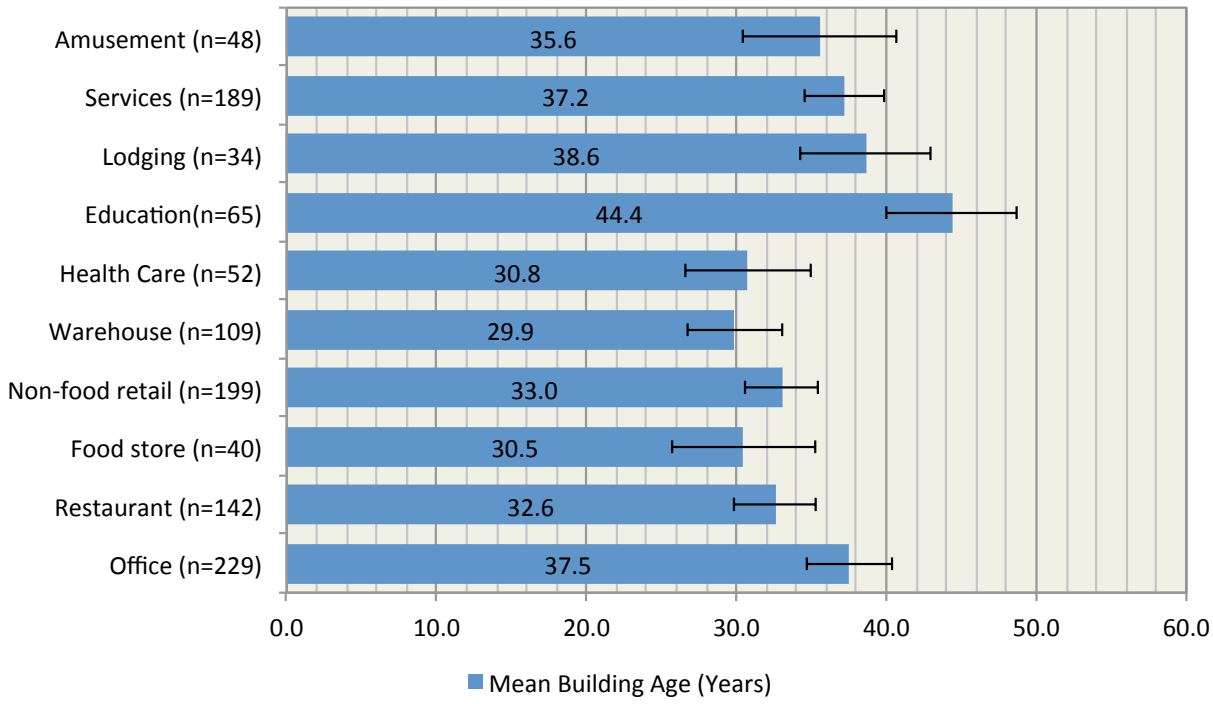
Figure 83 – Building Age, by County



Source: Mail and On-site Surveys

As shown in Figure 84 on the next page, the combined mail and on-site results indicate that education buildings have the oldest average age, followed by lodging, offices and service establishments. Warehouses and food stores have the lowest average age. The length of the band around each value represents the 90 percent confidence interval around the mean, and highlights which differences are significant and which are not.

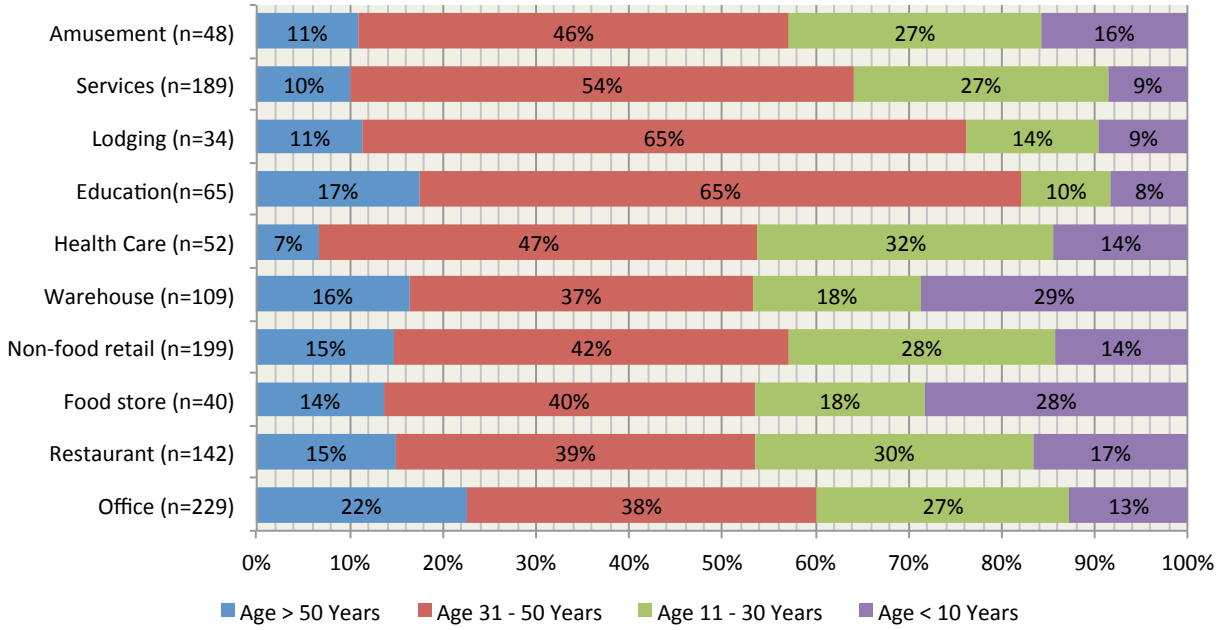
Figure 84 – Average Building Age, by Business Type



Source: Mail and On-site Surveys

Figure 85 presents the age distribution of buildings by business type, and shows that while offices have the highest percentage of buildings more than 50 years old (22%), more than three-fourths of schools (81%) and lodging facilities (76%) are over 30 years old. The low mean age of warehouses and food stores is explained by the fact that these two sectors have significantly higher percentages of buildings less than 10 years old. At the other extreme, fewer than 10 percent of buildings in the education, lodging and services sectors were built within the past 10 years.

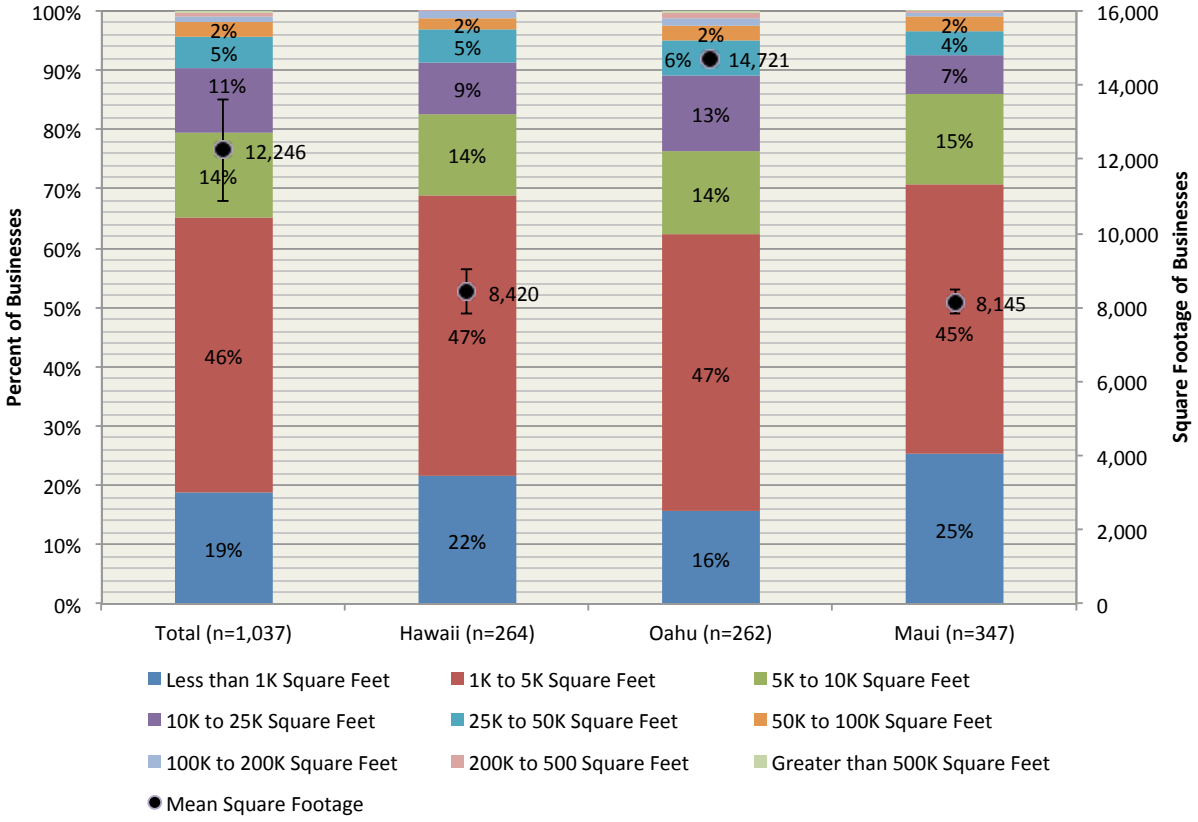
Figure 85 – Building Age, by Business Type



Source: Mail and On-site Surveys

Average size of buildings is one indicator of the relative cost of reaching out to various market segments to encourage energy efficiency. On average, business buildings are slightly over 12,000 square feet in size, but almost two-thirds are less than 5,000 square feet. As shown in Figure 86, buildings on Oahu are larger than those in other counties, with both Hawaii and Maui buildings averaging less than 8,500 square feet.

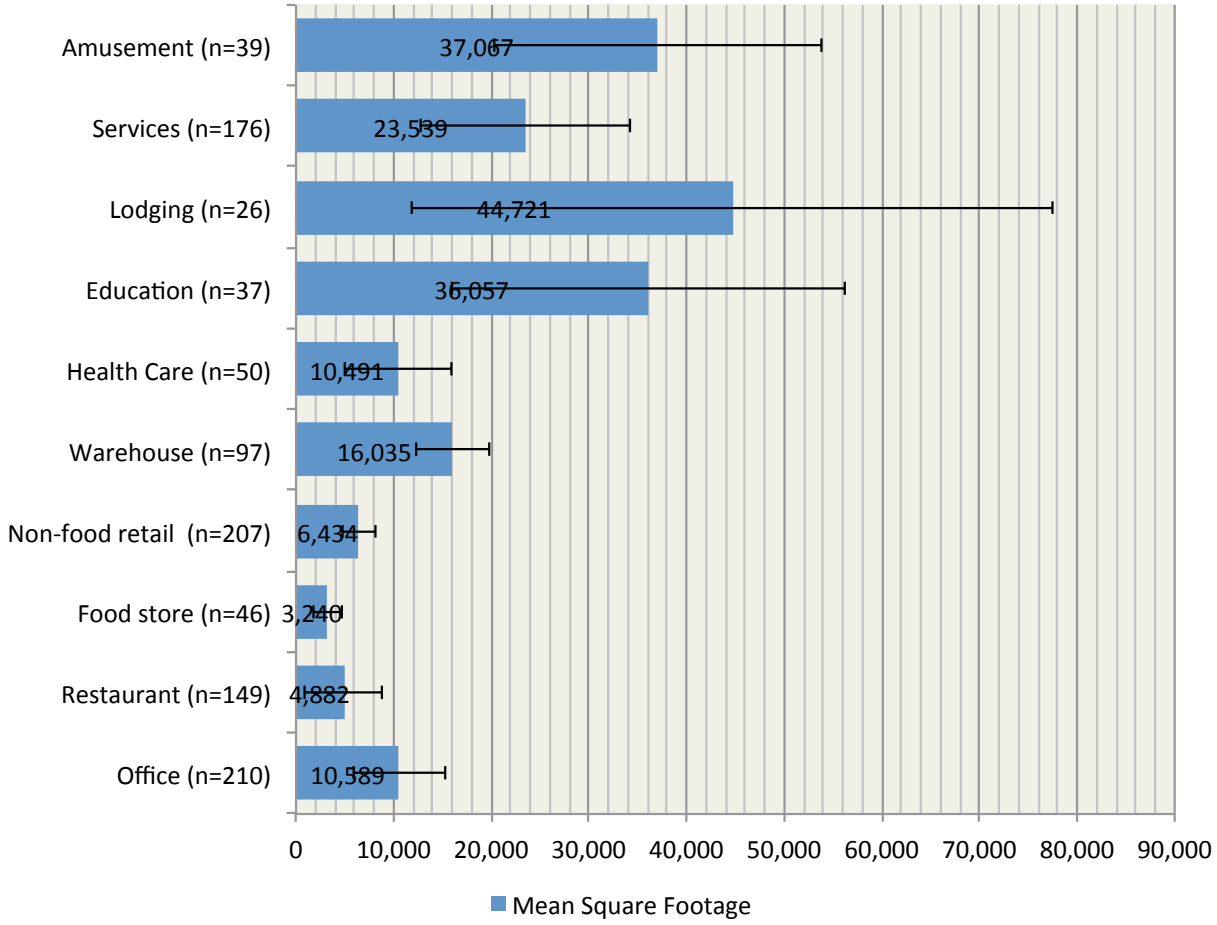
Figure 86 – Building Size, by County



Source: Mail and On-site Surveys

Figure 87 presents the average building size by business type, and shows that warehouses, schools and amusement facilities have significantly higher average square footage than other building types, while the average size of food stores is significantly lower than all other business types except restaurants.

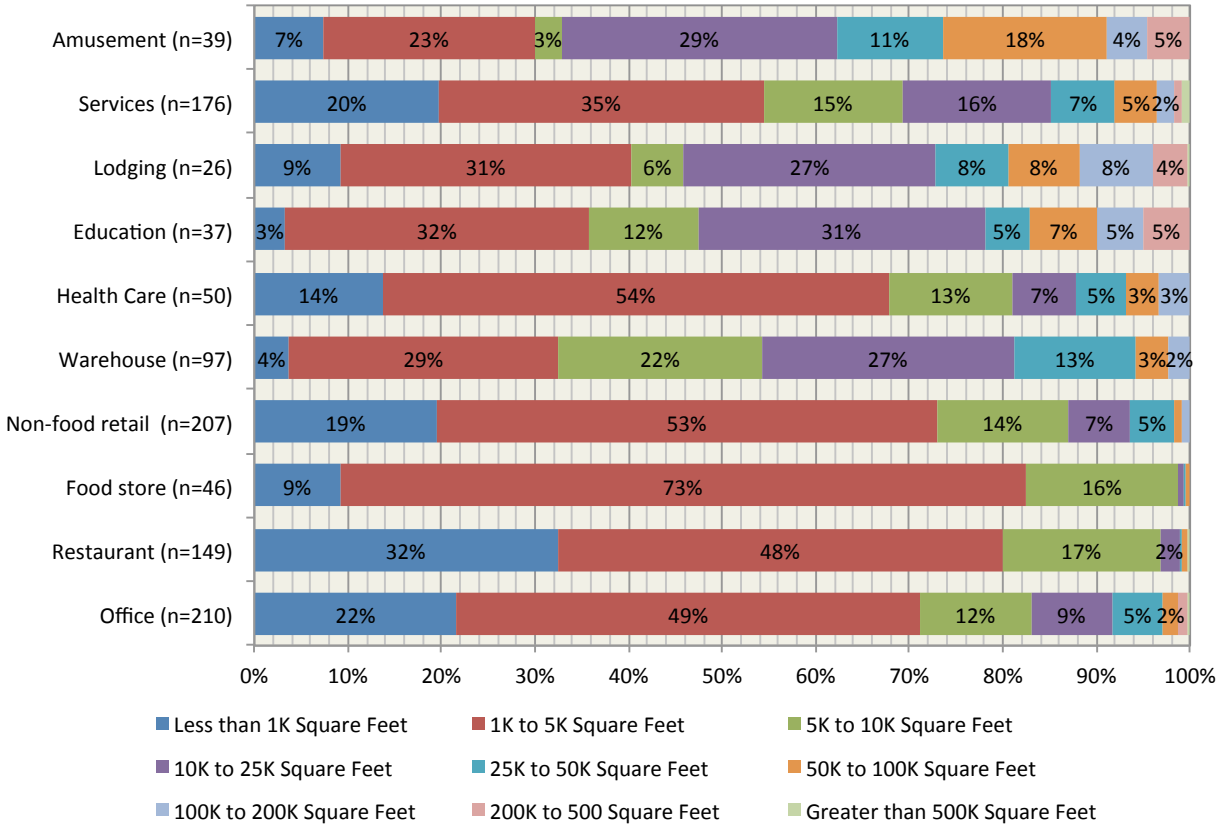
Figure 87 – Average Building Size, by Business Type



Source: Mail and On-site Surveys

The distribution of buildings by size range across business types, presented in Figure 88, shows that the warehouse, education and amusement sectors all have fewer buildings under 5,000 square feet than other segments (the difference is not significant for lodging). Amusement facilities have the highest percentage of buildings over 25,000 square feet: 38 percent compared to 10 percent for the overall population of business buildings.

Figure 88 – Building Size Distribution, by Business Type



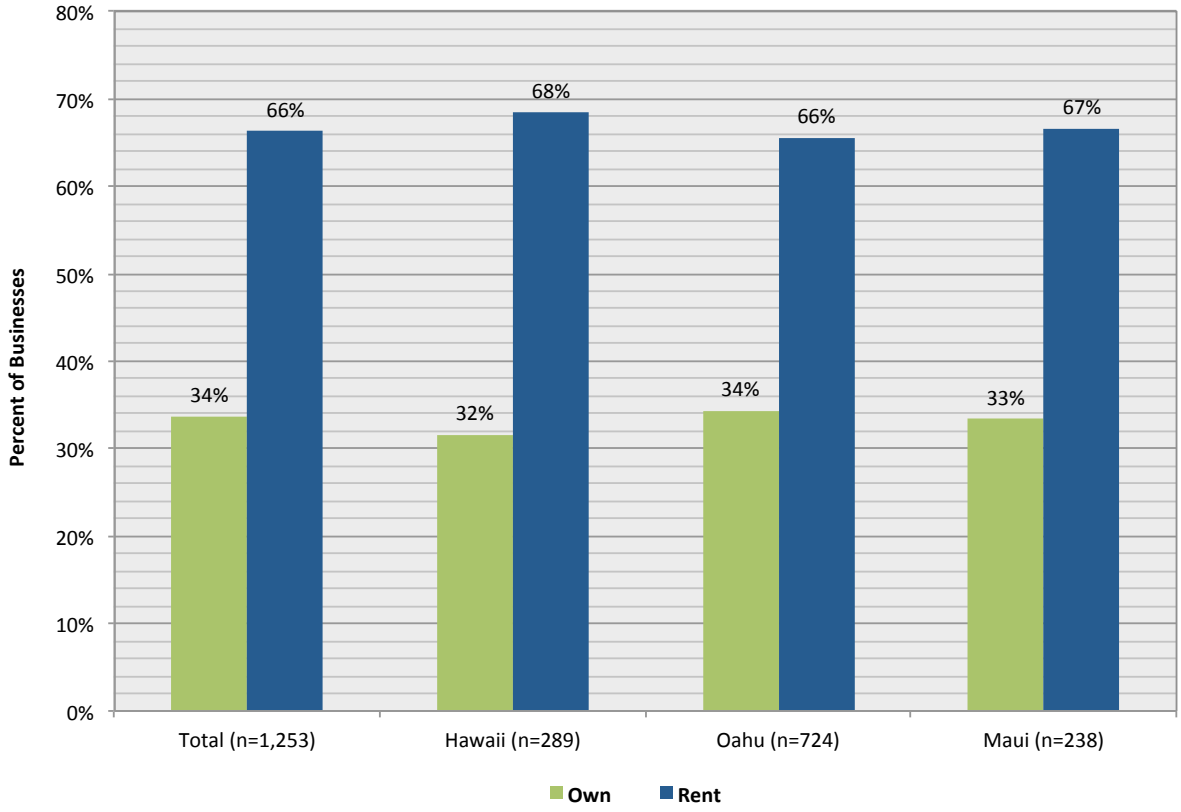
Source: Mail and On-site Surveys

5.3 Business Characteristics

This subsection presents results on characteristics of the businesses surveyed, including ownership status, number of employees, hours of operation and opinions on participation in demand response initiatives. These data were obtained both from the mail survey and from the self-administered business characteristics questionnaire that auditors gave to study respondents at businesses where on-sites were conducted. As in the previous section, results are presented both by island/county and by business type and represent combined mail and on-site results unless one or the other is specified.

As shown in Figure 89, about two-thirds of business facilities are rented, with little variation across counties.

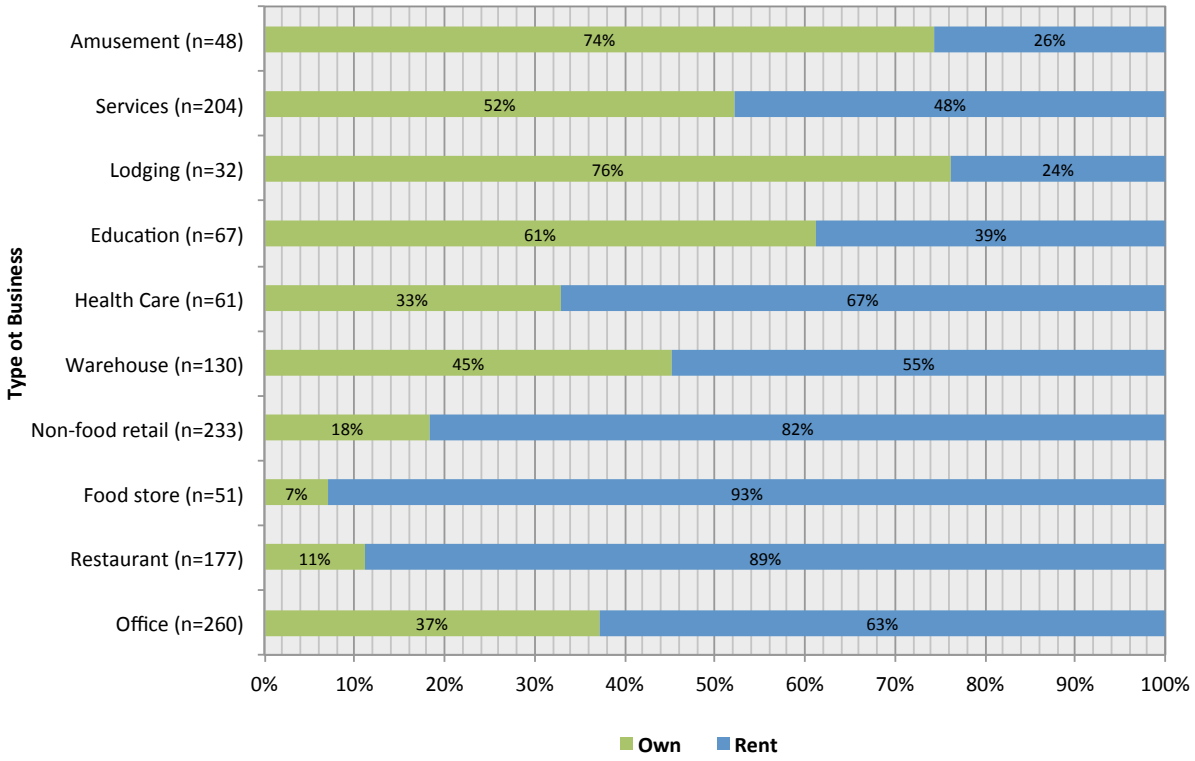
Figure 89 – Buildings Ownership, by County



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Figure 90 below presents the percentage of owners and renters by business type, and shows that there is much more variation in the percentage of owner-occupied facilities than across counties. The lodging, amusement and education sectors all have more than 60 percent owner-occupied buildings, while food stores and restaurants have the highest proportions of renters.

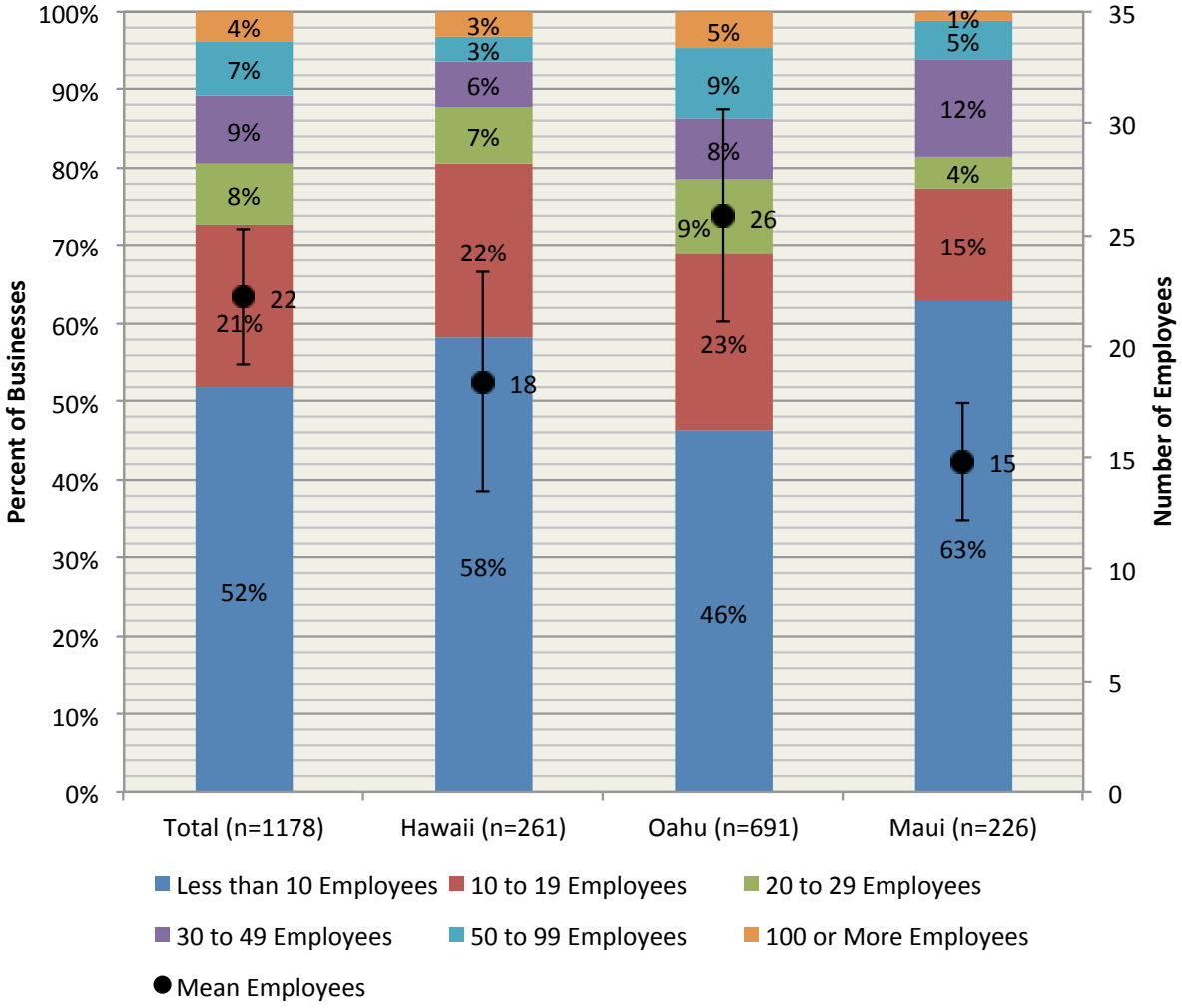
Figure 90 – Building Ownership, by Business Type



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Figure 91 on the next page shows the number of employees per business by county. Overall, over half of businesses employ fewer than 10 people, with an overall average of 22 employees per building. Oahu averages the most employees, while Maui has the lowest average. Similarly, Oahu has the lowest percentage of facilities with fewer than 10 employees and the highest percentage with 50 or more.

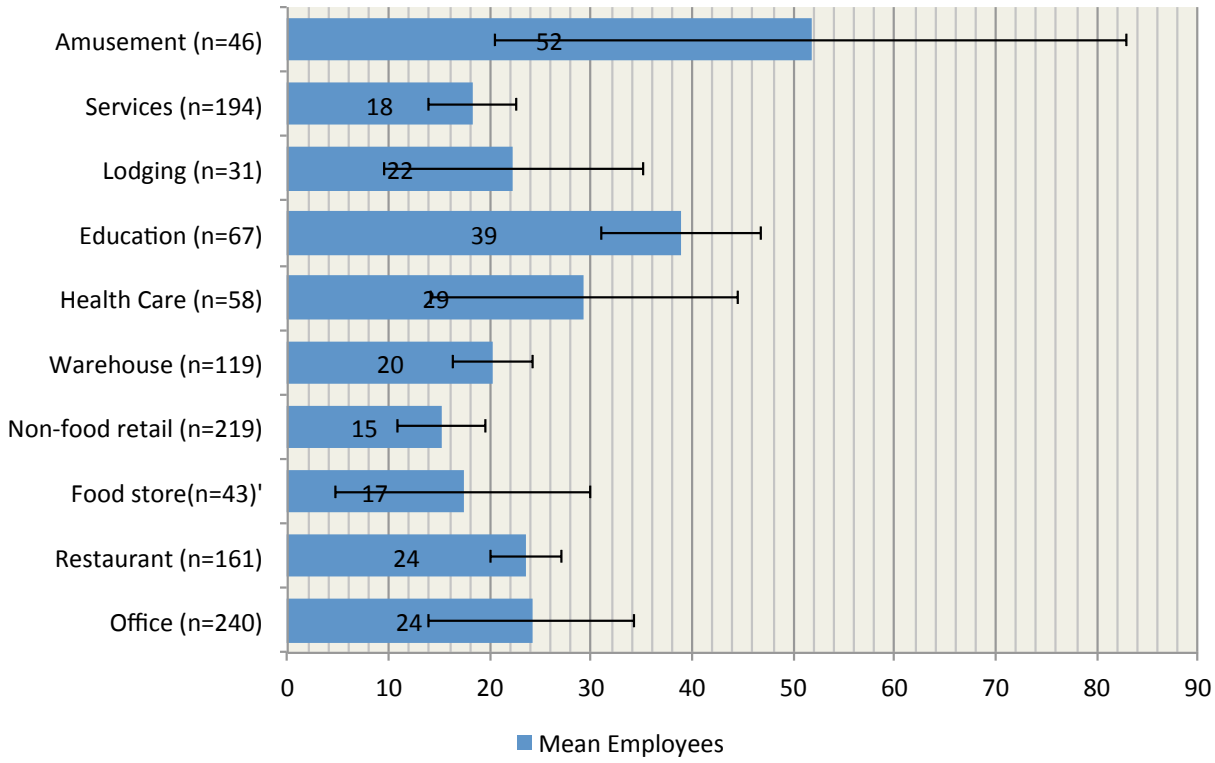
Figure 91 – Number of Employees, by County



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Across business types, the highest average number of employees is found in the amusement (52) and education (39) sectors, while both food (15) and non-food retail (18) average fewer workers than other segments, although most of the differences are not statistically significant, as shown in Figure 92.

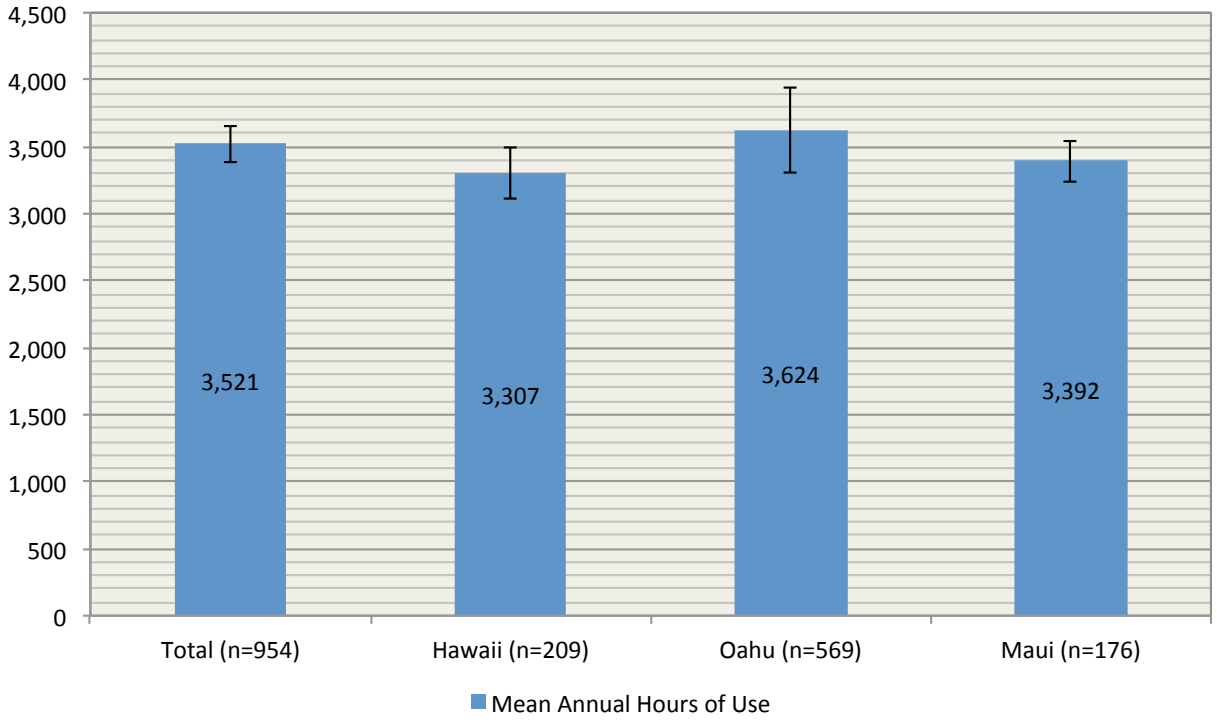
Figure 92 – Average Number of Employees, by Business Type



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Another business characteristic influencing the potential for energy efficiency technologies is the number of hours of operation. On average, surveyed businesses operate 3,521 hours a year, as presented in Figure 93. Oahu businesses operate an average of about 10 percent longer than do Hawaii and Maui County businesses—not a statistically significant difference.

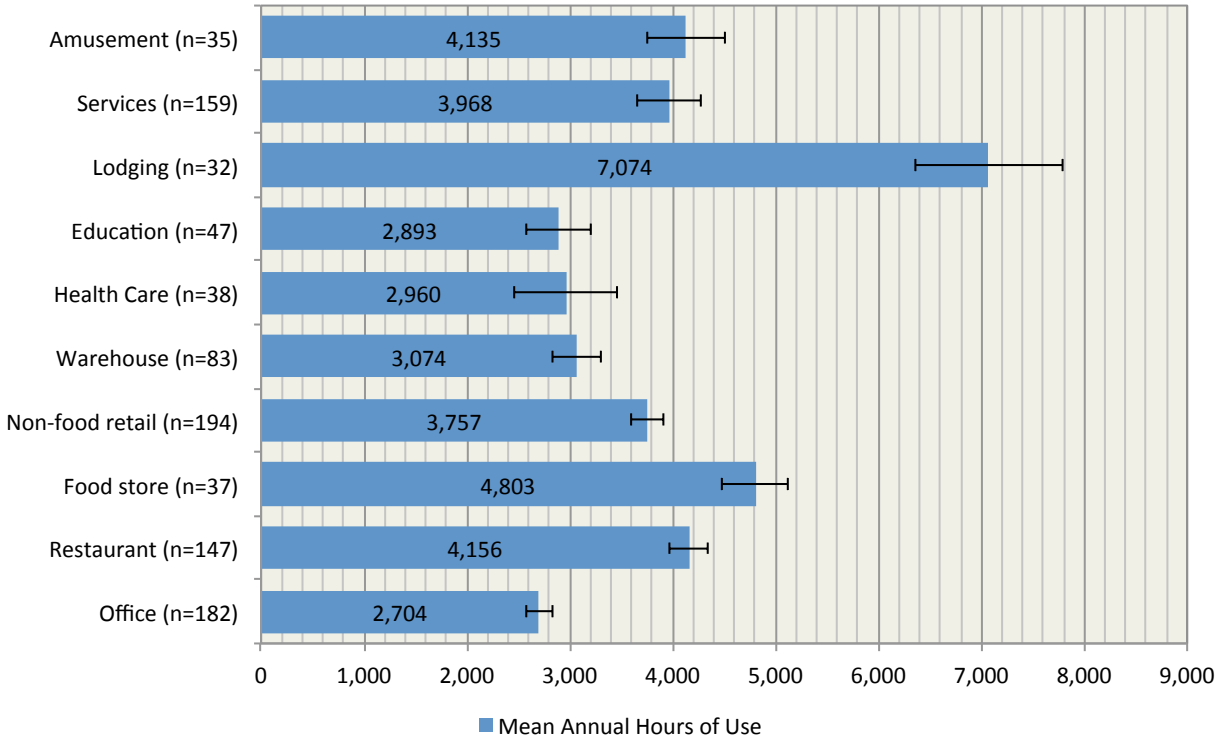
Figure 93 – Annual Hours of Operation, by County



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Hours of use vary much more widely by business type than by county. As indicated by the results in Figure 94, the highest, lodging (7,074), averages about 2.5 times the hours of offices (2,704). No other business type averages more than 5,000 annual hours of operation. As before, the lines and end points show the 90 percent confidence intervals around the means, so that significant differences can be seen.

Figure 94 – Annual Hours of Operation, by Business Type

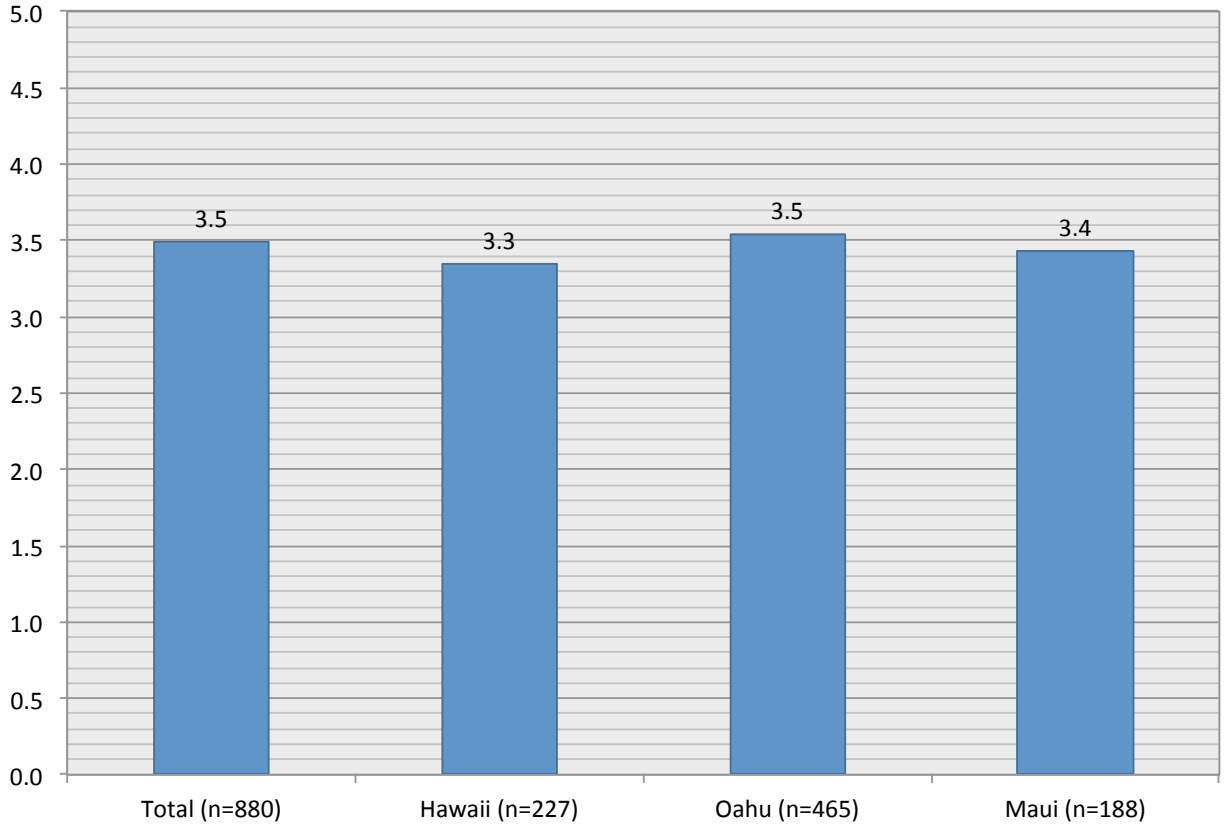


Source: Business on-site self-administered business characteristics questionnaire and mail survey

The mail survey questionnaire posed questions related to the willingness of the business to participate in demand response programs, as well as the perceived importance of various factors in encouraging participation in such programs. Respondents were asked to select from ratings for both their likelihood of participation and the importance of each factor in encouraging participation on a 1 to 5 scale, where 1 was "not at all likely/important" and 5 was "extremely likely/important."

Figure 95 shows that the average likelihood of participating in a demand response program was 3.5, or evenly between "somewhat likely" and "very likely." There was no statistically significant differences in the likelihood of participation among islands.

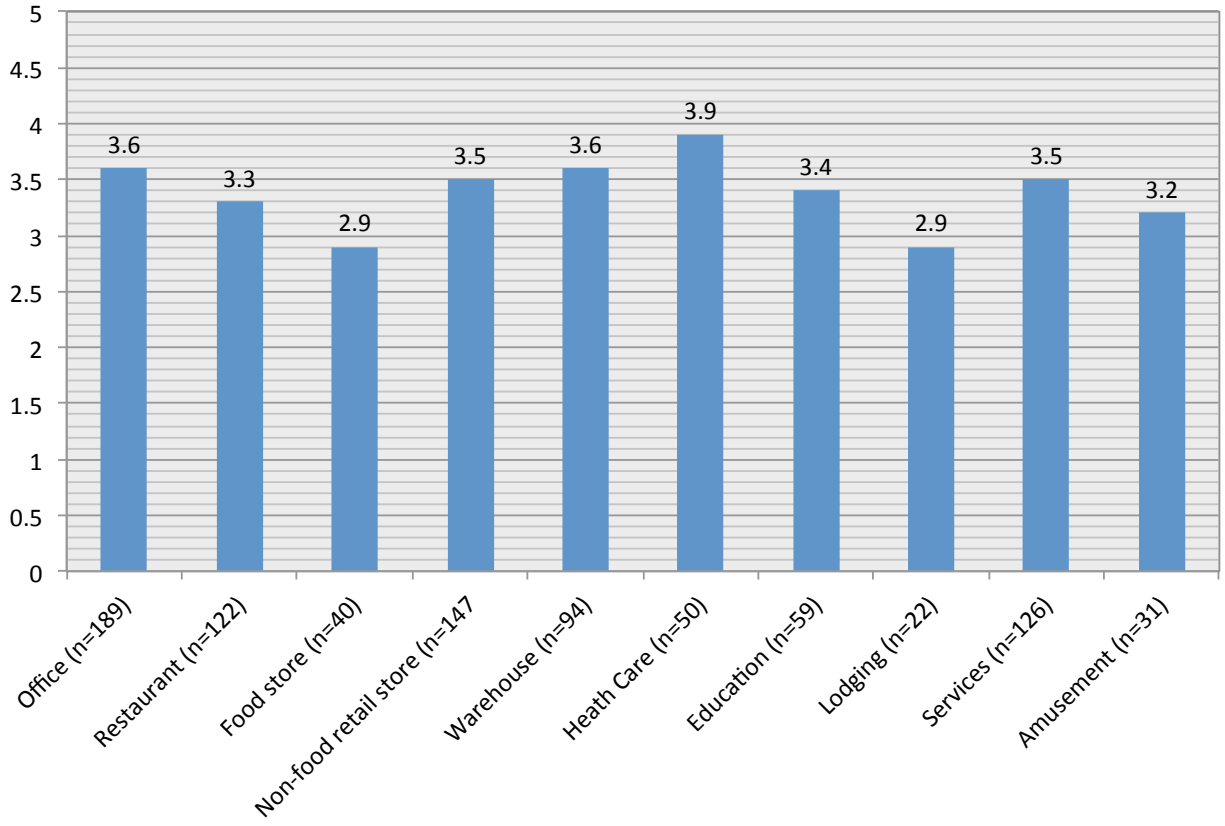
Figure 95 – Likelihood of Participating in Demand Response Program, by County (Mean Likelihood on 1 to 5 scale)



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Across business types, health care facilities had the highest mean likelihood of participation (3.9), while food stores and lodging has the lowest (2.9), as shown in Figure 96.

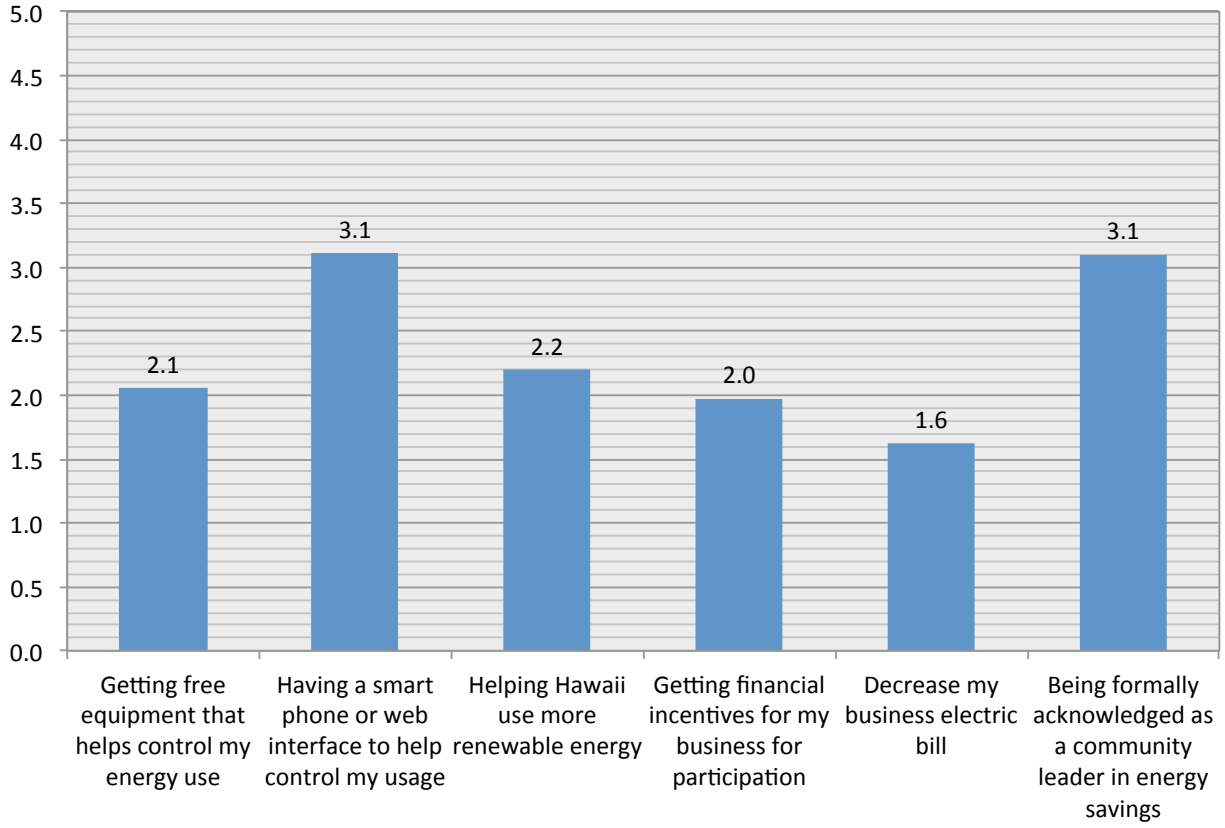
Figure 96 – Likelihood of Participating in DR Program, by Business Type



Source: Business on-site self-administered business characteristics questionnaire and mail survey

Respondents were also asked about the importance of various factors in motivating them to participate in a demand response program, again using a 1 to 5 scale. Results are presented in Figure 97, and show that, for users overall, respondents were more motivated by the prospect of being able to control their usage via smart phone and of getting recognition for their demand control efforts than they were by the prospects of free equipment, bill savings or incentives. The segments most likely to participate – health care, offices and warehouses – all assigned the highest importance to being recognized for their demand control efforts.

Figure 97 – Importance of Factors Encouraging Participating in DR Programs – All



Source: Business on-site self-administered business characteristics questionnaire and mail survey

5.4 Lighting

This next subsection presents results on the inventory that auditors took of light bulbs being used in the study sample. For this section, except for the last two charts that show lighting control data that reflect both on-site and mail survey data, only the results of the on-site investigations conducted by engineers are presented, because we have greater confidence that these auditors observed and recorded a complete inventory of lighting equipment. Please note that we are presenting only the on-site data here (except for the lighting controls data); the mail survey results can be found in Appendix E.

First, we report on the percentage of business buildings with various lighting technologies installed, by county and business type. We also address the overall number of installed lamps to help us understand the extent to which efficient technologies have been adopted by various sectors and where potential still remains. We also report on the extent to which various control strategies are in place to manage lighting use.

Figure 98 depicts the percentage of facilities with each type of lamp installed overall and for each of the three counties, and shows the wide range of lighting types currently being

used, with an average of 2.6 lighting types per building. Overall, T8 linear fluorescents are the dominant lighting type, but about 42 percent of businesses still have T12 fluorescents and roughly one-third still have incandescent lamps. Across the counties, Oahu has the highest percentage of facilities with T8 lamps (78%), but even there, more than 40 percent of businesses still have T12 lamps in their buildings as well.

Figure 98 – Percent of Buildings with Various Lighting Types, by County

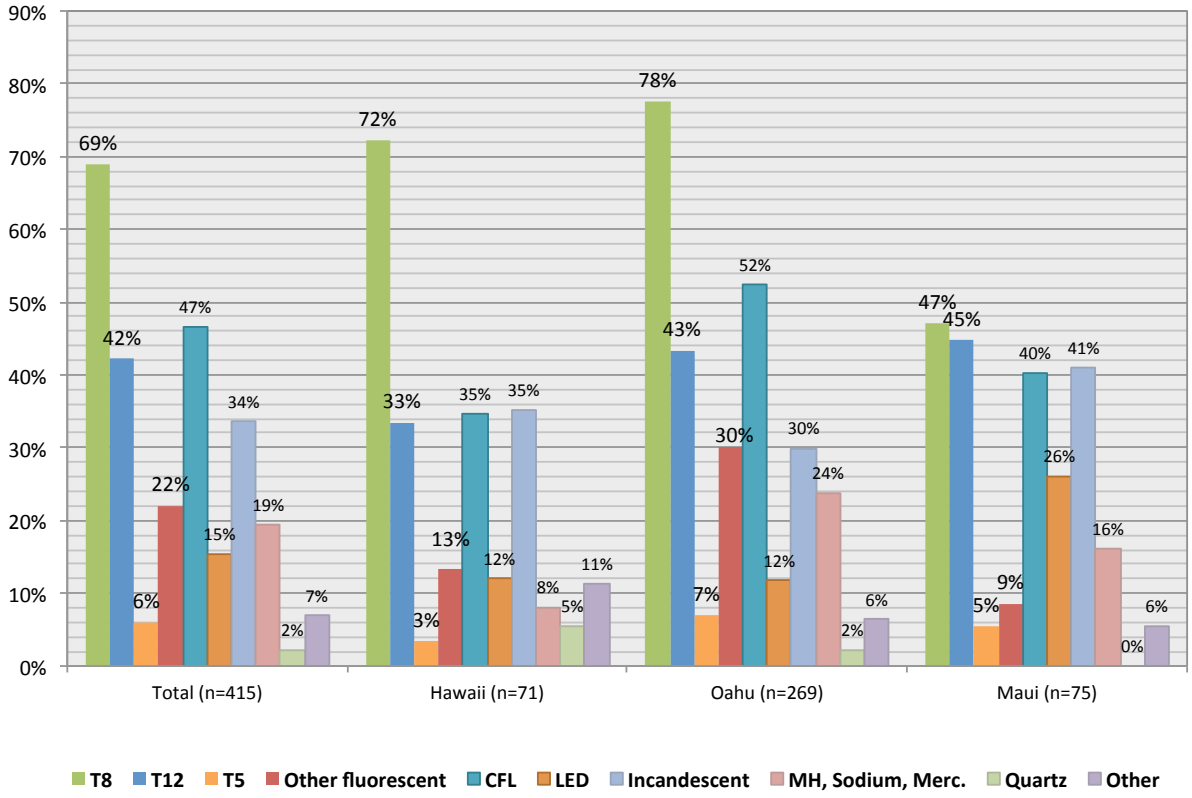
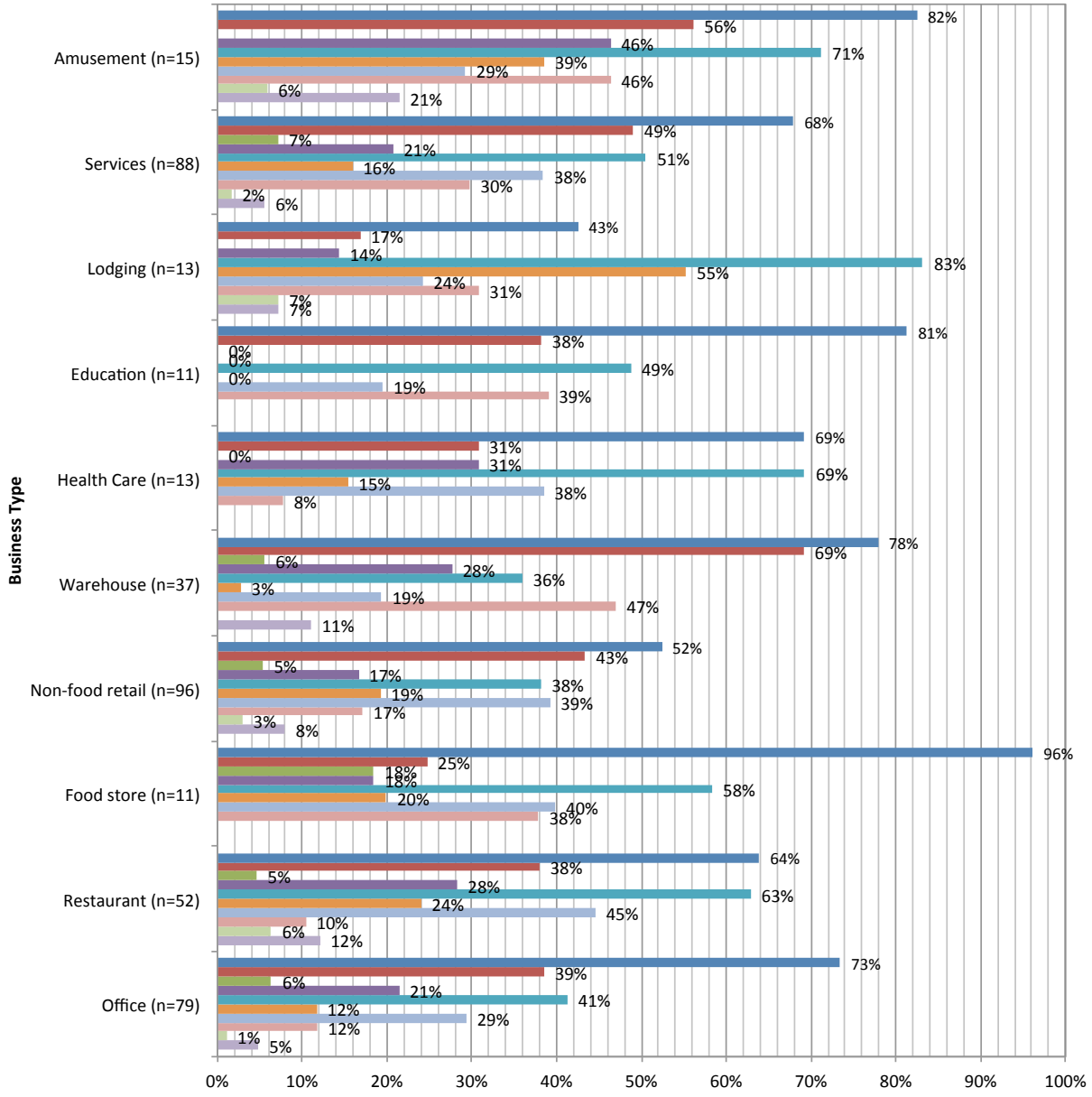


Figure 99 shows the percentage of building with various types of lighting by business type. Food stores have the highest percentage of facilities with T8s and T5 linear fluorescents, while lodging facilities have the highest share with CFLs and LEDs. The warehouses and amusement sectors both have T12s at more than half their facilities, and both have over 45 percent of buildings with metal halide, high pressure sodium or mercury vapor lamps. The latter result suggests that these sectors have significant potential to retrofit high-bay lighting with T5 or high performance T8 lamps.

Figure 99 – Percent of Buildings with Various Lighting Types, by Business Type



	Office (n=79)	Restaurant (n=52)	Food store (n=11)	Non-food retail (n=96)	Warehouse (n=37)	Health Care (n=13)	Education (n=11)	Lodging (n=13)	Services (n=88)	Amusement (n=15)
T8	73%	64%	96%	52%	78%	69%	81%	43%	68%	82%
T12	39%	38%	25%	43%	69%	31%	38%	17%	49%	56%
T5	6%	5%	18%	5%	6%	0%	0%	0%	7%	0%
Other fluorescent	21%	28%	18%	17%	28%	31%	0%	14%	21%	46%
CFL	41%	63%	58%	38%	36%	69%	49%	83%	51%	71%
LED	12%	24%	20%	19%	3%	15%	0%	55%	16%	39%
Incandescent	29%	45%	40%	39%	19%	38%	19%	24%	38%	29%
MH, Sodium, Merc.	12%	10%	38%	17%	47%	8%	39%	31%	30%	46%
Quartz	1%	6%	0%	3%	0%	0%	0%	7%	2%	6%
Other	5%	12%	0%	8%	11%	0%	0%	7%	6%	21%

An alternate view of the mix of lighting types is an assessment of the overall number of lamps installed. Results overall and by county are presented in Figure 100, and show that T8s account for the overwhelming majority of lighting installed in buildings where lighting inventories were taken. Similarly, while more than 40 percent of buildings have T12s, the total percentage of T12 lamps is only seven percent, indicating that many buildings with T12s only have them in very limited numbers. The percentage of incandescent lamps (3%) is also much smaller than the 33 percent of facilities that have at least one such lamp. The results show that efficient linear fluorescents (T8s and T5s) have the largest market share in Oahu and Hawaii, while Maui has the highest percentage of CFLs (18%) or LEDs (12%).

Figure 100 – Distribution of Installed Lighting Technologies, by County

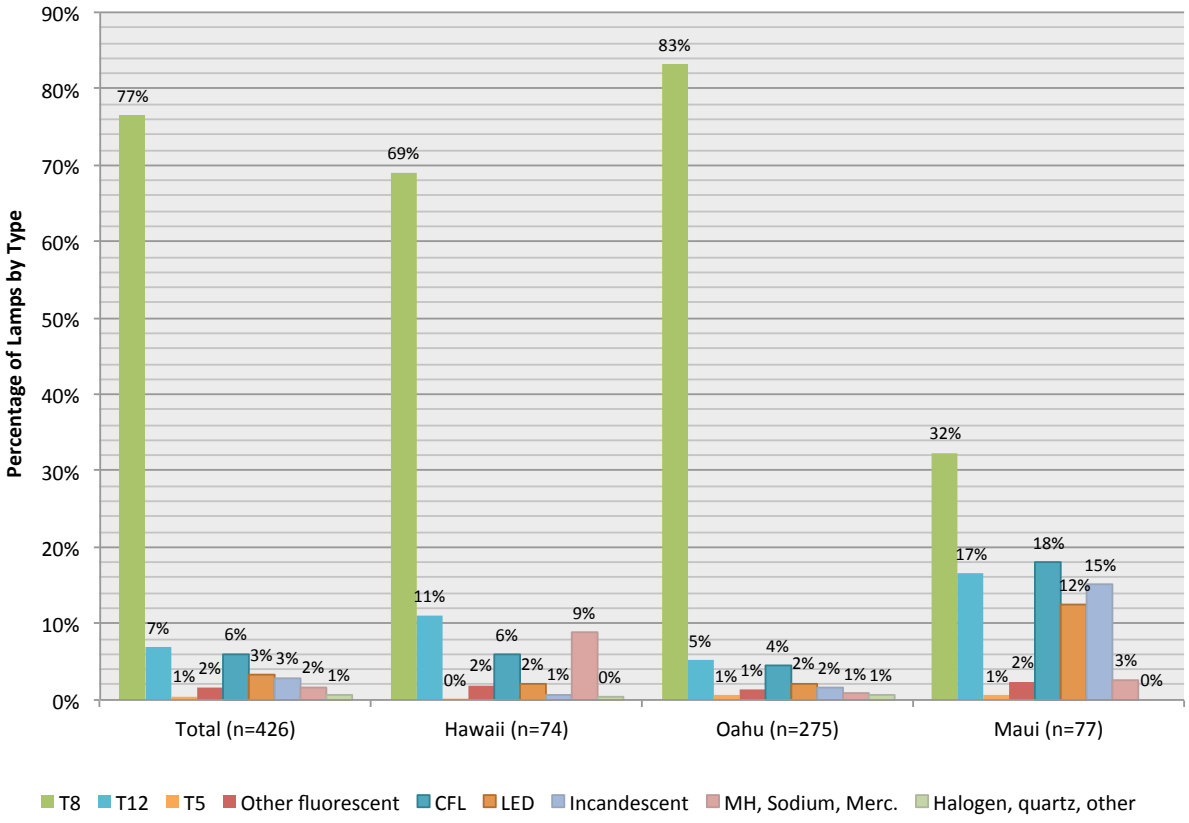
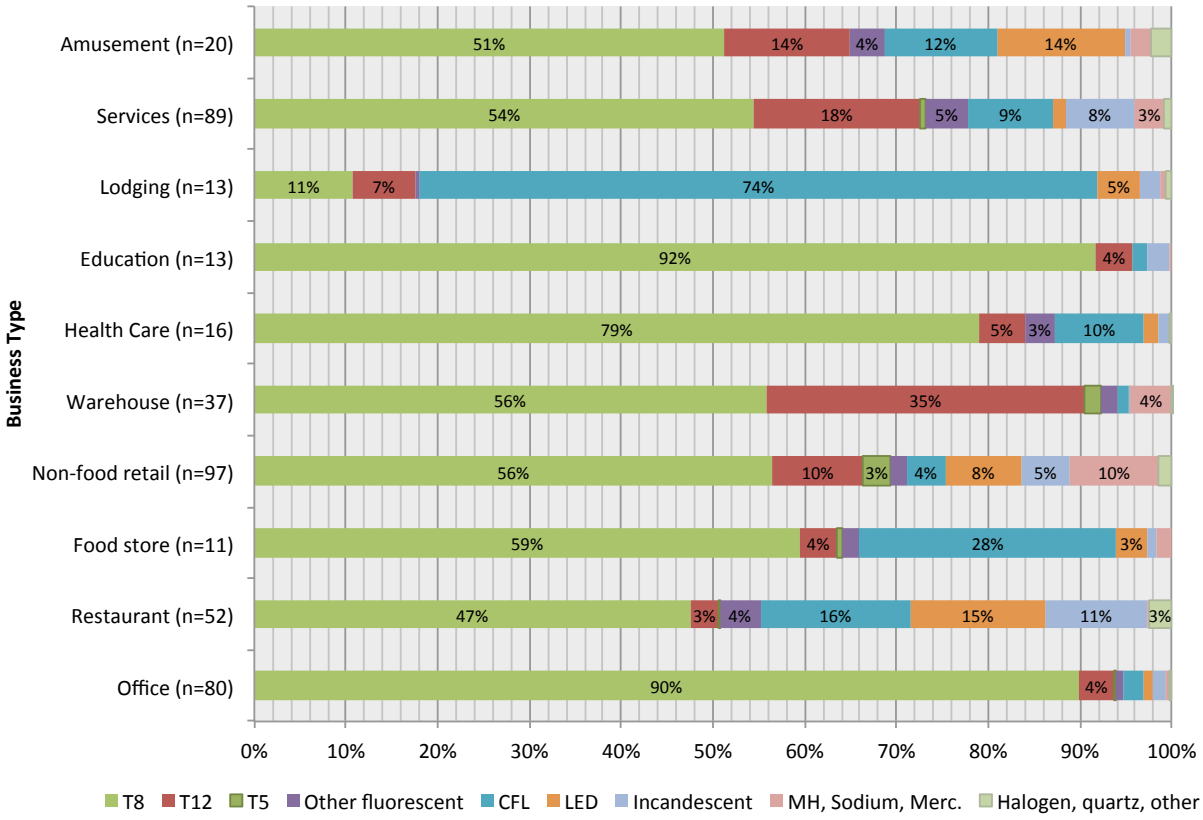


Figure 101 provides results across business types, and shows that the share of T8 and T5 lamps is highest in the office and education sectors, while warehouses have the greatest percentage of T12 lamps (35%), indicating that there may still be opportunities to encourage upgrades to more efficient linear fluorescents in this sector. Another sector with potential is services, which still shows a relatively high proportion of T12s (18%) and incandescent bulbs (8%).

Figure 101 – Distribution of Installed Lighting Technologies, by Business Type



One area where efficient lighting practices have made only limited inroads is control strategies. As shown in Figure 102, few businesses overall and across counties use anything other than on-off switches to control lights. While roughly one-fourth of businesses on all islands used some form of automated controls (i.e., automation systems, occupancy sensors and time clocks), the nature of those controls varied by county. Buildings on Oahu and Maui were more likely to control lighting using a photo cell, while Hawaii businesses were twice as likely as others to use occupancy sensors. For Figure 102 and Figure 103, note that we are using data from both on-site and mail surveys.

Figure 102 – Lighting Control Strategies, by County

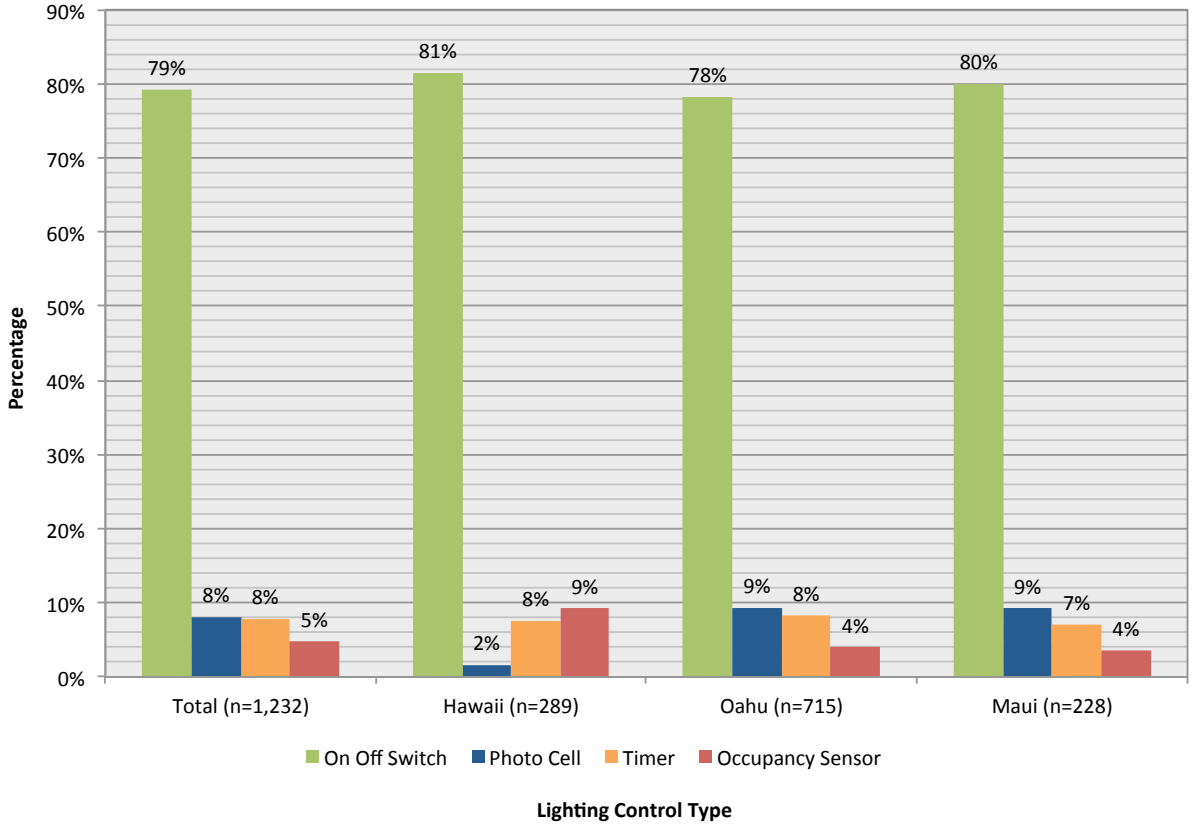
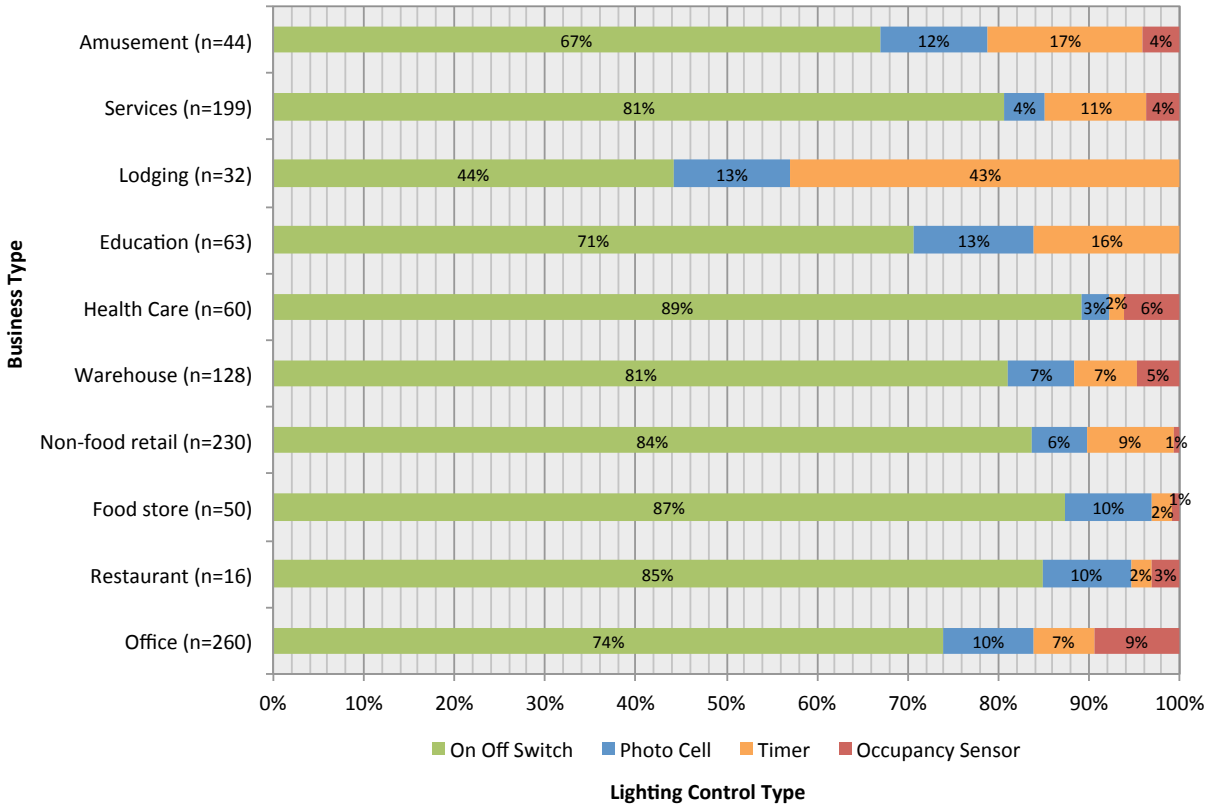


Figure 103 presents similar data for the different business types. Lodging has by far the lowest percentage of on-off switch controls and the highest percentage of facilities using timers. Offices are the most likely to use occupancy sensors, while education and lodging have the highest percentage of facilities using photocells, although these differences are not statistically significant compared to most other segments.

Figure 103 – Lighting Control Strategies, by Business Type



Overall, the results show that many business customers in Hawaii have embraced energy efficient lighting technologies, but that control strategies to manage lighting use remain unsophisticated in most sectors.

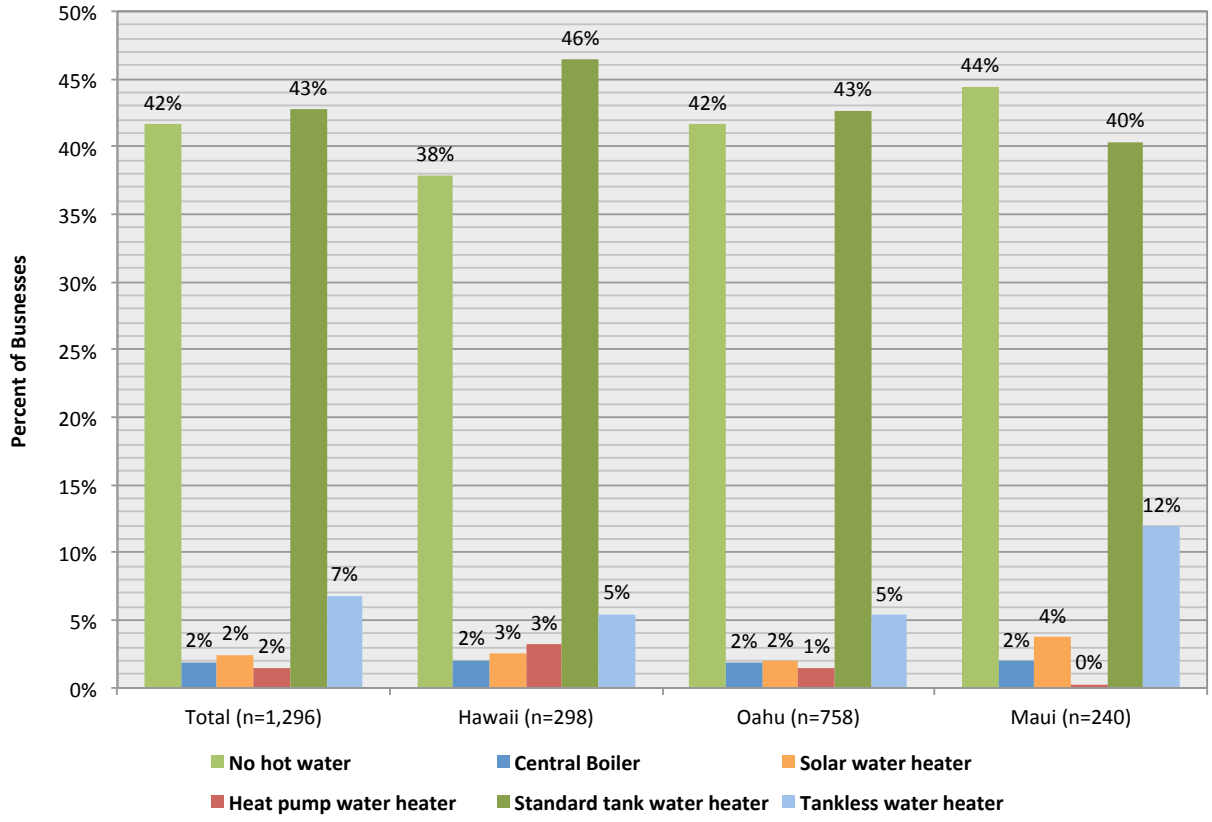
5.5 Water Heating

The next set of exhibits focuses on characteristics observed regarding water heating equipment. First, we present results on the percentage of buildings with various types of hot water equipment, as well as the percentage using electricity to heat water. Overall, electricity provides the heat source for about 70 percent of buildings with hot water, while propane fuels hot water heating for eight percent, natural gas for seven percent, and solar for four percent.

Figure 104 on the next page shows the percentage of business buildings with various types of water heating equipment overall and by county. Note that more than 40 percent of buildings have no hot water – a percentage that ranges from 38 percent for Hawaii to 44 percent for Maui, although these differences are not statistically significant. Conventional tank storage systems are the most common water heating equipment, and can be found in about three-fourths of all building with hot water, and 42 percent of buildings overall.

Tankless or instant hot water systems are found in seven percent of buildings, followed by solar and heat pump systems. Maui has the highest percentage of buildings with solar (4%), while Hawaii has the highest percentage of heat pump hot water systems (3%).

Figure 104 – Water Heating Type, by County



Comparing by business type, the largest percentage of buildings with hot water equipment is in the lodging sector, at 97 percent, as shown in Figure 105. Other sectors with high percentages of hot water use include amusement, education, services, health care and warehouses. The lodging sector also has the highest proportion of buildings with heat pump (12%) and solar (8%) water heaters. Education has the largest percentage of buildings with central boilers (12%), while the amusement sector has the highest percentage with tankless systems (12%).

Figure 105 – Water Heating Type, by Business Type

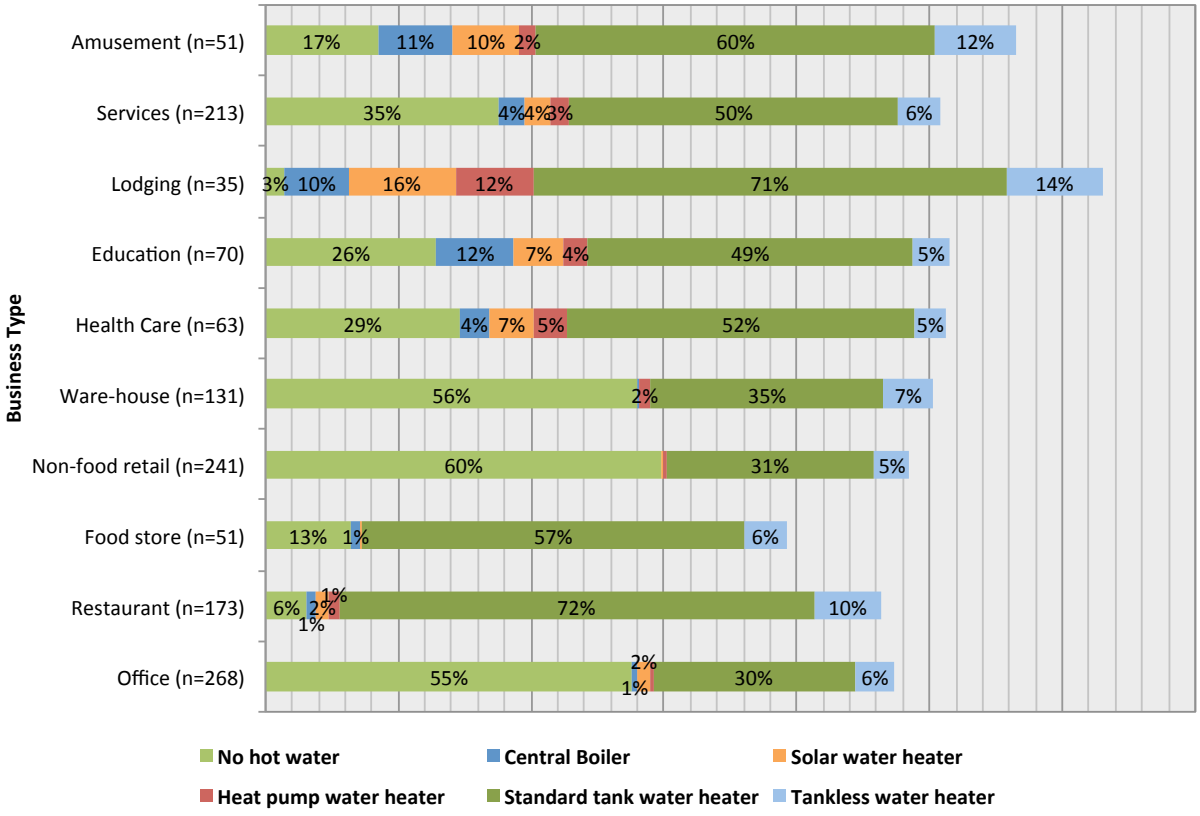
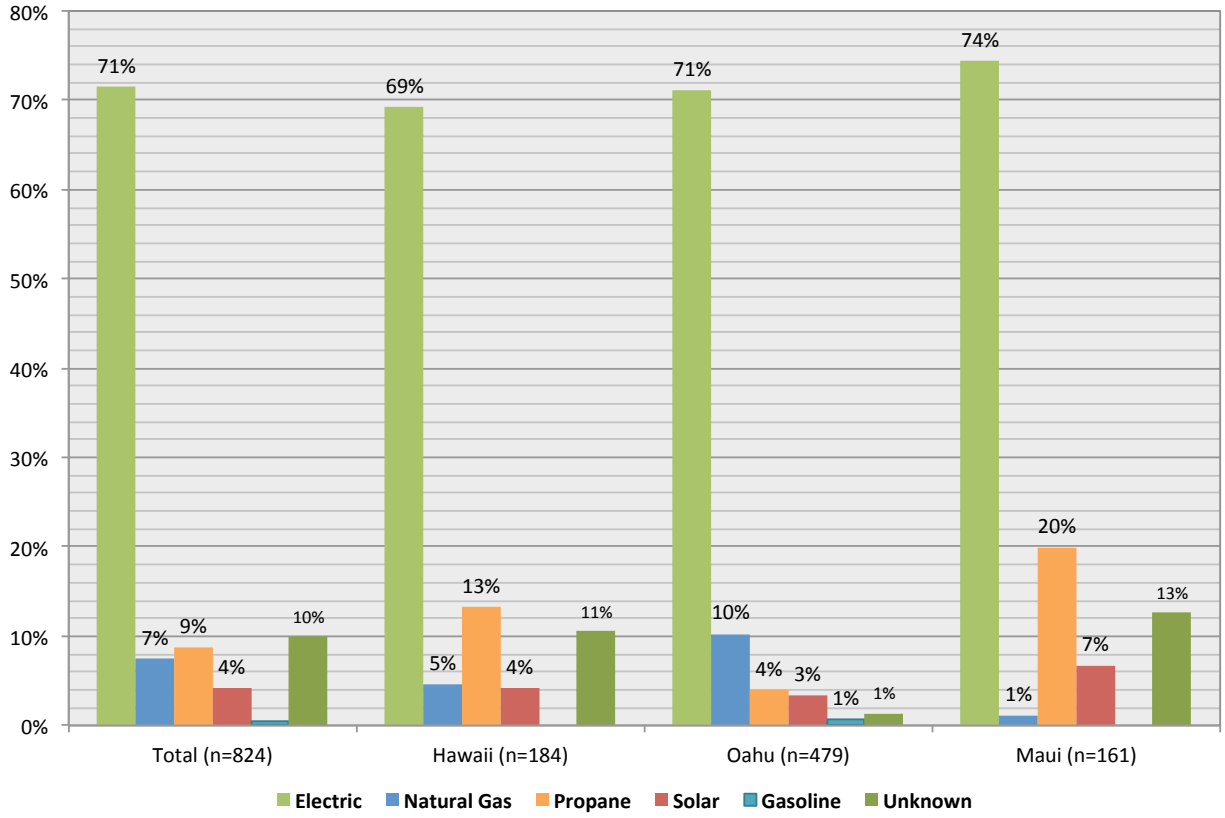


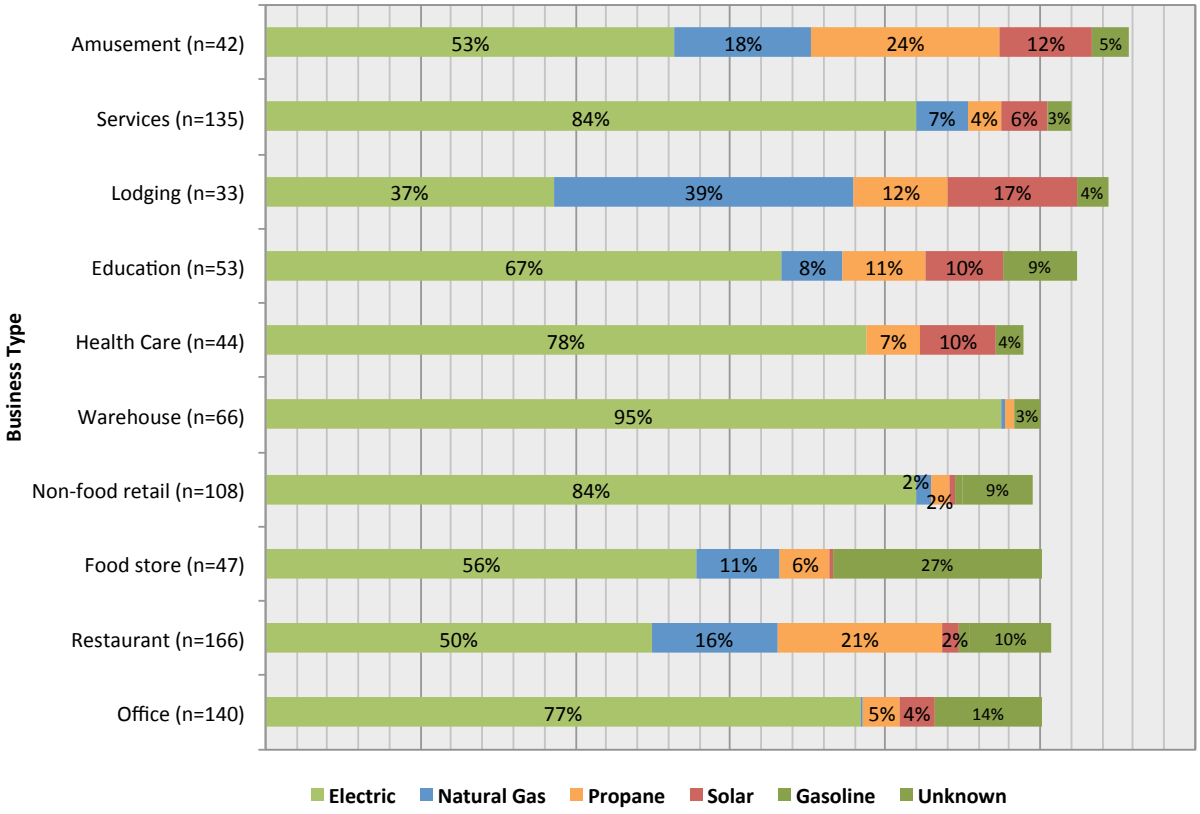
Figure 106 shows the water heater fuel types of businesses, by county. Of those buildings with hot water, more than 70 percent use electricity. Natural gas is more common on Oahu than elsewhere (10% vs. 7% overall – not a statistically significant difference), while Maui buildings have the highest share of hot water systems fueled by propane (20%) and solar (7%). For 10 percent of buildings, the fuel source was not reported or could not be determined.

Figure 106 – Water Heating Fuel Source, by County



While most business sectors use electricity as their primary hot water heating source, Figure 107 shows that the hospitality industry (restaurants and lodging) uses non-electric fuel sources in more than half of hospitality buildings that have hot water. A high percentage of restaurants use natural gas (16%) and propane (21%), while the lodging sector has more sites with natural gas than electric hot water (39% vs. 37%, not a significant difference) and also has the highest share with solar hot water (17%). At the other extreme, 95 percent of warehouses with hot water use electricity and none use solar.

Figure 107 – Water Heating Fuel Source, by Business Type



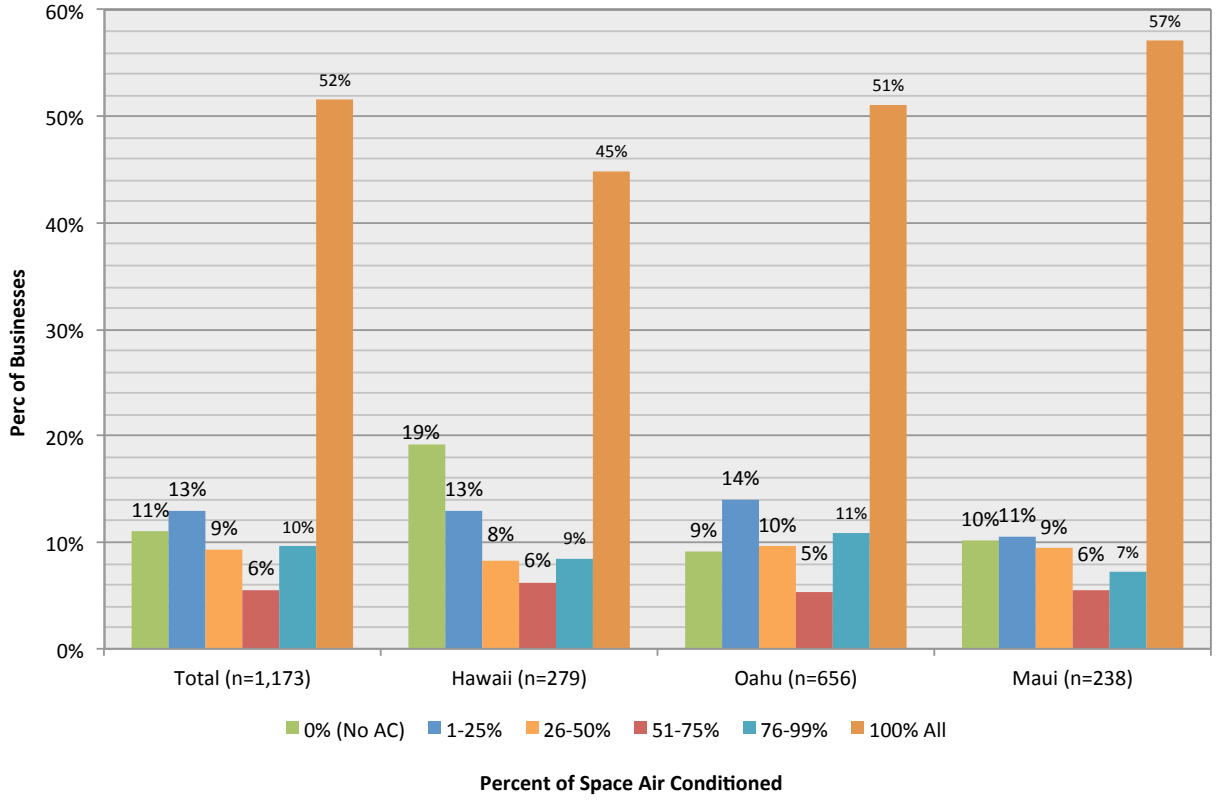
In contrast to the residential sector, where solar hot water has become relatively common, solar hot water heating is still rare in business buildings. Other efficient water heating technologies such as heat pump water heaters are also found in only a small percentage of buildings.

5.6 Space Cooling

This subsection presents results based on both the auditor observations of space cooling and responses to the mail survey. First, we present the percentage of space cooled by island/county and business type, followed by the percentage of buildings with various types of cooling equipment present, as well as the overall population of cooling equipment by number of units and by cooling capacity. Finally, we present information about control strategies being used in different buildings by county and business type.

Figure 108 shows the distribution of percentage of indoor space that is cooled for all buildings and by county. Note that the percentage of buildings with no air conditioning is almost twice as high on Hawaii as on Oahu, and Hawaii also has the lowest percentage of buildings that are 100% air-conditioned.

Figure 108 – Percent of Interior Space Cooled, Overall and by County



The percentage of cooled space by business type is presented in Figure 109, and shows that offices are least likely to have no air conditioning and most likely to have all their interior space cooled. More than 60 percent of offices, food and non-food retail stores and health care buildings have over three-fourths of their square footage cooled. In contrast, warehouses are the only sector where more than 60 percent of buildings have less than one-fourth of their square footage cooled.

Figure 109 – Percent of Interior Space Cooled, by Business Type

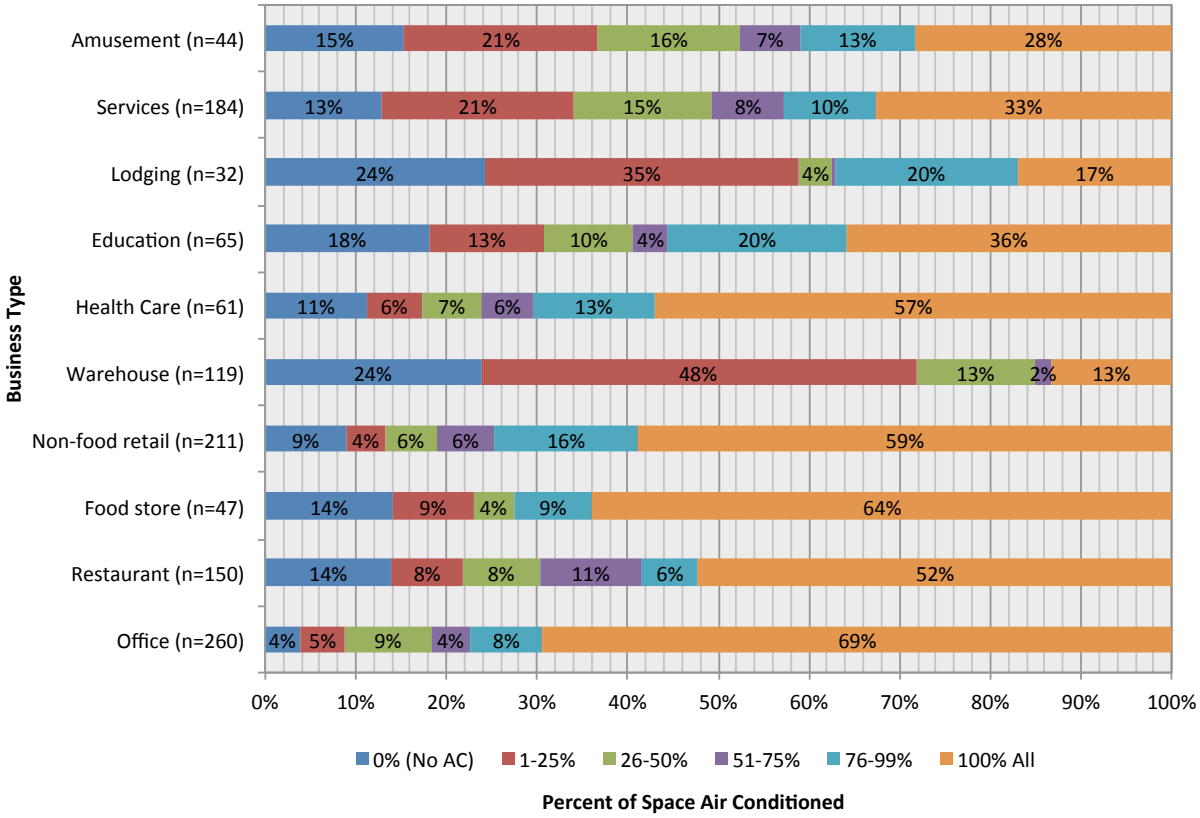


Figure 110 shows the percentage of buildings with various types of space cooling equipment, overall and by county. Split systems are most common (32%), while 26 percent of buildings have packaged units and 25 percent have room, window or wall units. Hawaii had the highest percentage of buildings with split systems (46%), while Oahu buildings were the most likely to have package units (31%). Note that the percentage of buildings with room/window/wall units showed very little variation across counties.

Figure 110 – Percent of Buildings with Cooling Equipment Types, by County

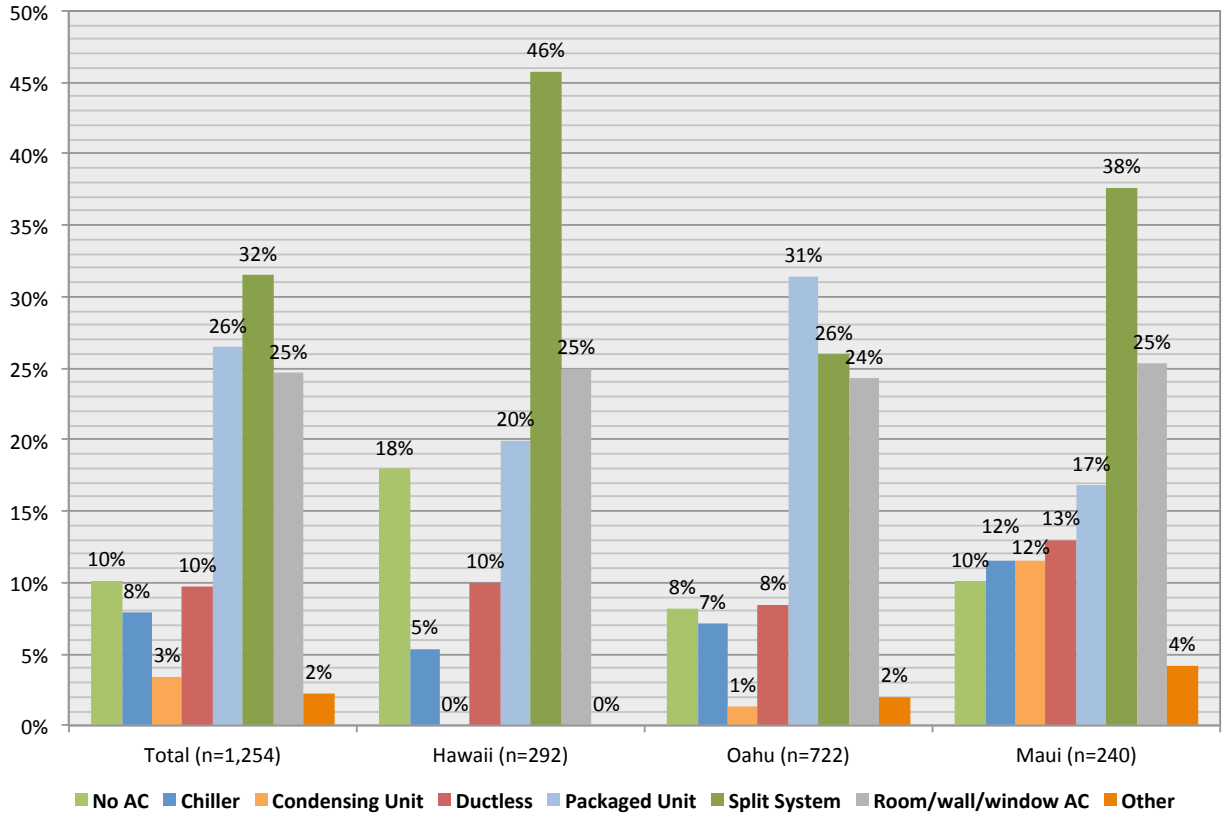
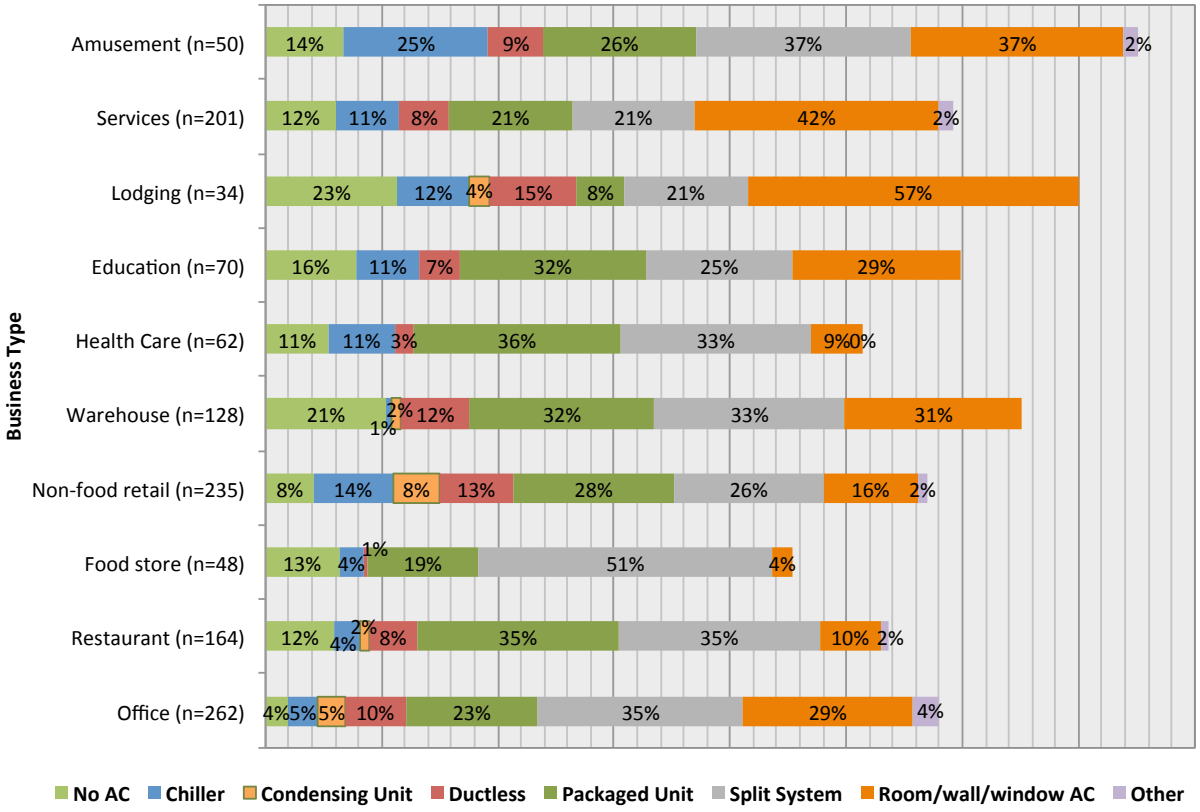


Figure 111 shows the percentage of buildings with various types of cooling equipment by business type (the percentages total more than 100 percent because some building had more than one type of cooling equipment). Amusement facilities were the most likely to have chillers, while food stores had the highest percentage of buildings with split systems (51%), and the restaurant, warehouse, health care and education sectors each had about one-third of facilities with packaged units. In contrast to the lack of variation across counties, the percentage of facilities with room/wall/window units varied widely, ranging from four percent for food stores to 57 percent for lodging.

Figure 111 – Percent of Buildings with Cooling Equipment Types, by Business Type



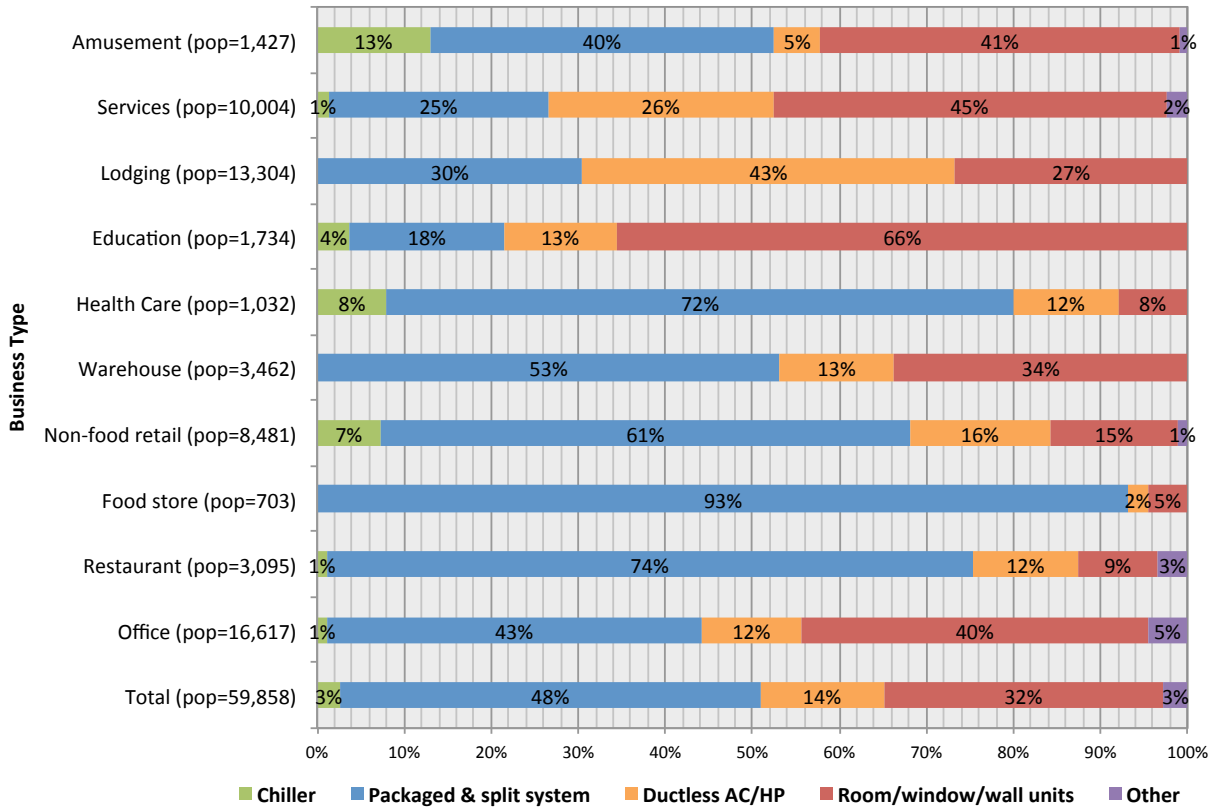
The overall distribution of the number of units of cooling equipment installed is quite different from the percentage of buildings that have a certain type of unit on the premises. For this analysis, we divided the cooling units into five categories: built-up systems (chillers); direct expansion systems (packaged and split systems), including both packaged units, split systems, and condensing units; ductless heat pump and AC systems; room/wall/window units and miscellaneous other systems. Broken down this way, Figure 112 presents the overall population of cooling equipment by island/county, and shows that packaged and split systems account for almost half of installed cooling equipment, while window/wall units account for roughly one-third and chillers for less than three percent.

Figure 112 – Percentage Distribution of Cooling Equipment Units, by County

Population of Cooling Units	Total 59,858	Hawaii 5,804	Maui 28,790	Oahu 25,265
Chiller	3%	2%	5%	2%
Packaged & split system	48 %	59%	43%	49%
Ductless AC/HP	14%	11%	15%	15%
Room/window/wall units	32%	29%	32%	33%
Other	3%	0%	5%	2%

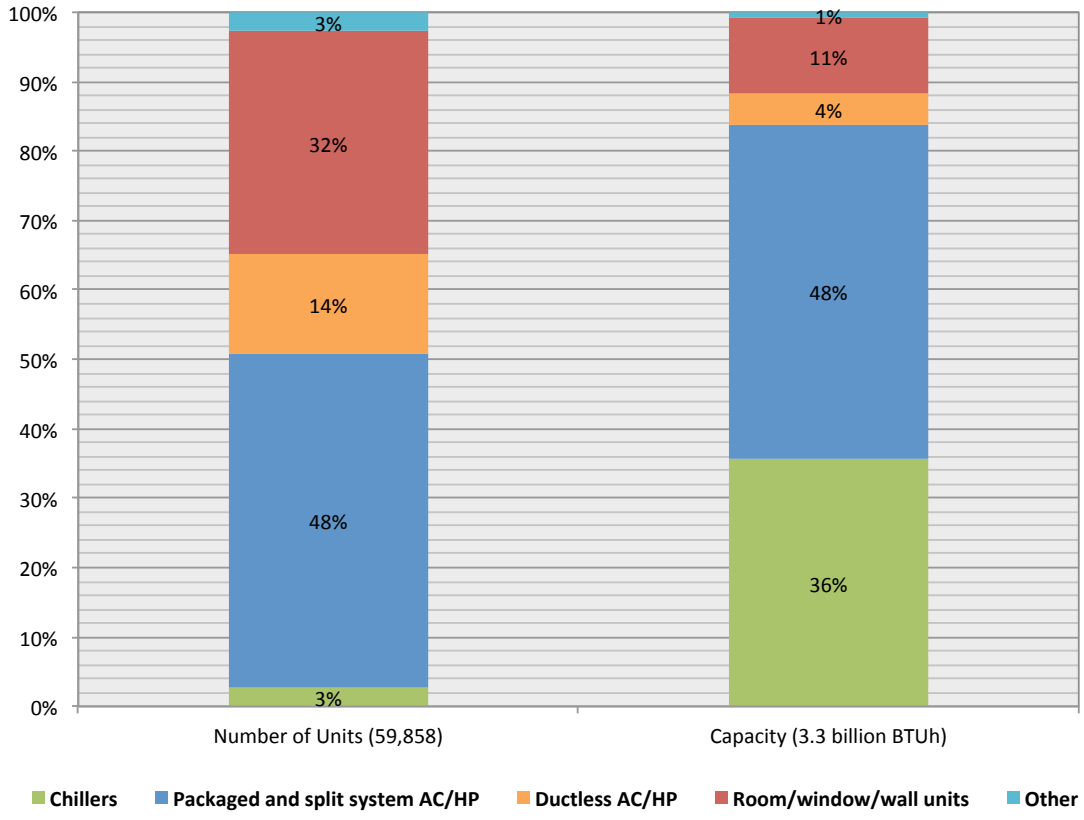
Figure 113 shows the same distribution of cooling equipment by business type, and again highlights the different types of equipment used in different industries. The retail store, health care and amusement sectors all use more chillers than other business types, while food stores overwhelmingly operate packaged and split systems, lodging facilities have more ductless unit than any other type of equipment, and room/window/wall units account for almost two-thirds of the cooling units in the education sector.

Figure 113 – Percentage Distribution of Cooling Equipment Units, by Business Type



For a subset of the equipment inventoried, capacity data were collected. The average capacity for each type of system was applied to the population of that system type to estimate the percentage breakdown of cooling capacity compared to the percentage breakdown of the number of units. Results, presented in Figure 114, indicate that while chillers make up less than two percent of the equipment at surveyed buildings, they represent more than a third of cooling capacity. In contrast, room/window/wall units account for almost one-third of the population of equipment, but only 11 percent of cooling capacity. Packaged and split systems account for both 38 percent of the population and 38 percent of capacity.

Figure 114 – Percentage Distribution of Units and Cooling Capacity



Finally, the use of various kinds of controls was investigated. Overall, the vast majority of business buildings in Hawaii use only the simplest controls, with fewer than one-third – both overall or for any of the counties – using programmable thermostats or whole building control systems, as shown in Table 22.

Table 22 – Percentage Distribution of AC Control Methods – by County

AC Control Strategies	Total n=856	Hawaii n=469	Maui n=164	Oahu n=223
On-off switch	38%	42%	27%	31%
Manual thermo	16%	16%	21%	13%
Programmable thermostat	25%	23%	30%	26%
Whole building system	5%	6%	2%	3%

A similar analysis across business types, summarized in Table 23, shows that while offices, retail stores and health care facilities all have more than 30 percent of buildings using programmable thermostats, only the office and amusement sectors have more than 10 percent of buildings with whole building automation systems.

Table 23 – Percentage Distribution of AC Control Methods – by Business Type

AC Control Strategies	On-off switch	Manual thermostat	Programmable thermostat	Whole building system
Office (n=185)	28%	21%	32%	11%
Restaurant (n=117)	40%	19%	26%	2%
Food store (n=39)	33%	17%	24%	4%
Non-food retail (n=143)	35%	14%	34%	6%
Warehouse (n=94)	38%	17%	15%	5%
Health Care (n=48)	32%	26%	31%	3%
Education (n=56)	38%	12%	29%	6%
Lodging (n=20)	37%	7%	20%	0%
Services (n=124)	56%	13%	14%	2%
Amusement (n=30)	30%	11%	20%	11%

5.7 Appliances

This subsection describes dishwashers, clothes washers and clothes dryers at the business buildings surveyed, including the frequency of buildings with each of these appliances, and where appropriate, whether they were Energy Star qualified. Most of the results are broken out by county and business type.

Figure 115 presents the percentage of buildings with each of these appliances and shows the extent to which businesses employ these traditionally "residential" measures, with 25 percent of buildings having at least one washer on site, and almost that many (21.5%) having dryers, which included both residential and commercial sized units. Electric dryers outnumber gas models by about five to one, with Hawaii having the highest percentage of gas dryers. Penetration of efficient Energy Star appliances is highest for clothes washers – particularly in Maui, where more than 80 percent of washers were Energy Star rated. While

this result appears to have been driven by a single building with a large number of Energy Star washers, it does illustrate the kinds of gains in efficient equipment penetration that can be achieved.

Overall, the percentage of efficient clothes washers is greater than that of dishwashers, but this is not the case in Hawaii or Oahu, where there are significantly higher percentages of Energy Star dishwashers than clothes washers.

Figure 115 – Penetration of Appliances and Energy Star Ratings, by County

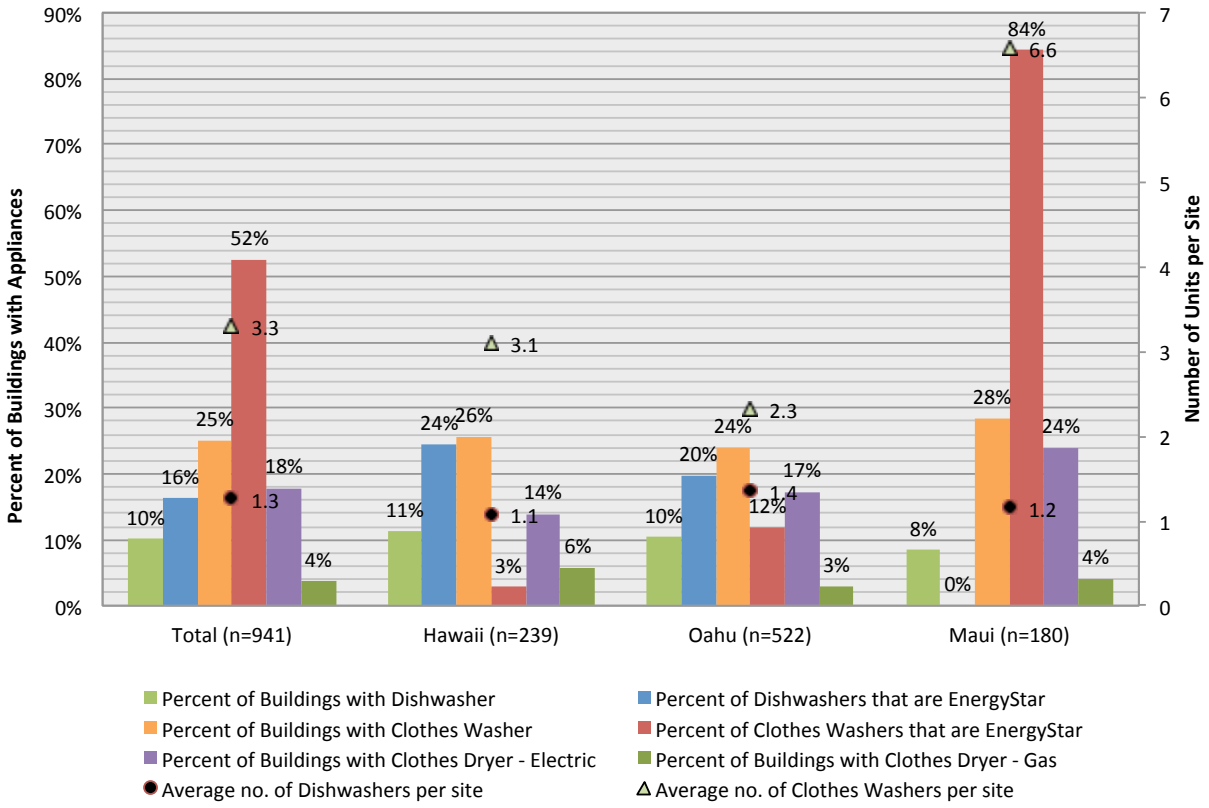
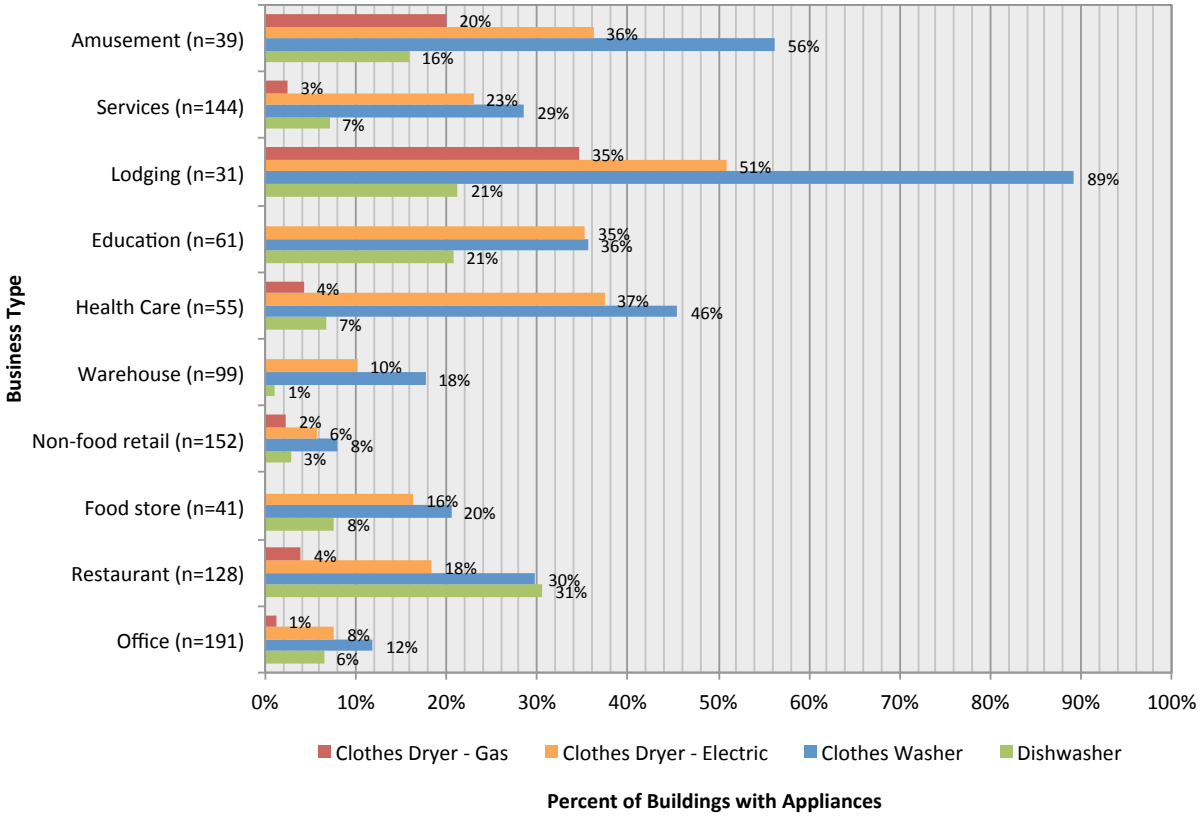


Figure 116 presents appliance penetration by business type. The figure shows that, not surprisingly, the restaurant, education and lodging sectors have the highest percent of buildings with dishwashers, while lodging has by far the highest percentage with washers and dryers – both electric and gas.

Figure 116 – Penetration of Appliances by Business Type



Finally, it should be noted that business appliances – notably clothes washers and dryers – tend to be more heavily used than are their residential counterparts. On-site survey respondents who provided an estimate of how often they used their washers and dryers reported an average of 46 wash loads and 44 dryer loads per week.

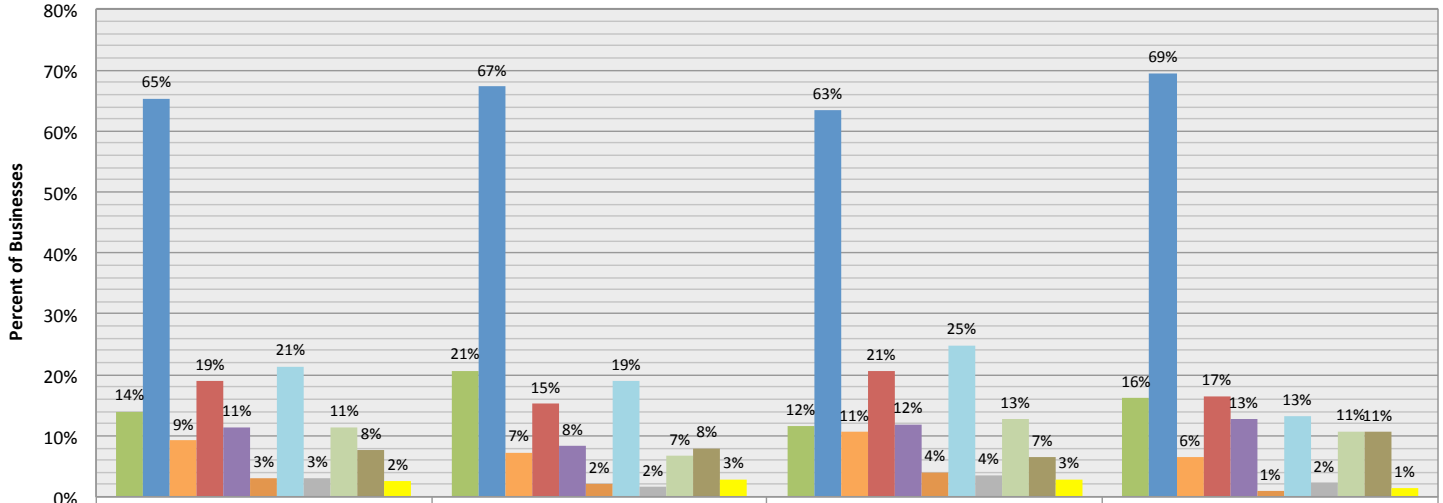
5.8 Refrigeration and Cooking Equipment

This subsection describes refrigeration and cooking equipment being used at the businesses visited and surveyed. As with appliances, a significant percentage of buildings have residential-style refrigerators, freezers and microwaves, as well as more specialized cooling and cooking equipment.

Overall, all but 14 percent of the buildings in the mail and on-site samples have some kind of refrigeration equipment, as shown in Figure 117. Residential refrigerators are found in almost two-thirds of buildings across islands/counties, while about one-fifth of sites have residential freezers. Larger commercial standalone refrigerators and freezers are the next most common measures, while fewer sites have centralized refrigeration systems associated with vertical and coffin cases and walk-in coolers/freezers. Oahu generally has a

slightly higher percentage of buildings with commercial refrigeration measures, but the differences are not statistically significant.

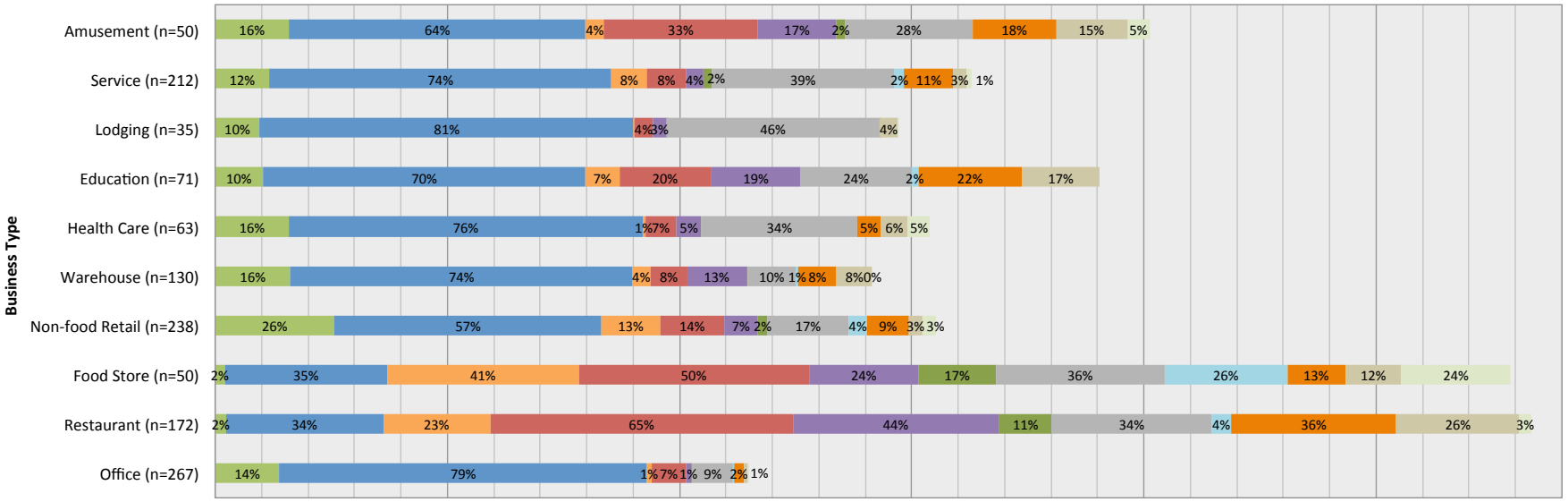
Figure 117 – Penetration of Refrigeration Equipment, by County



	Total (n=1,288)	Hawaii (n=288)	Oahu (n=754)	Maui (n=236)
No refrigeration equipment	14%	21%	12%	16%
Residential refrigerator	65%	67%	63%	69%
Vertical refrigerated cases	9%	7%	11%	6%
Commercial standalone refrigerator	19%	15%	21%	17%
Walk-in refrigerated cases	11%	8%	12%	13%
Refrigerated coffin cases	3%	2%	4%	1%
Residential freezer	21%	19%	25%	13%
Vertical frozen cases	3%	2%	4%	2%
Commercial standalone freezer	11%	7%	13%	11%
Walk-in freezer	8%	8%	7%	11%
Freezer coffin cases	2%	3%	3%	1%

Figure 118 presents the percentage of buildings with each category of refrigeration equipment by business type. Not surprisingly, food stores and restaurants have the highest penetration of refrigeration equipment overall, as well as the most buildings with commercial standalone refrigerators, walk-in and other types of cases. The education and amusement sectors both have relatively high percentages of buildings with commercial standalone and walk-in freezers. Food stores, which are most likely to have centralized refrigeration, have the highest penetration of open horizontal "coffin" cases, both refrigerated and frozen, which may provide opportunities to replace these generally inefficient cases with closed cases that use less energy.

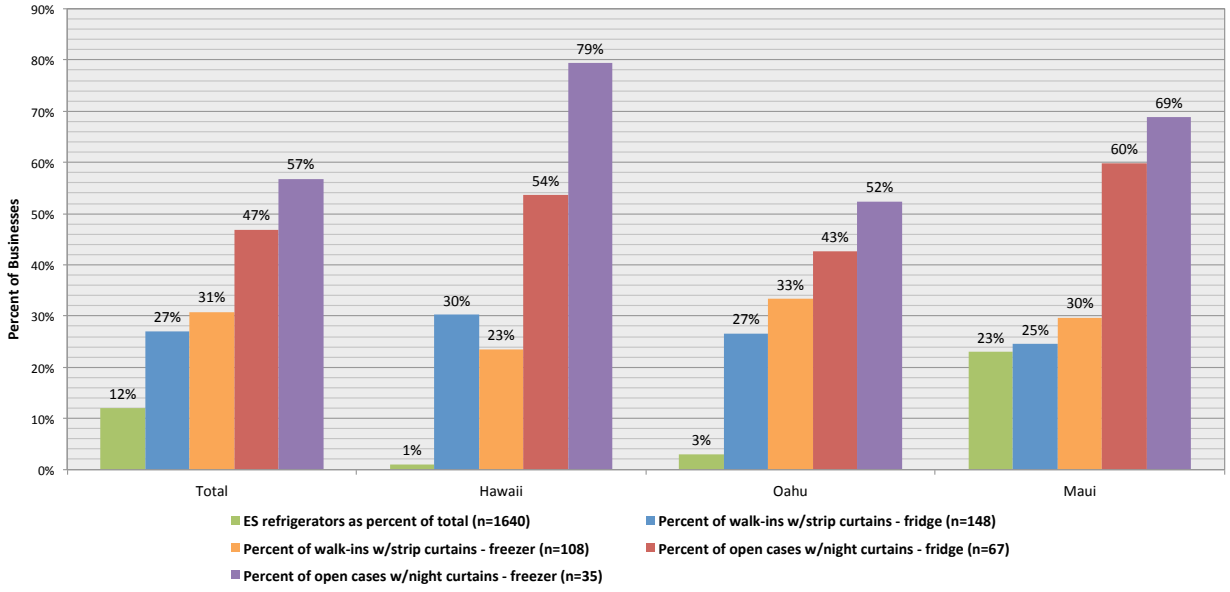
Figure 118 – Penetration of Refrigeration Equipment, by Business Type



	Office (n=267)	Restaurant (n=172)	Food Store (n=50)	Non-food Retail (n=238)	Warehouse (n=130)	Health Care (n=63)	Education (n=71)	Lodging (n=35)	Service (n=212)	Amusement (n=50)
No refrigeration equipment	14%	2%	2%	26%	16%	16%	10%	10%	12%	16%
Residential refrigerator	79%	34%	35%	57%	74%	76%	70%	81%	74%	64%
Vertical refrigerated cases	1%	23%	41%	13%	4%	1%	7%	0%	8%	4%
Commercial standalone refrigerator	7%	65%	50%	14%	8%	7%	20%	4%	8%	33%
Walk-in refrigerated cases	1%	44%	24%	7%	13%	5%	19%	3%	4%	17%
Refrigerated coffin cases	0%	11%	17%	2%	0%	0%	0%	0%	2%	2%
Residential freezer	9%	34%	36%	17%	10%	34%	24%	46%	39%	28%
Vertical frozen cases	0%	4%	26%	4%	1%	0%	2%	0%	2%	0%
Commercial standalone freezer	2%	36%	13%	9%	8%	5%	22%	0%	11%	18%
Walk-in freezer	1%	26%	12%	3%	8%	6%	17%	4%	3%	15%
Freezer coffin cases	0%	3%	24%	3%	0%	5%	0%	0%	1%	5%

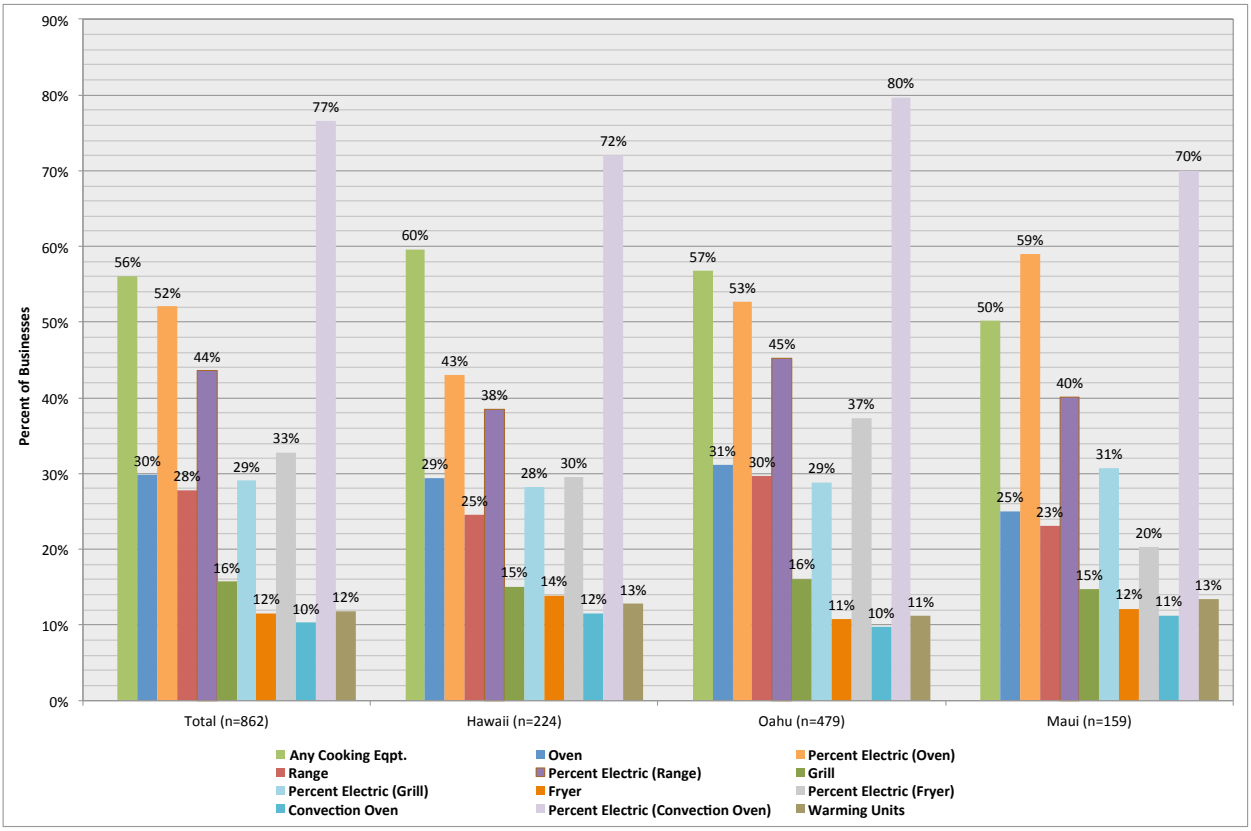
Other opportunities for improved efficiency may be evident in the extent to which certain refrigeration-related efficiency actions have or have not been implemented. At the high percentage of sites with residential refrigerators, only about 12 percent of more than 1,600 refrigerators observed by on-site auditors carry the Energy Star label. Figure 119 shows the percentage of Energy Star refrigerators, as well as the incidence of other efficiency actions such as the use of strip curtains on walk-in coolers/freezers and the use of night curtains on open cases. For both walk-in and open cases, the use of strip curtains or night curtains is generally (but not significantly) higher for freezer cases than refrigerator cases, suggesting that business owners recognize the greater cost of keeping these units at the required temperature.

Figure 119 – Penetration of Energy Efficiency Measures



Cooking equipment also has a high penetration rate among business sites across the state. As shown in Figure 120, more than half of sites on all three islands/counties have some kind of cooking equipment. Microwave ovens are the most common type of equipment, and are found at 49 percent of sites overall, with an average of 1.4 units per site. Conventional ovens and ranges also have relatively high market penetration, with more than 25 percent of buildings having an average of 1.5 ranges and two ovens on site. The percentage of electric rather than gas units for cooking equipment ranges from more than 85 percent for warming units to less than 30 percent for grills/griddles.

Figure 120 – Penetration and Fuel Source of Cooking Measures

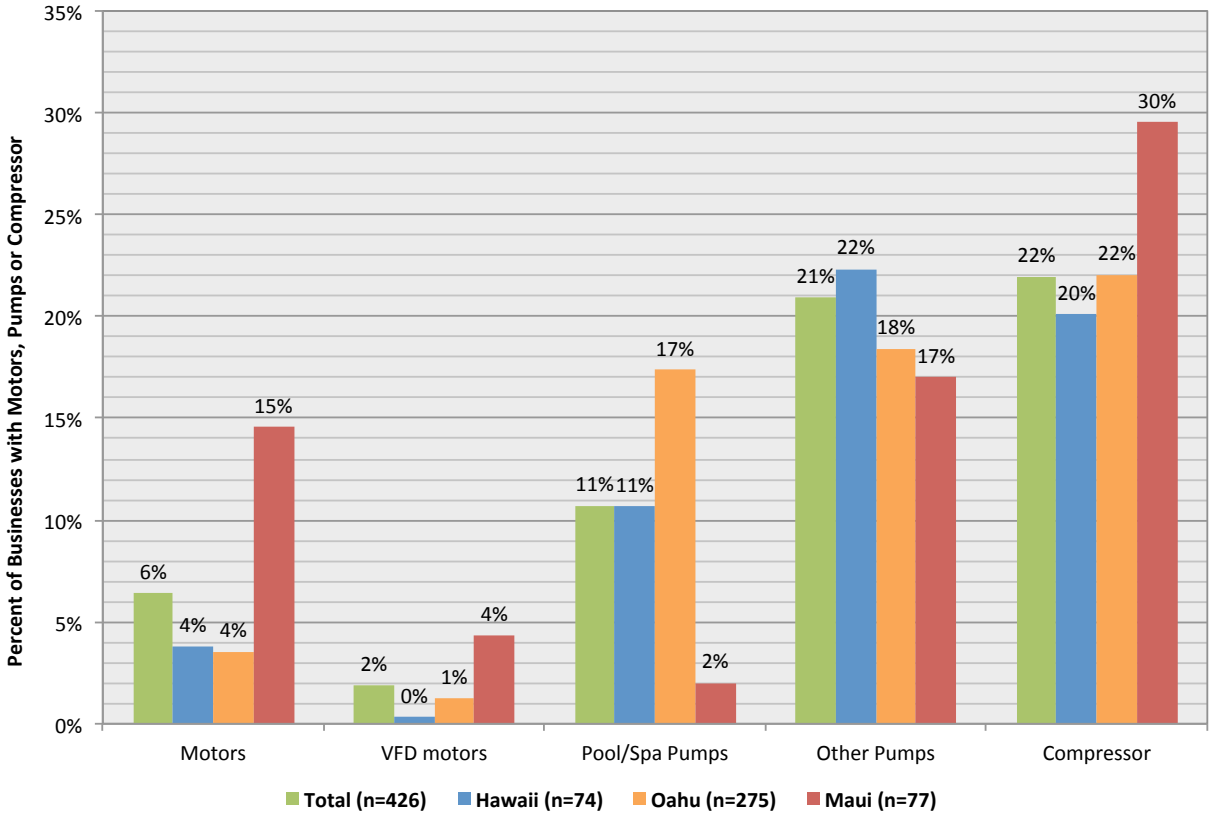


5.9 Motors, Compressors and Pumps

Motors, compressors and pumps are potentially significant users of energy at commercial sites, and both the mail and on-site surveys collected data on the presence of such equipment at business sites. Results presented here are from the on-site survey for motors and variable frequency drives (VFDs), and from the mail survey for pumps and compressors.

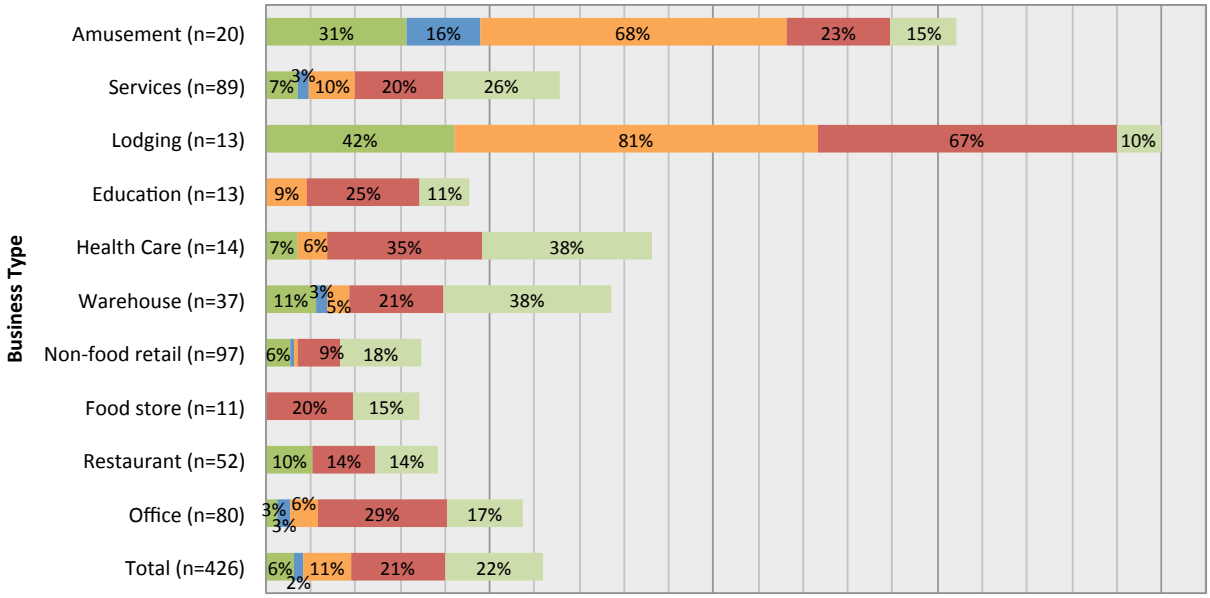
Figure 121 presents the percentages of buildings with various types of pumps, compressors, motors and VFDs. As shown by the data, both compressors (an average of 1.6 units per site) and non-pool pumps (an average of 1.7 units) were reported at more than one-fifth of sites. In contrast, only 6 percent of buildings had motors, but those that do have an average of 9.3 per site. Both the percentage of buildings with VFDs (2%) and the average number of units (4.2) were lower than for motors alone. Maui had the highest percentage of buildings with compressors (30%), motors (15%) and motors with VFDs (4%); Hawaii had the most non-pool pumps (22%), and Oahu the highest percentage of pool/spa pumps (17%), although most of the differences between counties are not statistically significant.

Figure 121 – Buildings with Motors, Pumps and Compressors, by Island/County



As expected, the percentage of buildings with different motor-related equipment varies by business type, as illustrated in Figure 122. Lodging and amusement facilities both have a significantly higher percentage of buildings with pool pumps and motors than other sectors, but while over half the amusement facilities with motors also have VFDs, none of those in the lodging sector do. More than one-third of warehouses and health care buildings have compressors, as do about one-fourth of sites in the service sector; no other business type had compressors at more than 20 percent of buildings.

Figure 122 – Buildings with Motors, Pumps and Compressors, by Business Type



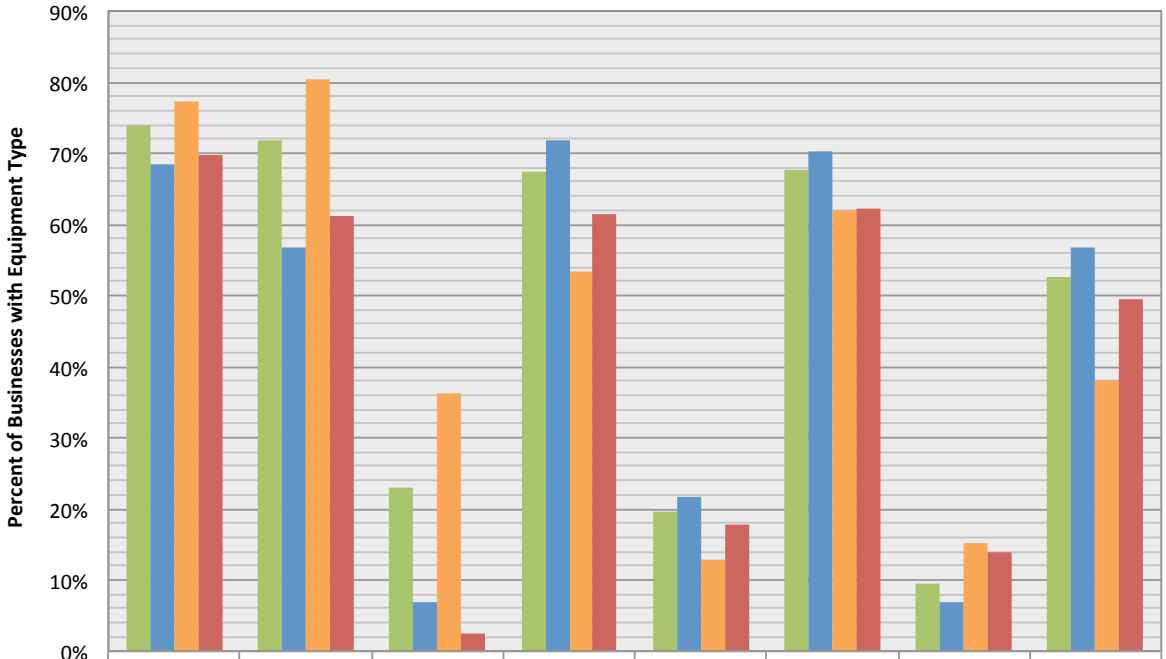
	Total (n=426)	Office (n=80)	Restaurant (n=52)	Food store (n=11)	Non-food retail (n=97)	Warehouse (n=37)	Health Care (n=14)	Education (n=13)	Lodging (n=13)	Services (n=89)	Amusement (n=20)
Motors	6%	3%	10%	0%	6%	11%	7%	0%	42%	7%	31%
VFD motors	2%	3%	0%	0%	1%	3%	0%	0%	0%	3%	16%
Pool/Spa Pumps	11%	6%	0%	0%	1%	5%	6%	9%	81%	10%	68%
Other Pumps	21%	29%	14%	20%	9%	21%	35%	25%	67%	20%	23%
Compressor	22%	17%	14%	15%	18%	38%	38%	11%	10%	26%	15%

5.10 Computers, Electronics and Miscellaneous

Because commercial buildings have a variety of equipment types that do not fall into the usual end use categories, this section briefly presents information about the extent to which some of those non-standard measures were found or reported at various surveyed sites. Figure 123 and Figure 124 show the percentage of sites, overall and by island/county, that have various items on the premises. The results show that more than three-fourths of buildings have computers (an average of 11.6 units), printers/copiers (an average of 4.5 units), televisions (an average of 6.1 TVs) and audio equipment (an average of 2.6 units), and about half have battery charging equipment. Miscellaneous office equipment was reported at 23 percent of buildings overall, but at more than one-third of Oahu buildings and less than 10 percent of Hawaii and Maui buildings. Fewer sites have medical (20%) or broadcasting (9%) equipment.

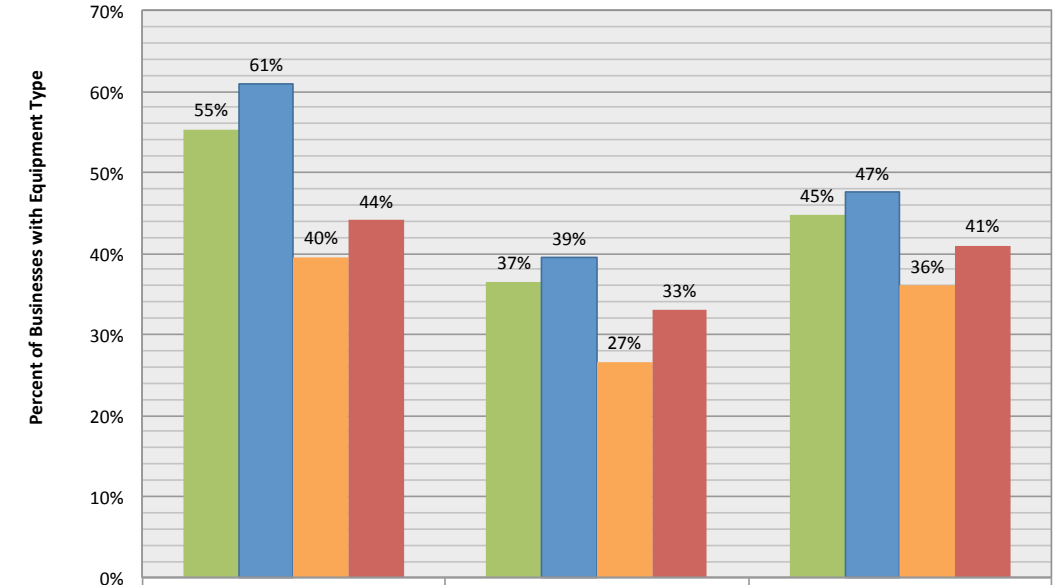
More than half of buildings have drinking fountains/water coolers, while about one-third have vending machines and 45 percent have ice machines.

Figure 123 – Buildings with Miscellaneous Electronic Equipment



	Computer	Copier/ scanner/printer	Misc. Office Equipmt.	TVs	Medical Equipment	Audio Equipment	Broadcasting Equipment	Battery Charger
Total (n=426)	74%	72%	23%	68%	20%	68%	9%	53%
Hawaii (n=74)	69%	57%	7%	72%	22%	70%	7%	57%
Oahu (n=275)	77%	80%	36%	53%	13%	62%	15%	38%
Maui (n=77)	70%	61%	3%	61%	18%	62%	14%	49%

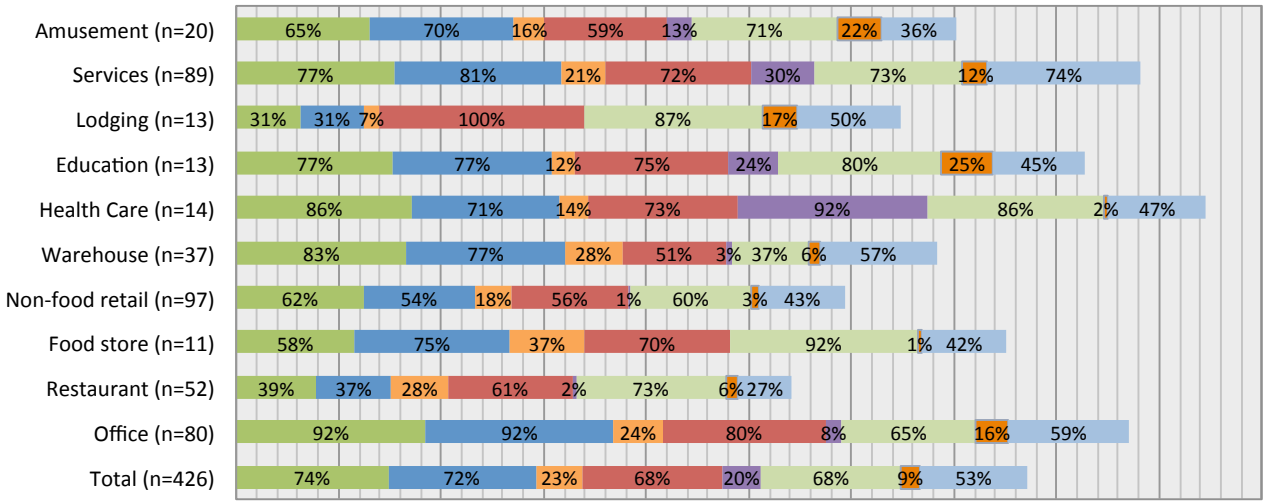
Figure 124 – Buildings with Miscellaneous Non-Electronic Equipment



	Drinking Fountain/water cooler	Vending Machine	Ice Machine
Total (n=426)	55%	37%	45%
Hawaii (n=74)	61%	39%	47%
Oahu (n=275)	40%	27%	36%
Maui (n=77)	44%	33%	41%

The sometimes dramatic variation in the presence of these miscellaneous items across business types is shown in Figure 125 and Figure 126. More than 90 percent of office buildings have computers and printers/copiers, but fewer than one-third of sites in the lodging sector do. On the other hand, almost 100 percent of lodging sites have TVs, compared to only about half of warehouses. Similarly, more than 92 percent of health care buildings have medical equipment, as do 24 percent of schools and 30 percent of buildings in the service sector, but most other sectors have fewer than 10 percent of buildings with this equipment.

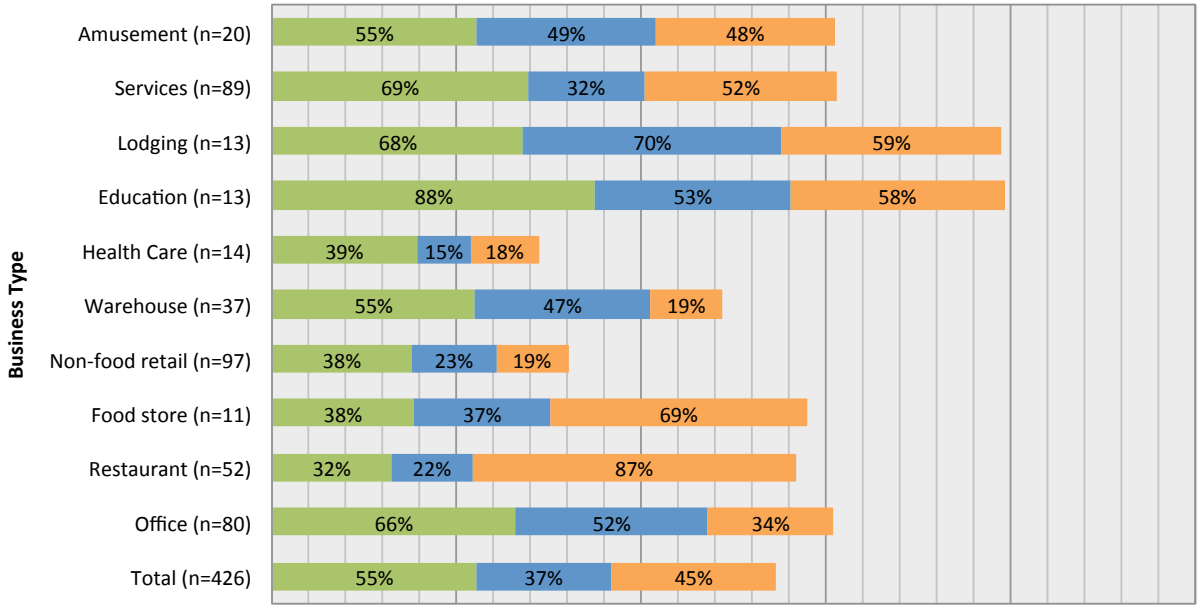
Figure 125 – Buildings with Miscellaneous Electronic Equipment



	Total (n=426)	Office (n=80)	Restaurant (n=52)	Food store (n=11)	Non-food retail (n=97)	Warehouse (n=37)	Health Care (n=14)	Education (n=13)	Lodging (n=13)	Services (n=89)	Amusement (n=20)
Computer	74%	92%	39%	58%	62%	83%	86%	77%	31%	77%	65%
Copier/scanner/printer	72%	92%	37%	75%	54%	77%	71%	77%	31%	81%	70%
Misc. Office Equipmt.	23%	24%	28%	37%	18%	28%	14%	12%	7%	21%	16%
TVs	68%	80%	61%	70%	56%	51%	73%	75%	100%	72%	59%
Medical Equipment	20%	8%	2%	0%	1%	3%	92%	24%	0%	30%	13%
Audio Equipment	68%	65%	73%	92%	60%	37%	86%	80%	87%	73%	71%
Broadcasting Equipment	9%	16%	6%	1%	3%	6%	2%	25%	17%	12%	22%
BatteryCharger	53%	59%	27%	42%	43%	57%	47%	45%	50%	74%	36%

Among non-electronic equipment types, the office building, education, lodging and amusement business types all have high penetrations of drinking fountains, vending machines and ice machines, indicating that they may be suitable targets for efficiency measures appropriate for these equipment types.

Figure 126 – Buildings with Miscellaneous Non-Electronic Equipment



	Total (n=426)	Office (n=80)	Restaurant (n=52)	Food store (n=11)	Non-food retail (n=97)	Warehouse (n=37)	Health Care (n=14)	Education (n=13)	Lodging (n=13)	Services (n=89)	Amusement (n=20)
Drinking Fountain/water cooler	55%	66%	32%	38%	38%	55%	39%	88%	68%	69%	55%
Vending Machine	37%	52%	22%	37%	23%	47%	15%	53%	70%	32%	49%
Ice Machine	45%	34%	87%	69%	19%	19%	18%	58%	59%	52%	48%

5.11 Large and Assigned Accounts

In this section, we present selected results of the on-site surveys of a sample of large and assigned accounts. The Large/Assigned account rate covers a wide variety of building types and sizes. Some buildings in our sample were indeed very large, with one site encompassing more than one million square feet. However, many sites receive service as assigned accounts not because the specific site is large, but because it is controlled or owned by an organization with multiple buildings that in aggregate have high electric usage. Our large and assigned account sample comprised both these kinds of buildings, with the result that there are dramatic differences in building size and type. Moreover, the relatively small size of the sample (n=42)[35] makes disaggregating data into island and especially business type segments problematic; given the small number of sample points, it is unlikely that any differences observed between these segments will be statistically

[35] Note that we conducted 52 on-site surveys with large/assigned customers, but 10 were with multi-family properties, which are reported in Section 5.12.

significant, and results should be interpreted as such. We will also draw some comparisons between the full large/assigned account sample to the aggregate small and medium sample discussed in the previous sections.

As some of the sites were extremely large and complex, on-site visits did not make sense for two of the largest customers: the Board of Water/Sewers (BoWS), and the four branches of the military that have bases in the state. Instead of conducting site visits, the evaluation team completed case studies for these customers to provide some meaningful data and metrics (see Section 6 for case study results).

5.11.1 Building Characteristics

Table 24 shows the distribution of building size for the sites surveyed, overall and by island, along with a comparison to the same distribution for the small and medium sample. On average, the surveyed sites are roughly a hundred times larger than those in the small-medium sample. However, not all the large/assigned account sites are on this scale; while 43 percent of the buildings are over 100,000 square feet, over one-third are in the under-25,000 square feet range typical of small and medium buildings.

Table 24 – Building Square Footage – Large Business Compared to Small-Medium

Square Feet	Large (n=42)	Small-Medium (n=1,037)
Less than 1K Square Feet	0%	19%
1K to 5K Square Feet	12%	46%
5K to 10K Square Feet	9%	14%
10K to 25K Square Feet	12%	11%
25K to 50K Square Feet	2%	5%
50K to 100K Square Feet	23%	2%
100K to 200K Square Feet	27%	1%
200K to 500 Square Feet	4%	1%
Greater than 500K Square Feet	12%	0%
Mean	1,223,294 sq. ft.[36]	12,246 sq. ft.

Table 25 shows that the sampled large/assigned account buildings are slightly newer than the larger population of small and medium sites, but the difference in mean age is not statistically significant. While somewhat fewer small-medium than large buildings are less than 10 years old, significantly fewer are over 30 years old (68% vs. 59%). Although not shown in the table, sample buildings on Oahu (average age 34) are, on average, somewhat

[36] There is one particularly large site that brings the mean up significantly. If this largest site is removed from the analysis, the mean square footage of large businesses we surveyed is approximately 307,000 square feet.

older than those on Maui and Hawaii (both 27), but again, the differences are not significant.

Table 25 – Building Vintage, Large Business Compared to Small-Medium

Vintage	Large (n=41)	Small-Medium (n=1,107)
Age > 50 Years	14%	16%
Age 31 - 50 Years	54%	43%
Age 11 - 30 Years	25%	26%
Age < 10 Years	17%	15%
Mean Building Age (Years)	31.0	34.9

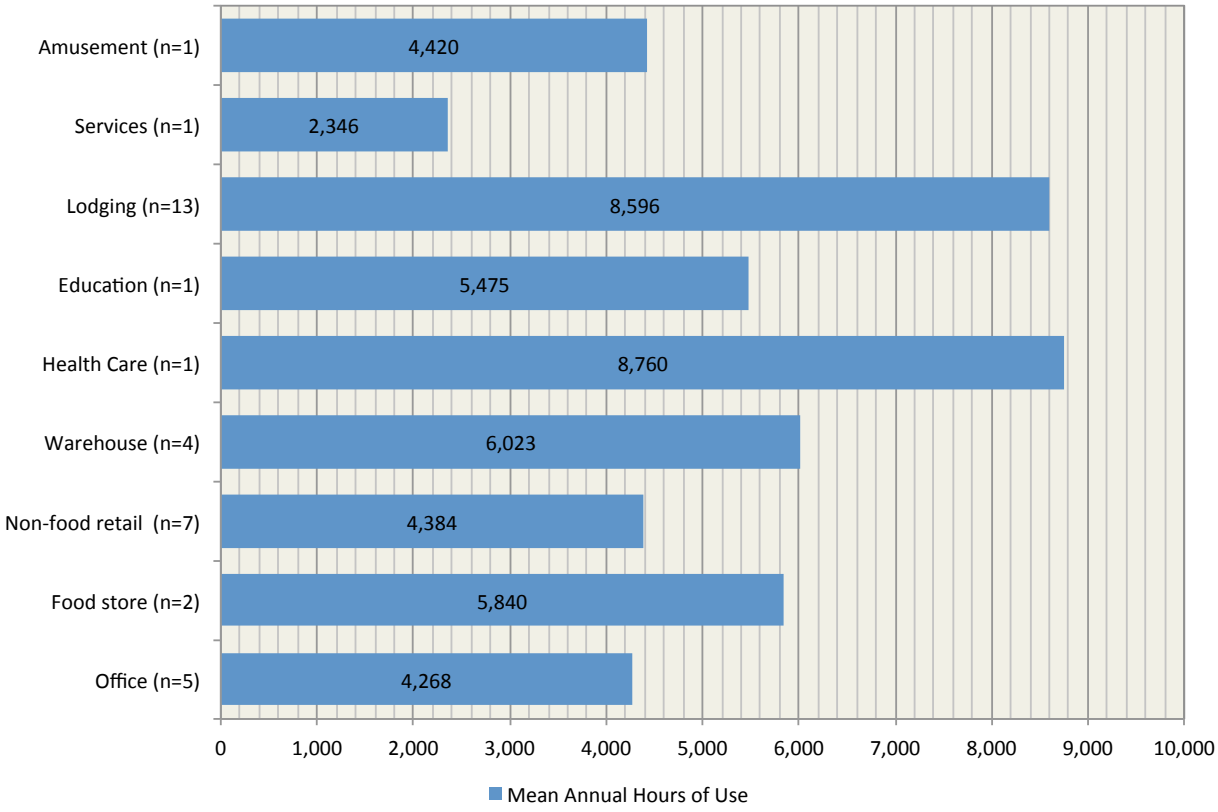
As with building size, Table 26 shows that the average number of employees for large/assigned accounts is an order of magnitude greater than for small-medium sites (241 vs. 22). Forty-three percent of the surveyed large sites have over 100 employees. On the other hand, there are 27 percent of large/assigned buildings that have fewer than 20 employees, including some offices, a warehouse, a retail store and a small hotel. None of the buildings on Maui house fewer than 50 employees, while 38 percent of buildings on Oahu have fewer than 20.

Table 26 – Number of Employees, Large Business by Island

Number of Employees	Large				Small-Medium (n=1,178)
	Total (n=40)	Hawaii (n=9)	Maui (n=7)	Oahu (n=24)	
Less than 10 Employees	16%	7%	0%	22%	52%
10 to 19 Employees	11%	4%	0%	16%	21%
20 to 29 Employees	11%	52%	0%	0%	8%
30 to 49 Employees	6%	13%	0%	4%	9%
50 to 99 Employees	14%	13%	18%	13%	7%
100 or More Employees	43%	11%	82%	45%	4%
Mean Number of Employees	241	152	376	235	22

Another characteristic of the large/assigned buildings sample that appears to differ from the small and medium group is the annual hours of operation. On average, buildings in the large sample reported being open 5,592 hours, compared to 3,521 for the small-medium group, a statistically significant difference. Average hours open by business type are presented in Figure 127, and show that the high overall average is driven in part by the relatively large number of lodging and warehouse facilities and food stores in the sample (45% of the total), all of which have high levels of annual use.

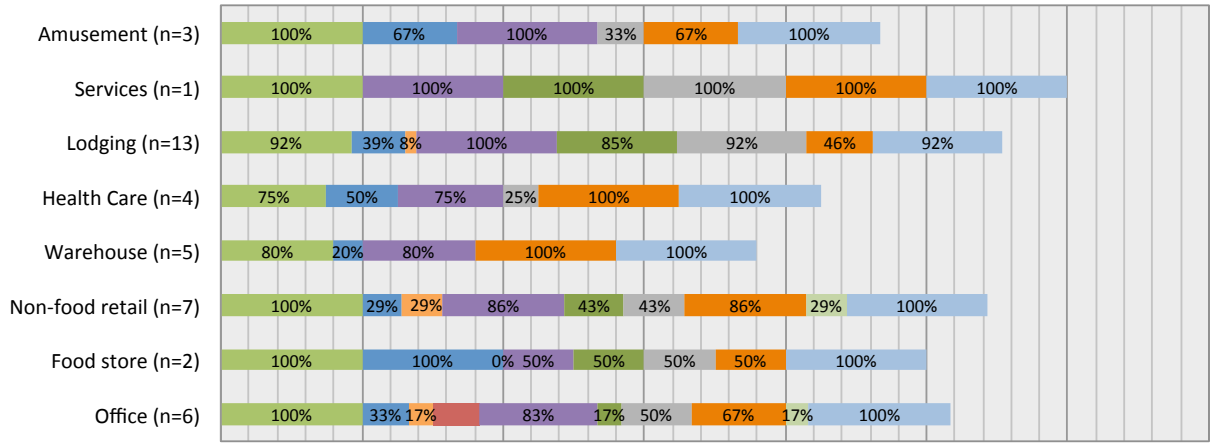
Figure 127 – Annual Hours of Use, by Business Type



5.11.2 Lighting

The percentage of large/assigned building with various lighting technologies in place is shown in Figure 128. While all sites have at least some miscellaneous lighting types classified as "other," T8s are by far the most common technology, having been recorded at 93 percent (39 out of 42) of sites. More than 80 percent of sites have CFLs and almost half have incandescent bulbs, while 37 percent of buildings have T12s and 13 percent have T5s.

Figure 128 – Lighting Technology Penetration, by Business Type

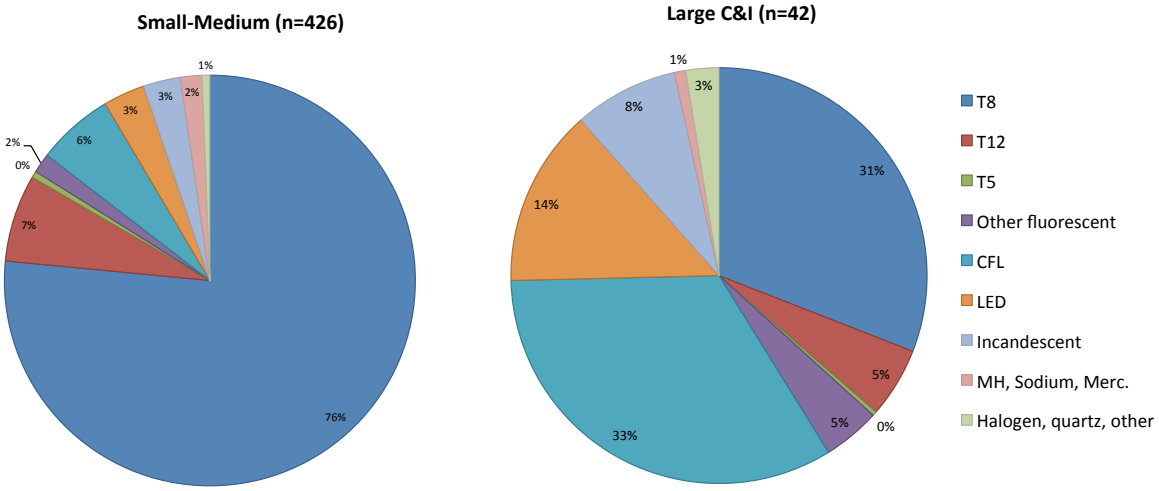


	Office (n=6)	Food store (n=2)	Non-food retail (n=7)	Warehouse (n=5)	Health Care (n=4)	Lodging (n=13)	Services (n=1)	Amusement (n=3)
T8	100%	100%	100%	80%	75%	92%	100%	100%
T12	33%	100%	29%	20%	50%	39%	0%	67%
T5	17%	0%	29%	0%	0%	8%	0%	0%
Other fluorescent	33%	0%	0%	0%	0%	0%	0%	0%
CFL	83%	50%	86%	80%	75%	100%	100%	100%
LED	17%	50%	43%	0%	0%	85%	100%	0%
Incandescent	50%	50%	43%	0%	25%	92%	100%	33%
MH, Sodium, Merc.	67%	50%	86%	100%	100%	46%	100%	67%
Quartz	17%	0%	29%	0%	0%	0%	0%	0%
Other	100%	100%	100%	100%	100%	92%	100%	100%

NOTE: the one education site was not included in the lighting chart as no lighting types were recorded due to the size of the site.

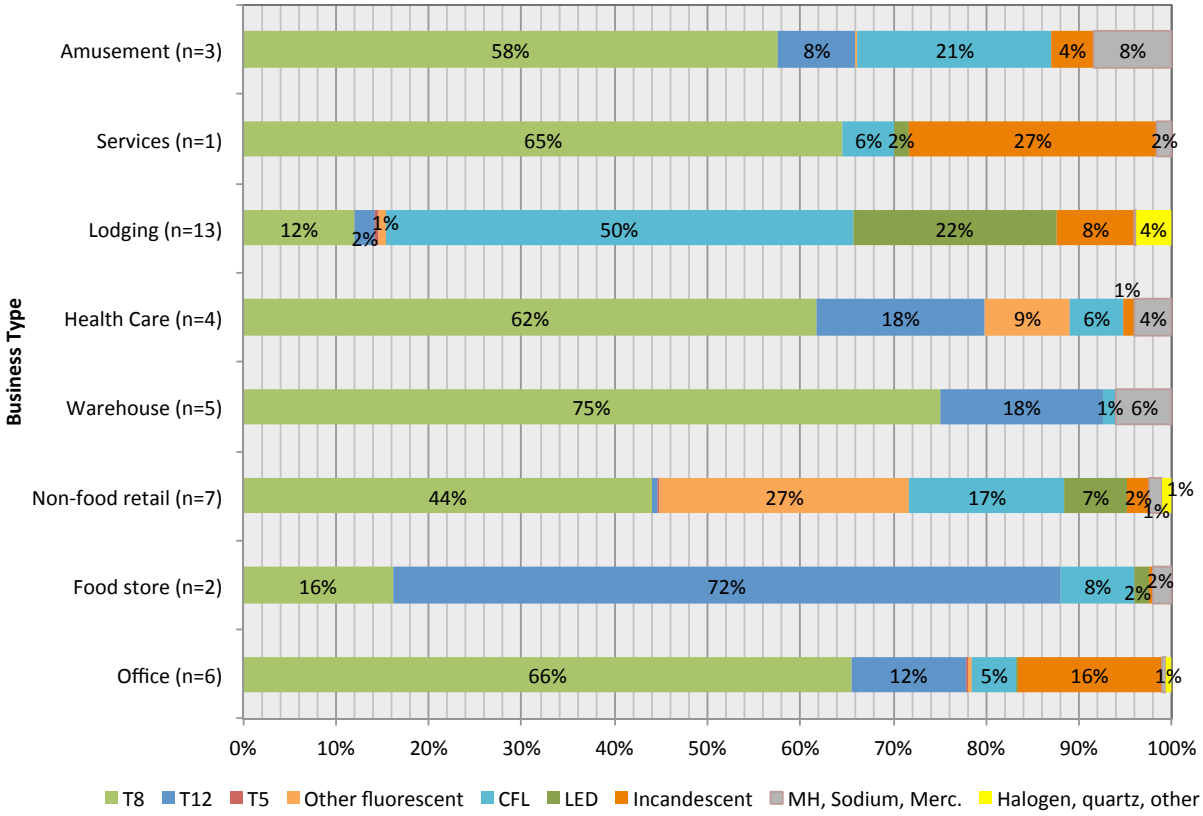
A better representation of the relative share of various lighting types is offered by the overall population of lamps for the sampled sites, presented in Figure 129. These results show that CFL lamps account for the largest share (one-third) of the lamps at the sampled large/assigned account sites, followed closely by T8 lamps, which account for 31 percent of the lighting population. Overall, T12s represent less than five percent of the lamps noted at large/assigned account sites.

Figure 129 – Population of Lighting Technologies, by Lamp Type



Results by business type, shown in Figure 130, demonstrate that the lodging sector accounts for almost 90 percent of the CFLs, confirming the extent to which guest room lighting is dominated by this technology. The prevalence of CFLs in the lodging sector was also found in the small-medium buildings, but lodging facilities account for a smaller share of the small-medium survey sites, and CFLs are therefore a smaller percentage of the total. Even outside the lodging sector, CFLs outnumber incandescent lamps in all business types except the services industry and office buildings. In most sectors, T8 lamps account for over half the lighting population, with the notable exception of two food stores that have a high proportion of T12s.

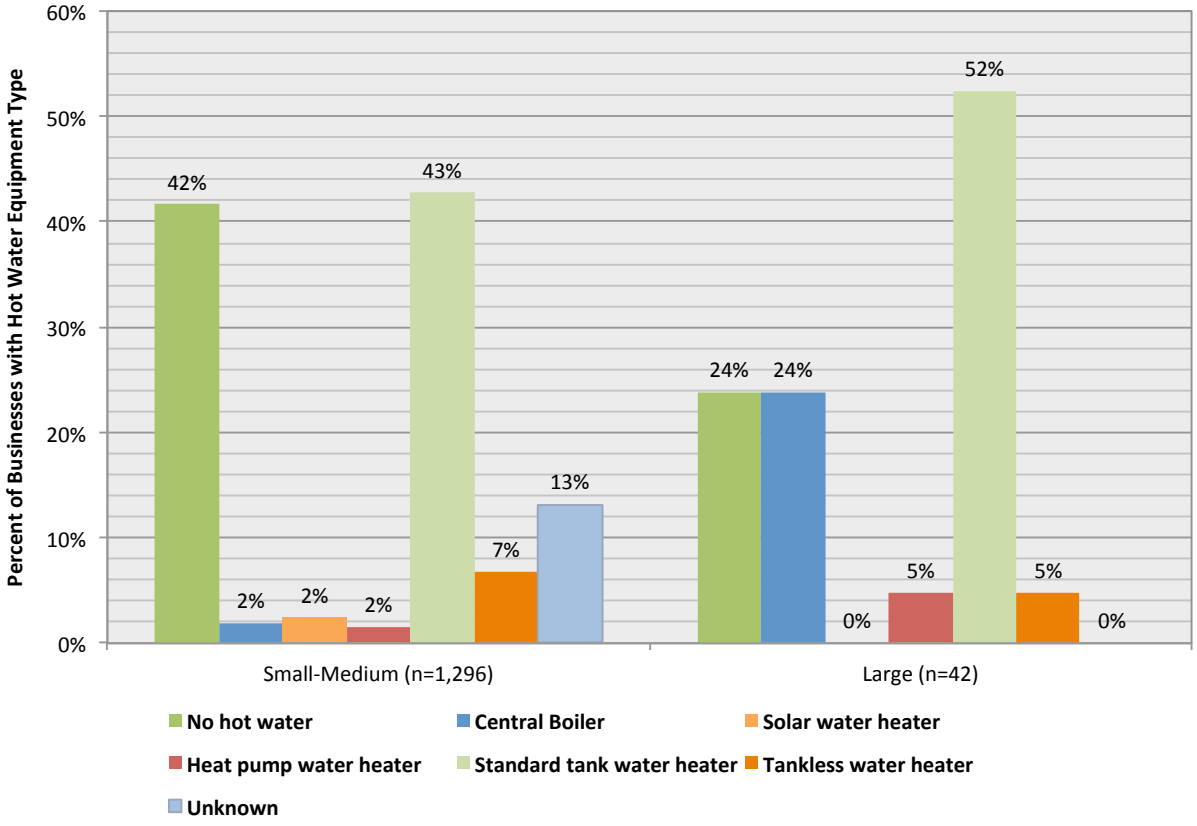
Figure 130 – Lighting Population by Lamp Type – By Business Type



5.11.3 Hot Water Heating

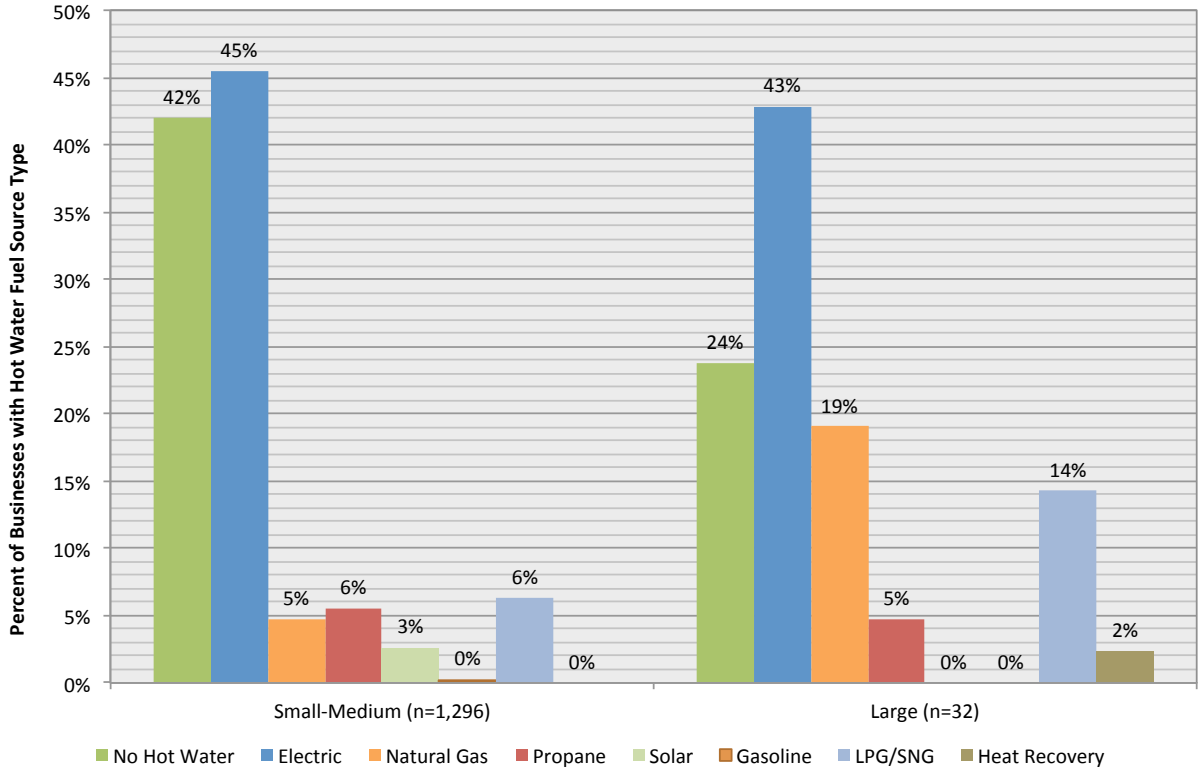
Figure 131 presents the percentage of large/assigned account sites with various types of hot water heating, and also provides the same data for the small-medium sites (presented previously in Section 4.5) as a basis for comparison. The figure shows that 24 percent of large buildings have no hot water, compared to 42 percent of small-medium sites – a statistically significant difference. Standard tank type water heaters are most common (52% of all buildings), while another 24 percent of buildings have central boilers and five percent (2 sites) have at least one tankless system. Average capacity per unit observed at the large sites is 1,456 gallons for the boilers and 450 gallons for tank style heaters, indicating that these units are significantly larger than comparable hot water heaters found at small-medium sites, where the average capacity was 237 gallons for boilers and 72 gallons for standard tank systems.

Figure 131 – Hot Water Heating Equipment – Large vs. Small-Medium



Hot water fuel sources are shown in Figure 132, illustrating that of the 76 percent of buildings with hot water, about two-thirds (43% of all buildings) use electricity, while the remainder use natural gas, liquefied propane (LP), gas and propane, in that order. Note that none of the surveyed large sites have solar as a hot water system fuel.

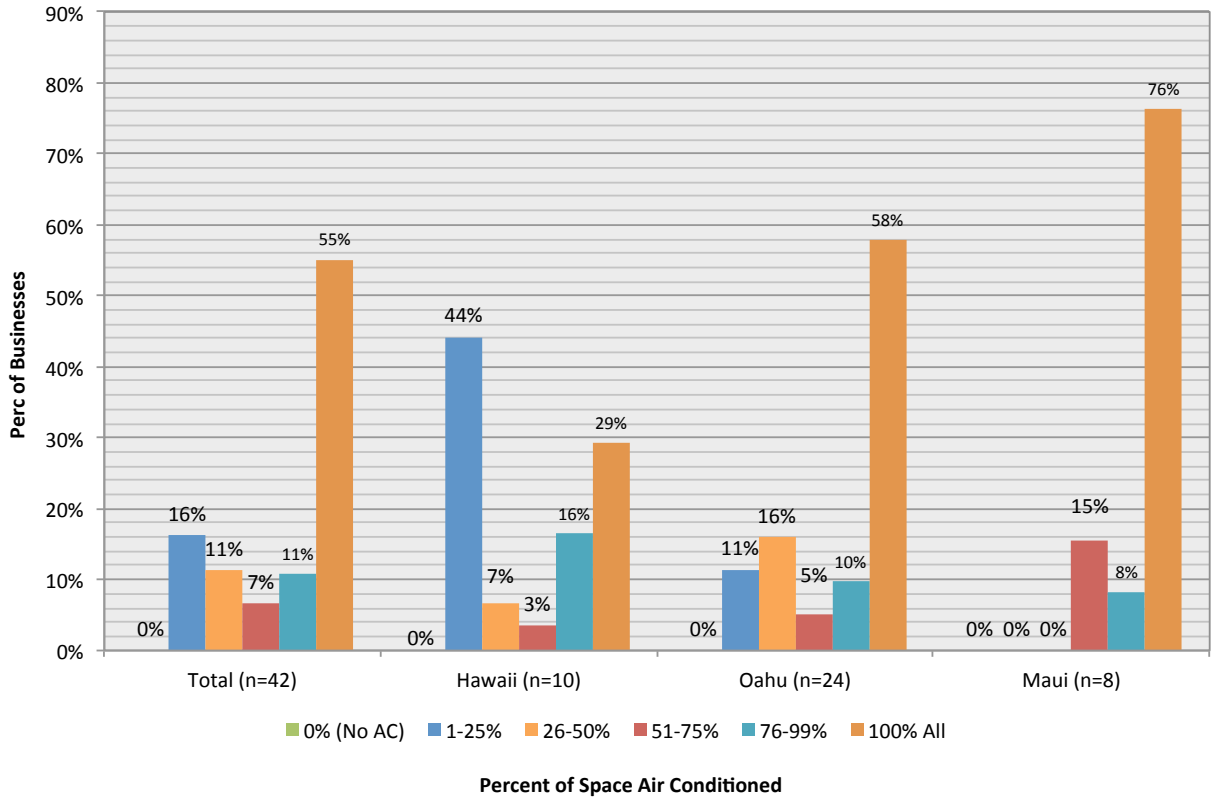
Figure 132 – Hot Water Heating Fuel Source – Large vs. Small-Medium



5.11.4 Cooling

Unlike buildings in the small-medium sample, none of the large/custom sites surveyed are without any air conditioning, as shown in Figure 133. Overall, more than half of large/assigned buildings have 100 percent of their space cooled, ranging from 29 percent in Hawaii to 76 percent in Maui.

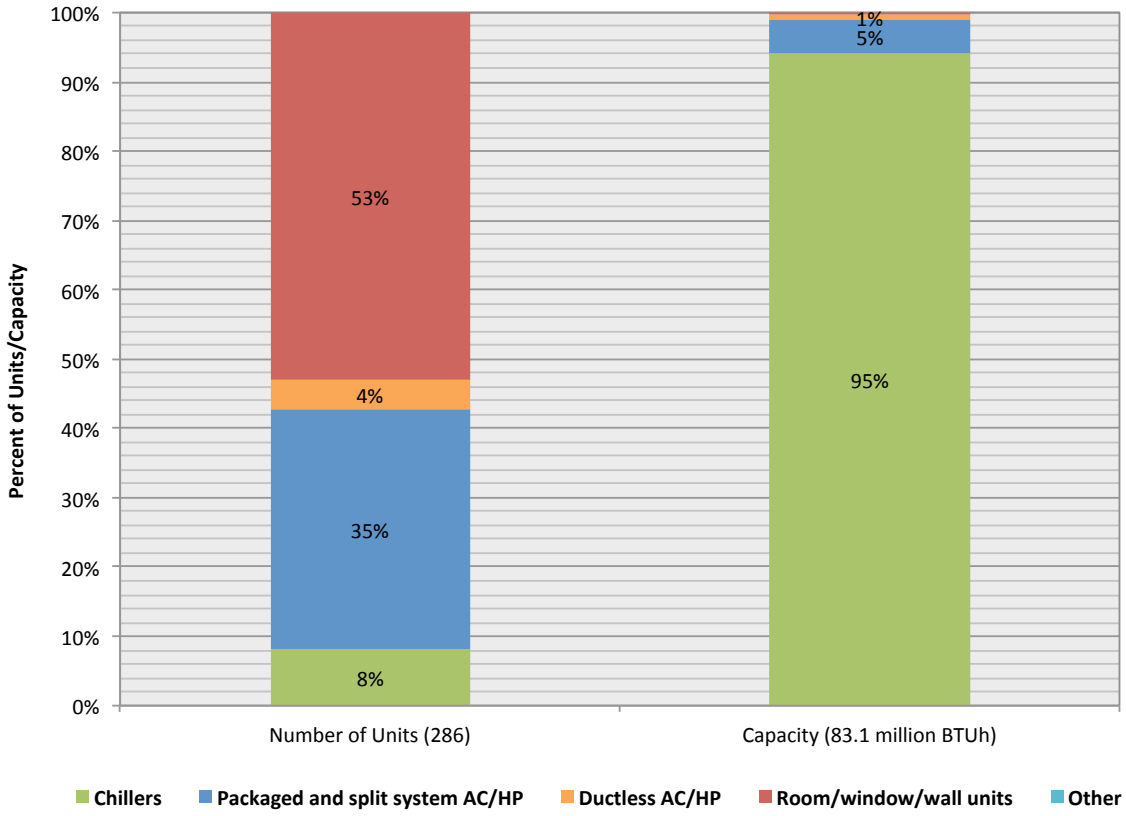
Figure 133 – Percent of Space Cooled, Overall and by Island/County



Because large businesses might have multiple cooling equipment types, we are focusing here on the total population of various kinds of cooling equipment observed by the on-site auditors. As noted in the discussion of air conditioning technologies in small and medium sites, the breakdown of the number of units and the breakdown of overall cooling capacity accounted for by various equipment types varies dramatically, so Figure 134 presents data on the percentage breakdown of both units and cooling capacity.

For the 42 large/assigned sites visited, a total of 54 chillers were observed, representing eight percent of the 667 cooling equipment units. However, these chillers account for almost 95 percent of cooling capacity. In contrast, more than 350 room/window/wall units account for less than one percent of cooling capacity. Recall that even among small-medium sites, chillers also account for more than a third of cooling capacity, meaning that for all business users, achieving efficiency gains in chiller selection and operation clearly offers significant potential for savings in the cooling end use.

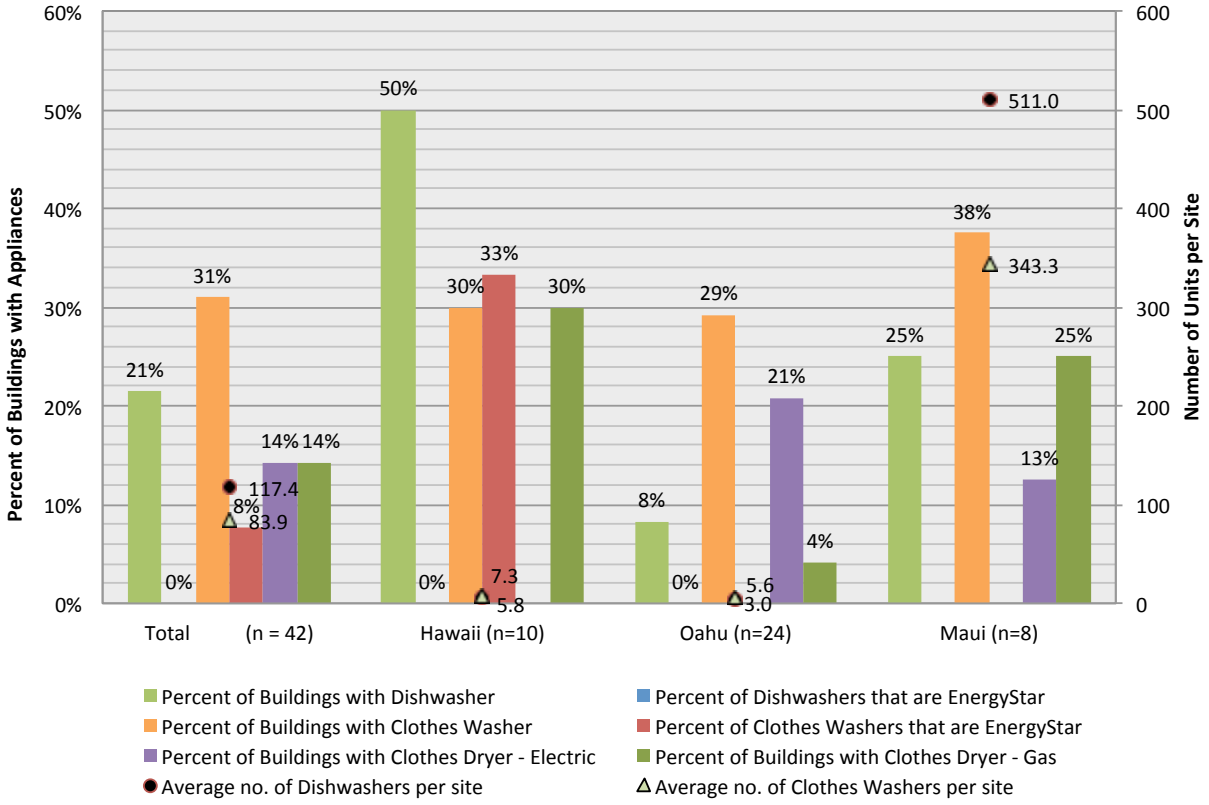
Figure 134 – Cooling Equipment Types, by Number of Units and Capacity



5.11.5 Appliances

Both the presence of appliances at large/account sites (along the left hand vertical axis) and the average number of units (along the right hand vertical axis) are shown in Figure 135. The most common appliances are washers, which are found at 31 percent of sites and include both standard residential size washers and larger commercial units. About eight percent of the clothes washers across all sites carry Energy Star labels. Clothes dryers are found at 28 percent of sites, equally divided between electric and gas dryers. While only 21 percent of sites have dishwashers, some of these have hundreds of units in place. However, none of the more than 1,000 units observed are Energy Star-labeled. While age is not shown on the figure, average age of washers is about nine years; of dryers, about eight years, neither of which is significantly different from the ages of comparable equipment at the small-medium sites (about 8 years for washers, 7 years for dryers).

Figure 135 – Percent of Sites with Appliances, Overall and by Island/County



5.11.6 Refrigeration and Cooking

While more than 76 percent (32 of 42 sites) have some type of refrigeration equipment, relatively few of the large/assigned sites have commercial cooking or refrigeration equipment, in part because there are only two food stores and no restaurants in the sample. As shown in Table 27, upright residential refrigerators were noted at 57 percent (24) of sites, with an average of more than 200 units per site. Overall, just eight percent of residential units at large sites are Energy Star certified. Among commercial refrigeration equipment types, the most common are walk-in cases, both refrigerated (12 sites) and frozen (11 sites), while vertical refrigerated and frozen cases were each noted at six sites.

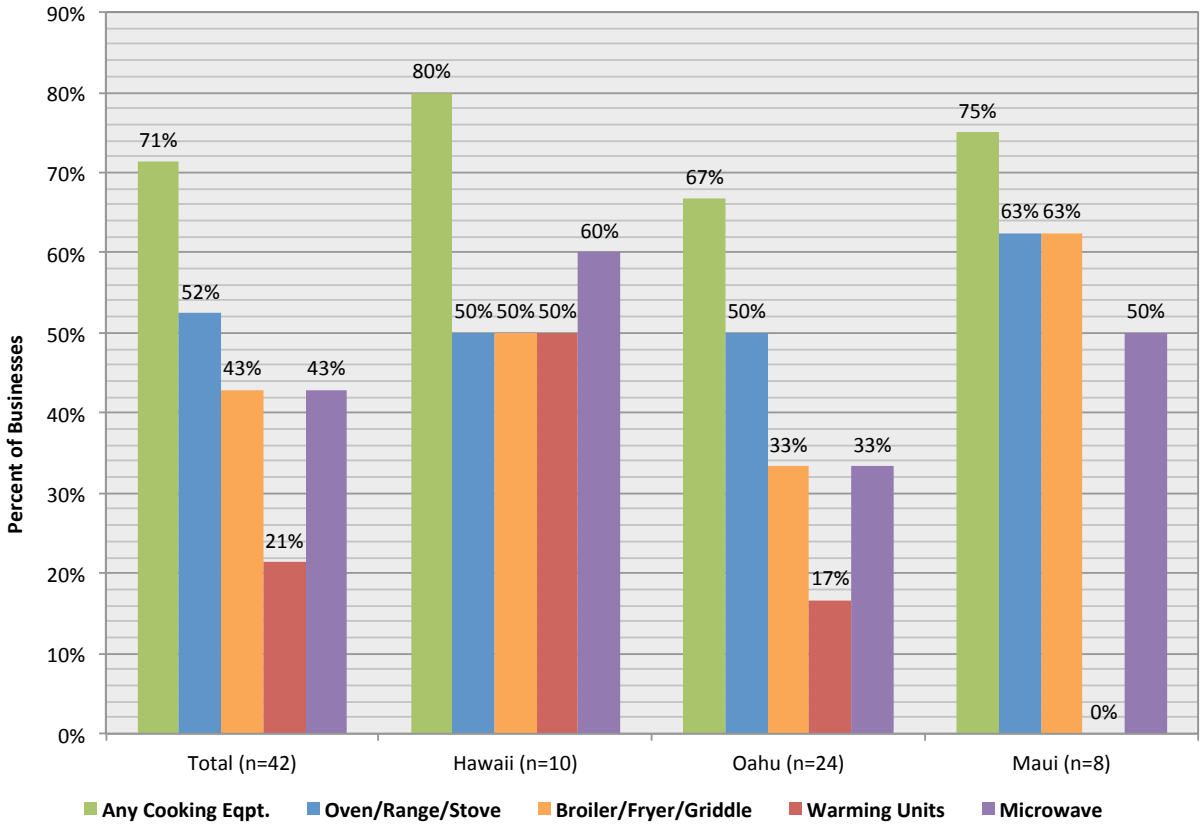
Table 27 – Percent of Large Sites with Refrigeration

Refrigeration Type	Large (n=42)	Avg. per site
No refrigeration equipment	24%	NA
Residential refrigerator	57%	220
Vertical refrigerated cases	14%	37
Commercial standalone refrigerator	41%	6
Walk-in refrigerated cases	29%	4
Refrigerated coffin cases	0%	NA
Residential freezer	10%	2
Vertical frozen cases	14%	33
Commercial standalone freezer	21%	3
Walk-in freezer	26%	2
Freezer coffin cases	2%	25

Note: Sites with refrigeration may have multiple types of refrigeration equipment

Even though there are no restaurants and few food stores in the sample, more than 70 percent of large sites have some kind of cooking equipment, as shown in Figure 136. Overall, more than half (52%) of businesses have at least one oven, range or stove, with an average of 87 units per site. While the percentage of sites with microwaves was lower (43%), the average number of units per site was somewhat higher (95).

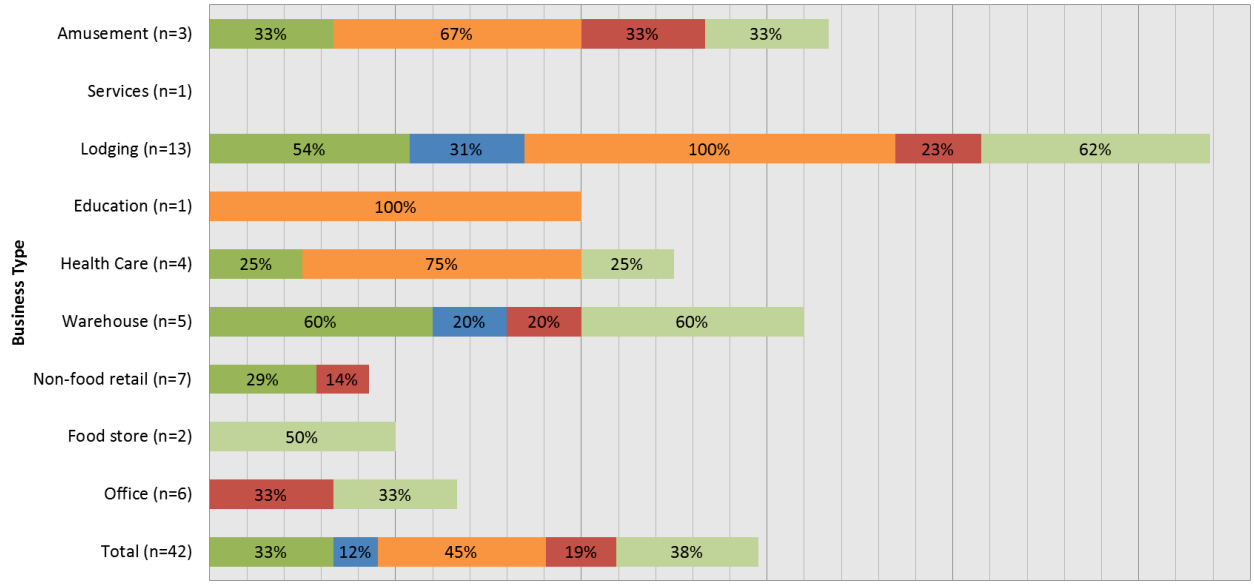
Figure 136 – Percent of Sites with Cooking Equipment



5.11.7 Motors, Pumps and Compressors

One-third of all large sites visited have motors, with the warehouse/manufacturing and lodging sectors accounting for most of the total, as shown in Figure 137. A larger percentage of sites have pool pumps (45%) and compressors (38%), with the lodging sector accounting for the majority of both equipment types. VFD motors are present at only five of the 14 businesses with motors.

Figure 137 – Percent of Sites with Motors, Pumps and Compressors

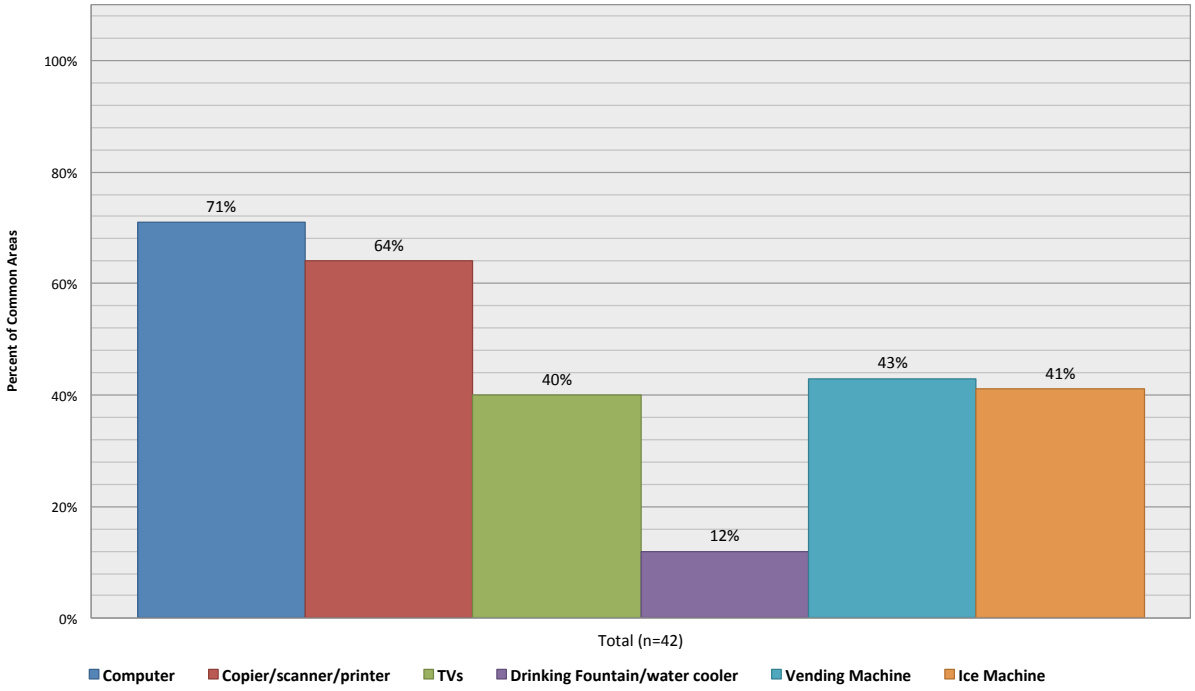


	Total (n=42)	Office (n=6)	Food store (n=2)	Non-food retail (n=7)	Warehouse (n=5)	Health Care (n=4)	Education (n=1)	Lodging (n=13)	Services (n=1)	Amusement (n=3)
Motors	33%	0%	0%	29%	60%	25%	0%	54%	0%	33%
VFD motors	12%	0%	0%	0%	20%	0%	0%	31%	0%	0%
Pool/Spa Pumps	45%	0%	0%	0%	0%	75%	100%	100%	0%	67%
Other Pumps	19%	33%	0%	14%	20%	0%	0%	23%	0%	33%
Compressor	38%	33%	50%	0%	60%	25%	0%	62%	0%	33%

5.11.8 Electronics and Miscellaneous

Among other types of equipment, most large buildings (71%) have computers, while almost two-thirds (64%) have printers/scanners/copiers. As shown in Figure 138, common non-electronic equipment types include vending machines and ice machines (both found at more than 40% of large sites) and drinking fountains, found at 12 percent. On average, buildings with vending machines have five of these units, while those with water coolers/drinking fountains have two.

Figure 138 – Percent of Sites with Electronics and Other Equipment



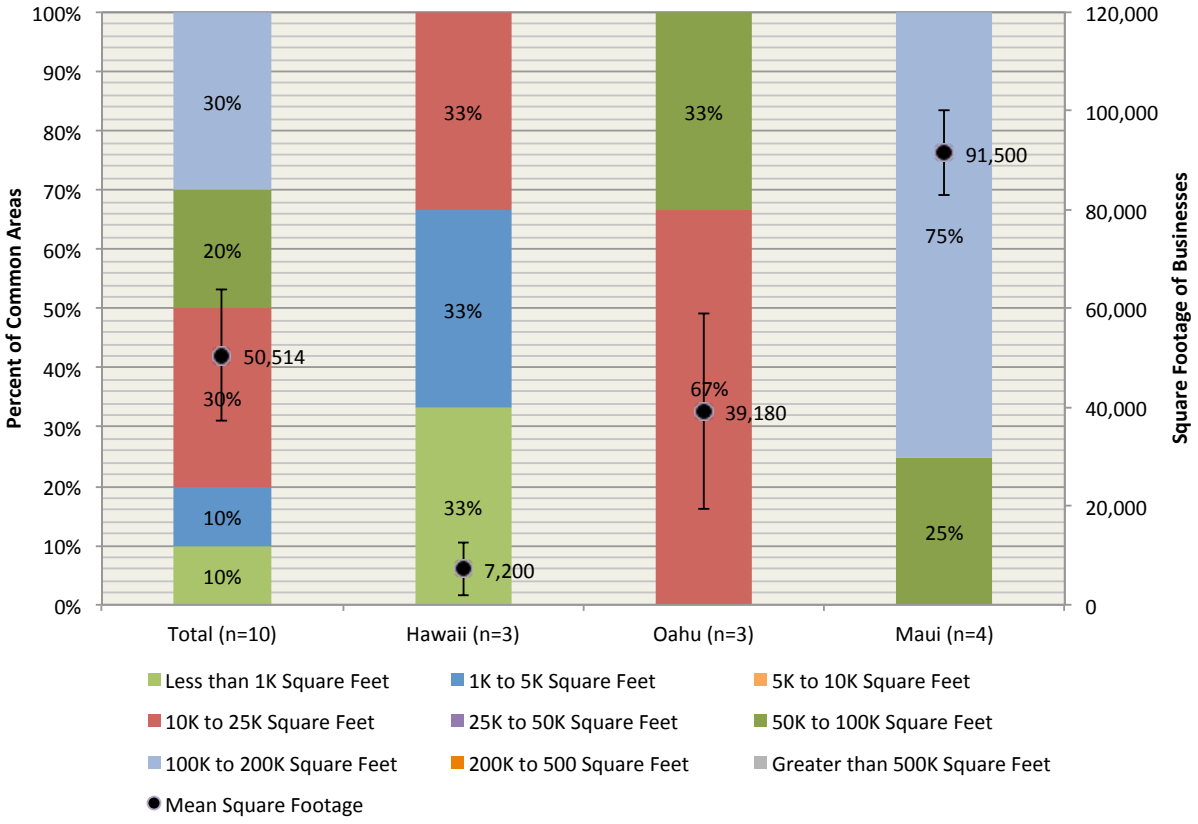
5.12 Multi-Family Common Area

While the characteristics and equipment holdings of dwelling units in condos and apartment were discussed in the residential section of this report, this section presents findings for the area within those buildings that is not used as living space. Multi-Family common area comprises lobbies, hallways, meeting rooms, laundry and maintenance areas and similar spaces. In all, the common areas of 10 multi-family buildings were included in the large/assigned account sample.

5.12.1 Building Characteristics

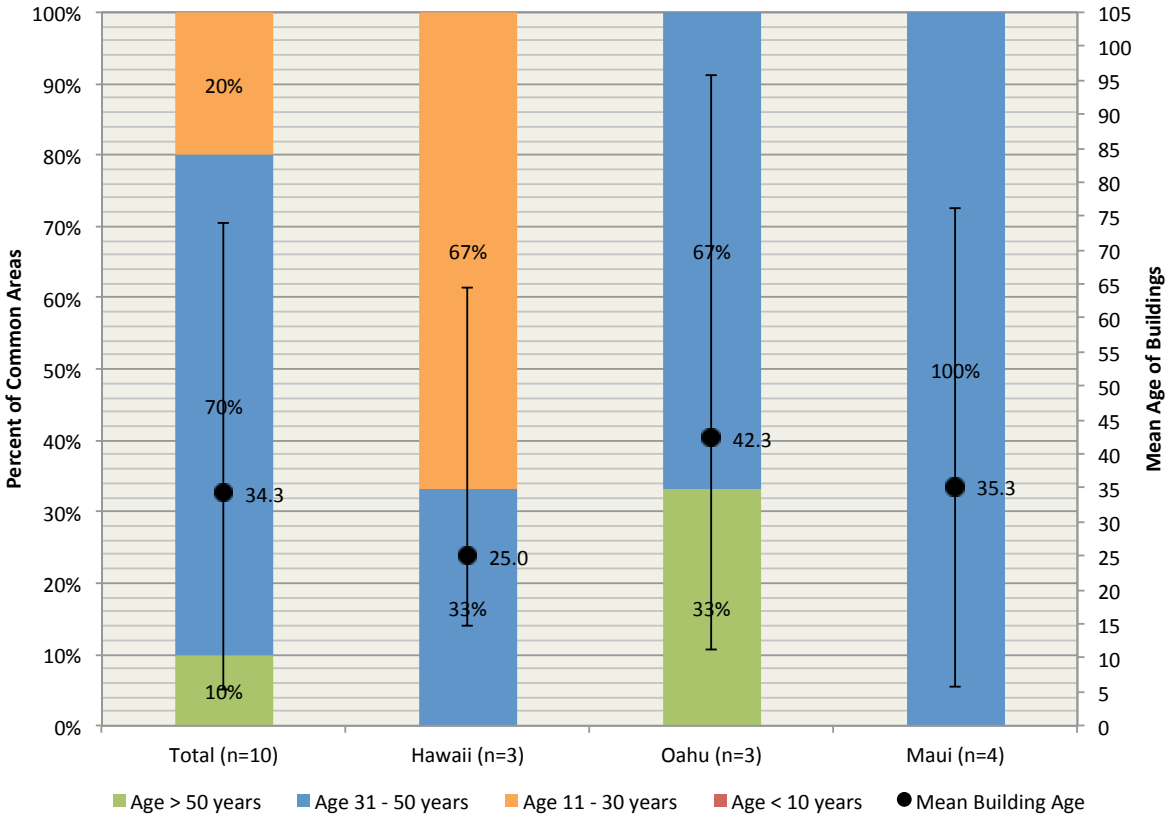
The distribution of these buildings by size and by county/island is presented in Figure 139, and shows that the common areas of three surveyed buildings on Hawaii are much smaller than the overall average, while those in Maui County are larger, with three of the four Maui buildings having common areas in excess of 100,000 square feet.

Figure 139 – Multi-Family Common Area – Size by Island/County



Building age does not vary significantly by island. As shown in Figure 140, the average age of all 10 multi-family buildings is 35 years, ranging from 25 years on Hawaii to 42 on Oahu, but these differences are not statistically significant (by comparison, the multi-family buildings in the residential on-site survey were an average of 38 years old). Overall, seven of the 10 buildings are in the 31-50 year age range.

Figure 140 – Multi-Family Common Area – Age by Island/County

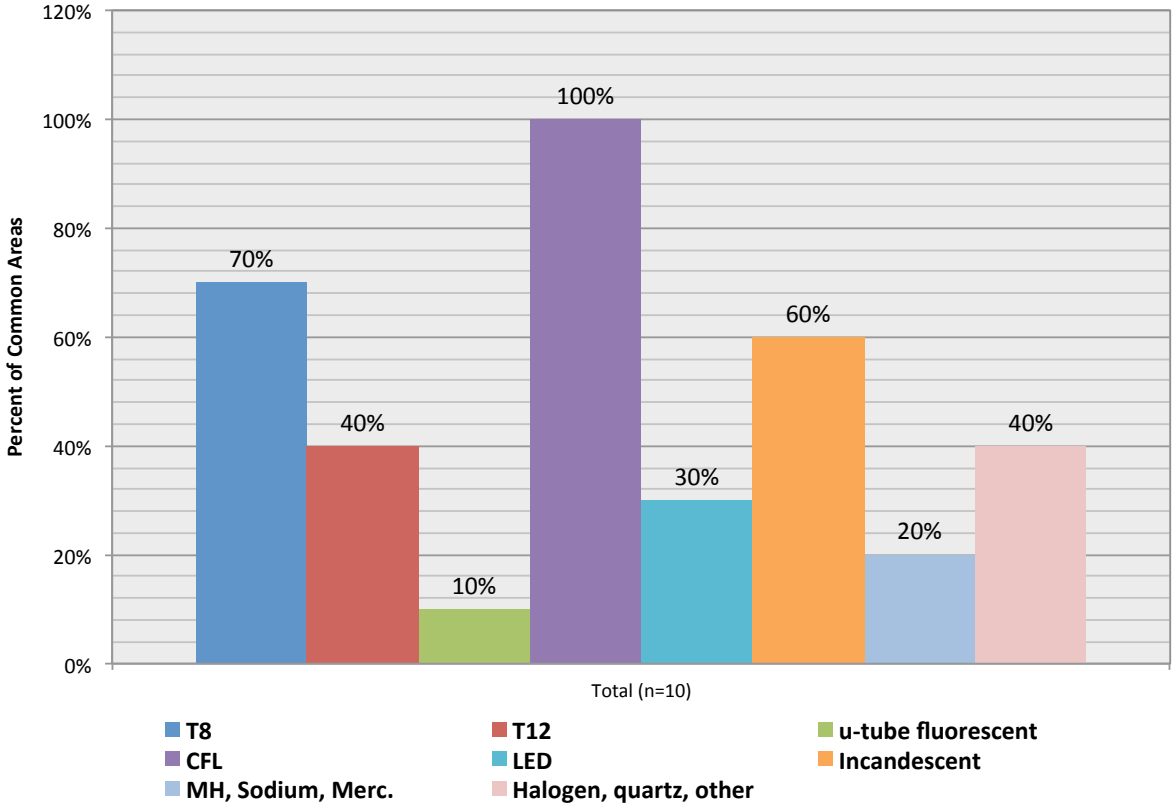


Because there are so few buildings per island/county in the sample, the remainder of this section presents results for all 10 multi-family common area sites combined.

5.12.2 Lighting

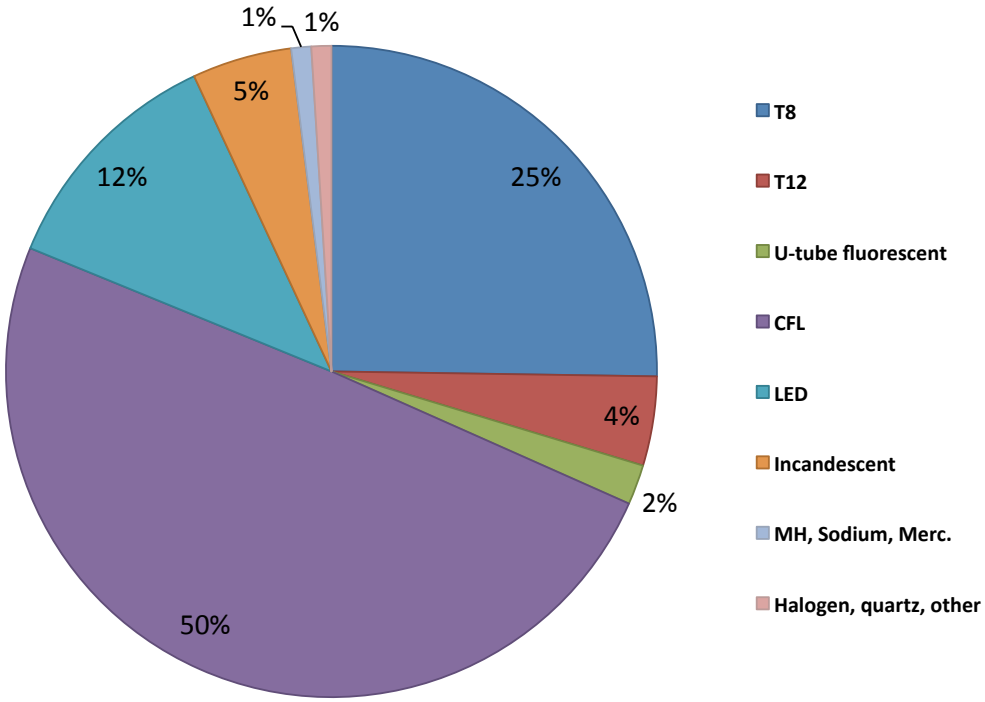
Figure 141 presents the percentage of sites with various types of lighting. All 10 sites have CFLs, while seven of 10 have T8s and six of 10 have incandescent bulbs. None of the sites have T5s and four have T12 lamps – one more than the three sites with LED lighting.

Figure 141 – Percent of Multi-Family Common Area Sites with Various Lighting Types



The total population of lamps across all 10 multi-family common area sites is shown in Figure 142. Overall, CFLs account for about half of installed lamps, followed by T8 lamps (25%) and LEDs (12%). Incandescent and T12 lamps, taken together, account for approximately nine percent of total bulbs, while u-tube fluorescents make up two percent.

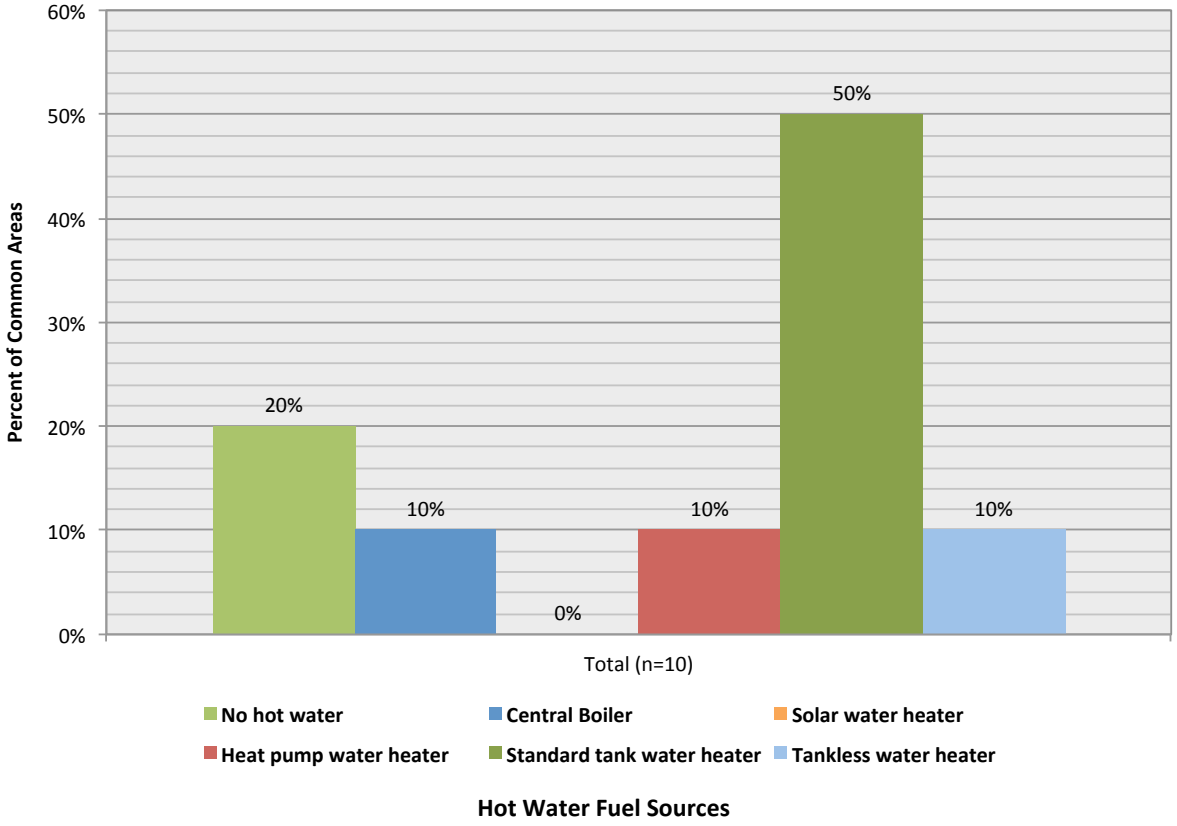
Figure 142 – Percentage Breakdown of Installed Lamps (n=10)



5.12.3 Hot Water

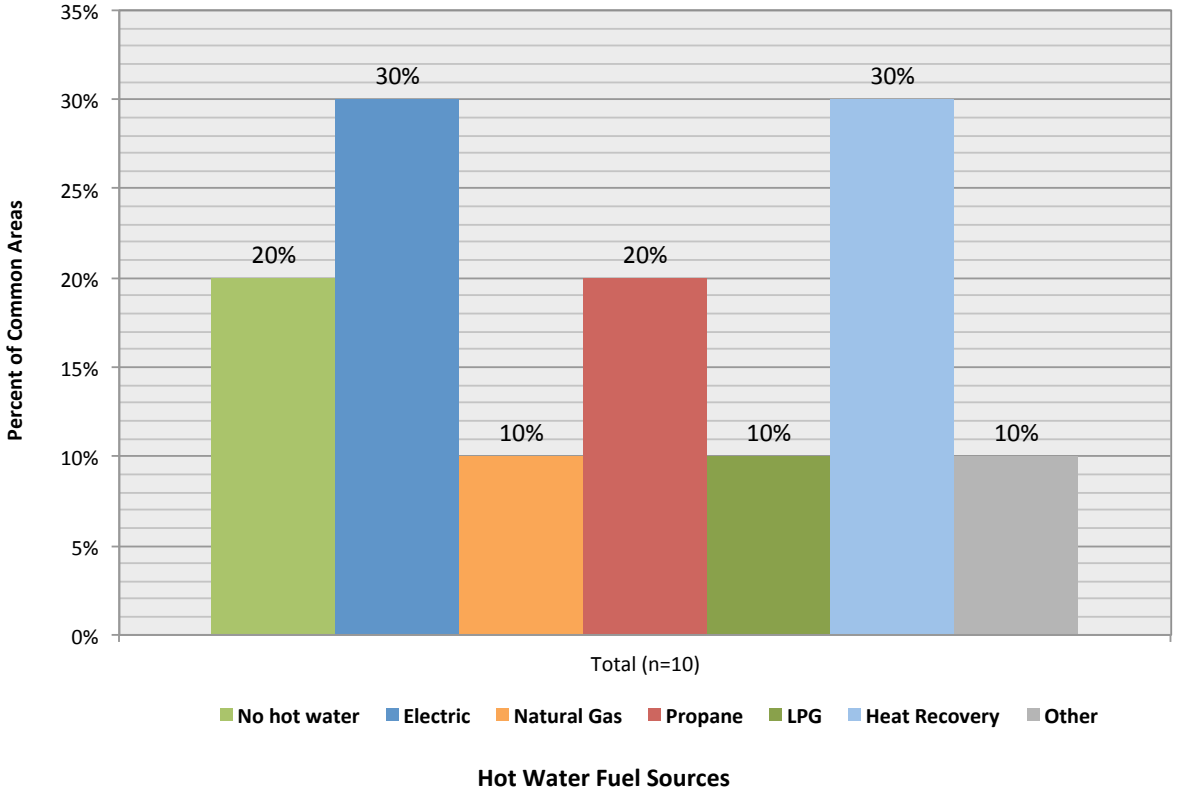
The types of hot water equipment at multi-family common area sites are shown in Figure 143. Note that two sites have no hot water in the common area, presumably because only the individual dwelling units have hot water. Five sites (50%) have standard tanks waters, while one site each has a central boiler, heat pump water heater and tankless water heater. None has solar hot water heat.

Figure 143 – Percentage Breakdown of Hot Water Heating Technologies



Electricity and heat recovery each provide the fuel for hot water heating at three buildings (30%), while propane is used at two multi-family common area sites, as illustrated by Figure 144.

Figure 144 – Multi-Family Common Area Hot Water Heating Fuels



5.12.4 Cooling

All of the multi-family buildings whose common areas were surveyed cool at least some of their space as needed, and 70 percent (7 of 10) cool 100 percent, as shown in Figure 145.

Figure 145 – Percent of Multi-Family Space Cooled

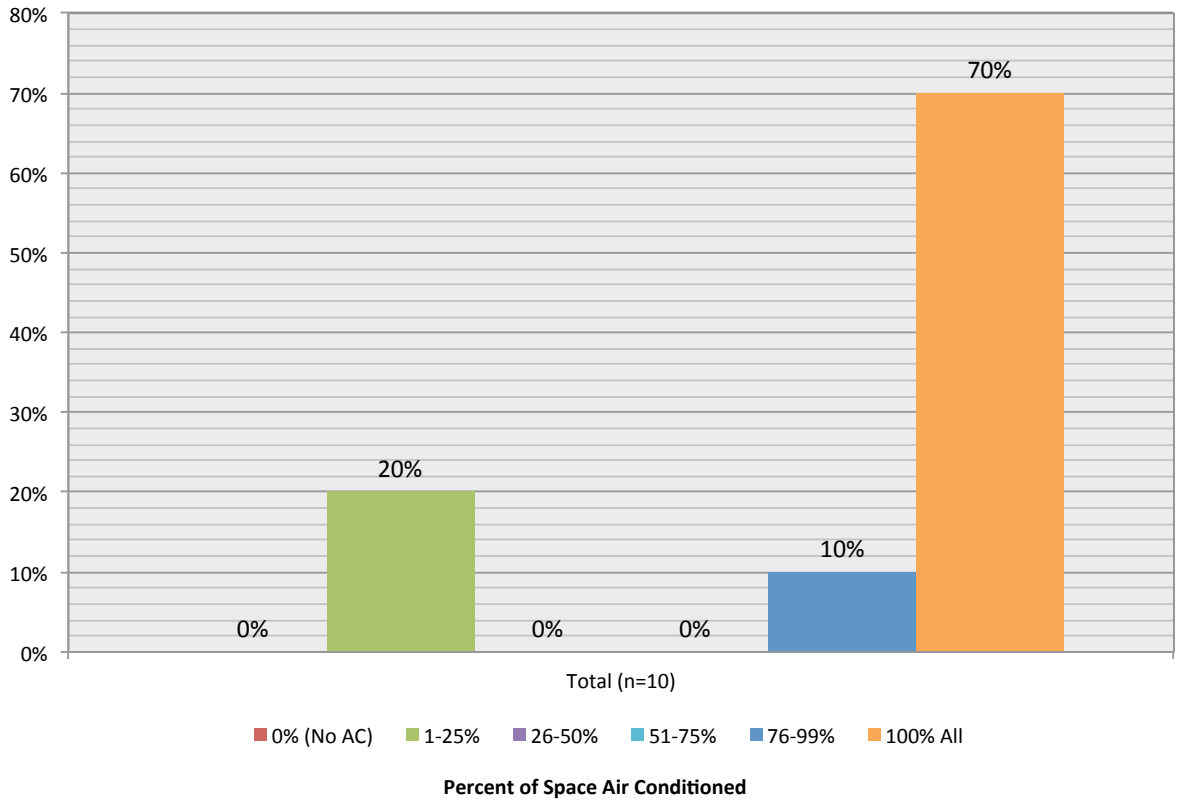
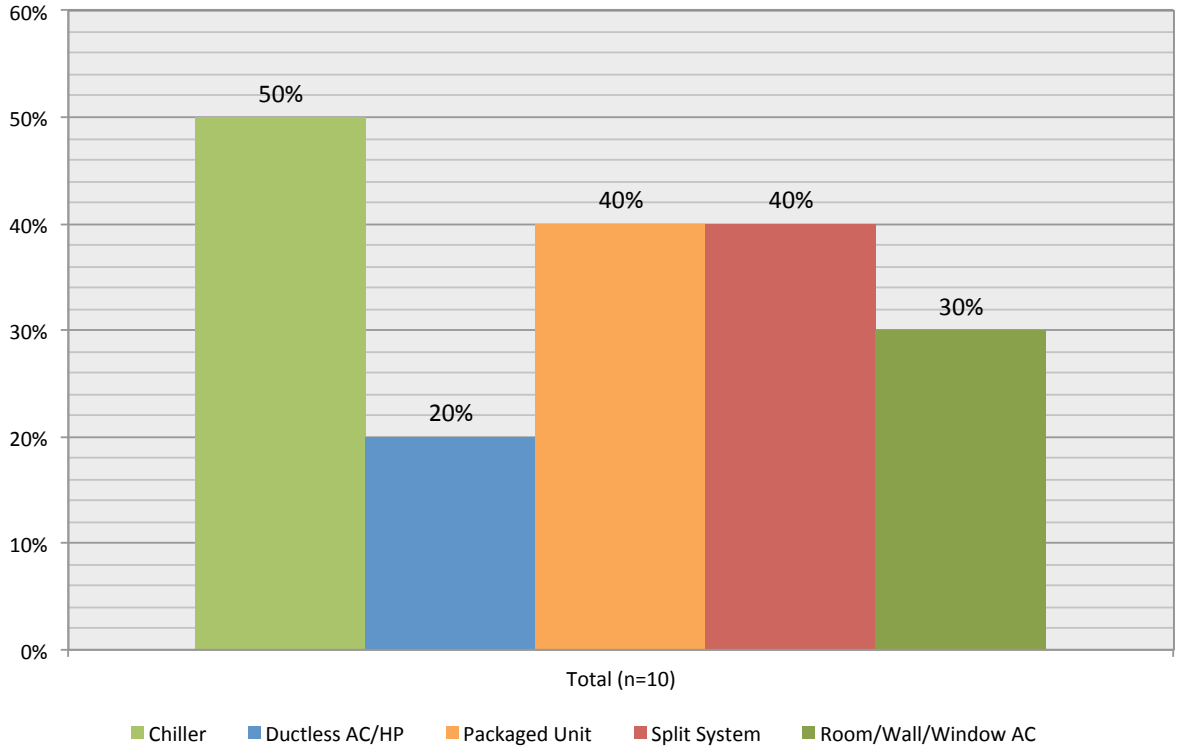


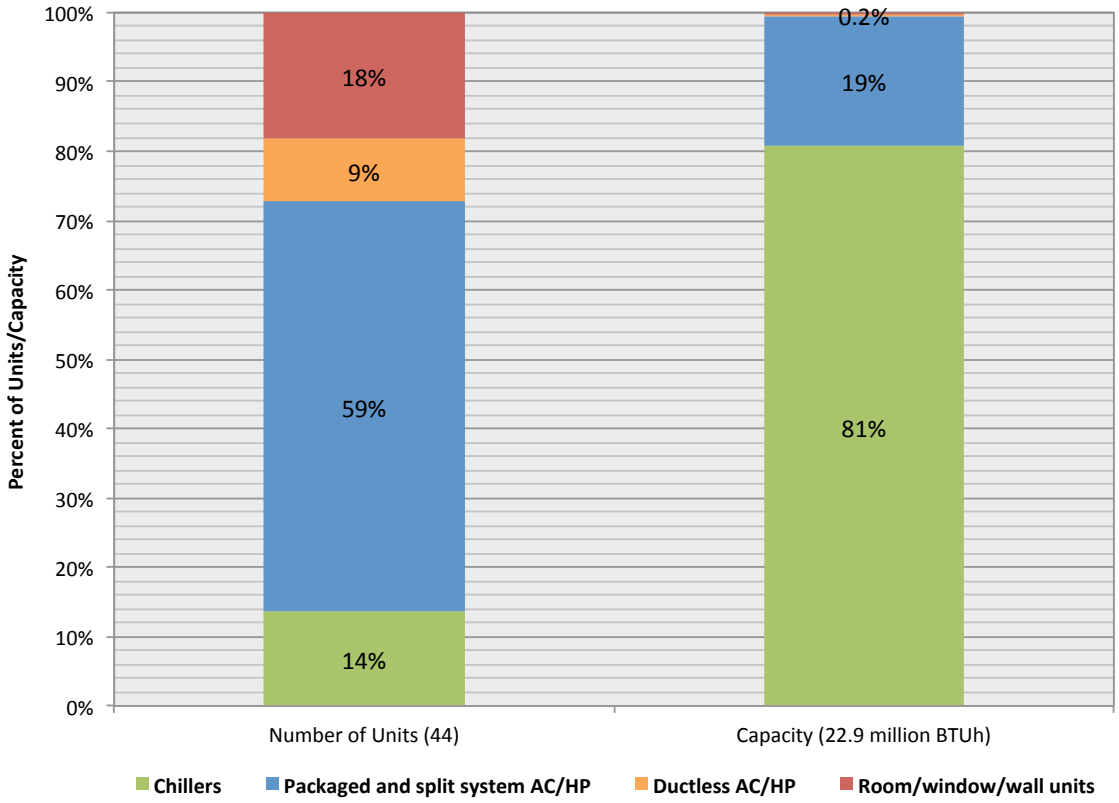
Figure 146 shows that installed cooling equipment ranges in size from chillers (at 5 of 10 sites) to window/wall units (at three sites). Some multi-family properties have more than one type of cooling equipment in their common areas.

Figure 146 – Presence of Cooling Equipment



Packaged and split systems account for almost 60 percent of the total of 44 cooling units observed. As shown in Figure 147 below, chillers represent about 14 percent of the units installed, but more than 80 percent of installed cooling capacity at the surveyed sites, while ductless and room/window/wall units account for less than one percent of capacity.

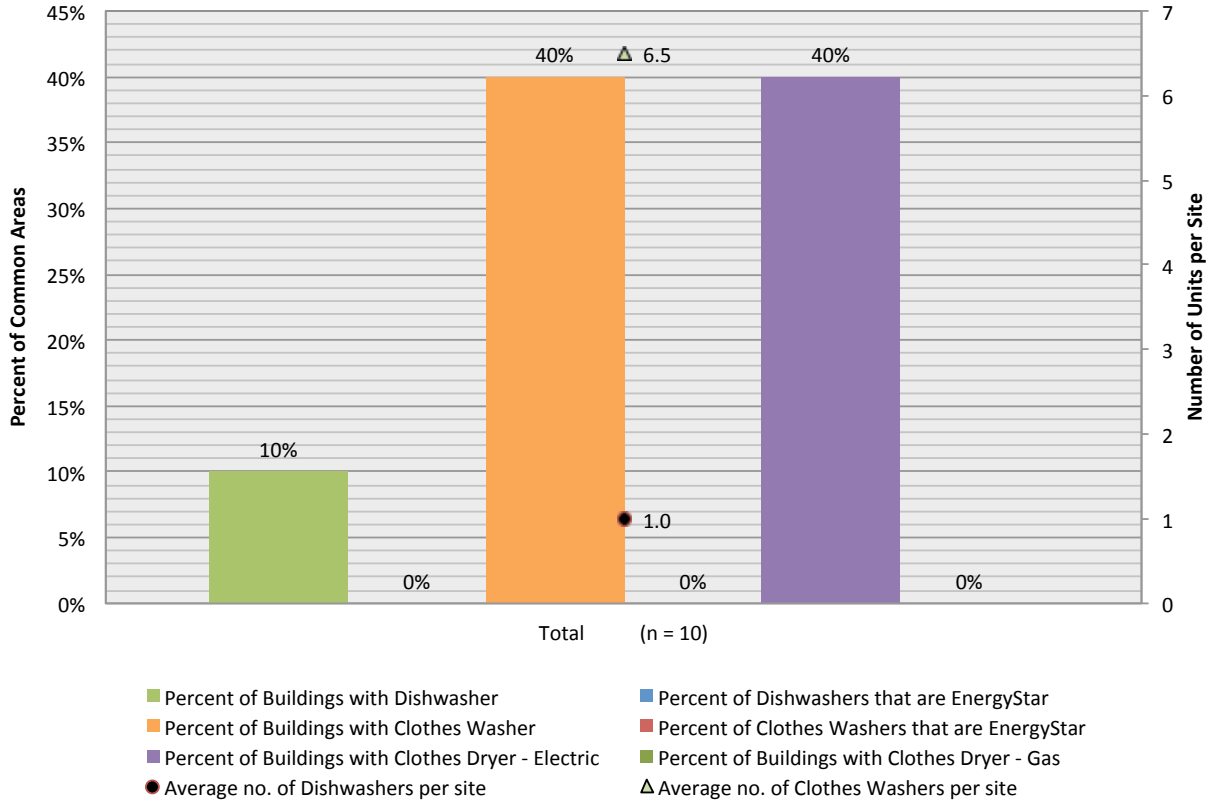
Figure 147 – Cooling Equipment Types, by Number of Units and Capacity



5.12.5 Appliances

Only one building in the sample has a single, non-Energy Star dishwasher in the common area, while four sites have washers and dryers, including both smaller residential and larger commercial models. Three of the buildings with washers have just one or two, but one has 21 washers, raising the average per site to 6.5 washers, as shown in Figure 148, which presents the percentage of buildings with various appliances on the left vertical axis and the average number of appliances per site on the right vertical axis. All of the dryers are electric, and there are no Energy Star washers.

Figure 148 – Presence of Appliances in Multi-Family Common Areas



5.12.6 Cooking and Refrigeration

Only four of the ten buildings surveyed have any cooking equipment in their common area; all four of those have microwaves, while one also has a conventional oven/range. Refrigeration equipment is only slightly more common, as shown in Table 28. Half the multi-family common area sites have no refrigeration, while four have residential units (an average of 3.5 per site) and two have standalone commercial refrigerators. No sites have any other refrigeration equipment (other than vending machines and water coolers, discussed below). Only a single refrigerator out of a total of 14 is Energy Star rated.

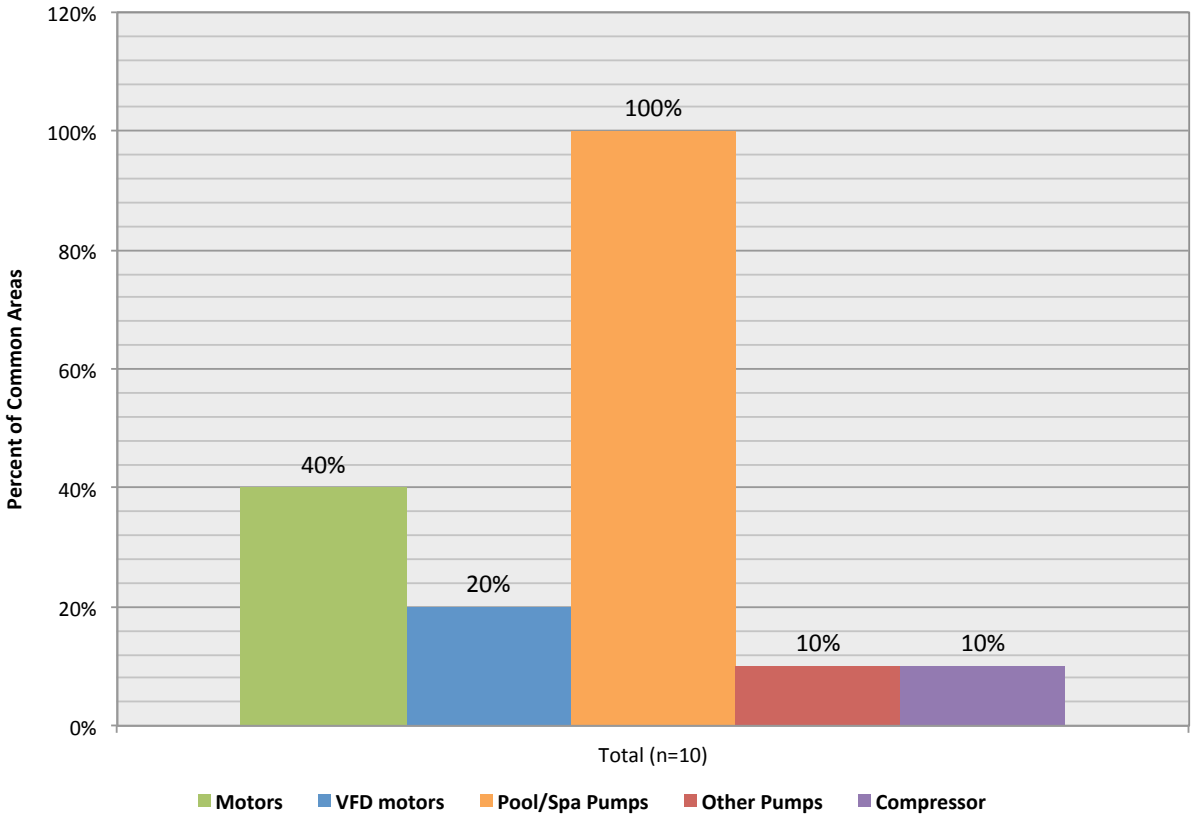
Table 28 – Presence of Refrigeration Equipment

Refrigeration Type	Total (n=10)
No refrigeration equipment	50%
Residential refrigerator	40%
Commercial standalone refrigerator	20%

5.12.7 Motors, Pumps and Compressors

Figure 149 presents data on the presence of motors, pumps and compressors at the 10 surveyed sites. Note that pool pumps were observed at all 10 sites, while four buildings have motors and two of those have motors with VFDs.

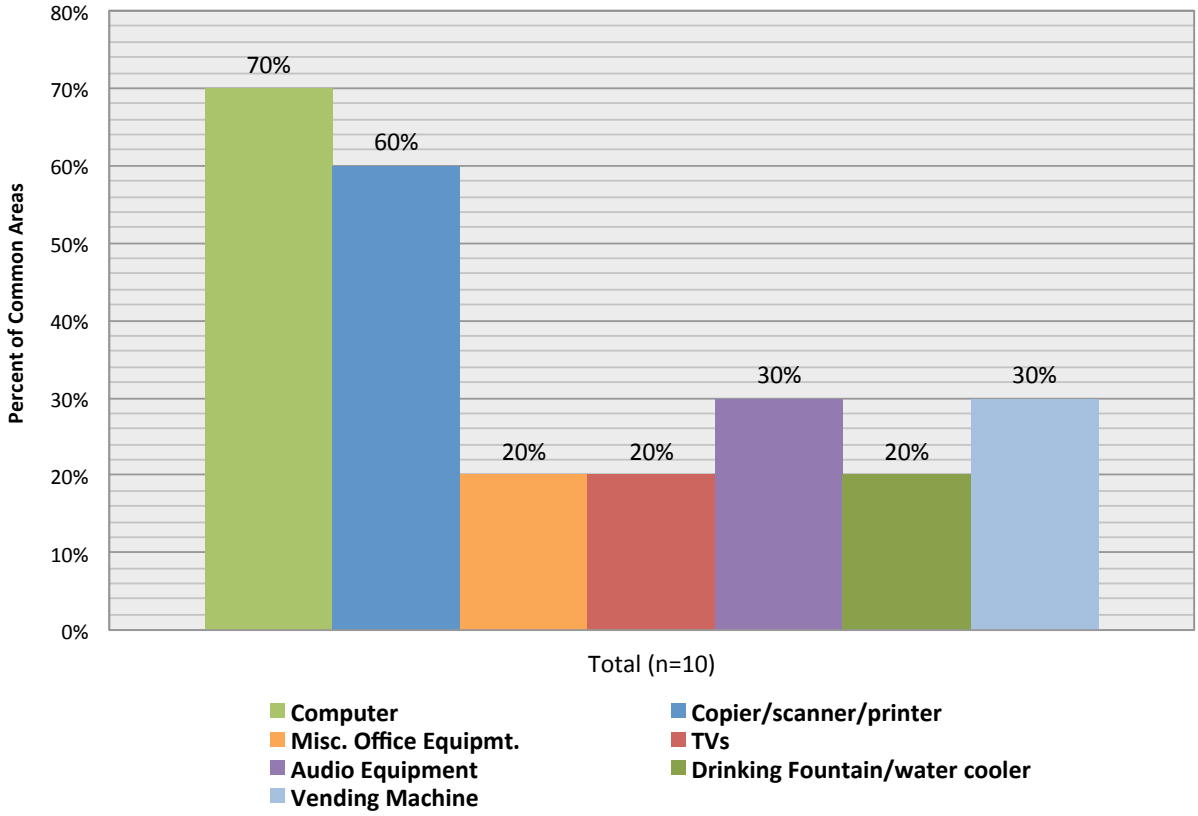
Figure 149 – Presence of Motors and Related Equipment in Multi-Family Common Areas



5.12.8 Electronics and Miscellaneous

Among various types of electronics, a majority of sites have computers (70%) and printers/copiers/scanners (60%) in the common areas surveyed. As shown in Figure 150, relatively few sites have other electronics, including miscellaneous office equipment (20%), TVs (20%) and audio equipment (30%). None of the common areas in multi-family buildings have medical equipment, broadcast equipment or battery chargers. Other miscellaneous equipment found at some sites includes drinking fountains/water coolers (20%) and vending machines (30%). None of the sites have ice machines.

Figure 150 – Presence of Electronics and Miscellaneous Equipment in Multi-Family Common Areas



6 Hawaii Large C&I Case Study Report

Some of the sites were extremely large and complex, so on-site visits did not make sense for two of the largest customers: the Board of Water/Sewers (BoWS), and the four branches of the military that have bases in the state. Instead of conducting site visits, the evaluation team completed case studies for these customers to provide some meaningful data and metrics.

The case studies were completed by interviewing key staff members to determine their typical energy efficiency practices, significant projects or energy efficiency initiatives that have been implemented recently, future plans for energy efficiency projects, and any useful characteristics regarding their facilities and energy usage.

Additionally, the historical electricity usage was obtained for the entire commercial population. The electricity usage data for the military and BoWS sectors was combined with the interview data to assist in quantifying any useful energy usage metrics.

6.1 Completed Interviews

The main source of information gathered for the military and BoWS sectors was through phone interviews. During the data collection effort, several interviews were completed:

- Marine Corps Base Hawaii Commercial Energy Efficiency – A phone interview with two Resource Efficiency Managers was completed on May 22, 2013. They manage and facilitate energy efficiency improvements and projects for Marine Corps Base Hawaii.
- Army and Air Force Military Housing – A phone interview with a Marketing Manager and Project Engineer from Island Palm Communities was completed on May 20, 2013. Island Palm Communities is a subsidiary of Lend Lease Corporation. Lend Lease Corporation manages the properties for the Army and Air Force.
- Navy and Marine Corps Base Hawaii Military Housing – A phone interview with a VP of Development at Forest City Military Communities was completed on May 31, 2013. Forest City manages the military housing for the Navy and Marine Corps Base Hawaii.
- Board of Water and Sewer – A phone interview with a senior energy management professional and professional engineer at SAIC was completed on June 10, 2013. Hawaii Energy, the implementer of energy efficiency programs on behalf of the HPUC, is currently working with the Board of Water and Sewer on a large-scale efficiency improvement effort. The engineer interviewed has extensive knowledge of water treatment and wastewater facilities and has been collecting data on the water and wastewater facilities in Hawaii since 2012.

The remaining commercial branches of the military (Navy/Air Force, Army) chose not to participate in the interviews for the potential study citing legal reasons regarding disclosing energy usage information. Additionally, members of the engineering staff at the BoWS could not be reached for participation in a phone interview.

6.2 Sector Electricity Usage

This section shows the billed data analysis and the sector energy usage for the completed case studies.

6.2.1 Billed Data Analysis

Billing data for the military and board of water supply customers was obtained starting from 2008 through January of 2013. The billing data received was at the meter level, which was then aggregated to customer account number level. This was accomplished by summing the meter usages for each account number for a given month.

This process was successful for accounts where there was only one meter present at the facility. This would include all of the customers designated as "small" and a majority of those designated as "medium". However, for the remaining medium customers and all of those designated as "large", there appeared to be an inconsistency in the billing data.

Some of the large and medium customers have more than one meter, and also more than one service line into the facility (a service line is where the facility is connected to the grid). This resulted in the aggregated billing data having more than one usage entry for each month. An example can be seen in Table 29.

Table 29 – Billed Usage Example

Size	Segment	Island	Electricity Usage (kWh)	Start Billing Period Date	End Billing Period Date
Medium	Board of Water/Sewers	OA	5,520	5/15/2008	6/13/2008
Medium	Board of Water/Sewers	OA	13,200	5/15/2008	6/13/2008
Medium	Board of Water/Sewers	OA	5,520	6/13/2008	7/15/2008
Medium	Board of Water/Sewers	OA	12,800	6/13/2008	7/15/2008
Medium	Board of Water/Sewers	OA	6,240	7/15/2008	8/13/2008
Medium	Board of Water/Sewers	OA	14,880	7/15/2008	8/13/2008
Medium	Board of Water/Sewers	OA	6,240	8/13/2008	9/15/2008
Medium	Board of Water/Sewers	OA	15,360	8/13/2008	9/15/2008
Medium	Board of Water/Sewers	OA	6,720	9/15/2008	10/16/2008
Medium	Board of Water/Sewers	OA	14,960	9/15/2008	10/16/2008
Medium	Board of Water/Sewers	OA	6,080	10/16/2008	11/14/2008
Medium	Board of Water/Sewers	OA	12,880	10/16/2008	11/14/2008

Due to a change in the utility billing process, the multiple billing instances were consolidated into a single billing instance beginning in June 2012. However, the magnitude of the post consolidation billing did not appear to be consistent with the pre-billing data. An example can be seen in Table 30.

Table 30 – Example Usage Data Including the 2012 Transition

Size	Segment	Island	Electricity Usage (kWh)	Start Billing Period Date	End Billing Period Date
Medium	Board of Water/Sewers	OA	15,360	2/21/2012	3/21/2012
Medium	Board of Water/Sewers	OA	6,720	2/21/2012	3/21/2012
Medium	Board of Water/Sewers	OA	14,960	3/21/2012	4/20/2012
Medium	Board of Water/Sewers	OA	6,080	3/21/2012	4/20/2012
Medium	Board of Water/Sewers	OA	14,320	4/18/2012	5/20/2012
Medium	Board of Water/Sewers	OA	15,120	5/20/2012	6/20/2012
Medium	Board of Water/Sewers	OA	16,000	6/20/2012	7/22/2012
Medium	Board of Water/Sewers	OA	16,800	7/22/2012	8/20/2012
Medium	Board of Water/Sewers	OA	14,960	8/20/2012	9/22/2012
Medium	Board of Water/Sewers	OA	15,360	9/22/2012	10/21/2012
Medium	Board of Water/Sewers	OA	14,000	10/21/2012	11/20/2012
Medium	Board of Water/Sewers	OA	14,640	11/20/2012	12/22/2012

The data show that before the billing system changeover, the monthly usage was approximately 20,000 kWh per month. However, after the change, the usage is approximately 15,000 kWh. This suggested there was some inconsistency between the usage data available before June 2012 and the data after.

Through discussions with Hawaii Energy, as well as Hawaii Electric Light Company (HELCO), the utility that provides electric service to the island of Hawaii, it was determined that the billing data pre-June 2012 was broken out by service lines, as previously mentioned. It appeared as though the total facility usage was included in one of the billing line items, and the other was only the usage for those particular service lines. Thus, the maximum of the two billing line items was assumed to be the appropriate monthly usage.

Due to the billing change that occurred in June of 2012 it was unclear that the 2012 usage information was completely accurate. In many instances, the 2012 billing data was 20 to 30 percent less than all previous years. It was unclear why there was such a significant discrepancy in the billing data; therefore, the year 2012 was excluded from the analysis presented in this report.

A second assumption used in the analysis of the billing data was that the months between March 2011 and August 2011 were not included in the original set of billed data (four out of 12 months of data). Therefore, the 2011 usage for the eight months in which data were available was extrapolated linearly out for 12 months (multiplied by 1.5). This way, the data compares 12 months of billing data for all years 2009 through 2011.

It should be noted that the basis of the spreadsheet is the electricity billing data received from the Hawaii Electric Companies. Therefore, it does not contain any data with regards to the island of Kauai. There is a small military installation on the island of Kauai, but it is not believed to be a significant part of the state's overall military presence.

6.2.2 Sector Energy Characteristics

The energy usage characteristics of the entire military and BoWS sectors are presented in the subsequent tables. The tables in this section detail the statewide electricity usage by sector, size and island. The two sectors, based on the sector codes in the billing data, are military and BoWS. The sizes are large, medium and small based on the billing rate class of the customer from the billing data. The islands are abbreviated where HA = Hawaii Island, LA = Lanai, MA = Maui, MO = Molokai, and OA = Oahu.

Table 31 shows the total number of unique account numbers broken down by sector, size and island. Table 32 shows the total electricity usage in kWh broken down by sector, size, and island. The BoWS was the larger consumer of electricity on all islands except Oahu during 2011. However, the military consumed almost six times as much electricity overall. Table 33 shows the percent of statewide energy usage for each sector broken down by size and island. The percentages of statewide energy usage were calculated by taking the values shown in Table 32 and dividing them by the total statewide electricity consumption of 7,404,689,688 kWh in 2011.[37] Military electricity usage was 16.86 percent of statewide electricity usage in 2011, while the BoWS was 4.44 percent.

[37] Obtained from billing data received from Hawaii Energy for the entire state residential and non-residential population.

Table 31 – Number of Unique Account Numbers, by Sector, Size and Island

Sector	HA Large	Medium	Small	HA Total	LA Medium	Small	LA Total	MA Large	Medium	Small	MA Total
Board of Water/Sewers	14	88	84	186	2	3	5	17	52	62	131
Military	1	6	16	23				1	4	2	7
Total	15	94	100	209	2	3	5	18	56	64	138

Sector	MO Small	MO Total	OA Large	Medium	Other	Small	OA Total	Grand Total
Board of Water/Sewers	1	1	28	203		220	451	774
Military	2	2	14	6	2	3	25	57
Total	3	3	42	209	2	223	476	831

Table 32 – 2011 Electricity Usage (kWh), by Sector, Size and Island

Sector	HA Large	Medium	Small	HA Total	LA Medium	Small	LA Total	MA Large	Medium	Small	MA Total
Board of Water/Sewers	28,692,120	35,585,669	581,175	64,858,964	375,450	53,516	428,966	37,689,015	15,601,364	756,165	54,046,544
Military	2,178,600	2,585,721	200,511	4,964,832	-	-	-	3,016,500	792,075	86,570	3,895,145

Sector	MO Small	MO Total	OA Large	Medium	Other	Small	OA Total	Grand Total
Board of Water/Sewers	-	-	116,107,500	92,174,165	-	1,461,069	209,742,734	**329,077,206**
Military	24,120	24,120	1,231,856,700	7,366,290	25,704	82,553	1,239,331,247	**1,248,215,343**

Table 33 – Percent of 2011 Statewide Electricity (kWh) Usage

Sector	HA Large	Medium	Small	HA Total	LA Medium	Small	LA Total	MA Large	Medium	Small	MA Total
Board of Water/Sewers	0.39%	0.48%	0.01%	0.88%	0.01%	0.00%	0.01%	0.51%	0.21%	0.01%	0.73%
Military	0.03%	0.03%	0.00%	0.07%	0.00%	0.00%	0.00%	0.04%	0.01%	0.00%	0.05%
Total	0.42%	0.52%	0.01%	0.94%	0.01%	0.00%	0.01%	0.55%	0.22%	0.01%	0.78%

Sector	MO Small	MO Total	OA Large	Medium	Other	Small	OA Total	Grand Total
Board of Water/Sewers	0.00%	0.00%	1.57%	1.24%	0.00%	0.02%	2.83%	4.44%
Military	0.00%	0.00%	16.64%	0.10%	0.00%	0.00%	16.74%	16.86%
Total	0.00%	0.00%	18.20%	1.34%	0.00%	0.02%	19.57%	21.30%

6.3 Military Non-Residential

This section shows the billed data analysis, energy efficiency practices, and additional energy information for military non-residential buildings.

6.3.1 Billed Data Analysis

The military sector has two distinct components: residential on base housing, and the remaining non-residential operations. This section focuses on the non-residential aspects of the military sector. Information regarding the military residential sector can be found in Section 6.4.

Table 34 shows the annual electricity consumption (kWh) of the entire military sector from 2009 through 2011.

Table 34 – Annual Electricity Usage (kWh) for Entire Military Sector

Year	HA Large	Medium	Small	HA Total	LA Medium	Small	LA Total	MA Large	Medium	Small	MA Total
2009	2,279,600	2,762,523	277,750	5,319,873	-	-	-	3,708,000	669,140	110,513	4,487,653
2010	2,176,000	2,676,531	325,898	5,178,429	-	-	-	3,256,000	697,710	94,230	4,047,940
2011	2,178,600	2,585,721	200,511	4,964,832	-	-	-	3,016,500	792,075	86,570	3,895,145
Average	2,211,400	2,674,925	268,053	5,154,378	-	-	-	3,326,833	719,642	97,104	4,143,579

Year	MO Small	MO Total	OA Large	Medium	Other	Small	OA Total	Grand Total
2009	26,400	26,400	1,095,104,600	8,888,080	25,840	64,735	1,104,083,255	1,113,917,181
2010	19,200	19,200	1,067,124,200	9,317,240	25,704	73,839	1,076,540,983	1,085,786,552
2011	24,120	24,120	1,231,856,700	7,366,290	25,704	82,553	1,239,331,247	1,248,215,343
Average	23,240	23,240	1,131,361,833	8,523,870	25,749	73,709	1,139,985,162	1,149,306,359

It is important to note that the values in Table 34 include both the residential and commercial components of the military. Since the housing is on base, it can be on the same account as the commercial facilities at the same installation. Since the specific military branch is the customer, the residential usage is included in the billing data. Hawaii Energy (PBFA) was able to provide an estimated breakdown of energy consumption for the Navy/Air Force Joint Base Pearl Harbor-Hickam. The detailed breakdown from the previous fiscal year can be seen in Table 35.

Table 35 – Estimated Breakdown of Energy Usage, by Division for the Navy

Division	Energy Usage (kWh)	% of Total
Operational	159,548,000	27.6%
Housing	92,656,000	16.0%
Industrial	105,416,600	18.3%
Operational Support	219,687,900	38.1%
Total	577,308,500	100.0%

According to the data, residential housing makes up approximately 16 percent of their total electricity consumption. The commercial end-uses account for the remaining 84 percent of the base's annual electricity consumption. The other military installations on Oahu would be expected to have similar usage characteristics to those shown in Table 36. Military installations on other islands do not have the extensive on base housing as those on Oahu, therefore their usage would be expected to be solely non residential end uses.

The available billing data was used to determine the electricity consumption by specific military branch where Army is the United States Army, MCBH is Marine Corps Base Hawaii, USAF is the United States Air Force, US Navy is the United States Navy, and USCG is the United States Coast Guard. Table 36 shows the breakdown of electricity consumption by military branch from 2009 through 2011.

Table 36 – Annual Electricity Consumption (kWh), by Military Branch from 2009 to 2011

Branch	Year		
	2009	2010	2011
Army	310,292,712	313,322,812	309,630,222
MCBH	148,502,400	143,961,600	136,900,800
USAF	3,708,000	3,256,000	3,016,500
US Navy	649,365,140	623,146,204	796,642,404
USCG	428,292	380,617	358,889
Other	1,620,637	1,719,319	1,666,529
Total	1,113,917,181	1,085,786,552	1,248,215,343

The Navy was the largest military branch, accounting for 63.8 percent of the military usage in 2011. The largest three branches, the Navy, Army and Marine Corps, accounted for 99.6 percent of the military usage in 2011. Table 37 shows the 2011 energy usage by branch and island.

Table 37 – 2011 Electricity Usage (kWh), by Branch and Island

Branch	Hawaii Island	Lanai	Maui	Molokai	Oahu	Total
Army	4,261,572	-	-	-	305,368,650	309,630,222
MCBH	-	-	-	-	136,900,800	136,900,800
USAF	-	-	3,016,500	-	-	3,016,500
US Navy	-	-	-	-	796,642,404	796,642,404
USCG	-	-	57,870	-	301,019	358,889
Other	703,260	-	820,775	24,120	118,374	1,666,529
Total	4,964,832	-	3,895,145	24,120	1,239,331,247	1,248,215,343

6.3.2 Energy Efficiency Practices

According to the phone interviews, all Department of Defense divisions have been mandated to meet the 2007 Energy Independence and Security Act (EISA) requirements that they reduce energy consumption from 2005 levels by 30 percent by 2025. Additionally, they must reduce their water usage by two percent annually, and generate 25 percent of the electricity consumed from renewable sources. This translates to a reduction in energy usage of between two and three percent annually. One of the ways the different military branches in Hawaii have attempted to achieve this goal is through participation in the Hawaii Energy program. Table 38 shows the military participation in the Hawaii Energy program from 2009 through 2011.

Table 38 – Military Participation in the Hawaii Energy Program (kWh)

Branch	2009	2010	2011	Total	Average per Year
Army	8,551,917	1,702,783	12,736,745	22,991,445	7,663,815
MCBH	7,621,562	5,868,822	4,984,972	18,475,356	6,158,452
USAF	1,204,102	2,360,188	2,605,566	6,169,855	2,056,618
US Navy	1,491,884	1,379,393	1,551,837	4,423,114	1,474,371
Total	18,869,465	11,311,185	21,879,120	52,059,771	17,353,257

According to the data in Table 38, the 2011 military participation in the Hawaii Energy program was approximately 1.75 percent of total electricity consumption, and over the last three years, they have averaged 1.50 percent of electricity usage. Continuing this rate of

energy savings through the program would indicate there is potentially 243.4[38] GWh of electricity savings achievable before the year 2025. Similarly, in order to meet the EISA standards, the military will have to produce energy savings of approximately 334.2 GWh by 2025.

6.3.2.1 Marine Corps Base Hawaii

The Marine Corps provided a presentation that detailed all of their significant energy efficiency plans that had been completed recently, and that are planned for the near future. While these projects may not be typical of all military installations in the state, it provides some useful insight into the types of measures being pursued and the scale at which they are implemented. Their list of completed projects includes:

- Day lighting with controls in warehouses and hangers
- Solar hot water on all residential building with no central AC
- Heat recovery for buildings with hot water and AC
- ESPC contract for $2.5 million in annual energy savings

In addition to those completed projects, there is also a significant amount of projects currently underway:

- 380 parking/street lights where they are replacing HID fixtures with LED fixtures
- Airfield LED lighting
- EISA mandated retrocommissioning (RCx)[39]
- There will be smart meters installed in 365 buildings by September 2013

The final area where there is significant effort is on the generation side. Due to the EISA standard requiring that 25 percent of the electricity consumed be provided by renewable sources, a large part of this effort is focused on renewable generation.

- Three buildings with 32 kW of solar PV generation each
- Carports with a total of 471 kW of solar PV generation capacity
- A total of 26 kW of solar shingles
- 30-60 MW multi-fuel power plant

6.3.3 Additional Energy Information

Based on the completed interviews, it was not possible to determine specific saturation levels, equipment characteristics or building stock inventories to provide substantial detail toward determining the electric potential. Therefore, it is suggested that the potential from the civilian sector be applied to the military using the breakdown shown in Table 39.

[38] Calculated by assuming 1.5% of the 2011 annual military electricity usage each year for the next 13 years.

[39] The EISA standard requires that the retrocommissioning cover enough facilities to account for 75 percent of the electricity consumption, and that 25 percent of these facilities are audited annually.

Table 39 – Estimated Energy Consumption, by Facility Type for Military Installations

Facility Type	Estimated Percent Usage
Office Buildings	26.8%
Hotels	0.0%
Health	10.2%
Education	13.2%
Manufacturing	5.3%
Services	14.9%
Restaurant	0.0%
Retail - Food	0.0%
Retail - Nonfood	4.9%
Wholesale	4.7%
Communications	7.6%
Food Processing	3.2%
Cold Storage	1.3%
Amusement	7.1%
Street Lighting	0.8%

The information in Table 39 was developed based on the percent electricity usage by facility type for the entire state of Hawaii. Many of the military installations have a wide range of building types present including schools, medical facilities, warehouses, office buildings and retail spaces. The statewide building profile was taken and adjusted in order to be more closely aligned with what is typically expected to be seen on military installations found in Hawaii.[40] This is an assumption made for purposes of this analysis, since the actual distribution of energy use in buildings is not available for this research.

6.4 Military Residential

The second component of the military sector is the residential housing on base. As stated in the beginning of Section 6.3, the military has both residential and non-residential buildings on base. There are approximately 16,500 military homes on Oahu.[41] All homes are owned

[40] The non-residential population had a significant number of hotels and retail spaces. Based on our experience, these building types are not as prevalent on military installations. Therefore, the hotel, restaurant, and retail – food types were set to zero.

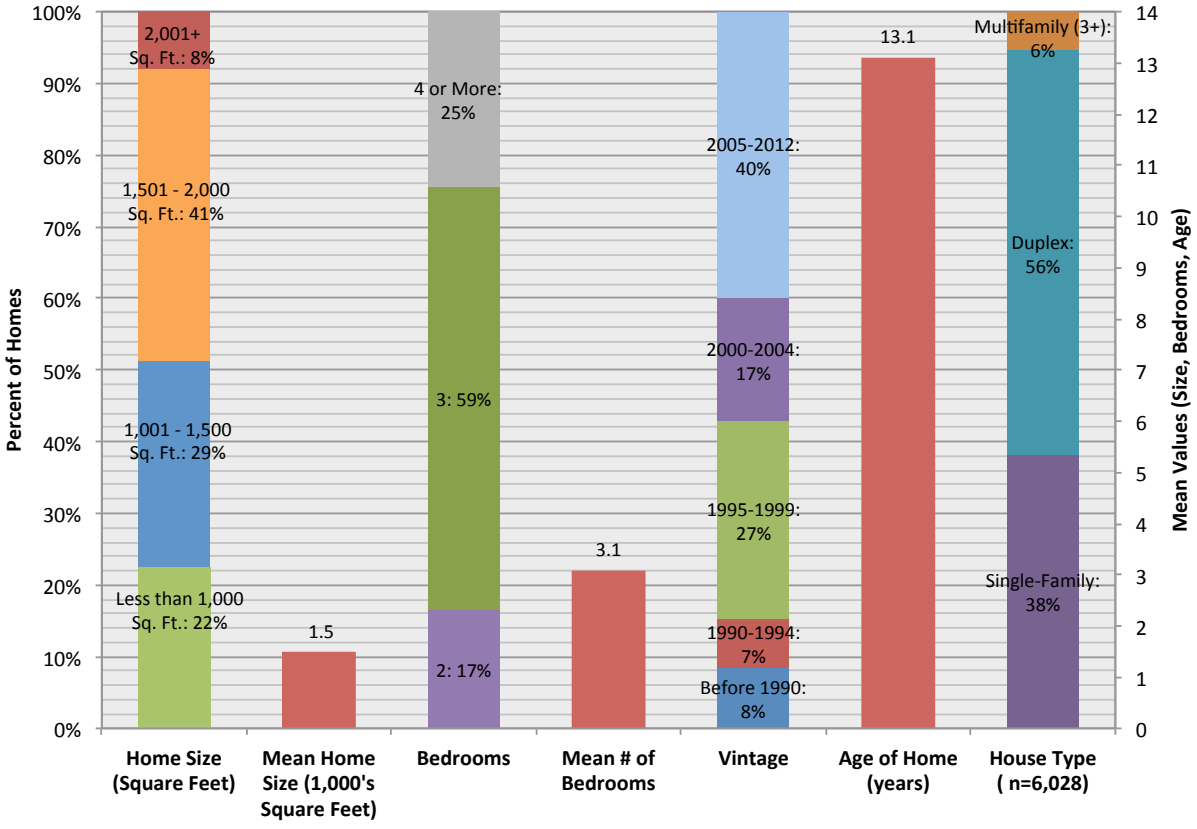
[41] Housing stock data obtained from Forest City and Island Palm Communities.

by the military branches and are rented to personnel and their families. Most homes are duplex, triplex or other single-family attached, (i.e. multi-family) structures.

As part of the data collection effort, 100 site visits were completed at military on base homes. Our sample of military homes was 76 percent multi-family and 24 percent single-family detached homes. The homes are rented and maintained by two property management and development companies, Forest City Military Communities and Lend Lease Corporation. Both of these companies provided additional information regarding their housing stocks, as well as assisted in recruiting customers for the site visits.

One of these builders, Forest City, provided a detailed database on the nearly 7,000 military homes they have built and currently manage, representing nearly half of the military housing stock in Oahu County. The data included size, home type, year of construction, the number of bedrooms and more. Figure 151 below summarizes the data provided on the 7,000 Forest City military homes. The data show a mean home size of 1,478 square feet, a mean age of 13.1 years, and that over half the homes (56%) are duplexes (i.e., two homes per building).

Figure 151 – Forest City Housing Data: Home Size, Bedrooms, Vintage, and Type



Additional characteristics of the visited homes and the military housing population were collected during the completed site visits. These results are discussed in detail in Section 4.10. The remainder of this report will focus on the overall energy usage of the military homes and the information gathered during the phone interviews.

6.4.1 Billed Data Analysis

As mentioned previously, the electricity usage from the billing data was not broken down between residential and non-residential components of the military customers. Therefore, the billing data was analyzed in conjunction with information obtained during the interview process.

According to the information obtained from Hawaii Energy, previously displayed in Table 35, Navy records indicate that during the previous fiscal year, the residential electricity consumption was 16 percent of their overall electricity usage. During the phone interview, Forest City estimated that each of their homes averages approximately 1,000 kWh of electricity usage per month. If this assumption is used for the entire military housing population of 16,500 homes, the on base housing component consumed 198 GWh of electricity in 2011. This represents 15.9 percent of the statewide military usage, almost exactly what the Navy had estimated. This confirmed that 16 percent (199.7 GWh) of the overall military sector consumption is a valid estimation of the annual electricity consumption by the military housing component statewide.

6.4.2 Additional Energy Details

This section will summarize the information obtained during the phone interviews with Forest City and Lend Lease. These two companies manage the military housing for the military installations on the island of Oahu. Forest City manages approximately 7,000 homes located on or near Navy and Marine Corps bases. Lend Lease manages approximately 10,000 homes on or near Air Force and Army bases. Both companies took over the property management from the respective military branches beginning around 2004, and each has a 50-year contract to maintain, develop and manage the properties.

The first 10 years of the contract involved tearing down and rebuilding approximately half of the existing housing stock. The remaining half was updated with new heating and air conditioning equipment, lighting and appliances. The last of the rebuilt homes are scheduled to be completed during the summer of 2014. The next rebuild cycle, where homes are demolished and rebuilt, is not scheduled to start for approximately 15 years. However, if entire neighborhoods become significantly worn down and in need of repair, the build cycle could be started earlier.

As discussed previously, Forest City estimates that its average home now consumes approximately 1,000 kWh per month. Forest City began tracking the electricity usage of its homes in 2007. Since that time, its energy efficiency projects have reduced residential electricity consumption by approximately 30 percent (indicating a 2007 usage of about 1,500 kWh per home). As discussed in Section 4.1, the typical usage of a non-military home was 7,048 kWh per year, approximately 590 kWh per month. Even at the current usage

levels, this suggests that civilian homes consume 40 percent less energy than existing military homes.

6.4.2.1 Previous Efficiency Projects

Both Forest City and Lend Lease indicated that they have completed significant energy efficiency improvements to their housing stock since they began managing them in 2004. A majority of the lamps in each home have been changed to CFLs, a majority of the appliances have been upgraded to Energy Star rated appliances, and most of the homes are now equipped with solar hot water heaters.[42] Both companies also indicated that they are continuing to update appliances, lighting and air conditioning equipment during tenant turnover periods. According to both companies, the average tenant turnover rate is 2.5 years, and units are vacant for approximately one to two weeks.

Lend Lease has also implemented a thermostat control strategy. Tennant thermostats are fixed between 72F and 74F. Tenants are allowed to adjust the thermostat as they wish, however, after two hours the thermostat reverts back to its original setting. This helps to eliminate residents from overcooling their homes and prevents excessive cooling electricity usage.

The most significant change that both companies have made to the homes they manage is the electricity billing. Previously, the military branch paid for the entirety of each tenant's electricity bill. However, as of this year, nearly all tenants are now responsible for their own electricity bill should it be significant. This was accomplished by implanting a type of sub-metering on each unit. Each unit receives its own electricity statement at the end of every month. The statement also compares each unit's energy usage to those with similar homes in the same neighborhoods. The bills also indicate the average of those similar homes, and an upper and lower limit. The average usage is calculated by taking the average of the monthly electricity usage of all homes in a given neighborhood that are the same size, minus the top five percent and bottom five percent of energy users. The upper and lower limits are the average amount plus or minus 10 percent, respectively. If a tenant has usage that is within the range, they do not owe anything for electricity for that month. When a tenant's usage is over 10 percent above the average, the tenant is responsible for paying the difference back to the management company. For example, if a tenant used 15 percent more than the average, they would be responsible to pay five percent of their electricity bill back to the company. Similarly, if a tenant is more than 10 percent under the average, they receive a credit back to them. For example, if a tenant used only 85 percent of the average, they would receive a five percent credit to their account.

[42] Specific saturations and details regarding saturation by home type can be found in sections 4.5 and 4.6 of the Baseline Energy Appliance, Equipment and Building Characteristics Study Report.

6.4.2.2 Future Energy Efficiency Efforts

Forest City indicated there were several project coming down its pipeline. The first is common area lighting. There are a total of 35 neighborhoods where it is responsible for a portion of the common area lighting. The Navy Facilities Engineering Command owns and operates a majority of the street lights, and all other common area lighting is operated by Forest City. Forest City estimated that between eight and 18 percent of its monthly electricity bill goes towards common area lighting. Ideally, these fixtures would be replaced with LED lights. Most now are either HID fixtures or fluorescent fixtures.

Additionally, Forest City is working on increasing its renewable energy portfolio. It is currently working out a long term purchase agreement for a ground-based 1.0 MW solar PV array. Additionally, it just started a second purchase agreement where solar PV systems will be installed on the roof tops of its units. The target capacity is 24 to 25 MW, and the project is scheduled to be completed four years from now.

6.5 Board of Water and Sewer

The final sector of the case study research was the Board of Water/Sewer (BoWS). There are a large number (774) of different accounts in the BoWS sector. The BoWS installations are spread across four of the five islands covered by this report. The billed data suggests that there are no BoWS facilities on the island of Molokai. However, it appears as though the Molokai facilities are included in the Maui sites due to Molokai being part of Maui county. There was not sufficient data to separate the two islands, so the billed data was left unchanged. The BoWS facilities both supply water to the different counties and process the wastewater. There is a wide range of facility types and sizes throughout the state.

The information presented in this section was obtained through phone interviews with Hawaii Energy (PBFA). Currently, Hawaii Energy is working closely with the BoWS to conduct audits of a majority of their facilities to determine how efficient they are currently operating, and what improvements can be made to help reduce the electricity consumption of this segment.

Hawaii Energy is currently in the early stages of this process, and as a result the amount of quantitative data for this sector is limited. The numbers presented in this section are based on the engineers' experience in Hawaii thus far, and the amount of data they had gathered prior to this report.

According to Hawaii Energy, there are several key areas that appear to be barriers to the BoWS facility managers from conducting energy efficiency projects. One of the main reasons for lack of interest is that BoWS facilities are required to maintain certain production and quality levels, but not energy consumption. The main concern is meeting the demand with plenty of extra capacity and backups not being as efficient as possible.

However, Hawaii Energy has also discovered that funding is important to BoWS facilities. Their overall budgets are always a concern for the facility managers, but many of them are not aware how much they are spending on energy, or how much capital could be saved by

conducting energy efficiency projects. Once facility managers are educated regarding the finances of energy efficiency, they appear to be more receptive to implementing projects.

6.5.1 Billed Data Analysis

The billed data was analyzed in order to determine the electricity consumption for the BoWS sector. Table 40 shows the annual electricity consumption for the BoWS sector from 2009 through 2011.

Table 40 – Annual Electricity Usage (kWh) for the Entire BoWS Sector

Year	HA Large	Medium	Small	HA Total	LA Large	Medium	Small	LA Total	MA Large	Medium	Small	MA Total
2009	33,554,360	35,883,991	603,171	70,041,522	-	391,920	52,680	444,600	32,826,710	14,600,561	762,330	48,189,601
2010	34,380,040	34,993,192	560,066	69,933,298	-	391,920	59,183	451,103	39,393,610	17,396,105	756,853	57,546,568
2011	28,692,120	35,585,669	581,175	64,858,964	-	375,450	53,516	428,966	37,689,015	15,601,364	756,165	54,046,544
Average	32,208,840	35,487,617	581,471	68,277,928	-	386,430	55,126	441,556	36,636,445	15,866,010	758,449	53,260,904

Year	MO Large	Medium	Small	MO Total	OA Large	Medium	Small	OA Total	Grand Total
2009	-	-	-	-	112,111,880	94,333,162	2,833,396	209,278,438	327,954,161
2010	-	-	-	-	118,138,240	95,416,076	2,303,197	215,857,513	343,788,482
2011	-	-	-	-	116,107,500	92,174,165	1,461,069	209,742,734	329,077,206
Average	-	-	-	-	115,452,540	93,974,468	2,199,221	211,626,228	333,606,616

6.5.2 Additional Energy Details

According to Hawaii Energy, the current state of the Hawaii water and wastewater landscape is very similar to how the state of Wisconsin was several years ago. Hawaii Energy has been gathering data to begin benchmarking the facilities in Hawaii to both other facilities in Hawaii and national averages. There were only a few facilities available to be included in this report; however, follow-up with Hawaii Energy could be used later on into the fall to determine if there have been any significant updates to the data collection.

Based on the discussions with Hawaii Energy, their initial estimate was that BoWS facilities could save as much as 20 to 25 percent of their annual electricity usage. Many of the facilities have older outdated technologies that could be replaced with newer more efficient processes.

During the research process, a report published by SAIC in 2006 regarding the progress made in the state of Wisconsin was found. While there are likely differences between the BoWS facilities found in Wisconsin and those found in Hawaii, the results of the report can provide some useful indication as to the variability in facility energy consumption and potential savings that could be attributed to this sector. Table 41 shows the comparison between the average facility, the top energy efficient quartile of facilities, and the best practice benchmark for water and wastewater treatment facilities in Wisconsin.[43]

Table 41 – Results Comparing Water Facilities in Wisconsin

Facility Type	Flow Range (MGD)	Average Energy Usage (kWh/MGD)	Top Performance Quartile (kWh/MGD)	Best Practice Benchmark (kWh/MGD)	Average Potential Savings
Activated Sludge	0 - 1	5,440	< 3,280	3,060	44%
	1 - 5	2,503	<1,510	1,650	34%
	> 5	2,288	< 1,350	1,760	23%
Aerated Lagoon	< 1	7,288	< 4,000	3,540	51%
Oxidation Ditch	< 1.2	6,895	< 4,000	4,320	37%
			Average Savings Potential	**2,866**	**38%**

The numbers shown in Table 41 show that there was a maximum of 51 percent and a minimum of 23 percent savings potential between the average facility and the best practice benchmark facilities. The average savings potential for these facilities was 38 percent. SAIC provided some usage characteristics for nine facilities that they have visited as part of their

[43] WATER & WASTEWATER INDUSTRY ENERGY BEST PRACTICE GUIDEBOOK. Focus on Energy, Prepared by SAIC. December 2006.

efficiency effort. The detailed usage information for 2012 for these facilities can be seen in Table 42.

Table 42 – Electricity Usage for Nine BoWS Facilities in Hawaii

Facility	Type of process	Average MGD	Average Daily kWh	kWh/MG
Facility 1	Biotowers/reaerate return	25.41	29,957	1,179
Facility 2	Oxidation ditch and SBR	0.18	1,299	7,217
Facility 3	Biotowers /reaerate return	11.26	20,155	1,790
Facility 4	Activated sludge	0.43	3,418	7,949
Facility 5	Oxidation ditch	0.09	2,163	24,033
Facility 6	Primary Treatment	62.82	91,916	1,463
Facility 7	New WWTF under construction	1.68	12,135	7,223
Facility 8	Biotowers/reaerate return	3.15	7,522	2,388
Facility 9	Activated sludge w/anoxic zone	0.6	2,370	3,950

The units MGD stand for million gallons per day, and are a typical representation of the amount of water processed at water treatment facilities. There is not a large enough sample to draw significant conclusions from this data. However, it can provide some further support for the previously stated savings estimates. The data from Table 41 and Table 42 were combined to determine how some of the Hawaii facilities compare to the industry best practice facilities discussed in the SAIC report. The results of this comparison can be seen in Table 43. Only facilities with similar types were compared and presented in the table.

Table 43 – Comparison of Hawaii Facilities to Industry Best Practice Facilities from Wisconsin

Facility	Type of process	kWh/MG	Best Practice kWh/MG	Percent Difference
Facility 1	Biotowers/reaerate return	1,179	NA	NA
Facility 2	Oxidation ditch and SBR	7,217	4,320	40%
Facility 3	Biotowers /reaerate return	1,790	NA	NA
Facility 4	Activated sludge	7,949	3,060	62%
Facility 5	Oxidation ditch	24,033	4,320	82%
Facility 6	Primary Treatment	1,463	NA	NA
Facility 7	New WWTF under construction	7,223	NA	NA
Facility 8	Biotowers/reaerate return	2,388	NA	NA
Facility 9	Activated sludge w/anoxic zone	3,950	3,060	23%

Examination of the table shows that there could be significant energy savings potential at the various BoWS facilities. The maximum difference between the Hawaii sites and the best practices sites from Wisconsin is 82 percent. While this is most likely an extreme, it again gives additional support that savings potential of at least 20 percent is likely possible at BoWS facilities in the state of Hawaii.