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Consumer Use of Dishwashers, Clothes Washers, and Dryers: Data Needs and Availability

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Introduction

The U.S. Department of Energy (DOE) prescribes test and rating procedures and minimum energy efficiency standards for various residential appliances and commercial equipment under a mandate established by the Energy Policy and Conservation Act (PL 94-163) (EPCA), as amended [2]. Furthermore, in accordance with the requirements of EPCA, DOE relies on the National Institute of Standards and Technology (NIST) to assist in the technical development of the testing and rating procedures.

The rules and regulations define the energy efficiency requirements for products sold in the U.S., regardless of where they are manufactured. Appliance test procedures specify the measurements and calculations that must be performed by the manufacturers or testing entities in order to report product energy efficiency to the Department of Energy [3, 4, 5, 6]. This energy performance data is used by DOE to determine whether the minimum standards have been met, and to provide energy performance information on new appliances, which consumers can use to aid their purchasing decisions. The data is also the basis for Energy Star product labeling, which identifies top energy performers [7], and the Federal Trade Commission's Appliance Labeling Rule, which sets labeling requirements including estimates for annual energy cost and usage [8]. The Department of Energy also has the authority to add other useful measures of energy consumption that are likely to assist consumers in making purchasing decisions.

Historically, appliances test procedures have been designed to measure the energy consumption of an appliance that is performing its main function in a way that is representative of consumer use. Dishwashers are tested in the cycle designated for cleaning a test load of normally soiled dishes; clothes washers are tested over multiple iterations of the manufacturer recommended cycle for cottons/linens, run at different wash and rinse temperatures; clothes dryers are tested over the part of a drying cycle that is needed to dry a test load to bone-dry conditions[1]. In order to test these appliances according to expected use, information (in the form of data) is needed about energy consumption, water consumption, and consumer habits. This data gives DOE and NIST the context that is necessary to accurately update the test procedures to reflect how consumers are actually using their appliances.

From June 2010 through August 2010, NIST sought to collect the data available to support test procedure revisions. NIST performed an assessment of publically available data from manufacturers, trade associations, non-profits, international organizations, environmental groups, utilities, and universities. The results are summarized in this report.

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[1] "Bone dry" is defined as "a condition of a load of test clothes which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1 percent or less." 10 CFR part 430, subpart B, Appendix D, Section 1.2

Data Needs

To begin, a review of the current test procedures was conducted to determine what information would be useful in supporting the test procedures. A statement, titled "Appliance Inquiry Statement" was developed that listed the key points of information needed for the dishwasher, clothes washer, and clothes dryer test procedures. This statement is shown in Appendix 1. The statement mainly centers on consumer buying and usage habits, such as frequency of use, cycle usage, and size of a typical load.

Additionally, the test procedure review was used to create a detailed list of existing data needs, which can be found in Tables 1, 2, and 4. The objective of this document is to create a comprehensive list of data that could be used to support the test procedures. The tables list the Item type (where D indicates dishwashers, W indicates clothes washers, and CD indicates clothes dryers) and list the relevant section number in the DOE test procedure. They also provide a description of the subject of referenced section, identify the data that is needed to support that section, and indicate any potential sources for that data.

Table 1: Dishwasher data needs

Item #	Section #	Test Procedure	Field Data Required	Potential Source of Field Data
D1	5.6	The representative average dishwasher use	Frequency of dishwasher use	Energy Information Agency (EIA), Australian Bureau of Statistics (ABS), manufacturers[a], market research firms[a], Proctor & Gamble [b], California Energy Commission, trade organizations
D2	2.6, 2.7 5.1.2 5.3.2	Test unit loading (number of place settings, serving pieces, etc.) The weighing factors based on consumer use of light/medium/heavy responses	Representative soil levels, load sizes, and materials used (e.g., plastics, glassware)	Proctor & Gamble, Reckitt Benckiser [a], manufacturers [a], market research firms [b]
D3	5.1.2 5.3.2	The weighing factors based on consumer use of light/medium/heavy responses	Consumer pre-treatment habits (rinsing/scraping)	Proctor & Gamble, Reckitt Benckiser [a]
D4	2.6	Test cycle selection (non-soil sensing)	Representative consumer cycle selection (light/normal/heavy/automatic/sanitize/others)	Proctor & Gamble, Reckitt Benckiser, manufacturers [a], market research firms [b]
D5	Future rule-making	Smart Grid	Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities	AHAM, Smart Grid Interoperability Panel
D6	5.2.2	Power-dry consumption use factors (not currently considered)	Consumer usage of power-dry feature	Proctor & Gamble, Reckitt Benckiser [a], Manufacturers [a]
D7	2.3	Water temperature tolerances	Representative water heater temperature output range	Laboratory tests, water heater manufacturers
D8	2.4	Water pressure tolerances	Representative residential water pressure	Water utilities
D9	2.5	Room ambient temperature	Representative residential thermostat setting	EIA, California Energy Commission

Item #	Section #	Test Procedure	Field Data Required	Potential Source of Field Data
D10	5.6 (Draft)	Annual cycle finished hours	Hours in cycle finished mode	Laboratory tests
D11	5.6 (Draft)	Time in "inactive" mode Time in "off" mode	Hours in "inactive" Hours in "off"	Laboratory tests, AHAM, manufacturers
D12	5.4 (electric) 5.5 (gas)	Nominal water heater recovery efficiency (not currently considered for electric water heaters)	Representative values for both gas and electric water heaters	Water heater manufacturers
D13	5.4	Nominal water heater temperature rise	Cold water supply temperature	Water utilities
D14	5.4	Nominal water heater temperature rise	Representative water heater temperature setting	California Energy Commission, water heater manufacturers
D15	2.8	Detergent ("use half the quantity of detergent specified according to ANSI/AHAM DW–1")	Consumer usage of detergents (quantity used; liquid/powder/gel; cold water; tablet) and rinse agents	Proctor & Gamble, Reckitt Benckiser [a]

a Proprietary data

b Market research firms (e.g. JD Power and Associates, Consumers Union)

c The full description of the procedures used in this paper requires the identification of certain commercial products and their suppliers. The inclusion of such information should in no way be construed as indicating that such products or suppliers are endorsed by NIST or are recommended by NIST or that they are necessarily the best materials, instruments, software or suppliers for the purposes described.

Discussion of Key Data Needs for Dishwashers

This section discusses key data that is needed to improve the DOE test procedure for residential dishwashers.

D1: Frequency of dishwasher use

The representative average dishwasher use is used to determine both Estimated Annual Energy Use (EAEU) and Estimated Annual Operating Cost (EAOC). DOE has historically relied on the Energy Information Agency (EIA) and industry to share data from surveys that they have conducted. The trend in the past 20 years has shown that dishwasher use is dramatically reduced from original estimates in 1977 (416 cycles/year), and 1983 (322 cycles/year), and is in the range of the current DOE estimate of 215 cycles/year. Figure A-1 in Appendix 2 shows data on dishwasher use frequency. The most recent data shows quite a range in use; surveys conducted in 2007, 2008, and 2009 showed dishwasher use to be 238 cycles/year according to Proctor and Gamble, 152 cycles/year according to the Australian Bureau of Statistics (ABS), and 202 cycles/year according to Consumers Union. Surveys should be evaluated to determine if further changes are needed to the value for representative annual dishwasher use.

D2: Representative soil levels, load sizes, and materials used (e.g., plastics, glassware) and D3: Consumer pre-treatment habits (rinsing/scraping)

In 2003, in response to changes in dishwasher technology, DOE introduced a new test procedure that challenged 'smart' soil sensing dishwashers with a realistic test load of soiled dishes to provide more accurate energy ratings that consumers could use to compare the energy costs of dishwasher models. Three soil loads were introduced to capture a 'light', 'medium', and 'heavy' soil load. However, because the manufacturers' data provided to DOE in 2003 showed that consumers often pre-treat their dishes, the soil load used in the DOE test procedure is generally less than one-third of the soil load that manufacturers design their machines to handle. For example, the ANSI/AHAM DW-1-2010 energy and cleaning performance test uses 12 soiled place settings while the 'heavy' load of the DOE test procedure is 4 soiled place settings [9,6].

Recent Proctor and Gamble data from 2007 showed 79 % of respondents rinsed items with water before putting them in the dishwasher. This behavior results in redundant cleaning efforts, an inefficient use of water and energy. DOE should bolster efforts to change consumer practice to minimize pre-treatment to provide the greatest long-term benefit to consumers in terms of energy and water savings. In addition, introducing heavier DOE test soil loads that match the best practice of scraping foods off the plates, rather than the soil levels one would find after pre-treating dishes with water, would align the test procedure "heavy" soil load conditions with the conditions found when consumers do follow best practice, as well as cover a wider range of the dishwashers capabilities.

D4: Typical consumer cycle selection (light/normal/heavy/automatic/sanitize/others)

An equally important facet of consumer use is the cycle selection. In the current test procedure, estimates of wash selections for soil-sensing dishwashers are used to weight energy consumption under the soil-sensing light, medium and heavy cycles. For conventional dishwashers, it is assumed that the normal cycle is selected. However, a poorly performing dishwasher may lead consumers to select more energy-intensive cycles in order to overcome performance deficiencies. For example, consumer's impression that hot temperature rinses are more sanitary may shift user behavior to using these more energy intensive cycles with increased frequency. The usage frequency of these cycles is not currently known.

D5: Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities

Appliance manufacturers are working to add Smart Grid capabilities to their products in large numbers in the near future. The goal is to enable the shift of energy use away from peak pricing events to times with a lower energy cost or environmental impact (e.g., in response to a utility broadcast need for demand load reductions). Dishwashers are particularly well-suited to respond since there is little risk to consumers. However, adding this capability will have an impact on standby power use, which must be examined together with the potential energy benefits.

Table 2: Clothes washer data needs

Item #	Section #	Test Procedure	Field Data Required	Potential Source of Field Data
W1	4.1.1	Temperature use factors (TUFs)	Consumer temperature selection for rinse and wash	EIA, ABS, manufacturers [a], Proctor & Gamble, market research firms [b], trade organizations
W2	430.23 NOPR 4.4 [10*]	The representative average clothes washer use	Frequency of clothes washer use	EIA, ABS, California Energy Commission, Proctor & Gamble, manufacturers [a], market research firms [b], trade organizations
W3	Future rule-making	Frequency of cycle use	Determine if cycles other than normal cotton/linen cycle are used frequently enough to warrant inclusion in the test procedure	EIA, ABS, Proctor & Gamble, manufacturers [a], market research firms [b], trade organizations
W4	Future rule-making	Smart Grid	Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities	AHAM, Smart Grid Interoperability Panel, manufacturers
W5	1.3.2	Cycle type definitions & test procedure for each cycle	Existence of new wash modes such as sanitize and steam	Manufacturers [a]
W6	2.4	Water pressure tolerances	Representative residential water pressure	Water utilities
W7	2.3	Cold water supply ranges	Cold water supply temperature	Water utilities
W8	2.3	Hot water supply ranges	Representative residential water heater temperature selection	California Energy Commission, water heater manufacturers
W9	2.1	Wash time setting	Representative consumer wash time setting	Market research firms [b], manufacturers [a]

Item #	Section #	Test Procedure	Field Data Required	Potential Source of Field Data
W10	2.7, 5, 6.3	Test load sizes, Use of the adaptive water fill cycle	Representative consumer load size	Proctor & Gamble, manufacturers [a], market research firms [b],
W11	4.1.3	Load use factors	Representative consumer fill setting selection	Proctor & Gamble, manufacturers [a], market research firms [b]
W12	4.3	Load adjustment factor (LAF)	Average load size (consumer data or capacity?)	Proctor & Gamble, manufacturers [a], market research firms [b]
W13	4.3	Dryer usage factor (DUF)	Average percentage of washer loads dried in a clothes dryer	EIA, Proctor & Gamble, manufacturers [a], market research firms [b]
W14	2.6.1	Energy Test Cloth	Representative clothing materials in a load	Proctor and Gamble, market research firms [b]

a Proprietary data

b Market research firms (e.g. JD Power and Associates, Consumers Union)

Discussion of Key Data Needs for Clothes Washers

This section discusses key data that is needed to improve the DOE test procedure for residential clothes washers.

W1: Consumer temperature selection for rinse and wash

There have been reports from industry that the temperature use factor (TUF) of 0.27 for warm rinse used in the DOE clothes washer test procedure is higher than the field research shows. DOE defines TUF for particular wash/rinse temperature setting, as the percentage of the total number of washes that an average user would wash with that setting. The current TUF is based on data from a survey done in the 1990's. Initial review of more current surveys indicates that the TUF is too high. For example, data from the Residential Energy Consumption Survey (RECS) from 2005 indicates that a TUF of 0.22 might be more appropriate (19.9 % of rinses used warm water and 1.7 % of rinses used hot). As the test procedure only addresses one rinse temperature selection above cold, the warm and hot are grouped together, resulting in a combined percentage of 21.6 %).

The TUFs for wash temperature selection also need to be reviewed. Analysis of three datasets (RECS 2005 [11], Residential Appliance Saturation Survey (RASS) 2003 [12], and P&G 2006 [13]) shows somewhat contradictory trends. For hot washes, one dataset indicated a higher TUF, one indicated a lower, and one was close to the current TUF. For warm washes, one dataset indicated a higher TUF, while the other two indicated a lower TUF. For cold wash, all indicated a slightly higher TUF. The calculated TUFs from the datasets are shown in Table 3. When analyzing the RASS and P&G datasets, certain assumptions were made in the analysis, but the ranges of reasonable choices do not change the trends significantly[2]. No data set was found that contained consumer use information on extra hot washes. In addition to the temperature selections already included in the test procedure, some manufacturers are adding new temperature selections (steam, sanitize) that may result in higher energy use and shift the overall usage pattern. These temperature selections are distinct from cycle selections with similar names; for example, some models may have a 'steam cycle' and some may have a 'steam' temperature selection that could be used in previously available cycles. It is recommended that DOE and NIST obtain data on consumer temperature selections for rinse and wash, including data on new temperature selections.

[2] The RASS data is presented as loads/week for hot, warm, and cold washes, with the options as discreet numbers 1 to 9, or 10+. The TUFs presented used a count of 11 for the 10+ range. Using a value of 15 loads/week changed the TUFs to 0.21, 0.39, and 0.40. The P&G data was presented as frequency of washes, with the choices as all loads, most, half, few, and none. For all, half, and none, values of 100 %, 50 %, and 0 % were assigned. For the most and few choices, values of 90 % and 10 % were used to calculate the TUFs presented. The TUFs were also calculated using values for most between 95 % and 65 %. It was noted that the TUF for warm and cold washes decreased slightly as the 'most' parameter decreased, while the TUF for hot washes varied from 0.125 at 95 % to 0.21 at 65 %.

Table 3: Comparison of calculated TUF values

	DOE J1	RECS 2005	RASS 2004	P&G 2006	Average
TUF Hot	0.14	0.07	0.21	0.14	0.147
TUF Warm	0.49	0.55	0.40	0.44	0.463
TUF Cold	0.37	0.38	0.39	0.42	0.390

W2: The representative average clothes washer use

As is the case for dishwashers, the average clothes washer use effects the calculations for annual energy use, and it is critical that it be as accurate as possible. Based on a review of the RECS data from 2005, NIST recommends that DOE consider reducing the average number of cycles from 392 to 295. As this value has shown a downward trend, and the revised value is from 2005, it would be appropriate to continue to examine this value to ensure that it remains accurate.

W3: Determine if cycles other than normal cotton/linen cycle are used frequently enough to warrant inclusion in the test procedure

Some clothes washer models include a much larger selection of cycles than was available previously. It is possible that some of these cycles see frequent use and that they would have a different energy use profile than the normal cotton/linen cycle used for the test procedure. These factors should be examined to determine if additional cycles need to be added to the test procedure to maintain its accuracy.

W4: Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities

Appliance manufacturers are planning on adding Smart Grid capabilities to their products in large numbers in the near future [14]. This feature will have an impact on standby power use that must be examined. Smart Grid capabilities may also enable energy usage to be shifted to times with a lower energy cost or environmental impact. For example, a clothes washer may run at off-peak times when there is a lower rate available, or it might use stored renewable energy instead of energy from an inefficient peaking plant [15].

W5: Existence of new wash modes such as sanitize and steam

New washers are equipped with many cycles. This may lead to confusion as to which ones are to be tested outside of the normal cotton/linen cycle. This issue is related to Item W3. It is not recommended to attempt to examine every cycle available on current machines to determine if it is used frequently enough to be relevant to Item W3, and it is not known what additional cycles may be introduced in the near future. Additionally, some proposed clothes washer designs allow the consumer to modify wash cycles. However, categories of cycles can be determined. This categorization could be based on deviations from the normal cycle for a particular machine, or

based on deviation from industry wide averages for different elements of the normal cycle, such as time spent or energy used in different modes. Having a reasonable number of categories might also facilitate the determination of correct use factors.

W6: Typical residential water pressure

Some clothes washers use a timer based on the fill level setting when filling the clothes container with water. The water pressure in the supply line to a clothes washer can affect the volume of water actually used in a washer. There has been discussion that the water pressure used in the test procedure is lower than that found in most residential plumbing systems, which would lead to an underestimation of the amount of water used. This issue should be investigated to ensure that the test procedure is properly accounting for the water use in real world situations.

Table 4: Clothes dryer data needs

Item #	Section #	Test Procedure	Field Data Required	Potential Source of Field Data
CD1	4.7	Average cycles/year	Consumer frequency of use	EIA, RASS, ABS, Proctor and Gamble [a], market research firms [b], manufacturers [a]
CD2	4.2 4.4	Field Use Factors	Consumer washing/drying practices (e.g., wash characteristics that impact dryer testing, representative amount of over drying)	Proctor and Gamble , market research firms [b]
CD3	2.6	Test Cloths	Typical clothing materials in a load	
CD4	Future rule-making	Smart Grid	Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities	AHAM, Smart Grid Interoperability Panel
CD5	2.7.1 2.7.2	Compact size dryer load Standard size dryer load	Typical load size	Proctor and Gamble , market research firms [b]
CD6	4.10	Off/inactive mode operation	Typical ratio for off/inactive mode operation	
CD7	4.7	Hours of a continuously burning pilot light during operation	Typical hours of pilot light operation	
CD8	2.2.1	Room ambient temperature, humidity (Dryer testing)	Typical residential thermostat setting	EIA, California Energy Commission
CD9	2.2.2	Room ambient temperature (Standby testing)	Typical residential thermostat setting	EIA, California Energy Commission

a Proprietary data

b Market research firms (e.g. JD Power and Associates, Consumers Union)

Discussion of Key Data Needs for Clothes Dryers

This section discusses key data that is needed to improve the DOE test procedure for residential clothes dryers.

CD1: Frequency of clothes washer use

The current Supplemental Notice of Proposed Rulemaking (SNOPR) 2010 (AHAM-2) [16] proposes to mathematically correct the *E up* equation, listed in Section 4.4 from 10CFR430 Appendix D as shown in Listing 1 below, by adding parentheses around the term '8760-140', and also updating the current number of cycles used/year. Surveys indicate that the average number of clothes dryer cycles in a year has dropped to approximately 250 cycles to 280 cycles, as shown in Figure A-15. Additional research on the annual number of cycles would help to increase the accuracy of the equations calculating energy use, such as that for *E up* and the equations that rely on it.

Listing 1- Section 4.4 from 10CFR430 Appendix D

> *4.4 Per-cycle gas dryer continuously burning pilot light gas energy consumption. Calculate the gas dryer continuously burning pilot light gas energy consumption/cycle, E up expressed in Btu's/cycle and defined as:*
> *E up =E pg × (8760−140/416)×GEF*
> *E pg=the energy recorded in 3.4.6.3*[3]
> *8760=number of hours in a year*
> *416=representative average number of clothes dryer cycles in a year*
> *140=estimated number of hours that the continuously burning pilot light is on during the operation of the clothes dryer for the representative average use cycle for clothes dryers (416 cycles/year)*
> *GEF as defined in 4.3 (as the gas heating value)*

CD2: Consumer washing/drying practices (e.g., wash characteristics that impact dryer testing, representative amount of over-drying)

Field use factors are inserted into the DOE test procedure to obtain values that are closer to real world consumer use. Many of these factors must be revisited to determine if changes are needed. For example, in Section 4.1 of the clothes dryer test procedure, the current equation to calculate total per-cycle electric dryer energy consumption (*E ce*) should be reevaluated because it is based on the current test cycle definition, as given in Section 3.3, and there are some factors that are experimentally established such as moisture content and field use factor. The current SNOPR 2010 (AHAM-2) is addressing this question by proposing more testing for the field use factor.

[3] This and all similar references to section numbers in this discussion refer to sections from 10CFR430, Appendix D unless otherwise noted.

More raw data (not corrected data) should be used to determine the initial moisture content of a test load.

Listing 2- Section 4.1 from 10CFR430 Appendix D

> *4.1 Total per-cycle electric dryer energy consumption. Calculate the total electric dryer energy consumption per cycle, E ce expressed in kilowatt-hours per cycle and defined as:*
> *E ce=[66/ W w− W d)]× E t× FU*
> *E t=the energy recorded in 3.4.5.*
> *66=an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.*
> *FU=Field use factor.*
> *=1.18 for time termination control systems.*
> *=1.04 for automatic control systems which meet the requirements of the definitions for automatic termination controls in 1.11.1, 1.12 and 1.13.*
> *W w=the moisture content of the wet test load as recorded in 3.4.2.*
> *W d=the moisture content of the dry test load as recorded in 3.4.3.*

The impact of preconditioning the test cloth and the clothes dryer on the energy consumption of clothes dryers should be evaluated, for example, reducing the wash water temperature from 140 °F to a lower value that is more representative of the consumer use. The AHAM SNOPR has proposed a change to the detergent specification; a new test method should consider this issue. Further tests may determine a water temperature selection that is more closely related to consumer's use. The impact of different water temperature should be determined in order to either keep the current recommended value or to change it.

Listing 3- Sections 2.6.3 and 2.7.2 from 10CFR430 Appendix D

> *2.6.3 Test Cloth Preconditioning.*
> *A new test cloth load and energy stuffer cloths shall be treated as follows:*
> *(1) Bone dry the load to a weight change of ±1 percent, or less, as prescribed in Section 1.2.*
> *(2) Place test cloth load in a standard clothes washer set at the maximum water fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 6.0 grams of AHAM Standard Test Detergent, IIA, per gallon of water.* ***Wash water temperature*** *is to be controlled at 140 °±5 °F (60 °±2.7 °C). Rinse water temperature is to be controlled at 100 °±5 °F (37.7±2.7 °C).*
> *(3) Rinse the load again at the same water temperature.*
> *(4) Bone dry the load as prescribed in Section 1.2 and weigh the load.*
> *(5) This procedure is repeated until there is a weight change of one percent or less.*
> *(6) A final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.*
> *2.7.2 Standard size dryer load. Prepare a bone-dry test load of energy cloths which weighs 7.00 pounds ±.07 pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer*

cloths per load. Dampen the load by agitating it in water whose temperature is 100 ° ±5 °F and consists of 0 to 17 parts per million hardness for approximately two minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 66.5 percent to 73.5 percent of the bone-dry weight of the test load.

In Section 2.8, the test procedure prescribes a method for preconditioning the clothes dryer.

Listing 4- Section 2.8 from 10CFR430 Appendix D

2.8 Clothes dryer preconditioning. Before any test cycle, operate the dryer without a test load in the non-heat mode for 15 minutes or until the discharge air temperature is varying less than 1 °F for 10 minutes, whichever is longer, in the test installation location with the ambient conditions within the specified rest condition tolerances of 2.2.

Preconditioning is not a common practice with consumers. This difference between the test procedure and consumer usage may result in a difference in energy usage. Research should be conducted to evaluate any difference in energy usage between preconditioned clothes dryers and clothes dryers that have not been preconditioned. This would ensure that a fair representation of the actual energy use can be determined. Furthermore, as part of the test cycle, the cool down period should be considered as well. Research might be able to provide a repeatable test method for a non-forced-termination cycle. The desire is to replicate, as accurately as possible, the consumer behavior because ultimately they assume the cost of using these machines. Currently, the DOE test procedure is a forced termination cycle, as described in Section 3.3 of the test procedure.

Sections 4.2 and 4.3 both rely on field use factors that should be reevaluated with new survey data (i.e., the field use factor and the number 66 which was experimentally determined as given in Section 4.1.)

Listing 5- Sections 4.2 and 4.3 from 10CFR430 Appendix D

4.2 Per-cycle gas dryer electrical energy consumption. Calculate the gas dryer electrical energy consumption per cycle, E ge, expressed in kilowatt-hours per cycle and defined as:
$E = [66/(W_w - W_d)] \times E \times FU$
E =the energy recorded in 3.4.6.1
FU, 66, W w, W as defined in 4.1
4.3 Per-cycle gas dryer gas energy consumption. Calculate the gas dryer gas energy consumption per cycle, Egg expressed in Btu's per cycle as defined as:
$E_{gg} = [66/(W_w - W_d)] \times E_{tg} \times FU \times GEF$
E tg=the energy recorded in 3.4.6.2
GEF =corrected gas heat value (Btu per cubic feet) as defined in 3.4.6.4
FU, 66, W w W d as defined in 4.1

CD3: Energy test cloth/typical clothing materials found in a dryer load

The test cloths are defined in Section 2.6.1 but this material is not commonly found in the market. It would reduce the test burden if the procedure allowed testers to use commonly found household cloths. Additionally, it might make the test procedure more representative of consumer usage pattern if a mixture of cloth types were used. For example, a material such as denim, commonly used in jeans, could be included. Research should be conducted to determine if this method of altering the test cloth selection would result in consistent test results.

Listing 6- Section 2.6.1 from 10CFR430 Appendix D

> *2.6.1 Energy test cloth. The energy test cloth shall be clean and consist of the following:*
> *(a) Pure finished bleached cloth, made with a momie or granite weave, which is a blended fabric of 50 percent cotton and 50 percent polyester and weighs within +10 percent of 5.75 ounces per square yard after test cloth preconditioning and has 65 ends on the warp and 57 picks on the fill. The individual warp and fill yarns are a blend of 50 percent cotton and 50 percent polyester fibers.*
> *(b) Cloth material that is 24 inches by 36 inches and has been hemmed to 22 inches by 34 inches before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width.*
> *(c) The number of test runs on the same energy test cloth shall not exceed 25 runs.*

CD4: Market penetration of Smart Grid enabled products, energy consumption associated with added capabilities

Two large appliance manufacturers, General Electric and Whirlpool, have made significant announcements of their plans to develop Smart Grid enabled clothes dryers and washers. Prototype demonstrations have shown how the number of activated heating elements can be reduced in response to a peak load event. The impact generally results in longer drying times but does not increase overall energy consumption, or drying performance. Market data should be monitored to identify the technological approaches brought forward so that the test procedure can be modified to capture relevant energy usage.

Potential Sources

After developing the Appliance Inquiry Statement, potential sources of consumer data were identified. Historical documentation was reviewed to gather contact information from companies already involved in the DOE Appliance program. In addition, companies and organizations were contacted to determine appropriate points of contact. A general inquiry was sent to each point of contact to open up communication.

In cases where the point of contact indicated that the data being sought exists, the inquiry was pursued to qualify what data exists and whether it was public or proprietary. The results of the analysis were then documented and reported. Key points of the analysis can be found in Appendix 3 of this report.

In some cases, it was found that a particular contact possessed the desired data but that the data could not be released due to its proprietary nature. In that situation, NIST asked the contact to use the inquiry to indicate the type of data they had so that the existence of the data could still be documented.

NIST attempted to contact 63 companies/organizations to determine the availability of data. A complete listing of the companies and organizations can be found in Appendix 02. The following section outlines the most notable sources that were found.

Energy Information Agency (EIA)

EIA provides independent statistics and analysis on a variety of topics. The most relevant survey topic is from the Residential Energy Consumption Survey (RECS). The RECS contains a collection of surveys pertaining to residential energy and is conducted every four years. The most recent survey available is from 2005. In February 2010, EIA began another round of data collection for RECS, but the results are not yet available. Housing characteristics data are slated for release in the 1st quarter of 2011. Consumption data are slated for release at the end of 2011 or early 2012. The sample is created by first dividing up U.S. households into successively smaller areas until a unit of 50 households is created.

"Home Appliance Usage Indicators" (found in RECS tables HC2.10 through HC15.10) contains data on how often consumers use their appliances in a week, which can then be averaged and converted to cycles/year. How to determine the representative number of cycles/year for dishwashers, clothes washers, and clothes dryers is an important question for DOE, as the current values specified in the test procedure should be updated. The 2005 survey also includes data about Energy Star dishwashers and clothes washers. In addition, it contains data about the wash and rinse temperature selections. This information is also being sought by DOE to learn about consumer habits.

"Home Appliance Characteristics" (found in RECS tables HC2.9 through HC15.9) provides data on the age of dishwashers, clothes washers, and clothes dryers owned by consumers.

"Space Heating Usage Indicators" (found in RECS tables HC2.5-HC15.5) provides data on the thermostat settings of homes during the colder months. "Air Conditioning Usage Indicators" (found in tables 2.7-15.7) provides data on the thermostat settings of homes during the warm months. The test procedures specify an ambient air temperature for an appliance test facility. Data from this survey could be used to review that specification.

"Water Heating Characteristics" (found in RECS tables 2.8-15.8) provides data on topics such as the number of water heaters, the age of the water heaters, and the fuel used. The energy used to heat water for appliances is factored into the overall energy consumption of the appliance and is reflected on the EnergyGuide label.

An analysis of the EIA RECS data produced the following conclusions:

- Dishwasher use is on a downward trend. The most recent average for 2005 was calculated to be 166 cycles/year.
- Clothes Washer use is on a downward trend. The most recent average for 2005 was calculated to be 311 cycles/year, using the midpoint of each range in the calculations.
- Clothes dryer use is relatively stable. The most recent average for 2005 was calculated to be 281 cycles/year. However, the DOE test procedure is currently estimated at 416 cycles/year.
- For clothes washers, the selection of warm wash is decreasing while the selection of cold wash is increasing. The selection of hot wash is relatively constant. The most recent average for 2005 for hot, warm, and cold wash temperature selections was calculated to be 7 %, 55 %, and 38 %, respectively.
- For clothes washers, the majority of consumers choose the cold rinse (78 %), followed by warm rinse (20 %) and hot rinse (2 %).
- Ownership of front loading clothes washers is increasing (12 %) while ownership of traditional top loading clothes washers is decreasing (86 %). The most recent average for 2005 was calculated to be 92 % for top loaders and 8 % for front loaders.
- For clothes dryer ownership, most people have an electric dryer (77 %), followed by natural gas (22 %) and propane (1 %).
- For room thermostat settings, the most recent average for 2005 was calculated to be 70 °F for the heating season and 74 °F for the cooling season.

Proctor and Gamble (P&G)

P&G is the parent company of a number of consumer products, including clothes washing and dishwashing detergents. P&G does extensive consumer research and conducts over 6000

surveys worldwide [17]. Nationally representative data is obtained using an independent organization [18].

P&G conducts a consumer habits study every three to five years. The most current laundry study is from 2006 and the most current dishwasher study is from 2007. The study focuses on pre-treating practices, but also addresses cycle frequency, cycle selection, and loading conditions. P&G is currently looking into methods to quantify the amount of soil in a load prior to running the dishwasher. The results from this study will address the bulk of the information needed to support the appliance test procedures.

An analysis of a data summary based on the 2006 Laundry Habits & Practices (H&P) Study and the 2007 Dish Habits & Practices Study provided by Proctor and Gamble [9] produced the following conclusions:

Dishwashers:

- At 4.57 cycles/week, or 238 cycles/year, dishwasher use is slightly higher than the DOE consumer use estimate of 215 cycles/year.
- The H&P Study asks which cycle setting is used most often and which cycles have been used ever. Consumers use the Normal cycle most of the time (76 %).
- According to the study, 66 % of these households regularly use the Heated Dry feature.
- Rinse Aid: In this study, 98 % of dishwasher users indicated they are aware of rinse aid and 42 % have used it within the last 3 months. This number (42 %) is higher than has been historically observed (typically in the 25 % to 30 % range in past studies).
- According to the study, consumers are still doing a significant amount of pre-treating prior to washing their dishes in the dishwasher. Respondents indicate that the key reason for pre-treating is so that the leftovers do not become dry and then too difficult to clean off. There is a perception that if soil becomes dry the dishwasher and detergent will not be able to clean it.
- Consumers are likely to wash several types of items in the dishwasher: dishware, glasses, mugs, plastic cups and dishware, utensils, glass bakeware, casserole dishes, both durable and disposable plastic containers, and baby bottles.
- Only 20 % to 40 % of respondents wash the following items in the dishwasher: metal pots and pans, Teflon/non-stick pots and pans, metal bakeware, coffee pots, chopping boards, wooden items, fine China and stemware.

Clothes Washers

- Respondents wash an average of approximately 5.9 loads/week (307 loads/year) in both traditional vertical-axis washers and horizontal-axis washers.
- Respondents are selecting the normal clothes washer cycle only about 60 % of the time, while the heavy duty cycle is chosen about 19 %. There is some variation between types

of clothes washer (traditional vertical-axis, high efficiency vertical-axis, and horizontal axis) but the sample size is not sufficient to draw conclusions on the variations.

- With only 10 % of clothes washer loads in traditional vertical-axis washers rated by respondents as small, 25 % as medium, 45 % as large, and 20 % as very large, the load usage factors in Table 4.1.3 of J1 may be improperly biased towards small loads.
- Horizontal-axis washers are used by 12 % of respondents, which is an increase over the previous RASS 2004 report of 7.7 %. High efficiency vertical-axis washers are used by 2 % of respondents.
- Approximately the same percentage of respondents used the recommended amount of detergent for traditional horizontal-axis (53 %) and vertical-axis washers (57 %). More respondents used less than recommended in horizontal-axis washers (31 %) than vertical-axis (16 %) but fewer respondents used more detergent than recommended in horizontal-axis washers (4 %) than vertical-axis (14 %). High efficiency vertical-axis washers are not evaluated due to low sample size.

Clothes Dryers:

- More than half of respondents dry all of their laundry in their dryer, and use their dryer for an average of 5.47 loads/week (284 cycles/year).
- While over 1/3 of consumers simply dry everything in the dryer, approximately 2/3 of consumers consciously decide whether or not to line-dry based on the type of fabric or garment instructions.
- Again, approximately 1/3 of consumers indicated that they always use the same drying temperature, but 2/3 base their decision on the fabrics and garment instructions.
- Over half of the respondents use the automatic timing or sensing feature of the dryer, and almost a quarter of them dry loads the same length every time.
- Almost 80 % of consumers remove clothing within 30 minutes of the dryer stopping.
- Re-wear and re-fluff are fairly common. 60 % of respondents indicated they use the dryer for this purpose.
- Lastly, the key reason not to dry something in the dryer is to maintain the integrity of the garment (avoid shrinking or shape changes, garment instructions).

Association of Home Appliance Manufacturers (AHAM)

AHAM is a trade association for appliance manufacturers. AHAM maintains a number of surveys in which it polls its members for information. In 1995, NIST was in communication with AHAM in a similar effort. AHAM obtained usage statistics via the Soap and Detergent Administration (SDA; now the American Cleaning Institute).

AHAM provided NIST with data regarding energy efficiency and consumption trends for clothes washers and dishwashers. The contact indicated that this was the only data available that fit our needs. Two separate inquiries to SDA also indicated that they no longer collect this type of data.

However, AHAM is in a good position to poll its industry members for information. It is possible to develop a formal solicitation with specific information that AHAM can use to get data from industry and report to DOE. This would be a good option for DOE if it is found that public data is inadequate.

An analysis of the AHAM data produced the following conclusions:

- Clothes washer tub volume is increasing. The most recent average from 2008 is 0.091 m^3 (3.22 ft^3).
- Clothes washer energy consumption is decreasing. The most recent average from 2008 is 0.80 kWh/cycle.
- Clothes washer efficiency is increasing with time. The most recent average from 2008 is 1.67 ft^3/(kWh/cycle).
- Dishwasher energy consumption is decreasing with time. The most recent average from 2008 is 1.52 kWh/cycle.
- Dishwasher energy efficiency is increasing with time. The most recent average from 2008 is 0.67 cycles/kWh.

Consumers Union

Consumers Union is the non-profit publisher of Consumer Reports, which provides ratings for a number of items, including appliances. The Annual Product Reliability Survey is representative of their subscribers and has a sample size of approximately one million consumers.

Consumers Union conducted a 2009 Annual Product Reliability survey. Information regarding usage frequency was provided based on the results of that survey. In addition, some articles were provided that outline some basic consumer habit statistics. An analysis of the Consumer Union data produced the following conclusions:

- Dishwasher use was calculated to be 202 cycles/year.
- Clothes washer use was calculated to be 257 cycles/year for front loaders and 241 cycles/year for top loaders.
- Clothes dryer use was calculated to be 247 cycles/year.
- 83 % of consumers typically run a full load in a dishwasher.
- 10 % of consumers do not rinse their dishes before loading them into the dishwasher.
- 18 % always or often line-dry their clothes.

JD Power and Associates (JDPA)

JDPA is a marketing information firm that conducts independent and unbiased surveys of customer satisfaction, product quality and buyer behavior. Information that is collected is "based on survey responses from millions of consumers worldwide."[19]

The latest consumer survey by JDPA was conducted during the spring of 2010. JDPA collects data on the demographics of the household being queried. In addition, they possess data on usage frequency and typical cycle selection for dishwashers, clothes washers, and clothes dryers. This information is not publically available.

Whirlpool

Whirlpool is a manufacturer of consumer appliances. The contact was able to respond to the inquiry by indicating what data existed. Whirlpool does possess a large portion of the data that NIST is seeking, but it is unable to provide it because it regards it as proprietary information.

Whirlpool has data on:

- Use frequency (cycles/year)
- Cycle selection
- Load sizes
- Pre-treating practices
- Use of rinsing agents/detergents
- Wash and rinse temperature selections (clothes washers)
- Water level selection (clothes washers)

Natural Resources Canada

Natural Resources Canada publishes a report titled: "Energy Consumption of Major Household Appliances". The full report is published every two years; the latest version was published in December 2008. On the off years, a summary report is published; the latest version was published in December 2009.

The focus of this report was on the energy consumption of appliances. Overall, the report concluded that the energy consumption of dishwashers and clothes washers are on a downward trend, while the energy consumption of clothes dryers is fairly constant. Shipments of front-loading clothes washers are increasing while shipments of top-loading clothes washers are decreasing, which may account for some of the change in energy consumption, as front-loading clothes washers consume significantly less energy than top-loading clothes washers.

An analysis of the report produced the following conclusions:

- 99 % of front loading clothes washers on the market are Energy Star qualified.
- 9.4 % of top loading clothes washers on the market are Energy Star qualified.
- Ownership of front loading clothes washers is increasing with time. The most recent average from 2009 is 55 % for front loaders, and 45 % for top loaders.
- The market share of electric clothes dryers is 97 % and for gas dryers it is 3 %.

Bosch and Siemens Home Appliances Corporation (BSH)

BSH Home Appliances Corporation is a manufacturer of consumer appliances. The contact was not able to provide raw data due to its proprietary nature. However, the contact was able to respond to the inquiry by providing testimony for each point based on the data in his possession. In particular, a response was given for cycle frequency, cycle use, and pre-treating.

The answers were general at best and may not be particularly useful in justifying a change to a test procedure. However, the answers could serve as a general baseline when comparing the results of other analyses. In addition, this shows that BSH does possess data that could be potentially useful to DOE.

- BSH indicated that it has data on:
- Use frequency (cycles/year)
- Cycle selection
- Load sizes
- Wash and rinse temperature selection (clothes washers)
- Water level selection (clothes washers)

California Energy Commission

In 2003, the California Energy Commission published the Residential Appliance Saturation Survey (RASS). This survey was done with the cooperation of five major utilities within the state of California. The report is the result of almost 22,000 customer responses and extensive analysis of the collected data to determine information about saturation, population characteristics, dwelling characteristics, and consumption patterns. The published report focused mostly on the actual consumption, and not the usage patterns, of the various appliances. However, the report also publishes the raw data. From that, more useful information can be gleaned.

Although this is a very large and thorough study, it may be of limited relevance because it only represents one state, rather than the entire country, and that data was collected in 2003.

An analysis of the data produced the following conclusions:

- Dishwasher use was calculated to be 170 cycles/year.
- Clothes washer use was calculated to be 145 cycles/year.
- For clothes washers, the selection of hot, warm, and cold wash temperature was calculated to be 28 %, 36 %, and 36 %, respectively.
- Ownership of top and front loading clothes washers is 91 % and 9 %, respectively.
- Thermostat settings for the heating and cooling season were calculated to be 67 °F and 75 °F, respectively.

- Water heater temperature was typically set on the medium setting (factory setting) (82 %), while 4 % were adjusted higher, and 14 % were adjusted lower.

Australian Bureau of Statistics

The Australian Bureau of Statistics contains a wealth of data on a number of topics, including appliances. A report was published in March 2008 titled "Environmental Issues: Energy Use and Conservation." The data published in conjunction with the report could be used for comparison. The data addresses appliance characteristics and use for dishwashers, clothes washers, and clothes dryers. There are some drawbacks to using this data. The habits of Australians are not necessarily representative of the habits of Americans, so this data could not be used directly. In addition, data points are loosely defined and it would be difficult to obtain an average without a large amount of uncertainty.

An analysis of the data produced the following conclusions:

- Dishwasher use is decreasing annually. The most recent average from 2008 was calculated to be 152 cycles/year.
- Clothes washer use is decreasing annually. The most recent average from 2008 was calculated to be 250 cycles/year.
- Clothes dryer use is steady. The most recent average from 2008 was calculated to be 16 cycles/year, although it must be noted that this number is probably not accurate due to poor phrasing of the question. Typically, 30 % to 50 % of the respondents indicated that their dryer use "depends on the weather", making an accurate analysis difficult.
- The market share of front loaders is increasing with time. The most recent average from 2008 was calculated to be 22 %.

Government of Australia

The Australian government commissioned a study titled: "Energy Use in the Australian Residential Sector, 1986-2020." The focus of the study was energy consumption, although some limited information on usage was available.

The estimated usage of dishwashers is 175 loads/year. The estimated usage of clothes washers is 312 loads/year. The estimated usage of clothes dryers is 60 loads/year, although dryer usage varies tremendously by area.

Overall Findings

Public information in the form of published reports mainly dealt with energy consumption. Demographics for that data include California, Canada, and Australia. This information has limited use for this effort.

Thus far, EIA RECS data has been the single best public source for usage statistics, consumer habits, and appliance characteristics. Although the data is from 2005, it is the latest publically available information with the most nationally representative demographics of all the sources reviewed. By working directly with the EIA to formulate targeted survey questions, DOE could better obtain the information needed to support its Appliance Standards Program.

In many cases, where the information that is being sought is considered proprietary or private, the source and the type of information that exists are documented. In the future, if NIST or DOE finds that it is necessary to obtain the private data, the necessary leads and contact information will have already been established.

Data from the Australian Bureau of Statistics would only be useful as a comparison due to the drastic difference in demographics.

Notably, none of the data sources have been ideal, even for the subset of the data they contain. They are either a subset of the population (i.e., only California), or are not recent enough to reflect advances in technology and appliance design (i.e., usage for newer cycles and temperature selections, such as steam cycles in clothes washers).

Recommendations

Due to the importance and significance of these test procedures, it would be appropriate for DOE and NIST to develop a survey which could be conducted periodically and delivered to an appropriate demographic representation. This survey would ensure the integrity and accuracy of the test procedures.

Further research on improving the current test procedure and foreseeing the future technological advancement of clothes dryers should be considered, particularly Smart Grid capabilities. New test procedures will have to address the network mode energy consumption and possibly the impact of the Smart Grid on the energy performance of electric clothes dryers.

Although Smart Grid is under development, some research can be conducted in parallel to assist DOE in developing a test procedure that would account for the network mode energy consumption. Some questions that were posed in the SNOPR for clothes dryers are also applicable to other appliances as well:

- Is the network function turned on immediately when the product is turned on, or does the user have to activate it?
- If it is the latter, are there different settings that can be used and which would be the most typical setting that should be measured?
- What if products are designed to only have 1 and 5 minute interval periods?

These types of questions should be addressed. Currently, there are no devices available that can be evaluated and the Smart Grid communication protocol has not yet been finalized. DOE and NIST should attempt to obtain test units for evaluation when they are available. The uncertainty relating to the Smart Grid protocol highlights the challenge of maintaining relevant and representative test procedures in a time of rapidly changing appliance technology.

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Appendix 1 – Appliance Inquiry Statement

After reviewing the test procedures, the following statement was developed to outline the key information that NIST was seeking. This statement was provided to the contact once communication had been opened up.

In regard to dishwashers, I am interested in the following information:

1) Frequency of use (e.g. Number of cycles/week)
2) Energy consumption (During use, standby power, etc.)
3) Water Consumption
4) "Energy Star" dishwasher (Yes/No)
5) Size/type of dishwasher owned (Compact, standard) ("dish-drawer", "soil-sensing", etc.)
6) Temperature of the inlet water
7) Temperature of the wash water
8) How often are the following cycles used:
   a) Rinse/Hold
   b) Heavy Wash
   c) Normal Wash
   d) Light Wash
   e) Others (Please List)
9) Method of drying (Setting dishwasher to air dry vs. heated drying)
10) Size of a typical load
11) Pre-treating practices (rinsing, scraping, etc.)
12) Use of rinsing agents (Type, amount)
13) Use of soap/detergents (Type, amount)
14) Performance statistics of various soaps/powders/detergents

In regard to clothes washers, I am interested in the following information:

1) Thermostat Setting Frequency of use (e.g., # of cycles/week)
2) Energy Consumption (During use, standby power, etc.)
3) Water Consumption
4) How often a water temperature setting for wash cycle is selected (Cold, warm, hot, extra hot/sanitize)
5) How often a water temperature setting for rinse cycle is selected (Cold, warm, hot)
6) "Energy Star" clothes washer (Yes/No)
7) High efficiency "He" label (Yes/No)
8) Size/type of clothes washer owned (Compact, Standard, Large) (Front loading, top loading) (agitator, impeller, or nutator)
9) How often are the following cycles used:
   a) Normal

b) Hand Wash/Delicate
c) Heavy Duty
d) Permanent Press
e) Steam/Sanitize/Other similar cycles
f) Others (please list)

10) How often an extra rinse is selected
11) Size of a typical load
12) Typical water level selected (Low, Medium, High, Auto)
13) Use of soap/detergents/bleach/fabric softener (type/amount)
14) Performance statistics of various soaps/detergents/bleaches

In regard to clothes dryers, I am interested in the following information:

1) Frequency of use (e.g., # of cycles/week)
2) Energy consumption (During use, standby power, etc.)
3) "Energy Star" clothes dryer (Yes/No)
4) Size/type of clothes dryer owned (Compact, standard)
5) How often are the following cycles selected:
   a) Timed dry
   b) Delicate
   c) Normal
   d) Heavy
   e) Permanent Press
   f) Automatic termination (e.g., Moisture Sensor, temperature sensor)
   g) Others (Please List)
6) Energy source (Electric/Natural Gas/Propane)
7) Size of a typical load

Appendix 2 – Source Contact Summary Sheet

Table A-1 summarizes the companies that were contacted, the type of company, and whether or not data was available. "Yes" indicates that data was available and obtained. "No" indicates that no data was available. "No Reply" means that a reply from the contact was not received. "Yes. Proprietary" means that the contact had data, but was not able to share it.

Table A-1: Source contact summary sheet

Company	Type of Company	Data available
TIAX LLC	Consultant	No
California Energy Commission	Energy Policy Planning Agency	Yes
Earthjustice	Environmental Group	No Reply
National Resources Defense Council	Environmental Group	No Reply
Government of South Australia, Department for Transportation, Energy,	Government	No
Natural Resources Canada	Government	Yes
Sustainable Energy Group – Australian Greenhouse Office	Government	Yes
Lawrence Berkeley National Laboratory	Government Laboratory	No Reply
International Energy Agency	International Policy Advisor	No
International Electrotechnical Commission (IEC)	Int'l Standards Organization	No
International Survey Center	Int'l survey organization	No
Appliance Magazine	Magazine Publisher	No Reply
All	Manufacturer	No Reply
Alliance Laundry Systems LLC	Manufacturer	No
Arm and Hammer	Manufacturer	No Reply
BSH Home Appliances	Manufacturer	Yes. Proprietary.
BioKleen	Manufacturer	No Reply
Bosch	Manufacturer	No Reply
Cascade	Manufacturer	No Reply
The Clorox Company	Manufacturer	No Reply
Country Save Corporation	Manufacturer	No
Electrolux	Manufacturer	No Reply
Fisher & Paykel	Manufacturer	No Reply
Frigidaire	Manufacturer	No Reply
GE	Manufacturer	Yes. Proprietary.
Kenmore	Manufacturer	No Reply
KitchenAid	Manufacturer	No Reply
Kohler	Manufacturer	No Reply
LG	Manufacturer	No reply
Maytag	Manufacturer	No
Method	Manufacturer	Yes. Proprietary.

Company	Type of Company	Data available
Miele	Manufacturer	No Reply
OxiClean	Manufacturer	No Reply
Proctor & Gamble	Manufacturer	Yes
Reckitt Benckiser	Manufacturer	No Reply
Seventh Generation	Manufacturer	No
Whirlpool	Manufacturer	Yes. Proprietary.
Wisk	Manufacturer	No Reply
Woolite	Manufacturer	No Reply
Consumer Union	Market Research Firm	Yes
Consumers Digest	Market Research Firm	No
JD Power and Associates	Market Research Firm	Yes. Proprietary.
American Council for an Energy-Efficient Economy	Non-Profit	No Reply
Institute for Market Transformation	Non-Profit	No
Underwriters Laboratory	Product Safety Organization	No Reply
Consortium for Energy Efficiency	Public Benefits Organization	No
Australian Bureau of Statistics (ABS)	Public Survey Repository	Yes
Energy Information Agency (EIA)	Public Survey Repository	Yes
Australian Research Council	Research Management	No
American National Standards Institute (ANSI)	Standards Organization	No
American Water Works Association	Trade Organization	No
Association of Home Appliance Manufacturers (AHAM)	Trade Organization	Yes
Association of Manufacturers of Domestic Appliances	Trade Organization	No
European Committee of Domestic Equipment Manufacturers	Trade Organization	No Reply
National Kitchen and Bath Association	Trade Organization	No Reply
Northeast Energy Efficiency Partnerships	Trade Organization	No Reply
Northwest Energy Efficiency Alliance	Trade Organization	No
Oregon Department of Energy	Trade Organization	No Reply
American Cleaning Institute (formerly the Soap & Detergent Association (SDA))	Trade Organization	No
University of Melbourne (Australia)	University	No Reply
Virginia Polytechnic Institute and State University (Virginia Tech)	University	No
Pacific Gas & Electric	Utility	No Reply
San Diego Gas and Electric	Utility	No Reply
Southern California Edison	Utility	No Reply

Appendix 3 – Key points of the analysis

This section contains a summary of data from multiple sources outside of NIST, as noted on each chart. Information on the uncertainty is not available for all data.

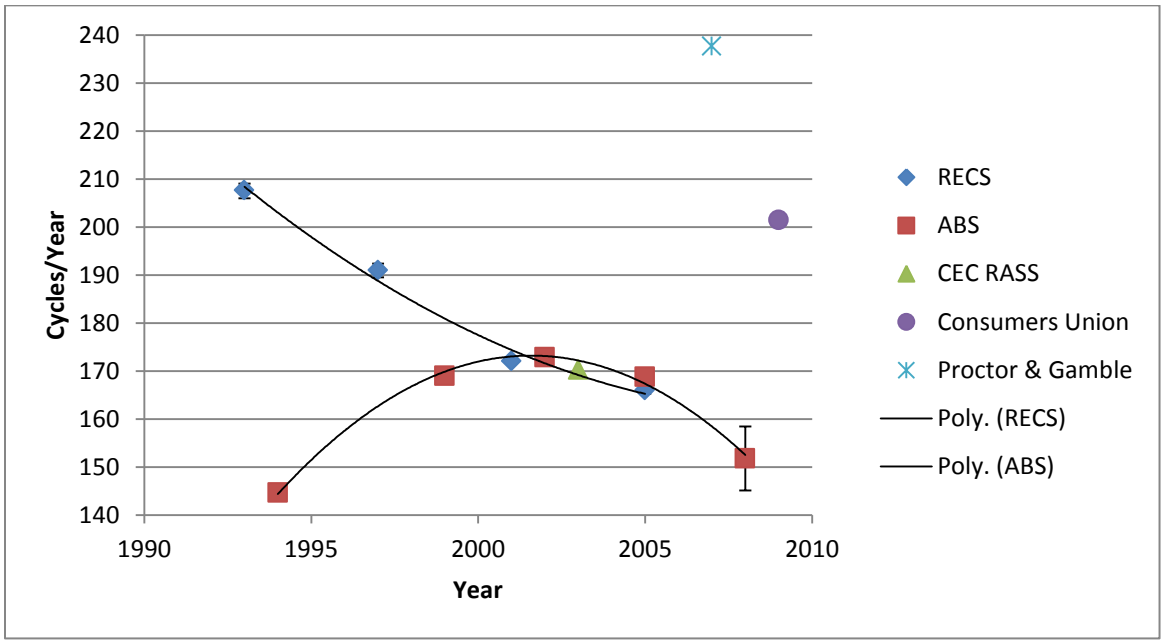

Figure A- 1: Dishwasher use frequency

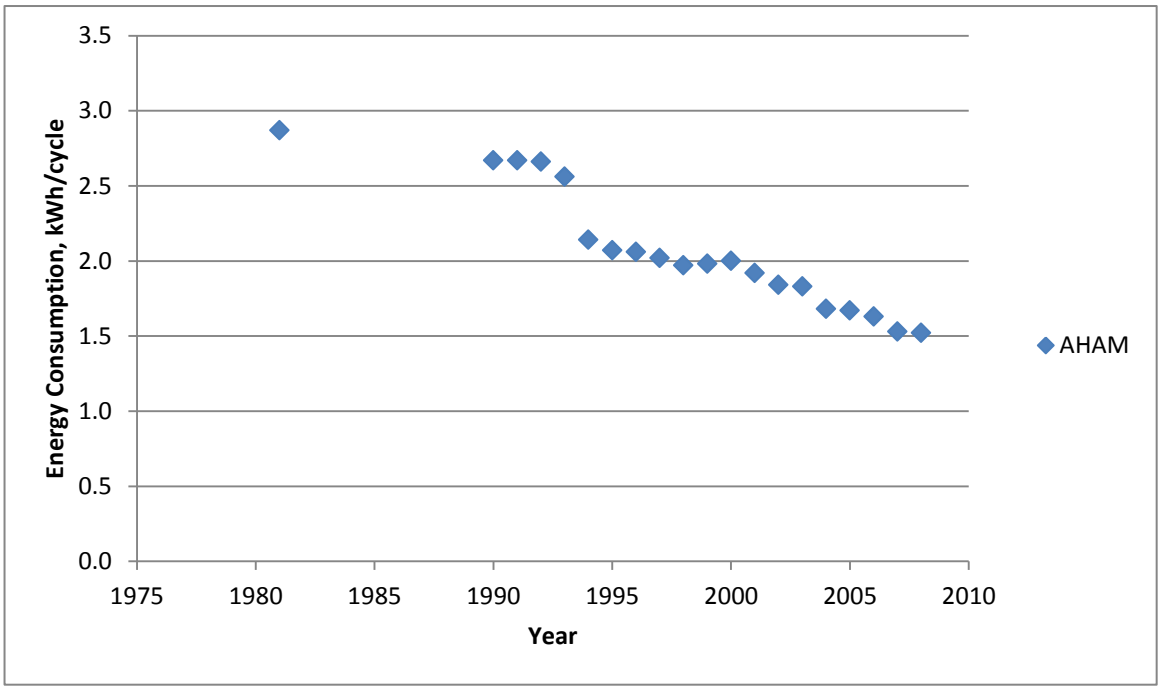

Figure A- 2: Dishwasher energy consumption

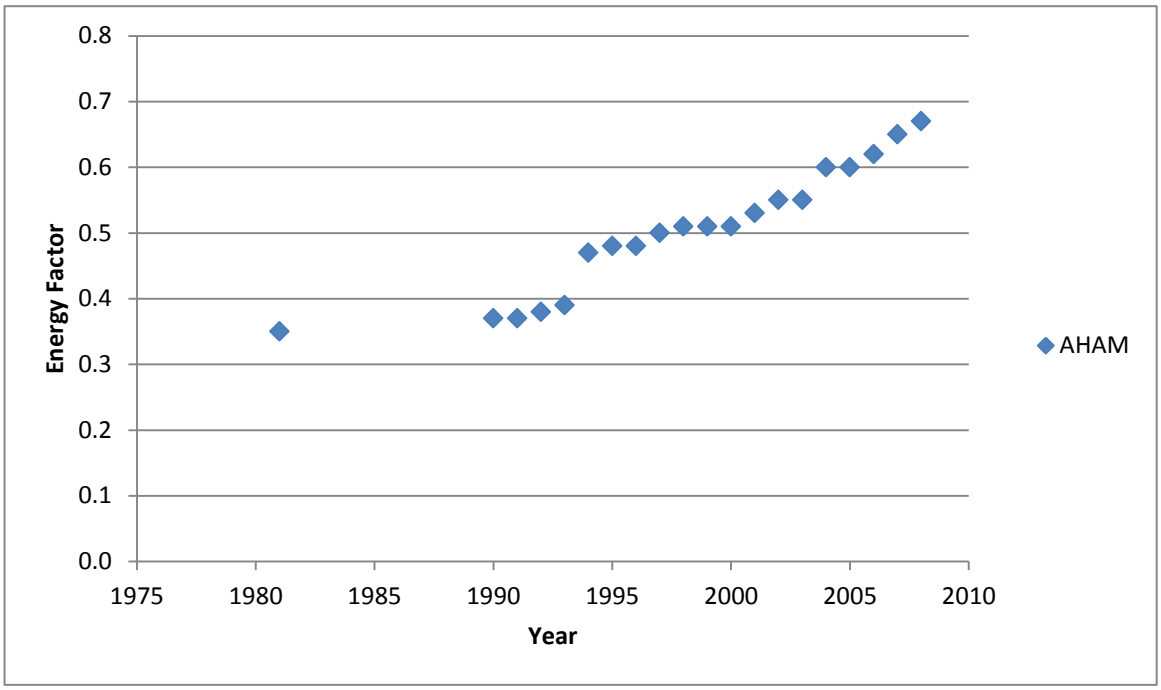

Figure A- 3: Dishwasher energy efficiency

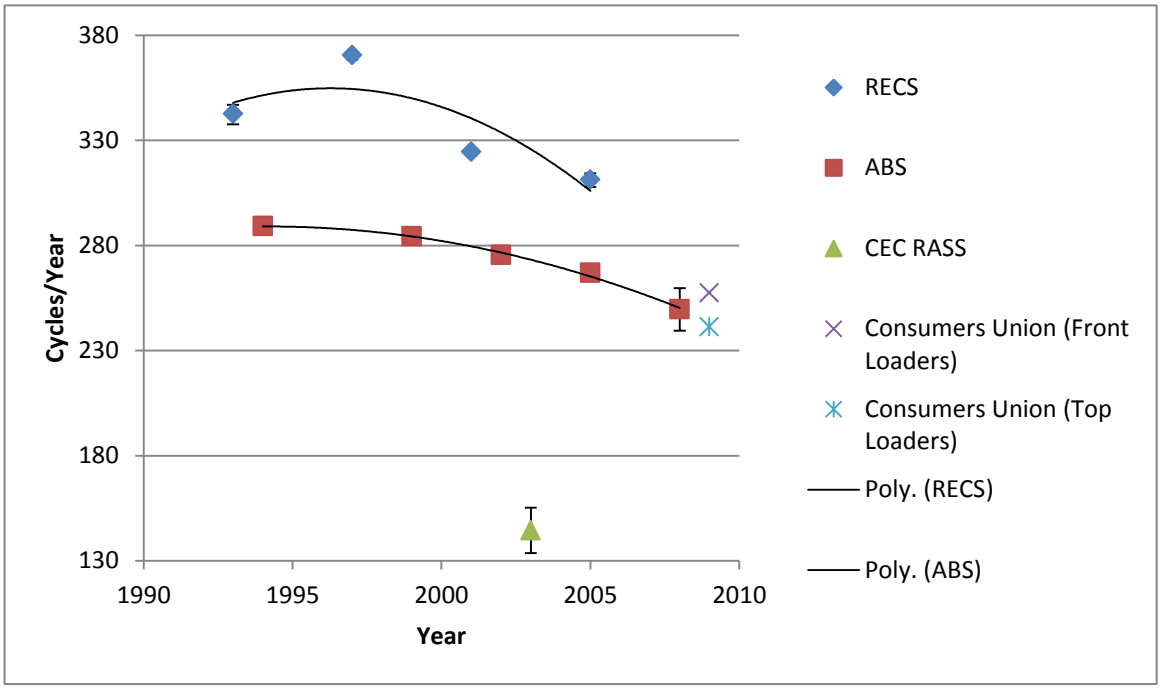

Figure A- 4: Clothes washer use frequency

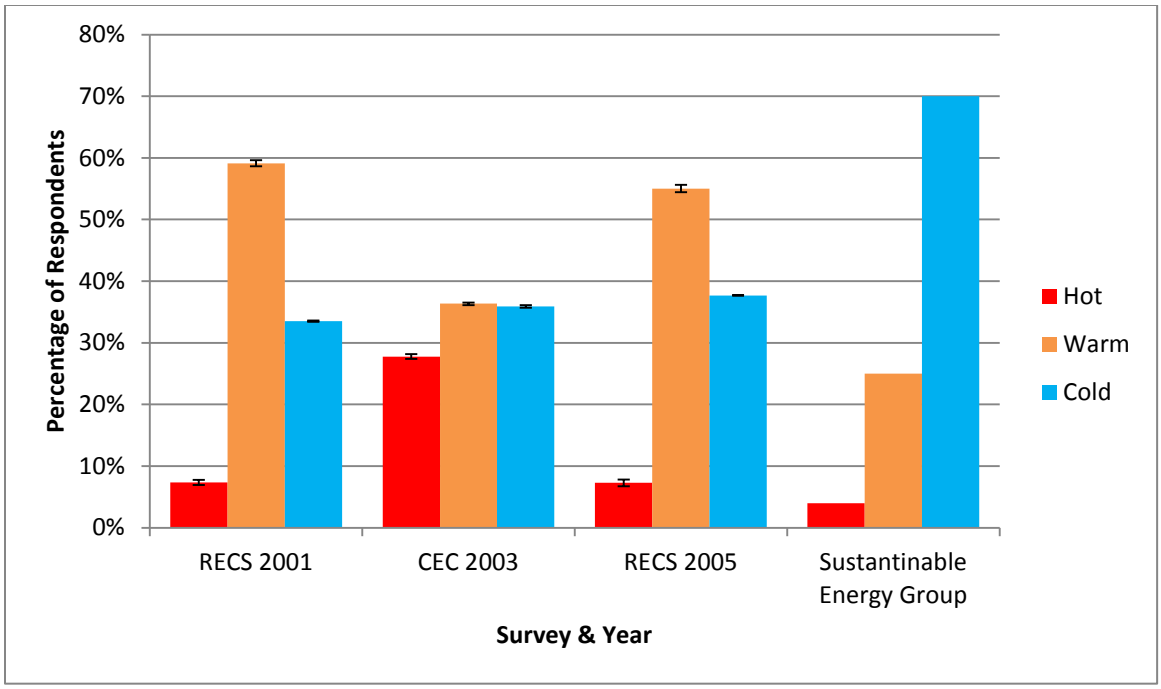

Figure A- 5: Wash cycle temperature settings, by survey

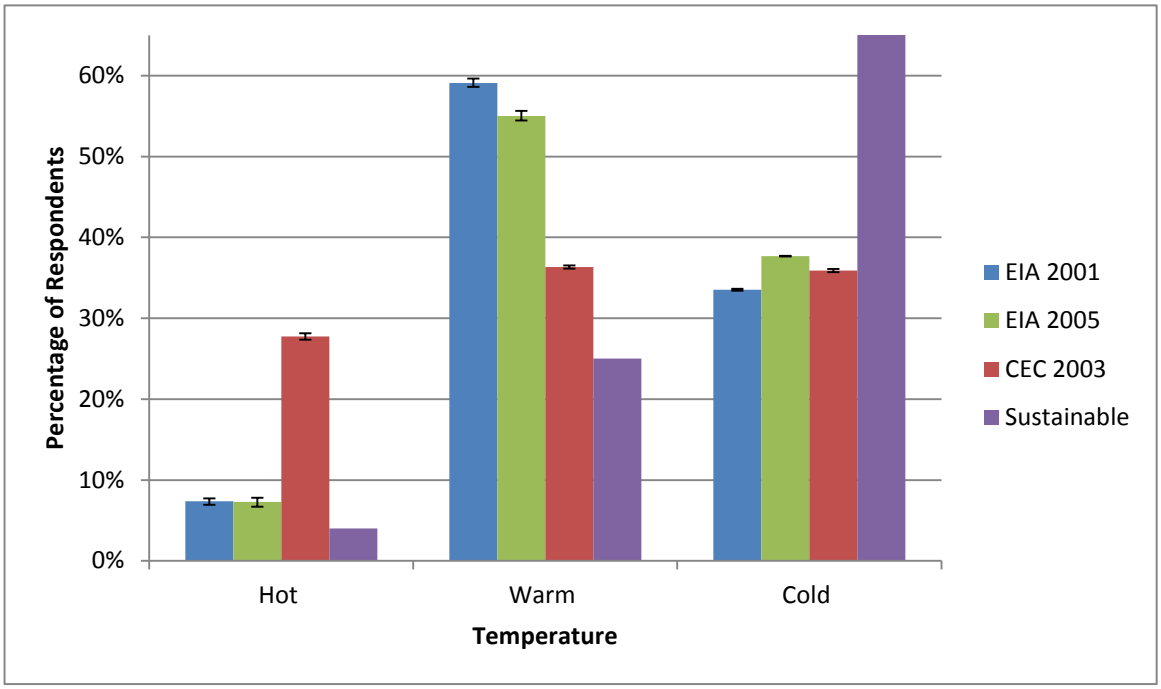

Figure A- 6: Wash cycle temperature settings, by temperature

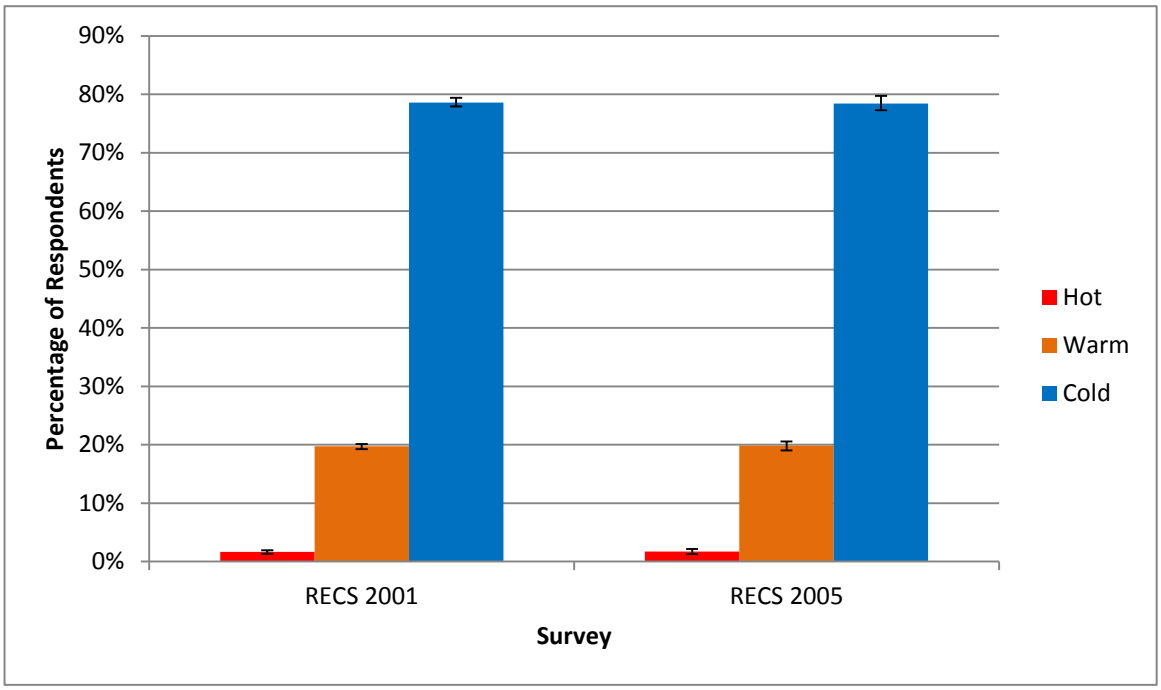

Figure A- 7: Rinse cycle temperature settings, by survey

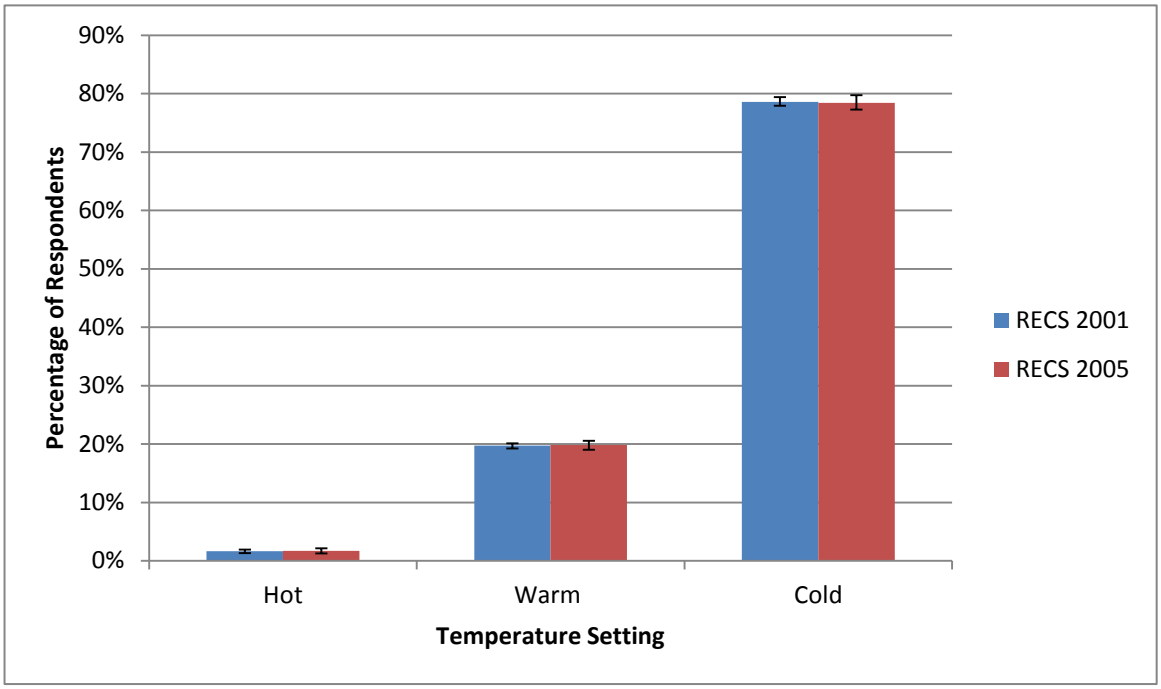

Figure A- 8: Rinse cycle temperature settings, by temperature

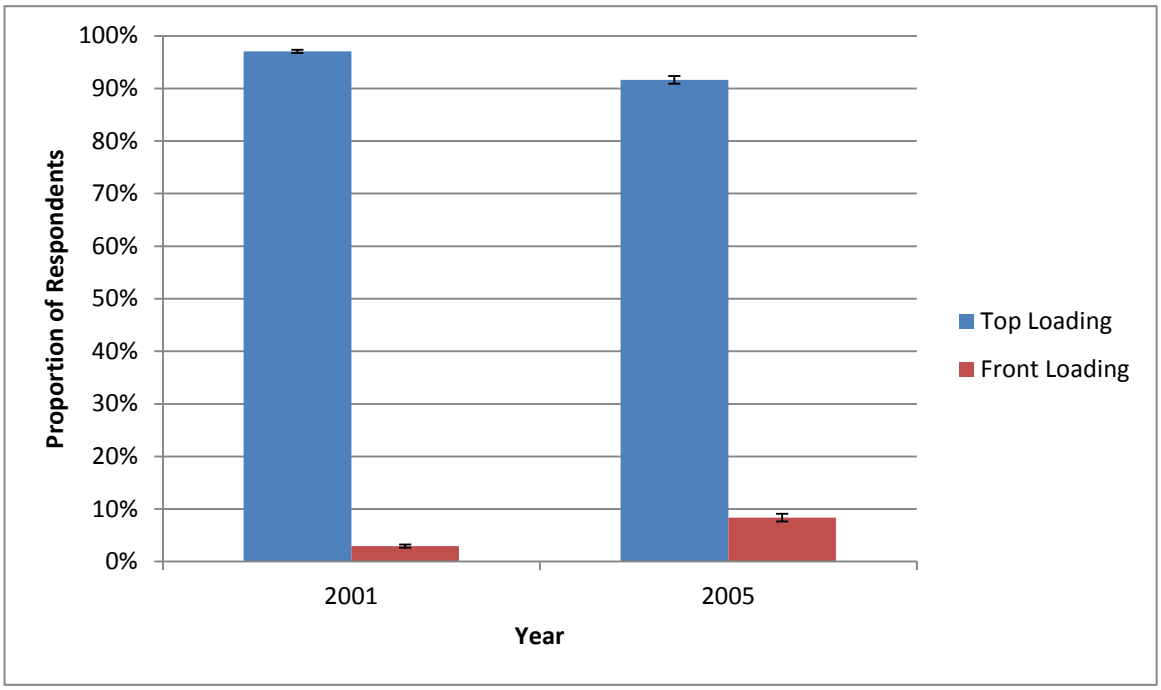

Figure A- 9: RECS, type of clothes washer

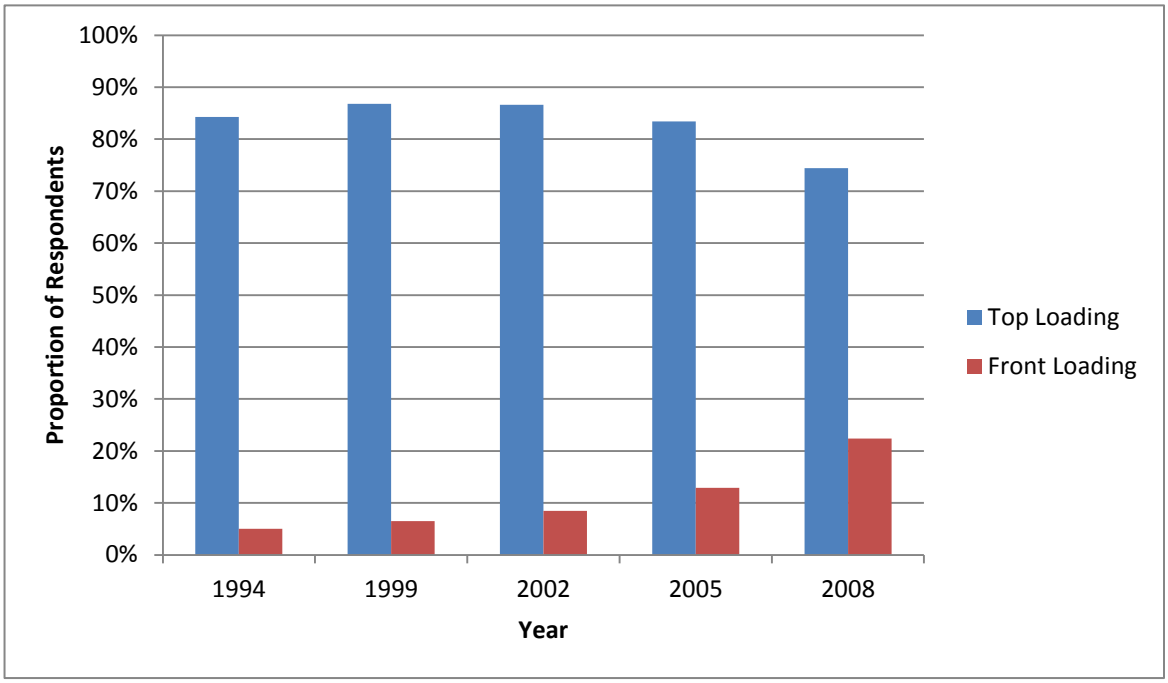

Figure A- 10: ABS, type of clothes washer

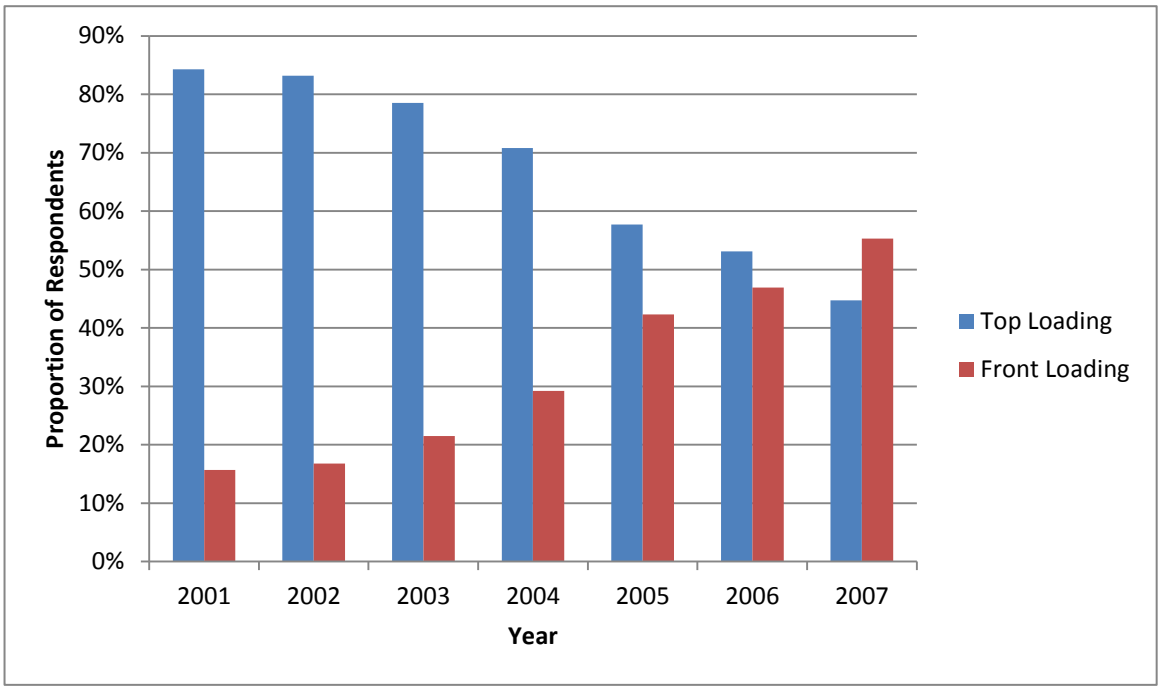

Figure A- 11: NRCan, type of clothes washer

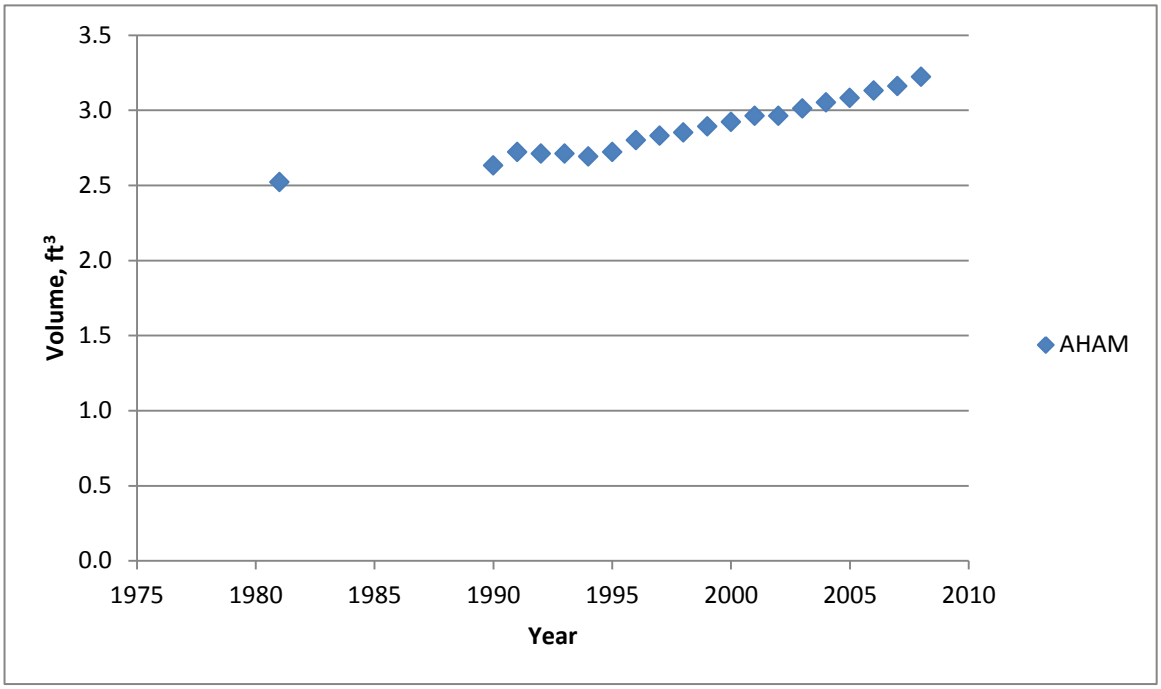

Figure A- 12: Clothes washer tub volume

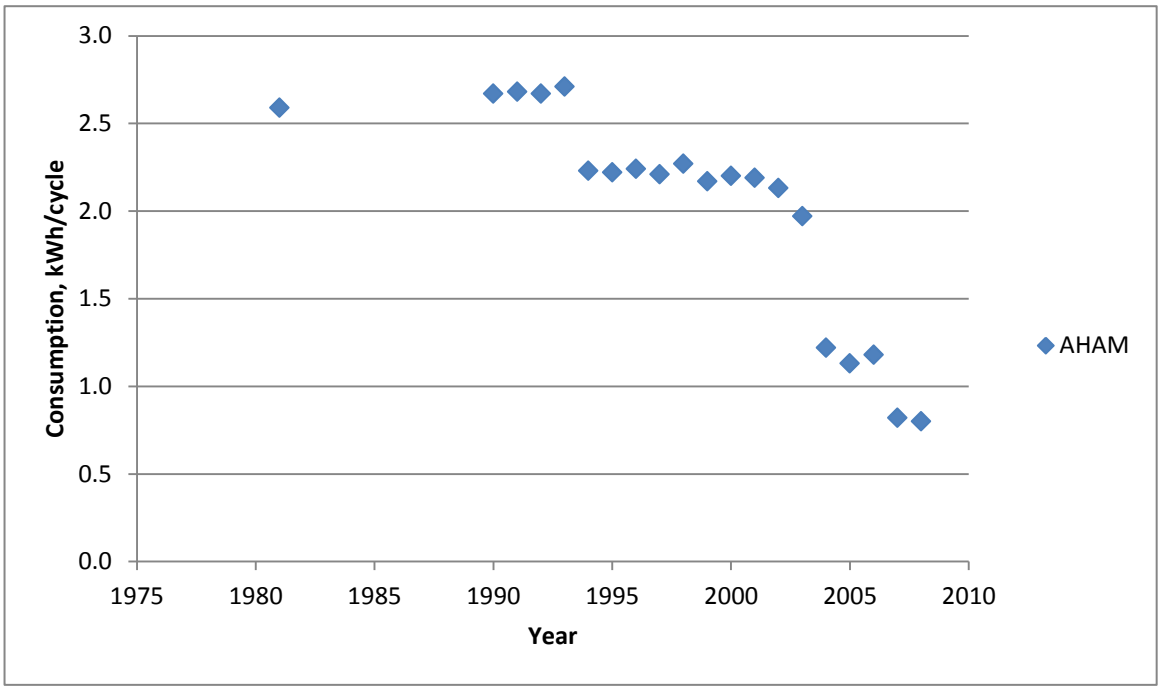

Figure A- 13: Clothes washer energy consumption

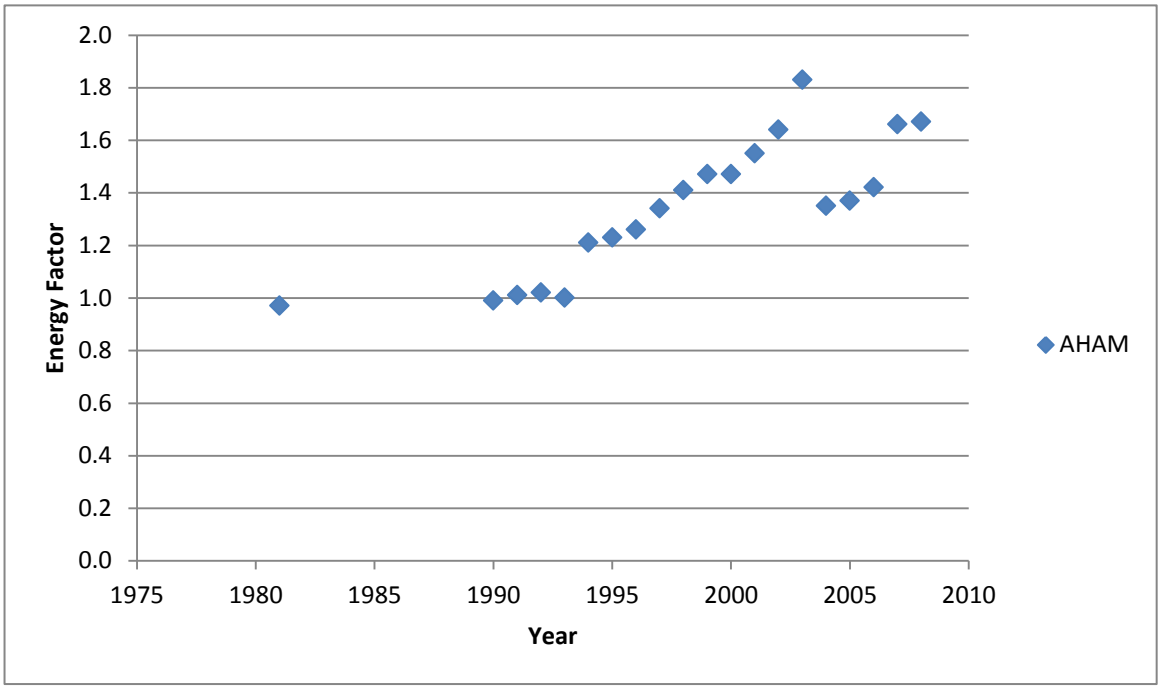

Figure A- 14: Clothes washer energy efficiency

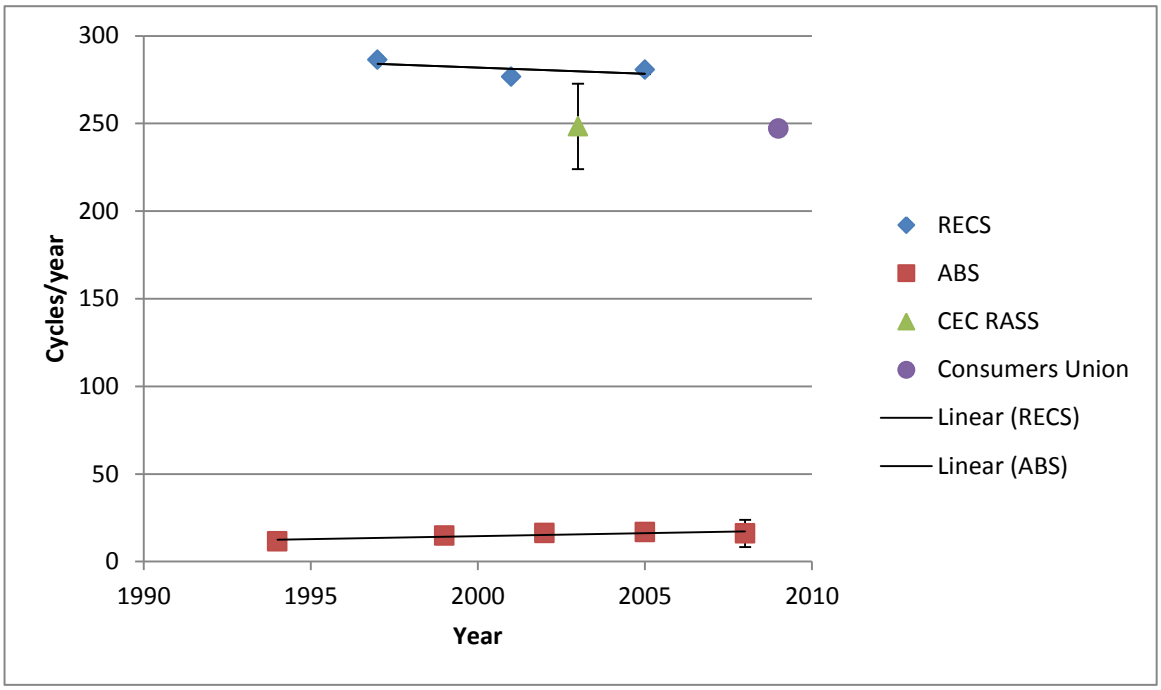

Figure A- 15: Clothes dryer use frequency

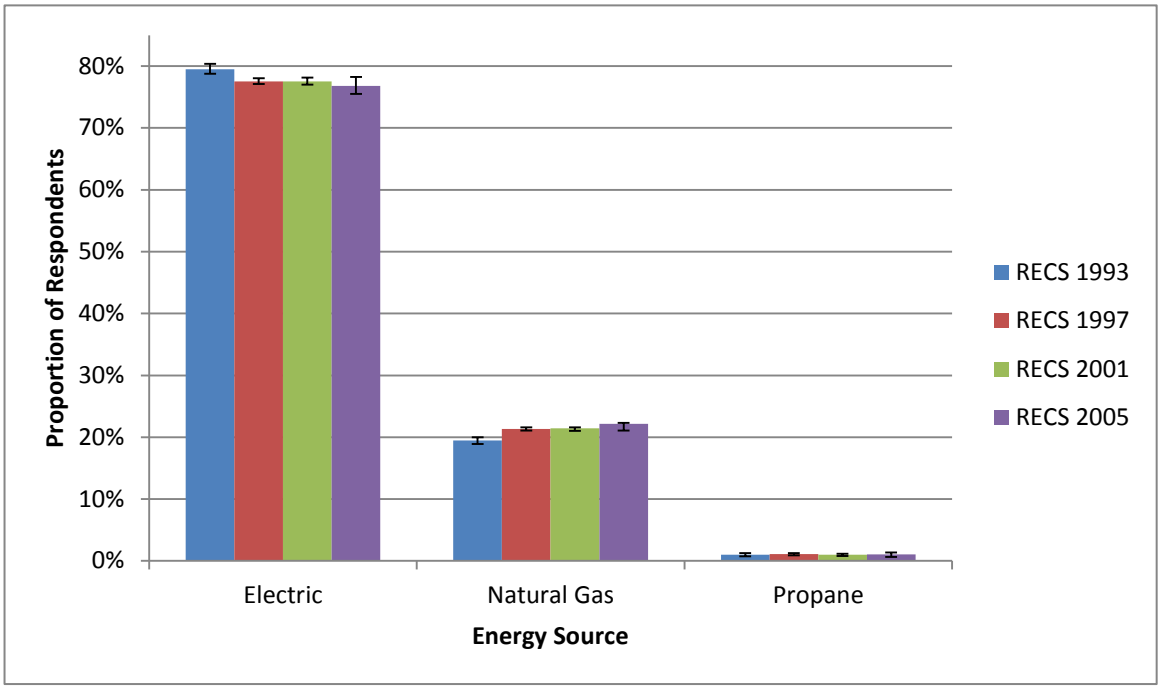

Figure A- 16: RECS, type of clothes dryer

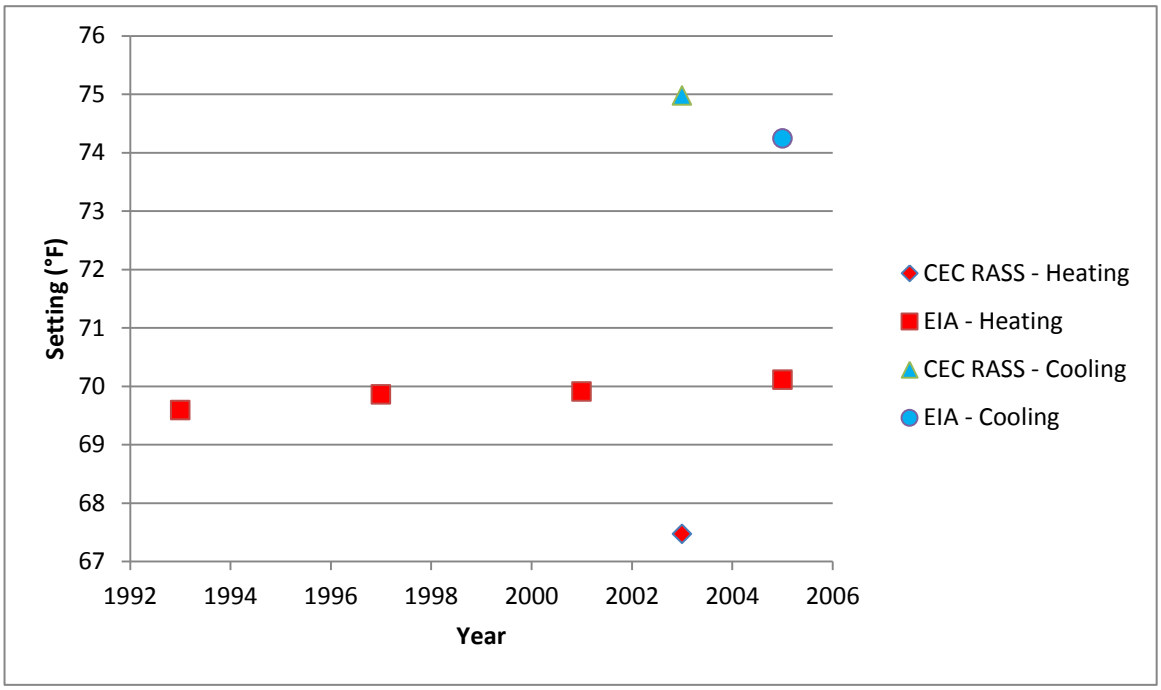

Figure A- 17: Thermostat setting, heating and cooling season

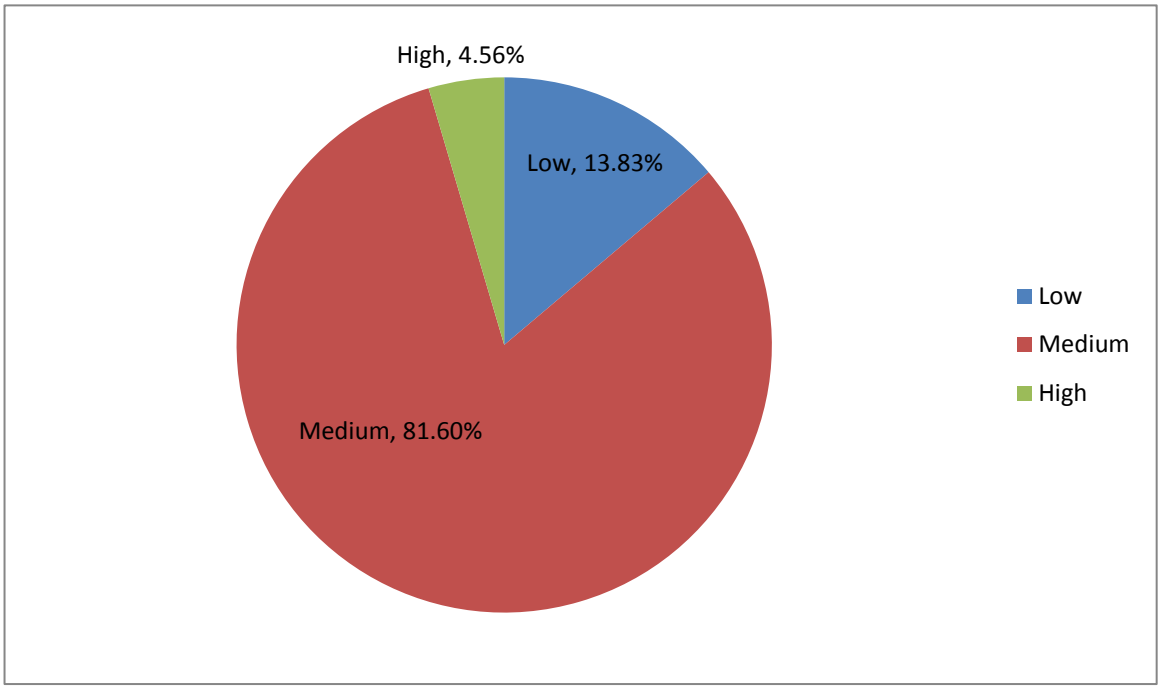

Figure A- 18: Water heater temperature setting