Massachusetts Residential Retail Products:
Consumer Electronics Saturation

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Executive Summary

This report presents the findings of research conducted in Massachusetts to examine the use of selected consumer electronics and appliances and to explore related plug load concerns. NMR Group, Inc., and its subcontractor DNV KEMA, performed the research and are collectively referred to as "the team."[1] The report focuses on the types of consumer electronics customers use, the characteristics of those products, and the configurations of products that customers use together. We also examine the use of power strips, both conventional and smart strips. Finally, we present information on the use and characteristics of refrigerators, freezers, clothes washers, clothes dryers, dishwashers, and water heaters. Later in 2012, NMR will submit an in-depth qualitative exploration of program potential for consumer electronics.

Methodology and Analysis Approach

The findings are largely based on the results of visits to 150 households in Massachusetts conducted between February and April 2012, although we also summarize responses to questions about consumer electronics asked in an earlier consumer survey. The team identified households for inclusion in the onsite study through the consumer survey, which was performed in December 2011 and January 2012. We randomly called the subset of consumer survey respondents who had expressed interest in the onsite to schedule an actual visit. The team weighted the data based on home ownership/renter status and educational attainment so the results would better reflect the distribution of households in Massachusetts.

The analyses largely involved calculating descriptive statistics such as means and percentages of products and their characteristics. However, we turned to a more complex analysis to describe the most common configurations of products found in onsite households—a procedure that relies on a Venn diagram approach (i.e., a series of overlapping circles), but in tabular format. The Venn diagram method allowed us to specify certain products for inclusion in the analysis and then report the occurrence of groupings of the specified products in the onsite households.

Key Results

The analyses revealed a number of key findings about consumer electronics, plug load, appliances, and water heaters, as summarized below.

Television and Set-top Boxes

Television equipment—and in fact television viewing and use—is in a state of change. The diversity of television types, screen sizes, and the peripheral devices that can be connected to them have proliferated in recent years. In response, our analyses focused on describing the

[1] Lighting inventories also occurred during the visits, as summarized in a separate draft report. NMR. *Results of the Massachusetts Onsite Compact Fluorescent Lamp Surveys*, Delivered on June 11, 2012.

diversity of equipment found in homes and identifying the most common configurations of products found together. Some highlights of the results include the following:

- The average home used two televisions, but one-third of homes had three or more televisions. NMR verified through either visual confirmation or post-fielding analysis that about one-third of the televisions qualified for the ENERGY STAR label.[2] Only four percent of the televisions were "smart" in that they could connect to the internet and stream content, but this status was sometimes difficult to determine either visually or via model numbers.
- Most of the televisions relied on a liquid crystal display (LCD) screen (56%), but 37% were still cathode ray tubes (CRT); the remainder were rear projection types (6%) or plasma screens (1%). About two-thirds (66%) of the television screens were smaller than 40 inches; LCD, rear projection, and plasma televisions tended to be larger than CRT screens. Most of the televisions (62%) had high definition resolution. Note that, whenever possible, the team determined definition by model number; when the model number was not available, the technician relied on whatever information was available on the television.
- Almost all televisions (91%) had a set-top box (STB) attached to them that delivered programming from a cable, satellite, or fiber optic provider. Over one-third (37%) of the STBs was found to be ENERGY STAR qualified. Cable service remains the most common signal type for STBs (65%), followed by satellite (21%), and fiber optic (12%). Most of the STBs only received cable or satellite data (61%), while another 18% served as both a DVR and cable/satellite receiver. Other types of STBs included multi-room receivers and digital transport adapters (DTAs).
- Next to STBs, standard digital video disk players (DVDs) are the most common peripheral device connected to televisions; DVD players were found in 70% of homes with an average of about one DVD player per household. No other *individual* peripheral device was found in more than 50% of households, but most households had at least one peripheral device connected to at least one television.
- We found a diversity of television and peripheral equipment in homes, but configurations of television equipment remained relatively simple. Households usually had a "main" television that tended to be located in a living room or family room, had a larger screen, and was connected to a STB and one other peripheral device; the peripheral device was most often a DVD player alone or in combination with another device. We found secondary televisions in such places as bedrooms and kitchens; these televisions often had smaller screens and typically had only the cable-provided STB attached to them.

[2] Note that for televisions and all other products, the methods for verifying ENERGY STAR qualification have shortcomings, as qualified devices do not always have the label and we could not always identify manufacturer and model number.

Office Equipment

Like most of the other consumer electronics products discussed in this report, the home office is changing. Home office equipment is no longer used only for typical office activities—paying bills, budgeting, and word processing—but has also joined the television as a major source of home entertainment. Household members interact on social media sites, play online video games, use their gaming system with a high resolution computer monitor, and stream movies over internet perhaps as much—if not more than—they engage in more typical "office" activities in the home office. This fact influenced the analyses and findings regarding home office equipment, as discussed below.

- As with televisions, the team found a diversity of home office equipment; wireless routers, desktop computers, laptop computers, monitors, printers, and game consoles were the most common equipment found in the home office environment.
- About 42% of homes had at least one desktop computer, and 65% had at least one laptop computer. Many households had more than one computer, quite often having a desktop computer and a laptop.
- Most home offices also had wireless routers (70%), one-half (50%) had a multifunction printer, and 45% had a game console in the home office environment. Standard printers, fax machines, and scanners were rare.
- We observed the ENERGY STAR label on 47% of multifunction printers, 30% of scanners, 27% of laptop computers, and 26% of printers. We suspect more products qualified for the ENERGY STAR but could not verify this to be the case, as we did not collect manufacture and model number information for home office equipment.
- Consumers rarely reported using the power management functions (e.g., sleep and hibernate modes) on their home office equipment.
- Due to limitations on the number of products that could be included in the analysis of common configurations, we ran separate analyses for homes with desktops and for homes with laptops, although the analysis did allow us to show the number of homes with both desktops and laptops. The most common configuration (28%) of home office equipment in the 81 homes with desktop computers included the desktop plus a router, a laptop, a monitor, a game console, and a multi-function printer—in other words, every device we entered into the analysis. The same configuration was also the most common one found in the homes with laptops (20% of 110 homes). The second most common configuration in each type of home excluded the game console (21% of homes with desktops and 15% of homes with laptops).

Power Strips and Plug Load

The team examined the issue of plug load—that is, electricity used simply because the device is plugged into an outlet—and phantom load—that is, electricity used in standby modes—through

analyses of configurations of television and home office equipment (see above) as well as exploration of the current use of power strips, both standard strips and smart strips. Not surprisingly, the findings point to substantial opportunity to reduce plug load through the use of smart power strips and increased consumer education on how best to use power management settings on their consumer electronics.

- Ample opportunity exists for plug load reduction programs associated with the main television in the home; this is the television typically located in the living room or family room and is the most likely to have one or more peripheral devices associated with it. Currently, the most common configuration of devices plugged into power strips involves a television, STB, and a DVD or Blu-ray player, accounting for 19% of all power strips; television equipment dominates most of the other common power strip configurations. Together, television equipment comprises 46% of devices plugged into power strips.

- Home office equipment accounted for 34% of the devices currently plugged into power strips, and 12% of the most common power strip configurations primarily involve home office equipment. Given the diversity of home office products, it appears that the home office environment offers potential for plug load management through the use of power strips. However, increased education over the use of power management settings could also reduce the amount of energy used by home office equipment.

- We found a total of 286 power strips in homes, but only 13 of them were smart power strips. All of the smart strips in use were in the home office or associated with the main television in the home. For the most part, the power strips were being used correctly; that is, the householders had the television or main computer plugged into the "control" outlet and the peripheral devices into the "controlled" outlets. STBs were only used with three of the smart strips, and in each of these the STB was in a dependent slot. The low use of STBs with smart strips suggests that consumers plug STBs into other outlets, likely in order to keep them at least in a standby mode at all times.[3] The two strips not being used correctly had nothing installed in the control outlet.

- In addition to home office and television equipment, households plugged a variety of other products into power strips, accounting for 20% of the outlets. These other products included lamps, charging devices (e.g., for cellular phones), telephones, and stereo equipment.

- Telephone survey respondents were asked about their awareness of smart strips, both "unaided" (i.e., without a description) and "aided (i.e., with a description). The results indicate that 36% of respondents voiced unaided awareness of smart strips; respondents exhibiting "early adopter" tendencies were slightly more aware of smart strips. However,

[3] Although we did not ask why, this is most likely because STBs must download programming information from cable, satellite, and fiber optic providers each time the STB fully loses power. Similarly, STBs that also act as DVRs would need to be drawing power in order to record shows at desired times even with the television off.

when asked what a smart power strip does, only 11% of the respondents voicing unaided awareness could describe with accuracy the purpose of a smart strip. Aided awareness was somewhat higher at 54% of respondents, again with early adopters showing somewhat more awareness of smart strips.

Appliances

NMR also gathered information on a variety of appliances, including ENERGY STAR qualification and the age of the products. We determined ENERGY STAR qualification either by observing the label on the appliance or through internet-based searches of the model's ENERGY STAR qualification status, both current and historic. In other words, if the appliance was ever ENERGY STAR qualified, we count it as being qualified in this study. In this executive summary, we focus only on the percentage of homes with products and their ENERGY STAR qualification, but the main body of the report addresses other characteristics, including ENERGY STAR qualification by age of the appliance.

- All homes had a primary refrigerator and 24 households (16%) also had a secondary refrigerator. We verified that about 24% of the primary refrigerators were ENERGY STAR qualified, but none of the secondary ones was.
- Only 15% of the homes had stand-alone freezers, and we verified that only 3% were ENERGY STAR qualified.
- About three-quarters (73%) of homes had clothes washers. We were able to verify that 38% of these were qualified for the ENERGY STAR label.
- Most homes (70%) had clothes dryers, and about 90% of these are electric, making it worthwhile to delve more deeply in future research into the program and savings potential of heat pump dryers in an effort to be prepared for possible program support when they become available in the US. Likewise, many of the homes with electric dryers are plumbed for natural gas (based on the existence of natural-gas water heaters), making fuel switching an option in these homes.
- About three-quarters (77%) of homes had dishwashers, and 40% of them qualified for the ENERGY STAR label.

Water Heaters

At the request of the PAs and EEAC consultants, the team collected fairly detailed information on water heaters. Although the PAs currently offer rebates for heat pump water heaters (HPWH), they desired more information on the potential for this technology. The information collected included not only water heater type and fuel type, but also other characteristics of the water heater space that may enhance or limit replacement with a HPWH. A separately delivered matrix developed by NMR compares the onsite water heaters on a number of characteristics and rates the strength of their candidacy for replacement with HPWH.

- Of the 126 water heaters we could inspect, only 15 relied on electric water heaters, while approximately 33 systems heated water with fuel-oil either instantaneous or through integrated storage tanks.[4] One-half of the homes (75 of 150) heated water with natural gas, mainly through the use of storage tanks.
- Because they use the warmth of the air to heat water, HPWHs work best in spaces that have a moderate temperature; these spaces also tend to be conditioned, or have at least some insulation. Although most water heaters in the onsite sample were located in rooms with no insulation, more than one-third of the 15 electric water heaters (38%) were located in a room with both ceiling and wall insulation, and electric water heaters were the most likely to be located in conditioned spaces. Most oil water heaters (80%) were located in unconditioned basements. The temperature of rooms containing water heaters hovered around 55 degrees Fahrenheit for all water heater and fuel types.
- Across fuel types, water heaters in the sample served an average of three household members, which is approximately the average size of a household in Massachusetts. Looking more closely at the distribution of household size reveals that about one-half (47%) of the 15 electric water heaters served only one person. Examining the number of rooms in homes served by the water heaters revealed that larger homes tended to be served by systems with tanks, whether integrated or storage, regardless of the fuel type. One-half of the electric water heaters, all storage units, were located in houses with eight or more rooms. Electric and natural gas storage tanks also served smaller homes more frequently than did fuel-oil systems.
- In 2015, electric water heater storage tanks over 55 gallons will be required to have an energy factor of 2.0 or greater; currently only HPWHs meet this specification[5]. The average electric storage tank in our sample held 57 gallons, and, likewise, 76% of the tanks held between 41 and 80 gallons, suggesting that, in the future, many of these units will likely be replaced by HPWH. Natural-gas and fuel-oil fired water heaters that had stand alone or integrated storage tanks tended to be somewhat smaller; 70% of natural gas tanks and 77% of fuel-oil tanks held 21 to 60 gallons. Yet, the largest tanks—over 80 gallon capacity—were natural gas or fuel-oil tanks.
- The average age of water heaters ranged from six years for natural-gas water heaters to 10 years for fuel-oil water heaters, with this higher average being driven in part by the instantaneous systems fueled directly from aging boilers. Electric water heaters were about eight years old, on average.
- HPWHs require the ability to drain condensate created through the process of heating water. For this reason, the team searched for the nearest drain that could receive

[4] Given the small sample sizes of electric and fuel-oil fired water heaters, all results reported in this section about these types of water heaters should be interpreted with caution.

[5] http://www.energystar.gov/ia/partners/prod_development/downloads/Spec_At-A-Glance_PD.pdf

condensate from water heaters. Potential condensate drains were not found in a majority of onsite homes. When they existed, the average drain was about 10 feet away from electric and fuel-oil water heaters and six feet away from natural-gas water heaters. Installation of a HPWH in most homes, therefore, would necessitate using long hoses or adding drains.

- We also took various measurements around existing water heaters, as HPWH are typically larger in size than other tank styles with the same capacity. The average dimensions were as follows, reported in feet using the length, width, and height convention: electric 6x5x3, natural gas 12x9x3, and fuel oil 10x3x3.

Energy-related Smart Phone Applications

Telephone survey respondents were asked if they were aware of smart phone applications that allowed them to monitor their home energy use or to identify energy efficient products. One-fourth of respondents were aware of applications that allowed them to monitor their home energy use, but only 11% were aware of applications for finding energy efficient products. Of those aware of such applications, fewer than 10% used either type.

Conclusions and Recommendations

This onsite saturation study served to describe the types of consumer electronics, appliances, and water heaters found in homes and began to assess the potential for a program designed to reduce plug load in residences in Massachusetts. A qualitative program potential study is currently in progress and the report is forthcoming in 2012. In the current report, the team refrains from offering detailed recommendations on consumer electronics and plug load potential until the program potential study is complete, but we have identified a few key conclusions and recommendations.

Conclusion 1: The results of the consumer electronics saturation study strongly suggest that program potential exists to reduce plug load by targeting television and home office equipment. However, these results will need to be verified and the implications clarified through the forthcoming program potential study. However, neither this saturation study nor the forthcoming program potential study provides information to estimate the *savings* potential from a plug load management program.

Recommendation 1: The team suggests that the PAs and EEAC consultants consider an hours of use study on televisions, computers, and peripheral equipment in order to help identify the areas of use to target in potential programs. Depending on the breadth of the study, it may be most cost effective to partner with other PAs and energy efficiency organizations in the region. If such a study is not feasible, the PAs could explore the applicability of data from other jurisdictions to Massachusetts. If at all possible, the devices that will be monitoring use should be able to measure electricity draw both while

the devices are in use and when they are turned off (or in a standby mode) but still drawing power from the electricity grid.

Conclusion 2: The market for consumer electronics is large, diverse, and changing rapidly. Consumers buy electronics at a faster rate than many other ENERGY STAR qualified products (with lighting being an obvious exception), which means consumers have numerous opportunities to choose between more and less efficient models. Not only will tracking the market share, penetration, and saturation of ENERGY STAR qualified consumer electronics solely through onsite studies be expensive, but the results will have a short shelf life.

Recommendation 2: The PAs should work with consumer electronics retailers and manufacturers to develop procedures to track sales data in order to track the market share of ENERGY STAR products sold in Massachusetts. Given the challenges the PAs have had with obtaining similar data for lighting, it is likely that the Massachusetts PAs will have to work with other PAs and energy-efficiency industry leaders across the nation to develop procedures that will be acceptable to manufacturers and retailers.

Conclusion 3: The analysis of clothes dryers demonstrates that 70% of homes have clothes dryers, and most of these are heated with electricity. Because dryers are almost always paired with a clothes washer, it is highly likely that a drain that could be used for condensate is located near the dryer, although we did not explicitly measure this in our study. These conditions make it likely that potential exists for a heat pump dryer program when they become available in the US market.

Recommendation 3: The PAs and EEAC consultants should explore the potential for heat pump dryers in more depth so that they can be prepared to offer a program when these products became available in the US. It would not only determine program potential but also estimate the savings potential and cost effectiveness of supporting this emerging technology. The PAs and EEAC consultants should also consider working with manufacturers, trade organizations, and the Super Efficient Dryer Initiative[6] to accelerate the introduction of heat pump dryers in the US market.

Conclusion 4: Based on the homes included in this sample, some of the barriers that exist in securing a greater number of HPWH installations include access to a condensate drain and having a large enough space into which the larger HPWH could fit.

Recommendation 4: The team recommends that the PAs and EEAC consultants continue supporting the installation of HPWHs using the current program model, but take into account the challenges of installation these measures in many homes in Massachusetts. It may also be worthwhile to perform a second onsite study examining water heaters that is more directly informed by the MassSAVE program criteria for HPWH installations, which were not available to the team when developing the onsite protocols.

[6] For more information see http://www.energystar.gov/ia/partners/downloads/meetings/2011/Super%20Efficient%20Dryer%20Initiative.pdf.

1 Introduction

This report presents the findings of research conducted in Massachusetts to examine the use of selected consumer electronics and appliances and to explore related plug load concerns.[7] The findings are largely based on the results of visits to 150 households in Massachusetts conducted between February and April 2012, although we also summarize responses to questions about consumer electronics as asked during the consumer survey fielded in December 2011 and January 2012. NMR Group, Inc., and its subcontractor DNV KEMA, performed the research and are collectively referred to as "the team."[8] The report focuses on the types of consumer electronics customers use, the characteristics of those products, and the configurations of products that customers use together. We also examine the use of power strips, both conventional and smart strips (in which a master outlet controls power to other outlets on the power strip). Finally, we present information on the use and characteristics of refrigerators, freezers, clothes washers, clothes dryers, dishwashers, and water heaters. Later in 2012, NMR will submit an in-depth qualitative exploration of program potential for consumer electronics.

1.1 Methodology

The team identified households for inclusion in the onsite study through the consumer survey performed in December 2011 and January 2012.[9] After completing the telephone survey, each survey respondent was offered a $150 incentive to participate in an onsite visit to their home. DNV KEMA randomly selected among all survey respondents voicing interest and called to set up an onsite visit. The visits were conducted between February and April of 2012. The team successfully completed the desired 150 onsite visits. This sample size exceeds a 10% sampling error at the 90% confidence level for all households in Massachusetts.

During the onsite visits, a trained technician gathered detailed information on the following product types:

- Televisions
- Set-top boxes (STBs)
- Audiovisual equipment and game consoles
- Office equipment
- Refrigerators and freezers

[7] As explained more in Section 4, plug load refers to the electricity used by a product simply because it is plugged into an outlet. Phantom load refers to the electricity used by a product when in a standby mode. For ease of discussion, we generally use the term plug load to apply to both types of load.

[8] Lighting inventories also occurred during the visits, as summarized in a separate draft report. NMR. *Results of the Massachusetts Onsite Compact Fluorescent Lamp Surveys*, Delivered on June 11, 2012.

[9] NMR, *Massachusetts Consumer Survey Results*. Delivered to the Massachusetts Program Administrators on April 16, 2012.

- Clothes washers and dryers
- Dishwashers
- Water heaters

Because they were conducted during the lighting onsite saturation visits, the consumer electronics procedures followed the same initial protocols. A trained technician arrived at the home at a pre-scheduled time, introduced himself or herself, and asked for the contact person who had been identified when scheduling the visit. The respondent and the technician walked through each room of the home examining all lighting sockets. To collect data for the consumer saturation portion of the visit, while in each room the technician also gathered information on any televisions, STBs, home office equipment, power strips, appliances, and other targeted electronics that were present. The technician also noted key characteristics of the products such as manufacturer and model number, special features, size, and ENERGY STAR® qualification, among other characteristics. If any power strips were used the technician noted the room type, whether it was a standard strip or a smart strip, strip technologies that may have been present (uninterrupted power source, surge protection, occupancy or load sensors), and if the strip was manually controlled. The technician also recorded the type of device, plug type (standard, smart), and plug control (control, switched, always on) for each outlet that was occupied on the power strip. Customers were also asked why they decided to use a power strip for the devices that were recorded. If a smart strip was used, customers were asked why certain devices were plugged into the control and switched outlets.

Visual inspection of equipment does not always yield reliable information on such characteristics as ENERGY STAR® status or advanced features (e.g., televisions and set top boxes than can stream internet content). Therefore, after the visit, the team used information on manufacturer and model number to perform online searches to verify the ENERGY STAR status of equipment and note any special features associated with the equipment. If a unit was ever qualified for as ENERGY STAR, it is treated as a qualified product in this analysis.

The team also applied weights to the data in order to improve our ability to generalize the results to all households in Massachusetts. The weighting scheme adjusted for householder education and home ownership/renter status as estimated by the United States Bureau of the Census's 2006 to 2010 *American Community Survey* (Table 1-1).[10] These schemes mirror those used in the 2009 and 2010 lighting onsite reports.[11]

Table 1-1: Population, Sample Sizes, and Weights for Onsite Survey – Massachusetts

	Households	Sample Size	Proportionate Weight
State Total	*2,512,552*	*150*	*n/a*
Owner-occupied, High School degree or less	474,060	13	2.13
Owner-occupied, some College, Associate's Degree, Bachelor's degree or higher	1,134,414	108	0.61
Renter-occupied, High School degree or less	407,684	4	5.96
Renter-occupied, some College, Associate's Degree, Bachelor's degree or higher	496,394	22	1.32
Refused*	n/a	3	1.00

* Respondents refused to answer either the home ownership or the education question, or both, so could not be assigned a weight.

1.2 Analysis Approach

The analyses largely involved describing the consumer products found in onsite households; as such, we used Excel and the Statistical Package for Social Sciences (SPSS) to calculate means and percentages of counts of products and their characteristics. However, we turned to a more complex analysis to describe the most common *configurations* of products found in onsite households. Using the statistical package STATA, the team used a procedure that relies on a Venn diagram approach (i.e., a series of overlapping circles), but in tabular format. The Venn diagram method allowed us to specify certain products for inclusion in the analysis and then report the occurrence of groupings of the specified products in the onsite households. The limitations of the Venn diagram approach include that only five variables could be specified and that it was not possible to run the analysis with weights. Therefore, all of the results on configurations of products are unweighted.

[10] United States Bureau of the Census. *2006-2010 American Community Survey 5-Year Estimates.* *http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_5YR_B25013&prodType=table* Accessed April 25, 2012.

[11] NMR Results of the Massachusetts, 2011.

2 Televisions and Set-top Boxes

In the U.S., televisions account for about one-third of annual energy consumption by consumer electronics.[12,13] For this reason, we examined the number and characteristics of televisions in the onsite participants' homes. We also considered the many devices that households plug into televisions, including STBs, video recording and playback devices, audio equipment, gaming systems, and devices devoted to streaming internet content over televisions. We provide an overview of the television equipment found in homes and then describe the most common configurations of equipment.

2.1 Characteristics of Televisions in Households

The number of televisions per household in the onsite sample ranged from zero (1%) to six (<1%), with an average of just over two televisions per household (mean=2.1) (Table 2-1). Homes commonly had one (35%), two (32%), or three (20%) televisions, while fewer had more than three televisions.

Table 2-1: Number of Televisions per Household

(Base: All onsite households)

Number of Televisions	
Sample Size (Number of households)	*150*
Mean	*2.1*
0	1%
1	35%
2	32%
3	20%
4	10%
5	1%
6	<1%

[12] Fraunhofer Center for Sustainable Energy Systems. "Energy Consumption of Consumer Electronics in U.S. Homes in 2010." December 2011. Accessed April 26, 2012. http://www.ce.org/CorporateSite/media/Government-Media/Green/Energy-Consumption-of-CE-in-U-S-Homes-in-2010.pdf.

[13] The current saturation report shares some information on the function and relative energy use of the various devices addressed here. However, the forthcoming consumer electronics potential study will delve into these issues in more detail.

Over one-third (36%) of televisions qualified for the ENERGY STAR label (Table 2-2).[14]

Table 2-2: Percent of Televisions that are ENERGY STAR Qualified

(Base: All televisions)

ESTAR Qualified?	
Sample Size (Number of TVs)	*331*
Yes	36%
No	64%

The majority of television screens (56%) were liquid crystal display (LCD), but over one-third (37%) were the more traditional cathode ray tube (CRT) variety (Table 2-3). Six percent were rear projection screens. LCD technology is more energy efficient than CRT technology; however, LCD screens are often larger, frequently causing them to use more energy overall. As we discuss below, larger televisions tended to be located in family and living rooms, while smaller televisions were found in other rooms of the home. The energy use of LCD and rear projection screens depends on the light source used in the projection system, with LEDs being the most energy efficient. However, this information was not available for the televisions in our sample. It is notable that only 3 (1%) of the televisions in our sample had plasma screens, which often, although not always, use more energy than either CRT or LCD screens.

Table 2-3: Television Screen Types

(Base: All televisions)

Types of Screens	
Sample Size (Number of TVs)	*331*
LCD	56%
CRT	37%
Rear Projection	6%
Plasma	1%

[14] Note that for televisions and all other products, the methods for verifying ENERGY STAR qualification are fallible, as qualified devices do not always have the label and we could not always identify manufacturer and model number. Moreover, ENERGY STAR status determined through the label reflected status as the time of manufacture; the product may no longer meet current standards.

Screen size is the single most important factor determining the amount of energy used by a television, with energy use increasing with screen size, although the amount of increase depends on the type of screen. Table 2-4 shows the percentage of television screens that fall into various size ranges in the onsite sample overall and broken down by screen type. Overall, the screens ranged from ten to 62 inches wide, with most of the screens (79%) being between 20 and 49 inches. The single most common range was between 20 and 29 inches, with one-third of televisions falling into this range. Looking at individual screen types, the data confirm that CRT screens tend to be the smallest, while rear projector and plasma televisions have the largest screens; LCDs fall somewhere in between. Thus, although CRT technology is less efficient than LCD technology, the smaller screen sizes of CRTs likely offset the difference in overall energy use to some extent.

Table 2-4: Television Screen Size

(Base: All televisions by screen type)

Screen Size Ranges (in Inches)	All Televisions	CRT Screens	LCD Screens	Rear Projector	Plasma Screens
Sample Size (Number of TVs)	*331*	*117*	*194*	*16*	*3*
10-19	13%	29%	7%	0%	0%
20-29	33%	59%	16%	0%	0%
30-39	20%	10%	28%	0%	0%
40-49	26%	3%	38%	31%	2%
50-59	8%	0%	11%	56%	1%
60+	1%	0%	1%	13%	0%

"Smart TVs" allow consumers to use a number of internet-connected services, including applications similar to those found on many "smart phones," including media streaming, Web browsing, games, and Internet Protocol Television[15]. Table 2-5 shows that fewer than one in twenty televisions among onsite households were Smart Televisions.

Table 2-5: Percent of Televisions That Are Smart TVs

(Base: All televisions)

TV Type	
Sample Size (Number of TVs)	*331*
Smart	4%
Standard	97%

[15] For more information, see Pendelbury, Ty. "Smart TV: What you need to know." Accessed June 15, 2012 from http://asia.cnet.com/smart-tv-what-you-need-to-know-62208829.htm.

As shown in Table 2-6, nearly two-thirds (62%) of televisions were high-definition (HD), meaning that they have a much higher resolution (based on the pixels per field, with the exact numbers varying by screen size) than standard definition televisions. Note that, whenever possible, the team determined definition by model number; when the model number was not available, the technician relied on whatever information was available on the television.

Table 2-6: Percent of Televisions That Are High-Definition

(Base: All televisions)

HD Versus SD	
Sample Size (Number of TVs)	*331*
High-Definition (HD)	62%
Standard-Definition (SD)	38%

As shown in Table 2-7, approximately one-half (49%) of televisions were plugged directly into a wall socket, and nearly as many (47%) were plugged into a regular power strip. Just three percent of televisions were plugged into a smart power strip in which all devices plugged into certain outlets on the strip will be completely turned off (i.e., not enter stand-by mode) when the controlling device is turned off. As non-ENERGY STAR qualified televisions use a substantial amount of energy while in stand-by mode,[16] the relatively infrequent use of smart power strips indicates that a large amount of energy is being wasted while consumers are not actively watching their televisions. Note that the hard-wired television was wall-mounted. We discuss power strips and plug arrangement in more detail in Section 4.

Table 2-7: Television Power Sources

(Base: All televisions)

Power Sources	
Sample Size (Number of TVs)	*331*
Wall	49%
Regular Power Strip	47%
Smart Power Strip	3%
Hard-wired	2%

2.1.1 Characteristics of Set-top Boxes in Households

According to ENERGY STAR, "a 'set-top box' (STB) is a cable, satellite, Internet Protocol, or other device the primary function of which is to receive television signals from a specific source and deliver them to a consumer display and or recording device, such as a television or DVR."[17]

[16] For more information see Department of Energy, Lawrence Berkeley National Laboratory. "Ranges of Standby Power." Accessed June 25, 2012 from http://standby.lbl.gov/summary-chart.html.

[17] ENERGY STAR. 2012. "Set-top Boxes & Cable Boxes." Accessed April 26, 2012 from http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=ST.

Set-top boxes are usually provided to consumers as part of a contract with a service provider rather than being sold to consumers in stores, and are required for the consumer to receive the media content from their cable, satellite, or fiber optic provider. Therefore, the results imply that 91% of the households in the sample subscribe to some sort of cable, satellite, or fiber optic television service. Set-top boxes represent nearly 13% of total annual electricity consumption by consumer electronics in the U.S.[18]

Households in the onsite sample had between zero (9%) and five (1%) STBs attached to televisions (Table 2-8). Most had just one (35%) or two (31%) STBs, but one in four households (25%) had three or more. On average, each household had close to two STBs (mean=1.8), slightly fewer than the average number of televisions per household (2.1).

Table 2-8: Number of Set-top Boxes per Household

(Base: All onsite households)

Number of Set-top Boxes	
Sample Size (Number of households)	*150*
Mean	*1.8*
0	9%
1	35%
2	31%
3	18%
4	6%
5	1%

Smart STBs were relatively uncommon; they were found in 2% of households (Table 2-9). These devices allow users to play streaming digital video from Internet sources like Netflix, Hulu, and iTunes. They do not receive content from cable or satellite providers.

Table 2-9: Percent of Set-top Boxes That Are Smart STBs

(Base: All STBs)

STB Type	
Sample Size (Number of STBs)	*285*
Smart	2%
Standard	98

[18] Fraunhofer Center 2012.

The most common type of STB, found in 61% of households, was a cable or satellite receiver designed to serve a single TV (Table 2-10). Eighteen percent of households had a cable or satellite STB with digital video recorder (DVR) functionality, and 8% had multi-room DVR STBs that can send recorded content to other STBs within the home. Eight percent of homes had digital transport adapter STBs (DTA). DTAs allow cable customers to view digital cable signals on an analog television, but are limited to basic cable service. Note that these functions have been verified using model numbers.

Table 2-10: STB Type and Function

(Base: All STBs)

Type	
Sample Size (Number of STBs)	*285*
Cable/satellite receiver	61%
DVR cable/satellite receiver	18%
Multi-room DVR cable/satellite receiver	8%
DTA	8%
Other/unknown	5%

More than one-third (37%) of all STBs in households qualified for the ENERGY STAR label (Table 2-11).

Table 2-11: Percent of Set-top Boxes That Are ESTAR

(Base: All STBs)

ESTAR Qualified?	
Sample Size (Number of STBs)	*285*
Yes	37%
No	63%

Table 2-12 shows the different types of signals used by the STBs in households. Close to two thirds (65%) of these STBs used cable signals, while 21% percent used satellite technology. The least common signal types were fiber optic (12%) and Internet (2%).

Table 2-12: STB Signal Types

(Base: All STBs)

Signal Type	
Sample Size (Number of STBs)	*285*
Cable	65%
Satellite	21%
Fiber optic	12%
Internet	2%

Table 2-13 shows the power sources into which the STBs were plugged. Just over one-half (54%) were plugged into regular power strips, and the remaining (46%) were plugged into the wall. None of these STBs was plugged into a smart power strip. Most STBs in use in the U.S. consume close to the same amount of power when not in use (in stand-by mode) as they do when in use; two-thirds of a unit's total energy consumption is consumed when the unit is not in use.[19] However, many STBs reset completely when they are unplugged or installed in a controlled outlet of smart power strip; this means that they lose all the programming information (e.g., the menu and program guide and information offered by a cable or satellite provider). When power is restored, the device must download all the programming information again, which can take up to an hour. It is NMR's understanding that this characteristic is not technologically necessary, but instead reflects providers' current practice, presenting a potential opportunity to work with service providers to reduce plug load in the future. For this reason, current STBs may not be good candidates for smart power strips, unless they are plugged into the outlets that do not control and are not controlled by other devices.[20]

Table 2-13: STB Power Sources

(Base: All STBs)

Power Sources	
Sample Size (Number of STBs)	*285*
Regular Power Strip	54%
Wall	46%

[19] Natural Resources Defense Council. 2011. "Energy Facts. Better Viewing, Lower Energy Bills, and Less Pollution: Improving the Efficiency of Television Set-Top Boxes." June. Accessed May 4, 2012 from http://www.nrdc.org/energy/files/settopboxes.pdf.

[20] We also noted that less than one percent of STBs use thin clients and only one percent of STBs serve multiple rooms.

2.1.2 Audiovisual Equipment and Game Consoles Attached to Televisions

In addition to STBs, the team found a variety of audiovisual equipment as well as video game consoles attached to televisions in the on-site sample.

Devices that allow household members to record television shows or watch previously recorded material were common in the onsite households we visited. Among the 148 households with televisions, 70% had at least one digital video disc (DVD) player attached to a television—although only about one out of ten households (12%) had more than one (Table 2-14). The average number of DVD players per household was just under one (0.8).

More than one-third (36%) of households with at least one television had one or more digital video recorders (DVRs) attached to televisions.[21] Just over one-tenth (12%) had more than one DVR. The average number of DVRs per household was 0.5. Because DVRs record material, they are usually on all the time, which increases their electricity use compared to some other peripheral devices.

Blu-ray disc players, which have a similar purpose to DVD players but use a newer technology, were less common among households than were standard DVD players; the team found them installed in only 22% of homes. No home had more than two Blu-ray players. Fewer than one-half (43%) of households with televisions had a video cassette recorders (VCRs) attached to a television. The average number of VCRs per household was 0.5.

Table 2-14: Number of Video Recording and Playback Devices per Household

(Base: All households with televisions)

Number of Standard DVD Players	DVD	DVR	Blu-ray	VCR
Sample Size (Number of households with TVs)	*148*	*148*	*148*	*148*
Mean	*0.8*	*0.5*	*0.2*	*0.5*
0	30%	65%	78%	57%
1	59%	25%	20%	34%
2	10%	7%	2%	9%
3	1%	4%	0%	0%
4	<1%	0%	0%	0%
5	0%	<1%	0%	0%

[21] DVRs are typically rented to customers by cable, satellite, or fiber optic service providers, although consumers can also chose to purchase DVR service on their own (e.g., TiVO can be purchased directly by the consumer).

About one-quarter (24%) of households with televisions had at least one audio receiver or amplifier attached to televisions, with only two percent having more than one (Table 2-15). The average number of receivers/amplifiers per household was 0.3. Approximately one-third (34%) of households with televisions had one or more game consoles attached to televisions, with very few (6%) having more than one. Just over one out of ten households with televisions (12%) had at least one digital-to-analog (DTA) converter in use; these devices allow those with analog televisions who do not subscribe to cable or satellite service to receive over-the-air digital broadcast signals.[22] The average number of DTAs per household was 0.2.

Table 2-15: Number of Receivers/Amplifiers Connected to TVs (per Household)

(Base: All households with televisions)

Number of Receivers/Amplifiers	Receivers / Amplifiers	Game Consoles	Digital-to-Analog Converters
Sample Size (Number of households with TVs)	*148*	*148*	*148*
Mean	*0.3*	*0.4*	*0.2*
0	76%	66%	88%
1	23%	28%	4%
2	2%	5%	7%
3	0%	1%	1%

Other products attached to televisions were relatively rare. These included various devices devoted to streaming internet content to the television or syncing television watching across devices (Apple TV® in 3 households and Roku® and Sling Box® in one house each) as well as a cassette tape player (one household) (Table 2-16).

Table 2-16: Other Audiovisual Equipment Attached to Televisions

(Base: All households with televisions)

Type of STB	Unweighted counts and percents
Sample Size (Number of households with TVs)	*148*
Apple TV®	3 (2%)
Cassette Tape Player	1 (1%)
Roku®	1 (1%)
Sling Box®	1 (1%)

[22] The mandated switch from analog to digital broadcast in June 2009 created the need for DTAs. These devices will slowly become obsolete as the analog based televisions they serve stop working, as all televisions manufactured for the United States are now designed for digital service.

2.1.3 Configurations of Audiovisual Equipment Attached to Televisions

Table 2-17 shows the most common configurations of audiovisual equipment plus gaming consoles among all televisions in the onsite sample. For this analysis, we examined configurations of three of the most frequently occurring types of audiovisual equipment—DVRs, DVD players, and Blu-ray players—as well as game consoles. We did not include STBs in the analysis because 91% of the televisions have a STB attached to them, which most televisions need to access the digital and "on-demand" services of cable, fiber-optic, and satellite providers. Therefore, STBs should be considered to be nearly ubiquitous device when addressing the energy use of television, and one should assume that most of the televisions configurations described below also include a STB.

Nearly one-third (31%) of televisions had none of the four types of equipment attached (Table 2-17). These "stand-alone" televisions tended to be located in places in the household where "secondary" televisions are often kept (e.g., bedrooms, kitchens, porches, attics, music rooms, etc.) Very few stand-alone televisions were found in living rooms, family rooms, or basements; in contrast about two-thirds of the televisions in bedrooms and offices were stand-alone.

Most of the other televisions in the homes had only one other device plugged into them. Specifically, close to one-quarter (22%) had only a standard DVD player attached, while 10% had a game console only. Fewer televisions had only a DVR (8%) or Blu-ray player (5%) attached to them. Fewer still had a DVR plus a Blu-ray player (4%) or a DVD player plus a game console (4%). About one-fifth of the televisions (18%) had more than one device attached, with all the multiple devices involving a DVR plus something else, typically a standard DVD player (10%) but occasionally a Blu-ray player (4%) or game console (4%).

Table 2-17: Most Common Configurations of AV Equipment Attached to TVs (DVRs, DVD Players, Blu-ray Players, and Game Consoles)

(Base: All televisions in onsite homes, unweighted results)

Products attached to TVs	
Sample Size (Number of TVs)	*331*
None (no DVR, DVD, Blu-ray, or Game console)	31%
DVD player only	22%
Game console only	10%
DVR plus DVD player	10%
DVR only	8%
Blu-ray player only	5%
DVR plus Blu-ray player	4%
DVD player plus Game console	4%

3 Office Equipment

Like most of the other consumer electronics products discussed in this report, the home office is changing. Home office equipment is no longer used only for typical office activities—paying bills, budgeting, and word processing—but has also joined the television as a major source of home entertainment. When household members hop on a computer, they are probably as—if not more—likely to be engaging friends via social media, streaming movies or music over the internet, shopping online stores, or playing online video games than they are to be tracking budgets or working on reports. Therefore, in our exploration of home office equipment, the team considered not only computers, monitors, printers, scanners, fax machines, and routers but we also included game consoles found in the home office environment in the analysis. It was the team's understanding that the PAs and EEAC consultants desired information on devices found in the home office more for understanding potential issues of plug load than supporting ENERGY STAR qualified equipment, and our data collection and reporting reflect that understanding.

3.1 Characteristics of Home Office Equipment

The onsite study revealed that most homes in Massachusetts have at least one laptop computer (65%), while less than one-half have desktop computers (42%) (Table 3-1 on the next page). We found monitors in 43% of the homes; although the percentages of monitors mirrors that of desktops, closer analyses reveals that some desktops do not have an external monitor (e.g., many Macintosh computers have an integrated desktop/monitor) and some laptops have been attached to monitors (see Section 3.2 below for a detailed discussion of office equipment configurations). Households somewhat rarely had more than one desktop or monitor in the home (11% and 10% respectively), but 26% of households had more than one laptop in the home. The average number of desktop computers and monitors was 0.5 per home, but the average number of laptops was one, due to the fact that many homes had multiple laptops. It is also worth noting that 57 households (38%) had both desktop and laptop computers.[23] On a per unit basis, laptops consume less power than desktops, particularly when one considers that many desktops require the use of both a central processing unit (CPU) and a monitor. The research did not, however, explore why households chose desktops or laptops as their main computer, a question that should be addressed in future research should the PAs decide to implement an office equipment or office equipment plug load program in the future.

[23] The computer market is shifting to ever smaller devices, first from desktops to laptops, then to netbooks, and most recently to tablets. For more information see Schonfeld, Erick. "Forrester Projects Tablets will Outsell Netbooks by 2012, Desktops by 2013." Accessed on June 23, 2012 from http://techcrunch.com/2010/06/17/forrester-tablets-outsell-netbooks/.

Table 3-1: Number of Computers and Monitors per Household

(Base: All onsite homes)

Number of Devices	Desktop	Laptop	Monitor
Sample Size	*150*	*150*	*150*
Mean	*0.5*	*1.1*	*0.5*
0	58%	35%	57%
1	31%	38%	32%
2	10%	14%	10%
3	1%	10%	0%
4	0%	1%	<1%
5	0%	<1%	0%
6	0%	1%	0%

The office equipment portion of the onsite study did not distinguish CRT monitors from flat panel monitors though the power strip portion of the onsite study did make the distinction between monitor types. The power strip monitor data cannot be assumed to be referring to the same monitors found in the home office data (because monitors may have been located outside of a home office) but the power strip data is still useful in telling us which type of monitors are being used in the home. The power strip data show that there were 78 power strips with computer monitors plugged into them; these 78 power strips were located across 67 homes. Of the computer monitors plugged into power strips 16% were CRT monitors and 84% were flat panel monitors (Table 3-2).

Table 3-2: CRT and Flat Panel Monitors

(Base: Power Strips with Computer Monitors plugged into them)

Type of Monitor	
Sample Size	*78*
Flat Panel	84%
CRT	16%

Turning to the types of peripheral equipment located in home offices, the team found that 70% of homes had at least one wireless router installed (Table 3-3). Note that wireless routers serve more than just computers, as so-called Smart devices (i.e., certain mobile phones, MP3 players, tablet computers, handheld game consoles, audiovisual equipment, etc.,) also can use wireless signals to connect to the internet. One-half (50%) of homes had a multi-function printer (i.e., printer that also serves as a scanner and/or fax machine). Game consoles are also commonly used in the home-office environment, most likely for use with high resolution monitors, although some were also associated with televisions found in the home office (and thus were described earlier). The average home used 0.4 game consoles per television, but had 0.7 game consoles located with other home office equipment. In fact, just under one-half (45%) of the households had a game console in their home office, and 15% of homes had more than one game console in their home office environment. Households make less use of the remaining home office equipment; only 24% had a stand-alone printer, and just about 5% had a stand-alone fax machine or scanner. With the notable exception of game consoles, very few homes had multiple home office peripheral devices.

Table 3-3: Number of Peripheral Home Office Equipment per Household

(Base: All onsite homes)

Number of Devices	Router	Printer	Fax	Scanner	MF Printer	Game Console
Sample Size	*150*	*150*	*150*	*150*	*150*	*150*
Mean	*0.8*	*0.3*	*0.1*	*<0.1*	*0.6*	*0.7*
0	30%	76%	95%	96%	50%	55%
1	64%	20%	5%	3%	45%	29%
2	6%	3%	0%	<1%	5%	9%
3	0%	1%	0%	0%	0%	6%
4	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	<1%

The onsite technicians also noted whether the ENERGY STAR label appeared on home office equipment. However, because the team collected home office equipment with an eye to potential plug-load management more than to understand the ENERGY STAR penetration and saturation of the equipment, we did not collect the manufacturer and model number information needed to verify ENERGY STAR qualification. Therefore, it is likely that additional home office equipment qualified for ENERGY STAR than what is listed below. We also examined the type of outlet used for the home office equipment and if the householder reported using the equipment's power management systems.

Very few of the computers and monitors found in onsite homes visibly displayed the ENERGY STAR label. Table 3-4 shows that just over one-quarter of laptops (27%) displayed the ENERGY STAR label, while only nine percent of the monitors and three percent of the desktop computers did. Households plugged most of the laptops into standard outlets, but about one-fourth of the desktops (25%) and monitors (24%) were plugged into power strips. Most respondents reported using the power management systems on their desktops (56%), laptops (65%), and monitors (58%).

Table 3-4: Power-related Characteristics of Computers and Monitors*

(Base: All specified devices found in homes)

Characteristic	Desktop	Laptop	Monitor
Sample Size	*106*	*186*	*109*
ENERGY STAR	3%	27%	9%
Plugged in standard outlet	25%	77%	24%
Power Management Enabled	56%	65%	58%

* Note that the sample sizes are not weighted, explaining why dividing the sample sizes in this table by those in the Table 3-1 yields slightly different estimates of the average number of products per home.

Turning to the peripheral devices associated with home offices, just under one-half of the multifunction printers (47%) visibly displayed the ENERGY STAR label, while 30% of stand-alone scanners and 26% of stand-alone printers did (Table 3-5). Only two percent of the routers displayed the ENERGY STAR label, and none of the gaming systems or stand-alone fax machines found in the homes were labeled as ENERGY STAR.

Table 3-5: Power-related Characteristics of Peripheral Home Office Equipment*

(Base: All specified devices found in homes)

Characteristic	Router	Printer	Fax	Scanner	MF Printer	Gaming System
Sample Size	*127*	*53*	*6*	*9*	*96*	*104*
ENERGY STAR	2%	26%	0%	30%	47%	0%
Plugged in standard outlet	37%	21%	41%	49%	44%	47%
Power Management Enabled	0%	0%	0%	0%	0%	0%

* Note that the sample sizes are not weighted, explaining why dividing the sample sizes in this table by those in the Table 3-3 yields slightly different estimates of the average number of products per home.

3.2 Configurations of Home Office Equipment

The team also considered the common configurations of home office equipment. The fact that office equipment is so varied challenged the analysis precisely because households used the equipment in many different configurations. In order to keep the analysis of configurations as straightforward as possible, the team assumed that households with computing equipment also

had a router. While this assumption is not accurate for all homes (19 of the 81 homes with desktops did not have routers and five of the 110 homes with laptops did not have routers), it reflects the actual situation for the majority of homes in the sample. Therefore, one should assume that a router was present in most of these configurations, much the same way that STBs were assumed to be associated with each television. We also ran separate analyses for homes with desktops and for homes with laptops, a decision driven by the fact that the statistical analysis software limits the number of devices one can include in the Venn diagram procedure; however, the analysis was able to account for homes with both types of equipment.

Table 3-6 shows that 28% of the homes with desktop computers also had a laptop, monitor, game console, and multi-function printer in the same home office environment—in other words, every device we included in the analysis. The second most common configuration (21%) had both types of computers, a monitor, and a multi-function printer. Other configurations found in more than 10% of homes include the desktop, monitor, and printer (14%) or the desktop, laptop, and monitor (11%).

Table 3-6: Most Common Configurations associated with Desktop Computers

(Base: Onsite homes with desktop computers, unweighted results)

Home Office Combinations	Occurrence in Homes
Sample Size	*81*
Desktop, Laptop, Monitor, Game Console, Multi-function Printer	28%
Desktop, Laptop, Monitor, Multi-function Printer	21%
Desktop, Monitor, Multi-function Printer	14%
Desktop, Laptop, Monitor	11%
Desktop, Laptop, Monitor, Game Console	9%
Desktop, Monitor	8%
Desktop, Monitor, Game Console, Multi-function Printer	4%
Desktop, Monitor, Game Console	3%
Desktop, Laptop	1%
Desktop, Laptop, Multi-function Printer	1%

Homes with laptops displayed a great deal of variation in their home office configurations. One-fifth of the households with laptops also tended to have all of the devices included in the analysis—that is a laptop, desktop, monitor, game console, and multi-function printer. Another 15% of laptop-using households had a desktop, monitor, and printer, 13% had only a laptop and printer, and 12% had a laptop, game console, and printer. Ten percent of households had a laptop paired only with a game console, and another 10% used the laptop alone.

Table 3-7: Most Common Configurations associated with Laptop Computers

(Base: Onsite homes with laptop computers, unweighted results)

Home Office Combinations	Occurrence in Homes
Sample Size	*110*
Laptop, Desktop, Monitor, Game Console, Multi-function Printer	20%
Laptop, Desktop, Monitor, Multi-function Printer	15%
Laptop, Multi-function Printer	13%
Laptop, Game Console, Multi-function Printer	12%
Laptop, Game Console	10%
Laptop	10%
Laptop, Desktop, Monitor	8%
Laptop, Desktop, Monitor, Game Console	6%
Laptop, Monitor, Multi-function Printer	2%
Laptop, Monitor, Game Console, Multi-function Printer	2%
Laptop, Desktop	1%
Laptop, Desktop, Multi-function Printer	1%

In contrast to televisions, in which configurations tended to be limited to the television, STB, and perhaps a DVD player, most home offices had multiple devices connected to their computers. Moreover, the use of power management systems (e.g., sleep or hibernate modes) remains limited. Based on the number of devices typically used in the home office environment and the fact that more than one-third to nearly one-half of respondents self-reported that they did not use power-management systems, home office equipment appears to offer potential for plug-load management through the use of smart power strips and increased education about use of power-saving modes. However, the amount of potential remains unknown, and, as recommended for television equipment, NMR recommends an hours of use study—including measurement of power draw when the devices are not in use—to determine the savings potential associated with home office equipment.

4 Power Strips and Plug Load

The proliferation of equipment that uses electricity in homes has created concerns about "plug load" and "vampire or phantom" load. According to a 2009 presentation posted on the EPA website, "A plug load is the energy consumed by any electronic device that is plugged into a socket," while "A vampire (or phantom) load is the amount of energy a device consumes while in standby mode or switched 'off.'"[24] The team explored the issue of plug load through analyses of consumer electronics and home office equipment configurations described above, but also through questions on the Wave 1 consumer survey about Smart strips (fielded in December 2011 and January 2012) and by examining use of power strips in onsite homes. This section focuses on the results of the consumer survey and onsite examination of power strips.

4.1 Awareness of Smart or Advanced Power Strips

The team asked respondents to the Wave 1 consumer survey two questions to gauge their awareness of smart power strips. First, we simply asked if they had heard of "smart power strips" or "advanced power strips;" this question measures unaided awareness. We later read all respondents a description of smart strips to gauge aided awareness. Measuring aided awareness allowed the respondent to confirm whether they had the same understanding of "smart power strip" as the team did and provided those who said "no" to the unaided awareness questions the opportunity to change their response after being provided more information about smart power strips. We present responses on awareness below, and examine smart strip awareness by self-reported early adopter tendencies.

[24] Rivas, Jessica, *Managing Plug Loads: Laptops & Charges & Fans, Oh My!* Presented at the Climate Leaders Web Conference, February 11, 2009.

Just over one-third (36%) of the respondents demonstrated unaided awareness of smart power strips, saying that they had heard of these devices; respondents who espoused opinions more in keeping with those of early adopters showed slightly more awareness of smart strips (Table 4-1). Specifically, 44% of respondents *not* skeptical of new technology, 42% of respondents who like to have new technology, and 36% of respondents comfortable learning about new technology said they were aware of smart strips, compared to 32% of technology skeptics, 32% of respondents who prefer to wait to buy a new technology, and 27% of respondents who are less comfortable learning about new technology. As expected, aided awareness of smart power strips was higher among all groups (54% overall), with early adopters tending to voice awareness more than others respondents.

Table 4-1: Unaided and Aided Awareness of Smart or Advanced Power Strips

(Base: All telephone survey respondents)

Heard of Smart or Advanced Power Strips	**Overall**	**Skeptical of New Technology**		**Likes to have New Technology**		**Comfortable Learning about New Technology**	
	n/a	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Unaided Awareness							
Sample size	*582*	*378*	*196*	*190*	*386*	*532*	*47*
Yes	36%	32%	44%	42%	32%	36%	27%
No	63%	67%	54%	57%	67%	62%	73%
Don't know/Refused	1%	1%	2%	1%	1%	1%	0%
Aided Awareness							
Sample size	*582*	*378*	*196*	*190*	*386*	*532*	*47*
Yes	54%	54%	59%	60%	52%	56%	45%
No	40%	40%	40%	38%	42%	39%	53%
Don't know/Refused	6%	6%	2%	2%	6%	5%	2%

Even though respondents may voice awareness, in reality they may not have a great deal of understanding of smart power strips and may confuse them with other power strip technology. For this reason, the team asked respondents who voiced *unaided* awareness of smart power strips where they had heard about them and also to describe their understanding of what "a smart power strip does." Table 4-2 summarizes the results of the first of these questions, revealing that respondents heard about smart power strips from a wide variety of sources. The most common sources included internet or phone applications (16%), seeing them on store shelves (15%), displays at the mall or a store (14%),[25] through television and radio (12%), at school, work, or a conference (10%), and claims to already be using one (10%).

Table 4-2: Where Seen or Heard Information about Smart Power Strips or Advanced Power Strips

(Base: Respondents voicing unaided awareness of smart power strips)

Where seen or heard information, multiple response	
Sample size	*221*
On the internet or a phone application	16%
Saw on store shelves	15%
Display at a mall or a store	14%
Television or radio	12%
At work, school, or a conference	10%
Already use/saw one in use (self-reported)	10%
Word of mouth	9%
Magazine or newspaper	8%
Ads from stores	6%
Mailing from electric company	2%
Computer store	<1%
Other	2%
Don't know/Refused	10%

[25] Unfortunately, we are unable to determine if these were MassSAVE displays from which smart power strips were sold along with various lighting technologies.

Responses to the second question about smart strip understanding determined if respondents who said they had heard of smart power strips or advanced power strips could accurately describe their purpose. The results indicate that about 11% of respondents asked could either name the intended purpose of smart power strips or describe the color coding on smart power strips that facilitates their accurate use (Table 4-3). Another 38% of respondents understood that a smart power strip somehow saves energy, but they did not accurately identify how this happened. About one-half of the respondents (49%) provided answers that applied to all power strips, not just smart ones. These included such features as surge protection and providing more outlets. It is important to keep in mind that this question allowed respondents to provide more than one answer; therefore, for example, someone who understood that smart power strips turn off peripheral devices may also have noted that they save energy and offer surge protection. Finally, about one-fourth of respondents (26%) said they did not know what a smart power strip does.

Table 4-3: Understanding of Smart Power Strips or Advanced Power Strips

(Base: Respondents voicing unaided awareness of smart power strips)

Respondents' understanding of Smart Power Strips or Advanced Power Strips, multiple response	
Sample size	*221*
High Understanding – understands purpose	
Turns off peripheral devices, prevents phantom load	9%
Can plug in multiple devices and turn off when do not need them	2%
Color coding for where to plug in certain devices*	<1%
Some Understanding –recognize that they manage energy consumption, but incomplete understanding of how	
Saves power even when plugged in	19%
Shuts down equipment when not in use after a period of time	11%
Monitors or controls energy use	7%
Better for the environment	1%
Equipment does not need to be shut off**	<1%
Little Understanding – features available on regular power strips	
Offers surge protection	27%
Provides more outlets, flexible plug configuration	14%
Similar to regular power strip	2%
Keeps cords more compact, safer	1%
Other	5%
Don't know/Refused	26%

* Although this response does not name energy management, the respondent was clearly describing a smart power strip.

** We have placed this response here even though it is not completely accurate; the control device needs to be shut off for the smart power strip to work as intended but the rest of the devices do not.

4.2 Power Strips in the Home

The team identified a total of 286 power strips in the 150 homes included in the onsite sample; 29% of the homes had a single power strip, 35% had two power strips and 34% had three or more power strips (Table 4-4). Note that we looked for power strips in all rooms of the home, not just those with consumer electronics or home office equipment.

Table 4-4: Power Strips in Home

(Base: Onsite homes)

Number of Power Strips	
Sample Size	*150*
Mean power strips per home	*1.85*
Total power strips	*286*
0 power strips	12%
1 power strip	29%
2 power strips	35%
3 power strips	12%
4 power strips	11%
5 power strips	1%

Telephone survey respondents who expressed *aided* awareness of smart power strips were asked if they currently use them. A total of 48% of 322 respondents aware of smart power strips reported using them, which represents 27% of all 582 respondents (Table 4-5). While onsite, however, we found smart power strips installed in just nine (6%) of the 151 households, implying that even with the verbal description, telephone survey respondents remained confused about whether they used smart power strips in their home.

Table 4-5: Smart Power Strips or Advanced Power Strips Installed in Home

(Base: Varies as shown in table)

Had Smart Power Strips or Advanced Power Strips Installed	**Aware Telephone Survey Respondents**	**All Telephone Survey Respondents**	**Verified Onsite Use**
Sample size	*322*	*582*	*150*
Yes	48%	27%	6%
No	49%	27%	94%
Don't know/Refused/Not aware	3%	46%	n/a

The overwhelming majority of the 286 power strips (95%) were standard power strips, with the remaining 5% being smart strips (Table 4-6).

Table 4-6: Power Strip Types

(Base: All power strips)

Power Strips	
Sample Size (number of power strips)	*286*
Smart Strips	5%
Standard Strips	95%

4.2.1 Power Strip Use in the Home

The team asked onsite householders why they plugged their devices into each power strip found in the home; respondents told us that they used 71% of the power strips because they needed more outlets (Table 4-7). Other reasons offered for the use of power strips were the combined need for additional outlets and surge protection (15%) or for surge protection alone (9%).

Table 4-7: Reasons Given for the Use of Power Strips

(Base: All power strips)

Reason	
Sample Size	*286*
Needed more outlets	71%
Needed more outlets and surge protection	13%
Surge Protection	9%
No reason	1%
Energy Savings	1%
For the strip switch and surge protection	<1%
Needed three-prong outlets	<1%
Other	4%

The team found a total of 1,160 devices, representing 69 different types of products, plugged into power strips in the 150 onsite homes; Table 4-8 lists the 20 most common of the 69 product types. Televisions, STBs, DVD or Blu-ray players, VCRs, and other television related devices collectively accounted for 46% of the devices that were plugged into power strips, while home office equipment (including game consoles) accounted for another 34% of the devices.

Table 4-8: Most Common Devices Plugged into Power Strips

(Base: All devices plugged into power strips)

Devices	Percent of Devices
Sample Size	*1,160*
Television Related	
TV	13%
Set top box	13%
DVD/Blu Ray	8%
Game Console*	5%
VCR	3%
Other television related (8 devices)	4%
Television Total	***46%***
Home Office Related	
Wireless Router	6%
Desktop	5%
Flat Panel Monitor	5%
Multi-function printer	4%
Laptop	3%
Stand-alone Printer	3%
Computer speakers	3%
Cable Modem	1%
CRT Computer Monitor	1%
External Hard Drive	1%
Other Home office related (12 devices)	5%
Home Office Total	***34%***
All Other Devices	
Lamp	7%
Charging Device	3%
Telephone w/o Answering Machine	2%
A/V Receiver	2%
A/V Amplifier	1%
Other (28 devices in other category)	5%
All Other Devices Total	***20%***

* Could be television or home-office-related but we placed with televisions due to the shared use for "home entertainment."

Configurations of power strips in the homes were numerous, Table 4-9 list the ten most common power strip device configurations. The five most common configurations involve entertainment devices and account for 37% of the 286 power strips.

Table 4-9: Ten Most Common Combinations of Devices in Power Strips

(Base: All power strips, unweighted)

Device Combinations	Count
Sample Size	*286*
Television, STB, DVD/Blu-ray	19%
Television, STB	7%
Television, STB, DVD/Blu-ray, VCR	4%
Television, STB, DVD/Blu-ray, Game Console	4%
Television, Game Console	3%
Desktop, Flat Monitor	3%
Desktop, Flat Monitor, MF Printer	3%
Television, STB, Game Console	3%
Desktop, Flat Monitor, Printer	3%
Laptop	3%
Other	48%

4.2.2 Smart Power Strip Use in the Home

Respondents did not use many smart power strips. Of the 286 power strips in use, only 13 were smart strips. Three of the 13 respondents with smart strips reported that the smart strips were being used because of the ease of shutting multiple items off at once and efficiency (Table 4-10). One of the "other" responses provided by a respondent helps to illustrate the challenges of explaining the correct use of smart strips to consumers; when asked why they used a smart strip, the respondent said, "Because … my son told me to".

Table 4-10: Reasons Given for Plugging Devices into Smart Outlets on Smart Power Strips

(Base: Smart power strips in onsite homes)

Reason, multiple response	Count
Sample Size	*13*
Ease of shutting multiple items off at once and efficiency	3
Wanted device to always be on	2
Made sense to use it as it was made to be used	2
Other	8

There were 11 separate configurations of devices among the 13 power strips (Table 4-11). Of the 13 smart strips, eight had televisions in the control outlet device, and three had desktops in the outlet device; assuming the households turn off the television or desktop, these configurations reflect smart strip usage that would reduce plug load. STBs were only used with three of the smart strips, and in each of these the STB was in a dependent slot. The low use of STBs with smart strips suggests that consumers plug STBs into other outlets, likely in order to keep them at least in a standby mode at all times.[26] However, two of the smart strips did not have anything in the control outlet, an action that will not reduce plug load because none of the attached devices are ever fully turned off.

Table 4-11: Smart Strip Configuration

(Base: All smart power strips, unweighted)

Control Outlet Device	Dependent Device	Dependent Device	Dependent Device	Dependent Device
Television	Game Console	Game Console	Sound Bar	Live Media Player
Television	Set top box	DVD/Blu Ray	Game Console	Speaker
Television	Set top box	DVD/Blu Ray	VCR	
Desktop	Flat Panel Monitor	computer speakers		
Television	Game Console	Game Console		
Television	Game Console	Game Console		
Television	Set top box	DVD/Blu Ray		
Television	DVD/Blu Ray			
Television	DVD/Blu Ray			
Desktop	Flat Panel Monitor			
Desktop	Flat Panel Monitor	External Hard Drive	External Hard Drive	External Hard Drive
None	Laptop	MF Printer	Computer Speakers	External Hard Drive
None	Television	External Hard Drive		

Taken together, the information presented on television and related equipment, home electronics, and current use of power strips suggests a great deal of opportunity to reduce plug load and vampire load through the use of smart strips. These two types of equipment are the predominant use of power strips, yet only 13 of the existing power strips are smart strips—and two of them are being used incorrectly. The amount of savings that could be achieved, however, remains unknown and would require a savings potential study that involves estimating hours of use—both in active and standby modes—of targeted equipment.

[26] Although we did not ask why, this is most likely because STBs must download programming information from cable, satellite, and fiber optic providers each time the STB fully loses power. Similarly, STBs that also act as DVRs would need to be drawing power in order to record shows at desired times even with the television off.

5 Appliances and Water Heaters

NMR also gathered information on a variety of appliances and water heaters. At the PAs and EEAC consultants' request, we used the opportunity of being in 150 customer homes to perform lighting inventories and consumer electronics saturation studies to gather high level information on appliances in lieu of a full residential appliance saturation study. Specifically, we examined the number of appliances found in onsite homes and noted particular characteristics of them (e.g., ENERGY STAR qualification, refrigerator door configuration, type of fuel used to dry clothes, etc.). One particular item of note is the inclusion of clothes dryers among the appliances examined in this study, as it is likely that heat pump dryers will soon be available in the United States market, raising the possibility of including this appliance among program offerings.

Similarly, HPWH technology has recently become more cost effective from a programmatic standpoint. We collected detailed information on water heaters, including fuel type, configuration, number of households served by the water heater and other characteristics that could help the EEAC consultants and PAs in their continuing efforts at program design and implementation around HPWH.

5.1 Household Appliances

The team collected information on five different household appliances: 1) refrigerators, 2) freezers, 3) clothes washers, 4) clothes dryers, and 5) dishwashers. We summarize the information collected below.

5.1.1 Refrigerators

The team examined both primary (i.e., main) and secondary refrigerators in onsite households. As expected, all households had a refrigerator and 24 households (16%) also had a secondary refrigerator. Table 5-1 shows the breakdown of refrigerator door configurations among both primary and secondary refrigerators. Slightly less than one-half (47%) of the primary refrigerators and about two-thirds of the secondary refrigerators had a top freezer. More than one-third (37%) of primary refrigerators and about one-fourth (23%) of secondary refrigerators featured side-by-side refrigerator and freezer compartments. Another 15% of primary refrigerators and 12% of secondary refrigerators had a bottom freezer compartment. Very few households had single-door and compact refrigerators.

Table 5-1: Door Configuration of Refrigerator

(Base: All refrigerators)

Type	Primary	Secondary
Sample Size (Number of refrigerators)	*150*	*24*
Top freezer	47%	66%
Side-by-side	37	23
Bottom freezer	15	12
Single door	1	0
Compact	1	0

All households installed their primary refrigerators in the kitchen, but, as Table 5-2 shows, they installed secondary refrigerators in a wider variety of locations. Nearly two-thirds of secondary refrigerators (64%) were located in an unconditioned basement, while 9% were in a conditioned basement. Householders used the remaining secondary refrigerators in a wide variety of locations.

Table 5-2: Location of Secondary Refrigerator

(Base: All refrigerators)

Location	Secondary
Sample Size (Number of secondary fridges)	*24*
Unconditioned basement	64%
Conditioned basement	9%
Porch	6%
Kitchen/pantry	5%
Garage	5%
Office	3%
Hall	3%
Basement (not specified whether conditioned)	3%
Bar	3%

The majority of primary refrigerators (69%) were no more than ten years old; in fact, over one-third were between one and five years old (37%) (Table 5-3). Fifteen percent were between 11 and 15 years old, and the remaining 9% were 16 years old or older. The average age of primary refrigerators was just under eight years. The ages of secondary refrigerators varied more widely. Forty-three percent were no more than ten years old, while another 39% were 16 years or older. The average age of secondary refrigerators was 14 years, nearly double the age of primary refrigerators.

Table 5-3: Age of Refrigerator

(Base: All refrigerators)

Age in Years	Primary	Secondary
Sample Size (Number of households)	*150*	*24*
Mean Age	*7.9*	*14.0*
1-5	37%	17%
6-10	32%	26%
11-15	15%	8%
16-20	7%	25%
21-25	2%	5%
26-30	0%	9%
Not Available	8%	9%

As shown in Table 5-4, three-quarters of primary refrigerators were between 16 and 25 cubic feet in size. The average size was 20 cubic feet. Secondary refrigerators tended to be slightly smaller than primary ones. Nearly two-thirds (64%) of the secondary refrigerators were 16 cubic feet or larger, with the average size being about 18 cubic feet.

Table 5-4: Size of Refrigerator

(Base: All refrigerators)

Size in Cubic Feet	Primary	Secondary
Sample Size (Number of refrigerators)	*150*	*24*
Mean Size	*20*	*17.6*
1-5	1%	0%
6-10	1%	10%
11-15	6%	26%
16-20	36%	21%
21-25	39%	43%
26-30	5%	0%
Not Available	13%	0%

About one out of four primary refrigerators (24%) qualified for the ENERGY STAR label, but none of the secondary refrigerators was ENERGY STAR qualified (Table 5-5).

Table 5-5: Percent of Primary Refrigerators that are ENERGY STAR Qualified

(Base: All primary refrigerators)

ESTAR Qualified?	Primary
Sample Size (Number of households)	*150*
Yes	24%
No	76%

Table 5-6 shows the ENERGY STAR status of primary refrigerators for each age category of primary refrigerators. More than one-half (53%) of the refrigerators one to five years old qualified for ENERGY STAR. Five percent of refrigerators that were between six and ten years old, and ten percent of eleven-to-fifteen year-old refrigerators, were ENERGY STAR qualified. None of the refrigerators that were over sixteen years old qualified for the ENERGY STAR label.

Table 5-6: Percent of Primary Refrigerators that are ENERGY STAR Qualified by Age of Refrigerator

(Base: All primary refrigerators)

Age in Years	ENERGY STAR Qualified
Sample Size (Number of households)	*150*
1-5	53%
6-10	5%
11-15	10%
16-20	0%
21-25	0%
26-30	0%
Not Available	11%

5.1.2 Freezers

Only 15% of the homes in the onsite sample had a separate freezer. Slightly more than one-half of freezers (53%) were chest-type freezers, and the remainder (47%) were upright (Table 5-7).

Table 5-7: Type of Freezer

(Base: All freezers)

Type	
Sample Size (Number of freezers)	*27*
Chest	53%
Upright	47%

More than one-quarter (29%) were ten cubic feet or smaller, while another quarter were 16 cubic feet or larger (Table 5-8). More than one-third (37%) of the freezers were between 11 and 15 cubic feet, with the average freezer size being just under 13 cubic feet.

Table 5-8: Size of Freezer

(Base: All freezers)

Size in Cubic Feet	
Sample Size (Number of freezers)	*27*
Mean Size	*12.5*
1-5	14%
6-10	15%
11-15	37%
16-20	20%
21-25	5%
Not Available	8%

As shown in Table 5-9, the majority of freezers (52%) were no more than five years old. However, about one-quarter (26%) were 21 years or older. The average freezer was about 11 years old.

Table 5-9: Age of Freezer

(Base: All freezers)

Age in Years	
Sample Size (Number of freezers)	*27*
Mean Age	*10.8*
1-5	52%
6-10	9%
11-15	8%
16-20	0%
21-25	14%
26-30	12%
Not Available	5%

Table 5-10 shows the locations of freezers within the onsite households. Similar to secondary refrigerators, the majority of freezers (68%) were in an unconditioned basement. About one out of ten (11%) were located in the garage, and a few were in a utility room or closet (6%), the kitchen (6%), or the basement (6%, not specified whether conditioned or unconditioned). Only 3% of freezers were in a conditioned basement.

Table 5-10: Location of Freezer

(Base: All freezers)

Location	
Sample Size (Number of freezers)	*27*
Unconditioned basement	68%
Garage	11%
Utility room/closet	6%
Kitchen	6%
Basement (not specified whether conditioned)	6%
Conditioned basement	3%

Only one freezer (3%) qualified for the ENERGY STAR label (Table 5-11). This freezer was between one and five years old.

Table 5-11: Percent of Freezers that are ENERGY STAR Qualified

(Base: All freezers)

ESTAR Qualified?	
Sample Size (Number of freezers)	*27*
Yes	3%
No	97%

5.1.3 Clothes Washers

About three-quarters (73%) of the onsite households had a clothes washer installed in their home. Table 5-12 shows that approximately three-quarters (74%) of clothes washers were top-loading, while the remaining one-quarter (26%) were of the front-loading variety.

Table 5-12: Type of Clothes Washer

(Base: All clothes washers)

Type	
Sample Size (Number of clothes washers)	*121*
Top load	74%
Front load	26%

One-half of the clothes washers were no more than five years old, and more than one-quarter (29%) were between six and ten years old (Table 5-13). Fourteen percent were between 11 and 30 years old.

Table 5-13: Age of Clothes Washer

(Base: All clothes washers)

Age in Years	
Sample Size (Number of clothes washers)	*121*
Mean Age	*6.7*
1-5	50%
6-10	29%
11-15	8%
16-20	4%
21-25	1%
26-30	1%
Not Available	8%

More than one-third (38%) of clothes washers qualified for the ENERGY STAR label (Table 5-14).

Table 5-14: Percent of Clothes Washers that are ENERGY STAR Qualified

(Base: All clothes washers)

ESTAR Qualified?	
Sample Size (Number of clothes washers)	*121*
Yes	38%
No	62%

As shown in Table 5-15, most of the ENERGY STAR qualified clothes washers were relatively new. A majority (61%) of the one-to-five year old clothes washers were ENERGY STAR qualified, as were 16% of those that were between six and ten years old. No ENERGY STAR qualified clothes washers were found among those that were eleven years old or older.

Table 5-15: Percent of Clothes Washers that are ENERGY STAR Qualified by Age of Clothes Washer

(Base: All clothes washers)

Age in Years	**ENERGY STAR Qualified**
Sample Size (Number of clothes washers)	*121*
1-5	61%
6-10	16%
11-15	0%
16-20	0%
21-25	0%
26-30	0%
Not Available	0%

5.1.4 Dryers

As shown in Table 5-16, more than nine out of ten dryers (92%) were electric, while the remaining dryers (9%) used natural gas. Given that HPWHs are an electric technology, it appears that substantial electricity could be saved when heat pump dryers are available in the US market. It is also worth noting that many of the homes with electric dryers have natural gas service for water and space heating, offering an opportunity for fuel switching from electric to natural gas, if this is a desirable option for the PAs.

Table 5-16: Dryer Fuel

(Base: All dryers)

Type	
Sample Size (Number of dryers)	*118*
Electric	92%
Natural gas	9%

Table 5-17 shows the percent of dryers that fall into various age ranges. Nearly one-third (31%) were five years old or newer, while over one-half (55%) were between six and fifteen years old. Fewer than one in ten dryers (7%) were between sixteen and thirty years old. The average dryer was about eight years old.

Table 5-17: Age of Dryer

(Base: All dryers)

Age in Years	
Sample Size (Number of dryers)	*118*
Mean Age	*8.3*
1-5	31%
6-10	45%
11-15	10%
16-20	4%
21-25	1%
26-30	2%
Not Available	6%

5.1.5 Dishwashers

Over three-quarters of households (77%) had dishwashers. Table 5-18 shows that close to one-third (31%) of dishwashers in households were five years old or newer, while more than one-quarter (28%) were between six and ten years old. Another 15% of dishwashers were between 11 and 15 years old, and nearly one out of ten (8%) were between 16 and 40 years old.

Table 5-18: Age of Dishwasher

(Base: All dishwashers)

Age in Years	
Sample Size (Number of dishwashers)	*120*
Mean Age	*8.5*
1-5	31%
6-10	28%
11-15	15%
16-20	4%
21-25	1%
26-30	1%
31-35	0%
36-40	2%
Not Available	19%

Forty percent of dishwashers qualified for the ENERGY STAR label (Table 5-19).

Table 5-19: Percent of Dishwashers that are ENERGY STAR Qualified

(Base: All dishwashers)

ESTAR Qualified?	
Sample Size (Number of dishwashers)	*120*
Yes	40%
No	60%

As with the other appliances, the newer dishwashers were more likely to be ENERGY STAR qualified than were the older ones (Table 5-20). The large majority (84%) of dishwashers that were between one and five years old had the ENERGY STAR label, as did one-third (33%) of those that were between six and ten years old and 16% of those that were between eleven and fifteen years old. No dishwashers older than fifteen years were ENERGY STAR qualified.

Table 5-20: Percent of Dishwashers that are ENERGY STAR Qualified By Age of Dishwasher

(Base: All dishwashers)

Age in Years	
Sample Size (Number of dishwashers)	*120*
1-5	84%
6-10	33%
11-15	16%
16-20	0%
21-25	0%
26-30	0%
31-35	0%
36-40	0%
Not Available	13%

5.1.6 Water Heaters

At the request of the PAs and EEAC consultants, the team collected fairly detailed information on water heaters. Although the PAs currently offer rebates for HPWHs, they desired more information on the potential for this technology. This document provides a description of the water heaters found in the onsite homes and the characteristics of the spaces in which they were located. In a separate Excel spreadsheet, the team has created a matrix that lists some of the most important criteria related to HPWH potential and has rated each water heater system on how amenable it is to replacement with a HPWH. In fact, none of the 126 water heaters appears to be a "perfect candidate" for a HPWH, but the team believes that program managers and implementers who are more familiar with the acceptable conditions for HPWH installation may be able to identify systems in the matrix that in fact could be replaced with HPWHs. NMR submitted this matrix separately, and it is not a part of this final report.

In discussing water heaters, however, terminology presents a challenge. In New England, the prevalence of boilers that heat homes through forced hot water or steam also mean that many homes have systems in which the boiler also heats the home's water through a dedicated zone; this type of system is often called "tankless" or "on-demand" or "instantaneous." Yet, these types of systems are uncommon in the rest of the United States; in the broader literature on energy efficient water heaters, tankless or instantaneous refer almost exclusively to highly efficient systems, often attached to walls, that use relatively little energy to heat water when a hot water

faucet is turned on.[27], In this study, we use the term "instantaneous" to refer to both types of systems. In addition, some households use an integrated water heater, in which a zone from the boiler or furnace also heats water, but the system has a storage tank; this system is sometimes known as an indirect water heater, but we refer to it here as integrated. Finally, the most common type of water heater in New England and the United States is the stand alone storage tank.

Of the 150 respondents, 24 of them had water heaters that were inaccessible (usually located in a central and locked location in a multifamily building) and we were unable to collect any data on them, leaving 126 homes with useable water heater data. As expected, storage tanks served as the most common type of water heater found in the onsite homes, 69% of which were fueled by natural gas (Table 5-21). Far fewer homes relied on instantaneous water heaters (18 in total, approximately four of which were the highly efficient tankless type) or integrated systems (26 in total). Most of the of the integrated water heater systems (83%) were fueled by oil, while the instantaneous systems were split between natural gas, oil, and other fuels (typically propane and even wood).

Table 5-21: Fuel Type by Water Heater System

(Base: Onsite homes with accessible water heaters)

Fuel Type	System Type		
	Instantaneous	**Integrated**	**Storage**
Sample Size (Number of water heaters)	*18*	*26*	*82*
Electric	0%	0%	23%
Natural Gas	33%	17%	69%
Oil	28%	83%	7%
Other	39%	0%	1%

[27] Sachs, H., J. Talbot, and N. Kaufman. *Emerging Hot Water Technologies and Practices for Energy Efficiency as of 2011*. October 2011. American Council for an Energy-Efficient Economy.

Looking at the results from the perspective of fuel type, we find that all of the electric water heaters were the storage tank variety (as expected), and most (84%) of the natural gas water heaters were storage tanks. In contrast, 66% of the fuel-oil water heaters were integrated systems, and another 17% stand-alone storage tanks. The very few other types (propane and wood-fired) were generally instantaneous, and given that there were only three of them we do not discuss the results further, although we do present the findings for the interest of some readers. It is also important to note that only 15 households heated water with electricity, the fuel used in HPWH technology, although some opportunities may exist to convert fuel-oil systems to heat pump systems. This small sample size must be kept in mind when interpreting the results presented below for electric water heaters.

Table 5-22: Water Heater System by Fuel Type

(Base: Onsite homes with accessible water heaters)

System Type	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*75*	*33*	*3*
Instantaneous	0%	10%	17%	88%
Integrated	0%	6%	66%	0%
Storage	100%	84%	17%	12%

About 38% of electric water heaters were located in spaces with both ceiling and wall insulation; another 28% had only ceiling insulation, and 17% had only wall insulation. This frequent presence of insulation is conducive to the use of HPWH, as they perform better in rooms with moderate temperatures, and insulation helps to create this condition (Table 5-23). The remaining 17% of electric water heaters were located in spaces with no insulation. In contrast, natural gas and fuel oil water heating systems were most commonly found in rooms with no insulation (52% of the natural gas water heaters and 67% of oil water heaters). When present, ceiling insulation was more common in areas with a natural gas water heater, while wall insulation was more common in rooms with fuel-oil water heaters.

Table 5-23: Water Heater Room Insulation by Fuel Type

(Base: Onsite homes with accessible water heaters)

Insulation Type	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*75*	*33*	*3*
Ceiling	17%	24%	13%	14%
Wall	17%	13%	20%	0%
Ceiling and Wall	38%	11%	0%	0%
None	28%	52%	67%	86%

The team determined whether a space was "conditioned" based on the presence or absence of active heating or cooling of the room. Therefore, the location of a water heater in an insulated room was not always synonymous with being in a conditioned room. Electric water heaters located in rooms with ceiling insulation were always in unconditioned spaces; one-half of the oil water heaters located in rooms with ceiling insulation were also in unconditioned spaces (Table 5-24). All of the oil water heaters located in rooms with wall insulation were located in conditioned space, as were the majority (67%) of electric water heaters located in rooms with wall insulation. All electric water heaters located within rooms with ceiling and wall insulation were in conditioned spaces. When the water heaters were located in rooms without any ceiling or wall insulation they were always found in an unconditioned space.

Table 5-24: Conditioned/Unconditioned Water Heater Location by Water Heater Room Insulation and Fuel Type

(Base: Onsite homes with water heaters fueled by electricity or oil)

Type of Space	Water Heater Room Insulation Type			
	Ceiling	Wall	Ceiling and Wall	None
Sample Size	*11*	*4*	*2*	*31*
Unconditioned	100%	11%	0%	100%
Conditioned	0%	89%	100%	0%
Electric Sample Size	*5*	*3*	*2*	*5*
Unconditioned	100%	33%	0%	100%
Conditioned	0%	67%	100%	0%
Oil Sample Size	*6*	*1*	*0*	*26*
Unconditioned	50%	0%	--	100%
Conditioned	50%	100%	--	0%

Table 5-25 shows that the majority of water heaters powered by natural gas (76%), oil (80%) and other fuel types (87%) were located in an unconditioned basement. Equal percentages of electric water heaters were located in unconditioned basements and conditioned closets (44% for each), with the remainder in conditioned basements and unconditioned closets (6% each).

Table 5-25: Location of Water Heater by Fuel Type

(Base: Onsite homes with accessible water heaters)

Location	Fuel Type			
	Electric	**Natural Gas**	**Oil**	**Other**
Sample Size	*15*	*75*	*33*	*3*
Conditioned Closet	44%	4%	0%	13%
Conditioned Basement	6%	14%	0%	0%
Conditioned Space	0%	2%	20%	0%
Conditioned Kitchen	0%	2%	0%	0%
Unconditioned Basement	44%	76%	80%	87%
Unconditioned Closet	6%	0%	0%	0%
Unconditioned Shed	0%	2%	0%	0%

Likewise, the majority of water heaters (75%) were also located in unconditioned spaces. Only 6% of instantaneous systems, 39% of integrated systems and 27% of storage systems were located in conditioned space (Table 5-26). Electric water heaters were the most likely to be located in conditioned space (often in closets), while oil water heaters were the most likely to be located in unconditioned space.

Table 5-26: System Type by Unconditioned Space and Fuel Type

(Base: Onsite homes with accessible water heaters)

Type of Water Heater	System Type		
	Instantaneous	**Integrated**	**Storage**
Overall Sample Size	*18*	*26*	*82*
Overall Unconditioned	94%	71%	73%
Electric Sample Size	0	0	15
Electric Unconditioned	0%	0%	50%
Natural Gas Sample Size	*8*	*7*	*60*
Natural Gas Unconditioned	85%	75%	79%
Oil Sample Size	*8*	*19*	*6*
Oil Unconditioned	100%	70%	100%
Other Sample Size	*2*	*0*	*1*
Other Unconditioned	100%	0%	0%

As with insulation, the temperature of the room also influences how well a HPWH works, and therefore, the potential for using them in particular situations. Across all fuel-types, the average temperature of the water heater rooms hovered around 55 degrees (low of 53 degrees and a high of 56 degrees) (Table 5-27). The hottest temperatures were associated with electric water heater systems, which is an advantage when considering the potential for HPWH, although the small sample size limits our ability to generalize the results to all households using electric water heaters in Massachusetts. Recall that the onsite visits took place in late winter and early spring; these temperatures would likely be somewhat higher if taken in the summer.

Table 5-27: Temperature of Room Housing the Water Heater (degrees Fahrenheit)

(Base: Onsite homes with accessible water heaters)

Temperature	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*74*	*32*	*3*
Mean	*56.2*	*54.9*	*53.4*	*56.3*
35	0%	0%	3%	0%
41 to 45	11%	3%	0%	0%
46 to 50	22%	29%	20%	0%
51 to 55	11%	35%	30%	87%
56 to 60	6%	16%	43%	0%
61 to 65	0%	6%	0%	13%
66 to 70	50%	11%	4%	0%

The number of occupants in a home plays an important consideration in the type of water heating system, with larger households typically desiring greater capacity. The mean number of occupants served by most types of water heaters in our sample was three (Table 5-28). Homes heating water with electricity tended to be smaller than those using natural gas or oil; just under one-half (47%) of homes using electric water heaters had one occupant compared to 6% for natural gas and 12% for fuel oil. These findings are likely influenced by the small sample size.

Table 5-28: Number of Occupants served by Water Heater by Fuel Type

(Base: Onsite homes with accessible water heaters and did not refuse the question)

Occupants	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*63*	*27*	*2*
Mean	*3*	*3*	*3*	*2*
1	47%	6%	12%	50%
2	18%	43%	16%	50%
3	17%	16%	16%	0%
4	12%	16%	24%	0%
5	6%	11%	32%	0%
6	0%	6%	0%	0%
10	0%	2%	0%	0%

Table 5-29 displays the number of rooms (minus bathrooms, which we did not collect) served by water heater type and fuel. The analysis shows that larger homes tended to be served by systems with tanks, whether integrated or storage, irrespective of fuel type. One-half of the electric water heaters, all storage units, were located in houses with eight or more rooms. Electric and natural gas storage tanks also served smaller homes more frequently that did fuel-oil systems.

Table 5-29: Number of Water Heaters by Rooms in Home

(Base: Onsite homes with accessible water heaters; number of water heaters reported due to small sample sizes)

			Number of Rooms								
		Total # Water Heaters	Less than four	Four	Five	Six	Seven	Eight	Nine	Ten or More	Don't know
Instantaneous	Electric	*0*	0	0	0	0	0	0	0	0	0
	Natural Gas	*8*	1	0	2	3	0	2	0	0	0
	Oil	*8*	0	1	0	2	2	2	1	0	0
	Other	*2*	0	0	0	1	0	0	0	1	0
	Total	***18***	**1**	**1**	**2**	**6**	**2**	**4**	**1**	**1**	**0**
Integrated	Electric	*0*	0	0	0	0	0	0	0	0	0
	Natural Gas	*7*	0	1	0	0	1	2	0	2	1
	Oil	*19*	0	1	1	5	4	3	1	4	0
	Other	*0*	0	0	0	0	0	0	0	0	0
	Total	***26***	**0**	**2**	**1**	**5**	**5**	**5**	**1**	**6**	**1**
Storage	Electric	*15*	2	2	1	1	0	4	3	1	1
	Natural Gas	*60*	3	4	6	14	7	9	7	8	2
	Oil	*6*	0	0	1	2	1	0	0	2	0
	Other	*0*	0	0	0	1	0	0	0	0	0
	Other	***82***	**5**	**6**	**8**	**18**	**8**	**13**	**10**	**11**	**3**
Total	Electric	*15*	2	2	1	1	0	4	3	1	1
	Natural Gas	*75*	4	5	8	17	8	13	7	10	3
	Oil	*33*	0	2	2	9	7	5	2	6	0
	Other	*3*	0	0	0	2	0	0	0	1	0
	Total	***126***	**6**	**9**	**11**	**29**	**15**	**22**	**12**	**18**	**4**

The Department of Energy has mandated that in 2015 all new electric water heater tanks above 55 gallons must have an energy factor (EF) of 2.0 or greater; currently only HPWHs meet this specification.[28] The team examined the capacity of water heaters to see how many would be affected by this new standard when needing to be replaced. We found that the capacity of water heaters varied widely by fuel type, although this in part reflects the different types of systems across fuel types and the small sample sizes. Electric water heaters—all of which were storage tanks—had the largest capacity, with an average of 57.1 gallons (Table 5-30). The average certainly reflects the fact that 76% of the electric water heaters held 41 to 80 gallons, which make them subject to the new efficiency standards when needing to be replaced after 2015. Natural gas water heaters—many of which were storage tanks—had an average capacity of 41.8, and 60% held 21 to 40 gallons; the 10% of natural-gas water heaters with zero capacity were instantaneous water heaters, including the high efficiency kind. Fuel-oil water heaters had an average capacity of 35.2 gallons, although the largest tank holding more than 80 gallons was fuel-oil fired. As with natural gas, the 16% of fuel-oil water heaters with zero capacity were instantaneous types.

Table 5-30: Gallon Capacity of Water Heater

(Base: Onsite homes with accessible water heaters that were not instantaneous)

Capacity	Fuel Type			
	Electric	**Natural Gas**	**Oil**	**Other**
Sample Size	*15*	*74*	*32*	*3*
Mean	*57.1*	*41.8*	*35.2*	*13.3*
0	0%	10%	16%	88%
1 to 20	6%	0%	0%	0%
21 to 40	18%	60%	42%	12%
41 to 60	53%	19%	35%	0%
61 to 80	23%	8%	3%	0%
81+	0%	3%	4%	0%

[28] http://www.energystar.gov/ia/partners/prod_development/downloads/Spec_At-A-Glance_PD.pdf

Dividing the water heaters into two capacity categories, zero to 50 gallons and more than 50 gallons, shows that the majority of water heaters in every fuel type category have a capacity of 50 gallons or less (Table 5-31). Electric water heaters, which are subject to the new regulations, had the largest category of larger capacity units (39%); therefore, four out of every ten of the homes with electric water heaters would need to upgrade to a heat-pump water heater after 2015 if they needed to replace their system and wanted to retain the same capacity. Only 27% of oil units and 13% of natural gas units had a capacity above 50 gallons.

Table 5-31: Simplified Gallon Capacity of Water Heater

(Base: Onsite homes with accessible water heaters that were not instantaneous)

Capacity	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*74*	*32*	*3*
Mean	*57.1*	*41.8*	*35.2*	*13.3*
0 to 50	61%	87%	73%	100%
51+	39%	13%	27%	0%

The average age of water heaters among the onsite households was relatively young at seven years, but the age varied across types. Fuel-oil water heaters were the oldest, on average, at 10.3 years, although this average is skewed by the 17% of systems (mainly instantaneous) that were over 21 years; one-half of the fuel-oil water heaters was five years old or newer (Table 5-32). Electric water heaters were an average age of 7.5 years, with 82% of them being no more than 10 years old; installing HPWHs in the near future would likely involve promoting early replacement of existing electric water heaters. More than one-half (56%) of natural-gas water heaters were less than five years old; the average age of natural-gas water heaters was 6.3 years.

Table 5-32: Age of Water Heater

(Base: Onsite homes with accessible water heaters and could recall age)

Age	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*62*	*25*	*2*
Mean	*7.5*	*6.3*	*10.3*	*2.5*
1 or less	6%	10%	8%	50%
2 to 5	35%	46%	42%	50%
6 to 10	41%	27%	25%	0%
11 to 20	12%	17%	8%	0%
21+	6%	0%	17%	0%

HPWHs require the ability to drain condensate created through the process of heating water. For this reason, the team searched for the nearest condensate drain to the water heaters. Condensate drains were not found in a majority of onsite homes (Table 5-33). When they existed, the average condensate drain was about 10 feet away from electric and fuel-oil water heaters and six feet away from natural-gas water heaters. Installation of HPWHs in most homes, therefore, would necessitate using long hoses or adding drains.

Table 5-33: Distance between Water Heater and Condensate Drain (ft)

(Base: Onsite homes with accessible water heaters and access to condensate drains)

Distance (ft)	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*8*	*28*	*5*	*0*
Mean	*9.81*	*5.77*	*10.20*	*0*
0 to 5	17%	29%	7%	0%
6 to 10	6%	3%	0%	0%
11+	11%	10%	4%	0%
No Drain	66%	58%	89%	100%

Table 5-34 through Table 5-36 report the amount of open space that was found around the water heaters. We measured this space because HPWHs tend to be larger than typical storage tanks. The results indicate that the average length of open space around water heaters varied, with electric water heaters having the tightest fit at 6.4 feet; 39% of electric water heaters had less than one foot of space around them, and 89% had less than 10 feet around them (Table 5-34). Natural-gas water heaters had the largest average length around them, 12 feet.

Table 5-34: Measurement of Length of Open Space around Water Heater (ft)

(Base: Onsite homes with accessible water heaters)

Length (ft)	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*66*	*25*	*1*
Mean	*6.4*	*12*	*10.4*	*5*
0	39%	4%	4%	0%
1 to 5	22%	34%	41%	100%
6 to 10	28%	25%	28%	0%
11 to 15	6%	7%	11%	0%
16 to 20	0%	20%	12%	0%
21	5%	10%	4%	0%

The width around water heaters also varied, from a low of three feet, on average, for fuel-oil water heaters to about nine feet for natural-gas water heaters (Table 5-35). Electric water heaters tended to have about a width of five feet around them, but 41% had no width space.

Table 5-35: Measurement of Width of Open Space around Water Heater (ft)

(Base: Onsite homes with accessible water heaters)

Width (ft)	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*66*	*25*	*1*
Mean	*5.2*	*8.9*	*3.0*	*4.0*
0	41%	4%	4%	0%
1 to 5	29%	45%	46%	100%
6 to 10	18%	25%	42%	0%
11 to 15	0%	9%	4%	0%
16 to 20	12%	11%	0%	0%
21+	0%	6%	4%	0%

Finally, all types of water heaters typically had about three feet of space between them and the ceiling (Table 5-36). Only six percent of electric water heaters, four percent of natural-gas water heaters, and 15% of oil water heaters had space of more than three feet of space above them.

Table 5-36: Measurement of Height of Open Space around Water Heater (ft)

(Base: Onsite homes with accessible non-instantaneous water heaters)

Height (ft)	Fuel Type			
	Electric	Natural Gas	Oil	Other
Sample Size	*15*	*66*	*25*	*1*
Mean	*2.8*	*3.0*	*3.0*	*3.0*
2	22%	27%	4%	0%
2.5	6%	21%	37%	0%
3	66%	48%	44%	100%
3.5	0%	2%	7%	0%
4	6%	2%	4%	0%
5	0%	0%	4%	0%

6 Energy-related Smart Phone Applications

A popular television commercial for one of the most common Smart phone companies claimed, "There's an app for that" for a wide variety of different consumer wants. In fact, there are apps (short for applications) that help consumers monitor their home energy use or find energy efficient products. The team asked telephone survey respondents if they were aware of such applications and, if so, if they used them. One-quarter (25%) of respondents voiced awareness of applications that monitor home energy use, and 11% were aware of applications that help them find energy efficient products (Table 6-1). Given the low rates of awareness, it is not surprising to learn that use of these applications was rare—4% among those aware of applications that monitors home energy use and 7% among those aware of applications for finding energy efficient products. Less than one percent of all respondents used either application. The team did not examine these results by early adopter tendencies because too few respondents were aware of or used the technology to draw meaningful conclusions.

Table 6-1: Awareness and Use of Energy Related Smart Phone Applications

(Base: All telephone survey respondents; those aware of specific application)

Response	Aware of Application for Monitoring Home Energy Use	Use Application for Monitoring Home Energy Use (among those aware)	Aware of Application for Finding Energy Efficient Products	Use Application for Finding Energy Efficient Products (among those aware)
Sample size	*582*	*145*	*582*	*62*
Yes	25%	4%	11%	7%
No	75%	96%	88%	93%
Don't know/Refused	<1%	0%	1%	0%

7 Conclusions and Recommendations

This onsite saturation study served to describe the types of consumer electronics, appliances, and water heaters found in homes and began to assess the potential for a program designed to reduce plug load in residences in Massachusetts. A qualitative program potential study is currently in progress and the report is forthcoming in 2012. In this report, the team refrains from offering detailed recommendations on consumer electronics and plug load potential until the program potential study is complete, but we have identified a few key conclusions and recommendations.

Conclusion 1: The results of the consumer electronics saturation study strongly suggest that program potential exists to reduce plug load by targeting television and home office equipment. However, these results will need to be verified and the implications clarified through the forthcoming program potential study. However, neither this saturation study nor the forthcoming program potential study provides information to estimate the *savings* potential from a plug load management program.

> *Recommendation 1:* The team suggests that the PAs and EEAC consultants consider an hours of use study on televisions, computers, and peripheral equipment in order to help identify the areas of use to target in potential programs. Depending on the breadth of the study, it may be most cost effective to partner with other PAs and energy efficiency organizations in the region. If such a study is not feasible, the PAs could explore the applicability of data from other jurisdictions to Massachusetts. If at all possible, the devices that will be monitoring use should be able to measure electricity draw both while the devices are in use and when they are turned off (or in a standby mode) but still drawing power from the electricity grid.

Conclusion 2: The market for consumer electronics is large, diverse, and changing rapidly. Consumers buy electronics at a faster rate than many other ENERGY STAR qualified products (with lighting being an obvious exception), which means consumers have numerous opportunities to choose between more and less efficient models. Not only will tracking the market share, penetration, and saturation of ENERGY STAR qualified consumer electronics solely through onsite studies be expensive, but the results will have a short shelf life.

> *Recommendation 2:* The PAs should work with consumer electronics retailers and manufacturers to develop procedures to track sales data in order to track the market share of ENERGY STAR products sold in Massachusetts. Given the challenges the PAs have had with obtaining similar data for lighting, it is likely that the Massachusetts PAs will have to work with other PAs and energy-efficiency industry leaders across the nation to develop procedures that will be acceptable to manufacturers and retailers.

Conclusion 3: The analysis of clothes dryers demonstrates that 70% of homes have clothes dryers, and most of these are heated with electricity. Because dryers are almost always paired with a clothes washer, it is highly likely that a drain that could be used for condensate is located near the dryer, although we did not explicitly measure this in our study. These conditions make it

likely that potential exists for a heat pump dryer program when they become available in the US market.

> *Recommendation 3:* The PAs and EEAC consultants should explore the potential for heat pump dryers in more depth so that they can be prepared to offer a program when these products became available in the US. It would not only determine program potential but also estimate the savings potential and cost effectiveness of supporting this emerging technology. The PAs and EEAC consultants should also consider working with manufacturers, trade organizations, and the Super Efficient Dryer Initiative[29] to accelerate the introduction of heat pump dryers in the US market. .

Conclusion 4: Based on the homes included in this sample, some of the barriers that exist in securing a greater number of HPWH installations include access to a condensate drain and having a large enough space into which the larger HPWH could fit.

> *Recommendation 4:* The team recommends that the PAs and EEAC consultants continue supporting the installation of HPWHs using the current program model, but take into account the challenges of installing these measures in many homes in Massachusetts. It may also be worthwhile to perform a second onsite study examining water heaters that is more directly informed by the MassSAVE program criteria for HPWH installations, which were not available to the team when developing the onsite protocols.

[29] For more information see http://www.energystar.gov/ia/partners/downloads/meetings/2011/Super%20Efficient%20Dryer%20Initiative.pdf.