Nexus Market Research, Inc.

# MASSACHUSETTS ENERGY STAR® APPLIANCE PROGRAM MARKET PROGRESS AND EVALUATION REPORT: STATISTICAL ANALYSES OF MARKET PENETRATION OF ENERGY STAR-COMPLIANT APPLIANCES

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**Submitted to:**
**Massachusetts Electric Company**
**Nantucket Electric Company**
**NSTAR Electric**
**Western Massachusetts Electric Company**
**Fitchburg Gas and Electric Light Company**
**Cape Light Compact**

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## 1. Executive Summary

The research described in this report refines and extends the demonstration of market effects attributable to the Massachusetts ENERGY STAR® Appliance Program and similar programs around the U.S., described in the 2003 Appliance MPER. These reports, along with a limited number of others (e.g., Feldman 2003; Rosenberg 2003) constitute major breakthroughs in documenting the empirical validity of the concepts behind the market transformation approach promoted by energy efficiency advocates over the last decade and a half.

The report examines 2003 market penetration levels for qualifying clothes washers, refrigerators, room air conditioners, and dishwashers, and addresses the following questions about the effects of appliance programs in Massachusetts and other states:

- Was 2003 market penetration greater in states with active programs than in states without such programs?
- Is there evidence that prior program activities (i.e., before 2003) have had a market preparation effect, such that states with earlier programs demonstrated higher levels of market penetration than those without them?
- If states with 2003 program activities had higher levels of market penetration than others, is it possible that instead of being attributable to contemporaneous (2003) programs, might those differences be attributed to the earlier efforts (1998-2002) or to other differences between states, such as average residential electricity costs or socioeconomic variations?
- If differences in market penetration are attributable to program activities, are they appliance-specific or are they the result of synergism/spillover across appliances?

As with the other cited reports, this research is based on detailed statistical analysis of annual market penetration levels for ENERGY STAR-compliant products in each state, collected from national retailers by D&R International, under contract to the U.S. Department of Energy.

The analysis entails the development and assessment of statistical models designed to estimate those market penetration levels from three types of independent variables (predictors). The first set of predictors includes those that are not directly indicative of the activities of appliance programs, such as the average cost of electricity, the proportion of the population that is urban, and the density of “big box” stores in each state (where qualifying appliances are readily available for purchase). The second set of predictors are indicators of program activities, such as variables that represent the types of marketing support provided and product-specific rebates. The final set of predictors includes data on changes in market penetration for each appliance from 1998-2002—indictors of the effects of program activities in prior years.

Data on the first set of predictors was obtained from standard sources, such as the Energy Information Administration and the American Community Survey of the U.S. Census Bureau. Information for the second set of predictors was drawn from web sites, correspondence, and telephone interviews with program managers for 161 relevant programs in 23 states, identified through databases from the Consortium for Energy Efficiency, Northeast Energy Efficiency

Partnerships, Inc., and the Northwest Energy Efficiency Alliance, as well as referrals from other interviewees. The data on 1998-2002 changes in market penetration levels for the relevant appliances sold by national retailers in each state are those reported by D&R International.

The data thus collected were reviewed, subjected to preliminary analyses, and fine-tuned according to established statistical principles before they were subjected to the relevant multivariate analysis techniques (analysis of variance, regression analysis, and canonical correlation analysis). These preparations and analyses were comprehensive and complex. They are detailed in the report itself, but are not appropriate to this non-technical summary.

As suggested, the results of the study provide definitive evidence that energy efficiency programs such as that in Massachusetts shape appliance markets. More specifically, in response to the questions raised here, the statistical analyses demonstrate that:

- Market penetration levels of most qualifying appliances in 2003 were significantly higher in states with active programs than in other states. (Dishwashers stood as the sole exception: The lack of evidence of parallel effects in that market may reflect the very large proportion of models that qualified under the then-existing test procedures.)
- Earlier programs have helped to prepare the market for ENERGY STAR-compliant models of clothes washers, refrigerators, and room air conditioners. (Again, dishwashers stand as an exception.) Hence there is a cumulative effect, with current programs building on past programs.
- The differences in 2003 market penetration between states with active programs and those without them could not be fully explained by earlier program effects or by variables not directly connected with programs, such as average residential electricity costs or socioeconomic differences. This indicates that 2003 programs did have significant effects on the markets (again, excluding dishwashers).
- Differences in market penetration levels for clothes washers, refrigerators, and room air conditioners were not only parallel across states, but were also related to the same predictors, indicating that the programs had considerable synergistic or spillover effects.

The statistical models derived from these analyses can be used to estimate the *minimum* lifetime electricity savings attributable to the appliance efficiency programs, although this research was designed to determine the presence or absence of market changes and their genesis, rather than to produce savings estimates. (As applied, the models produce estimates of the minimum program effects for several reasons, which are explored in more detail elsewhere in the 2004 MPER. The models were designed to establish the savings that could not be reasonably attributed to factors other than 2003 program activities. Thus, any effects that may be jointly attributed—for example, both to program marketing and to socioeconomic differences between active states and inactive states—were accredited to the socioeconomic differences alone. Furthermore, the models lack a recursive element—a recognition of feedback loops that also help to encourage the sale of qualifying models, such as manufacturers producing and shipping a greater proportion of qualifying models to states with active programs than to other states, based on their awareness of the plans for those programs.) Nonetheless, with this caution in mind, it should be noted that separate but comparable models (for each appliance type) estimated that minimum lifetime savings attributable to Massachusetts ENERGY STAR appliance programs rose from 26,140 MWh in 2001, to 29,877 MWh in 2002, to 53,130 MWh in 2003. These estimates reflect only the incremental effects of the programs, over and above any effects of variables that may have acted in conjunction with program activities jointly or through feedback loops (e.g., manufacturers shipping a greater proportion of qualifying models to states with active programs, based on awareness of those programs). But even with these cautions, the models and the estimates they produce strongly and clearly demonstrate the effectiveness of ENERGY STAR appliance programs, their cumulative effects, and the presence of spillover/synergism across appliances.

## 2. Introduction and Background

This report presents and analyzes statistical models that relate components of ENERGY STAR-appliance initiatives and other variables to the market penetration of those products. The specific products include ENERGY STAR®-compliant clothes washers (CW), dishwashers (DW), refrigerators (RF), and room air conditioners (RAC). The work, conducted for the Massachusetts program sponsors and under their direction, was undertaken by Nexus Market Research, Inc. and Shel Feldman Management Consulting, as one method of assessing the effectiveness of the programs.[1] The current project builds from and improves upon a similar effort conducted for the Massachusetts ENERGY STAR Appliance Program sponsors as reported in the 2003 Appliances Market Progress and Evaluation Report, Appendix F (2003 MPER).

The goal of this study is to provide the Massachusetts ENERGY STAR Appliance Program sponsors with a better understanding of the impact of these programs on ENERGY STAR market penetration and net electricity savings for the years 2001, 2002, and 2003. To accomplish this goal, we completed four tasks. First, we explored trends in market penetration from 1998 to 2002 and their impact on 2003 market penetration. Second, we modeled the incremental effect of program activity on market penetration of ENERGY STAR-compliant appliances. Third, based on the model results, we estimated net energy savings resulting from the programs. Finally, we tested more specifically a hypothesis suggested by last year's analysis, that program support for one appliance coheres with and spills over to the other appliances.

[1] The program sponsors include Massachusetts Electric Company, Nantucket Electric Company, NSTAR Electric, Western Massachusetts Electric Company, Fitchburg Gas and Electric Light Company, and Cape Light Compact.

# 3. Identification and Collection of Context Variables

Statistical modeling techniques are designed to explain the impact of one or more independent variables on one or more dependent variables. The assumptions behind such models are that changes in the independent variables explain changes in the dependent variables. In the analyses described in this study, market penetration for each appliance and change in penetration from 1998 to 2002 for each appliance are the dependent variables. We attempt to explain market penetration based on various independent variables hypothesized to affect the level of market penetration. In this and the following chapter, we discuss these independent variables, not all of which are found to be useful in the final analyses. For clarity's sake, we divide the discussion of independent variables into two general categories. The first, discussed here, are the so-called context variables. The second, discussed in Chapter 4, are referred to as program variables.

## 3.1 Choosing Context Variables

Our efforts to identify potential context variables were similar to those described in the 2003 MPER. We turned first to the variables used by Rosenberg (2003). Then, as explained more fully in the sections that follow, we also selected variables that previous research efforts have found—or those we hypothesized—relate to energy-efficient behavior, including the purchase of ENERGY STAR-compliant appliances.

With the benefit of last year's efforts behind us, this year we targeted our data collection more narrowly. In particular, we updated data for the variables found to be significantly related to market penetration for at least one appliance in either what we called the "best" models in the 2003 MPER or in alternative models that were nearly as strong as the best ones. We have also located data addressing several questions raised by the 2003 MPER. For example, as last year's efforts showed, the patterns of market penetration for DW diverged from those of the other three appliances. Last year, we suggested the possibility that regional differences in housing growth may underlie this previously unexpected finding. To address this question, this year's study includes an index of the rate of increase in housing units from 2000 to 2002 for the forty-eight contiguous states.[2] All the context variables considered are listed and their sources are summarized in Table 3.1.

In contrast to last year, we have excluded variables that we believed lacked true explanatory power in the equation. More specifically, we excluded dummy variables for U.S. Census-defined regions and divisions. While it is clearly true that market penetration of ENERGY STAR-compliant appliances differs across parts of the nation, knowing that CW penetration is, for example, higher in the Northeast and lower in the South tells us little about why this is so. We have instead striven to include variables—such as an index of drought and precipitation—that may capture what it is about the Northeast and the South that leads to differing levels of CW penetration.

We have also excluded variables that described the concentration of specific home improvement, department, and electronic/appliance chain stores. The fact that these stores carry and promote

[2] We exclude Alaska and Hawaii from the analyses because the unique locations and socioeconomic and demographic characteristics of these states causes them to be outliers for many of the independent variables.

ENERGY STAR-compliant appliances can only serve to increase market penetration. However, we found that the regional variation in the concentration of stores led to unexpected and contradictory findings across appliances and years. Thus, we concluded that individual store variables provided no useful explanation for actual market penetration in a given state. However, because the concentration of several of these national retailers might affect penetration data, we have created a variable that describes the collective concentration of three nationwide chains—Best Buy, Home Depot, and Lowe's—in each state.[3]

As we did last year, we have included a proxy variable for electricity prices—the average revenue per kilowatt hour (Sales and Revenue Excel Files, EIA 2004). This proxy variable is highly related to the electricity rates paid by customers, which are not available at the state level for every state. We included this variable based on the hypothesis that market penetration will be greater in states with higher electricity prices, as customers will be more motivated to lower their monthly bills. We also included a variable for recognition of the ENERGY STAR label, measured as unaided recognition in the annual Consortium for Energy Efficiency (CEE) WebTV survey (2001 through 2003).[4] We used the recognition score for the state's Census division, to avoid false precision and limited reliability based on small samples in several states. We expected that market penetration will be higher in states where a greater proportion of the population recognizes the ENERGY STAR label.[5]

We have also included a number of socioeconomic and demographic variables. Prior studies of the adoption of energy-efficient or environmentally friendly technologies and behavior have found that people must be aware of the technology or behavior, to have the ability to adopt or enact it, or to perceive that their actions will have a positive effect on energy efficiency or the environment. Typically, studies operationalize awareness, ability, and perceived efficacy using a number of demographic and socioeconomic variables. We have followed suit, using the following variables: proportion of householders in certain age categories, the proportion of the population claiming its race as white, and the proportion of the population living in urban areas.

Income and education, furthermore, are perhaps the variables most often linked to the adoption of energy-efficient/environmentally friendly technologies and behavior. These two variables—operationalized as the median household income in each state and the percentage of adults with at least a college degree—are strongly correlated across the states ($r=.840$, $p<.001$). Their strong statistical relationship presented us with two choices—to use only one of the two variables in the equations or to combine them. In the 2003 MPER, we decided to use only the income variable;

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[3] This variable is only available for 2003 due to the lack of data on the number of Home Depot stores in each state in 2001 and 2002. The number of Sears's stores per state was not available for any year. However, Sears's stores tend to be ubiquitous in large and small malls across the nation, and in most cities and towns, likely displaying somewhat less variation in concentration per households between states.

[4] As discussed more fully in Section 4.4, it is likely that a recursive relationship (i.e., a feedback loop) exists among market penetration, program activity, and ENERGY STAR recognition. Program activity and higher market penetration likely increase recognition of the ENERGY STAR label. This recognition then serves to increase future penetration and, potentially, demand for continued or expanded programs.

[5] A Census division is a geographic boundary determined by the U.S. Census Bureau; nine divisions exist in the United States. The Census Bureau largely determines the divisions on purely a geographic basis, but there is some degree of cultural congruity within them. For example, New England is a Census division, and is made up of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. The divisions and the states included in them are listed in Appendix A.

we recognized, however, that this decision ignored the likely additional effect played by education on market penetration. Upon reconsideration for the 2004 MPER, we decided to combine the two variables, first standardizing them and then adding the scores together. The statistical analyses, then, captured a composite "income/education" variable.

In addition to the variables commonly found to relate to the adoption of energy-efficient behavior, we also included context variables that relate more directly to the reasons people may purchase ENERGY STAR-compliant appliances. The proportion of owner-occupied homes recognizes that home owners are more likely to purchase appliances than are renters. The variable for change in housing units takes into account the fact that new housing commonly leads to the purchase of new appliances. These new homes, however, are *less* likely to have RAC; according to the 2003 Massachusetts ENERGY STAR Homes New Home Buyer Survey, 71% of new homes in Massachusetts have central air conditioning installed (see more on air conditioning below). New homes are *more* likely to have DW installed than are older homes, and buyers rarely bring DW from their previous home (only 6% according to the Home Buyer Survey). In contrast, 22% bring RF and 42% bring CW from previous homes. Furthermore, it is likely that newer and older homes likely have similar rates of CW and RF installations.

Among the other relevant factors, we include the percentage of homes cooled with central air conditioners (CAC) in models attempting to explain the market penetration of ENERGY STAR-compliant RAC. Obviously, homes with CAC installed have less need for RAC. We also include two weather-and-climate related variables. The first variable, cooling degree days (CDD) is included in both the models for RF and RAC. We hypothesize that RF located in warmer climates may run more frequently, using more energy. This may lead consumers in warmer climates to purchase ENERGY STAR-compliant RF. The potential relationship between CDD and RAC penetration is, however, more complicated. On the surface, it would seem that more CDD would increase the penetration of RAC. However, places with more CDD are also more likely to have CAC, lowering the need for RAC.[6] This may lower market penetration of RAC in warm climates. We include CDD in RAC models in order to clarify the relationship between the two variables. The second weather-and-climate variable takes into account drought conditions and generally drier climates. It is applied to both CW and DW, the two water-using appliances. We reasoned that drier or drought-ridden climates may have higher penetration rates for CW and DW, as the energy-efficient models save water as well.

[6] Even though new houses nationwide typically have CAC installed, warmer climates tend to have a greater percentage of new housing and, therefore, the highest concentration of CAC in homes.

## Table 3.1 Context Variables Considered, Their Operationalization, and Sources

| Variable | Operationalization* | Data Source |
|---|---|---|
| *Energy and ENERGY STAR-related variables* | | |
| Unaided recognition of the ENERGY STAR label | Proportion of respondents reporting unaided recognition of the ENERGY STAR label; each state set equal to the score for its division to increase stability. (Data in Appendix A) | CEE, Results of Web TV Survey, 2001-2003 |
| Electricity Price Proxy | Average revenue per kilowatt hour | Energy Sales and Revenue File for 2001-2003, Energy Information Administration |
| *Demographic and Socioeconomic Variables* | | |
| Householders aged 45-54 | Proportion of householders aged 45-54 | ACS, 2002[a] |
| Householder aged 25-34 | Proportion of householders aged 25-34 | ACS, 2002 |
| Caucasian/white population | Proportion of population claiming race as Caucasian/white only | ACS, 2002 |
| Urban population | Proportion of population living in urban areas | Census of Population and Housing, 2000 |
| Composite education and income | Sum of standardized scores for % of adults with a college degree and the median household income | Computed from ACS, 2002 |
| Owner occupied housing | Proportion of units occupied by owners | ACS, 2002 |
| Change in housing units | Ratio of housing units 2002 to 2000 | ACS, 2002 and Census of Population and Housing, 2000 |
| *Other relevant factors* | | |
| Concentration of box stores | Sum of the number of Home Depot, Lowe's, and Best Buy stores in each state per 100,000 residents | 2003 annual reports of Lowe's and Best Buy and the Home Depot web site |
| Number of cooling degree days | Yearly statewide estimates, 2001-October 2003; adjusted for population distribution within the state | NOAA |
| Percentage of households cooled with central AC[b] | Census Division average applied to all states within division | Energy Information Administration, 2001 |
| Dry climate and drought conditions | Interaction of drought conditions from 2000 to 2003 and State-level precipitation data weighted by population in surveyed cities in each state | NOAA, (with precipitation data found on Missouri Botanical Gardens web site) |

[a] The *American Community Survey* (ACS) is an annual survey conducted by the U.S. Census Bureau to provide data to supplement those gathered during the Decennial Census. We use the 2002 ACS to update 2000 Census data, many of which were based on information from 1999, now five years out of date. Economic data in particular are quite different today from 1999 and even from 2002, the year most recently available at the time of data collection.
[b] In the 2003 MPER we used this variable's virtual opposite—percent of households cooled with RAC. This year we turn to the CAC variable as we found that it better clarified the findings.

# 4. Collecting and Summarizing Program Data

Programs that promote transformation of markets for ENERGY STAR-compliant appliances have not been evenly spread across the nation or across time. While a handful of states—Massachusetts among them—have been promoting such appliances for over a decade, new programs emerge from time to time in both active and formerly inactive states; of course, existing programs may also modify their level of promotion from one year to another. In order to build a useful predictive model of appliance market penetration, one must attempt to describe the population of programs that exist across the nation both historically and in a given year. Still, the fact remains that more than one-half of the states in the nation did not have appliance promotion programs from 2001 to 2003. In addition, few of the existing or historical programs have actively promoted all four appliances through rebates, loans, or other incentives for all three years covered in this analysis.

The uneven—though expanding—distribution of programs across time, space, and appliance type required us to spend a good deal of effort identifying and collecting data from active programs across the nation and describing programs quantitatively, at the state level. We summarize the results of these efforts in this chapter.

## 4.1 Identifying and Contacting Active Appliance Promotion Programs

In the 2003 MPER, we relied largely on appliance program summaries compiled by CEE, coupled with additional information provided by Northwest Energy Efficiency Alliance (NEEA) and Northeast Energy Efficiency Partnerships (NEEP), with only occasional phone calls and web searches to confirm information such as the number of customers served or to clarify discrepancies between CEE and NEEA or NEEP information. However, the CEE program summary of 2003 residential appliance programs was not yet available during the period we conducted the data collection and analysis. As described in the sections that follow, we relied more heavily in the current effort on gathering information directly from program sponsors across the nation. Thus, we believe the data used in the present statistical-modeling approach is not only the most current available, but also that it incorporates improvements over those used in the 2003 MPER, as it provides more detail on the topics most pertinent to this particular study.

Before describing in detail how we identified and contacted active appliance promotion programs throughout the United States, two points are worth making. First, we have not included in our analysis appliance promotions that are a part of home energy audits (e.g., Massachusetts Home Energy Services, recently renamed MassSave). The report focuses only on those programs that have promoted appliances specifically. Energy-audit programs offering rebates on appliances may also affect statewide market penetration. However, the research objective is to assess the incremental role played by programs that specifically promote ENERGY STAR-compliant appliances on market penetration. Second, it is possible that our method has not identified all relevant programs throughout the nation, particularly those of smaller program sponsors or in states that are less active in promoting ENERGY STAR or energy efficiency more generally. We did, however, identify several new promotional efforts and learned of programs that existed in prior years that were not captured by CEE in its program summaries.

### 4.1.1 Identifying Active Appliance Programs

In order to identify formerly and currently active appliance programs, we first used the list of programs included in prior CEE summaries from 2000 to 2002. While many active programs are listed in the CEE summaries, our professional knowledge of additional programs made clear that some were missing. Therefore, we also turned to summaries provided by NEEA and NEEP of the efforts of their 2001, 2002, and 2003 partner organizations. From these three sources, we believe that we identified *a majority* of the active programs throughout the nation.

However, our research into the Double Your Savings (DYS) and Retire, Recycle, Replace (RRR) campaigns revealed that the reliance on CEE, NEEA, and NEEP data had not identified *all* programs that were active in 2003.[7] As a result, we added to our list of programs those sponsors named by ENERGY STAR as participating in DYS and/or RRR. Some of these programs—particularly those associated with water agencies in California—have been in existence since the mid to late 1990s.[8] Other programs sponsors, however, promoted appliances for the first time in 2003 in large part because of the boost provided by the national promotions.

We then used the sampling technique known as snowball sampling. Through tips gained while talking to other program implementers and evaluators and gleaned from sponsors' web sites, we located still other active programs. For example, we learned from the Santa Clara Valley Water Agency in California that the City of Palo Alto has its own programs.

Together, these efforts allowed us to identify 161 individual organizations, companies, or municipalities in 23 states that promoted at least one ENERGY STAR-compliant appliance from 2001 to 2003.[9] (See Appendix B for a full list of program sponsors.) Our next task, of course, was gathering information on their 2003 programs.

### 4.1.2 Contacting Active Appliance Programs

With the help of Elizabeth Titus and Subid Wagley of NEEP, who were collecting information on NEEP partners' appliance programs, we contacted many appliance, energy-efficiency, and water-conservation program implementers and evaluators to gather information on appliance programs sponsored from 2001 through 2003. Typically, we made initial contact via e-mail. We

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[7] DYS and RRR were campaigns organized by the U.S. Department of Energy (DOE). (See U.S. DOE 2004a, 2004b) For the DYS campaign, individual sponsors of CW promotions and manufactures of ENERGY STAR-compliant CW partnered with the DOE to offer at least $100 rebates on CW from April 15 to July 15 of 2003. Manufacturers paid $50 for every unit sold, and program sponsors paid at least $50, with some paying greater amounts. The RRR campaign was a partnership of the U.S. DOE and individual program sponsors designed to increase both the number of old RAC, RF, or dehumidifiers recycled and the number of ENERGY STAR-compliant models sold. The RRR promotions were more diverse than the DYS ones and did not follow a set rebate structure.

[8] It is not at all surprising that CEE summaries include only a handful of these water utilities. Most of CEE's members focus on electric and gas savings, not on water savings. While CEE surveys program sponsors who are not members, not all the parties who were surveyed respond. In trying to increase response rates, CEE logically focuses its resources on securing information from its members.

[9] We counted each of the partners with active programs listed by MEEA, NEEA, NEEP as a separate program because not all partners of these organizations promote the same appliances using the same incentives. However, each partner was given the same field support and marketing scores as the umbrella organization. In addition, because of its participation in NEEP, New Jersey is counted as an active state.

then followed with phone calls and additional e-mails until we received the information we needed or found it on programs' web sites (typically in archived press releases and bill inserts).

For seven sponsors, we could not collect the 2003 information we sought despite repeated phone calls and e-mail attempts. Yet, we had either 2002 program data from CEE, 2003 data from the ENERGY STAR summaries of the DYS promotion, or, 2001 to 2003 data from other sponsors who are partners of the same organizations or partnerships as some missing sponsors. We also successfully gathered 2004 program details from each of those seven sponsors' web sites. Together, these efforts yielded enough information from which to build statewide estimates of appliance promotion programs as discussed in the next section.

## 4.2 Summarizing Program Data

Developing state-level variables that summarize all the active appliance-promotion programs within each state required numerous decisions and steps. First, we had to develop some way of measuring the impact of individual programs on the entire state. Second, we summarized the types of incentives and program support offered by appliance-program sponsors. Finally, we adjusted our methods to meet specific situations, notably the nature of Wisconsin programs and the existence in the Western United States of programs sponsored by water utilities.

### 4.2.1 Determining the Impact of an Individual Program on the State Population

Only a few states have one appliance program available on a consistent basis to all the residents of the state.[10] Thus, to build a variable for each state that takes into account not only the existence of an appliance program but also its nature and breadth, we had to develop a method of determining each program's impact on the entire population of the state. In order to do this, we relied as much as possible on sponsor-provided estimates of the number of residential customers served by the utility, program, or specific promotion.[11] If an estimate of the residential customers was not available, we used sponsors' estimates of all electric or water customers in terms of connections, which slightly overestimated their reach because of the inclusion of non-residential customers.[12] Finally, if we could only find estimates of the population served (as with many water utilities), if it was clear that large numbers of commercial and industrial customers were included in an estimate (as in metropolitan areas), or we located no estimates of the number of customers at all, we used United States Census Bureau estimates of the number of households in the approximate service area to provide an estimate of the number of customers served.

We determined the number of households in each state using the Census Bureau's *American Community Survey, 2002*, the most recently available survey at the time of data collection. We then divided the customers served by the number of households in the state. This provided the proportion of the state served by an individual electric or water utility or appliance program. We used this proportion to determine the impact of each program and its components at the state level.

[10] Maryland, Oregon, Vermont, and for the most part Wisconsin are four examples.
[11] We only used residential customer estimates if they were based on the number of water or electric connections, not the number of people living in the service area. Utilities sometimes offer promotions only to a subset of their residential customers, which we accounted for in developing our program variables.
[12] This group was largely made up of small rural electric cooperatives and public utilities districts.

### 4.2.2 Computing Indicators for Each Program Component

The most important aspect of data collection involved gathering information on the characteristics and components of each program sponsor's appliance-promotion efforts. We specifically asked each program sponsor (or gathered information) about the following:

- Cash and other "money-in-the-pocket" incentives such as rebates, tax credits, bill credits, purchase vouchers, or tax exemptions
- Low-interest loans[13]
- Field support in the form of circuit riders, sales person training, the equivalent of Sales Person Incentive Factory Funding (SPIFFs), assistance with labeling and the provision of rebate coupons
- Marketing approaches, specifically:
  - Direct to customer: bill inserts, newsletters, and special mailings
  - In store: POP displays, use of in-store coupons, product labeling
  - Mass media: television or radio commercials, print advertisements, cooperative advertising, and press releases
- Duration of the program (i.e., proportion of the year the program was offered)
- For CW, participation in the 2003 DYS campaign (which requires partners to provide at least a $50 rebate that was then matched by $50 from participating manufacturers)[14]

When talking to program contact persons directly, we also took the opportunity to update information on their 2001 and 2002 programs in order to obtain additional detail beyond what was already provided in the CEE program summaries.

The above information was then entered into an Excel spreadsheet for each state and appliance along with the data on the proportion of households served by the program. We then computed each program's impact on the state for each year, appliance, and program component (i.e., incentives, field support, and marketing approaches), based on the following equation:

***Program Impact = Proportion of Customers x Duration x Program Component***

We then added together the results for each program and component in the state to arrive at the final state score.

In order to compute statewide summaries for field support, marketing approaches, and participation in the DYS campaign, each program was scored either with a one if the program component was present or a zero if it was not. This score was then adjusted by the program's statewide reach, resulting in a score that ranges from 0 to 1 for each program sponsor. We then added the scores for each sponsor together to produce a statewide result.

For example, in 2001 Connecticut, Connecticut Light & Power (CL&P) and United Illuminating (UI) both offered field support for the entire year. CL&P served about 79% of the state, and UI

[13] Low-interest loans will have a cash-equivalent savings to the customer. However, because the sale price of appliances and the amount that customers' may have borrowed was not known to us, we could not compute the cash savings potential of the incentive.

[14] In 2004, the national program allowed manufacturers to vary rebate amounts based on the model of CW.

served the remaining 21%. The field support score for CL&P in 2001 was .79 (.79 [proportion of customers] *x* 1 [duration of year] *x* 1 [program component score]), while UI's is .21 (*.21 x 1 x 1*). When we add these values together, the state's score is 1.00. In 2003, however, field support was offered for nine and one-half months (.792 of the year). CL&P's individual score dropped to .63 and UI's to .17, for a state total of .80.

If a coordinating organization such as the Midwest Energy Efficiency Alliance (MEEA), NEEA, or NEEP provided assistance with marketing or field support, all utilities or programs that are partners in the association were also scored with a one, on the assumption that all benefit from the assistance provided.[15] Likewise, we assumed that field and marketing support for one appliance spills over to other appliances.[16] Thus, we hold the scores for these variables constant across appliances, using the highest level of support offered for any appliance as the overall score. Not surprisingly, it is typically CW that receive the greatest amount of support, with some exceptions (e.g., RF in Illinois, Minnesota, and Missouri for certain years).

There are four exceptions to the development of the scores for the other program components. First, a small number of program sponsors, including some in Massachusetts, offered SPIFFs. We wanted to account for the existence of SPIFFS in the analysis, but we knew that they occurred too infrequently to have an individual effect on the model. Therefore, we folded the use of SPIFFs into the field support variable, giving a utility an arbitrary score of one tenth (.10) for each ten dollars in SPIFF offered.[17] Second, when water utilities provided field or marketing support in the same area as power utilities, the score for these variables could potentially exceed one for the entire state, since the efforts were actually duplicative. This was especially true in California. Third, as all DYS promotions lasted for three months (April 15 to July 15, 2003), we simply noted the proportion of the population eligible for a DYS rebate. The $50 manufacturer rebate was embedded within the cash incentive. Finally, when manufacturer-specific promotions were held, we accounted for the rebates within the cash incentive.

Finally, as in the 2003 MPER, we should also note that we used the ratings of cumulative effects as determined by individuals with in-depth knowledge about appliance programs across the nation in order to capture the continuity of past program activity.[18]

### 4.2.3 Wisconsin: A Special Case

In most states, programs are administered by a vendor, contractor, or umbrella non-profit organization, but ultimately the promotions are tied directly to the decisions of individual utilities or cooperating groups of them. For example, in Massachusetts rebate amounts are set by program sponsors who then hire vendors to run the programs and pay out rebates.

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[15] The one exception is New Jersey. Although NEEP coordinates some of the state's efforts, New Jersey does not actively promote any appliance at this time. Therefore, while we have a cumulative effects rating for New Jersey, the rest of its program components are scored zero.

[16] This assumption is justified in part by the results reported in the 2003 MPER indicating that the program variable for CW helped explain market penetration of the other appliances.

[17] We considered using both slightly smaller and larger scores for SPIFFs, but their infrequent use meant that the score assigned did not affect the results.

[18] Last year, we also used experts' ratings of field support. However, by talking directly to many program developers and implementers this year, we were able to ask them directly if they offered field support. We could then score the variable like the other forms of program support, rather than relying on experts' ratings.

Wisconsin takes a different approach. The Wisconsin Department of Administration conducts the residential appliance program as part of Focus on Energy, using the Wisconsin Energy Conservation Corporation (WECC) as its implementation contractor. The program is available in all service territories served by investor-owned utilities in the state and many, but not all, municipal utilities; a total of 84% of the state is served by the program.

Importantly, the current Wisconsin program has been designed to leverage program funds and to recognize that the participating manufacturers and retailers compete for market share. Program funds are leveraged through rebates coordinated with individual manufacturers and retailers. Competition is respected by working with individual manufacturers or retailers on their schedule, not that of the state government administrator or the program implementers. This is accomplished in part by offering rebates ("customer rewards") at different times of the year and varying rebate amounts according to the manufacturer or retailer's schedule and often tied to specific models.

Other states—including Massachusetts—and the ENERGY STAR program are moving towards this model, to some extent. The 2003 Double Your Savings promotion, in which all Massachusetts sponsors participated, was a joint promotion by program sponsors and participating manufacturers. Furthermore, in 2004, the program was altered to take manufacturer competition into account. In addition, some of the Massachusetts utilities held individual promotional events with specific manufacturers and/or chain stores in 2003. The promotions of the Energy Trust of Oregon also share similarities with the Wisconsin model. Energy Trust has a rolling incentive, promoting the products of a different manufacturer each month.

Still, the relatively unusual nature of the Wisconsin program made it impossible to use the method described in Section 4.2.2 to develop estimates of program variables for the entire state. In the 2003 MPER, we had decided to use as the statewide estimate the average manufacturer rebates offered throughout the year with each manufacturer rebate adjusted for the length of time the rebate was offered. This produced estimates that greatly understated the rebates available to Wisconsin residents (e.g., $13 in 2002 and $16 in 2003 for CW). This year, we used an alternative estimation method for Wisconsin. We averaged the rebate amounts offered by WECC and the manufacturers without attending to how long each rebate was offered. Then, we determined the proportion of the year that *any* rebate was offered. This produced estimates in ranges that appeared to describe better the rebates available to Wisconsin residents on a yearly, statewide basis (generally in the $6 [for a two-month RAC rebate] to $60 range [2003 CW including DYS promotions]). One minor disadvantage of this method is that high rebate amounts offered for shorter periods of time slightly inflated the statewide effort.[19] However, we believe this slight inflation is justified compared to other methods (such as paying greater attention to the duration of specific rebates) that greatly understated programs in this state.

### 4.2.4 Water Utilities

In the Western United States, numerous water utilities promote ENERGY STAR compliant CW that also meet standards for water efficiency (measured by the Water Factor, WF). In fact, in

[19] For example, if we were to remove a one-month $75 and $100 refrigerator rebate from 2002, the estimates drops from $58.19 to $56.36, less than a $2.00 change.

some states, water utilities are more active than electric and gas utilities in promoting ENERGY STAR CW. In other parts of the West, the efforts of water and power utilities sometimes are coordinated and other times simply overlap, so that customers may be eligible for rebates from both their water and power providers. This is the case, for example, in parts of northern California where customers of certain water utilities that participate in the Northern California Water Utilities consortium and who are also customers of PG&E may receive up to $225 in rebates for ENERGY STAR-compliant CW.

In order to single out the incremental effects of promotions sponsored by electric and gas utilities on market penetration while also accounting for the role played by water utilities, we initially separated the program data for water utilities from those of programs offered exclusively to gas and/or electric customers. However, preliminary analyses made clear that there were too few water programs available to stand on their own in the regression models. Still, we strongly believed that the efforts of water utilities boosted penetration in certain western states. Therefore, we decided to fold the efforts of the water utilities into the statewide totals. We believe, however, that the inclusion of the drought/precipitation interaction variable helps capture the importance that water availability issues play in promoting efficiency in water-using appliances in the Western States.

### 4.2.5 Computing the Composite Program Variable

In the 2003 MPER we noted that, "Ideally, this analysis would provide policymakers and program designers with guidance as to the optimal level of financial incentives—the level that would stimulate the greatest increase in market penetration over baseline at the least cost." However, we explained that in real world settings, programs rarely separate cash incentives from field support or marketing efforts. If we had allowed each of these variables to enter regression equations separately they would have suffered "from the dread statistical disease, multicollinearity." Our solution was to combine all types of program support—including cash incentives—and the cumulative-effects rating into individual composite program variables for each appliance. We did so only after applying homogeneity tests to determine that the resulting composites were statistically appropriate and reliable.

In this 2004 MPER we were able to modify this approach slightly. More specifically, our efforts to expand the number of appliance programs produced some differentiation among programs that was lacking in the earlier study. When we subjected these new data to correlation analyses and homogeneity tests, we found that the cash incentives for RAC, RF, and DW were not as closely tied to other program components or to cumulative effects as was the CW cash incentive.[20] In other words, our models this year could allow cash incentives for RAC, RF, and DW to stand on their own, apart from an overall program variable. The full models we tested for these three appliances included both a cash incentive and a program support variable, the latter being composed of field support, marketing approaches, and the cumulative-effects rating. In contrast, the CW cash incentive remained inseparable from other program components; as a result, we used only one composite program variable made up of cash incentives, program support, and

[20] See Appendix C for the results of the homogeneity tests, including correlations between program components.

cumulative effects in the CW models. In addition, the 2003 CW program variable also included the DYS promotion.[21]

We built the program variables in the following manner. First, we transformed the data to adjust for skewed distributions (as described in more detail in Section 5.1). Second, since our individual program variables used three different scales (dollars, proportions, and rating scores), we standardized each set of scores. Next, we conducted homogeneity tests and computed the associated Cronbach's alpha statistic to determine which of the program variables should be combined into a composite program variable. Finally, we summed the appropriate program variables to form an overall composite program variable.

## 4.3 Change in Market Penetration

Evaluators of appliance-support programs have struggled to identify and quantify the cumulative effects of these programs on market penetration. Their studies typically have not had the data necessary to determine the effects of previous program activity on current market penetration, and have therefore been limited to assessing contemporaneous effects. In contrast, this study was able to include an analysis of the effect of previous changes in market penetration on 2003 market penetration. We refer to the impact of this variable as the momentum or cumulative effect in this study.

To model cumulative effects, we developed a variable representing the change in market penetration for each appliance over the five-year period leading up to 2003. Specifically, we computed the rate at which market penetration changed for each appliance from 1998 to 2002.[22] The rate of change in a given state is affected by a number of interacting and reinforcing factors. In active states, past programs most likely lead to higher increases in change in market penetration (an assumption we test, as discussed below in Section 5.3). However, it is also true that other factors increase the availability of ENERGY STAR-compliant appliances and the awareness of these products, affecting change in market penetration. For example, context variables such as the income/education composite and the electricity price proxy likely help explain change in penetration. Furthermore, programs in active states demonstrate to manufacturers and retailers the potential demand that exists for ENERGY STAR-compliant appliances. Manufacturers and retailers respond by increasing the availability of those products. In addition, the efforts of organizations such as CEE, ACEEE as well as the U.S. DOE also contribute to greater availability of energy-efficient appliances. These efforts are obviously interacting and reinforcing. Thus, Massachusetts' programs have some degree of spillover in other states in the nation, just as penetration in Massachusetts is affected not only by its own programs but also by those of other states and of national-level organizations and government agencies. In short, the observed change in penetration is not an indicator of the cumulative effects of prior program activity operating in a vacuum, but is also affected by feedback loops.

[21] The loan incentives were used by so few sponsors in so few states that they could not be included with the other program components. In addition, their rarity kept them from entering regression models as significant predictors of market penetration of any appliance.

[22] Note that the variable created (the slope of the line connecting market penetration for each appliance in 1998 and that for each appliance in 2002) takes into account both the change in market penetration and the values of the individual levels of market penetration. Thus, while Alabama and Massachusetts, for example, both saw their market penetration of RAC increase by more than two-and-a-half times, the slope indicates an approximate seven percent increase in MA per year and a two percent increase in AL per year.

In an effort to isolate the portion of the change in penetration variable due to Massachusetts's previous programs *within the state*, we subtract the national average change in penetration from that in Massachusetts. We assumed that the difference between the national and state score was due entirely to prior program activity in Massachusetts, an assumption that is likely not wholly accurate but is an improvement over not including the variable at all. Unfortunately, we were not able to determine which portion of the national increase in penetration is also due to the spillover of Massachusetts's programs.

We used these change in penetration variables in two analyses.[23] The first was an analysis of variance (ANOVA) that addressed the question of whether the increases in penetration in active states differed from those in non-active states. This analysis confirms the hypothesis that active programs underlie change in penetration, at least in part. The second analysis assessed the degree to which what may be seen as the momentum from earlier programs helped to explain the market penetration of appliances addressed by 2003 programs—or, conversely, whether 2003 programs add to the explanation of market penetration rates, once the momentum effect is taken into account. In other words, the second analysis was able to determine if contemporaneous programs still increase market penetration, or if penetration would be the same without the programs because of the momentum built from prior state programs and the efforts of ENERGY STAR, manufacturers, and retailers more generally.

## 4.4 Allocating Explanatory Power among Variables

Regression analysis has three primary uses.[24] The first is to "explain" (model, account for) variation in the values of the dependent variable. The greater the amount of variation explained, the more confident one can be that the model captures the important determinants of the dependent variable. The second is to assess whether a specific hypothesized determinant adds significantly to the explanation, and if so, what weight it carries when added to the model. The third is to predict values of the dependent variable for selected cases, given relevant values of the determinants, their weights, and the model structure.

The first and second of these are discussed in this section and illustrated in the hypothetical cases in Figure 4.1. The four pie charts represent 100% of the variation in market penetration. One section of the chart represents the amount of variation that is left unexplained by a regression model. The other sections of the charts indicate the amount of variation accounted for by individual determinants or by groups of variables.

Case 1 assumes that only the context variables (Section A) were included in a regression model. Although these context variables explain a good deal of the variation in market penetration, much of the variation is left unexplained. Cases 2 through 4 assume that adding the program variable (Section C, Cases 2 through 4) increases the amount of variation that is explained by the model (thereby making Section D much smaller). Importantly, although we have used the

[23] We attempted to build regression models to predict change in penetration. However, we lacked sufficient time series data—especially of state-level program activity from 1998 to 2000—to build statistically appropriate models. It is likely, however, that many of the same factors—context and program variables alike—that drive market penetration drive change in penetration as well.

[24] For more information on regression analysis see, e.g., Kahane (2001), Foster, *et al*. (1998), or Lunnenborg (1994).

example of the program variable, Section C could just as easily have been represented by any other significant predictor of market penetration. Especially noteworthy here is the expected impact that the cumulative effects variable is hypothesized to have on market penetration. We included this variable because we believed that it would significantly increase the amount of variation explained by the regression models *and* demonstrate its own incremental effect on market penetration.

It is also true, however, that the variables in the model, in addition to having their individual incremental effects, also have *joint*, *recursive* (or feedback loop), and *interactive* effects on market penetration.[25] We cannot determine what proportion of the market penetration we observe results from the joint or recursive action of context variables, cumulative effects, or program variables or their interactive effects, given that some relationships between program variables and context variables are themselves statistically significant.[26] This situation is also illustrated in Figure 4.1, Cases 2-4. Although we can identify the proportion of the explained variance in market penetration that is attributable solely to programs (Section C, which is the same size in Cases 2-4), we cannot distinguish between Case 2, Case 3, and Case 4 with respect to the proportions attributable to the context variables alone (Section A) and that due to joint effects (Section B), if they even exist (Case 2 assumes they do not). Again, the same is true for all other variables, most importantly that for cumulative effects.[27]

One implication of the likely presence of joint, recursive, and interactive effects is that the *incremental* effect attributed to any one variable could be somewhat overestimated or underestimated. Most importantly, the relationship of the program effect with the cumulative effect and with individual context variables, taken together with the order in which the contribution of the variables has been assessed, means that the program effect is likely underestimated. For example, it is very likely that the recursive effect of prior change in market penetration on contemporaneous programs is such that the cumulative effect robs the program variable of some of its incremental effect on market penetration. The same is likely true of context variables as well. These factors suggest that the effect of programs as drivers of market penetration and electricity savings is underestimated in the models presented here.

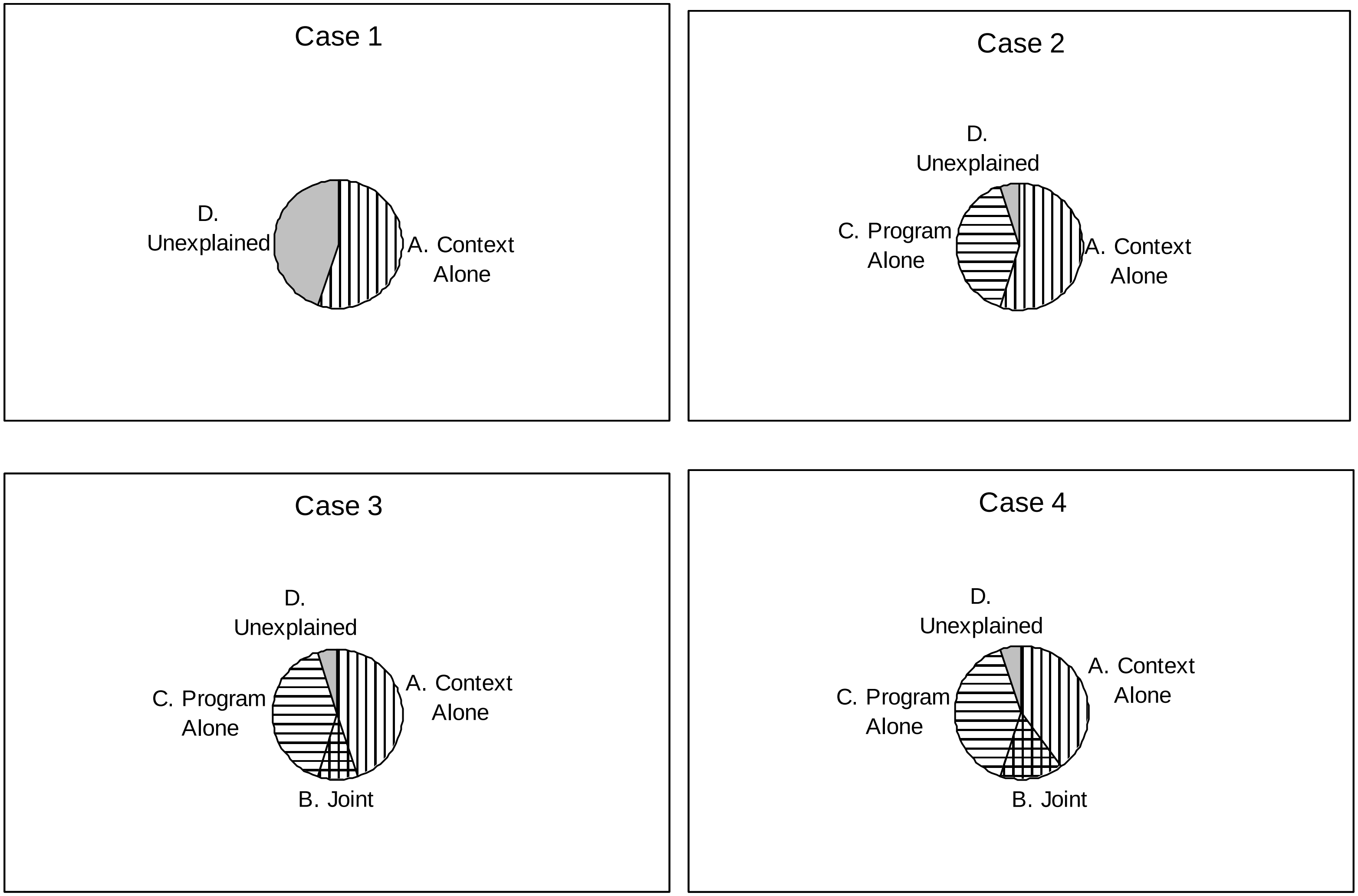
Ideally, we would have access to the appropriate data and have the statistical ability to model each of these joint, recursive, and interacting effects. Such data would allow us to determine the degree to which these models underestimate the program effect and to model more completely the full relationships between market penetration and the predictor variables. Unfortunately, the

[25] Likely recursive effects include the impacts pf past program activity and previous market penetration on ENERGY STAR recognition. As the program operates and more people purchase ENERGY STAR-compliant appliances, more people become aware of the label. This in turn may fuel increases in future market penetration.
[26] Pearson Correlation Coefficients for these relationships are presented in the full matrices in Appendix D. All variables included in the models were subjected to and passed tolerance tests in the regression analysis. Thus, while relationships between some of context variables exist, the relationships are weak enough to be included in a statistically appropriate manner in the same regression models. In other words, they do not violate the assumption that the predictor variables are statistically independent of each other.
[27] In fact, there are also likely joint effects among the context variables. For example, higher electricity prices are a major component of the cost of living. Places with higher costs of living are typically associated with higher income and education levels on average. The electricity price proxy and the income/education composite likely have joint effects that are not differentiated in the models discussed in Chapter 6.

data either do not exist or are unavailable in the needed format (e.g., for all states at the state level). Even if we had all the appropriate data, the small number of cases (48 states) limits the number of variables we can include in any single regression model (due to the small number of degrees of freedom). Therefore, we must accept that the models do not capture these other effects or allow us to better estimate the total effects of contemporaneous programs. As a result, in the models discussed in Chapter 6, we take a conservative approach by assuming that any effects not due to the program variable or to the cumulative effects variable alone are the result of context variables, although this scenario seems highly unlikely for reasons discussed heretofore. The major implication of the conservative approach is that we produce lower-bound estimates of the program effect and of electricity savings. The true electricity savings are likely greater than those that can be determined from the model.[28]

[28] Yet, it should also be remembered that, while the method likely underestimates the program effect, rarely has prior research been able to document so clearly and with statistical precision that a program effect actually exists for market penetration.

**Figure 4.1: Illustration of Explanatory Power of Context Variables and Program Variables**

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# 5. Data Examination and Preliminary Analyses[29]

Before applying more complex statistical procedures such as regression and canonical correlation analyses, we examined the data using simpler techniques that allowed us to identify potential problems with the dataset and gain an idea of the overall relationships among the variables. First, we used simple descriptive statistics (mean, standard deviation, kurtosis, and skewness) to determine the shape and normality of the distributions. Second, we used Pearson correlations to gain an understanding of the relationships among the variables in the data set. Full correlation matrices for all context variables included in the final models are presented in Appendix C. In this chapter, we limit our discussion to relationships between context variables and market penetration and program variables. Finally, we summarize the results of an ANOVA of differences in the rate of change in market penetration for active and inactive states.

## 5.1 Normalizing the Data

As mentioned at the beginning of Chapter 4, appliance promotion programs are not evenly spread across the nation. In fact, we have identified active programs in only 23 of the 48 contiguous United States.[30] The 23 states are listed below:

- California
- Colorado
- Connecticut
- Iowa
- Idaho
- Illinois
- Massachusetts
- Maryland
- Minnesota
- Missouri
- Montana
- New Hampshire
- New Mexico
- Nevada
- New York
- New Jersey[31]
- Oregon
- Rhode Island
- Texas
- Vermont
- Washington
- Wisconsin
- Wyoming

Furthermore, not every program promotes all appliances, provides field support, or markets using all three approaches analyzed for this study. When a state lacks an identifiable program or a certain promotional effort, we gave the state a score of zero for that particular component. For example, Alabama is scored with zeros for all program components for all appliances, as we have not been able to identify active appliance programs in the state. Massachusetts has field

[29] All data analyzed using SPSS Version 12.0. See Appendices C through E for additional analyses and results. Further analyses and results available upon request.

[30] This does not mean that residents of other states to not have access to information about ENERGY STAR-compliant appliances. Information about energy-saving appliances may be available through public service announcements, utilities, manufacturers, retailers, or other sources such as state agencies. However, to the best of our knowledge, these states lack efforts designed exclusively to promote market transformation of the energy-efficient appliances.

[31] New Jersey does not have active appliance promotions at this time, so it lacks specific appliance program variables. However, the state's location, participation in NEEP efforts, and prior program prompted us to have our outside experts give the state a cumulative-effects rating

support and marketing scores for each appliance, but its cash incentive amounts for DW and RF are both zero.

The program data are not normally distributed. At least 25 cases (non-active states) are scored with zeros for each program component. The other 23 cases range from zero (if a particular program component is absent for some appliances or for a particular year [e.g., no programs in Nevada in 2001 or 2002]) to whatever the highest score is for the particular program component. Three context variables—CAC, change in housing units, and CDD—were also not normally distributed.

The lack of normality in the data distributions has important statistical implications. Most statistical analyses assume that the data for each variable are distributed normally. Sometimes, however, the data are skewed, meaning that many cases are bunched at one end of the scale with other cases scattered in the middle and the other end. Some also suffer from kurtosis, meaning the distributions are overly steep. Data with high levels of skew and kurtosis bias predictive models and estimated effects, given the assumptions of those models. The results may misrepresent the relationship between the independent and dependent variables.

To limit the effects of skewness and kurtosis, we turned to a common and highly accepted approach—transforming the data. In most cases, we did this by taking the cubic root of the raw scores. The cubic-root transformation greatly improved (i.e., lowered) the skewness and kurtosis scores of the program variables and of CDD. However, the cubic root transformation did not affect the skew and kurtosis for change in housing and actually worsened them for CAC, so we used the untransformed data for these two variables. (See Table 5.1 for a list of transformed variables).

**Table 5.1: Transformed Variables**

| Variable | Transformation |
|---|---|
| Market penetration | Arcsine root weighted |
| Cash incentives | Cubic root |
| Pre-standardized, non-cash program components | Cubic root |
| Cooling Degree Days | Cubic root |

As noted in Table 5.1, we also transformed the market penetration data. While these data did not generally suffer from skew or high kurtosis scores, they were binary results (i.e., purchased or not purchased an ENERGY STAR-compliant model) reported in the form of proportions. Thus we needed to modify them via the arcsine root transformation (High 2004).[32] This transformation involves taking the square root of the raw penetration data and then computing the arcsine of those data.

[32] As High (2004) explains, had we had original count data—that is the actual number of ENERGY STAR and non-ENERGY STAR purchases by state—we could have used another type of regression model, the logit model.

## 5.2 Pearson Correlations

Pearson correlations are the standard measure of a relationship between two continuous variables. The larger the correlation, the more consistently the indicated pattern is found in the data. So, correlations of .8 mean that most of the cases adhere to the pattern, while those of .3 indicate many more exceptions. The Pearson correlations between the market penetration variables and all independent variables showing statistically significant ($p < .10$) relationships in at least one regression model for at least one year (to be discussed in Chapter 6) are presented in Table 5.2.[33] The full correlation matrices, including non-significant results are included in Appendix D. Importantly, the strong correlations between the market penetration data and many potential explanatory variables suggest that we should be able to explain a great degree of the variation in market penetration using regression analysis, to which we turn next.[34]

[33] Not all variables listed in Table 5.2 were included in *every* regression model presented in Table 6.1 and in Appendix E. We only included a variable in a yearly regression model if it was also significant in the parsimonious models developed for each appliance. Thus, some correlation relationships shown in Table 5.2 are marked as NA in Table 6.1 (e.g., age of householder 45-54 in 2002).

[34]We included the CAC variable in RAC models in addition to those shown. However, this variable was highly collinear with other variables, in particular ENERGY STAR recognition and electricity price. The greater explanatory power of these and other variables led to CAC's exclusion from all final RAC models.

## Table 5.2: Statistically Significant Correlations (p < .10) between Dependent and Independent Variables, by Appliance

| | Clothes Washers (CW) | | | | Room Air Conditioners (RAC) | | | | Refrigerators (RF) | | | | Dishwashers (DW) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Independent Variables[a] | 2001 | 2002 | 2003 | Chng | 2001 | 2002 | 2003 | Chng | 2001 | 2002 | 2003 | Chng | 2001 | 2002 | 2003 | Chng |
| *Program Variables* | | | | | | | | | | | | | | | | |
| Change in Penetration 98-00 | NA | NA | 0.97 | 1.00 | NA | NA | 0.75 | 1.00 | NA | NA | 0.31 | 1.00 | NA | NA | 0.34 | 1.00 |
| Program Support | NA | NA | NA | NA | 0.57 | 0.55 | 0.63 | 0.44 | ----- | 0.62 | 0.71 | 0.44 | ----- | ----- | ----- | ----- |
| Cash Incentive | NA | NA | NA | NA | ----- | 0.26 | 0.45 | 0.32 | 0.32 | ----- | 0.43 | 0.40 | ----- | ----- | ----- | ----- |
| CW Program Support | 0.63 | 0.64 | 0.73 | 0.70 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Context Variables* | | | | | | | | | | | | | | | | |
| Electricity Price Proxy | 0.35 | 0.42 | 0.42 | 0.41 | 0.61 | 0.50 | 0.57 | 0.33 | ----- | 0.67 | 0.68 | ----- | ----- | ----- | ----- | ----- |
| Energy Star Recognition | 0.67 | 0.62 | 0.59 | 0.59 | 0.55 | 0.39 | 0.44 | ----- | ----- | 0.69 | 0.66 | ----- | ----- | ----- | ----- | ----- |
| Composite Income/Education | 0.63 | 0.62 | 0.60 | 0.62 | 0.56 | 0.47 | 0.50 | 0.35 | 0.32 | 0.75 | 0.72 | ----- | ----- | ----- | ----- | -0.26 |
| % Population that is White | 0.44 | 0.42 | 0.50 | 0.39 | 0.38 | 0.51 | 0.47 | 0.45 | -0.43 | ----- | ----- | ----- | -0.59 | -0.65 | -0.37 | -0.35 |
| % Householders Aged 45-54 | 0.47 | 0.46 | 0.54 | 0.46 | 0.41 | 0.55 | 0.48 | 0.36 | ----- | 0.41 | 0.44 | ----- | -0.25 | -0.31 | ----- | ----- |
| % Householders Aged 25-34 | ----- | ----- | ----- | ----- | -0.40 | -0.44 | -0.37 | -0.33 | 0.43 | ----- | ----- | ----- | 0.39 | 0.39 | 0.25 | ----- |
| % Owner Occupied Housing | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | -0.34 | -0.31 | -0.26 | -0.36 | ----- | ----- | ----- | ----- |
| % Population in Urban Areas | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | 0.57 | 0.39 | 0.32 | 0.26 | 0.34 | 0.35 | 0.33 | |
| Change in Housing Units | ----- | ----- | ----- | ----- | -0.46 | -0.42 | -0.31 | -0.34 | 0.49 | ----- | ----- | ----- | 0.32 | 0.29 | ----- | ----- |
| Concentration of Box stores | NA | NA | ----- | ----- | NA | NA | -0.38 | ----- | NA | NA | ----- | ----- | NA | NA | 0.40 | 0.25 |
| Interaction of Precipitation and Drought[b] | -0.46 | -0.49 | -0.45 | -0.47 | NA | NA | NA | NA | NA | NA | NA | NA | 0.45 | 0.48 | ----- | ----- |
| Cooling Degree Days[c] | NA | NA | NA | NA | -0.60 | -0.78 | -0.64 | -0.56 | 0.28 | -0.52 | -0.46 | ----- | NA | NA | NA | NA |

Chng is change in penetration 1998 to 2002, NA = not applicable; ----- is not significant.

[a] Operationalization and data sources discussed in Chapters 3 and 4.

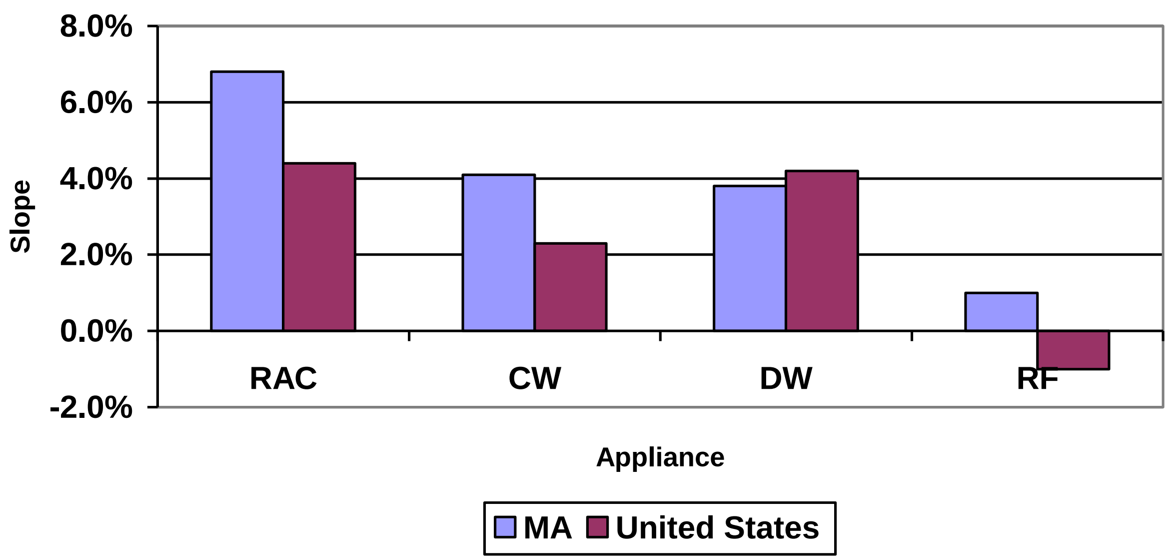
[b] Negative relationship suggests that drier climates with drought conditions have higher penetration levels.

[c] Negative relationship with room air conditioner likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## 5.3 Analysis of Variance of Change in Penetration

As demonstrated in Figure 5.1, the rate of change in market penetration of all ENERGY STAR-compliant appliances increased in Massachusetts from 1998 to 2002. Rates also generally increased nationally, except that RF showed a small decrease.[35] In fact, the increase in market penetration of DW nationally somewhat exceeded that of Massachusetts, likely reflecting the fact that the housing stock in the state tends to be older and is less likely to have DW installed. In contrast, many new houses—more highly concentrated in the South and Southwest—have DW installed.

**Figure 5.1: Rate of Change in Market Penetration, 1998-2002**




[35] This decrease—as well as the small increase in RF penetration in MA—represent the fact that penetration rates, measured as a percentage of total sales, are still recovering from the tightening of ENERGY STAR and federal specifications in late 2000 and early 2001. While the other three appliances also experienced specification changes in the fall of 2000 (for RAC) or in January of 2001 (for CW and DW), some existing models of the other three appliances already met new standards and new models were made available in a timely fashion. The same was not true for RF; manufacturers did not have existing models on the market that met the new standards, leading to a temporary yet large decrease in market penetration

The fact that penetration rates have generally increased across the nation raises the question as to whether ENERGY STAR-appliance programs boost penetration rates, or if the increased penetration rates in active states simply reflect a national trend. We used a relatively simple statistical procedure, ANOVA, to address this question. We divided states into two groups, active and inactive (putting New Jersey in the active group, considering its participation in NEEP and the fact that we had a cumulative-effect rating greater than zero for the state). We then used ANOVA to determine if a statistically significant difference in change in penetration for each appliance existed between these two groups. The results of the ANOVA show that program activity boosts market penetration in the active states. (See Table 5.3) In particular, the mean increase in CW and RAC penetration in the active states is statistically higher than in the inactive states. Furthermore, although both groups of states saw decreases in mean RF penetration, the decreases were significantly smaller in states with active programs. Finally, the change in DW penetration from 1998 to 2002 shows no statistical difference between active and inactive states. Again, as new DW testing procedures are implemented, we may begin to see differences in penetration rates that more closely resemble those for the other three appliances.

**Table 5.3: Change in Penetration Analysis of Variance**

| Appliance | State Activity | n | Mean Slope | F | Sig. |
|---|---|---|---|---|---|
| CW | Active | 23 | 3.6% | 31.7 | .000 |
| | Inactive | 25 | 1.8% | | |
| RAC | Active | 23 | 6.3% | 11.8 | .001 |
| | Inactive | 25 | 3.6% | | |
| RF | Active | 23 | -0.2% | 15.7 | .000 |
| | Inactive | 25 | -1.4% | | |
| DW | Active | 23 | 4.0% | <1.0 | NS[a] |
| | Inactive | 25 | 4.3% | | |

[a] NS=Not Significant

# 6. Regression Analyses and Estimates of Energy Savings

Regression analysis allows us to build models to estimate the energy savings that result directly from appliance programs. In particular, a comparison of model results that omit programs as explanatory factors with programs that include programs estimates their incremental effects on market penetration, which are precursors to estimating program-induced energy savings.

## 6.1 Regression Analysis

In the 2003 MPER, we developed individual models for each appliance in each year. This year, however, we took a slightly different approach. We determine the full set of variables that significantly help to explain market penetration of any of the four target appliances in a given year.[36] We then apply a single model to each appliance for that given year. Therefore, models vary slightly between years but are the same for each appliance within a year.[37] This approach allows for an easier identification of the common factors that drive market penetration of ENERGY STAR-compliant appliances. There is one exception to this general approach. We only include a variable in a given model if it was relevant to that appliance. Therefore, we include the drought/precipitation interaction variable only in the CW and DW models and cooling degree days only in the RAC and RF models.

The resulting models explained between 28% and 97% of the variance in market penetration of the four appliances. (The low was for DW in 2003 without change in penetration in the model; the high, for CW with change in penetration in the model.) Most of the explained variance percentages fell between 60% and 90%, depending on the year and the appliance. The difference between predicted and actual market penetration in Massachusetts ranged from .2% (CW, DW, and RF in various years) to 6.5% (RAC in 2003, using the models that lack the change in penetration variable). In all but one case, the models over-predicted penetration; the one exception was RF in 2002, when the model under-predicted market penetration by .7%. (See Appendix E for detailed results.)

Table 6.1 indicates which independent variables have statistically significant incremental effects on market penetration for each appliance in each year. Furthermore, we present two models for 2003, one that excludes the change in penetration data (measured from 1998-2003) and one that includes it. The results demonstrate that program support leads to increased market penetration especially of CW and RAC and, to a lesser extent, RF. As other analyses have indicated, contemporaneous program support does not contribute significantly to DW market penetration.

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[36] This was accomplished by building more parsimonious models for each appliance. In certain years, some variables (e.g., ENERGY STAR recognition, age of householders 45-54) were not found to be significantly related to market penetration in the parsimonious models for any of the four appliances. They were, therefore, not included in the full model for that year. This is why these variables are marked as not applicable (NA) in some years and not in others.

[37] We build different models for each of the three years for two reasons. First, especially in light of ENERGY STAR and federal specification changes in 2001, the factors driving market penetration could change over the years. Second, and more practically, we do not have access to a sufficient amount of data to conduct time series analyses. More specifically, while we have market penetration data from 1998 to 2003, we do not have access to data on programs, ENERGY STAR recognition, or box store concentration for the same six years. The lack of these data meant that we could not conduct time series analyses.

It is important to note that cash incentives did not explain incremental increase in RAC penetration in any year; RF penetration is explained by cash incentives only in 2001. In contrast, the CW cash incentive is a part of that appliance's program support variable, suggesting that cash incentives do increase CW market penetration, but as part of a comprehensive program effort.

In addition to program support, other important factors contributing to increased market penetration of these three appliances include:

- High electricity prices (as measured by average revenue per kilowatt hour)
- Higher levels of education and income, which are likely surrogates for customer awareness and ability to purchase
- Greater proportions of white residents, which may also relate to awareness and ability to purchase energy-efficient appliances
- Previous increases in market penetration

Furthermore, market penetration of CW, RF, and DW is related to increases in the number of housing units in a state in certain years. Penetration of CW is also greater in places with higher levels of directly measured recognition of the ENERGY STAR label. CW penetration is also higher in drier climates, while DW penetration is higher in wetter climates. The opposite relationship between these two water-using appliances likely reflects the fact that many program sponsors in drier climates highlight the water saving benefits of CW but not necessarily those of DW. In addition, water utilities in drier climates sometimes offer substantial cash rebates for CW that can be used in combination with electric-utility rebates. The same is not true for water utilities' treatment of DW. Finally, other variables fail to demonstrate consistent relationships with market penetration.

## Table 6.1: Independent Variables Significantly Related to Market Penetration in Final Models, by Appliance

| | Clothes Washer | | | | Room Air Conditioner | | | | Refrigerator | | | | Dishwasher | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | | 2001 | 2002 | 2003 | | 2001 | 2002 | 2003 | | 2001 | 2002 | 2003 | |
| **Independent Variables[a]** | | | w/o chng | w/ chng | | | w/o chng | w/ chng | | | w/o chng | w/ chng | | | w/o chng | w/ chng |
| *Program Variables* | | | | | | | | | | | | | | | | |
| Change in Penetration (chng) | NA | NA | NA | **P** | NA | NA | NA | **P** | NA | NA | NA | ----- | NA | NA | NA | **P** |
| Overall Program Support | NA | NA | NA | NA | **P** | **P** | **P** | **P** | ----- | ----- | ----- | **P** | ----- | ----- | ----- | ----- |
| Cash Incentive | NA | NA | NA | NA | ----- | ----- | ----- | ----- | **P** | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| CW Program Support | **P** | **P** | **P** | **P** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Context Variables* | | | | | | | | | | | | | | | | |
| Electricity Price Proxy | ----- | ----- | ----- | ----- | **P** | **P** | **P** | **P** | ----- | **P** | **P** | **P** | ----- | **N** | ----- | ----- |
| Energy Star Recognition | **P** | **P** | **P** | NA | ----- | **N** | ----- | NA | ----- | ----- | ----- | NA | ----- | **P** | ----- | NA |
| Composite Income/Education | **P** | **P** | **P** | **P** | ----- | ----- | **P** | **P** | ----- | **P** | **P** | **P** | ----- | ----- | ----- | ----- |
| % Population that is White | **P** | **P** | **P** | **P** | ----- | ----- | **P** | **P** | ----- | ----- | **P** | ----- | ----- | **N** | ----- | ----- |
| % Householders Aged 45-54 | ----- | NA | NA | NA | ----- | NA | NA | NA | **P** | NA | NA | NA | ----- | NA | NA | NA |
| % Householders Aged 25-34 | ----- | ----- | NA | NA | ----- | **N** | NA | NA | ----- | ----- | NA | NA | ----- | ----- | NA | NA |
| % Owner Occupied Housing | NA | NA | NA | ----- | NA | NA | NA | ----- | NA | NA | NA | ----- | NA | NA | NA | **P** |
| % Population in Urban Areas | ----- | ----- | **N** | **N** | ----- | ----- | ----- | ----- | **P** | ----- | ----- | ----- | ----- | **P** | ----- | **P** |
| Change in Housing Units | ----- | **P** | ----- | NA | ----- | ----- | ----- | NA | **P** | **P** | ----- | NA | **P** | **P** | ----- | NA |
| Concentration of Box stores | NA | NA | ----- | NA | NA | NA | ----- | NA | NA | NA | ----- | NA | NA | NA | ----- | NA |
| Interaction of Precipitation/Drought[b] | **N** | **N** | **N** | NA | NA | NA | NA | NA | NA | NA | NA | NA | **P** | **P** | **P** | NA |
| Cooling Degree Days[c] | NA | NA | NA | NA | **N** | **N** | NA | NA | **P** | **N** | NA | NA | NA | NA | NA | NA |

Chng = Change in Penetration 1998 to 2002; P = Statistically significant positive relationship ($p < .10$), N = Statistically significant negative relationship ($p < .10$), NA = Not applicable, ----- Not significant in the full model (although may be in the more parsimonious models for individual appliances)

[a] Operationalization and data sources discussed in Chapters 3 and 4.

[b] Negative relationship suggests that drier climates with drought conditions have higher penetration levels.

[c] Negative relationship with room air conditioner likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## 6.2 Estimated Electricity Savings

The strength of the results and the statistically significant incremental program effect for CW, RAC, and RF (the last being significant only in the 2003 models with change in penetration) allowed us to estimate electricity savings in Massachusetts resulting from the states' appliance promotion programs. To determine electricity savings, we began by estimating market penetration for each appliance, based on the context variables alone, thus assuming that no programs were in effect. We then estimated the market penetration for each appliance, based on the full regression models, which include the program variables. In other words, we estimated market penetration assuming the program did and did not exist. Finally, we compared the two estimates, thus obtaining a lower-bound estimate of the incremental effect of the sponsors' appliance programs on electricity savings.

Using only information generated by the models appears to severely underestimate the program effect, as discussed earlier in Section 4.4.

- Context variables robbing the program effect of some of its explanatory power
- The inability to model the joint effect of program and context variables
- The inability to take into recursive relationships (or feedback loops)account a number of other factors (e.g., the marketing strategy of a national retailer) that may also be affected by the presence of programs

We used the savings calculators produced by D&R and posted on the ENERGY STAR web site in late 2003 and early 2004 to develop a one-year electricity savings estimate per unit for DW, RF and RAC (D&R 2004a,b,c). D&R has more recently replaced these calculators with others that take new 2004 ENERGY STAR-specifications into account. However, as we are estimating electricity savings that preceded the new specifications, we relied on the previous savings calculators. After developing the one-year savings estimates, we then used the expected lifetime estimates for each appliance found on the U.S. DOE's Federal Energy Management Program's (FEMP) web site (http://www.eere.energy.gov/femp/technologies/eeproducts.cfm, energy-efficiency recommendations links), which are those used by the Massachusetts program sponsors in their filings with regulatory agencies of the Commonwealth of Massachusetts.

For CW savings we took a slightly more complicated approach. The electricity savings for ENERGY STAR-compliant CW are based on what is known as the modified energy factor (MEF), which takes into account not only the amount of energy needed to run the clothes washer and heat the water, but also the energy needed to dry the clothes. A larger MEF signifies a more efficient washer.[38] Yet, homes heat their water and dry their clothes with various combinations of electric and non-electric water heaters and clothes dryers. In Massachusetts, about 78% of homes use electric dryers and 30% use electric water heaters (according to data provided by Angela Li of NGRID and based on surveys NGRID has conducted). Taking various heating/drying fuel source configurations into account adjusts electric savings downward, because the gas utilities

[38] MEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, and the energy required for removal of the remaining moisture in the wash load, D. The higher the value, the more efficient the clothes washer is. The equation is $MEF = C/(M+E+D)$ (http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers).

receive some of the energy savings resulting from qualifying CW. As with the other three appliances, we used the expected lifetime estimates of CW as listed on the U.S. DOE's FEMP web site.

Finally, we were unable to attribute any program-generated electricity savings to RF and DW in the 2001 model or DW in the 2003 model using change in penetration, since the models indicated no significant effect with overall program support. We address this issue further in the Key Findings and Discussion chapter.

The results, presented in Tables 6.2 through 6.4, suggest that the Massachusetts program sponsors collectively saved at least 26,140 MWh in 2001, 29,877 MWh in 2002, and 53,130 MWh in 2003 *from the incremental sales resulting from the program in each year alone*. In each case, more than one-half of the savings are attributable to incremental CW penetration, with the next greatest amount attributable to incremental RAC penetration. The increased electricity savings in 2003, based on the models lacking the change in penetration variable, may be due to the state's participation in the successful DYS and RRR campaigns. These two promotions—which involved large cash incentives during relatively short periods of the year—leveraged the funds of the Massachusetts program sponsors with those of manufacturers, retailers, and the U.S. DOE/ENERGY STAR. It is also worth noting that the savings attributed to RF penetration also increased dramatically in 2003, perhaps because support given to other appliances—in this case CW and RAC—also boosted penetration of other appliances, a hypothesis we test more directly in the next chapter. Again, we stress that these estimates are the *minimum* savings attributable to the 2003 program. These estimates are not meant to stand on their own, and should instead be used in conjunction with those developed through other methods, as we discuss more fully in the 2004 MPER final report.

## Table 6.2: Estimated Lifetime Electricity Savings Resulting from 2001 Program Activities in Massachusetts

| | Estimated Number Sold (Based on RDD Survey)[a] | Estimated ENERGY STAR Units Sold (Model derived) | Non-Program Sales (Model derived) | Program -Induced Sales (Model derived) | Lifetime kWh saved/unit[b] | Lifetime MWh saved overall[c] |
|---|---|---|---|---|---|---|
| CW | 126,954 | 25,224 | 17,995 | 7,229 | 2,484 | 172,957 |
| RAC | 233,089 | 58,758 | 47,432 | 11,326 | 723 | 8,183 |
| **Total Estimated Savings** | | | | | | **26,140** |

[a] Survey of Appliance Shoppers and Purchasers (NMR *et al*. 2003).
[b] One-year CW electricity savings calculated from data provided by the NEEA and U.S. DOE. The CW estimates are based on a modified energy factor of 1.257, adjusted for the proportion of electric water heaters and electric dryers in MA. One-year RAC electricity savings calculated with data provided by D&R on the ENERGY STAR web site, and based on Climate Region 2, which includes Massachusetts. The estimated lifetime of both CW and RAC are those provided by the U.S. DOE's Federal Energy Management Program.
[c] Results subject to rounding error.

## Table 6.3: Estimated Lifetime Electricity Savings Resulting from 2002 Program Activities in Massachusetts

| | Estimated Number Sold (Based on RDD Survey)[a] | Estimated ENERGY STAR Units Sold (Model derived) | Non-Program Sales (Model derived) | Program -Induced Sales (Model derived) | Lifetime kWh saved/unit[b] | Lifetime MWh saved overall[c] |
|---|---|---|---|---|---|---|
| CW | 126,954 | 35,707 | 28,014 | 7,693 | 2,484 | 19,111 |
| RAC | 233,089 | 113,422 | 99,959 | 13,463 | 723 | 9,727 |
| RF | 176,041 | 43,463 | 43,311 | 152 | 1,295 | 197 |
| DW | 80,475 | 28,778 | 28,239 | 539 | 1,544 | 832 |
| **Total Lifetime Electricity Savings (MWh)** | | | | | | **29,877** |

[a] Survey of Appliance Shoppers and Purchasers (NMR *et al*. 2003).
[b] One year CW electricity savings calculated from data provided by the NEEA and U.S. DOE. The CW estimates are based on a modified energy factor of 1.257, adjusted for the proportion of electric water heaters and electric dryers in MA. One year RF, DW, and RAC electricity savings calculated with data provided by D&R on the ENERGY STAR web site. RF electricity savings were adjusted to MA percentages for types of units sold (i.e., as defined by location of freezer, presence of through-the-door ice/water), RAC electricity savings based on Climate Region 2, which includes Massachusetts. The estimated lifetimes of all appliances provided by the U.S. DOE's Federal Energy Management Program.
[c] Results subject to rounding error

**Table 6.4: Estimated Lifetime Electricity Savings Resulting from 2002 Program Activities in Massachusetts Based on Models Lacking Change in Penetration**

| | Estimated Number Sold (Based on RDD Survey)[a] | Estimated ENERGY STAR Units Sold (Model derived) | Non-Program Sales (Model derived) | Program -Induced Sales (Model derived) | Lifetime kWh saved/unit[b] | Lifetime MWh saved overall[c] |
|---|---|---|---|---|---|---|
| CW | 126,954 | 51,813 | 40,594 | 11,219 | 2,484 | 27,870 |
| RAC | 233,089 | 121,578 | 93,757 | 27,821 | 723 | 20,101 |
| RF | 176,041 | 59,265 | 55,470 | 3,795 | 1,295 | 4,915 |
| DW | 80,475 | 47,568 | 47,410 | 158 | 1,544 | 244 |
| **Total Lifetime Electricity Savings (MWh)** | | | | | | **53,130** |

[a] Survey of Appliance Shoppers and Purchasers (NMR *et al*. 2003).

[b] One year CW electricity savings calculated from data provided by the NEEA and U.S. DOE. The CW estimates are based on a modified energy factor of 1.257, adjusted for the proportion of electric water heaters and electric dryers in MA. One year RF, DW, and RAC electricity savings calculated with data provided by D&R on the ENERGY STAR web site. RF electricity savings were adjusted to MA percentages for types of units sold (i.e., as defined by location of freezer, presence of through-the-door ice/water), RAC electricity savings based on Climate Region 2, which includes Massachusetts. The estimated lifetimes of all appliances provided by the U.S. DOE's Federal Energy Management Program.

[c] Results subject to rounding error

The electricity savings estimates presented in Table 6.5 are based on the 2003 regression models that include change in penetration and estimate the electricity savings that can be attributed not only to 2003 program activity but also to the cumulative effects of prior programs on 2003 penetration.[39] In other words, the savings result only from the sale of ENERGY STAR-compliant models in the year 2003. The results in this table are based on slightly different assumptions than those used in the previous tables. As presented in Tables 6.2 through 6.4, we estimated market penetration assuming the program did and did not exist. Here, however, we also had to estimate the impact of prior programs on 2003 market penetration. To do so, in the model that assumed the 2003 program effect did not exist, we also used the national average change in penetration for each appliance to represent the "no prior effect" scenario. As explained in Section 4.3, the use of this variable reflects the fact that penetration has been increasing for all appliances (except RF) at the national level. Thus, we would expect to see some increase in Massachusetts penetration even if programs did not exist. When we then compared the "no program" and "no prior effect" model to the "with program" and "with prior effect" model, we were able to estimate the penetration increases in Massachusetts due both to 2003 program activity and to the prior Massachusetts appliance program activity.

Together, the program and cumulative effects have saved a great deal, accounting for 75,601 new lifetime MWh of electricity saved in 2003 alone. The cumulative effect accounts for 39,715 MWh of the new lifetime savings (Line H in Table 6.5), and the remaining 35,866 MWh can be attributed to 2003 program activity. It is also important to note that the majority of savings resulting from CW is attributable to prior program activity, not 2003 programs. This is to be expected, given the long history of promotions targeted to that appliance. In contrast, 2003 programs are responsible for greater RAC and RF electricity savings, programs with a shorter history of direct promotions. Again, we stress that these estimates of energy savings—both those of the contemporaneous program effect and the cumulative effect are likely to be underestimates.

[39] Because the model used to generate results in Table 6.4 differs from that used in Table 6.5, the estimated ENERGY STAR units sold are also different.

**Table 6.5: Estimated Lifetime Electricity Savings Resulting from Prior Program Activity and 2003 Program Activities in Massachusetts, Based on Change in Penetration Models**

| | CW | RAC | RF | Total Lifetime Electricity Savings (MWh) |
|---|---|---|---|---|
| A. Estimated Number of Appliances Sold (Based on RDD survey)[a] | 126,954 | 233,089 | 176,041 | |
| B. Estimated ENERGY STAR Units Sold (Model derived) | 50,196 | 118,316 | 60,099 | |
| C. Sales Attributable to Prior Program Activity (Model derived) | 13,226 | 10,248 | 500 | |
| D. Sales Attributable to 2003 Program (Model derived) | 5,161 | 21,581 | 5,770 | |
| **E. Total Program Sales (C + D)** | **18,387** | **31,829** | **6,270** | |
| F. Non-Program Sales (B – E) | 31,932 | 86,487 | 53,829 | |
| G. Lifetime kWh saved/unit[b] | 2,484 | 723 | 1,295 | |
| H. Electricity saved (MWh) due to 2003 sales attributable to prior programs (C *x* G) | 32,854 | 6,417 | 443 | 39,715 |
| I. Electricity saved (MWh) due to 2003 sales attributable to 2003 program (D *x* G) | 12,821 | 15,592 | 7,473 | 35,886 |
| **H. Lifetime MWh saved overall due to program-related 2003 sales ([E *x* G/1,000] or [H + I])[c]** | **45,675** | **22,009** | **7,916** | **75,601** |

[a] Survey of Appliance Shoppers and Purchasers (NMR *et al*. 2003).
[b] One year CW electricity savings calculated from data provided by the NEEA and U.S. DOE. The CW estimates are based on a modified energy factor of 1.257, adjusted for the proportion of electric water heaters and electric dryers in MA. One year RF and RAC electricity savings calculated with data provided by D&R on the ENERGY STAR web site and by the DOE's FEMP program. RF electricity savings adjusted to MA percentages for types of units sold (i.e., as defined by location of freezer, presence of through-the-door ice/water), RAC electricity savings based on Climate Region 2, which includes Massachusetts. The estimated lifetimes of all three appliances provided by the U.S. DOE's Federal Energy Management Program.
[c] Results subject to rounding error.

The regression models and estimates of electricity savings, then, clearly show that the Massachusetts appliance-promotion programs have both important contemporaneous effects and striking cumulative impacts on electricity savings. The results also appear to demonstrate the benefits that resulted from Massachusetts's participation in national promotions; with similar or even smaller budgets, the program sponsors were able to boost electricity savings dramatically. However, we cannot say with certainty that this is the case, because the increase in 2003 may also result from the many years of market preparation in Massachusetts. The findings also suggest—as they have before—that support given for one appliance may increase penetration for the others as well, a topic to which we turn in the final set of analyses, using canonical correlation.

## 7. Canonical Correlation Analysis[40]

The analyses conducted for the 2003 MPER strongly suggested implied that programs supporting one appliance—especially CW—may create spillover—additional positive effects on the market penetration of other types of ENERGY STAR-compliant appliances. To explore this suggestion more systematically in this study, we applied canonical correlation analysis, which is a generalization of regression analysis. Regression analysis develops models for using information about several independent variables (here, context variables and program variables) to predict a single dependent variable (here, the market penetration of one appliance). Canonical analysis, in contrast, uses the information about the several independent variables and program variables to predict the behavior of *several* dependent variables. Canonical correlation analysis serves as a tool, then, to help us understand more about the overlapping effects of program components and other context variables on the market penetration of all the appliances under consideration.

The results of the canonical analysis of 2003 market penetrations are presented in Tables 7.1 through 7.3. Overall, they indicate that three canonical variates[41] account for 63.0 percent of the variation in market penetration of all four appliances, across the 48 contiguous states.

[40] For more information on canonical correlation analysis see Levine (1977), Monash University (2004), Thompson (1984), and World of Visual Statistics (2004).
[41] A variate is the linear combination defined by the relationship between a designated set of independent variables and a corresponding set of dependent variables.

Table 7.1 includes the results most important to the issues in this study. The correlation of .995, indicates a very strong relationship between the set of market penetration (dependent) variables and the program and context (independent) variables.[42] It shows that the market penetration levels of CW, RAC, and RF are all part of a single coherent dependent variable that can be identified as a high penetration rate of energy-efficient appliances. Penetration of DW, however, is not part of that coherent dependent variable.

The predictor side of the equation shows that *change* in penetration of CW and RAC, program components and cash incentives (including for DW) are all highly important, as is awareness of the ENERGY STAR label. Thus, the data indicate that considerable spillover occurs across appliances.

In addition, several context variables promote market penetration of these same appliances. The relevant context variables include high average residential electricity prices, a greater proportion of residents reporting their race as white, and having a higher proportion of heads of households in their middle years (45-54 years of age), and with the socioeconomic ability to learn about and purchase the appliances are positively related to high adoption rates.

To reiterate, these results suggest a generalized or cumulative effect of appliance programs and market penetration. Providing program support for one appliance—especially but not only CW—has positive impacts on the market penetration of all of them.

[42] The three canonical correlations in this chapter are significant at the $p<.010$ level. A fourth canonical correlation was not significant ($p > .100$). Bolded results have canonical or cross loadings at .3 or higher, indicating they are relatively strong components of the relevant canonical variates.

## Table 7.1: Canonical Correlation Analysis, First Correlation

| Canonical Correlation = .995 | | |
|---|---|---|
| | Market Penetration | |
| Dependent Variable | Canonical Loadings | Cross Loadings |
| CW Penetration | **.993** | **.988** |
| RAC Penetration | **.890** | **.885** |
| RF Penetration | **.902** | **.897** |
| DW Penetration | -.176 | -.175 |
| | | |
| Predictor Variable | Program/Context | |
| | Canonical Loadings | Cross Loadings |
| CW Change in Penetration | **.975** | **.970** |
| RAC Change in Penetration | **.672** | **.669** |
| RF Change in Penetration | .231 | .230 |
| DW Change in Penetration | **-.405** | **-.403** |
| CW Program Support[a] | **.746** | **.742** |
| RAC cash incentive | **.480** | **.478** |
| RF cash incentive | **.447** | **.445** |
| DW cash incentive | **.448** | **.446** |
| Electricity Price Proxy | **.490** | **.487** |
| Energy Star Recognition | **.610** | **.607** |
| Composite Income/Education | **.635** | **.632** |
| % Population that is White | **.455** | **.453** |
| % Householders Aged 45-54 | **.535** | **.533** |
| % Householders Aged 25-34 | -.196 | -.195 |
| % Owner Occupied Housing | -.130 | -.130 |
| % Population in Urban Areas | .147 | .146 |
| Change in Housing Units | -.079 | -.079 |
| Concentration of Box stores | -.192 | -.191 |

[a] Because the CW program variable includes other forms of program support, we excluded the program support variable from appearing separately in the analysis, to avoid multicollinearity. Conceptually, however, one can consider program support to have an influence through the CW program variable.

The analysis of the 2003 data also yielded two additional significant canonical correlations, presented in Tables 7.2 and 7.3. The second variate explains much of the DW variance, which is not covered in the relationships shown in Table 7.1. Summarized in Table 7.2, it shows that DW penetration is high in states with higher ENERGY STAR awareness, high socioeconomic status (measured by the income/education composite), young householders, a relatively high percentage of urban dwellers, fewer white residents, more new housing, and a greater concentration of box stores. In other words, DW penetration is high in places with greater housing growth and with a young, financially secure, and educated population—likely concentrated in the South and Southwest, regions with larger populations of African American and Latino residents. Residents of states with higher DW penetration know what ENERGY STAR is, even though those states may not generally have active appliance programs or high penetration rates of the other ENERGY STAR-compliant appliances.

### Table 7.2: Canonical Correlation Analysis, Second Correlation

| Canonical Correlation = .914 | | |
|---|---|---|
| | Market Penetration | |
| Dependent Variable | Canonical Loadings | Cross Loadings |
| CW Penetration | -.035 | -.032 |
| RAC Penetration | **-.306** | -.279 |
| RF Penetration | .265 | .242 |
| DW Penetration | **.555** | **.508** |
| | | |
| | Program/Context | |
| Predictor Variable | Canonical Loadings | Cross Loadings |
| CW Change in Penetration | .076 | .070 |
| RAC Change in Penetration | **-.400** | **-.365** |
| RF Change in Penetration | .091 | .083 |
| DW Change in Penetration | .225 | .205 |
| CW Program Support[a] | .126 | .115 |
| RAC cash incentive | .196 | .179 |
| RF cash incentive | .139 | .127 |
| DW cash incentive | .128 | .117 |
| Electricity Price Proxy | .206 | .188 |
| Energy Star Recognition | **.407** | **.372** |
| Composite Income/Education | **.403** | **.368** |
| % Population that is White | **-.602** | **-.551** |
| % Householders Aged 45-54 | -.091 | -.083 |
| % Householders Aged 25-34 | **.406** | **.371** |
| % Owner Occupied Housing | -.232 | -.212 |
| % Population in Urban Areas | **.640** | **.585** |
| Change in Housing Units | **.492** | **.449** |
| Concentration of Box stores | **.679** | **.621** |

[a] Because the CW program variable includes other forms of program support, we excluded the program support variable from appearing separately in the analysis, to avoid multicollinearity.

The third canonical correlation relates to RAC and RF penetration but the cross loading with the predictor side of the model is weak, below the .3 threshold typically used to designate coherence with other variables. On the predictor side, the variate indicates states that have a higher RAC cash incentive, high average residential electricity prices, fewer residents who describe themselves as white, and less new housing. In the cross loadings, however, only the electricity price proxy variable and the change in housing units cohere into a single independent variable. There is, then, an association between RAC and RF penetration on the dependent side and high electricity prices but less new housing on the independent side, over and above the relationships seen in the first canonical variate.

**Table 7.3: Canonical Correlation Analysis, Third Correlation**

| Canonical Correlation = .834 | | |
|---|---|---|
| | Market Penetration | |
| Dependent Variable | Canonical Loadings | Cross Loadings |
| CW Penetration | -.103 | -.086 |
| RAC Penetration | **.338** | .282 |
| RF Penetration | **.335** | .280 |
| DW Penetration | .004 | .004 |
| | | |
| | Program/Context | |
| Predictor Variable | Canonical Loadings | Cross Loadings |
| CW Change in Penetration | -.083 | -.069 |
| RAC Change in Penetration | .179 | .194 |
| RF Change in Penetration | .278 | .231 |
| DW Change in Penetration | -.233 | -.194 |
| CW Program Support[a] | .038 | .032 |
| RAC cash incentive | **.311** | .259 |
| RF cash incentive | .019 | .016 |
| DW cash incentive | **-.322** | -.269 |
| Electricity Price Proxy | **.687** | **.572** |
| Energy Star Recognition | .042 | .035 |
| Composite Income/Education | .197 | .164 |
| % Population that is White | **-.341** | -.284 |
| % Householders Aged 45-54 | -.074 | -.062 |
| % Householders Aged 25-34 | -.278 | -.232 |
| % Owner Occupied Housing | -.296 | -.247 |
| % Population in Urban Areas | .129 | .107 |
| Change in Housing Units | **-.390** | **-.325** |
| Concentration of Box stores | -.072 | -.060 |

[a] Because the CW program variable includes other forms of program support, we excluded the program support variable from appearing separately in the analysis, to avoid multicollinearity.

To summarize, the canonical analysis indicates three independent relationships between the predictors and market penetration of CW, RAC, RF, and DW. First and foremost, the market penetration of CW, RAC, and RF is strongly associated with prior increases in CW and RAC penetration, program variables, and awareness of ENERGY STAR, as well as the socioeconomic ability to learn about and pay for qualifying appliances. Second, market penetration of DW occurs in places where people recognize the ENERGY STAR label, are more likely to live in urban areas, and to have the socioeconomic ability to learn about and pay for the appliances. Finally, there is an association between RAC and RF penetration, on the one hand, and high electricity prices but small increases in new housing, on the other.

## 8. Summary of Findings and Discussion

The current research featured several improvements over last year's effort. The improvements included additional data collection activities (e.g., interviews with program managers and inclusion of programs by water utilities), further specification and identification of variables (e.g., the concentration of box stores in each state and, most important, the creation of an index of the cumulative effect of earlier programs), as well as more sophisticated data analyses. The more sophisticated analyses included examination of cross-program spillover using canonical analysis, and investigation of the momentum effect using both canonical analysis and regression modeling. The resulting efforts have led to several conclusions we consider central to the planning and implementation of future appliance programs, which we reiterate here.[43]

In brief, the research and analyses demonstrate that ENERGY STAR appliance programs, such as that led by the Massachusetts sponsors, have stimulated and are continuing to simulate a very high level of energy savings for residential customers, the utilities and efficiency organizations that serve them, and the nation as a whole. At this time, the programs for several appliances (CW, RAC, and RF) demonstrate considerable synergism. Moreover, these programs appear to be increasing market penetration for the most recent year studied (2003), over and above what would be expected as a result of other factors ("context variables," such as the proportion of urban dwellers in each state and their average socioeconomic status) and the significant momentum effects generated by program activities in prior years.

In the remainder of this section, we provide some additional discussion of these points and several related ancillary findings.

- **Energy savings.** During 2003, the Massachusetts ENERGY STAR Appliance Program—both contemporaneous and previous programs—generated considerable new, incremental kWh savings in the state. The regression models for market penetration in 2003 indicate that the additional ENERGY STAR appliance purchases stimulated by the program were responsible for more than 75,600 MWh of lifetime savings. Parallel analyses suggest that the lifetime savings attributable to the program during the three-year period, 2001-2003, total between 109,147 MWh and 131,618 MWh. We arrived at these results by adding the total electricity saved from Tables 6.2, 6.3, and 6.4 for the lower estimate and 6.2, 6.3, and 6.5 for the higher estimate. Thus, although the program may be reaching maturity with respect to its design and implementation, and while it is beginning to reap the benefits of prior investments, the progressive increase in energy savings estimates from 2001 to 2003 demonstrate that there is no evidence that the program's effectiveness is on the wane.

- **Synergism.** The canonical analysis indicates that the market penetration of most of the appliances supported by the program (RAC, CW, RF) increase in parallel and that these gains can be explained by the same set of drivers. These drivers include a composite of CW program support activities, prior investments in the relevant markets, and cash

[43] A considerable number of findings have been detailed throughout the chapters leading up to this summary. We focus here on those we believe to be of the greatest general interest, without meaning to downplay those other results.

incentives for the individual products involved, as well as customer awareness of the ENERGY STAR brand. Taken together, these results suggest that CW program support and ENERGY STAR promotion create considerable spillover, although appliance-specific efforts are also important. Future planning and implementation efforts would seem advisable to continue to leverage the synergism involved, and to deepen its effectiveness where possible.

- **Effects of prior investments.** Regression modeling of the 2003 market penetration levels for each appliance showed that, although contemporaneous programs made a significant difference, key results were predictable to a significant degree on the basis of earlier changes in those markets. In other words, prior investments and adjustments were still working through those appliance markets.[44] This is not to say that those markets have been fully transformed—as may be seen from the fact that contemporaneous programs were still having an incremental effect. But these findings do indicate that contemporaneous programs are building on the "market preparation" created by earlier efforts.

  - The cumulative effect of earlier refrigerator programs was not statistically significant, however. This finding most likely stems from the continuing impact of the lack of market readiness for the 2001 changes in federal standards and ENERGY STAR specifications for refrigerators and the consequent anomalies in levels of market penetration. Cumulative effects of RF programs seem likely to reappear as relevant activities continue over the coming years, however, given the synergism that has been observed.

  - The effect of 2003 dishwasher programs was also not statistically significant. In large part, this result most likely reflects the prevalence of qualifying models in the market, given the test standards that were in place during the years studied. The relatively ubiquitous, popular qualifying models gained in market share without significant assistance from appliance programs, particularly in regions with high levels of new housing growth.[45] The value of continuing efforts to support qualifying DW models seems likely to depend upon the future availability and pricing of models that meet the new test procedures—which remain to be seen.

- **Program support activities.** Insofar as can be determined, given the relatively narrow range of program designs in use across the U.S. (Wilson-Wright et al. 2004), the various non-cash components of program support (i.e., consumer marketing approaches and field support for retailers) are crucial to the success of efforts to increase the market penetration of qualifying appliances. Cash incentives appear to be important to the CW program, but separate incentives for other appliances seem to have little effect on the market penetration of these other appliances, at least at the levels of incentives offered

[44] This finding is particularly noteworthy, given changes over time in NAECA standards and ENERGY STAR specifications for the relevant appliances. But see the further discussion regarding RF and DW.
[45] Nonetheless, the canonical analysis and the 2002 regression model suggest that awareness of ENERGY STAR may contribute to the market penetration of DW.

and with the program designs used. The allocation of resources among future program activities should take these findings into consideration.

- **Non-program drivers.** The emphasis here is on the effects of contemporaneous and program-related activities and prior program investments. This should not suggest that other factors ("context variables") are unimportant in the market penetration of qualifying appliances. The canonical analysis, in particular, suggests the following drivers:[46]

  - Having a need for energy-efficient appliances, indexed by the age of the householder (those in the range most likely to be purchasing new appliances) and the price of electricity

  - Being aware of relevant information, including the need for and benefits of energy efficiency, as well as ENERGY STAR, indexed by socioeconomic status, which includes an educational attainment component.

  - Having access to the needed capital, indexed socioeconomic status, which also includes an income component, and by race.

  Future programs may be able to take advantage of these drivers through new designs and implementation mechanisms, increasing the market penetration of qualifying appliances and broadening the range of customers who benefit from them.

[46] We recognize that the following list refers to the demographic indicators available for the analysis, but goes beyond the data in suggesting the factors underlying the relevant findings. We invite discussion on other ways of interpreting the relevant findings.

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# APPENDICES

# Appendix A
# Unaided Energy Star Recognition by State, Region, and Division

(All WebTV respondents; percentages weighted by state population)

| Place | Recognition 2001 | | Recognition 2002 | | Recognition 2003 | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| **US** | **1,936** | **18.1** | **1,167** | **21.4** | **2,673** | **24.0** |
| **Northeast** | **351** | **23.0** | **483** | **26.5** | **326** | **27.3** |
| *Mid-Atlantic* | *255* | *18.2* | *159* | *21.2* | *212* | *24.7* |
| NJ | 55 | 23.1 | 37 | 18.2 | 51 | 22.2 |
| NY | 122 | 25.8 | 63 | 32.9 | 88 | 32.1 |
| PA | 78 | 6.1 | 59 | 15.4 | 73 | 17.7 |
| *New England* | *96* | *35.1* | *324* | *36.8* | *114* | *36.1* |
| CT | 28 | 46.5 | 16 | 48.7 | 21 | 34.1 |
| MA | 53 | 33.1 | 289 | 31.1 | 84 | 40.0 |
| ME | NA | NA | NA | NA | NA | NA |
| NH | 9 | 19.3 | 5 | 14.6 | 6 | 33.3 |
| RI | 6 | 15.7 | 14 | 39.7 | 3 | 14.3 |
| VT | NA | NA | NA | NA | NA | NA |
| **Midwest** | **439** | **12.0** | **178** | **19.1** | **1,070** | **14.1** |
| *West No. Central* | *78* | *14.5* | *38* | *12.1* | *587* | *11.5* |
| IA | NA | NA | NA | NA | 226 | 12.5 |
| KS | 7 | 10.8 | 3 | 0 | 3 | 0 |
| MN | 49 | 9.6 | 18 | 21.9 | 345 | 19.2 |
| MO | 22 | 20.2 | 18 | 10.9 | 12 | 4.4 |
| ND | NA | NA | 17 | 0 | NA | NA |
| NE | NA | NA | NA | NA | 1 | 0 |
| SD | NA | NA | NA | NA | NA | NA |
| *East No. Central* | *361* | *11.4* | *140* | *22.3* | *483* | *15.0* |
| IL | 80 | 7.5 | 32 | 36.8 | 332 | 13.8 |
| IN | 43 | 10.2 | 21 | 9.2 | 48 | 4.0 |
| MI | 74 | 7.8 | 28 | 9.2 | 32 | 20.3 |
| OH | 101 | 10.0 | 40 | 22.5 | 47 | 9.5 |
| WI | 63 | 27.5 | 19 | 29.0 | 24 | 43.2 |

# Appendix A
# Unaided Energy Star Recognition by State, Region, and Division, cont.

| Place | Recognition 2001 | | Recognition 2002 | | Recognition 2003 | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| **US** | **1,936** | **18.1** | **1,167** | **21.4** | **2,673** | **24.0** |
| **South** | **503** | **11.9** | **300** | **12.4** | **441** | **17.9** |
| *West So. Central* | *137* | *13.5* | *60* | *4.2* | *116* | *18.7* |
| AR | 5 | 0 | 13 | 0 | 17 | 16.7 |
| LA | 8 | 11.8 | 12 | 0 | 19 | 15.6 |
| OK | 13 | 4.5 | 13 | 0 | 18 | 0 |
| TX | 111 | 16.3 | 22 | 9.4 | 62 | 23.5 |
| *South Atlantic* | *302* | *11.4* | *177* | *13.5* | *271* | *18.6* |
| DE | 1 | 0 | 1 | 0 | 5 | 20.0 |
| FL | 169 | 9.4 | 59 | 18.6 | 109 | 15.3 |
| GA | 36 | 8.1 | 28 | 13.9 | 36 | 19.1 |
| MD | 16 | 21.0 | 13 | 23.9 | 20 | 23.5 |
| NC | 49 | 14.2 | 48 | 7.5 | 59 | 17.7 |
| SC | 9 | 9.0 | 7 | 0 | 16 | 15.8 |
| VA | 16 | 8.8 | 21 | 6.8 | 24 | 25.5 |
| WV | 4 | 26.3 | NA | NA | 2 | 25.0 |
| *East So. Central* | *64* | *11.0* | *63* | *19.3* | *54* | *14.0* |
| AL | 24 | 5.2 | 16 | 22.5 | 14 | 14.3 |
| KY | 11 | 15.3 | 17 | 23.3 | 11 | 15.6 |
| MS | 1 | 0 | 1 | 0 | NA | NA |
| TN | 28 | 13.6 | 29 | 13.0 | 29 | 12.7 |
| **West** | **643** | **22.2** | **206** | **28.5** | **836** | **35.8** |
| *Pacific* | *515* | *26.3* | *148* | *32.9* | *648* | *41.7* |
| AK | NA | NA | NA | NA | NA | NA |
| CA | 496 | 26.2 | 119 | 34.5 | 170 | 43.3 |
| HI | NA | NA | NA | NA | NA | NA |
| OR | 7 | 55.3 | 13 | 13.3 | 167 | 35.2 |
| WA | 12 | 21.0 | 16 | 42.4 | 311 | 39.8 |
| *Mountain* | *128* | *11.6* | *58* | *19.8* | *188* | *20.5* |
| AZ | 34 | 13.8 | 18 | 17.2 | 18 | 15.9 |
| CO | 33 | 17.9 | 14 | 20.5 | 14 | 22.4 |
| ID | NA | NA | NA | NA | 65 | 35.0 |
| MT | NA | NA | NA | NA | 57 | 35.7 |
| NM | 15 | 13.3 | 14 | 19.4 | 15 | 15.0 |
| NV | 19 | 8.2 | 6 | 9.1 | 12 | 12.5 |
| UT | 27 | 3.2 | 5 | 23.2 | 6 | 18.2 |
| WY | NA | NA | 1 | 100 | 1 | 0 |

# Appendix B
# Program Sponsors Included in Study

**California (25)**
Alameda County Water District
Bay Area Water Supply and Conservation Agency
City of Anaheim
City of Davis
City of Millbrae
City of Lompoc
City of Palo Alto
Contra Costa Water District
East Bay Municipal Utilities District
Los Angeles Department of Water and Power
Marin Municipal Water Agency
Metropolitan Water District
Pacific Gas and Electric
Riverside Public Utilities-Electric
Riverside Public Utilities-Water
Sacramento Municipal Utilities District
San Diego County Water Authority
San Diego Gas and Electric
Santa Clara Valley Water District
Sonoma County Water District
Sierra Pacific Power (for Lake Tahoe Region, although a NV-based utility)
Silicon Valley Power
Southern California Edison
Southern California Gas
Zone 7 Water District

**Colorado (3)**
City of Boulder
Denver Water
City of Fort Collins

NB: Xcel Energy also operates in Colorado, but research indicated that they do not sponsor energy-efficiency programs in the state.

**Connecticut (2)**
Connecticut Light and Power
United Illuminating

**Iowa (4)**
Indianola Municipal
Interstate Power and Light
Muscatine Power and Water
Waverly Power and Light

**Idaho (10)**
Avista Power
City of Plummer
Clearwater Power
Fall River Electric Co-op
Idaho County Light and Power
Idaho Falls Power
Kootenai Electric Co-op
Northern Lights, Inc.
Riverside Electric Co-op
United Electric Co-op

**Illinois (2)**
Commonwealth Edison
Statewide refrigerator promotion coordinated by MEEA

**Massachusetts (5)**
Cape Light
National Grid
NSTAR
Unitil/Fitchburg Gas and Electric
WMECO

**Maryland (1)**
State of Maryland

**Minnesota (4)**
Instate Power and Light
Minnesota Power Company
Southern Minnesota Municipal Power Agency
Xcel Energy

**Missouri (1)**
AmerenUE

**Montana (5)**
Flathead Electric
Glacier Electric Co-op
Lincoln Electric Co-op
Mission Valley Power
Northwestern Energy

**New Hampshire (5)**
Granite State Electric
Unitil
Public Service of New Hampshire
New Hampshire Electric Co-op
Connecticut Valley Power

**New Mexico (1)**
City of Albuquerque

**Nevada (2)**
Nevada Power
Sierra Pacific Power

**New York (2)**
Long Island Power Authority
New York State Energy Research and Development Authority

**Oregon (32)**
Blachly-Lane Electric Co-op
Central Electric Co-op
City of Ashland
City of Bandon
City of Forest Grove
City of Hillsboro
City on Monmouth Power and Light
City of Tigard
Clackamas River Water
Clatskanie Public Utilities District
Columbia River Public Utilities District
Consumer Power, Inc.
Corvallis Public Works
Douglas Electric Co-op
Emerald Public Utilities District
Eugene Water and Electric Board
Hermiston Electric
Hood River Electric Co-op
Lane Electric Co-op
McMinnville Water and Light
Midstate Electric Co-op
Milton-Freewater Light and Power
Pacific Power
Portland Gas and Electric
Oregon Office of Energy
Salem Electric
Springfield Utility Board
Tillamook Public Utilities District
Tualatin Valley Water District
Umatilla Electric Co-op
Wasco County Public Utilities District
West Oregon Electric Co-op

**Rhode Island (1)**
Narragansett Electric

**Texas (3)**
Austin Energy
City of Austin
San Antonio Water System

**Vermont (1)**
Efficiency Vermont

**Washington (50)**
Avista Power
Benton Public Utilities District
Benton Rural Electric Association
Big Bend Electric Co-op
Chelan County Public Utilities District
City of Cheney
City of Chewelah
City of Ellensburg
City of Issaquah Conservation
City of Kent Water Utility
City of Richland
City of Sumas
Clallam County Public Utilities District
Clark County Public Utilities District
Covington Water District
Cowlitz County Public Utilities District
Cross Valley Water District
Ferry County Public Utilities District
Franklin County Public Utilities District
Grant County Public Utilities District
Grays Harbor Public Utilities District
Inland Power and Light
King County Water District 111
Klickitat County Public Utilities District
Kootenai Electric Co-op from Idaho
Lewis County Public Utilities District
LOTT Partnership
Mason Co. Public Utilities District #1
Mason County Public Utilities District #3
Modern Electric Water Company
Nespelem Valley Electric
Northeast Sammish Sewer
Okanagon County Electric Co-op
Okanagon County Public Utilities District
Orcas Power and Light
Pacific County Public Utilities District #2
Pend Oreille County Public Utilities District
Port Angeles City Light
Puget Sound Energy
Sammamish Plateau Water and Sewer
Seattle City Light
Seattle Public Utilities
Skamania County Public Utilities District
Snohomish Public Utilities District 1-electric
Snohomish Public Utilities District 1-water

**Washington, Continued**
Tacoma Power
Tanner Electric
Town of Coulee Dam
Wahkiakum County Public Utilities District
WashWise Program (Some participating utilities [e.g. Seattle City Light] also listed separately because of individual programs that preceded the WashWise effort)

**Wisconsin (1)**
Wisconsin Energy Conservation Corporation/Focus on Energy

**Wyoming (1)**
Lower Valley Energy

# Appendix C
# Results of Homogeneity Tests

To assess the homogeneity of the program components and the degree to which each should be considered integral to the overall program support variable, we applied statistical tests of the coherence among them. The components of the program support variable include field support, marketing approaches, and the cumulative effects rating. In addition, the CW program support variable in 2003 also includes the DYS campaign.

The first outcome of these tests is found in Table C.1, which shows the degree to which each set of components defines a single coherent program variable for each appliance in each of the years studied. The statistic reported (Cronbach's alpha) normally ranges from 0 to 1.00, and standard texts suggest that a result of 0.70 is an acceptable demonstration of coherence. The scores for the *potential* composite variables never fall below 0.94. The highest alphas are always associated with the program support plus the CW cash incentive, which is tied with overall program support lacking cash incentives in 2001. The high alphas for program support plus any cash incentive also suggest the appropriateness of combining all program components into one variable.

**Table C.1: Cronbach's Alpha by Appliance and Year**

| Program Elements Included | 2001 | 2002 | 2003 |
|---|---|---|---|
| Program Support (no Cash Incentives) | .97 | .97 | .97 |
| Program Support plus CW Cash Incentive | .97 | .98 | .99 |
| Program Support plus RAC Cash Incentive | .94 | .95 | .97 |
| Program Support plus RF Cash Incentive | .94 | .95 | .97 |
| Program Support plus DW Cash Incentive | .94 | .95 | .96 |

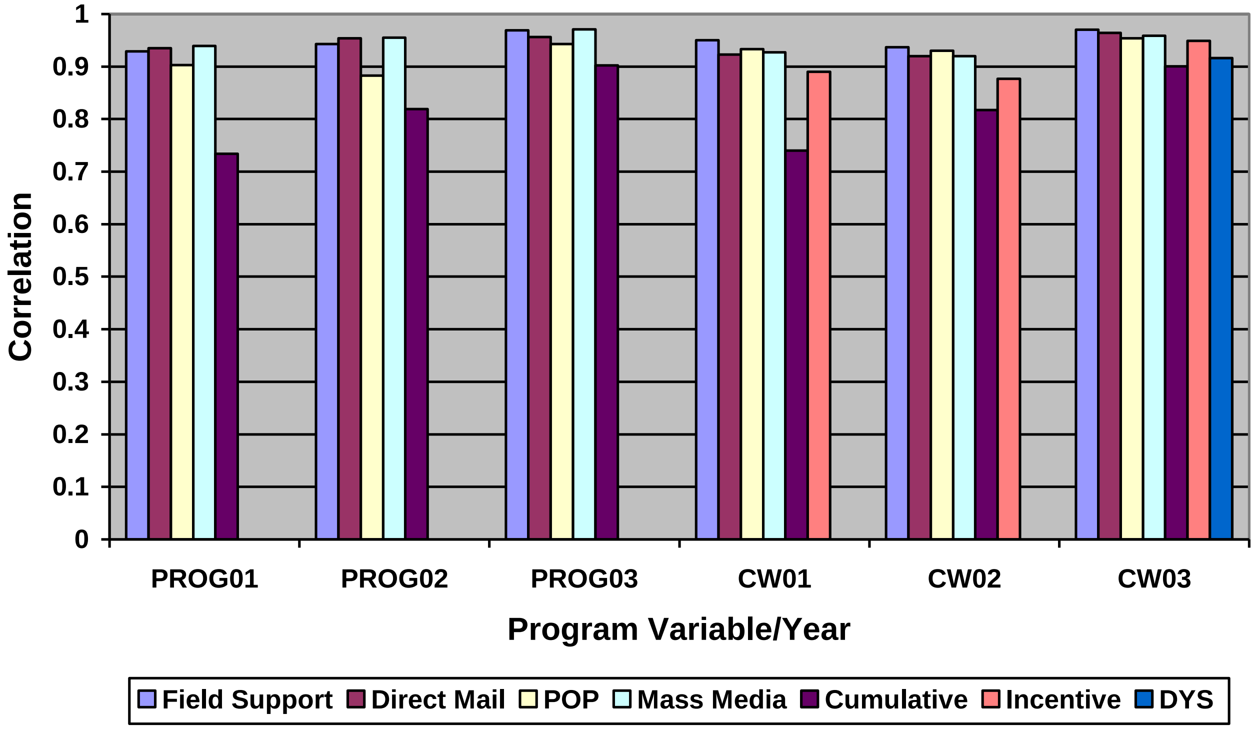
However, we recognize that the Massachusetts program sponsors would like, if at all possible, to ascertain the unique contribution of cash incentives and other types of program support to market penetration of ENERGY STAR-compliant appliances. While the results in Table C.1 demonstrate that the cash incentives for all four appliances are homogenous with other forms of program support, the results in Table C.2 indicate that the cash incentive is the least weakest contributor to the homogeneity of the program components for RAC, RF, and DW, in that the alpha coefficient remains high—or increases—when the cash incentive is removed from the composite. This finding legitimizes removing the RAC, RF, and DW cash incentives from the overall program support variable, allowing us to test for the incremental effect of cash incentives for these appliances separately from those of overall program support. For CW, however, the cash incentive remains a vital component of program support. Therefore, we must leave the CW cash incentive with the program support variable and will not be able to test the incremental effect of the cash incentive on market penetration.

**Table C.2: Cronbach's Alpha if Each Item is Deleted**

| | CW | | | RAC | | | RF | | | DW | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Program Component | 2001 | 2002 | 2003 | 2001 | 2002 | 2003 | 2001 | 2002 | 2003 | 2001 | 2002 | 2003 |
| Field Support | .96 | .97 | .98 | .91 | .93 | .96 | .91 | .93 | .95 | .91 | .93 | .94 |
| Direct Mail | .96 | .97 | .98 | .91 | .93 | .96 | .91 | .93 | .95 | .92 | .94 | .95 |
| In Store | .96 | .97 | .99 | .91 | .93 | .96 | .91 | .94 | .95 | .92 | .94 | .95 |
| Mass Media | .96 | .97 | .98 | .91 | .93 | .96 | .91 | .93 | .95 | .92 | .94 | .95 |
| Cumulative Effect | .98 | .98 | .99 | .93 | .94 | .96 | .94 | .95 | .96 | .94 | .95 | .96 |
| Cash Incentive | .97 | .97 | .99 | .97 | .97 | .98 | .97 | .97 | .98 | .97 | .97 | .98 |
| DYS (2003 CW only) | NA | NA | .99 | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Given that the components are indeed coherently related to one another, it may then be asked whether any one or any subset can be identified as the quintessential indicator of the underlying concept, or—conversely—whether one or more could be eliminated without reducing the measurement power of the composite. The degree to which each of the individual components is a quintessential part of the overall program support index can be assessed through a study of the correlation between that component and the index formed by the remaining elements. Figure C.1 shows those correlations for the overall program support variable and for the CW program variable for each of the years studied. As can be seen, the field support and marketing variables are the components most closely related to the index formed by the other components. Among the CW program variables, field support is the most strongly related to the index. In all cases, the cumulative-effect rating displays the weakest relationship with the index, but its coherence with the index steadily increases over time. Based on these results, then, we believe that no individual component could be eliminated without reducing some of the measurement power of the composite.

**Figure C.1: Corrected Item Total Correlations**



# Appendix D
# Full Correlation Matrices

In all tables in Appendix D, bolded correlations are significant at $p \leq .10$ or better.

## Table D.1: Static Variables (Do not change across appliances or time)

| | Income/ Education | White | Householders 45-54 | Householders 25-34 | Owner-Occupied | Urban |
|---|---|---|---|---|---|---|
| % Population that is White | -0.05 | 1.00 | | | | |
| % Householders 45-54 | **0.36** | **0.27** | 1.00 | | | |
| % Householders 25-34 | 0.06 | **-0.40** | **-0.51** | 1.00 | | |
| % Owner-Occupied Housing | **-0.26** | **0.38** | 0.06 | **-0.24** | 1.00 | |
| % Population in Urban Areas | **0.57** | **-0.40** | -0.20 | **0.41** | **-0.52** | 1.00 |
| Change in Housing Units | -0.06 | -0.22 | **-0.37** | **0.66** | -0.02 | 0.23 |

## Table D.2: 2001 CW Correlation Matrix

| | CW Penetration | CW Program | Electricity Price Proxy | ENERGY STAR Recognition | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|
| CW Program | **0.63** | 1.00 | | | |
| Electricity Price Proxy | **0.35** | **0.50** | 1.00 | | |
| ENERGY STAR Recognition | **0.67** | **0.63** | **0.55** | 1.00 | |
| Composite Income/Education | **0.63** | **0.48** | **0.52** | **0.47** | -0.07 |
| % Population that is White | **0.44** | 0.02 | -0.09 | **0.26** | -0.30 |
| % Householders 45-54 | **0.47** | **0.35** | 0.22 | **0.45** | -0.03 |
| % Householders 25-34 | -0.08 | -0.11 | -0.22 | -0.18 | -0.22 |
| % Owner-Occupied Housing | -0.16 | **-0.49** | **-0.45** | -0.19 | 0.05 |
| % Population in Urban Areas | 0.22 | **0.32** | **0.25** | 0.15 | -0.11 |
| Change in Housing Units | -0.03 | **-0.26** | **-0.26** | -0.19 | -0.41 |
| Interaction of Precipitation and Drought[a] | **-0.46** | -0.05 | 0.17 | 0.00 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

## Table D.3: 2001 RAC Correlation Matrix

| | RAC Penetration | Overall Program Support | AC Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Cooling Degree Days |
|---|---|---|---|---|---|---|
| Overall Program Support | **0.57** | 1.00 | | | | |
| AC Cash Incentive | 0.14 | **0.43** | 1.00 | | | |
| Electricity Price Proxy | **0.61** | **0.51** | **0.32** | 1.00 | | |
| ENERGY STAR Recognition | **0.55** | **0.63** | 0.12 | **0.55** | 1.00 | |
| Composite Income/Education | **0.56** | **0.48** | **0.29** | **0.52** | **0.47** | **-0.40** |
| % Population that is White | **0.38** | 0.03 | **-0.35** | -0.09 | **0.26** | **-0.57** |
| % Householders 45-54 | **0.41** | **0.35** | 0.17 | 0.22 | **0.45** | **-0.68** |
| % Householders 25-34 | **-0.40** | -0.12 | 0.12 | -0.22 | -0.18 | **0.29** |
| % Owner-Occupied Housing | -0.20 | **-0.48** | **-0.60** | **-0.45** | -0.19 | -0.05 |
| % Population in Urban Areas | 0.13 | **0.31** | **0.34** | **0.25** | 0.15 | 0.16 |
| Change in Housing Units | **-0.46** | **-0.26** | -0.14 | **-0.26** | -0.19 | **0.41** |
| Cooling Degree Days[a] | **-0.60** | **-0.44** | -0.11 | -0.17 | **-0.63** | 1.00 |

[a] Negative relationship likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## Table D.4: 2001 RF Correlation Matrix

| | RF Penetration | Overall Program Support | RF Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Cooling Degree Days |
|---|---|---|---|---|---|---|
| Overall Program Support | 0.17 | 1.00 | | | | |
| RF Cash Incentive | **0.32** | **0.45** | 1.00 | | | |
| Electricity Price Proxy | 0.19 | **0.51** | 0.01 | 1.00 | | |
| ENERGY STAR Recognition | 0.09 | **0.63** | 0.24 | **0.55** | 1.00 | |
| Composite Income/Education | **0.32** | **0.48** | 0.18 | **0.52** | **0.47** | **-0.40** |
| % Population that is White | **-0.43** | 0.03 | -0.12 | -0.09 | **0.26** | **-0.57** |
| % Householders 45-54 | -0.07 | **0.35** | 0.18 | 0.22 | **0.45** | **-0.68** |
| % Householders 25-34 | **0.43** | -0.12 | 0.08 | -0.22 | -0.18 | **0.29** |
| % Owner-Occupied Housing | **-0.34** | **-0.48** | **-0.31** | **-0.45** | -0.19 | -0.05 |
| % Population in Urban Areas | **0.57** | **0.31** | 0.21 | **0.25** | 0.15 | 0.16 |
| Change in Housing Units | **0.49** | **-0.26** | -0.05 | **-0.26** | -0.19 | **0.41** |
| Cooling Degree Days | **0.28** | **-0.44** | -0.22 | -0.17 | **-0.63** | 1.00 |

## Table D.5: 2001 DW Correlation Matrix

| | DW Penetration | Overall Program Support | DW Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|---|
| Overall Program Support | -0.04 | 1.00 | | | | |
| DW Cash Incentive | 0.11 | **0.50** | 1.00 | | | |
| Electricity Price Proxy | 0.07 | **0.51** | -0.04 | 1.00 | | |
| ENERGY STAR Recognition | -0.06 | **0.63** | **0.32** | **0.55** | 1.00 | |
| Composite Income/Education | 0.04 | **0.48** | 0.08 | **0.52** | **0.47** | -0.07 |
| % Population that is White | **-0.59** | 0.03 | 0.01 | -0.09 | **0.26** | **-0.30** |
| % Householders 45-54 | **-0.25** | **0.35** | 0.15 | 0.22 | **0.45** | -0.03 |
| % Householders 25-34 | **0.39** | -0.12 | 0.09 | -0.22 | -0.18 | -0.22 |
| % Owner-Occupied Housing | -0.23 | **-0.48** | **-0.32** | **-0.45** | -0.19 | 0.05 |
| % Population in Urban Areas | **0.34** | **0.31** | 0.16 | **0.25** | 0.15 | -0.11 |
| Change in Housing Units | **0.32** | **-0.26** | -0.03 | **-0.26** | -0.19 | **-0.41** |
| Interaction of Precipitation and Drought[a] | **0.45** | -0.07 | -0.11 | 0.17 | 0.00 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

## Table D.6: 2002 CW Correlation Matrix

| | CW Penetration | CW Program | Electricity Price Proxy | ENERGY STAR Recognition | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|
| CW Program | **0.64** | 1.00 | | | |
| Electricity Price Proxy | **0.42** | **0.45** | 1.00 | | |
| ENERGY STAR Recognition | **0.62** | **0.65** | **0.61** | 1.00 | |
| Composite Income/Education | **0.62** | **0.51** | **0.53** | **0.48** | -0.07 |
| % Population that is White | **0.42** | 0.04 | -0.06 | 0.05 | **-0.30** |
| % Householders 45-54 | **0.46** | **0.40** | **0.28** | **0.40** | -0.03 |
| % Householders 25-34 | -0.07 | -0.09 | -0.23 | -0.11 | -0.22 |
| % Owner-Occupied Housing | -0.14 | **-0.44** | **-0.42** | **-0.41** | 0.05 |
| % Population in Urban Areas | 0.23 | **0.33** | 0.22 | 0.24 | -0.11 |
| Change in Housing Units | 0.03 | **-0.24** | -0.22 | -0.16 | **-0.41** |
| Interaction of Precipitation and Drought[a] | **-0.49** | -0.13 | 0.09 | 0.00 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

## Table D.7: 2002 RAC Correlation Matrix

| | RAC Penetration | Overall Program Support | AC Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Cooling Degree Days |
|---|---|---|---|---|---|---|
| Overall Program Support | **0.55** | 1.00 | | | | |
| AC Cash Incentive | **0.26** | **0.52** | 1.00 | | | |
| Electricity Price Proxy | **0.50** | **0.46** | **0.36** | 1.00 | | |
| ENERGY STAR Recognition | **0.39** | **0.63** | **0.32** | **0.61** | 1.00 | |
| Composite Income/Education | **0.47** | **0.52** | **0.43** | **0.53** | **0.48** | **-0.40** |
| % Population that is White | **0.51** | 0.05 | -0.24 | -0.06 | 0.05 | **-0.59** |
| % Householders 45-54 | **0.55** | **0.39** | **0.28** | **0.28** | **0.40** | **-0.65** |
| % Householders 25-34 | **-0.44** | -0.09 | -0.02 | -0.23 | -0.11 | **0.26** |
| % Owner-Occupied Housing | -0.09 | **-0.43** | **-0.39** | **-0.42** | **-0.41** | -0.01 |
| % Population in Urban Areas | -0.06 | **0.33** | **0.33** | 0.22 | 0.24 | 0.14 |
| Change in Housing Units | **-0.42** | **-0.24** | -0.20 | -0.22 | -0.16 | **0.38** |
| Cooling Degree Days[a] | **-0.78** | **-0.53** | -0.20 | **-0.25** | **-0.50** | 1.00 |

[a] Negative relationship likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## Table D.8: 2002 RF Correlation Matrix

| | RF Penetration | Overall Program Support | RF Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Cooling Degree Days |
|---|---|---|---|---|---|---|
| Overall Program Support | **0.62** | 1.00 | | | | |
| RF Cash Incentive | **0.39** | **0.59** | 1.00 | | | |
| Electricity Price Proxy | **0.67** | **0.46** | 0.06 | 1.00 | | |
| ENERGY STAR Recognition | **0.69** | **0.63** | 0.24 | **0.61** | 1.00 | |
| Composite Income/Education | **0.75** | **0.52** | **0.36** | **0.53** | **0.48** | **-0.40** |
| % Population that is White | 0.05 | 0.05 | -0.04 | -0.06 | 0.05 | **-0.59** |
| % Householders 45-54 | **0.41** | **0.39** | **0.30** | **0.28** | **0.40** | **-0.65** |
| % Householders 25-34 | -0.06 | -0.09 | -0.03 | -0.23 | -0.11 | **0.26** |
| % Owner-Occupied Housing | **-0.31** | **-0.43** | -0.12 | **-0.42** | **-0.41** | -0.01 |
| % Population in Urban Areas | **0.39** | **0.33** | **0.25** | 0.22 | 0.24 | 0.14 |
| Change in Housing Units | -0.02 | **-0.24** | -0.15 | -0.22 | -0.16 | **0.38** |
| Cooling Degree Days | **-0.52** | **-0.53** | **-0.33** | **-0.25** | **-0.50** | 1.00 |

## Table D.9: 2002 DW Correlation Matrix

| | DW Penetration | Overall Program Support | DW Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|---|
| Overall Program Support | -0.12 | 1.00 | | | | |
| DW Cash Incentive | -0.08 | **0.61** | 1.00 | | | |
| Electricity Price Proxy | -0.10 | **0.46** | 0.10 | 1.00 | | |
| ENERGY STAR Recognition | 0.02 | **0.63** | **0.50** | **0.61** | 1.00 | |
| Composite Income/Education | -0.04 | **0.52** | 0.17 | **0.53** | **0.48** | -0.07 |
| % Population that is White | **-0.65** | 0.05 | 0.07 | -0.06 | 0.05 | **-0.30** |
| % Householders 45-54 | **-0.31** | **0.39** | **0.28** | **0.28** | **0.40** | -0.03 |
| % Householders 25-34 | **0.39** | -0.09 | -0.05 | -0.23 | -0.11 | -0.22 |
| % Owner-Occupied Housing | -0.18 | **-0.43** | **-0.27** | **-0.42** | **-0.41** | 0.05 |
| % Population in Urban Areas | **0.35** | **0.33** | 0.18 | 0.22 | 0.24 | -0.11 |
| Change in Housing Units | **0.29** | **-0.24** | -0.12 | -0.22 | -0.16 | **-0.41** |
| Interaction of Precipitation and Drought[a] | **0.48** | -0.13 | -0.18 | 0.09 | 0.00 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

## Table D.10: 2003 CW Correlation Matrix

| | CW Penetration | Change in CW Penetration | CW Program | Electricity Price Proxy | ENERGY STAR Recognition | Box stores | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|---|---|
| Change in CW Penetration | **0.97** | 1.00 | | | | | |
| CW Program | **0.73** | **0.70** | 1.00 | | | | |
| Electricity Price Proxy | **0.42** | **0.41** | **0.45** | 1.00 | | | |
| ENERGY STAR Recognition | **0.59** | **0.59** | **0.62** | **0.59** | 1.00 | | |
| Composite Income/Education | **0.60** | **0.62** | **0.48** | **0.51** | **0.48** | 0.19 | -0.07 |
| % Population that is White | **0.50** | **0.39** | 0.15 | -0.06 | 0.05 | **-0.50** | **-0.30** |
| % Householders 45-54 | **0.54** | **0.46** | **0.44** | **0.28** | **0.40** | **-0.28** | -0.03 |
| % Householders 25-34 | -0.18 | -0.07 | -0.11 | **-0.25** | -0.11 | **0.54** | -0.22 |
| % Owner-Occupied Housing | -0.10 | -0.17 | **-0.44** | **-0.42** | **-0.41** | 0.01 | 0.05 |
| % Population in Urban Areas | 0.11 | 0.22 | **0.28** | 0.21 | 0.24 | **0.41** | -0.11 |
| Change in Housing Units | -0.06 | 0.03 | -0.11 | **-0.26** | -0.16 | **0.55** | **-0.41** |
| Concentration of Box stores | -0.21 | -0.10 | -0.16 | -0.06 | -0.10 | 1.00 | 0.02 |
| Interaction of Precipitation and Drought[a] | **-0.45** | **-0.47** | **-0.24** | 0.16 | 0.00 | 0.02 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

## Table D.11: 2003 RAC Correlation Matrix

| | RAC Penetration | Change in RAC Penetration | Overall Program Support | AC Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Box stores | Cooling Degree Days |
|---|---|---|---|---|---|---|---|---|
| Change in RAC Penetration | **0.75** | 1.00 | | | | | | |
| Overall Program Support | **0.63** | **0.44** | 1.00 | | | | | |
| AC Cash Incentive | **0.45** | **0.32** | **0.67** | 1.00 | | | | |
| Electricity Price Proxy | **0.57** | **0.33** | **0.45** | **0.49** | 1.00 | | | |
| ENERGY STAR Recognition | **0.44** | 0.24 | **0.61** | **0.49** | **0.59** | 1.00 | | |
| Composite Income/Education | **0.50** | **0.35** | **0.48** | **0.55** | **0.51** | **0.48** | 0.19 | **-0.39** |
| % Population that is White | **0.47** | **0.45** | 0.14 | -0.12 | -0.06 | 0.05 | **-0.50** | **-0.60** |
| % Householders 45-54 | **0.48** | **0.36** | **0.43** | **0.31** | **0.28** | **0.40** | **-0.28** | **-0.66** |
| % Householders 25-34 | **-0.37** | **-0.33** | -0.10 | -0.08 | **-0.25** | -0.11 | **0.54** | **0.32** |
| % Owner-Occupied Housing | -0.14 | -0.13 | **-0.42** | **-0.44** | **-0.42** | **-0.41** | 0.01 | -0.09 |
| % Population in Urban Areas | -0.01 | -0.02 | **0.29** | **0.34** | 0.21 | 0.24 | **0.41** | 0.18 |
| Change in Housing Units | **-0.31** | **-0.34** | -0.10 | **-0.30** | **-0.26** | -0.16 | **0.55** | **0.45** |
| Concentration of Box stores | **-0.38** | -0.50 | -0.15 | -0.18 | -0.06 | -0.10 | 1.00 | **0.42** |
| Cooling Degree Days[a] | **-0.64** | **-0.56** | **-0.43** | **-0.26** | -0.23 | **-0.39** | **0.42** | 1.00 |

[a] Negative relationship likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## Table D.12: 2003 RF Correlation Matrix

| | RF Penetration | Change in RF Penetration | Overall Program Support | RF Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Box stores | Cooling Degree Days |
|---|---|---|---|---|---|---|---|---|
| Change in RF Penetration | **0.31** | 1.00 | | | | | | |
| Overall Program Support | **0.71** | **0.44** | 1.00 | | | | | |
| RF Cash Incentive | **0.43** | **0.40** | **0.64** | 1.00 | | | | |
| Electricity Price Proxy | **0.68** | 0.20 | **0.45** | 0.09 | 1.00 | | | |
| ENERGY STAR Recognition | **0.66** | 0.18 | **0.61** | **0.26** | **0.59** | 1.00 | | |
| Composite Income/Education | **0.72** | 0.19 | **0.48** | **0.32** | **0.51** | **0.48** | 0.19 | **-0.39** |
| % Population that is White | 0.17 | -0.04 | 0.14 | 0.00 | -0.06 | 0.05 | **-0.50** | **-0.60** |
| % Householders 45-54 | **0.44** | 0.22 | **0.43** | **0.26** | **0.28** | **0.40** | **-0.28** | **-0.66** |
| % Householders 25-34 | -0.16 | -0.16 | -0.10 | 0.00 | **-0.25** | -0.11 | **0.54** | **0.32** |
| % Owner-Occupied Housing | **-0.26** | **-0.36** | **-0.42** | -0.19 | **-0.42** | **-0.41** | 0.01 | -0.09 |
| % Population in Urban Areas | **0.32** | **0.26** | **0.29** | 0.21 | 0.21 | 0.24 | **0.41** | 0.18 |
| Change in Housing Units | -0.06 | -0.18 | -0.10 | 0.02 | **-0.26** | -0.16 | **0.55** | **0.45** |
| Concentration of Box stores | -0.03 | -0.22 | -0.15 | -0.16 | -0.06 | -0.10 | 1.00 | **0.42** |
| Cooling Degree Days | **-0.46** | -0.04 | **-0.43** | -0.21 | -0.23 | **-0.39** | **0.42** | 1.00 |

## Table D.13: 2003 DW Correlation Matrix

| | DW Penetration | Change in DW Penetration | Overall Program Support | DW Cash Incentive | Electricity Price Proxy | ENERGY STAR Recognition | Box stores | Interaction of Precipitation and Drought[a] |
|---|---|---|---|---|---|---|---|---|
| Change in DW Penetration | **0.34** | 1.00 | | | | | | |
| Overall Program Support | 0.02 | -0.09 | 1.00 | | | | | |
| DW Cash Incentive | 0.05 | 0.06 | **0.59** | 1.00 | | | | |
| Electricity Price Proxy | 0.05 | -0.20 | **0.45** | -0.05 | 1.00 | | | |
| ENERGY STAR Recognition | 0.07 | -0.04 | **0.61** | **0.44** | **0.59** | 1.00 | | |
| Composite Income/Education | 0.15 | **-0.26** | **0.48** | 0.06 | **0.51** | **0.48** | 0.19 | -0.07 |
| % Population that is White | **-0.37** | **-0.35** | 0.14 | 0.03 | -0.06 | 0.05 | **-0.50** | **-0.30** |
| % Householders 45-54 | -0.20 | -0.18 | **0.43** | 0.19 | **0.28** | **0.40** | **-0.28** | -0.03 |
| % Householders 25-34 | **0.25** | 0.21 | -0.10 | 0.13 | **-0.25** | -0.11 | **0.54** | -0.22 |
| % Owner-Occupied Housing | -0.06 | -0.18 | **-0.42** | **-0.37** | **-0.42** | **-0.41** | 0.01 | 0.05 |
| % Population in Urban Areas | **0.33** | -0.03 | **0.29** | 0.20 | 0.21 | 0.24 | **0.41** | -0.11 |
| Change in Housing Units | 0.20 | 0.07 | -0.10 | 0.13 | **-0.26** | -0.16 | **0.55** | **-0.41** |
| Concentration of Box stores | **0.40** | **0.25** | -0.15 | -0.11 | -0.06 | -0.10 | 1.00 | 0.02 |
| Interaction of Precipitation/Drought[a] | 0.22 | 0.22 | **-0.26** | **-0.37** | 0.16 | 0.00 | 0.02 | 1.00 |

[a] Drier, drought plagued states have lower scores in this interaction term. Thus, negative relationships suggest that drought ridden areas more likely to exhibit a given characteristic.

# Appendix E
# Full Regression Models and Change in Explained Variance

This appendix includes tables (Tables E.1, E.4, E.7, E.10) that indicate the regression coefficients and t-statistics for the models summarized in Chapter 6 and that were used to estimate energy savings. In addition, other tables (Tables E.2, E.5, E.8, and E.11) show the accuracy with which the regression models predicted actual market penetration in Massachusetts, as reported by D&R. Finally, Tables E.3, E.6, E.9, and E.12 specify the additional amount of variance explained by adding program, cash incentive, and change in penetration variables into regression models.

All variables indicated with an NA were not applicable to that model. There are two reasons that variables may not be applicable to a particular model. First, some variables were included only for certain appliances, specifically CDD for RAC and RF and the precipitation/drought variable for CW and DW. In all other cases, the individual variable was not found to be significantly related to any of the appliances, in the more parsimonious models built for each individual appliance in each year or with change in penetration in the model. For example, the ENERGY STAR recognition variable was not found to be significantly related to market penetration in 2003 once the change in penetration variable was added to the model. The more parsimonious models developed for each appliance in each year are available upon request.

## Table E.1: CW Penetration Models

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| $R^2$ | **86.7%** | **85.8%** | **88.0%** | **97.4%** |
| Constant | -.336 (-.626) | -.854 (.132) | -.274 (-.401) | .167 (1.622) |
| Change in Penetration 1998-2002 | NA | NA | NA | **7.382 (15.944)** |
| CW Program Support | **.005 (3.641)** | **.005 (2.946)** | **.07 (4.148)** | **.003 (3.842)** |
| Electricity Price Proxy | -.002 (-.546) | 1.17E-04 (.083) | .004 (.667) | .001 (.629) |
| Energy Star Recognition | **.220 (2.410)** | **.289 (2.835)** | **.255 (2.125)** | NA |
| Composite Income/Education | **.019 (4.098)** | **.021 (4.571)** | **.030 (5.179)** | **.008 (2.546)** |
| % Population that is White | **.237 (.003)** | **.307 (3.866)** | **.427 (4.285)** | **.171 (3.657)** |
| % Householders Aged 45-54 | .287 (.406) | NA | NA | NA |
| % Householders Aged 25-34 | -.077 (-.157) | -.445 (-.850) | NA | NA |
| % Owner-Occupied Housing | NA | NA | NA | .110 (.944) |
| % Population in Urban Areas | -.042 (-.742) | -.054 (-.902) | **-.177 (-2.441)** | **-.086 (-2.464)** |
| Change in Housing Units | .477 (1.013) | **1.109 (2.013)** | .555 (.851) | NA |
| Concentration of Box stores | NA | NA | -.001 (-.049) | NA |
| Interaction of Precipitation/Drought[b] | **-3.97E-04 (-3.731)** | **-4.31E-04 (-3.542)** | **-.001 (-3.279)** | NA |

[a] B-statistic presented on first line, t on second line in parentheses, bolded results are statistically significant at .10.
[b] Model includes predictors from best models that include change in penetration as an independent variable.

## Table E.2: Predicted and Actual CW Penetration in Massachusetts

| **Penetration Estimate** | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| Predicted Penetration | 19.9% | 28.1% | 40.9% | 39.6% |
| Actual Penetration | 19.1% | 24.9% | 39.5% | 39.5% |
| Difference[a] | .8% | 3.2% | 1.5% | .2% |

[a] Subject to rounding error.

## Table E.3: CW Change in Explained Variance Using Program Variable[a]

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| $R^2$ w/o program | 82.0% | 82.6% | 82.5% | 80.8% |
| $R^2$ w/ program | 86.7% | 85.8% | 88.0% | 97.4% |
| Change in $R^2$[c] | **4.8%** | **3.2%** | **5.5%** | **16.6%** |

[a] Bolded results are statistically significant at .10.
[b] This change in $R^2$ is based on exclusion and inclusion of change in penetration.
[c] Results subject to rounding error.

## Table E.4: Full Room Air Conditioner Models, 2001 through 2003

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| **$R^2$** | **76.5%** | **81.7%** | **76.8%** | **81.8%** |
| Constant | .964 (1.492) | .621 (.965) | .102 (.090) | -.039 (-.103) |
| Change in Penetration 1998-2002 | NA | NA | NA | **2.287 (4.077)** |
| Overall Program Support | **.004 (1.843)** | **.005 (1.689)** | **.015 (3.200)** | **.010 (2.571)** |
| Cash Incentive | -.015 (-1.039) | 1.56E-04 (.014) | -.012 (-.499) | -.002 (-.130) |
| Electricity Price Proxy | **.020 (3.461)** | **.022 (3.576)** | **.033 (3.406)** | **.025 (3.032)** |
| Energy Star Recognition | -.237 (-1.594) | **-.439 (-3.079)** | -.338 (-1.527) | NA |
| Composite Income/Education | .008 (.247) | .006 (.904) | **.035 (3.045)** | **.020 (1.864)** |
| % Population that is White | .179 (1.529) | .160 (1.264) | **.541 (2.843)** | **.396 (2.336)** |
| % Householders Aged 45-54 | -1.231 (-1.067) | NA | NA | NA |
| % Householders Aged 25-34 | -1.055 (-1.358) | **-1.443 (-1.981)** | NA | NA |
| % Owner-Occupied Housing | NA | NA | NA | .125 (.293) |
| % Population in Urban Areas | .080 (.955) | .029 (.327) | -.198 (-1.467) | -.181 (-1.401) |
| Change in Housing Units | -.323 (-.465) | .319 (.452) | .067 (.061) | NA |
| Concentration of Box stores | NA | NA | -.039 (-1.530) | NA |
| Cooling Degree Days[c] | **-.018 (-2.309)** | **-.030 (-4.198)** | NA | NA |

[a] B-statistic presented on first line, t on second line in parentheses, bolded results are statistically significant at .10.
[b] Model includes predictors from parsimonious, appliance-specific models that include change in penetration as an independent variable.
[c] Negative relationship with room air conditioner likely the result of warmer climates having more CAC installed, thereby decreasing need for RAC.

## Table E.5: Predicted and Actual RAC Penetration in Massachusetts

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| Predicted Penetration | 25.1% | 48.7% | 52.2% | 50.7% |
| Actual Penetration | 24.6% | 45.9% | 45.6% | 45.6% |
| Difference[a] | .5% | 2.8% | 6.5% | 5.0% |

[a] Subject to rounding error.

## Table E.6: RAC Change in Explained Variance[a]

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| $R^2$ w/o program and cash incentive | 74.2% | 80.1% | 69.3 | 74.0% |
| $R^2$ w/ program and cash incentive | 76.5% | 81.7% | 76.8% | 81.8% |
| Change in $R^2$[c] | 2.4% | 1.6% | **7.5%** | **7.8%** |

[a] Bolded results are statistically significant at .10.
[b] This change in $R^2$ is based on exclusion and inclusion of change in penetration.
[c] Subject to rounding error.

## Table E.7: Full Refrigerator Models, 2001 to 2003

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| **$R^2$** | **64.4%** | **80.2%** | **81.0%** | **79.0%** |
| Constant | **-.691** **(-2.376)** | -.316 (-1.228) | -.152 (-.500) | **.235** **(1.891)** |
| Change in Penetration | NA | NA | NA | .175 (.440) |
| Overall Program Support | -2.90E-04 (-.262) | 1.15E-04 (.095) | .002 (1.601) | **.003** **(2.386)** |
| Cash Incentive | **.009** **(2.369)** | .005 (1.334) | .005 (1.213) | .004 (.836) |
| Electricity Price Proxy | .003 (.983) | **.008** **(2.833)** | **.010** **(3.626)** | **.011** **(3.943)** |
| Energy Star Recognition | .044 (.692) | .088 (1.510) | .083 (1.326) | NA |
| Composite Income/Education | .001 (.409) | **.007** **(2.572)** | **.010** **(3.280)** | **.010** **(2.907)** |
| % Population that is White | .011 (.208) | -.015 (-.305) | **.111** **(2.156)** | .076 (1.500) |
| % Householders Aged 45-54 | **1.089** **(2.127)** | NA | NA | NA |
| % Householders Aged 25-34 | .338 (.982) | -.387 (-1.298) | NA | NA |
| % Owner-Occupied Housing | NA | NA | NA | .176 (1.253) |
| % Population in Urban Areas | **.064** **(1.706)** | .023 (.647) | -.016 (-.426) | .020 (.467) |
| Change in Housing Units | **.641** **(2.064)** | **.782** **(2.745)** | .474 (1.563) | NA |
| Concentration of Box stores | NA | NA | .002 (.245) | NA |
| Cooling Degree Days | **.007** **(2.154)** | **-.005** **(-1.830)** | NA | NA |

[a] B-statistic presented on first line, t on second line in parentheses, bolded results are statistically significant at .10.
[b] Model includes predictors from parsimonious, appliance-specific models that include change in penetration as an independent variable.

## Table E.8: Predicted and Actual RF Penetration in Massachusetts

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| Predicted Penetration | 16.6% | 24.7% | 33.7% | 34.1% |
| Actual Penetration | 16.4% | 25.4% | 31.4% | 31.4% |
| Difference[a] | .2% | -.7% | 2.3% | 2.8% |

[a] Subject to rounding error.

## Table E.9: RF Change in Explained Variance[a]

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration[b] |
|---|---|---|---|---|
| $R^2$ w/o program and cash incentive | 58.4% | 78.9% | 75.6% | 78.9% |
| $R^2$ w/ program and cash incentive | 64.4% | 80.2% | 81.0% | 79.0% |
| Change in $R^2$[c] | **6.0%*** | 1.4% | **5.4%***** | 0.1% |

[a] Bolded results are statistically significant at .10.
[b] This change in $R^2$ is based on exclusion and inclusion of change in penetration.
[c] Subject to rounding error.

## Table E.10: Full Dishwasher Models, 2001 to 2003

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration |
|---|---|---|---|---|
| **$R^2$** | **66.1%** | **71.8%** | **28.4%** | **35.3%** |
| Constant | **-1.411 (-2.479)** | -.949 (-1.606) | .405 (.701) | **.413 (2.041)** |
| Change in Penetration | NA | NA | NA | **1.092 (2.674)** |
| Overall Program Support | -4.54E-04 (-.234) | 4.86E-04 (.220) | 2.14E-04 (.096) | -.001 (-.311) |
| Cash Incentive | .011 (1.270) | -.004 (-.469) | .007 (.586) | .008 (.880) |
| Electricity Price Proxy | .003 (.686) | **-.009 (-1.685)** | 7.59E-05 (.015) | .006 (1.332) |
| Energy Star Recognition | -.015 (-.155) | **.216 (1.880)** | -.007 (-.060) | NA |
| Composite Income/Education | -.004 (-.721) | -.006 (-1.272) | 4.78E-04 (.092) | 2.53E-04 (.053) |
| % Population that is White | -.101 (-1.267) | **-.225 (-2.657)** | -.028 (-.326) | -.095 (-1.262) |
| % Householders Aged 45-54 | .655 (.872) | NA | NA | NA |
| % Householders Aged 25-34 | .491 (.939) | .200 (.356) | NA | NA |
| % Owner-Occupied Housing | NA | NA | NA | **.482 (2.305)** |
| % Population in Urban Areas | .087 (1.440) | **.133 (2.066)** | .053 (.859) | **.129 (2.107)** |
| Change in Housing Units | **1.499 (2.999)** | **1.510 (2.571)** | .357 (.647) | NA |
| Concentration of Box stores | NA | NA | .013 (1.133) | NA |
| Interaction of Precipitation/Drought[b] | **.001 (4.903)** | **.001 (4.966)** | **2.28E-04 (1.704)** | NA |

[a] B-statistic presented on first line, t on second line in parentheses, bolded results are statistically significant at .10.
[b] Model includes predictors from parsimonious, appliance-specific models that include change in penetration as an independent variable.

## Table E.11: Predicted and Actual DW Penetration in Massachusetts

| | 2001 | 2002 | 2003 | 2003 with Change in Penetration |
|---|---|---|---|---|
| Predicted Penetration | 18.6% | 35.8% | 59.1% | 58.1% |
| Actual Penetration | 18.4% | 34.1% | 54.0% | 54.0% |
| Difference[a] | .2% | 1.6% | 5.1% | 4.1% |

[a] Subject to rounding error.

## Table E.12: DW Change in Explained Variance[a]

| | **2001** | **2002** | **2003** | **2003 with Change in Penetration[b]** |
|---|---|---|---|---|
| $R^2$ w/o program and cash incentive | 64.5% | 71.6% | 27.2% | 23.4% |
| $R^2$ w/ program and cash incentive | 66.1% | 71.8% | 28.4% | 35.3% |
| Change in $R^2$[c] | 1.7% | 0.2% | 1.2% | **11.9%**** |

[a] Bolded results are statistically significant at .10.
[b] This change in $R^2$ is based on exclusion and inclusion of change in penetration.
[c] Subject to rounding error.