Appendix 1

Ecotope's Energy Impacts Evaluation of Select 2008 Avista Residential and Low Income Demand-Side Management Programs

Energy Impacts Evaluation of Select 2008 Avista Residential and Low Income Demand-Side Management Programs

ECOTOPE
CONSULTING
RESEARCH
DESIGN

Report

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Executive Summary

This report documents the development of an energy impact evaluation conducted on several energy efficiency programs operated by Avista in the residential sector in the 2008 program year. In general these programs focus on energy savings in two main categories: residential space heating and domestic hot water (DHW). The specific programs evaluated were divided into three categories:

1. Regular income gas efficiency measures administered through the Avista's Home Improvement Incentive Program marketed primarily through "Every Little Bit".
2. Regular income Electric efficiency measures aimed at replacement windows primarily marketing through "Every Little Bit" outreach.
3. Low income gas efficiency and electric efficiency measures administered by contract through Community Action Programs (CAPs) throughout the Avista service territory.

Gas Efficiency Measures

Home Improvement Gas efficiency measures marketed through "Every Little Bit" outreach were the major energy efficiency measures evaluated. The program included about 6,850 separate gas efficiency incentives for 5,077 separate customer accounts. For this evaluation, the incentives were divided into five categories: furnace upgrade, insulation retrofit, efficient window retrofit, demand DHW installation, and efficient DHW tank upgrade. After the incentives were grouped into these five categories, they were evaluated with a conditional demand analysis (CDA) approach.

The evaluation methodology proceeded in five steps:

1. **Bills and Account Screening**: This step involved reviewing all the billing records associated with the participating customer accounts, including bills from previous or subsequent occupants if it was determined that a customer had moved during the evaluation period. All the accounts were screened for complete billing records for the 2007-2009 period, as all the measures under evaluation were installed in the 2008 calendar year. The 2007 calendar year was taken as the "pre-installation" year and 2009 was taken as the "post-installation" year. In 5% of the cases accounts were dropped from the evaluation either because the billing record was incomplete or because the billing pattern suggested ineligibility. An additional 17% of the sample was not used to establish the savings estimates, but was used to develop the final program realization.
2. **Weather Normalization**: All bills received were evaluated using a variable base degree-day (VBDD) to normalize for climate variations over the study period. Space heating estimates and base load estimates were developed from this analysis in all accounts, which allowed an assessment of gas fuel use within these accounts.
3. **Conditional Demand Analysis**: The change in normalized gas consumption for each account was combined in a regression specification that attached indicator variables to individual measures and allowed the regression to specify the impact by estimating the coefficients on the indicator variables. Bills from 2007 and 2009 were used and the differences between the consumption in those years became the dependent variable in the regression.
4. **Control Group**: A similar bill screening and weather normalization process was done for a group of non-participating customer accounts to create a control group. These accounts and their change in gas consumption were introduced into the regression.
5. **Realization Rate**: The realization rates for the five evaluated measure types were calculated using the estimated impacts from the CDA regression. The total realization rate was based on the

savings estimates derived without the control group; the net realization rate was derived from the savings estimates made with the control group.

The results of this analysis showed a total realization rate of 79% in the gas efficiency measures under the regular income Home Improvement Incentive Program. When the control group was introduced the net realization rate was reduced to 51%. In this analysis the total realization is probably a more accurate reflection of savings in this program.

Electric Efficiency Measure

Only one electric efficiency measure under the regular income Home Improvement Incentive Program was evaluated. This was the window replacement measure aimed at electrically heated homes. A total of 822 customer accounts received incentives for this measure. An evaluation procedure similar to that used to evaluate the gas saving measures was used to screen and normalize the bills. Because of the relative lack of electric bills with evidence of electric space heat (at least 5000 kilowatt hours/yr in normalized space heat estimated from the VBDD analysis), the impact of the account screening was large: more than 57% of the accounts were dropped from the analysis. With this reduction in savings accounts the overall realization rate calculated for this measure was 26%.

A control group was developed for this group of electrically heated homes, but it did not provide a significant adjustment to the realization rate. It did support the account screening that reduced the number of applications.

Low-Income Program

The evaluation of the Low-Income (LI) Program extended to all the measures and accomplishments filed under the program in 2008, which included electric and gas savings measures and electric-to-gas conversions for space and/or water heating. A total of 454 accounts were filed with about 1,350 separate measures. The same bill screening and analysis process as was done for the gas savings measures evaluation in the regular income Home Improvement Incentive Program was used to screen the bills in the LI program. The analysis of the LI program's savings was divided into three parts: gas savings in gas heated homes, electric savings in electric heated homes, and electric savings that resulted from conversion of space heat and/or water heat from electric-to-gas. This division was done to simplify the analysis in the face of the complexities introduced by the fact that both electric and gas fuels were involved in the savings measures. About 16% of the total accounts filed were dropped from the analysis largely because the space heat signature suggested that these homes were not heated by the fuel that was specified by the savings claim. An additional 24% were not included in the total savings estimations, but were included in the final assessment of the realization rates.

The development of a non-participant control group proved problematic. Since the control group was not drawn specifically from a comparable group, the statistical relation to the program participants was not statistically significant. Overall given the small size of this program we abandoned this analysis and reported only the total savings and realization.

For the LI program three total realization rates were computed: 23% for gas measures; 35% for electric measures; and 69% for electric-to-gas conversions.

Overall Impacts

Table E1 shows a summary of the savings impacts for each measure category based on both the total and net realization rates calculated across the entire Avista service territory.

Table E2 and summarize the savings impacts for the states of Washington and Idaho respectively.

Table E1. Total Evaluated Savings by Measure Category, Avista Service Territory

Measure Category	Gas Claim	Elect. Claim	Realization		Net Realization	Total Savings		Net Savings
	Therms	kWh/yr	Gas	Electric	Gas	Gas	Electric	Gas
Gas	652,120		0.797		0.515	519,951		336,141
Electric		1,493,964		0.268			400,382	
LI Gas	110,663		0.226			24,999		
LI Electric		948,427		0.353			334,678	
LI Conversions		906,965		0.693			628,414	
Total Savings	762,783	3,349,356				544,950	1,363,475	

Table E2. Washington Evaluated Savings by Measure Category

Measure Category	Gas Claim	Elect. Claim	Realization		Net Realization	Total Savings		Net Savings
	Therms	kWh/yr	Gas	Electric	Gas	Gas	Electric	Gas
Gas	487,771		0.797		0.515	388,911		251,426
Electric		1,001,634		0.268			268,438	
LI Gas	98,647		0.226			22,285		
LI Electric		652,750		0.353			230,341	
LI Conversions		906,965		0.693			628,414	
Total Savings	586,418	2,561,349				411,196	1,127,193	

Table E3. Idaho Evaluated Savings by Measure Category

Measure Category	Gas Claim	Elect. Claim	Realization		Net Realization	Total Savings		Net Savings
	Therms	kWh/yr	Gas	Electric	Gas	Gas	Electric	Gas
Gas	164,349		0.797		0.515	131,039		84,715
Electric		492,330		0.268			131,944	
LI Gas	12,016		0.226			2,714		
LI Electric		295,677		0.353			104,338	
Total Savings	176,365	788,007				133,753	236,282	

The overall lesson from this evaluation is the need for better oversight and increased quality control in delivering Avista's residential energy efficiency programs, especially in the insulation and window replacement measures where the realization rates are unacceptably low. These results suggest that the programs should be redesigned to ensure a minimum cost-effectiveness in these measures through better on-site quality control or better oversight of the contractors delivering these services.

The equipment measures, such as efficient furnace upgrades and conversions, perform much better. This suggests that contractors delivering these measures have an independent procedure for insuring a quality installation.

1. Introduction

Ecotope has performed an impact evaluation on selected measures in the Avista gas and electric conservation portfolio. There are three types of programs evaluated in this report:

1. A program of gas savings measures that support more efficient windows, furnaces, insulation and domestic hot water heaters in the residential sector gas customers, delivered throughout the Avista service territory in Washington and Idaho.
2. A program to support more efficient windows aimed at electric heating customers.
3. A program aimed at Low-Income (LI) customers with both electric and gas savings largely from space heating measures and electric-to-gas conversions.

The principal goal of this evaluation is to provide a third party estimate of the savings achieved by the installation of the energy (gas therms and electric kilowatt hours) savings measures in each of the above programs, with as much specificity as possible, and then to compare these estimated, or actual, savings to the Avista savings claims in order to develop a realization rate.

This evaluation was performed using billing analysis techniques coupled with a review of the tracking database for each of the individual filings. While some of the insights into the program design were developed during an earlier verification phase (Ecotope 2010), for the most part, this impact evaluation used the actual billing performance of the individual houses and the documented measures and savings claims for each participating customer to establish program realization rates.

1.1. Programs Evaluated

Gas Savings Measures: The main targets of this evaluation were Avista's residential gas savings measures. These individual or combined and related measures were grouped into five major categories for evaluation:

1. Insulation and Weatherization
2. Furnace Upgrades and Conversions
3. Replacement and New Windows
4. Tankless (demand) Water Heaters
5. Efficient DHW tanks

Electric Savings Measures: In addition to the gas measures, a single family window replacement measure was evaluated for homes that were said to be electrically heated as part of their incentive application. This measure was evaluated completely separately from the gas heated homes using the electric bills provided for those customers.

Low-Income Program: Finally, the Low-Income (LI) program was evaluated for both gas and electric savings. This program has numerous measures so the evaluation focused on changes in gas bills and/or electric bills that resulted from participation in Avista's LI program. The gas savings and the electric savings were evaluated separately. In addition, about half of the electric savings claimed by this program were the result of conversions from electric heating or hot water. These conversions were evaluated separately from the other energy savings measures.

1.2. Evaluation Goals

The primary goals of the evaluation of the selected Avista demand-side energy savings programs are:

1. To develop the realization rates associated with savings claims made by Avista for these individual measures and the overall programs. This is meant to be inclusive of the observed changes in energy consumption that were identified through an examination of the individual customer's bills associated with the measures supported by the Avista efficiency programs.
2. To review the files and applications to determine customers who had either been inappropriately awarded incentives or who were ineligible because their fuel-type or heating system type was not consistent with the savings claimed in their application.
3. To review billing data and determine the fractions of measures, particularly furnace and water heater measures, that involved conversion from electric or other fuels to gas and ensure that proper savings were calculated for these even though before and after billing records are not available.

2. Methodology

The evaluation methodology used here began with a complete set of billing records for all homes that received incentives under the select Avista programs evaluated (*participants*). In addition, a control group (*non-participants*) was designed to provide estimates of underlying consumption changes in the Avista service territory. The control group is meant to be a surrogate for net-savings under the theory that aggregate shifts in consumption in the Avista service territory should be taken into account in developing the final realization rate of participating customers. There were several distinct steps in this process.

2.1. Bill Screening and Customer Attrition

First, all of the bills collected, from both participants and non-participants, were screened for a complete billing record for the 2007 and 2009 calendar years. Second, a regression analysis was conducted and homes with insufficient billing data or erratic bill patterns were dropped from the statistical analysis. In about 20% of the applicant billing records the customer and account that applied for the incentive moved or changed occupancies resulting in a different account. For this group the utility retrieved bills for the site from the previous occupant and these were used in the analysis. This process was imperfect and some fraction of the applications were lost.

2.2. Removed Sites

In addition to screening the billing records for completeness, further customer attrition was applied in each program evaluated. In some cases, especially the electric heating cases, there was no evidence of space heating in the target fuel. That is, the home did not use the type of space heating that it was said to use. Those cases were dropped from the analysis and the savings claims associated with those homes were dropped from the final realization rate.

In a small number of cases the bills were missing entirely. For the gas measures evaluation some cases had no gas bills, but did have electric bills.

Some bills were anomalous. The principal cause was the lack of bills from the pre-2008 period. This seemed to be an indication of new construction. These bills were dropped from the analysis since that population is not directly applicable to the Avista programs or this evaluation.

2.3. Weather Normalization

All bills submitted were evaluated using a variable based degree-days (VBDD) methodology (Fels, 1986). This has the advantage of determining energy consumption with respect to the changes in temperature and the time of year. The result of this analysis was a direct estimate of space heating requirements normalized to a common weather condition. Additionally, our analysis corrects for seasonal trends in non heating loads (e.g. a DHW load). All accounts, both electric and gas, used this method. Thus, heating estimates were constructed in both 2007 (the pre-installation year) and 2009 (the post-installation year) insofar as complete billing records were available. In some cases the bills were either missing or had serious anomalous readings that made this normalization impossible. For the most part these applications were removed from the savings analysis.

A total of twelve weather sites were used to characterize the Avista service territory. Table 1 shows the weather sites from the NWS Cooperative Network used in this evaluation and the distribution of participants and non-participants assigned to those sites.

Table 1. Percentages of Participant and Non-Participant Accounts Assigned to Each Weather Site

Weather Station	State	Participants	Non-Participants
Bayview	ID	0.5%	0.0%
Chewelah	WA	2.5%	1.8%
Coeur d'Alene	ID	8.4%	12.5%
Ephrata	WA	0.4%	0.2%
Kellogg	ID	2.1%	2.4%
Lewiston	ID	12.2%	11.1%
Moro	ID	0.2%	0.0%
Moscow	ID	6.2%	6.9%
Priest River	ID	1.4%	2.3%
Spokane	WA	65.6%	62.5%
Troutdale	WA	0.0%	0.0%
Winchester	ID	0.5%	0.0%

2.4. Normalized Heating Requirements

Upon completion of the weather normalization regressions a home's normal energy use was recalculated using the weather average at each weather site for the five year period ending in 2009. This process gave a standard weather year for both pre-installation and post-installation years and comparable weather across all programs. Subsequent comparisons of accounts using this average weather were directly comparable independent of annual climate transients.

A similar process was done for the electric window measure using the electric bills. In cases where an electric savings was claimed, but the bill records showed no electric heat or a substantial gas heating signature, the application was dropped from further consideration and removed from the realization rate.

For the LI program a similar process was used to normalize heating requirements, but gas and electric were evaluated separately based on the observed bills.

In the case of the LI program a substantial number of measures were electric-to-gas conversions. These were evaluated using the weather normalized bill totals from the electric bill. This had the effect of documenting the electric savings. While the corresponding gas bills were also weather normalized the increase in gas was not included in the program evaluation. Thus, the averages from the remaining low-income gas measures were used to calculate the measure savings for those homes.

2.5. Realization Rates

Realization rates were calculated for each measure or group of measures evaluated where the data sets were sufficiently large for a disaggregation. Generally, the evaluation procedure for developing these rates was based on savings estimates developed in a conditional demand analysis (CDA) in which a

simple linear regression was specified with the aim of assigning savings calculated to the measures used in each particular home. Appendix A details this methodology. The dependent variable in the regression is the change in normalized savings estimated from the VBDD analysis. The resulting coefficients can be interpreted as the savings associated with each measure specified. For this procedure to be effective a sufficiently large number of cases are required. All the gas savings measures were estimated using this technique. Only one measure was estimated for the electric savings claims (window replacement) so the CDA format was modified to include the effects of nonparticipants.

In the LI program the conversion measures were estimated this way since even though there were a small number of participants the size of the savings was sufficient to allow a statistically significant coefficient to be generated. There were insufficient cases in the remaining measures in the LI program to perform a CDA analysis, so only total electric and gas savings were estimated for that group.

Gas measures were grouped into broader categories for the CDA analysis. Presence or absence of each of these measure categories was then indicated using the dummy variable specification. The regression coefficient was used to estimate a savings numbers for each measure category independent of all the other measures. The ratio of these estimated savings to the claimed savings in Avista's files is taken to be the total realization rate for these measures.

As with any regression this approach has its limitations and pitfalls (See Appendix A for a more complete discussion). The certainty with which the savings can be estimated is a function in part of the absolute size of the savings and in part on the number of available cases to estimate those savings, and on how measures are distributed across the participants. In most cases in the Avista program adequate amounts of both the size of the savings and the number of cases were present. In one case, conventional DHW tanks, this was not the case; because of the small number of valid cases and the very small estimated savings this estimation procedure could not discern a significant coefficient, and could not discern any significant savings from these measures.

2.6. Net Realization Rates

The VBDD process was repeated using the non-participant control group. The savings analysis used a comparison between 2007 and 2009 weather-normalized consumption for each site. These accounts were then included in the CDA regression. The control group has no measures (by definition) therefore, changes in consumption are included in the constant term in the CDA regression. The assertion is that the control group represents the non-participant customers in the Avista service territory and that they have adjusted their gas consumption as a result of macroeconomic factors such as reduced economic activity, unemployment, or as a result of changes in the gas utility rates that were paid for their heating and hot water. This systemic change occurred independent of any measures that might have been installed by the participating customers. A second CDA was specified using the control group. This resulted in across the board reductions in estimated savings and thus across the board reductions expressed as a net realization rate.

The same VBDD process was repeated for the electric measures and for the LI measures. In both of these programs the control group offset was not statistically significant and did not actually impact the overall savings estimated from the gross realization rate.

3. Impact Evaluation, Gas Savings Measures

The first step in applying the evaluation methodology to the gas savings program was to carefully screen the actual savings measures (the actual applications from which the savings claims were derived). A total of 5,077 accounts received incentives under Avista's "Every Little Bit" Home Improvement Incentive Program. Within these applications there were approximately 6,800 separate measures represented, spanning about 10 separate measure types. For this evaluation, these measures were grouped into five categories, and about 9% of all the applications were combined into the 5,077 accounts in the evaluation.

For each customer account the applications were collapsed so that all of the measures types that any particular customer installed were included. For example, if a customer insulated their house and put in a new gas furnace, the indicators for that customer in the regression would flag those two measure categories and the other measure flags would be set to zero. In these cases the coefficient of the regression represents the savings estimate and the statistics associated with that coefficient – the standard error, confidence interval and significance level – are the results of that regression.

3.1. Conditional Demand Analysis Measures

The measure groupings that were ultimately used for the conditional demand analysis and for the final impact evaluation were:

1. **Insulation and Weatherization**. This measure category includes all weatherization measures insulating particular components of a home. This includes insulation retrofit into floors, walls and ceilings. The program savings are based on the savings calculator developed by Avista and those are translated into the savings claim for each individual measure. For this analysis, all the insulation measures and all the savings from those measures were combined into a single measure.
2. **Furnace Upgrades**. These upgrades are applied to furnace and boiler replacements in existing homes. The furnace upgrade was from an AFUE 78 gas furnace (meeting the minimum code for performance to a condensing gas furnace with an AFUE above 90. In some cases it appears that these upgrades were applied on top of fuel conversions in existing homes. In such cases the site was not used in CDA, because there was no prior gas usage to compare with post-installation usage, although such conversion sites were included in calculations of program effects.
3. **Replacement Windows**. Windows are treated separately from other weatherization measures. The window measure was based on a new window that achieved a U=0.30, which represented a 14% improvement over current code requirements for residential windows.
4. **Efficient Domestic Hot Water (DHW) tanks**. This measure is designed to upgrade a conventional tank from current code (EF=58%) to a measure with a rating of EF=62%. This amounts to small improvements in nominal efficiency of approximately 6%.
5. **Tankless Water Heaters**. This measure is somewhat specialized and uses a tankless gas water heater technology; essentially a small modulating gas boiler, as the basis for delivering instantaneous hot water to the home. In general, these devices are in excess of EF=80% hot water efficiency. This measure replaces the existing gas hot water tank with a rating of about EF=58% with this higher efficiency option.

The evaluation used these five categories to proceed with estimating impacts from the measures in the gas savings program. Table 2 summarizes the initial savings claims associated with each of the above

measure categories, including the total number of applications that used these particular measures. It should be pointed out that the overlaps between measures results in a somewhat larger number of applications (5,618) than the actual number of accounts (5,077) used in the evaluation (as shown in the "Total N" in Table 2); some accounts had two or more measures and thus appeared in two or more categories. Approximately 91% of the accounts that filed applications had only used one measure category; the remaining 9% used multiple measures.

Table 2. Claimed Savings by Measure Type

	Customer Savings		Total
Measure	**Therms/Cust.**	**N**	**Therms**
Furnace	123.9	2,377	294,620
Insulation	182.5	857	156,438
Windows (gas)	97.6	1,953	190,683
DHW Demand	56.6	124	7,020
DHW Tanks	9.9	307	3,052
Total			**651,814**

N = # of customer accounts

3.2. Bill Screening, Attrition

The first step in applying the evaluation methodology to the gas savings program was to carefully screen the actual savings measures (the actual applications from which the savings claims were derived).

The second step in applying the evaluation methodology to the gas savings program was to carefully screen the 5,077 bill histories collected from the gas savings applicants for a complete billing record for the 2007 and 2009 calendar years to arrive at a working estimation sample (see Table 3). The impact evaluation targeted energy usage in the 2007-2009 period. Table 3 shows the actual attrition rates that resulted from the bill screening process.

Table 3. Customer Attrition Totals, Gas Measures

Screening Stage	Bills Removed	N	Account Status
0	n/a	**5,077**	Total customer accounts delivered
1	-43	5,034	Total accounts with gas bills (missing bills removed)
2	-188	**4,846**	Total accounts with bills before 2008 (bills for new construction removed)
3	-523	4,323	Total accounts with bills before 2008 (bills for conversions removed)
4	-406	**3,917**	Total accounts for successful regression (estimation sample)

N = # of customer accounts

As can be seen in Table 3, forty-three accounts were lost in the early stages of this analysis as these accounts had no gas bill and no discernible gas usage. We assumed from this result that these accounts were not eligible for the Avista gas program and subsequently they were removed from the savings claim analysis and the overall program customer accomplishments results.

In the second screening stage, 188 accounts were removed as there were no bills of any sort before 2008. This suggested that these accounts were new construction of some sort. Since this evaluation is an evaluation of the *retrofit* and conversion program these accounts were removed from the analysis and the realization rate.

The third screening stage identified 523 accounts where gas was added as part of a conversion to gas heat and subsequently savings measures were also added to the house. This group was not included in the normalized heating analysis or the CDA analysis, but the savings derived from the remaining cases were used and they were added into the realization rate calculation. It was assumed that the savings derived from the measures in these applications would be predicted by the savings observed in the remaining applications.

The fourth screening stage identified 406 accounts that were removed from the evaluation because deficiencies in the billing record that made the VBDD impractical. Usually this was the result of skipped or combined bills or the result of insufficient bills for the billing analysis to return a reasonable answer. These accounts were treated like the preceding screen and added back into the realization rate calculation using the savings estimated on the remaining accounts.

The first two screening stages in Table 3 resulted in approximately 231 accounts being dropped (about 4.6% of the total accounts) from the gas saving impact analysis. The second two screening stages in Table 3 resulted in 929 accounts being removed (about 18.3% of the total accounts). The accounts remaining after the third and fourth screenings were used to estimate the savings and were included in the CDA to establish the individual savings estimates for each measure type. The final savings impacts were calculated with 3,917 accounts. Once this phase was complete the final savings were calculated using the accounts available after the second screen to calculate the final gross and net savings for the program (N = 4,846 in Table 3 and Table 4).

The distribution of the accounts by measure, after the review of the bills and savings claims, is shown in Table 4. The shaded areas show the total at that stage of the screening. The center shaded column shows the number of homes that were used to develop the realized program savings. The final column shows the number of accounts that had sufficient data to estimate the saving from the measure categories used in the gas program.

Table 4. Customer Attrition by Measure Type, Gas Measures

Measure	N Claimed	Screening Stage 1 + 2 (Missing Bills & New Construction Removed)	N Accounts Realized	Screening Stage 3 (Conversions Removed)	Screening Stage 4 (Bill Records)	N Estimation Sample
Furnace	2377	-191	2186	-498	-229	1459
Insulation	857	-6	851	-23	-86	742
Windows (gas)	1953	-21	1932	-36	-121	1775
DHW Demand	124	-17	107	-11	-18	78
DHW Tanks*	307	-13	294	-19	-41	234
Total (accounts)	**5,077**	**-231**	**4,846**	**-523**	**-406**	**3,917**

N = total # of accounts

3.3. Total Savings Analysis

The entire estimation database from Table 4 was used to estimate the total savings available from each measure type. The original specification of this regression was based on the theory that many of the accounts from the Avista program applications would include more than one measure. In the end, only approximately 91% of the accounts that filed applications had only used one measure category.

The procedure for developing this indicator variable (CDA) regression analysis was based on the procedure for weather normalization and normalized heating requirements introduced in Section 2 and detailed in Appendix A. The process was conducted in three steps:

1. The first step was to develop a variable-based degree day analysis (VBDD) analysis for the year before and the year after the claimed installation of a measure. The VBDD analysis is designed to weather normalize the heating estimate and the overall energy use, or normalized energy consumption (NAC), for each home.
2. The before-and after response coefficients from VBDD regressions for each site were then applied to "average" weather from the weather station used in the VBDD regressions. "Average" in this case means the average annual degree-days calculated over the five years ending in 2009.
3. The changes in normalized heating estimates and in NAC from 2007 to 2009 were then compiled into a data set that included indicator variables for the measures used. The CDA regression then generated a coefficient for each indicator which is the estimate of the average impact on gas consumption of each measure.

The results of this procedure are summarized in Table 5.

A second analysis was conducted on the subset of accounts that had only one measure category in their applications. This group was a large fraction of the overall estimation sample (3566 accounts out of 3917 accounts in the full sample). This resulted in a separate savings estimates for each measure category. The purpose of this exercise was to compare with the results of the CDA regression and to provide an estimate of the variation in savings estimates. Since the number of accounts with more than one measure type of the total accounts collected is only 9% of the total population the single measure review is very informative.

To arrive at savings estimates for these single measure cases a simple differences approach was used:

1. The normalized consumption for the 2007 period was subtracted from the normalized consumption in the 2009 period.
2. This resulted in a savings estimate calculated directly for each account.
3. The distribution of these estimates allowed a mean savings estimate as well as the confidence interval to be computed for each measure category.

The results of the CDA analysis and the single measure analysis are summarized in Table 5. In the case of DHW tanks neither the estimate from the CDA or the single measure analysis is statistically significant. When compared to the unit saving estimates in Table 2 these values are somewhat different and in most cases that difference is statistically significant. In particular the DHW tank measures are more than double the *ex ante* estimate.

Table 5. Total (Gross) Unit Savings Estimates, Gas Program

	Total Savings Estimate			
	Full CDA Method		Single Measure Method	
Measure	Therms/Cust	N	Therms/Cust	N
Furnace	-145.5†	1459	-150.5†	1272
Insulation	-113.1†	743	-137.4†	536
Windows (gas)	-49.9†	1773	-58.4†	1531
DHW Demand	-60.8†	78	-113.3†	51
DHW Tanks	-19.5*	234	-22.2*	176
Total		3,917		3,566

N = # of accounts
*Estimate not statistically significant at 90% level
†Significantly different from 0 at 95% level

3.4. Net Savings Analysis

The evaluation of program savings impacts can be influenced by aggregate macro-economic conditions that induce an aggregate change in consumption across all Avista gas customers. While the relation

between the savings of individual participants to some aggregate sample of gas customers is somewhat debatable, an effort was made to account for any shifts in consumption that might have occurred in the period 2007 to 2009.

3.4.1. Control Group

In order to determine the impact of macroeconomic effects on overall consumption in the Avista service territory, a control group was drawn from the residential sector gas customers in the period between 2007 through 2009. No incentives or measures of any type were present in this group. The homes were drawn at random with the initial size of the control group being approximately 350 homes. When the same weather normalization and VBDD procedures were applied to this group of non-participants as those used on the participant groups (see Section 3.3) a total of about forty therms of incremental energy savings was observed; seemingly as a result of the combination of the relatively poor economy and changes in gas billing rates in the 2007 period.

This appeared to be a substantial fraction of the claimed savings. To confirm this trend an additional 3,600 bills were then drawn and the exercise was repeated. After using the same bill-screening criteria on the non-participant control group as was used on the participant group (see Section 3.2), the final sample was reduced to 3,186 accounts. This larger group was used to establish the impact of the aggregate consumption shifts on the observed saving and to assess the net savings impacts.

3.4.2. Net Savings Results

To generate a net savings analysis using the control group the CDA regression was repeated with the addition of the control group (all the indicator variables were set to zero). The regression itself was re-specified to include a constant term. The interpretation here is that to the extent the non-participant group (or the participant group) had changes in consumption beyond those attributed to the measures installed under the Avista program.

For the single measure estimates a regression was specified with a single variable for each measure type. This became a two parameter regression when the control group was included in the specification. The constant term of the regression determined the impact of the control group and the net savings of these single measure cases. Table 6 summarizes the results of this analysis.

Table 6. Net Unit Savings Estimates, Gas Program

	Net Savings Estimate			
	Full CDA Method		Single Measure Method	
Measure	Therms/Cust.	N	Therms/Cust.	N
Furnace	-107.9†	1459	-110.4	1272
Insulation	-82.5†	743	-97.4†	536
Windows (gas)	-12.5†	1773	-18.4†	1531
DHW Demand	-33.6*	78	-73.5†	51
DHW Tanks	12.3*	234	17.8*	176
Total		**3,917**		**3,566**

*Estimate not statistically significant at 90% level
† Significantly different from 0 at 95% level

These results are appreciably different from the total savings estimates (see Table 5). The reduction in savings estimates for the individual measures is slightly over 40 therms/customer/year. This is a robust result and, in every regression that used the control group, the constant term that represents the impact of the control group was statistically significant. The savings estimates for the DHW efficient tank measure is not statistically significant, but when it is combined with the control group, it actually changes sign and is assigned a negative savings impact.

The control group is thought to be an index of changes in consumption inside the overall energy requirements, especially heating energy, in the Avista Service territory. Since the analysis first normalized for temperature changes at every site, the apparent change in consumption was thought to be an actual effect of changes in behavior on the part of Avista customers in the 2007-2009 period. If this analysis is used, then the behavior of the control group does act as a major influence in the assessment of gas savings.

3.5. Gas Savings Realization Rates

Table 7 shows the relationship between the gas savings evaluation developed in this evaluation and the gas savings claimed by Avista. This table shows the relationship between the estimated customer level savings developed in the savings analysis and the savings claims used by Avista to calculate the *ex ante* savings for an individual measure.

The most significant reduction from savings claimed to savings actually achieved occurred in the window replacement measure. This measure was influenced by the lack of cooling savings and an absolute reduction in the estimated gross savings. The analysis was unable to develop a significant cooling savings estimate (see Section 4.4). When combined with the underlying trends in gas consumption, as expressed in the net savings, the impact of the window measures is nearly eliminated. It appears that a combination

of program effects and overestimation of the initial saving impacts result in a significant reduction of the impact of this measure.

For the comparison between claimed and evaluated savings shown in Table 7 only the estimation sample was used (see Table 6 for the net savings estimation sample and Table 5 for the total savings estimation sample), except in the case of the water heater measures. In the case of the water heater measures the efficient conventional tank measure was not a significant result in either the CDA or the single measure analysis, and in the case of the demand hot water heaters the CDA net savings analysis was unsuccessful, so the single measure savings were used to calculate the total and net savings.

Table 7. Gas Program Realization Rates (Estimating Sample Only)

	Claimed Savings	Evaluated Savings			
		Total		Net	
Measure	Therms/Cust.	Therms/Cust.	Realization Rate	Therms/Cust.	Realization Rate
Furnace	-123.9	-145.5	1.17	-107.9	0.87
Insulation	-182.5	-113.1	0.62	-82.5	0.45
Windows (gas)	-97.6	-49.9	0.51	-12.5	0.13
DHW Demand†	-56.6	-113.3	2.00	-73.5	1.30
DHW Tanks*	-9.9	0.0	0	0.0	0

* Not statistically significant @ .10

† Demand DHW evaluated using single measure analysis to determine savings

In both the net and total realization rates presented in Table 7 the analytical sample of 4,846 accounts (see "Accounts Realized" in Table 4) developed during the customer attrition analysis) was used to calculate the overall realization rate. When the realization rate is recast using the "Accounts Realized" totals from Table 4 an additional adjustment to the program realization results. Table 8 shows the realization rates that result.

There is one exception here and that is that the net tankless (demand) DHW savings were taken from the single measure analysis. This measure had fewer cases but the single measure saving analysis was more robust. To use this analysis the single measure population (with the cases dropped for statistical reasons added back) was used to calculate the overall impact of the measure. The total realization rate shown in Table 8 represents the application of the results for each measure type applied to the total number of accounts. In effect this is a realization rate for the entire residential gas program.

Table 8. Final Realization Rates (Realized Sites, Realized Savings)

	Realization Rates	
Measure	**Total**	**Net**
Furnace	1.080	0.801
Insulation (Wx)	0.615	0.449
Windows (gas)	0.506	0.127
DHW Demand**	1.259	0.817
DHW Tanks*	0.000	0.000
Total	0.793	0.512

*Savings not statistically significant
**Single measure analysis used to calculated final realization

It is important to realize that the net realization rates are the product of both the program measures and their actual performance in the participating residences and an underlying shift in residential gas use during the analysis period. Given that the factors influencing this shift are likely to shift further as the economy improves or as the relatively volatile gas prices force rate adjustments we have become convinced that the total realization rate is more representative of the performance of the Avista gas program.

4. Impact Evaluation of Electric Savings Measures

An electric savings impact evaluation was targeted for one measure: replacement windows installed in electrically heated homes. This measure is similar to the window replacement measure in the gas program in that it has the same reporting requirements and the same specifications.

The analysis was developed around a single measure which was operated in parallel with the gas savings program. The overall savings claim for the window measures under this program was 1,493,964 kilowatt hours. This was generated by 822 separate accounts with one or more individual applications for replacement windows. This computes to 1,817 kilowatt hours per account. This final savings number coupled with the number of accounts claiming savings under this program form the basis for the computation of electric realization rates.

There were some problems in evaluating the electric savings from the replacement windows measure that were not significant in the parallel gas program:

1. Electrically heated homes are often heated in part by supplemental heat (usually wood). This feature makes weather normalization more difficult. It also reduces the amount of electric heat used in the home, which lowers the measurable electric heating load and creates a problem for estimating savings relative to electric heat alone.
2. There are only 822 unique applications for this measure (as opposed to the 5,077 applications for the gas program), thus, with any significant attrition rate, the size of the sample available to estimate energy savings is relatively small.
3. There were significant reporting issues within the Avista program that made the exact nature of some applications unclear. For example, some applications appeared to have substantial gas loads in the home or their billing pattern suggested new construction.

4.1. Customer Attrition

Table 9 shows the bill screening review of the account records for the savings claims of the 822 accounts with applications for windows in electrically heated homes. 199 of those accounts had gas heat as evidenced by the gas bills that were provided from the utility, and they were dropped from further analysis. In the next screen those applications where an electric bill was not present at all or only in part of the period of analysis (2007-2009) were dropped. Additionally, if there was no electric bill prior to 2008, then we interpreted that to mean that the home was new construction and thus was not eligible for this Avista program. Sixty-seven accounts were dropped from the original 822 applications for missing bills or ineligibility and removed from further analysis. Thus, the total number of cases to begin the evaluation was 556 accounts (see N=556 in Table 9), or 67% of the original number of applications.

In the next screening stage forty-seven of the 556 accounts ready for evaluation failed a billing analysis. These accounts usually had some problem in the structure of their bills (such as with missing bills or other anomalies in the billing record). While these cases were not included in the individual savings analysis they were used in assessing the overall program accomplishments 509 accounts.

These sites were evaluated using the weather normalization procedures discussed in the gas savings analysis in Sections 3.3 and 2.3. As with the gas applications, a heating estimate was made for both the 2007 and before period and for the 2009 period. The difference between these heating estimates was taken as the impact of the window replacement measure.

Using the results of this billing analysis the homes with electric space heat estimates that were less than 5000 kilowatt hours were screened out. This had the effect of reducing the total number of cases but it also had the effect of focusing on those accounts with significant electric heat. The result of this screen was a reduction of 202 cases. The results of both of the last two screens are discussed below. It was assumed that if the larger number could develop a significant savings it would be preferable.

Table 9. Customer Attrition Totals,
Replacement Windows Measure, Electric Savings

Screening Stage	Bills Removed	N	Account Status
0	n/a	822	Total customer accounts delivered with electric claims for window measures
1	-199	623	Total accounts with no gas heating signature (bills with gas heating signatures removed)
2	-67	**556**	Total accounts with bills before 2008 (missing bills and bills for new construction removed)
3	-47	509	Total accounts with successful regression (bills with Failed Billing Analysis removed)
4	-202	307	Total accounts with electric heat signature greater than 5,000 kWh/yr

N = # of customer accounts

4.2. Control Group

Like the gas savings program evaluation a control group was constructed from the original sample of non-participating accounts drawn by Avista and screened to develop electrically heated homes that could serve as a control group for the electric savings analysis. Accounts were removed that had gas bills (many of which were used for the gas saving analysis) to create an "all electric" sample set of homes with only electric bills for the 2007-2009 period. The accounts were further screened following the same screening process as was conducted on the participant applications (see discussion of Table 9 above). A total of 82 non-participating all electric homes were identified in this process. This group was directly parallel to the results of the third screen in Table 9 on the participant group. Using the weather normalization procedures already discussed the change in consumption was developed and this group became the non-participant group in the electric analysis.

4.3. Electric Savings Estimation

Table 10 shows the results of a differences analysis for the accounts with window savings claims. The analysis uses the same procedure as used for the single measure billing analysis in the gas program (see

Section 3.4). For this analysis the accounts that passed all the screens except an electric heat signature were used. For this table all the cases that passed the screen at the third stage (N=509 in Table 9) were used. This screen did not require that the accounts exhibit an indication of electric heat only that they did not have a gas bill.

As can be seen in Table 10, the control group exhibited 690 kilowatt hours of savings between the 2007 and 2009 period. This was then included in a CDA analysis with the control group. A total of 66 kilowatt hours of savings were identified as the net savings for this analysis.

While the individual components of this analysis were significant at the 90% level, when these were combined with the relatively small sample set of participants there were no significant savings identified. This can be attributed to the ambiguity of the heating systems in both the participants and the non participants. It is reasonable to assume that most of these homes use some sort of supplemental heat such as wood, pellets, or propane. Even if these sources represent a fraction of the total heating requirements the impact on the savings analysis can be very significant. Thus, for this group as a whole the electric savings associated with any electric heating measure is uncertain and not distinguishable from the consumption shifts of the non participant group

Table 10. Electric Savings Estimates without Heating Screen

	Savings Estimates		
Source	**kWh/yr**	**N**	**Comment**
Participant Successful Regression Group (no heat screen)	-756.9	509	significant @ .10 level
Control Group (no heat screen)	-690.6	82	significant @ .10 level
Net (no heat screen)	-66.8	588	Not significant @ .10 level

To solve this problem the 2007 normalized electric estimate was screened to limit the analysis to homes with at least 5,000 kilowatt hours of space heat. When this was done, the number of cases was reduced from 509 to 307. The control group was also screened for 5,000 kilowatt hours per year of space heat in order to insure comparability. This resulted in a further reduction in the size of the control group from 82 to 28 electrically heated homes. The total and net savings analysis described above was then repeated using the smaller population with a demonstrated heating load.

The result of this analysis is shown in Table 11. In this case, the total savings from the applications with the window measure was increased to 1,129 kilowatt hours (a 60% increase in savings estimate) while the control group heating consumption change was reduced to 124 kilowatt hours a year. The reduction to the control group's savings estimates resulted in an estimate that was not statistically significant and, when combined with the participants in the CDA analysis remained not significant. For purposes of this analysis the simple differences in the heating load for participant group in Table 11 was then taken as the total net impact on the heating load from the window replacement measures.

Table 11. Electric Savings with Heating Screen

Source	Savings Estimates		
	kWh/yr	N	Comment
Participant Group (with electric heating screen)	-1129.1	307	Significant at 95%. level
Control Group (with electric heating screen)	-124.8	28	Not significant @ 90% level

4.4. Cooling Energy Impact Analysis

In addition to the heating savings, a cooling savings estimate was calculated. Weather-normalizing of monthly cooling-related energy use is difficult for climates such as Spokane's. The cooling season is relatively short, and energy use is often not truly thermostat-controlled, as CDD calculations implicitly assume. To make the task more tractable, only the gas replacement window measures (sites with gas heat) were used to establish per-site cooling savings. This approach allowed the potential interaction between electric heating and air conditioning in the swing seasons to be avoided. Monthly cooling loads in the Avista climates easily overlap with the heating season in months such as May and September. By limiting the analysis to homes with gas heat the change in consumption over the entire potential cooling season could be calculated.

Even restricting the analysis sample to gas-heated sites, CDD weather-normalization proved problematic, with poorly defined coefficients, many response coefficients of the wrong sign, and savings estimates highly sensitive to small changes in screening criteria. We instead opted to compare raw changes in cooling season electric usage for suitably screened sites, with a control group subjected to the identical screening criteria.

Both the gas window measure sites and the control group were screened in two steps:

1. Verifiable gas heating signatures in both 2007 and 2009
2. Complete electric bill series for 2007 and 2009. Several sites were dropped because even though a valid heating estimate was made using gas bills the electric bills were incomplete.

A total of 994 out of 1,953 participant cases met these screens and were included in the analysis. It was our intent to assign the results of this analysis to all valid cases in both electric and gas window replacement applications.

The results of the cooling savings analysis are shown in Table 12. The window measure had a small calculated cooling benefit. The gross cooling savings was 145 kilowatt hours and was statistically significant. The analysis was repeated with the screened nonparticipant group. When this group was included in a CDA regression the net savings impact was reduced to 30.4 kilowatt hours and the result was not statistically significant. Given that the changes in summer consumption were not weather-normalized, including a control group is essential in making sense of the year-to-year consumption change.

Since the participant summer kilowatt hours change net of control group changes was small and not significant, the cooling savings were dropped and not included in the final realized savings from either electric heated or gas heated accounts.

Table 12. Window Measure Cooling Impacts

Cooling Applicants	Savings Estimate	N	Confidence Interval (90/10)	
			low	high
	kWh/yr		kWh/yr	kWh/yr
Window Replacements (Gas)	145.9	994	100.2	191.6
Nonparticipant Energy Impact	115.6	2826	71.5	159.7
Net Cooling Savings*	30.4	994	-48.8	109.6

*not significant at 90% level

4.5. Electric Realization Rates (Window Measures)

It is important to note here that the impact of the window measures on electric heating savings is compromised considerably by the mechanism by which this measure is delivered and the incentives paid. The Avista program does not actively check on the heating system that is used and claimed by the prospective applicants. In other words, there is no mechanism to verify that the homes applying for electric heating incentives are actually electrically heated. The fact that our heating estimate usage in the absence of screening directly for electric space heat (Table 11) did not result in any statistically significant savings, especially when the control group was taken into account, suggests that an approach that does not require any screening or inspection to insure that the applicants are electrically heated, has not been and is not likely to be successful. Once electric heat had been established, even at a reduced rate, these savings become much more significant, with over 62% net realization rate for each individual case. This suggests that if electric heat were the primary or exclusive heating source, then the original savings calculations for window replacements in electrically heated homes were reasonably justified. Since the program does not actually screen for any of the criteria the amount of electric savings is reduced even in places where electric heat is clearly dominant.

The realization rates are reduced as a result of three factors:

1. The reduced space heating savings for the cases that were identified with electric heat.
2. The reduced number of total applications/total number of accounts, for which a savings calculation could be made either because of obvious gas heat identified in the bills or because the heating analysis in the face of alternative space heat or other factor.
3. The lack of identified cooling impact was a small but consistent impact on the final savings estimate.

Table 13 shows the realization rates associated with the electric window replacement program. The original measure of about 1.5 million in kilowatt hours was predicted using an average of 1,817 kilowatt hours per home for the 822 accounts. This is based on the direct claims, which were in turn based on the number of square feet rebated by the window measure. In the evaluated case a total of 307 buildings were evaluated, with an average savings rate of 1,129 kilowatt hours.

The total savings was 346,000 kilowatt hours for a total realization rate of 23%. In stage three of the original bill screening process, forty-seven homes were removed from the analysis because of statistical failures in the billing analysis (see Table 9), not because they were necessarily poor candidates. While the lack of a billing analysis in this group makes it impossible to be certain that electric heat was actually being used in the house, the removed homes have been added back in to the analysis. By adding these extra forty-seven homes back in, the total savings increases, leaving a total realization rate for the window replacement measure at 27%, which can be seen in Table 13 below.

Table 13. Window Measure Realization Rates, Electric

	kWh/cust.	N	Total savings (kWh)	Realization
Claim	1,817	822	1,493,964	
Evaluated	1,129	307	346,603	0.232
Evaluated, Adjusted	1,129	354	399,666	0.268

5. Impact Evaluation of the Low-Income Program

The last phase of the impact analysis was to evaluate the LI program for both gas and electric savings. This program is operated by Community Action Programs (CAPs) under contract from the utility. A total of 454 separate accounts were included in the LI savings claim. Each of these 454 accounts represented a single residential account in which gas and/or electric savings measures were installed. A total of 1,379 individual measures were claimed in the LI program for all the accounts.

5.1. Customer Attrition

The CAP agencies use a variety of gas and electric measures to promote energy savings in the LI program. These measures often include several different weatherization measures as part of the program's overall approach. In addition, health and safety measures, which do not necessarily save energy, but improve the quality of the home for its occupants, are included in the LI program. There were a total of 454 total applications with savings claims. There are three sources for these claims:

1. Electric Measures including refrigerators and weatherization for electrically heated homes.
2. Gas measures including improved DHW tank efficiency and weatherization applied to gas heated homes.
3. Electric-to-gas conversions of furnaces or electric DHW tanks. These measures largely overlapped with each other and sometimes overlapped with weatherization measures for both electric measures and gas measures (including electric-to-gas conversions).

Two-hundred seventy-three applications were identified as gas heated homes dominated by gas measures; including 88 applications that had electric-to-gas DHW conversions. One-hundred eighty-one accounts were identified as electrically heated homes with electric savings measures, but 33 of these applications also included homes that were converted to gas heat as part of the 2008 LI program. A total of 90 separate accounts converted their furnace and/or their DHW from gas-to-electric. All but two of the furnace conversions included a conversion to gas DHW. These categories were analyzed separately to establish the impacts of the three components of the LI program.

Table 14 summarizes the development of the evaluation sample for the LI program. There is some overlap in how the accounts were counted: where conversions were made that also included additional gas measures (such as weatherization) the account appears in both the conversion category and in gas savings category. As with the previous sections of this report, customer attrition is due in part to missing or partly missing bills from the 2007-2009 period and from the missing or combined bills that preclude a VBDD (see Section 2.3). After removing inapplicable bills, 383 accounts remained (both electric and gas).

The next factor in the attrition process was screening by heating type. There was some confusion in the accounts as a result of gas savings measures filed for buildings with no evidence of gas heat, or similarly misfiled electric measures. After these were removed, 372 accounts remained. The final estimation sample was established after removing homes that failed to produce useable weather normalized heating estimates.

The estimation sample represents all the LI applications that could be used in the regression analysis. However, the "Bills Available" account set of 383 accounts was used to develop the final realization rate for the LI program. The difference between the estimation sample and the realized population was the result of three factors:

1. Missing bills in the 2007 or 2009 period that were the result of occupancy changes not corrected in the LI program.
2. Partial missing bills that compromised the regression analysis but had otherwise received the measures and probably achieved equivalent savings to the homes included in the estimation sample.
3. Electric-to-gas conversions that did not have gas service prior to the conversion. This affected only those accounts that had additional gas savings measures applied to the converted heating system.

Table 14. Low-Income Attrition

	Accounts			
	Gas	**Electric**	**Conversions**	**Total**
Saving Claims	255	156	90	454
Bills Available	222	117	80	383
Proper Heat Type	221	108	79	372
Estimation Sample	156	81	63	274

5.2. Total Savings Analysis

The ability to estimate significant coefficients in the CDA regressions for the LI program following the methodology outlined in Section 2 was severely limited for particular efficiency measures. For the most part the small sample (and small savings impacts) precludes the possibility of estimating individual measure coefficients. This is not true of the conversions, however. Both the electric savings impacts and the gas use impacts of these conversions are large and estimating their impact with a CDA analysis proved effective. As a result a hybrid approach to the savings estimation was developed.

The conversion measures were estimated with the CDA approach used in the gas programs evaluation (Section 3) and the remaining impacts, both gas and electric, were estimated using an aggregation of the VBDD results that combined all the other measures. To do this the estimated impacts of the conversions were removed arithmetically from the electric saving estimates to develop the estimated impacts from the other measures. The gas savings estimates were computed with the remaining gas sample excluding the conversion cases.

Conversions, Electric-to-Gas

The major savings claim for the electric measures was the fuel conversions for both heating and DHW. Together these two measures represented 49% of the LI program electric program savings claims. While these savings are substantial they also result in an increase in gas usage that corresponds to a reduction in electric usage. Table 15 shows the result of the CDA estimates of the consumption patterns brought on by the conversions of the heating and/or the DHW systems. The realization rate shown reflects the savings in the sites analyzed only and not the impacts of attrition within the LI program.

Table 15. LI Conversion

	Claim		Conditional Demand Estimates				Site Realization (Elect. 0nly)
Conversion	N	kWh/cust	N	kWh/cust	Standard Error	Gas Impact th/cust	
DHW	88	-5548	80	-4318.2	650.4	68.4	0.778
Heating System	33	-12687	32	-8840.9	1119.4	519.3	0.697

All but two of the heating system conversions included a DHW conversion to gas. The remaining DHW conversions were conducted on homes that already had gas space heat and thus gas service. In the case of DHW conversions it is apparent that this measure was generally applied to a home with gas heating; 40% of these homes received additional conservation measures. This group was removed from the estimation of the gas measure savings since the impact of the DHW conversion swamped the consumption change in these homes. These cases were used in calculating the overall realization rate as though they had similar impacts to the remaining estimation sample.

Measure Savings, Gas and Electric

The same screening criteria as was used on the gas and electric measures in the "Every Little Bit" program (Sections 3 and 4) was used to evaluate the remaining measures in the LI program. Screening the accounts was complicated by some confusion as to the heating fuel used in the home. We identified homes with electric measures coupled with substantial gas usage, as well as homes with both electric and gas heat savings measures. All of these accounts were removed from the analysis and from the final assessment of the savings claims.

Table 16 shows the savings impacts from the LI program measures. This analysis was conducted on the homes that did not receive any conversions. The estimation sample from Table 14 was altered to remove all homes that had DHW conversions that also had weatherization measures. These measures were added back to the final N used in calculating the program accomplishments. Since N was calculated by comparing two weather normalized years – the 2007 pre-period and the 2009 post-period – all these cases use the same weather normalization procedures and average weather years that were used in the gas heated homes; namely, 2007 as the base case for the pre-case and 2009 for the post-case.

Table 16. Low-Income Program Savings Impacts

Electric				
	kWh/cust.	**N**	**Total Savings (kWh)**	**Realization**
Claim			948,427	
Evaluated	2,861	108	308,934	0.326
Evaluated, Adjusted	2,861	117	334,679	0.353
Gas				
	th/cust.	**N**	**Total Savings (th)**	**Realization**
Claim			110,655	
Evaluated	113	156	17,566	0.159
Evaluated, Adjusted	113	222	24,997	0.226

The savings shown in Table 16 are net of the conversion effects. Thus, the impact of the gas usage that resulted from a conversion was not included in describing the overall accomplishments of this program. In the estimation sample where some conversion overlapped the gas weatherization measures the gas use increase was about 97% of the savings estimated from the consumption estimated by the VBDD regression analysis. The gas savings and realization from this table represent the total evaluated gas savings from the LI program. The electric impact and realization do not include conversions.

5.3. Control Group

Only the gross savings were calculated for the low-income group, because we did not have a readily available control group. Given the size of this program, we suspect that a practical control group could not actually be constructed without doing a careful physical match between the various customer groups and similar groups that were not treated under the program.

5.4. Overall Realization Rates

Because the electric impact is a combination of conversions impacts and electric measures applied across the remaining program, a separate realization rate was calculated to combine these two program elements. The gas realization rate developed for Table 16 was used without modification. For the conversions the electric heat signature was estimated from the 2007 bills (before the conversion) and the savings were estimated from that heating signature and the change in electric consumption between the two years. The final realization rate combined these two components of the electric savings to get a final realization rate for the LI program. Table 17 summarizes this result.

Table 17. Electric LI Realization Rates

	Claimed	Evaluated	Realization
	kWh/cust.	kWh/cust.	
Measures	948427	334679	0.353
Conversions	906965	628365	0.693
Total	1855392	963043	0.519

In calculating the final realization rate the savings estimated were applied to all the cases where a conversion could be identified in the bills even if the size of the electric heating signature was small in the pre-period. Cases were only dropped altogether if there was evidence of gas heating in the pre-period. These accounts were added back into gas savings analysis and included in the final realization calculation.

The non-participant group developed for the electric and gas measures was not appropriate to the low-income clients of this program. As a result these final gross realization rates were elected as the evaluated savings for this program. The overall realization rate, however, suggests a combination of issues with the savings claims as calculated by the contractors, and suggests that there were reporting issues that overestimated the impacts of various components of the LI program.

6. Program Impacts, All Programs

The measures evaluated in this impact evaluation of Avista's "Every Little Bit" Home Improvement Incentive Program and Low-Income Program were divided into three categories:

1. Residential gas savings (all measures);
2. Electric savings (window replacement measures only);
3. Residential gas and electric savings in the Low-Income program (all measures).

These measures were evaluated using similar methods, but the final impact analysis and realization rates for each were based on the unique conditions of each program.

6.1. Gas Realization

The primary issue with the gas impact evaluation was the presence of significant consumption shifts in the large control group. The control group represented the actual consumption trend among Avista residential gas customers from 2007 through 2009. This period included a major recession and a significant increase in gas rates brought on by the volatility in the market for natural gas. Not surprisingly, these macro-economic effects resulted in an underlying a reduction in gas consumption in Avista's service territory.

While the results with and without the control group are reported as the net realization in Table 18 through Table 20, it should be pointed out that macroeconomic effects actually are the results of changes in behavior brought on by economic or other factors, and are, by definition, transient. In the event that the macroeconomic factors change, the apparent changes in consumption and net savings would drift back to original consumption patterns once more. This would not be true of the participants, since they have changed the underlying efficiency of their homes as a result of the measures installed under the Avista program.

In contrast to the control group, the participant group's observed improvements in efficiency were the result of actual efficiency improvements to the physical structure of their homes or improvements in the heating system of their home, which were supported, in part, by the Avista incentive programs. These improvements stem from permanent physical changes to the homes, rather than from behavioral changes by the inhabitants (as in the control group). Therefore, the savings observed in the individual measures should not be decremented by the control group. Nevertheless, the impact of the gas savings measures in the Avista savings program is reported both with and without the control group.

A second issue in developing the overall realization rate for the gas programs was the performance of the two classes of DHW measures. The DHW tank upgrade did not develop a significant savings estimate in any of the methods used. With the addition of the control group the sign of the savings actually changed (although it was not statistically significant). For the demand DHW measures the impact of the measure itself was potentially quite large, thus a significant estimate was developable through the analysis. Even though these estimates varied substantially, the savings analysis of the single measure analysis were the most likely to reflect the true savings from all of the gas savings measures under evaluation.

Table 18 summarizes the results of the gas savings impact analysis over the entire Avista service territory using the final realization rates from Table 8. This table incorporates the impacts of site attrition as well as the site impact realization rates. Table 19 shows the evaluated savings from gas measures applied to the Washington portion of the Avista Service territory. Table 20 shows the evaluated savings from gas measures applied to the Idaho portion of the Avista service territory.

Table 18. Total Gas Savings by Measure Type, Avista Service Territory

Measure Type	Savings Claim	Realization	Net Realization	Total Savings	Net Savings
	Therms			Therms	Therms
Furnace	294,744	1.080	0.801	318,294	235,994
Insulation (Wx)	156,621	0.615	0.449	96,361	70,301
Windows (gas)	190,683	0.506	0.127	96,460	24,136
DHW Demand	7,020	1.259	0.817	8,837	5,733
DHW Tanks*	3,052	0.000	0.000	0	0
Total	652,120	0.797	0.515	519,951	336,141

Table 19. Total Gas Savings by Measure Type, Washington

Measure Type	Savings Claim	Realization	Net Realization	Total Savings	Net Savings
	Therms			Therms	Therms
Furnace	208,434	1.080	0.801	225,088	166,888
Insulation (Wx)	122,497	0.615	0.449	75,366	54,984
Windows (gas)	150,160	0.506	0.127	75,961	19,007
DHW Demand	4,200	1.259	0.817	5,287	3,430
DHW Tanks*	2,480	0.000	0.000	0	0
Total	487,771	0.797	0.515	388,911	251,426

Table 20. Total Gas Savings by Measure Type, Idaho

Measure Type	Savings Claim	Realization	Net Realization	Total Savings	Net Savings
	Therms			Therms	Therms
Furnace	86,310	1.080	0.801	93,206	69,106
Insulation (Wx)	34,124	0.615	0.449	20,995	15,317
Windows (gas)	40,523	0.506	0.127	20,499	5,129
DHW Demand	2,820	1.259	0.817	3,550	2,303
DHW Tanks*	572	0.000	0.000	0	0
Total	164,349	0.797	0.515	131,039	84,715

6.2. Electric Realization

Table 21 summarizes the results of the savings impact analysis done on the electric efficiency measures aimed at replacement windows under the "Every Little Bit" Home Improvement Incentive program.

This table divides the total evaluated savings between Washington and Idaho proportionally to the overall realization rate and the separate savings claims for each state. Unlike in the gas measures' analysis, the

electric measures' net savings analysis did not develop a statistically significant adjustment, so the net realization rates were not calculated. Cooling savings claims for this measure were not statistically significant, so the final realization applies to the entire claim even though a portion of that claim assumes some impact on the air conditioning energy in the home.

Table 21. Electric Savings, by State and Full Territory

Measure Type	Territory	Savings Claim	Realization	Total Savings
		kWh		Therms
Replacement Windows	All Avista	1,493,964	0.268	400,382
Replacement Windows	Washington	1,001,634	0.268	268,438
Replacement Windows	Idaho	492,330	0.268	131,944

6.3. Low-Income Realization

The entire Low-Income (LI) program was evaluated for both electric and gas savings. The savings claims and realization rates were divided into three categories: gas savings in gas heated homes, electric savings in electric heated homes, and electric savings that resulted from conversion of space heat and/or water heat from electric-to-gas.

The control group's statistical relation to the program participants was not statistically significant. The dominant savings impact for the Avista LI program was heating and DHW fuel conversions from electric-to-gas. This measure was only applied in Washington. The savings claims for this conversion measure do not take the gas use that results from the conversion into account. The tables presenting the overall accomplishment of the LI program also do not include those impacts in the final savings estimates.

The realization rates were applied to all electric and gas savings claims. For some measures the analysis neglected small savings claims in the alternative fuels. The Health and Safety measures, for example, were assigned savings. This was a small savings and these measures were not included in our analysis. They were, however, included in the total claimed savings and they were adjusted by the realization rate. In a few cases the savings claim did not correspond to the fuel type. These savings were included in the savings claim but they were removed from the analysis. In these tables, the realization rate includes the impact of dropping those cases.

Table 22 shows the total impact of the LI programs on the entire Avista service territory. Table 23 and Table 24 show the distribution of savings claims and total evaluated savings estimated from this analysis for Washington and Idaho respectively.

Table 22. Total Energy Savings, Low-Income Program

Measure Type	Claimed Savings		Realization	Total Savings	
	Electric	Gas		Electric	Gas
	kWh/yr	Therms/yr		kWh/yr	Therms/yr
Furnace Conversions*	418,681		0.676	282,916	
DHW Conversions*	488,284		0.708	345,498	
Electric Measures	948,427		0.353	334,678	
Gas measures		110,663	0.226		24,999
Total	1,855,392	110,663		963,093	24,999

*excludes 22090 therms of gas use to replace electric equipment

Table 23. Total Energy Savings, Low-Income Program, Washington

Measure Type	Claimed Savings		Realization	Total Savings	
	Electric	Gas		Electric	Gas
	kWh/yr	Therms/yr		kWh/yr	Therms/yr
Furnace Conversions*	418,681		0.676	282,916	
DHW Conversions*	488,284		0.708	345,498	
Electric Measures	652,750		0.353	230,341	
Gas measures		98,647	0.226		22,285
Total	1,559,715	98,647		858,755	22,285

*excludes 22,090 therms of gas use to replace electric equipment

Table 24. Total Energy Savings, Low-Income Program, Idaho

Measure Type	Claimed Savings		Realization	Total Savings	
	Electric	Gas		Electric	Gas
	kWh/yr	Therms/yr		kWh/yr	Therms/yr
Furnace Conversions*	0		0.676	0	
DHW Conversions*	0		0.708	0	
Electric Measures	295,677		0.353	104,338	
Gas measures		12,016	0.226		2,714
Total	295,677	12,016		104,338	2,714

7. Conclusions and Recommendations

This evaluation only examined the impacts of gas and select electric measures in two of Avista's residential incentive programs ("Every Little Bit" Home Improvement Incentive Program and the Low-Income Program). The evaluated savings raise issues about the overall performance of these energy efficiency programs that should be considered in their future evolution. The following recommendations are based on the impact evaluation documented in this report, as well as on lessons learned from an earlier savings audit of the same programs (Ecotope, 2010). The observations that appear in this section of the report are organized by measure category and are meant to apply to all the programs evaluated.

In general, the primary lesson from the current impact evaluation is the need for better oversight and quality control in delivering Avista's residential energy efficiency programs, especially in the insulation and window replacement measures where the realization rates are unacceptably low. These results suggest that the program should be redesigned to ensure a minimum cost-effectiveness in these measures through better on-site quality control or better oversight of the contractors delivering these services.

The equipment measures, such as efficient furnace upgrades and conversions, perform much better than the insulation and window measures. This suggests that contractors delivering equipment measures have an independent procedure for insuring a quality installation. Additionally, the relatively good performance of the equipment measures suggests that they do not need as much improvement as the weatherization measures. Therefore, the following recommendations focus on those measures and programs with low realization rates (even where those measures are well established in other utility programs).

Replacement Windows

These measures were designed to provide Avista customers with an incentive to replace their existing windows with modern windows that meet or exceed the Washington State Energy Code standards. The program is designed to allow a homeowner to select their own windows and submit an invoice based on window size. The utility processes this request and sends an incentive check. While the program is designed to provide incentives to homeowners, it is used by many types of people: contractors who are involved in remodels and rehabilitation of existing homes; weatherization crews trying to address windows and insulation in an existing home to improve its efficiency; and do-it-yourself homeowners who purchase windows at a hardware store or home improvement center and install them. These mechanisms provide an effective delivery mechanism for the actual windows but there is no apparent quality control beyond that provided by the homeowner who files for the incentive.

The total savings impacts (on a per site basis) are about 50% of the anticipated savings in gas heated homes. In electric "heated" homes, the savings impact is eroded by the uncertainty of the heating system fuel. It appears that a high percentage of the electric heated homes with window replacement claims did not use a significant amount of electric heat. In some cases this could have been the result of some confusion in the application (e.g. where the customer checked a wrong box). But in most cases the use of some sort of supplemental fuel (not gas) would be the only explanation. This confusion over the actual heating energy used reduces the realization rate for this measure to about 25%. No measure can survive a cost-effectiveness test with such a realization rate.

If the replacement window measures are to remain as part of a cost-effective program, then a considerable change in program design would be necessary. Here are three recommended strategies:

1. Limit participation in the program to contractor installed window measures. Contractors should apply for the right to participate in the program. They should be reasonably experienced at home

remodel and rehabilitation or at home weatherization. It should be made clear to them that Avista is providing the incentives to improve the energy efficiency of the home. If new windows (not actual replacements of existing windows) are to be allowed they need to be incented separately; the application should clearly separate replacement windows from new windows installed in new openings.

2. Window replacement applications should be limited to window areas that imply a significant fraction of the glazing in a home. One hundred square feet (or more) might be considered a minimum area for an application under this program.
3. A limited utility-sponsored or utility-administered quality control program should be instituted. Contractors should know that one out of 10 or one out of 15 of their applications will be inspected by the utility. In the 2008 program this would amount to about 125 inspections of window jobs over the whole year, which would improve both the quality of the installations and the correct reporting of space heat type. However, in 2008 in excess of 50% of the applications would not be eligible under one of the above proposed criteria (accounting for about 20% of the claimed savings).

The above suggested changes may not be sufficient to develop cost-effective window measures in the Avista service territory, but they would greatly improve the possibility of a positive evaluation. The impacts of such applications should be large and the installation would be reasonably likely to meet Avista specifications.

Insulation and Weatherization

The insulation and weatherization measures evaluated mostly came from gas heated homes in the "Every Little Bit" Home Improvement Incentive Program, and a much smaller group was evaluated from the Low-Income (LI) Program. In both these programs the performance of individual sites (not including site attrition for one reason or another) created a realization rate of about 60%. This rate does not take into account the homes with very low space heat loads (especially in the LI program). This performance suggests that some redesign is needed to improve performance. Here are three recommended changes:

1. Limit the use of DIY in the insulation applications. In our verification work for the 2009 program the number of insulation applications submitted were minimal. It would be beneficial, however, if established weatherization contractors, or general contractors with experience in these measures, were required to make the incentive application. This would allow Avista to vet contractors and ensure some more predictable performance in these installations.
2. The weatherization measures should be subject to some quality assurance inspections. These could be only 5% or 10% of the applications. These inspections would provide both an incentive to the contractor and feedback to the utility on the progress and success of the program.
3. The Low-Income measures are somewhat different. In those cases the CAP agencies are like Avista contractors. This contracting mechanism with the providers should provide an avenue to improve quality control by discussing the need for more reliable savings from the program.

DHW Upgrades and Conversions

The DHW tank upgrade program does not appear to offer any reliable savings to the utility. It seems unlikely that any mechanism would result in a reliable savings from this measure unless the target efficiency for the incentive was raised considerably above current practice.

As a practical matter such a measure is already in the Avista program. The demand water heaters seem to show a great deal of promise in this evaluation. Total savings appears to be very comparable with the savings claims and in some cases somewhat better than claimed savings. With the demand water heater a careful review of products as they come into the market is probably needed especially given the number of new products and efficiency claims. Given the size and reliability of these savings a modest attention to equipment specifications would probably ensure an expanding role for this product in the Avista savings program.

Equipment Upgrades and Conversions

By far the most effective measures in this evaluation were the furnace upgrades and conversions. These measures require the use of licensed contractors and are well within the standard practice of the HVAC contractors that install these technologies. If anything is to be learned, it is that established contractors can be expect to deliver installations that meet specifications and have some quality control..

It should also be pointed out that equipment measures do not address underlying efficiencies in customer homes. It is not likely that HVAC contractors in the current program design would help identify or address other measures in a home. If the opportunity to do so was present or encouraged, then other measures that address insulation or duct sealing might be identified.

Other Observations

The residential programs evaluated here show some disappointing results. It should be pointed out however that these programs are almost all self-administered. The utility accepts the customer's assessment of both the nature of the claimed installation and the assessment of space heat in the home. Much of the difficulties with the realization rates can be traced to this approach. When compared to Avista's commercial/industrial (C/I) program virtually no comparable level of oversight by the utility is present in the residential programs. This is in part the result of a lack of technical resources inside the utility to actually address a quality control step in the residential sector. In the C/I program, by contrast, the program has substantial engineering oversight ranging from inspection to engineering to specification review. The C/I could not be transferred directly to the residential sector, but could inform the design of future residential programs. The use of more program oversight from the utility is feasible but would require additional technical resources.

The utility might require one or two specialists that are not currently available to implement the quality control and coordination suggested. Given the potential to substantially raise these realization rates, the savings from the gas program alone would likely approach 250,000 therms, level of savings now claimed, but not achieved. Adding capacity to address this savings would be very important to improving the overall performance of the programs in the residential sector.

Appendix A

CDA Methodology; Regression Specifications

Our basic analytic approach is to compute weather-normalized total annual consumption (NAC) for program participant sites (and a nonparticipant control group) before and after the installation of measures, and explain the change in NAC as a function of installed measures. In addition a control group of nonparticipants was developed and the methodology was designed to take account of the changes in consumption in that group. The net of the NAC difference observed in the nonparticipant control group, using a form of conditional demand analysis (CDA), was included in the net regressions to adjust the estimates of the savings from the measures and take account of the underlying shifts in consumption among Avista customers. The consumption takes the form of gas or electricity, depending on the measures in question; the effects for each energy source are estimated separately. Our presumption is that the program measures were installed some time in calendar year 2008, but we do not know exactly when. We compute "before" NAC using billed consumption from calendar year 2007, and "after" NAC consumption using calendar year 2009. Individual sites are mapped to a nearby source of weather data[1]. NAC is computed using standard variable-based-degree-day (VBDD) regression methodology[2]. We apply the identical NAC methodology to a control group of nonparticipants randomly selected from Avista's customer database.

Gas Savings Measures

We group individual measures (as defined by measure codes) into broader categories for purposes of creating explanatory variables. For residential gas conservation measures, the following groupings are used:

Code	Utility Description	Grouping for Gas CDA
RE4	G HE FURNACE	furnace
RE5	G HE BOILER	furnace
RE6	G HE WH 40G	DHW Tank
RE7	G HE WH 50G	DHW Tank
RE9	G INS - CEIL/ATTIC	insulation
RED	G INS - FLOOR	insulation
REF	G INS - WALL	insulation
RR0	G HE WH TANKLESS	tankless DHW
RRC	G REPLC WINDOWS	window
RRE	G REPLC WINDOWS	window

[1] Either a station maintained directly by the US Weather Bureau or a cooperating weather station. Twelve separate weather stations are used to cover Avista's service territory.

[2] See Fels (1986) or Geraghty et al. (2009) for a brief explanation of the methodology.

For our participant sites we create a set of indicator variables for each of these measure groupings, set to 1 if the site installed (received a rebate for) one or more measures in that particular measure grouping, and set to 0 if no measures in that grouping are present for that site. Possible multiplicity of measures does not affect the value of the indicator. For example, if a site has both floor and wall insulation measures, the value of the "insulation" indicator is set to 1, not 2. For the nonparticipant control group, the value of all these measure indicator variables is of course 0. These indicator variables are then used as the explanatory variables in a linear CDA regression with the dependent variable being the before-to after change (delta) in NAC. For the above residential gas measure participants, the resulting regression equation is as follows:

Where the subscript j refers to site j, and ε_j is an independently distributed error term for that site. This regression equation is fitted to the data (the participants and control group jointly) by choosing the six β (coefficient) values which minimize the sum of squared errors.

Because all the explanatory right-hand side variables are indicator variables with a value of 0 or 1, the β coefficients have an interpretation as conditional means, that is, the expected change in NAC due to the presence of a particular measure class at a site. The constant term β_0 is the expected change in NAC observed in the absence of any measures, that is, the expected NAC change for the control group. The expected change in NAC at a site with, e.g. a furnace measure and some insulation measures but nothing else, would be $\beta_0+\beta_1+\beta_2$.

This specification assumes that there are no savings interaction effects between different classes of measures installed at the same site. This is an *a priori* defensible assumption for the interaction of certain classes of measures—for example, there is no obvious mechanism for hot water heater replacement measures to interact significantly with envelope measures—but for others, notably furnace and insulation measures, the possibility of significant interactions should at least be explored (basic heat loss arithmetic implies that the joint savings from installing both classes of measures should be less than the sum of individual savings if only one class were installed at a site). In fact as an experiment we created a furnace-insulation interaction indicator (set to 1 if both furnace measures and insulation measures were claimed at the site, 0 otherwise) and added it to the above regression specification. Although the resulting coefficient was of the expected sign (positive, implying a reduction in savings), it was not statistically significant, and did not appreciably shift the estimated values of other coefficients, so in the interests of parsimony we excluded it from the final specification

Electric Savings Measures

For residential electric savings measures, the situation is in some respects much simpler, and in others more complex. The only measures which claim electric savings are replacement window measures: The "gwindow" measures already noted in the context of gas savings regressions (replacement windows installed in gas-heated houses), and the analogous "ewindow" measures (replacement windows installed in electrically heated houses). The "gwindow" measures claim electric savings because they are presumed to reduce energy consumption for summer cooling, which takes the form of electricity, even in gas-heated houses. "ewindow" measures claim savings for reductions in both winter electric heating consumption and summer electric cooling consumption. Thus, although there are far fewer electric savings measure categories to contend with than was the case with gas measures, there is the problem of estimating both summer (cooling) and winter (heating) effects. Our strategy for estimating these various savings

components is to estimate them in separate regression specifications. To estimate the effect on electric heat consumption of "ewindow" measures we use the very simple regression specification:

Where β_0 is the expected change in NAC observed in electrically heated houses in the absence of any measures, and $\beta_0+\beta_1$ is the expected change in NAC in electrically heated houses (ignoring any reduction in summer cooling load) which have installed one or more window replacement measures. The before-and after NAC estimates used to create the left-hand side ΔNAC terms in this regression are calculated with VBDD regressions including only heating-degree day terms, not cooling-degree-day terms. Because the VBDD methodology employed here excludes from the regressions any 0-heating-degree day (HDD) consumption months (which are also the months where most cooling would occur), the VBDD regression coefficients are largely insulated from biases which would result from summer cooling loads.

To estimate reduction in summer cooling loads, we estimate the very similar regression specification:

Where ΔNAC terms in this regression are calculated with VBDD regressions including only cooling-degree day terms, and we restrict the participants to "gwindow" (gas-heated) sites. Our reasoning is that the easiest way to isolate estimates of summer cooling loads from winter heating consumption is to perform the estimation on bill streams which do not embody any winter heating load (as is the case with electric bills in gas-heated houses). Our experience with joint estimates of HDD and CDD effects in a single VBDD regression specification using monthly data(such as one might fit to electric bills from a house with both winter electric heat and summer cooling) is that the regressions often appear ill-specified, and fit the data poorly. Cooling energy use in most parts of the inland northwest, including the Avista service territory, is intermittent and might occur to a notable degree for only a couple of months a year; it is not very fruitful to fit a two-parameter model to , in effect, two monthly data points. The chances of getting meaningful CDD response coefficients are greater if any cooling consumption in shoulder-season transition months is not contaminated by heating in the same month.

Although we thus use only gas-heated sites to estimate reductions in summer cooling load due to window retrofits, we assume that identical or very similar reductions occur at electrically heated sites, although we do not have good tools or techniques to measure these reductions directly using monthly billing data.

Low Income Measures

A similar analytic approach is used on the low-income residential programs. Compared to the regular residential conservation program, there are more measures, and a comparable number of measure groupings. Gas measure groupings for CDA are as follows:

program code	Utility description	grouping for CDA
L19	G HE WH 40G	gas conventional water heater (gcwh)
L20	G HE WH 50G	gas conventional water heater (gcwh)
L21	G INS - CEIL/ATTIC	gas heated envelope excluding doors and windows (genvelope)
L22	G INS - DUCT	gas heated envelope excluding doors and windows (genvelope)
L23	G INS - FLOOR	gas heated envelope excluding doors and windows (genvelope)
L24	G INS - WALL	gas heated envelope excluding doors and windows (genvelope)
L29	G AIR INFILTRATION	gas heated envelope excluding doors and windows (genvelope)
L10	G ENERGY STAR WINDOWS	gas heated envelope--doors and windows (gdoorwind)
L12	G ENERGY STAR DOORS	gas heated envelope--doors and windows (gdoorwind)
L18	G HE FURNACE	gas furnace (gfurn)
L13	E TO G FURNACE CONVERSION	conversion to gas furnace (egfurncnv)
L14	E TO G H2O CONVERSION	conversion to gas water heater (egh2ocnv)

Note that two of the measures (each its own "measure group" for CDA purposes) are actually electric-to-gas fuel conversion measures, which are not gas conservation measures; in fact they would be expected to increase measured gas consumption at a site (For program evaluation purposes they are considered electric conservation measures.). However, they need to be included in gas CDA regressions since some sites with these conversion measures also have gas conservation measures which apply to the gas heating in the post-period. For example, a previously gas-heated site might get a rebate for electric-to-gas hot water conversion and at the same time install rebated envelope measures. Without taking into account the new gas consumption from the hot water conversion, one might conclude that the envelope measures actually resulted in a significant increase in gas consumption. The resulting low-income gas measures CDA regression specification is:

Note that, unlike the regular residential program CDA specifications, there is no regression constant $\beta_{0.}$ This lack is due to the fact that we have no non-participant low-income residential control group available and comparable to that available for regular residential conservation programs. We are thus unable to estimate with accuracy any systematic tendency for low-income residential customers to change NAC over the period in question, independent of program participation. We are, in effect, making the convenient assumption that there is no such tendency, or, put differently, the low-income programs get the credit for it should it happen to exist.

For low-income electric conservation measures, we use the following groupings:

Program Code	Utility Description	Grouping for CDA
L01	E HE WH	electric conventional water heater (ecwh)
L02	E INS - CEIL/ATTIC	electrically heated envelope excluding doors and windows (eenvelope)
L03	E INS - DUCT	electrically heated envelope excluding doors and windows (eenvelope)
L04	E INS - FLOOR	electrically heated envelope excluding doors and windows (eenvelope)
L05	E INS - WALL	electrically heated envelope excluding doors and windows (eenvelope)
L28	E AIR INFILTRATION	electrically heated envelope excluding doors and windows (eenvelope)
L08	E ENERGY STAR REFRIGERATOR	refrigerator (erefrig)
Program Code	**Utility Description**	**Grouping for CDA**
L09	E ENERGY STAR WINDOWS	electrically heated envelope --doors and windows (edoorwind)
L11	E ENERGY STAR DOORS	electrically heated envelope --doors and windows (edoorwind)
L13	E TO G FURNACE CONVERSION	conversion to gas furnace (egfurncnv)
L14	E TO G H2O CONVERSION	conversion to gas water heater (egh2ocnv)

These specifications lead to the following CDA regression specification for low-income electric conservation measures:

There is no constant term here because there is no suitable control group was available. Also note that the fuel conversion measures appear in this regression, as in the gas CDA regression, but the interpretation is different. In this case the conversion measures are bona fide electric conservation measures, with potentially rather large negative coefficients (reflecting, for example, the significant reduction in electric consumption due to conversion of the heating system).

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