Long Term Study of Pennsylvania's Low Income Usage Reduction Program: Results of Analyses and Discussion

Consumer Services Information System Project
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Long Term Study of Pennsylvania's Low Income Usage Reduction Program: Summary of Key Findings

Pennsylvania's Low Income Usage Reduction Program (LIURP) is a statewide program designed to help low-income households reduce their energy bills and energy consumption through weatherization and education. The program is overseen by the Pennsylvania Public Utility Commission and implemented by individual electric and gas distribution companies. Households with high energy bill arrearages and high energy consumption are targeted for services. Since the program's inception in 1988, over $330 million have been spent on weatherization treatments for more than 292,071 households in Pennsylvania.

Ongoing evaluation has been built into the LIURP process since its initial implementation. Accordingly, companies collect data on each LIURP household for the thirteen month period prior to and following the installation of weatherization treatments. These data are reported to the Pennsylvania Public Utility Commission on a yearly basis. This report analyzes data for all households receiving LIURP from 1989 through 2006. Our analyses concludes that LIURP is a cost-effective method of reducing both energy consumption and energy bill arrearages but there is also room for possible modifications. The following is a summary of the key findings:

Profile of LIURP Households

- The head of the typical LIURP household is a 47 year old white female, with a high school diploma, who owns her home. She earns an average annual income of nearly $12,000 and has an arrearage on her energy bill.
- The average energy burden for LIURP households is 15.3 percent of annual household income, compared to 4 percent for all households nationwide.

Reduction of Energy Consumption

- Sixty-nine percent of LIURP households reduce their energy consumption following weatherization treatments, with an average reduction of 16.5 percent.
- Thirty-one percent of LIURP households experience no change in energy consumption or increase their energy consumption following weatherization, with an average increase of 19.9 percent. This is referred to as the "rebound" or "take-back effect," and has been attributed to a variety of factors, including correcting heating levels in households that did not heat properly prior to weatherization, and increases in family size.

- Small multi-unit households are most likely to increase their energy consumption following weatherization.

- Households receiving gas heating jobs are least likely to increase their energy consumption following weatherization.

- The greater the energy consumption in the pre-weatherization period, the greater the potential for energy savings. The amount of household energy usage in the pre-period is one of the factors most strongly associated with reductions in energy consumption.

- The greater the energy bill arrearage in the pre-period, the greater the reductions in energy consumption.

- The more residents in the household, the less the reduction in energy consumption.

Energy Conservation Treatment Measures

The most common measures used in the various weatherization jobs are:

Installation of more efficient lighting and lighting fixtures
Pipe insulation
Walk-through or pre-weatherization energy audits, without blower doors
Faucet aerators installed in either the kitchen or bath
Miscellaneous chimney, window and electrical repairs
Removal/replacement of old refrigerators/freezers with energy efficient models
Installation of low-flow showerheads
Furnace maintenance

- Removing or replacing inefficient refrigerators or freezers is the greatest contributor to reductions in electric energy consumption.

- Installing more energy efficient lighting is associated with reductions in electric energy consumption.

Costs of Weatherization Measures

The greatest amount of variance in energy usage from pre to post-period can be explained by examining the costs of the weatherization and energy conservation treatment measures, as opposed to the actual use of them.

- Side wall and attic insulation costs are positively associated with reductions in both electric and gas energy usage.

Reductions in Arrearage

- Of those households with energy bill arrearages, 40 percent reduce their arrearage following weatherization services.

- Thirty-seven percent of electric industry households reduce their arrearage, compared to 54.4 percent for the gas industry.

- The number of residents in the household is negatively associated with reductions in arrearage.

Energy Conservation Education

- Remedial energy conservation visits for households that fail to reduce their energy consumption are effective at reducing the “rebound” or “take-back” effect. Without such visits, the rebound effect could be considerably higher.

- The most effective education services are those that are provided as in-home visits.

- Because the number of people living in a household is negatively associated with both reductions in energy consumption and arrearage, education should involve all members of the household.

Other Findings

- Hispanic households may be underrepresented in LIURP. The number of Hispanic households in poverty has increased in recent years while the number of households in LIURP headed by Hispanics has decreased from 2.3 percent to 0.7 percent.

What Works and What Does not work

Our study finds that the following contribute toward reductions in energy consumption:

- Change outs of inefficient refrigerators and freezers

- Side wall and attic insulation

- Installation of more energy efficient lighting

- Targeting single family households with high energy usage and/or energy bill arrearages

- In-home educational visits

- Remedial energy conservation visits for households that are not reducing their energy consumption

The following do not contribute to reductions in energy usage or arrearage:

- Furnace maintenance

- Window and door treatments, and repairs (for electric baseload jobs)

Policy Recommendations for LIURP

LIURP is a cost effective and successful at meeting its goals of reduced energy consumption and energy bill arrearage. However, with modifications designed to reduce the rebound effect and to reach a greater number of eligible households, LIURP can be even more effective. With this in mind, we recommend the following:

- Explore methods for adjusting the percentage of the federal poverty level to determine eligibility for LIURP.

- Explore what percentage of reduced arrearage is due to reduced energy consumption and what is due to education, receipt of assistance such as LIHEAP, or participation in CAP. Doing this would require additional data gathering in order to have complete information on energy assistance.

- Specifically tailor energy conservation education to address the rebound effect and involve all household members. Companies should focus on in-home education rather than mailings or telephone calls.

- Explore methods to increase public awareness of the need for energy conservation in general and the existence of LIURP in particular.

- Examine the LIURP outreach and referral process for each company. Compare LIURP participants to census data for each service area to determine if any groups are underrepresented or not being reached. If so, companies should make efforts to include these households in LIURP.

- Place more emphasis on cooling needs in LIURP.

- Conduct a detailed study of a sample of LIURP households to gain a better understanding of behavioral impacts on energy conservation, and other factors not currently recorded in the LIURP database or reported on an optional basis.

- Examine LIURP itself for what changes may be needed in the data collection and reporting in order to answer relevant policy questions.

- Study the pilot programs of various companies to see if new techniques are working that should be adopted by other companies, and encourage companies to share information on the impacts of new or experimental weatherization measures.

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Section I
Introduction

This report examines the Low Income Usage Reduction Program (LIURP) as one option for meeting Pennsylvania's need for energy efficiency and conservation. LIURP is a utility-implemented weatherization program aimed at reducing the energy usage and utility bill arrearage of Pennsylvania's low-income population. This report analyzes LIURP's performance from its second year of operation[1] (1989) to the most recent year for which there is complete post-weatherization data (2005). Based upon the results of these analyses, the report offers recommendations for energy policy in Pennsylvania.

The Low Income Usage Reduction Program

The Low Income Usage Reduction Program (LIURP) is a statewide, utility-implemented energy conservation program mandated by the Pennsylvania Public Utility Commission (PUC) and administered through its Bureau of Consumer Services (BCS). The goals of the program are:

1. To assist low-income residential customers in conserving energy by reducing their energy consumption.

2. To assist participating households in reducing their energy bills.

3. To decrease the incidence and risk of customer payment delinquencies and the attendant utility costs associated with customer arrearage and uncollectible accounts.

4. To reduce residential demand for electricity and gas and peak demand for electricity.

To meet these goals, LIURP is targeted toward low-income households with the highest energy consumption. Of these households, those with payment problems and high arrearages are targeted. Since the program's inception in 1988 through 2006, the major electric and gas companies required to participate in LIURP have spent over $330 million to provide weatherization treatments to more than 292,071 low-income households in Pennsylvania. The majority of LIURP jobs (89.3 percent) are performed by the electric industry. While electric industry jobs outnumber gas jobs by nine to one, the electric industry spends approximately twice as much on energy conservation as does the gas industry.

It is expected that LIURP services will reduce energy consumption, thereby reducing energy bills and easing payment problems, which in turn reduce the collections and

[1] Data from 1988 was considered trial data during the initial implementation of the program and is not as complete as later data.

termination costs for companies. By reducing these costs, the level of rate increases for all utility customers may also decline. There are also many other societal benefits from reduced energy demand, discussed elsewhere in this report.

Eligible LIURP households must have utility-provided heating service in their homes and must have an annual income at or below 150 percent of the federally established poverty level.[2] Utility companies install weatherization treatments intended to reduce household energy consumption and repair existing housing defects, provided the condition of the dwelling does not pose a hazard to the safety of the work crew. Companies also provide programs to educate customers on how to conserve energy, refer eligible customers to payment assistance programs, and coordinate services with other energy companies when necessary.

Evaluation of Data

Evaluation has been an integral part of LIURP since its initial proposal. In accordance with this requirement, each participating company must submit to the BCS on a yearly basis information on each weatherized household, including full pre- and post-year energy usage and bill payment data. Because a post-year is required for effective evaluation, the most recent data available for analysis in 2008 (the year in which this report is being prepared) are for households weatherized during the 2006 calendar year.

All data are passed through several screening procedures before being included in analyses. Consequently, not all of the data submitted by companies makes it into the analyses due to missing variables or incomplete information. In order to strengthen the statistical integrity of the results, analyses are conducted on an individual case level. Depending on the specific variables essential to each analysis, extreme outlier values for those variables are also removed from analysis. (More detailed information on the data screening process is included in the section on LIURP household characteristics.) Therefore, the amount of cases available for each analysis varies due to the completeness of the information for those variables required for the analysis.

Throughout this report, reference is made where appropriate to several past studies conducted on the LIURP program, as well as to other literature on energy conservation. Also, due to the unique nature of its data,[3] the PECO Energy Company (PECO) is sometimes analyzed separately from the other energy companies. Whenever PECO differs substantially from the other companies, this difference is noted.

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[2] Companies do have some flexibility to provide services to a small number of households that are not at or below 150 percent of the federal poverty level.

[3] PECO is a dual service provider—providing both electric and gas service. Because of this, and other factors unique to PECO, their LIURP jobs are categorized by a different set of codes than other companies.

The Need for Energy Conservation

The need for energy conservation cannot be overstated, nor is it new in the United States. Research has called for government policies directed toward reducing energy consumption and increasing energy efficiency since at least the 1970s.[4] By reducing the demand for energy in the present, energy conservation and efficiency programs are the most cost-effective method of ensuring more energy in the future. Conserving now reduces construction costs for new energy facilities, helps reduce utility rate increases, and ensures greater energy reserves for future use. Reductions in energy consumption and increased efficiency of current energy use are also the most effective, quickest, and relatively inexpensive method for reducing greenhouse gas emissions. While most policies designed to reduce greenhouse gas emissions are directed toward transportation and industry, most experts agree that approximately 50 percent of gas emissions in the United States come from commercial and residential buildings[5]. Therefore, it is essential to have energy conservation and efficiency programs tailored specifically to buildings and residences.

The Need for Low-Income Energy Usage Reduction Programs

There are several approaches to meeting the home energy needs of low-income households in the United States. One approach is to provide monetary assistance for paying winter heating bills. Another is weatherization and other modifications to the housing structure to reduce energy consumption. Other approaches include educating households on how to change their energy consumption behavior and the promotion of more energy efficient technologies.

To date, payment assistance for energy bills has typically received the most funding, although such assistance is often just a temporary solution. Education is sometimes dismissed by experts as being ineffective, or difficult to measure in terms of its impacts. Recently, attention has been focused on promoting new energy-efficient technologies, often not accessible or affordable to low-income households with substantial needs for energy conservation. Most experts agree that, in the long run, the approach with the greatest impact for low-income households, as well as many other households, is weatherization.

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[4] According to the American Council for an Energy Efficient Economy, since 1970 energy efficiency has met 77 percent of the demands for new energy service in the United States, while new energy supplies provided for the other 23 percent of new energy service demands (Prindle, 2007).

[5] Depending on which factors are taken into account, studies generally estimate between 38 and 51 percent of greenhouse gas emissions come from buildings. According to Hal S. Knowles, in a paper presented at the 2008 International Emission Inventory Conference, buildings in the United States account for 48 percent of annual greenhouse gas emissions, with 36 percent of direct energy related to greenhouse gas emissions and an additional 8 to 12 percent of emissions related to the production of materials used in building construction. The residential sector within the United States specifically consumes approximately 20 to 25 percent of primary energy use, accounting for about 50 percent of the gas emissions within the U.S. buildings sector.

In recent years, many energy efficiency programs have been made available to consumers. However, the low-income sector of the population faces many barriers to participating in these programs. A review of energy efficiency and conservation programs offered by utilities and other organizations finds that most of these programs are available only to households with good payment histories.[6]

Low-income households rarely have the expendable money to afford energy efficient retrofits to their homes, and many have poor payment histories and thus are not eligible for the programs they desperately need. Because these homes are often older and less energy efficient, their energy usage may be higher than other homes, while the household's available income for paying for energy usage is less. The average growth in energy bills among low-income households exceeds any corresponding growth in income. Only weatherized homes are, on the average, able to buy as much energy now as they did six or seven years ago without spending a larger portion of their income.[7]

An Economic Opportunity Study in 1990 found that 30 percent of U.S. households (27.9 million) were qualified for federal energy assistance. According to the Energy Information Administration, this percentage increased to 33.8 in 2001 and has since risen to 38.6 percent in 2005. Two programs meet most of the energy needs of low-income households nationally. LIHEAP is designed to assist low-income households with their heating bills, while federal weatherization programs (WAP) are available to promote energy conservation. In 2004, the average annual income of LIHEAP and WAP eligible households was estimated at $22,428, compared to $53,817 for all U.S. households.

It is not surprising that the low-income population has payment problems when it comes to their utility bills. To put this in perspective, consider the concept of energy burden. Energy burden is defined as the percentage of annual income that goes toward paying energy bills. In 2004, the average household in the United States paid 3 to 4 percent of their income toward their energy bills, whereas low-income households paid an average of 13 to 19 percent.[8] Energy burden varies by area of the country. For the mid-Atlantic region, where Pennsylvania is located, the energy burden was 19 percent for low-income households in 2006, compared to 17 percent in 2001. In a 1994 study on natural gas heating bills, Osterberg and Sheehan concluded that "energy burdens are much more important to examine than energy bills."

Under these conditions, many low-income families must choose between paying their utility bill and paying for other essential bills such as rent, mortgage, food, medical care, schooling or transportation. In many situations, it is simply impossible for low-income

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[6] Our review of energy conservation and efficiency programs offered by utilities and other organizations consisted of reviewing the eligibility criteria and application forms in both program brochures and online web sites.

[7] See "Low-Income Consumers' Energy Bills and Energy Savings in 2003 and FY 2004," a report by Meg Power for the Economic Opportunity Studies group.

[8] These percentages are a general range found in the literature. Some researchers show this figure to be as high as 27 percent for specific subgroups of the low-income population, depending on their source of income. See Oppenheim and MacGregor (2000), "Low Income Consumer Utility Issues; A National Perspective" for a more detailed discussion.

households to pay all of their utility bills. Thus, it is generally agreed that these high energy burdens result in non payment of utility bills, which result in arrearage, possible termination of service, and increased collections costs for companies.

Energy burden is not uniform among the low-income, but varies. For low-income households with the highest energy burden in 1990, the average annual residential energy expense was $1,175. However, this group had lower-than-average income, only $5,419, compared to $10,048 for all low-income households. For this group, the energy burden was 30.1 percent.

So far, our discussion has focused mainly on low-income households. At times we have specified those households with annual incomes at or below the federal poverty level. It is generally recognized that there are substantial numbers of households above the poverty line in need of energy assistance and conservation services, which, although not officially living in poverty, are still, for all practical purposes, "low-income." A study by the National Consumer Law Center concluded that energy bill payment problems are not strictly the result of low-income or high energy usage.[9]

Several reports for Economic Opportunity Studies have also noted this, discussing the concept of "fuel poverty" as opposed to poverty itself. Fuel poverty is fundamentally a result of the quality and costs of housing.[10] As such, fuel poverty is not exclusive to the low-income but extends to many other families. In 2005, 36 percent of the fuel-impoverished households had incomes higher than the federal poverty level. Further, 39 percent of the households living in fuel-poverty are headed by residents who are 65 years of age or older, and half of these live alone. This fact is significant because the elderly population of the United States is rapidly increasing and only 7.3 percent of the elderly eligible for assistance such as LIHEAP in 2003 actually received it.[11] Further, many households which would not generally be considered low-income also face circumstances which make it difficult for them to pay their energy bills.

Weatherization services are often seen as the best solution for households living in fuel poverty. As Power and Clark (2005) state, "There is a far stronger connection between housing [condition] and the incidence of energy hardships than between income and non-payment of bills." Their findings emphasize the need for roof repairs and electrical work as weatherization investments. Weatherization produces savings in the form of avoided consumption and lower energy bills, or by diminishing increases in energy consumption that would otherwise occur. Power and Clark conclude that "a home in good repair is

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[9] See "Utility-Financed Low-Income Energy Conservation: Winning for Everyone," a report published in 1991 by the National Consumer Law center.

[10] The figures on Fuel Poverty noted in this paragraph are from Meg Power's "Fuel Poverty in the USA: The Overview and the Outlook," published in the March 2008 issue of Energy Action.

[11] See Bruce Tonn and Joel Eisenberg's "The Aging US Population and Residential Energy Demand," a report published in 2007 in Energy Policy. This report also finds that elderly persons generally use more residential energy than younger persons.

significantly less likely to run up bills beyond the resident's means."[12] In fact, a 2001 study by the U.S. Department of Energy concludes that "low-income families who receive weatherization have a lower rate of default on their utility bills and require less emergency heating assistance."[13]

The benefit of weatherization services are not just related to reduced energy consumption and bills, or reduced collection costs by utilities. These services are usually administered through a network of local agencies and subcontractors. Thus, weatherization programs produce jobs in the local economy. Additionally, weatherized homes provide a healthier environment for residents. To the extent that families can avoid service termination and resorting to unsafe alternate sources of heat, public safety is increased. Further, as the quality of housing stock increases, property values are improved.

The Increasing Need for Energy Assistance in Pennsylvania

Pennsylvania has the sixth largest population in the United States. However, its proportion of elderly residents is the second largest in the country. While the number of elderly is growing, the Commonwealth's population has remained relatively stable at about 12 million since 1970.[14] In addition, its housing stock is also aging. Since 2000, Pennsylvania has ranked as the sixth lowest state in new housing construction in the country.[15] It is not uncommon in Pennsylvania for payment troubled, low-income families to live in substandard housing. Both of these trends have strong impacts on the growing energy burden of Pennsylvania's low-income population, the percent of households in fuel-poverty, and the increasing need for energy conservation and energy efficiency in general, and for weatherization services in particular.

Although Pennsylvania has a number of energy efficiency initiatives, there is room for considerable improvement. In many ways Pennsylvania lags behind its neighboring states in the northeast and mid-Atlantic regions, spending less per capita on energy efficiency than either New Jersey or New York.[16] Further, while New York and New Jersey are fifth and sixth on the list of the nation's leading cost-effective energy efficiency programs, Pennsylvania is the only state in the northeast not to have Energy Efficiency Public Benefit Funds.

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[12] These quotes are from a paper presented by Meg Power and Jennifer Clark at the National Weatherization Training Conference, 2005: "Weatherization-Plus for Payment-Troubled Energy Customers: Can It Solve Utility Bill Collection Problems?"

[13] The study, "Weatherizing the Home of Low-Income Home Energy Assistance Program Clients; A Programmatic Assessment," by Bruce Tonn, Richard Schmoyer, and Sarah Wagner, finds that the need for LIHEAP does not diminish, but the need for crisis funds does.

[14] These statistics are from the 2000 census. Since the 1990's, Pennsylvania's population growth rate of 3.4 percent is higher than only two other states – West Virginia (0.8 percent) and North Dakota (0.5 percent).

[15] Data on housing stock and new construction are from a 2007 report by The Pennsylvania Housing Research Center, "Potential Benefits of Implementing a Statewide Residential Energy Efficiency Program in Pennsylvania."

[16] Figures reported by Liz Robinson, Executive Director of the Energy Coordinating Agency in Philadelphia, at the ACI Pennsylvania Home Energy Forum in Harrisburg, September 5, 2007.

As of the last census update, Pennsylvania has 4.8 million households. Of these, 4.6 million have electric utility service and 2.7 million receive gas heating bills. LIHEAP and WAP service approximately 4,000 low-income households in Pennsylvania each year, reducing their heating consumption by 20 to 25 percent.[17] Still, it is difficult to keep up with the demand for services. In August, 2007, a report by the state Auditor General's Office found that it would take up to nine years to clear the backlog of more than 9,000 applicants for weatherization services from WAP[18] in Pennsylvania. This is partly due to management problems discussed elsewhere in this report, but is also due to the fact that need for energy conservation services increases faster than the resources to meet it.

The average heating cost in Pennsylvania in 2005 was $1,400. By 2007, this cost rose to $1,800. These increases have significant impacts on low-income households. For example, between 1999 and 2007, the average low-income household heating costs in Philadelphia rose from $711 to $1,877, resulting in increased bill payment problems and more need for energy assistance.[19]

The passage of Chapter 14[20] by the Pennsylvania Legislature in 2004 has also contributed to the number of households in need of assistance. Chapter 14 essentially reduced the number of consumer protections and made it easier for utility companies to terminate service to low-income households.[21] In fact, the number of electric, natural gas and major water utility terminations in Pennsylvania increased from 181,695 in 2004 to 283,598 in 2005.[22] According to the Pennsylvania Public Utility Commission's Cold Weather Survey, 13,762 households entered the winter of 2008 without heat-related utility service.

About the same time that the impacts of Chapter 14 were being studied, the Pennsylvania Public Utility Commission voted in September, 2006 to initiate an investigation into demand side response (DSR), energy efficiency and conservation needs and advanced metering infrastructure. This investigation was in response to rising energy prices and their impacts on rates paid by utility customers. The objective was to identify and

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[17] These figures are from a presentation given by David Carroll, of the Applied Public Policy Research Institute for Study and Evaluation, at the ACI Pennsylvania Home Energy Forum in Harrisburg, September 5, 2007.

[18] WAP refers to the federal Weatherization Assistance Program.

[19] Figures reported by Liz Robinson, Executive Director of the Energy Coordinating Agency in Philadelphia, at the ACI Pennsylvania Home Energy Forum in Harrisburg, September 5, 2007.

[20] Chapter 14 was added to Title 66 utility regulations by Act 201, which went into effect December 14, 2004. The intent of the Act was to "protect responsible bill paying [utility] customers from rate increases attributable to the uncollectible accounts of customers that can afford to pay their bills, but choose not to pay."

[21] See, for example, "Final Report: Inquiry into the Implementation and Correctness of Act 201," published in 2007 by Joseph Rhodes, Jr. Rhodes concludes that not only was Act 201 not necessary, but it has also created an "unfair and potentially dangerous set of rules for utility service terminations, connections and reconnections" and threatens the "fair and balanced provision of utility services in [Pennsylvania]."

[22] From the Pennsylvania Public Utility Commission 2005 Annual Activity Report.

recommend cost-effective energy conservation and efficiency policies that could be implemented in Pennsylvania.[23]

Part of the emphasis for conducting this investigation had to do with the fact that electricity rate caps in Pennsylvania are currently expiring. These rate caps have already expired in several neighboring states, resulting in substantial rate increases. For example, when rate caps expired in 2005 for Baltimore Gas and Electric, electric rates rose by 70 percent. In Delaware, residents experienced a 60 percent rate increase.[24]

As this report is being prepared, rate caps have expired for 15 percent of Pennsylvania's electric customers. Customers of Penn Power have already experienced a 30 percent increase in rates, while customers of UGI utilities experienced a 35 percent increase, and customers of Pike County Light and Power received a 70 percent rate increase. The remainder of Pennsylvania residents will experience rate increases due to the removal of their rate caps in 2009 and 2010. As noted in the Public Utility Commission's December 2008 report on the implementation of Chapter 14, the current projections for rate increases are cause for concern when combined with diminishing purchasing power for customers in our recent economic climate. These factors make it more challenging and difficult for the electric industry to manage its collection performance and costs.[25]

Taken together, the aging population of Pennsylvania, the reduced consumer protections of Chapter 14, and the removal of rate caps for electric utility service, framed against the background of global warming and diminishing energy reserves, point to a strong need for increased emphasis on energy conservation and efficiency services, especially for the low-income population of Pennsylvania.

[23] The information on this study is taken from a presentation by Shane Rooney of the Pennsylvania Public Utility Commission, given at the ACI Pennsylvania Home Energy Forum in Harrisburg, September 5, 2007

[24] The information presented here on the expiration of rate caps is taken from the lead article in the November 2007 issue of Etcetera, the CET Engineering Newsletter.

[25] See page 38 of the Pennsylvania Public Utility Commission's Second Biennial Report to the General Assembly and the Governor Pursuant to Section 1415: Implementation of Chapter 14, published in December, 2008.

Section II
The LIURP Study Data Set and Regression Models

The Data Set Used in this Study

In order to evaluate any changes in energy consumption or payment behavior for households in LIURP, we need at least a full year of data for both the pre- and post-weatherization period, including monthly energy consumption, bill amounts, payment history, and arrearage amounts. However, as noted by Michael Blasnik in a 1989 paper on attrition bias, "Consumer fuel savings evaluation methodologies require more consumption data than are available for many participants in low-income weatherization programs. These data requirements often lead to sample attrition rates greater than 50 percent." Hence, it is not surprising that all of the 292,071 households receiving LIURP services between 1989 and 2006 are not suitable for analyses. The most common reason for a job being excluded from analyses is the reporting of incomplete data. This can happen for a variety of reasons, such as the household occupants moving before the LIURP data gathering period is over[26] or otherwise being dropped from the program before the LIURP job is complete, or simply because of incomplete or unreliable record keeping on the part of the LIURP provider. Common reasons for being dropped or excluded from analyses include an insufficient number of meter reads or non-continuous service due to service terminations.

Another requirement for inclusion in analyses is that all energy usage reported for a household must be weather-normalized. Weather normalization is a process by which energy usage figures represent the amount of energy that would be typically used from year to year in the same location, controlling for variations in weather that might occur from one year to the next and result in abnormally low or high energy usage. In other words, it is a method for determining how much energy would be used if weather conditions were the same in both the pre- and post-LIURP periods. This process thus removes the impact of weather on variations in reported energy usage. There are several methods available for weather-normalizing energy consumption. Companies can use any of these methods as long as both the pre- and post-period usage is normalized using the same technique.

To ensure that the same households are included in the majority of analyses for both the pre- and post-weatherization period, we excluded any households that were missing key variables necessary for our study in either period. We also excluded households where the company reporting the data indicated that other funding was leveraged with LIURP to complete a job. After this screening process was completed, the data set for this study consists of 164,871 households, or approximately 56.5 percent of the total households

[26] A household receiving LIURP is assumed to have moved or otherwise experienced a change in composition when the ratepayer on record changes. Census figures indicate that the low-income residential mobility rate is around 24 percent yearly.

weatherized by LIURP. All of the analyses in this report are run on the households in this data set.

The complete study data set is not used in all of the analyses contained in this report. This is because not all variables are reported for every household, and "missing" variables are removed from specific analyses that depend on that specific variable. For example, if all of the variables are reported for a given household except for the number of rooms in the home, this household would be included in most analyses but excluded from any reporting that involves the number of rooms.[27] Therefore, each individual analysis in this report is run for the total number of households for which the necessary variables for that particular analysis are available. However, 92,361 households are common to the majority of analyses in this report. This represents 31.6 percent of the total number of LIURP households (292,071), and 56 percent of the study's data set (164,871).

Most of the statistics cited in this report, unless otherwise indicated, come from the above described data set. Some variables reported in LIURP are excluded from specific analyses because of coding changes implemented in the data gathering process for households receiving LIURP services as of January 1, 2000. In some analyses it is possible to use variables for the entire period of 1989 through 2006 and in other cases it is not. Therefore, some analyses are run on a subset of the study's data set. Further, some variables are optional and not reported by all companies. These "optional" variables allow for another subset of data for analyses (these analyses are indicated as such in the text of this report). Finally, the LIURP program has undergone periodic reviews, during which variables have been added or deleted, providing a basis for yet another subset of the study's data set.[28]

Regression Models

To determine which factors are positively and negatively associated with reductions in energy consumption at a statistically significant level, we developed several regression models. Regression models test the relationship between various "independent" variables and designated "dependent" variables. For example, to determine the relationship between the number of residents in a household and the changes in energy consumption from the pre to the post weatherization period, we would designate the number of residents in the household as an independent variable, and the change in energy consumption as the dependent variable. The number of residents would be entered into the model along with other variables which are also thought to impact on changes in energy consumption, such as the age of the housing structure, the total amount of heated space, or the type of weatherization measures installed. The results of the model will identify the degree to which each independent variable contributes to the changes in energy consumption and the statistical significance of this contribution as well as how much variance in energy consumption between the pre- and post-weatherization period

[27] More information on specific analyses is presented in Appendix B: Technical Notes.
[28] A condensed history of the LIURP program is presented in Appendix A: History of LIURP.

the overall model accounts for. It is possible to observe the interaction of different variables, and to control for differences in type of weatherization job and other relevant factors. We ran the model with various combinations of variables to get the model that accounts for, or "explains," the most variance in energy consumption between the pre- and post-period. By withholding certain variables, such as weatherization measures, we can obtain an initial value for explained variance. Running the model a second time with the weatherization measures added will give us a different value. The difference between the first value and the second value will give us some indication of how much additional variance in the changes in energy consumption is explained by the addition of the specified weatherization measures.

We ran our models for the following dependent variables: household energy burden, percentage of the change in energy consumption from the pre- to post-period, and the change in energy bill arrearage from the pre- to post-period.[29] Each of these models was run for several data categories: type of LIURP jobs, type of household, industry (electric and gas), and those households that reduced their energy consumption following weatherization versus those that did not. Each of these models was first run without weatherization measures, and then with individual measures added. Next, they were run with measures condensed into the general groups defined in the LIURP Codebook,[30] including water-heating, infiltration control, mobile home, attic insulation, floor insulation, interior foundation insulation, miscellaneous/repairs, furnace work, audits, and appliance/lighting. Each model was also run with the costs of measures included. Finally, we ran a separate regression model to observe the impact of consumer education programs on reductions in energy consumption or arrearage. (Models run with the weatherization measure groups did not give many meaningful results and are not included in this report.)

Because of differences in the data structure and variable coding, PECO data was run in a separate model from the other companies and is noted where results are significantly different. Finally, the models were also run for each individual company to identify any individual company programs that varied significantly in its results from other companies. In general, we do not specify individual companies by name in this report unless its results vary substantially from the other companies. Occasionally, a specific company may be excluded from an analysis for failure to report correctly coded data for the necessary variables.

The basic regression model for most analyses included the following variables: annual household income, number of residents, amount of heated space, number of rooms, normalized energy usage in the pre-period, the amount of arrearage in the pre- and post-

[29] Because the regression models are dependent on the degree of change in energy consumption or utility bill arrearage, it is essential that enough data points be available for these variables to accurately calculate annual energy consumption and arrearage levels. Households without the necessary number of data points are excluded from the model.

[30] The LIURP Codebook is produced jointly by the PUC's Bureau of Consumer Services and the Penn State Consumer Information System Project, and defines each variable collected and reported as part of the LIURP data gathering process, and is updated periodically. See Appendix B for the general measure categories, as well as a list of the individual weatherization measures reported for LIURP companies.

period, the age of the home, whether the home was owned or rented, and percent of energy burden.[31]

Results of regression models are considered to be statistically significant if their P value is less than 0.05. The P value represents the amount of error present in determining that the values observed are more extreme than what would occur just by chance. A value of 0.05 or less indicates that there is 5 percent error or less in the results. Only the strongest, most significant associations are reported in the text. Detailed tables for each regression model are included in Appendix D.

[31] Prior to running the regression models we ran correlation reports for all of the available variables to identify which variables were highly correlated with one another. In such cases, both variables cannot be included in the model because their interaction can confound the results. We ran preliminary regression models with all possible combinations of suitable independent variables and chose our "basic" model from the combination that explained the highest degree of variance for each designated dependent variable. This group of variables resulted in the greatest amount of explained variance in energy consumption from the pre- to post-weatherization period.

Section III
Characteristics of LIURP Households and Jobs

Type of LIURP Job

Since 1989, LIURP jobs have been performed in over 1,854 communities, in every county in Pennsylvania. The highest concentration of jobs in our study's data set has been in Philadelphia (23.5%) and Pittsburgh (11.1%).[32] There are four types of LIURP jobs: electric heating, electric water heating, electric baseload, and gas heating. Baseload jobs are defined as services performed by electric utility companies where the electricity is not used for heating. The following table shows the breakdown of job types for the 92,361 households that are included in the majority of analyses, compared to the total number of LIURP jobs.

Table 1
Number of LIURP Job Types in the Study Data Set and Percentage of Total Jobs Included in Analyses

Job Type	Number of jobs in majority of analyses	Number of jobs in overall program	% of total jobs performed
Electric Heat	16,489	85,999	19.2
Electric Water Heat	21,764	59,788	36.4
Electric Baseload	28,216	115,058	24.5
Gas Heat	25,892	31,226	82.3
TOTAL	92,361	292,071	31.6

The most common jobs in the study's data set are classified as electric baseload. The distribution of jobs in the overall LIURP program is compared to the distribution in the study data set in Table 2. As can be seen in both Tables 1 and 2, the gas companies appear to report many more households with complete data that is suitable for analysis. Thus, a higher percentage of the total number of gas heat jobs makes it through the data screening process.

[32] The total number of LIURP jobs in the study data set for each county is included in the appendix.

Table 2
Comparison of Job Types in the Study Data Set to Total LIURP Job Types

Job Type	Job Types in Majority of Analyses		Job Types in Total LIURP households	
	N	%	N	%
Electric Heat	16,489	17.8	85,999	29.4
Electric Water Heat	21,764	23.6	59,788	20.5
Electric Baseload	28,216	30.6	115,058	39.4
Gas Heat	25,892	28.0	31,226	10.7
TOTAL	92,361	100.0	292,071	100.0

Type of Housing

LIURP jobs are available to all types of housing. For the purpose of analysis, type of housing is collapsed into four categories: single family detached dwellings, mobile homes, small multi-family and large multi-family units. The majority of the treated housing stock is detached single-family or duplexes (75 percent). The category of single-family homes includes all architectural styles and both single and multi-story structures. The category of small multi-unit family homes includes row houses[33]

There is substantial variation in the type of LIURP housing across Pennsylvania. For example, only 1 percent of LIURP jobs in Philadelphia are mobile homes, compared to 15.7 percent for the remainder of the state.

The following table compares the LIURP housing types in the study data set to the same categories for Pennsylvania. It must be noted that LIURP housing information is only for low-income households, whereas the information for Pennsylvania is for all households.[34] As can be seen in the next table, it is possible that multi-unit housing has been under-represented in LIURP in recent years, but this is most likely a result of increasingly effective targeting policies on the part of LIURP providers.

[33] Prior to the year 2000 we distinguished between row homes in the middle as opposed to row homes on the end, with an exterior wall exposed to the elements. Analyses of the data for just the years prior to 2000 reveal no significant difference in energy savings between end and middle row homes.
[34] We were unable to obtain housing type by income level from the census Bureau in time to include it in this report.

Table 3
Breakdown of Housing Type Receiving LIURP Services and Comparison to Pennsylvania Housing Types

Housing Type	N	%	Percent for All of Pennsylvania[35]
Single Family	67,011	75.0	53.0
Small Multi-Family	4,375	4.9	22.0
Large Multi-Family	4,956	5.5	20.0
Mobile Home	13,041	14.6	5.0
Total	89,383	100.0	100.0

Type of Housing by Year

The breakdown of type of housing receiving LIURP services has changed over the years. Overall, there has been an increase in single family homes while small and large multi unit households have decreased to nearly zero percent of LIURP jobs (see Table 4).

From 1989 through 1994, the percentage of single detached dwellings gradually increased from 40.5 percent to 53.8 percent, while large multi-unit jobs decreased from 30.4 percent of total LIURP jobs in 1989 to 16.6 percent in 1994, with a low of 11.8 percent in 1993. During this period mobile homes accounted for approximately 20 percent of the LIURP jobs and small multi-units accounted for between 11 and 14.9 percent.

However, beginning in 1995 and continuing until 1999 there was a shift in the distribution of types of homes receiving LIURP. Single family homes jumped sharply to 63 percent in 1995 and continued to rise, while large multi-unit jobs decreased sharply from 16.6 percent in 1994 to 7.1 percent in 1995 and continued to decrease, with a low of 0.8 percent in 1998. During this period, mobile homes accounted for between 9 and 19 percent of LIURP jobs and small multi-unit homes accounted for between 8.6 and 11.8 percent of LIURP jobs.

Beginning in 2000 a third shift occurred in the distribution of housing types. Single family homes continued to increase, reaching a high of 87.9 percent in 2006. Mobile homes continued to account for between 12 and 19.7 percent of LIURP jobs, but have held steady at 12 percent for both 2005 and 2006. Both small and large multi-unit homes decreased sharply, accounting for zero or near-zero percent of the total LIURP jobs from 2000 through 2006.

[35] Percentages of housing types for Pennsylvania are taken from the Pennsylvania Housing Research Center 2007 report, "Potential Benefits of Implementing a Statewide Residential Energy Efficiency Program in Pennsylvania."

Table 4
Trends in Housing Type for LIURP Jobs, 1989 to 2006

Housing Type	% 1989 – 1994	% 1995 – 1999	% 2000 - 2006
Single Family	40 – 53.8	63.3 – 72.2	79 – 87.9
Small Multi-Family	11 – 14.9	8.6 – 11.8	0.1 – 2.3
Large Multi-Family	11.8 – 30.4	0.8 – 7.1	0 – 0.04
Mobile Home	14.6 – 22.3	8.1 – 19.1	12 – 19.7

These patterns are the same for all individual companies, with the exception of PECO, which generally services many fewer mobile homes than the other companies. The uniformity of this pattern most likely indicates an increase in the effectiveness of targeting policies among LIURP providers. Research indicates that single family dwellings typically use more energy than multi-unit residences.[36] In our study data set, single family homes use on the average 69 percent more energy than large multi-unit households and 37.9 percent more than small multi-unit households. Given that the greater the energy usage, the greater the potential for energy savings,[37] it makes sense that LIURP providers target their limited resources at those households with both the highest usage and the greater potential for reductions in energy usage.

Age of Homes Receiving LIURP

The housing stock in Pennsylvania is relatively old, with 80 percent built prior to 1980.[38] The average age of homes in Pennsylvania receiving LIURP is 63.7 years. As with housing type, the average age of homes receiving LIURP varies throughout Pennsylvania. For example, the average age for LIURP homes treated by PECO in the Philadelphia area is 69.24 years, compared to 56.51 years for the rest of the state.

When LIURP began, it was thought by some program evaluators that the older housing stock might be treated first. However, the opposite has been true. Although there have been fluctuations, overall the age of the housing stock receiving LIURP has increased

[36] The 2001 Residential usage Consumption Survey, conducted by the Energy Information Administration, finds that single family homes use an average of 61.8 percent more energy than large multi-unit housing residences and 27.2 percent more than small multi unit housing residences. In a 2005 paper presented to the National Housing Conference in Australia, found that, controlling for socio-economic factors, single family dwellings use 18 percent more electricity than multi-unit dwellings.
[37] This is a common finding in the energy conservation research. See, for example, Linda Berry and Martin Schweitzer's 2003 report, *Meta Evaluation on National Weatherization Assistance Program Based on State Studies, 1993-2002, which states "households with larger pre-weatherization gas or electric usage will save more energy once weatherized."*
[38] This information is from a presentation on Pennsylvania's housing stock given by Mark Fortney, director of The Pennsylvania Housing Research Center, at the ACI Pennsylvania Home Energy Forum In September, 2007.

over time. From 1989 to 2006, the average age of the housing stock increased from 42.6 to 63.7 years.

Size of Treated Homes

There are two ways of thinking about the size of the homes treated in LIURP. One is the amount of heated space in the household. The other is the number of rooms in the house. Some energy conservation studies have found that the number and type of rooms is more closely related to reduction in energy usage than total amount of space. This is especially true for electric baseload jobs, where the energy usage is heavily determined by the number and type of household appliances. The more bedrooms that a house contains, for example, the greater likelihood it will have more televisions or computers. The greater number of bathrooms, the greater the potential use of heated water. Unfortunately, the LIURP program does not collect information on the type of rooms in a treated house. It does, however, report the total number of rooms for each home. The average LIURP home has 6.3 rooms and 1410 square feet of heated space. The amount of heated space for PECO customers is less than for the other companies, averaging 1220 square feet.

Section IV
Profile of LIURP Recipients

The LIURP program initially collected a substantial amount of information on each participating LIURP household. However, in an effort to streamline the data collection process for LIURP providers, many of these demographic and social background variables were changed from "required" to "optional" beginning with households weatherized in the year 2000. Most companies continued to report some, but not all, of the optional variables until 2004, at which point only a few companies continued reporting the optional variables. The profile of LIURP recipients presented in Table 5 is, except where noted, for required variables.

In general there are no significant differences between households that reduce their energy consumption and those that do not. To illustrate this fact, Table 5 presents information for the study data set and then for energy "non-saver" households and "energy saver" households.

Table 5
General Profile of Overall Study group, Energy Savers and Non-Savers

	Entire Study Group	Energy Non-Savers	Energy Savers
Average number of residents	3.0	3.1	3.0
Average household income	$11,980	$11,675	$12,496
Percent with utility-bill arrearage	88.8	87	90.7
Percent who own their home[39]	68.5	68.1	68.7
Percent who rent their home[40]	31.4	31.8	31.2
Average age of household head[41]	47.0	44.7	48.1
Percent of white heads of household	80.4	81.8	78.6
Percent with female heads of household	62.0	61.4	64.3
Percent completed high school or GED	49.1	51.9	48.5
Percent unemployed	38.7	37.6	39.1
Percent Employed full-time	30.3	29.7	30.5
Percent with arrearage on energy bill	87.8	44.9	54.4

[39] According to the American Community Survey for 2005, conducted by the US census, the home ownership rate for the US in 2005 was 67.3 percent. The rate for Pennsylvania was 71.7 percent.
[40] The reason that owners and renters do not add to 100 percent is that 0.1 percent of LIURP households indicate that they neither own nor rent their residence.
[41] Note that age of head of household is only available for the years 1989 through 2000.

Taken together, the head of the "typical" LIURP household is a 47 year old white female, who completed high school or obtained her GED, is either employed full-time or unemployed, owns her home, earns nearly $12,000 per year, and has an arrearage on her energy bill.

Primary Source of Household Income

The primary source of income for households in the study group is shown in Table 6.[42] The most common source of income is employment (either full or part-time), followed by a pension, retirement plan, or social security, and public assistance.[43]

Table 6
Source of Income for LIURP Households

	Number of LIURP Households	%
Employment	30,846	42.2
Pension/Retirement/Social Security	12,030	16.5
Public Assistance	8,639	11.8
Unemployment Compensation	6,486	8.9
Disability	6,269	8.6
Other	8,786	12.0
Total	73,056	100.0

Race of Head of Household

As indicated in Table 7, the majority of LIURP recipients (heads of household) are white. When these data are examined by individual year, there is a shift in the percentage of LIURP households with African American head of households beginning with the year 1997. Prior to 1997, 9.6 percent of the LIURP households had African American heads of household. This percentage increased to 28.5 percent for the years 1997 through 2006, with a high of 37 percent in 2005.

[42] Because source of income is only collected at the beginning of the pre-period for most LIURP households, it is possible for source of income to change during the study period and not be reflected in the LIURP coding.

[43] Some critics of assistance programs argue that the further the "distance" of the income from actual employment, the less likely the household is to reduce expenses. Applying this logic to LIURP, it would be assumed that those households on public assistance would be less likely to reduce their energy consumption because they are not spending money they "earned" toward paying for their energy bill. This study finds no support for this assumption. Households receiving public assistance as their primary source of income are no more or less likely to reduce their energy consumption than households whose primary source of income is full-time employment.

Table 7
Race/Ethnicity of Head of Household

	N	%
White	74,308	80.4
African American	15,218	16.5
Hispanic	2,015	2.2
Other	870	0.9
Total	92,361	100.0

The percentage of Pennsylvania households in poverty headed by African Americans has remained relatively stable since 1990: 23.2 percent in 1990, 23.0 percent in 2000, and 23.8 percent as of 2006.[44] It appears that prior to 1997 African American households were underrepresented in LIURP, but this has been corrected in the more recent program years (see Table 8). However, Hispanic households remain underrepresented, as the number of Pennsylvania households in poverty headed by Hispanics has increased from 4.7 percent in 1990 to 7.5 percent in 2006 while the percentage of LIURP households headed by Hispanics has decreased from 2.2 percent to 0.7.

Table 8
Race/Ethnicity of Head of Household by Year

	% 1989 – 1996	% 1997 - 2006
White	86.9	69.1
African American	9.6	28.5
Hispanic	2.2	0.7
Other	2.3	1.7
Total	100.0	100.0

[44] Note: The figures for each racial group (Anglo, African American, and Other Race) for Pennsylvania are imputed based on the subtraction of the proportion of Hispanic individuals from each racial group. Source: The U.S. Census Bureau. The 1990 and 2000 figures are derived from the decennial censes, and the 2006 figures are derived from the American Community Survey.

Other Social Background Characteristics

The majority of households in the study data have female heads of household (see Table 9). Most are either unemployed (43.4 percent) or work full-time (31.6 percent) (see Table 10). About 49 percent completed high school or received a GED (see Table 11).

Table 9
Gender of Head of Household

	N	**%**
Male	41,365	38.0
Female	67,188	62.0
Total	108,553	100.0

Table 10
Employment Status of Head of Household

	N	**%**
Full-time	28,337	30.3
Part-time	12,180	13.0
Unemployed	36,187	38.7
Retired	9,840	10.5
Homemaker	4,490	4.8
Other	1,912	2.7
Total	92,946	100.0

Table 11
Education Level of Head of Household

	N	%
No formal education	1,420	1.5
Some grade school	7,209	7.6
Completed grade school	2,872	3.0
Some high school	17,244	18.1
Completed high school or GED	46,764	49.1
Some college or technical school	12,619	13.3
Completed college or technical school	3,263	3.4
Some graduate school	663	0.7
Technical or Associate degree	2442	2.6
A graduate degree (Masters, Doctorate)	565	0.6
Other	75	0.1
Total	95,136	100.0

Utility Bill Arrearage

Nearly 88 percent of the LIURP households in the study data set have an arrearage on their energy bill at some point during the pre- and post-periods. Because LIURP only collects this information at four points in the LIURP process it is possible that this percentage is even higher.

Use of Supplemental Heat

Because the presence of supplemental heat is an optional variable, it is only available for a limited number of households. The majority of households for which these data are available (75.1 percent) do not have supplemental heat in the pre-period. Of those that do, electric heat is the most common source (these are households with gas as their primary heating fuel) (see Table 12).

Table 12
Use of Supplemental Heat among LIURP Households

	N	%
No supplemental heat	22,251	75.1
Electric	4,336	14.6
Fuel oil/kerosene	1,281	4.3
Wood	764	2.6
Utility gas	273	0.9
Coal	223	0.8
Bottled gas/propane	136	0.5
City steam	82	0.3
Solar	10	0.0
Other	259	0.9
Total	29,615	100.0

The use of supplemental heat is also recorded for the period following the installation of LIURP measures. However, the number of households for which this information is recorded is substantially lower than in the pre-period. Therefore, we are unable to say with certainty whether the use of supplemental heat increases or decreases during the post-period. Examining those households for which these data are recorded in both the pre- and post-period results in a relatively small data set of 15,893 households. Based on these data, it appears that the use of supplemental fuel decreases by 3 percent in the post-period.

Section V
Energy Burden for LIURP Households

The concept of energy burden has been discussed in a previous section of this report. The average energy burden for LIURP households is 15.3 percent, which is consistent with other research that places the average energy burden for low-income households at 14 to 16 percent, compared to 4 to 5 percent for all U.S. households.[45]

Energy burden is calculated using annual household income and annual energy expenditures. The average income for LIURP households is $11,980. The average annual energy bill for LIURP households is $1,150, with a minimum of $982.50.[46] To place the income of LIURP households in perspective, consider the fact that for 2005 average income for LIURP households was $14,035, compared to an average income of $52,848 for all Pennsylvania households.

Energy burden for LIURP households varies from year to year but in general has increased since the 1989 program year. In 1989 the average energy burden was 10.9 percent. By 2003, the average energy burden rose to 19.3 percent, before falling to 12.5 in 2005, and 8.8 in 2006. However, as rate caps are lifted for Pennsylvania's energy companies over the next several years, rates are expected in increase by a greater amount than income, resulting in increased energy burdens.

Energy burden can vary with the severity of the winter and with company rates. In LIURP, PECO customers have the highest energy burden of 28.2 percent. This is at least partly due to higher rates for PECO customers. According to the 2006 Public Utility Commission Rate Comparison Report, Allegheny Power residential heating customers using 2000 KWH paid $144.38, compared to PECO customers who paid $195.74 for the same amount of energy.

Results of Regression Model for Energy Burden

Various studies explain that although energy burden is defined as annual household income divided by annual energy bills, there is more to understanding energy burden than just these factors. Other factors include housing age, geographic location, age of home owner, type of heating fuel, and length of time in the residence.[47] To explore this notion, we developed a regression model using the LIURP data for the 1989 through 2005 program years. Energy burden was designated as the dependent variable. The purpose of this exercise was to discover which variables reported in the LIURP data set tend to

[45] Exact numbers vary slightly from study to study. Our figures are taken from several reports by Dr. Meg Power, and the 2007 Department of Energy report, "Reducing the Energy Burden on Needy Families."
[46] The energy burden is calculated for only those households that report both income and annual energy bills, and is computed on the individual case level, then averaged rather than being the average energy bill divided by the average income.
[47] See "Fuel Poverty in the USA," by Meg Power, in Energy Action, issue No. 98, March, 2006.

associate with, and possibly explain, variations in the amount of energy burden. The best model explained only 2.3 percent of the variance in energy burden, indicating that the vast amount of variance in energy burden is not explained by variables collected as part of the LIURP data gathering process. The following variables were found to be positively associated to a statistically significant degree with increases in energy burden:

- Number of household residents
- Amount of heated space
- Amount of energy payments made in the pre-period
- Age of head of household

The fact that the amount of energy bill payments made is positively associated with increases in energy burden suggests that households with higher energy burdens may actually pay a greater amount of their monthly energy bills, and may be less likely to miss a payment. Unfortunately, we do not have the necessary data to examine this relationship more closely.

Note also that, as the age of the head of household increases, so does the energy burden, suggesting that the elderly would be more likely to have higher energy burdens.

Finally, we also examined the difference in energy burden for households that reduced their energy consumption following weatherization and those that failed to reduce their energy consumption, and found no statistically significant differences between these groups. For the majority of years, average energy burden is higher for the households that reduce their energy consumption, but only by a small amount. For example, in 1994 energy burden for households that did not reduce consumption was 14.8 percent, compared to 16 percent for those that did reduce consumption. Similar differences exist for those few years in which the energy burden of households that reduced their consumption is lower than that of those that failed to reduce consumption. For example, in 1989 households that did not reduce their consumption had an average energy burden on 10.2 percent, compared to 8.9 percent for those that did reduce consumption. These differences are representative of the majority of years.

Section VI
Changes in Energy Consumption

Slightly less than a third of LIURP households either experience no change in energy consumption or increase their consumption after receiving weatherization treatments (see Table 13). This percentage is consistent across the years from 1989 to 2005. As for those households that reduce their energy consumption following weatherization, the average energy savings is 16.5 percent. This compares favorably with reviews of national weatherization programs. As noted by Michael Blasnik, many WAP evaluations find savings of 10 to 15 percent.[48]

Table 13
Comparison of LIURP Households that
Reduce and Do Not Reduce Energy Consumption

Households that do not reduce energy consumption:	
Percent of households that do not decrease energy consumption	31.0%
Average percent of increased energy consumption	19.9%
Households that reduce energy consumption:	
Percent of households that decrease their energy consumption	69.0%
Average percent of decreased energy consumption	16.5%

It is not uncommon for some weatherized households to increase their energy consumption following weatherization. One possible explanation for this increase is often referred to as the "take-back" or "rebound" effect.[49] While some studies have found no take-back effects, others have found take-back effects as high as 50 percent. For low-income households receiving weatherization or other efficiency measures, the take-back effect is often 30 to 35 percent, consistent with the pattern observed in LIURP. This take-back effect is often used as a basis for criticizing low-income weatherization programs. For example, an energy company in Texas claimed that its low-income weatherization program and programs that replaced inefficient appliances with more energy efficient models actually *cause* energy consumption to increase in low-income households.

[48] From the presentation, "Energy Conservation: What are my choices? What can I save?" presented at the 2007 National Low Income Energy Conference.
[49] See Horace Herring's contribution, "Rebound Effect," to Encyclopedia Earth, , 2006, and the article "Energy Efficiency and Consumption – The Rebound Effect – A Survey," by Lorna Greening, et al. published in Energy Policy, No. 28, 2000, pp. 398 - 401.

A large part of the reason for increased energy consumption is thought to be behavioral.[50] As noted by Verhallen and Raaij (1981), "improved" homes have a strong impact on energy consumption behavior – occupants will either adopt behavior in terms of saving energy or will instead enter into an "energy wasting mode." Most take-back effects for weatherized homes involve the increase in indoor temperature settings, which take back as much as 20 percent of potential energy savings in some studies. Other studies show that energy consumption for space heating jobs can increase by as much as 30 percent. Some experts explain this pattern by noting that many low-income households are accustomed to cutting back energy use to uncomfortable levels and once they receive energy conservation services they feel more justified in increasing the comfort level of their homes.

Other studies have shown that homes without attics or the ground floor units of apartment buildings are more likely to increase their consumption following weatherization. In LIURP, small multi-unit dwellings are most likely to increase their energy consumption, by 40.5 percent, compared to less than 30 percent for the other housing types (see Table 14). (Remember, however, that multi-unit households may be underrepresented in LIURP.) As for the type of LIURP job, homes receiving gas heating treatments are least likely to increase their energy consumption in the post-period (see Table 15).

Table 14
Change in Energy Consumption by Type of Housing

	Detached single family/duplex	Small multi-unit	Large multi-unit	Mobile homes
No change or increased energy consumption	29.6	40.5	24.0	29.0
Decreased energy consumption	70.4	59.5	76.0	71.0
Total	100.0	100.0	100.0	100.0

Table 15
Change in Energy Consumption by Type of LIURP Job

	Electric heating	Electric water heating	Electric baseload	Gas heating
No change or increased energy consumption	32.8	33.0	35.5	18.6
Decreased energy consumption	67.2	62.0	64.5	81.5
Total	100.0	100.0	100.0	100.0

[50] Verhallen and Raaij's study, for example, stated that household occupant behavior can account for up to 26 percent of the variance in energy consumption following the installation of energy conservation measures. The LIURP database does not include behavioral variables, so changes in occupant behavior cannot be taken into account when running regression models to explain variance in energy consumption from the pre- to pos-weatherization periods.

Several LIURP companies make an effort to determine why some weatherized households increase their energy consumption while others do not. The most common reasons given by First Energy can also be found in the energy conservation literature. They include:

- An increase in the use of electricity for supplemental heating or a change in the main heating fuel
- The heating of additional rooms that were not heated prior to weatherization because households no feel they can afford to heat them
- The addition of a major appliance
- An increase in the number of occupants or other change in the family
- A decision to increase the comfort level of the home (prior to weatherization occupants were purposely reducing their thermostats below their comfort level).

As noted in Section II, all calculations concerning energy consumption in this report are based on a full year of energy consumption prior to receiving weatherization services and a full year of energy consumption following these services. The average unit change in energy consumption from the pre- to post-period for households that reduced their energy consumption is shown in Table 16 and the average energy reduction by type of LIURP job is shown in table 17 below.

Table 16
Average Unit Change in Energy Consumption from the Pre- to Post-Period

Electric heating	1197.6 KWH
Electric water heating	443.4 KWH
Electric baseload	698.2 KWH
Gas heating	29.8 MCF

Table 17
Average Energy Reduction by Type of LIURP Job

Electric heating	20.3 %
Electric water heating	15.1 %
Electric baseload	19.1 %
Gas heating	21.4 %

Weather Normalized Energy Consumption

As noted previously, all energy usage data should be weather-normalized before being reported by LIURP companies. Average normalized energy consumption is presented in Table 18 for each industry.[51]

Table 18
Average Weather-Normalized Energy Usage by Industry

	Pre-Period	Post-Period	% Change
Electric (KWH)	13,559.3	12,665.0	6.6
Gas (MCF)	182.0	151.1	17.0

Costs Per Unit of Reduced Energy Consumption

The LIURP data set includes the costs of all weatherization services provided to each household[52] and the total cost of each LIURP job. Therefore, it is possible to compare the costs of services provided to each household with the resulting change in energy consumption, or calculate the dollar cost per unit change in energy consumption. Table 19 shows the costs per reduced units of energy consumption for KWH and MCF for the LIURP study data set.[53]

[51] The three job types for the electric industry are collapsed into a single category for this table.
[52] Where possible, labor and materials costs are reported separately for each weatherization measure or service provided to each household. This analysis uses total cost for each job (both material and labor).
[53] Table 19 includes data for both households that reduced their energy consumption and those that did not. It only includes those households for which enough data are reported to calculate both the percent change in energy usage and the average cost in dollars. Allegheny Power's data are not included in Table 19 because there are several years for which Allegheny Power reported incorrectly coded variables necessary to perform these calculations. PECO Energy is not included due to inconsistent job type categories for several years of cost data.

Table 19
Average Costs per Unit of Energy Saved by Job Type and Company

Type of Job	Average KWH/MCF Pre use	Average KWH/MCF Saved	% Change	Average Cost in Dollars	Cost per 100 KWH/MCF Saved
Electric Heating (KWH)	**17,790**	**1,564**	**8.8**	**$1,640**	**$105**
Duquesne	13,068	1,998	15.0	881	44
Met Ed	17,056	1,220	7.2	1,474	121
Penn Electric	18,684	1,699	9.1	1,451	85
Penn Power	24,094	1,716	7.1	1,525	89
PP&L	17,581	1,629	9.3	1,737	107
UGI Electric	20,658	1,250	6.1	1,060	85
Electric Water Heat (KWH)	**11,076**	**481**	**4.3**	**391**	**81**
Duquesne	11,095	187	1.7	314	168
Met Ed	11,132	485	4.4	512	105
Penn Electric	10,786	626	5.8	368	59
Penn Power	13,243	642	4.8	429	67
PP&L	10,117	613	6.1	467	76
UGI Electric	13,988	1,808	13.0	574	32
Electric Baseload (KWH)	**11,039**	**788**	**7.1**	**533**	**72**
Duquesne	9,681	934	9.6	418	45
Met Ed	12,602	596	4.7	777	130
Penn Electric	11,900	651	5.5	516	79
Penn Power	12,991	730	5.6	578	79
PP&L	11,038	750	6.8	581	78
UGI Electric	14,285	2,278	16.0	492	22
Gas Heating (MCF)	**180**	**30**	**17.0**	**1809**	**64**
Columbia	177	37	21.0	2,913	79
Dominion Peoples	198	46	23.0	1,930	42
Equitable	260	63	24.0	3,090	49
National Fuel	207	53	26.0	3,011	57
Philadelphia Gas Works	160	14	8.6	600	44
T.W. Phillips	149	22	15.0	2,058	94
UGI - Central Penn	194	22	11.0	1,704	77
UGI – Gas	158	26	16.0	1,896	73

Results of Regression Models for Change in Energy Consumption

Table 20 shows the amount of variance in the change in energy consumption explained by each model. Adding the individual weatherization measures into the model consistently increases the amount of explained variance. Adding the costs of each measure into the model in place of the actual measures generally results in the biggest increase in explained variance. As shown in the table, our basic model explains 11.7 percent of the variance in energy consumption from the pre- to the post-period for households that do not reduce their energy consumption, and 12.5 percent of the variance for households that do reduce their energy consumption. Once we add the weatherization measures to the model, this amount of explained variance increases to 13.3 percent for households that do not reduce their energy consumption, and 16.9 for those that do. Adding the costs of the measures to the model in place of the actual measures, results in an explained variance of 14.9 and 22.4 percent respectively.

Even though the above results are statistically significant, the models account for 22.4 percent of the variance at best. Therefore, at least 87.6 percent of the variance in energy consumption from the pre- to the post-period is unexplained for the LIURP households. This does not mean that all of this unexplained variance is not attributed to some aspect of LIURP. Instead, it means that it cannot be accounted for by the variables we have available for analysis. This is particularly true for assessing the impact of the educational component of LIURP. Changes in energy consumption behavior, [54] which are the target of education, and which the research literature suggests play an important role in determining reductions in energy consumption, are not collected by LIURP, and may account for some of this unexplained variance. (The energy education component of LIURP is discussed in more detail in Section VII.) Note also that household changes from the pre- to post-period are not recorded in LIURP, and many changes, such as children leaving, and new additions to the household, such as births or children moving back home, can impact on energy consumption.[55]

[54] Examples of such behavior include setting back thermostats or closing off unused rooms. Energy conservation tips such as these are included in the energy education programs that accompany the implementation of the LIURP weatherization measures.

[55] This discussion of unexplained variance is applicable to the results for each regression model in this report.

Table 20
Percent of Variance in Change in Energy Consumption Explained by Regression Models for Households That Did Not Reduce Their Energy Consumption and Those That Did

	Basic Model: % Variance Explained	Measures Added: % Variance Explained	Measure Costs Added: % Variance Explained
Households that:			
– Had no change or increased energy consumption in post-period	11.7	13.3	14.9
– decreased energy consumption in post-period	12.5	16.9	22.4

Table 21 shows the amount of variance explained by the models for the electric and gas industry. Each industry is also subdivided for households that reduced their energy consumption and households that did not. Overall, our models explain a greater amount of variance in energy consumption for the electric industry than for the gas industry. However, when the industries are subdivided into savers versus non-savers, the highest amount of variance is explained for gas industry households that failed to reduce energy consumption.

Table 21
Percent of Variance in Change in Energy Consumption Explained by Regression Models for the Electric and Gas Industry

	Basic Model: % Variance Explained	Measures Added: % Variance Explained	Measure Costs Added: % Variance Explained
Electric Industry	**20.8**	**25.5**	**26.6**
No change or increased consumption	16.0	18.2	19.6
Decreased energy consumption	9.2	14.4	14.8
Gas Industry	**13.8**	**13.8**	**19.8**
No change or increased consumption	21.4	22.7	29.2
Decreased energy consumption	7.2	9.4	21.9

When examined by type of job, we find that electric heating jobs have the greatest amount of explained variance (see Table 22). This amount is substantially greater than the other job types. This fact suggests that other variables, unaccounted for in LIURP, play a greater role in determining the reduction of energy consumption for the other job types.

Table 22
Percent of Variance in Change in Energy Consumption
Explained by Regression Models for Type of LIURP Job

	Basic Model: % Variance Explained	Measures Added: % Variance Explained	Measure Costs Added: % Variance Explained
Type of Job—Overall change in energy consumption from pre- to post			
Electric heating	52.0	55.1	56.0
Electric water heating	8.6	12.5	12.5
Electric baseload	13.6	19.9	21.6
Gas heating	8.2	9.5	19.8

Weatherization and Energy Conservation Treatment Measures

Up to 20 weatherization measures are coded for each weatherized household. There are 122 possible individual measures to choose from, grouped into the following categories: water heating, infiltration control, mobile homes, attic insulation, floor insulation, interior foundation insulation, furnace work, audits, appliance/lighting, and miscellaneous/ repairs.[56] The category of miscellaneous/repairs includes treatments such as chimney work, general roof repairs, off peak/time of day conversions, repairing wall plaster, sealing air vents, work on exhaust vents, connecting dryer vents, and work on ceiling fans.

Because the models run with the grouped categories did not yield meaningful results, we focus the rest of analyses concerning weatherization measures on the most commonly used measures. Each of the previously run regression models were run a second time with these individual measures added. These measures are listed in Table 23, along with the percentage of occurrences for each in the study's data set. The most commonly occurring measure is replacing lighting and fixtures with more efficient lighting (compact fluorescent lighting).

[56] There are also several other categories not listed here because they are rarely coded in the database. Also, a few of the categories listed here are an aggregation of several sub-categories.

Table 23
Most Commonly Used Weatherization Measures in LIURP

Measure	% of households receiving the measure
Install efficient lighting/fixtures	67
Pipe insulation	28
Walk through audit, excluding blower door	28
Faucet aerator – bath	26
Miscellaneous/Repairs	26
Change refrigerator/freezer	25
Low-flow showerhead	24
Pre-audit, excluding blower door	20
Furnace maintenance	16
Faucet aerator – kitchen	14

In general, national studies have found the following weatherized treatments to be effective at reducing energy consumption: Attic, wall and floor insulation (which are treated as separate variables in LIURP), low-flow showerheads, water heater insulation, and the replacement of inefficient heating systems. Lower energy savings are associated with storm window and door replacement or repair. [57] In the Pennsylvania Public Utility Commission's 1994 LIURP study, sidewall insulation and attic insulation were positively related to reduced energy consumption.

Michael Blasnik, in his recent review of weatherization programs,[58] finds that window replacements, heating system tune-ups and floor insulation do *not* contribute substantially towards reduced energy consumption. For electric baseload jobs, he finds that changing out refrigerators and freezers and replacing lighting with more efficient bulbs and fixtures are important contributors to reduced energy consumption. Our results more closely resemble Blasnik's findings than those of other studies.

Results of the Regression Models for Weatherization Measures

The following discussion summarizes the results of the regression models with the most explained variance in energy consumption between the pre- and post-weatherization period (those models containing either the individual weatherization measures or the weatherization measure costs). Results are presented for both households that reduced their energy consumption and those that did not, and by industry, type of job, and type of housing. The following discussion focuses on what "works" in terms of reducing energy

[57] See, for example, "Determinants of Program Effectiveness: Results of the National Weatherization Evaluation," written by Marilyn A. Brown and Linda G. Berry, and published in Energy, Vol. 20, No. 8, 1995, pp. 729 – 743.
[58] From a presentation, "Energy Conservation: What are my choices? What can I save?" presented at the 2007 National Low Income Energy Conference.

consumption, and what does not "work," or only works under certain circumstances and in certain situations. Detailed tables with the level of significance and specific degree of explained variance for individual variables are included in Appendix D.[59]

Our regression models found the following factors to be significantly associated with reductions in energy consumption. These factors are listed in order of their contribution to reductions in energy consumption, from strongest contribution to least. Each contribution is statistically significant.

Positively associated with reductions in energy consumption:

- Replacement of inefficient refrigerators and freezers
- The amount of energy used by the household in the pre-period
- The amount of energy bill arrearage in the pre-period
- Installation of more energy efficient lighting.

Negatively associated with reductions in energy consumption:

- Furnace maintenance
- Number of household residents
- Number of rooms in the household

Factors Positively Associated with Reductions in Energy Consumption

The largest single contributor toward reduction in energy consumption appears to be the changing out of refrigerators and freezers. Some of the LIURP companies have programs in which they identify inefficient or unnecessary refrigerators and freezers and offer to replace these with more energy efficient models. For example, these programs will swap two inefficient refrigerators for one new, energy efficient refrigerator, or maybe replace three with two. If such inefficient appliances are identified and swapped, even as part of gas heating jobs, this can contribute to significant reductions in energy consumption.

The second most consistent predictor of reduced energy consumption is the amount of energy used during the pre-period. Households with the largest energy usage tend to have the largest reductions in energy consumption following weatherization. This finding is consistent with various studies and noted in Berry and Schweitzer's "meta-evaluation" of national weatherization programs based on State studies from 1993 to 2003.

The next most significant, and most common, variable that is positively related to reductions in energy consumption is the amount of arrearage owed in the pre-period, suggesting that households with large arrearages are motivated to make the necessary

[59] Note also that there are, on occasion, some seemingly contradictory results when we look at households that reduce energy consumption versus households that do not, or compare results of individual measures to their costs.

behavioral changes to contribute toward additional reductions in energy consumption. It therefore makes sense to target households with higher arrearages when prioritizing LIURP jobs.

Factors Negatively Associated with Reductions in Energy Consumption

Furnace maintenance is the variable most negatively associated with reductions in energy consumption. A review of the literature finds that this is not uncommon. A 1986 report on New Jersey weatherization programs argues that this is due to the fact that many homes are not sufficiently heated because their furnaces do not work correctly and, once repaired, the furnaces now heat the home properly and to the correct levels, thus increasing energy usage. Most studies conclude that while tune-ups may prolong the life of the furnace, they do not necessarily reduce energy consumption.

The total number of household residents and the number of rooms in the home are also negatively associated with reductions in energy conservation. The number of rooms is more likely to be negatively associated with the reduction in energy consumption than amount of heated space.[60] This is consistent with the findings of several recent studies.

Costs of Measures

Costs of the measures were added to the regression model in a separate set of analyses from the actual treatment measures. When costs are included in the model, many more weatherization measures emerge as being related to the reduction of energy consumption. For the most part these costs are positively associated with reduced energy consumption, indicating that money spent on energy reduction treatments is a sound investment.[61] However, when examined by industry, the positive relationships are concentrated for the gas industry and negative relationships are more commonly significant for the electric industry.

Overall, we found the following measure costs to be significantly associated with reductions in energy consumption. As with the previous section, these costs are listed from the strongest contribution to reductions in energy consumption to the least. Each contribution is statistically significant.

Positively associated with reductions in energy consumption, for the electric industry:

- Attic insulation costs (for electric heating jobs)
- Sidewall insulation costs (for electric heating and baseload jobs)
- Baseload costs (for electric baseload jobs)

[60] This indicates a potentially important area of impact for energy education programs, in that they often recommend closing off rooms not used during the winter months.
[61] The vast majority of studies examining weatherization programs have concluded that they are cost-effective.

Positively associated with reductions in energy consumption, for the gas industry:

- Sidewall insulation costs
- Attic insulation costs
- Heating system costs
- Audit costs
- Other insulation costs

Negatively associated with reductions in energy consumption for the electric industry:

- Repair costs (for baseload jobs)
- Window and door costs
- Heating system cost (for baseload jobs)

Factors Associated with Changes in Energy Consumption

The cost of repairs is negatively associated with reductions in energy consumption for electric baseload jobs. Repairs include the costs of chimney, window and electrical repairs, which are reported together. The presence of such repairs is generally found to be positively related to reduced energy consumption (consistent with the findings of Meg Power), but as the costs increase in LIURP the amount of reduction in consumption apparently lessens.

The costs of wall and attic insulation are associated positively with reductions in energy consumption for electric heating and gas heating jobs. The cost of sidewall insulation is also positively related to reductions in energy consumption for electric baseload cases.

Heating system costs are positively associated with reduced energy consumption for the gas industry but are negatively associated for electric baseload jobs.

Housing Type

Examining measure costs by the type of housing reveals the following measure costs positively associated with reductions in energy consumption for single family dwellings: sidewall insulation, baseload, attic insulation, other insulation, heating system, audit, and cooling system costs. Considerably fewer measure costs are found to be significant for the other housing types.

Very few large or small multi-unit housing jobs have been done in recent years, suggesting that utility companies do not view them as cost-effective jobs. For large multi-unit housing jobs prior to 1995, heating system and sidewall insulation costs are statistically significant and positively related to reductions in energy consumption. (1995 is the year in which the percentage of multi-unit jobs sharply decreased.)

Optional Variables

In order to better understand the impact of the optional variables on the change in energy consumption from the pre- to post-period, we entered each of these variables into the regression model for just those companies and years for which they are reported. None of the demographic/social background variables, such as race, gender of head of household, education level or employment status have a significant impact on the change in energy consumption. Models were also run for households that do not reduce their energy consumption versus those that do, housing type, and type of job. None of these variables were significant for any of our models.

When the optional educational variables (educational contacts, remedial contacts and home visits), were entered, however, we found that the number of in-home educational visits is positively associated with reductions in energy consumption. (Note that the education program is examined in more detail in Section VII.)

We next entered the supplemental heat variables into the regression models. These variables include the presence or absence of supplemental heat, the type of supplemental heat and the amount of supplemental heat for both the pre- and post-period. Overall, the presence of supplemental heat is positively associated with reductions in energy consumption. Examining these data by type of LIURP job, the presence of supplemental heat in the pre-period is positively associated with reduction in energy consumption for electric baseload jobs, but negatively associated during the post-period for these same jobs. However, the supplemental heat variable is reported for substantially fewer LIURP jobs in the post period, and this may influence these results.

As noted previously, eligibility for many energy usage reduction programs is based upon having a good payment history. When the optional LIURP payment variables – number of full, partial or complete payments in the pre- and post-period – are entered into the regression model, the number of missed payments and full payments are not associated either positively or negatively with changes in energy consumption.

Due to coding changes and other changes in data reporting procedures, limited data are available for the number of household residents in different age groups. For overall change in energy consumption, the number of occupants over the age of 60 is not significant in any of the models. Nor is the number of small children. However, the number of teenagers is negatively associated with reduced energy consumption. When examined by type of job, the number of children is negatively associated with reductions in energy consumption and the number of persons over 60 years old is positively associated for electric baseload jobs only.

Section VII
Energy Bill Arrearages

One of the goals of LIURP is to decrease energy bill arrearages in the post-weatherization period. It is possible to say two things regarding changes in arrearage from the pre- to post-period for the LIURP data set. First, the average energy bill arrearage declines from the pre- to post-period. Second, it is not possible to assess how much of this reduction LIURP is directly responsible for. This is because part of the LIURP process is to recommend to, and enroll eligible households in payment assistance plans whenever possible, and the variables collected as part of LIURP are not specific enough to separate the impact of weatherization measures from the impact of payment assistance on reduced arrearages. For this reason, we can only look at general trends with regard to arrearage amounts.

Complete arrearage data for the pre- and post-period is reported for 41 percent of LIURP households. Arrearage is collected at four points in the LIURP process, at the beginning and end of the twelve month period prior to receiving weatherization services, and at the beginning and end of the twelve month period following the weatherization treatments. These four points allow us to compare the overall slope of arrearage of the year prior to weatherization and the year following weatherization. If LIURP is achieving its goal, this slope should be less in the post-period (see Figure 1).

The amount owed at the end of the pre-period is often identical to the amount owed at the beginning of the post-period. For this reason, Table 24 compares the average arrearage at the beginning of the pre-period to the average amount owed at the point of weatherization and the average amount owed at the end of the twelve months following weatherization.

Seventy-one percent of the households with complete arrearage data have an arrearage twelve months prior to receiving LIURP treatments. This amount increases to 97 percent at the month when LIURP services are received.[62] Hence, the percent of LIURP households with an arrearage increases by 26 points during the year prior to receiving weatherization services. By the end of the year following weatherization, 68 percent of the households have an energy bill arrearage, a decrease of 29 points.[63] Further, there is also an increase in the percent of households with a credit on their energy bill during this period, from 106 households at the beginning of the pre-period to 2705 households by the end of the post-period.

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[62] Note that in Section IV we said that 88 percent of LIURP households have an arrearage on their energy bill "at some point during the pre- and post-periods." This figure included all households for which an arrearage was reported *at any point* during the LIURP data gathering process. In order to calculate the slope shown in Figure 1 and change in arrearage from the pre- to post-weatherization periods, we need to have all the arrearage data points reported. Therefore, the households included in this analysis are a subset of those discussed in Section IV.

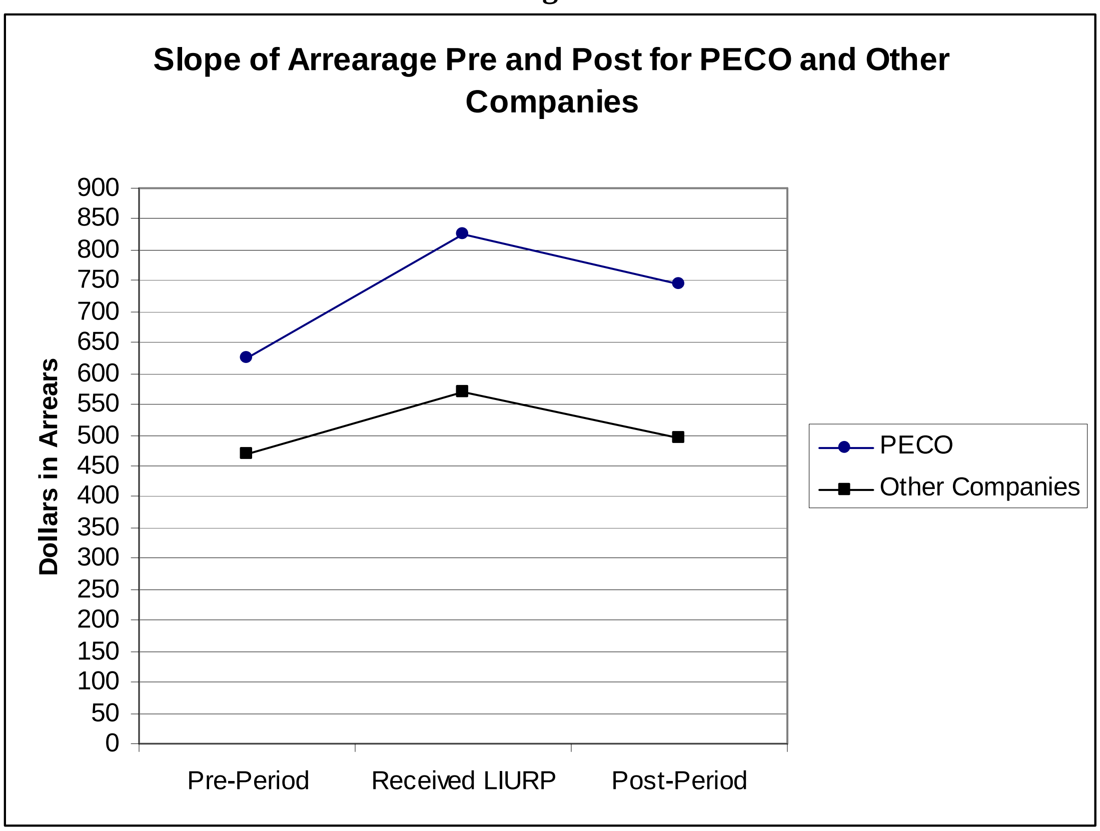
[63] Examining arrearage patterns by individual program years reveals that the decrease in arrearage for the post-period is consistent for all years except 1993. A Table showing average arrearage for each LIURP program year is included in Appendix C.

Several things are obvious from Table 24. First, arrearages for PECO households are from 33 to 51 percent higher than arrearages for other company households. Second, arrearage for PECO households increases faster than for other households. PECO households, for example, have a 32 percent increase in average arrearage during the pre-period, compared to 19.3 percent for other companies. Third, average arrearages decrease in the period following LIURP – by 10 percent for PECO and 12 percent for other companies.

Table 24
Average Energy Bill Arrearage for Pre and Post LIURP Period

	Average Arrearage at Beginning of Pre-Period	At End of Pre-Period/ Beginning of Post-Period	At End of Post-Period
PECO	$625.20	$825.49	$745.59
All other Companies	$442.94	$528.41	$465.45

Figure 1



To get a sense of the average change in arrearage, we calculated the change in utility bill arrearage for the pre- and post-period for each individual household. The average overall change in the pre-period is an increase of $240.90 for PECO and $72.85 for all other companies. In the post-period the average overall change in arrearage is a decrease of $43.79 for PECO and $52.36 for other companies.

Payment History

Various studies conclude that weatherization also improves payment behavior.[64] LIURP records the number of full, partial, and missed payments for each household for both the pre- and post-period. Because these variables are optional, we have only limited data available for analyses. Although the average number of full payments made does not vary from the pre- to post-period, the percent of households with missed payments decreased and the average number of partial payments increased (see Table 25).

Table 25
Average Energy Bill Arrearage for Pre and Post LIURP Period

	Pre-Period	Post-Period
Percent of households with at least one missed payment	89.3	80.8
Average number of partial payments	2.8	4.6

Changes in Energy Bill Arrearage

Overall, 40 percent of LIURP households reduce their arrearage during the post-period. Separate regression models were run to examine what factors are related to reduction in arrearage. Before running these models, it was necessary to control for the those households that received LIHEAP or were enrolled in Customer Assistance Programs (CAP)[65] in either the pre- or post-period, or both, since both of these programs have an effect on bill payments.

When we examine changes in arrearage by industry, a higher percentage of LIURP households in the gas industry reduce their arrearage in the post-period (see Table 26).

[64] For example, Tonn, Schmoyer and Wagner (2003) find that weatherized households have a lower default rate on energy bills, as well as require less energy assistance.

[65] Customer Assistance Programs are offered by utility companies in Pennsylvania to assist customers who have trouble paying their utility bills. Companies review billing data on the customer and determine a monthly payment amount that is less than the energy usage-based billing and consistent with their PUC-approved universal service plan. Typically, companies offer an arrearage forgiveness component for full CAP payments.

Table 26
Reduction of Arrearage by Industry

	Electric	Gas
No reduction in arrearage	63.0	45.6
Reduction of arrearage	37.0	54.4
Total	100.0	100.0

We also looked at whether renters or owners were more likely to reduce their arrearage, but found no difference (see Table 27).

Table 27
Change in Arrearage by Home Ownership Status

	Own	Rent
No reduction in arrearage	60.6	61.0
Reduction of arrearage	39.4	39.0
Total	100.0	100.0

Results of Regression Models for Changes in Arrearage

Any attempt to study the impact of LIURP variables on reductions in arrearage is limited because there are so many uncontrolled factors that influence how much money households can devote to paying their energy bills. Even though a 2004 statewide study of households with utility payment problems revealed that making utility payments was among the highest household budget priorities,[66] there are still many common household expenses that compete for a family's available dollars that are not recorded in LIURP, such as school, food, or medical expenses.

In general, our regression analyses yielded the following results:

Positively associated with reductions in energy bill arrearage:

- Change in energy usage from the pre- to post-period
- Cost of energy education (electric industry only)
- Total Annual household income (gas industry only)

[66] This survey was conducted by the Consumer Services Information System Project at Penn State University, using a sample of consumers who contacted the Pennsylvania Public Utility Commission seeking payment arrangements for utility bill arrearages. A report on the results was prepared in 2005.

Negatively associated with reductions in energy bill arrearage:

- Number of household residents
- Amount of heated space
- Age of dwelling (for electric heating jobs)
- Number of rooms (for electric industry)

<u>Factors Associated with Changes in Arrearage</u>

We initially ran the arrearage model twice, once with the amount of energy consumed in the pre-and post-periods included as an independent variable, and once with the change in energy consumption from the pre- to post-period. The model was run twice because these variables are highly correlated, as the amount of energy consumption in the pre-period is strongly associated with the amount of change in energy consumption from pre- to post-period. The model with the amount of energy consumed in the pre- and post-periods explained 9.6 percent of the observed variance in arrearage. Replacing these variables with the change in energy consumption from the pre- to post-period increased the explained variance to 12.7 percent. Thus, the change in energy usage from the pre- to post-period exerts the greatest influence on the reduction in arrearage. The only other factor to be positively associated with reduced arrearage is the cost of energy education services provided to the households.

Of those factors that are negatively associated with reductions in arrearage, the number of household residents has the greatest impact. It makes sense that the greater the number of residents, the greater the number of expenses that compete with energy bills. Other factors that are negatively associated with reducing energy bill arrearage include the age of the dwelling and amount of heated space.

Preliminary analyses suggested that there may be differences between the electric and gas industry in terms of what factors influence the reduction in arrearage. Running the regression model for each industry reveals that a few differences do exist. For example, whereas educational costs are positively associated with reductions in arrearage for the electric industry, they are not significant for the gas industry. Further, the number of rooms is negatively associated with reductions in arrearage for the electric industry. For the gas industry, annual household income is positively associated with reduced arrearage.

We next looked at the degree of reduced arrearage for two groups: those who fail to reduce their utility bill arrearage and those who succeed in reducing their arrearage in the post-period. For the first group, we are interested in seeing what variables influence a lesser increase in arrearage as opposed to those that are associated with a greater increase. In both models, change in energy usage from the pre- to post-period is positively associated with either reducing arrearage, or increasing arrearage to a lesser degree. Educational costs are also positively associated with reductions in arrearage for both models. The number of household residents and the age of the dwelling are negatively associated with arrearage reduction in both models, and the amount of heated space is associated with greater increases in arrearage following weatherization.

When examined by type of job, the change in energy consumption from the pre- to post-period continues to be positively associated with reductions in arrearage for all job types. Age of the dwelling is negatively associated with reduced arrearage only for electric heating jobs, while the number of residents is only significant for electric baseload and gas heating jobs. Note also that total annual household income is positively associated with arrearage reduction for gas heating jobs, but negatively associated with arrearage reduction for electric water heating and electric baseload jobs.

Finally, we examined the reduction in arrearage for both those households that reduced their energy consumption and those that did not. In both models, change in energy usage from the pre- to post-period is positively associated with reducing utility bill arrearage. The number of residents and age of the dwelling are negatively associated with arrearage reduction.

In conclusion, the single factor that most influences changes in arrearage is the change in energy consumption from the pre- to post-period. The factor that is most consistently associated with failure to reduce arrearage is the number of household residents.

Section VIII
The Impact of Energy Conservation Education on Reduced Energy Consumption and Utility Bill Arrearage

LIURP is designed to include energy conservation education as part of the weatherization process. As noted in previous sections, the number of in-home education contacts is positively associated with reductions in energy consumption, and the amount of money spent on education is positively associated with reductions in energy bill arrearage. As part of the data gathering process, information is collected on the number and type of educational contacts for each LIURP household in both the pre- and post-weatherization period. While these variables were made optional beginning in 2000, the costs of the educational contacts is still a required variable. Because education costs have shown to be significantly related to reductions in energy consumption and arrearage, to varying degrees in different models, we desired to learn more about the nature of the relationship between energy education and reductions in both energy consumption and utility bill arrearage. To do this, we developed separate regression models for just those years and companies for which the contact information is reported. The analyses presented here differs from the earlier analysis in that we have calculated for each household the number of each type of educational contact, during both the pre- and post-weatherization period. The data set is therefore limited only to those households for which enough data were reported to make these calculations.

The following independent variables were included in the regression model:

In-home educational contacts, pre-period
Other education contacts (telephone or mail), pre period
In-home educational contacts, post-period
Other education contacts (telephone or mail), post-period

Most company programs are designed so that households that fail to reduce energy consumption in the post-period receive follow-up, or remedial, energy education visits and contacts. Depending on when energy usage is monitored and remedial visits or contacts are scheduled, it is possible for a household to receive remedial energy education early in the post-period and still reduce their energy consumption by the end of the post-period. Thus, although it is natural to assume that remedial educational contacts will more often be associated with households that fail to reduce energy consumption, this may, in fact, not be the case.

Results of regression Models for Energy Conservation Education

The results of the regression model for the education data set, without the education contact variables included, explains 10.96 percent of the variance in the change in energy consumption from the pre- to post-period. Including the education contact variables increases this explained variance to 14.95 percent. These results differ from the previous analyses of optional variables in that remedial in-home educational visits are positively associated with reductions in energy consumption while pre-period in-home educational contacts are negatively related with reduced energy consumption.

Refining this model by running it for those household who did not reduce their energy consumption versus those that did, remedial in-home contacts is only significant for households that did not reduce their energy consumption. It thus appears that remedial energy education visits may be effective in minimizing the impact of the “rebound effect.” In other words, these educational visits contribute toward households increasing their energy consumption to a lesser degree than if they did not receive such visits. However, non-in home contact methods, such as telephone calls or mailings, do not have a significant impact in changes in energy consumption.

When examining the different job types, the remedial in-home contacts are most effective for gas heating jobs and pre-period in-home contacts are significant for electric heating and electric water heating jobs.

The same basic pattern of relationships also exists for changes in arrearage, with a few exceptions. When run without the educational contact variables, the model explains 10.95 percent of the variance. Adding the contact variables increases the explained variance to 11.66 percent.

When examined by type of job, pre-period in-home visits are positively associated with reductions in arrearage for the gas heating and electric water heating jobs.

Remedial in-home educational visits are positively associated with reductions in arrearage for both those households who fail to reduce their overall arrearage and those that do, and for households that fail to reduce their energy consumption and those that do. Thus, remedial educational visits appear to present a unique opportunity for companies to increase energy savings. The earlier that companies can identify non-saving households, the more impact they can have on reducing the rebound effect.

These results, although based on a limited number of households, suggest that education plays an important role in both the reduction of energy consumption and the reduction in energy bill arrearage. Remedial in-home educational visits appear to be particularly important, and should be emphasized when possible.

Section IX
Conclusions and Discussion

LIURP is successful in both reducing energy consumption and heating energy arrearages in treated homes. Additionally, LIURP is particularly well suited to Pennsylvania. Because Pennsylvania's housing stock is old and new housing construction is relatively scarce, especially for low-income families, the focus on existing housing stock is very important in meeting Pennsylvania's overall needs for energy conservation. Further, the focus on weatherization is the most effective means of reducing energy consumption for low-income households. The number of low-income homes weatherized by LIURP each year is also important due to the back-log of the federal WAP program.

Whereas the Auditor General found many problems with the implementation of WAP, including poor data keeping, lack of coordination among agencies, unreliable subcontractors, lack of feedback and evaluation, and a need to develop prioritizing procedures,[67] most of these criticisms do not apply to LIURP. Evaluation has been built into LIURP from its very inception, and coordination has been emphasized repeatedly. However, there are opportunities for further research and changes to LIURP that could result in improved performance and service to a larger number of needy households.

Summary of Findings

Although energy consumption and the amount of arrearage in the pre-period are significant predictors of the degree to which households reduce their energy consumption, there are also specific weatherization measures that have powerful impacts on reduced energy consumption. Most notably, the replacement of refrigerators and freezers with more efficient models, or the removal or disconnection of unnecessary units, is positively related to energy savings.

The number of residents in a household and the number of heated rooms are negatively associated with reductions in energy consumption. Furnace maintenance is the LIURP service most associated with the failure to reduce energy consumption following weatherization. One reason for this may be the increasing of comfort levels in the home once the furnace is properly working.

Analysis of costs associated with the weatherization measures reveals that LIURP is cost-effective, and that companies are seeing reductions in energy consumption for the money spent on weatherizing homes. When costs are taken into account, several other treatments become significantly associated with reduced energy consumption, most notably wall and attic insulation. The cost of repairs is negatively associated with reductions in energy conservation for electric baseload jobs.

[67] See the Pennsylvania Auditor General's Special report on the Department of Community and Economic Development's Weatherization Assistance Program, published in August, 2007.

Energy Conservation Education

Results indicate that energy education can play an important role in reducing both energy consumption and energy bill arrearage. Even though educational contacts are driven by the degree to which households are reducing their energy consumption, it is possible that these contacts also have impacts on improved bill payment behavior. Further study is needed to ascertain the exact nature of consumer education on bill paying behavior.

The fact that slightly less than one-third of LIURP households increase their energy consumption following weatherization is consistent with the figures found in other studies of the "take-back" or "rebound" effect. Our findings suggest that targeting education to households experiencing increased energy consumption following weatherization might be particularly effective in reducing the amount of "take-back" that might otherwise occur without the remedial education. The effectiveness of energy conservation education may be increased if it is specifically tailored to those factors that contribute to the rebound effect. The lack of specific household behavioral variables in the LIURP database prevents this study from making more specific recommendations. However, it is important to note that remedial in-home educational contacts are more effective than mailing informational brochures or making telephone calls. Because the number of people living in a household is negatively associated with both reductions in energy consumption and arrearage, education visits should include all members of the household.

It may also be beneficial to implement educational and informational programs designed to increase public awareness of LIURP and other energy assistance programs. Evidence suggests that LIURP may not be reaching all the eligible households. In particular, it appears that Hispanic households may be under represented.

Possible Changes to LIURP

Throughout this study the primary focus has been on reducing energy consumption. Although replacing inefficient air conditioners and other cooling-based treatments are available, most of LIURP is directed toward weatherizing homes in terms of heating. However, cooling needs account for a high degree of energy usage and should not be neglected. This is especially important because cities with a history of heat waves are likely to experience even more intense and frequent heat waves as a result of global climate change. It may thus be beneficial to place greater emphasis on cooling needs in LIURP. Doing this could especially benefit the elderly population.

Considerable evidence exists to indicate that there are households above 150 percent of the poverty level that are living in fuel poverty, and that this number will grow in the near future. For this reason, policymakers may want to consider expanding LIURP to a larger population and raising the eligibility limit to as high as 200 percent of the federal poverty level. In recent years, some cities such as New York have started exploring alternatives to the federal poverty level as a basis for determining legitimate need for assistance, and for establishing program eligibility.[68] There are a variety of tools available for assessing the poverty level that will allow LIURP to serve the greatest legitimate need. One possible method is a combination of Sensitivity Analysis and the Self Sufficiency Standard Index, developed by Diane Pearce at the University of Washington. Using this technique, a study conducted by the Consumer Services Information System Project at Penn State found that 185 percent of the poverty level was much more effective at meeting the need for utility bill payment assistance than 150 percent.[69]

Further, it may be beneficial to re-examine the most recent socioeconomic and census data for company service districts to determine if any groups are underrepresented or not being reached in LIURP. If so, company outreach programs should be examined with the objective of finding ways to better reach potentially eligible households.

<u>Suggestions for Future Study</u>

A potential criticism of LIURP is that evaluation is limited by the single year of post-weatherization data and the lack of behavioral variables, as well as the fact that several potentially useful variables are optional. Further, the true impact of many measures may not show up for several years.

While no single theory or model explains complicated energy-usage behaviors, applying some basic social science techniques with the proper data can yield meaningful information. It would be useful to conduct a survey of each company's LIURP households. Ideally, the sample for the survey should be structured to take into account all program years and changes in the households since receiving weatherization, but mobility of the population may make it more practical to restrict such a study to more recent years. The survey itself should include demographic and social background variables, changes in family composition, changes in income and employment status, and questions on energy conservation behavior. Some of the companies already collect such data and could possibly provide them for analyses. Participation of the companies in such additional data gathering could be either required or voluntary, depending on the needs of policymakers and regulators.

The community agencies and subcontractors currently assisting with the administration of LIURP provide a strong foundation for implementing any changes or added provisions. They are also an effective tool for increasing and tailoring home educational visits, and for implementing surveys.

LIURP reporting has remained relatively constant even though there have been significant changes in policies and technologies. We recommend a review the reports

[68] See "Bloomberg Seeks New Way to Determine Who is Poor," in the December 30, 2007 edition of the New York Times.
[69] See "A Comparison of Two Measures of Income Adequacy for Utility Consumers in Pennsylvania," by Asa Mukhopadhyay, Penn State University, 2005.

produced on a yearly basis to determine if they are meeting current reporting needs. If there are needs that are not being met, it is advisable to include additional variables in the LIURP reporting requirements. Even without adding new variables, it is possible to modify existing reports or create new reports.

Consider also the fact that no major revisions have been made to the LIURP data collection process since 2000. In the past, when revisions were made, the focus has been on streamlining the amount of information requested. It may be time to add some variables, depending on the type of questions policy makers would like answered. Another option is to expand some of the coding for existing variables. For example, it may be useful to be able to distinguish row houses and duplexes as distinct housing types in future analyses. As noted, these additional variables of interest, or expanded coding categories, may be better suited for a survey of a sample of households for each company.

It has already been noted that there are opportunities to further explore the nature of the relationship between consumer education and bill payment behavior, and for determining the relative contributions of energy assistance, payment programs, and reduced energy consumption to corresponding changes in utility-bill arrearage. Various other opportunities for further study also exist. Possible analyses of interest include a detailed examination of households that drop out of the LIURP program, and a more focused examination of households that fail to reduce energy consumption. It would be especially beneficial to collect additional information on energy assistance programs such as LIHEAP or customer payment assistance programs, so that the effects of such programs can be analyzed in conjunction with reductions in energy consumption and changes in arrearages and payment behavior.

Further, some companies implement pilot programs within LIURP in order to test new measures or approaches to energy conservation. The LIURP database contains a variable to identify households that participated in various pilot programs. It might be advantageous to complete specialized studies of these pilot households and determine which pilot studies produce the greatest reductions in energy consumption or arrearages.

Another option is to identify weatherization measures that are implemented primarily by specific companies and develop models to analyze the impacts of these measures on energy consumption. If such cases are identified and studied, recommendations may be developed for other companies regarding changes they may wish to consider making in their own programs, or new treatment measures they may wish to begin implementing.

Summary

In summary, LIURP is an effective program that has been successful in meeting its goals. However, there are still many eligible households to be served. There are several options for more detailed research into LIURP, which would allow us recommend changes that could enhance its effectiveness. Specifically, there are benefits to be gained from more detailed analysis into cost-effectiveness, energy conservation behavioral changes, the impact of education services, long-term energy savings, and the relationship between payment assistance programs and energy conservation programs. Some modifications to LIURP could potentially result in more effective targeting of needy households, further reductions in energy consumption, a decrease of the take-back effect, and a more comprehensive view of energy conservation.

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Appendix A
History of LIURP

Preliminary research for LIURP was conducted by the Bureau of Consumer Services and the Pennsylvania State University, which surveyed each state's weatherization services offered and the amount of need not being met by existing programs. Next, various experts in the fields of energy conservation and education were consulted and a policy paper was prepared in 1985 recommending the specific provisions of the LIURP program. This policy paper was submitted to the Pennsylvania Public Utility Commission for consideration. A program was subsequently outlined and regulations were drafted.

At its meeting on April 17, 1986, the Commission directed the publication for public comment of the proposed Low Income Usage Reduction Regulations. These regulations were subsequently published in the November 1, 1986 edition of the Pennsylvania Bulletin. Thereafter, the Attorney General, the Senate Consumer Protection and Professional Licensure Committee and the House Consumer Affairs Committee approved the proposed regulations. However, at its public meeting on December 1, 1986, the Independent Regulatory Review Commission (IRRC) disapproved the proposed regulations, and the Commission asked for, and received, an extension to submit a revised set of regulations.

The Commission subsequently made various modifications to its proposed regulations in response to the concerns of IRRC. Then, at its Public Meeting of May 22, 1987 the Commission issued an order adopting the regulations to establish residential low income usage reduction programs for eligible utility customers. These regulations were later approved by IRRC at its Public Meeting.

These regulations required affected utilities to establish fair, effective and efficient energy usage reduction programs for low income customers consistent with the provisions set forth under 52 Pa. Code §§501 and 1501. Monitoring and evaluating the implementation of these regulations was assigned to the Public Utility Commission's Bureau of Consumer Services. Before implementing specific programs for each company, a series of meetings were held with all participating companies. In these meetings, the Bureau of Consumer Services, Penn State University and representatives of each company developed the essential requirements for each company and designed a systematic evaluation procedure. Input was also solicited from consumer advisory panels and various consumer advocacy groups. As a result, each company was given flexibility in designing programs that met the specific needs of its service district and also involved local community agencies whenever possible while adhering to the regulatory requirements and fundamental program goals. Specifically, utility companies were given considerable freedom in designing their education program and were encouraged to develop, implement and evaluate new innovative methods for achieving usage reduction, including the implementation of pilot programs.

By the end of 1991, expenses for the program were incorporated in the rates of almost all of the major utilities required to participate in the program. Since federal funding for low income energy related programs had reached critically low levels, LIURP constituted good public policy for Pennsylvania. Furthermore, annual evaluation of program results showed that LIURP was successful in meeting its goals. Consequently, the Public Utility Commission recommended the continuation of the program.

Faced with a successful program that was soon scheduled to expire, the Commission revised the regulations and recommended a five year extension. By order adopted May 14, 1992 and entered June 2, 1992 at L-920065, the Commission initiated a proposed rulemaking to extend LIURP for another 5-year period. (LIURP was scheduled to expire on or before January 28, 1993.) In that order, the Commission recognized that LIURP's weatherization and conservation services had achieved significant benefits for both utilities and low income customers, and that the program would continue to do so in the future.

Based on the Commission's consideration of the comments received regarding the LIURP program, including the comments of IRRC and the House and Senate standing committees, the Commission proposed adoption of the final-form regulations. Accordingly, under 66 Pa. C.S. §§501, 1501 and 1505(b) and the Commonwealth Documents Law (45 P.S. §1201 et seq.) and the regulations promulgated thereunder at 1 Pa. Code §§7.1-7.4, the Commission proposed adoption of the final-form regulations at 52 Pa. Code §§58.1-58.18. The regulations of the Pennsylvania Public Utility Commission, 52 Pa. Code were amended by deleting §§69.151-69.168 and by adding §§58.1-58.18 to read as set forth in Annex A[70].

On July 7, 1992, the Office of Attorney General issued its approval of the proposed regulations as to form and legality. On July 15, 1992, copies of the proposed rulemaking were delivered to the Chairman of the house Committee on Consumer Affairs, the Chairman of the Senate Committee on Consumer Protection and Professional Licensure, the Independent Regulatory Review Commission (IRRC) and to the Legislative Reference Bureau. The proposed rulemaking was published for comment at 22 Pa.B. 3908 (July 25, 1992).

The House Committee on Consumer Affairs and the Senate Committee on Consumer Protection and Professional Licensure approved the proposed regulations on September 4, 1992 and September 15, 1992, respectively. On September 23, 1992, the Commission received comments from IRRC on the proposed regulations, as well as written comments from various other parties. Continuance of LIURP was recommended for several reasons. Evaluation studies showed that LIURP was successful in providing assistance to customers of electric and gas utilities by reducing the impact of energy costs on low income families, improving end-use energy efficiencies and improving their ability to pay

[70] Note: The text of the regulations amended in this annex was originally codified in Chapter 69 in error. Therefore, upon final adoption of these amendments, the text was moved from §§69.151-69.168, Pennsylvania Code pages 69-48-69-62, serial pages (126876)-(126888) and (140331)-140333) to §§58.1-58.18, the text of which appeared in Annex A.

for utility services. Furthermore, it provided benefits to the utilities and all ratepayers in terms of reduced costs of electric generation or natural gas acquisition, less impact on the environment and reduced peak demand growth.

On October 22, 1992, the Commission adopted an order promulgating final-form regulations extending the LIURP program for another 5-year period. From 1986 to 1992, this program provided weatherization and conservation services to over 62,000 Pennsylvania households. LIURP services were to be funded by a charge of 0.2 percent of utility revenues (or 2 cents for each ten dollars the utility collected). On December 2, 1992, the Independent Regulatory Review Commission approved the final-form regulations and on January 16, 1993 they were published in the Pennsylvania Bulletin, effective immediately. With the later implementation of the customer choice programs for the electric industry, LIURP was included under the Universal Service provisions (in 2000 for electric companies and 2002 for gas).

LIURP, from its inception, was intended to be modified as needed based upon yearly evaluation results, changes to regulatory policy, technology, service districts, and the field experience of the companies. After reviewing program results from the first several years and assessing the overall effectiveness of LIURP, including any problems encountered during the initial implementation years, the Commission made several revisions to LIURP, which went into effect on January 18, 1993.

Among the changes, electric utilities were allowed to provide usage reduction for high use baseload customers. Electric baseload measures addressed residential usage other than electric space heating and electric water heating. For some companies, the introduction of a baseload reduction component was new, while for other companies the baseload reduction proposal represented a continuation of proven, effective measures and an introduction of new, more sophisticated measures. The Commission expected that baseload treatments in LIURP would evolve as utilities gained experience and as technology improved in this rapidly developing area.

Another program modification was intended for households that received both gas and electric service. In such cases, participating utilities were required to coordinate the provisions of program services in order to promote a more comprehensive delivery of usage reduction measures. For example, when a gas utility provided gas heating usage reduction services to a customer that had electric water heating and baseload service provided by a covered electric utility, the gas utility was required to provide usage reduction education and low cost measures designed to reduce electric consumption. These low cost measures included the installation of efficient light bulbs where appropriate, and the installation of devices to reduce the flow of hot water in showers and faucets. Similarly, electric companies were required to provide, when applicable, natural gas conservation education and perform gas hot water tank wraps and pipe wraps, and install faucet aerators, where necessary.

Additionally, a twelve-year simple payback criterion for specific usage reduction measures was implemented, where the expected life time of the measure installed must exceed the payback period. However, all unspecified measures continue with a seven-year payback as stated in the original LIURP regulations. Specified measures include sidewall insulation, attic insulation, space heating system replacement, and water heater replacements. The extension from seven to twelve years for the specified measures was made because the specified measures are long-term, passive measures with a potential for substantial energy savings.

As noted elsewhere in this report, there are two primary methods for assisting low-income households with paying their energy bills. One is to reduce their energy consumption through weatherization programs such as LIURP. The other method is to provide payment assistance programs to assist with paying winter heating bills. The primary program of this type is LIHEAP. Other programs have been developed over the years to assist with promoting regular year-round utility bill payments and to reduce arrearages. In 1994, a major study of LIURP recommended coordinating these services whenever possible to provide the most comprehensive assistance to eligible households and to have maximum combined impact on both energy consumption reduction and improved bill payment behavior. In the years following this study, renewed emphasis was placed on coordinating these programs, where companies refer eligible LIURP households to both LIHEAP and customer payment assistance programs.

Finally, it must be remembered that LIURP is not a static program. Adjustments are made as technologies and regulations change. Companies can also make adjustments to their programs as they become more experienced with what works and what does not. Periodically, LIURP is reviewed with an eye toward adding variables that help with analyses and eliminating those that are not very useful or difficult to obtain. In 1994, various coding changes were made to the data reporting process, and again, in 2000, major coding changes were made to streamline the data gathering process. At this time, several variables were made optional and others were redesigned or eliminated, while variables were also added to capture information on changes in the regulatory environment. Further, specific measure codes are added when companies try new treatments. In recent years, companies have also had the option of implementing pilot studies within LIURP to test new treatments.

The PUC and Penn State continue to evaluate LIURP on a yearly basis and submit reports to each LIURP company. In 1994 the PUC published a major review of LIURP entitled, “LIURP: Historical Report and Program Analysis.” Updated statistics on LIURP are also included in each Public Utility Commission annual report, and in the yearly Universal Services reports.

Appendix B
Weatherization Treatment Measures

WATER HEATING

- Faucet Aerator – Bath
- Faucet Aerator – Kitchen
- Low Flow Showerhead
- Water Heater Jacket R-11
- Pipe Insulation
- Tank Temp Setback
- Leaky Faucet Repair
- Test/Replace Elements
- Water Heater Replace
- Water Heater Jacket R-8
- Repair Hot Water Leaks/Plumbing Repairs
- Gravity Fill Exchange Installed
- Heat Tape
- Faucet Replacement
- Solar Water Heating

INFILTRATION CONTROL – GENERAL

- Infiltration Work Including Blower Door
- Infiltration Work Excluding Blower Door
- Blower Door Test
- Caulking
- Switch & Outlet Gasket
- Air Conditioner Cover
- Wall Insulation
- Create Attic Hatch

INFILTRATION CONTROL – EXTERIOR DOOR

- Sweep
- Weather strip
- Fix Lock
- Replace Lock
- Repair
- Replace
- Construct
- Storm Door

INFILTRATION CONTROL – INTERIOR DOOR BETWEEN TWO HEATED AREAS

- Weather strip
- Replace Lock
- Construct

INFILTRATION CONTROL – INTERIOR DOOR BETWEEN A HEATED AND NON -HEATED AREA

- Construct
- Insulate with Rigid Bd.

INFILTRATION CONTROL – PRIME WINDOW

Replace Crkd Glass with Glaze
Reglaze Only
Repair/Replace Sash
Replacement Window
Window Quilt
Window Film

INFILTRATION CONTROL – STORM WINDOW

Interior Storms
Exterior Storm Repair
Install Exterior Storms

MOBILE HOME

Install Combination Door/Storm
Replace Ext Prime Door
Interior Storm Windows
Replace Prime Windows
Skirting
Roof Coating
Ceiling Insulation
Floor Insulation
Wall Insulation
Install Roof Cap
Install Zone Heating System

ATTIC INSULATION

Non Facd Batt Fiberglass R-19
Blown Insulation R-8
Blown Insulation R-10
Blown Insulation R-19
Blown Insulation R-20
Blown Insulation R-25
Blown Insulation R-27
Blown Insulation R-30
Blown Insulation R-38
Hatch Boxing
Attic Acc/No Stairs
Attic Acc/Fold. Stairs
Recessed Lighting Boxing
Add Roof Vent
Add Soffit Vent
Soffit Chutes

FLOOR INSULATION

Facd Bat Fiberglass R-11 16”
Facd Bat Fiberglass R-19 16”
Facd Bat Fiberglass R-19 24”

FLOOR INSULATION OVER UNCONDITIONED AREA

Facd Bat Fiberglass R-11 16"
Inst Vap Bar Crawl Space

STILL BOX INSULATION

Facd Bat Fiberglass R-11 16"

INTERIOR FOUNDATION INSULATION

Facd Bat Fiberglass R-19 24"
Insulate Knee Wall

GARAGE INSULATION MEASURE

Thermax Board
Facd Bat Fiberglass R-19

MISCELLANEOUS/REPAIRS

Misc. Repairs/Measure-Chimney/Windows/ Electrical Repairs
Off Peak Rate, Time of Day Conversions
Roof Repairs: General
Interior Repairs – Floor, Wall, Ceiling
Repair Floor Under Bath
Repair Wall Plaster
Repair Ceiling Plaster
Pre-Air Sealing Repairs
Exhaust Vents:
Replace/Install Kitchen and
Bathroom Exhaust Fan
Vent Exhaust Fans Outdoors
Dryer Vents:
Install Vent Duct and Hood
Connect Duct to Hood
Ceiling Fan
Clothes Line

FURNACE WORK

Heating System/Furnace Repairs & Retrofits
Efficiency Test (CO2)
Furnace Sizing
Duct Work Sizing & Repair
Duct Work Insulation
Burner Replacement
Boiler Replacement
Heat Exchanger Replacement
Furnace/Heating System Replacement
Baseboard Repair/Replacement
Furnace Maintenance:
Tune-up
Replace Filters
Replace Thermocouple/Clean Blower
Furnace Filter

AUDIT

Pre-Audit/Audit, Including Blower Door.
Pre-Audit/Audit, Excluding Blower Door.
Walk-Through Audit, Including Blower Door.
Walk-Through Audit, Excluding Blower Door.

APPLIANCE/LIGHTING

Change out Refrigerator/Freezer
Change out Air Conditioner
Change out Other Appliance
Install Efficient Lighting/Fixtures
Other Appliance Efficiency Improvements
Waterbed Retrofit
Window Air Conditioner Unit
Air-Conditioner Filter
Appliance/Air Conditioner Timer

Other Measures Installed

Cooling System Maintenance, Repair and Retrofit
Cooling System Replacement
Thermostat (Regular) – Recalibrate/Relocate/ Replace
Install Setback Thermostat
Miscellaneous Measures/ Multi-Family
Common Areas (prorated by units treated)

Appendix C
Additional Tables

Table C-1
Average Energy Bill Arrearage in Dollars by Year

	Average Arrearage in Pre-Period in Dollars	Average Arrearage at end of Pre-Period/ Beginning of Post-Period	Average Arrearage at end of Post-Period in Dollars
1989	340.45	499.77	220.19
1990	225.75	314.64	230.91
1991	176.37	283.78	218.28
1992	213.68	362.05	316.04
1993	223.20	289.07	298.89
1994	385.41	524.32	419.11
1995	504.74	599.34	473.69
1996	508.92	649.51	514.94
1997	808.25	833.45	717.48
1998	481.33	545.39	502.11
1999	609.44	741.73	684.20
2000	447.39	557.59	503.28
2001	441.70	571.42	519.31
2002	466.71	539.05	490.72
2003	372.58	501.93	481.62
2004	738.87	737.09	649.05
2005	723.09	728.56	649.13
2006	504.62	558.00	512.86

Appendix D
Detailed Results of Regression Models

The following tables are presented in the order in which they are discussed in the text. Two first column lists the independent variables found to be significant in the various regression models. The second column shows the Parameter Estimate for each variable which indicates the degree of change in the dependent variable for each observed unit change in the independent variable. The third column shows the level of statistical significance for the observed relationship shown in the second column. For example, in the first table, the change-out of refrigerators or freezers is associated with a reduction in energy consumption of 5.8616 percent, and this association is significant at the 0.0001 level.

Table D-1
Results of Basic Regression Model for Changes in Energy Consumption
For Households that Fail to Reduce Energy Consumption
And Households that do Reduce Energy Consumption

	Parameter Estimate	Level of Significance
Households that Have No Change or Increase their Energy Consumption		
Positive Relationship:		
• Amount of energy usage in pre-period	0.00106	<0.0001
• Amount of arrearage in pre-period	0.00416	<0.0001
• Number of residents in the household	0.79474	0.0011
• Total annual household income	0.00012	0.0489
Negative Relationship:		
• Furnace maintenance	-6.5857	<0.0001
• Chimney, windows, electric repairs[71]	-3.9212	0.0018
• Amount of space heated	-0.0009	0.0040
Households that Reduce Their Energy Consumption		
Positive Relationship:		
• Replace refrigerator/freezer	5.8616	<0.0001
• Chimney, windows, electrical repairs	2.5658	<0.0001
• Amount of energy used in the pre-period	0.00132	<0.0001
• Amount of arrearage in the pre-period	0.00132	<0.0001
Negative Relationship:		
• Furnace maintenance	-2.73464	<0.0001
• Number of residents in the household	-0.35248	0.0001
• Number of rooms in the home	-0.10463	0.0055
• Percent of energy burden	-0.00734	0.0163

[71] Miscellaneous Chimney, windows and electrical repairs are reported together in the data set and cannot be separated.

Table D-2
Results of Basic Regression Model for Changes in Energy Consumption
By Industry

	Parameter Estimate	Level of Significance
Electric Industry		
Positive Relationship:		
• Replace refrigerator/freezer	8.91799	<0.0001
• Amount of energy used in the pre-period	0.00154	<0.0001
• Amount of arrearage in pre-period	0.00601	<0.0001
• Install more efficient lighting	3.84603	0.0091
Negative Relationship:		
• Furnace maintenance	-22.01315	<0.0001
• Number of residents in the household	-0.99360	<0.0001
• Low flow shower heads	-3.00377	0.0006
• Chimney, windows and electric repairs	-2.82306	0.0027
Gas Industry		
Positive Relationship:		
• Amount of energy used in the pre-period	0.04427	<0.0001
• Chimney, windows and electric repairs	2.02033	0.0078
• Amount of arrearage in pre-period	0.04427	0.0263
Negative Relationship:		
• Number of rooms in the home	-0.53989	0.0044
• Low flow shower heads	-2.13023	0.0431
• Furnace maintenance	-1.36307	0.0496

Table D-3
Results of Basic Regression Model for Changes in Energy Consumption
By Type of LIURP Job

	Parameter Estimate	Level of Significance
Electric Heating Jobs		
Positive Relationship:		
• Amount of energy usage in the pre-period	0.00110	<0.0001
• Amount of arrearage owed in pre-period	0.00685	0.0004
Negative Relationship:		
• Furnace maintenance	-6.88141	0.0034
• Amount of heated space	-0.00137	0.0129
• Number of residents in the household	-1.87690	0.0401
• Number of rooms in the house	-0.97848	0.0431
Electric Water Heat Jobs		
Positive Relationship:		
• Replace refrigerator/freezer	6.52831	<0.0001
• Amount of energy used in the pre-period	0.00142	<0.0001
• Amount of arrearage in pre-period	0.00483	<0.0001
Negative Relationship:		
• Number of residents in household	-1.62406	<0.0001
Electric Baseload		
Positive Relationship:		
• Replace refrigerator/freezer	13.13593	<0.0001
• Amount of energy usage in the pre-period	0.00158	<0.0001
• Amount of arrearage owed in pre-period	0.00670	<0.0001
Negative Relationship:		
• Number of residents in the household	-0.66996	0.0041
• Number of rooms in the house	-0.56531	0.0502 (borderline)

<u>Gas Heating Jobs</u>		
Positive Relationship:		
• Amount of energy used in the pre-period	0.04427	<0.0001
• Amount of arrearage in pre-period	0.00149	0.0278
Negative Relationship:		
• Number of in-home education contacts	-1.69772	0.0006
• Number of rooms in the home	-0.53986	0.0044
• Costs of educational services	-0.01637	0.0249
• Furnace maintenance	-1.36307	0.0496

Table D-4
Results of Basic Regression Model for Changes in Energy Consumption
By Type of Housing

	Parameter Estimate	Level of Significance
Detached Single Family/Duplex		
Positive Relationship:		
• Replace refrigerator/freezer	11.76177	<0.0001
• Amount of energy usage in the pre-period	0.00030	<0.0001
• Amount of arrearage owed in pre-period	0.00270	<0.0001
• Chimney, windows, electric repairs	3.03920	<0.0001
Negative Relationship:		
• Lighting	-9.44380	<0.0001
• Educational costs	-0.02914	<0.0001
• Number of in home education contacts	-3.09092	<0.0001
• Low Flow shower head	-5.66653	<0.0001
Small Multi-Unit		
Positive Relationship:		
• Energy burden	27.83488	<0.0001
• Replace refrigerator/freezer	10.62629	0.0093
Large Multi-Unit		
Positive Relationship:		
• Amount of energy usage in the pre-period	0.005445	<0.0001
• Amount of heated space	0.01334	0.0019
Negative Relationship		
• Lighting	-10.23427	0.0084
• Pre audit excluding blower doors	-7.14912	0.0394
Mobile Homes		
Positive Relationship:		
• Educational costs	0.7591	<0.0303

Table D-5
Results of Regression Model with Measure Costs
For Changes in Energy Consumption
For Households that Fail to Reduce Energy Consumption
And Households that do Reduce Energy Consumption

	Parameter Estimate	Level of Significance
Households that Have No Change or Increase their Energy Consumption		
Positive Relationship:		
• Sidewall insulation costs	0.01046	<0.0001
Negative Relationship:		
• Heating system costs	-0.02780	<0.0001
• Repair costs	-0.00802	<0.0001
• Window and door costs	-0.00366	<0.0001
Households that Reduce Their Energy Consumption		
Positive Relationship:		
• Sidewall insulation costs	0.00548	<0.0001
• Attic insulation costs	0.00416	<0.0001
• Heating system costs	0.00372	<0.0001
• Baseload costs	0.01004	<0.0001
• Audit costs	0.01263	<0.0001
• Other insulation costs	0.00223	0.0348

Table D-6
Results of Regression Model with Measure Costs
For Changes in Energy Consumption
By Industry

	Parameter Estimate	Level of Significance
Electric Industry		
Positive Relationship:		
• Baseload costs	0.01037	<0.0001
Negative Relationship:		
• Repair costs	-0.00872	<0.0001
• Window and door costs	-0.00579	<0.0001
Gas Industry		
Positive Relationship:		
• Sidewall insulation costs	0.00564	<0.0001
• Attic insulation costs	0.00544	<0.0001
• Heating system costs	0.00357	<0.0001
• Audit costs	0.01464	0.0050
• Other insulation costs	0.00432	0.0101

Table D-7
Results of Regression Model with Measures
For Changes in Energy Consumption
By Type of LIURP Job

	Parameter Estimate	Level of Significance
Electric Heating Jobs		
• Audit costs	0.15071	<0.0001
• Attic insulation costs	0.00928	<0.0001
Electric Water Heat Jobs		
• Repairs costs	-0.00768	0.0207
Electric Baseload		
• Baseload costs	0.01075	<0.0001
• Heating system costs	0.03513	0.0017
• Repair costs	-0.02397	<0.0001
Gas Heating Jobs		
• Heating system costs	0.00351	<0.0001
• Sidewall insulation costs	0.00570	<0.0001
• Attic insulation costs	0.00539	<0.0001
• Other insulation costs	0.00119	0.0088
• Audit costs	0.01496	0.0025

Table D-8
Results of Regression Model with Measure Costs
For Changes in Energy Consumption
By Type of Housing

	Parameter Estimate	Level of Significance
Single Family/Duplex		
• Sidewall insulation costs	0.00638	<0.0001
• Baseload costs	0.01749	<0.0001
• Attic insulation costs	0.00714	<0.0001
• Heating system costs	0.00422	<0.0001
• Audit costs	0.01247	0.0001
• Other insulation costs	0.00636	0.0003
• Cooling system costs	0.10462	0.0155
Small Multi-Family		
• Sidewall insulation costs	0.01046	0.0004
• Infiltration costs	0.00852	0.0139
• Baseload costs	0.01461	0.0272
Large Multi-Family		
• Attic insulation costs	0.01078	0.0250
Mobile Homes		
• Repair costs	0.01362	0.0279

Table D-9
Results of Regression Model with Optional Variables
For Changes in Energy Consumption

	Parameter Estimate	Significance
Overall change in energy consumption		
Number of teenagers	-0.4535	0.0108
Electric baseload jobs		
Number of children	- 0.80413	0.0530
Number of seniors	+2.20916	0.0136

Table D-10
Results of Basic Regression Model for Reduction in Utility Bill Arrearage

	Parameter Estimate	Level of Significance
Positive Relationship:		
• Change in energy usage from pre to post	4.07004	<0.0001
• Educational costs	0.57312	0.0001
Negative Relationship:		
• Number of residents in household	-22.17368	<0.0001
• Age of dwelling	-0.03824	<0.0001
• Amount of heated space	-0.02074	0.0100

Table D-11
Results of Basic Regression Model for Reduction in Utility Bill Arrearage
By Industry

	Parameter Estimate	Level of Significance
Electric Industry		
Positive Relationship:		
• Change in energy usage from pre to post	4.3767	<0.0001
• Education costs	1.17992	<0.0001
Negative Relationship:		
• Number of residents	-9.01938	0.0013
• Number of rooms	-5.27652	0.0348
Gas Industry		
Positive Relationship:		
• Change in energy usage from pre to post	2.90797	<0.0001
• Annual income	0.00327	0.0201
Negative Relationship:		
• Number of residents	-16.21513	0.0009

Table D-12
Results of Basic Regression Model for Reduction in Utility Bill Arrearage
For No Reduction in Utility Bill Arrearage and Reduced Arrearage

	Parameter Estimate	Level of Significance
Households that Have No Change or Increase their Energy Bill Arrearage		
Positive Relationship:		
• Change in energy usage from pre to post	1.36717	<0.0001
Negative Relationship:		
• Number of residents in household	-33.02652	<0.0001
• Age of dwelling	-0.02087	0.0001
• Amount of heated space	-0.02387	0.0049
Households that Reduce Their Energy Bill Arrearage		
Positive Relationship:		
• Change in energy usage from pre to post	3.63514	<0.0001
• Education costs	0.47066	0.0003
Negative Relationship:		
• Number of residents in household	-22.42562	<0.0001
• Age of dwelling	-0.06496	<0.0001
• Annual household income	-0.00404	<0.0001

Table D-13
Results of Basic Regression Model for Reduction in Utility Bill Arrearage
By Type of LIURP Job

	Parameter Estimate	Level of Significance
Electric Heating Jobs		
Positive Relationship:		
• Change in energy usage from pre to post	3.06850	0.0011
Negative Relationship:		
• Age of dwelling	-0.03135	0.0001
Electric Water Heat Jobs		
Positive Relationship:		
• Change in energy usage from pre to post	3.35163	<0.0001
Negative Relationship:		
• Annual household income	-0.00343	0.0292
Electric Baseload		
Positive Relationship:		
• Change in energy usage from pre to post	7.83292	<0.0001
• Education costs	5.00741	<0.0001
Negative relationship:		
• Number of Residents in Household	-41.08931	<0.0001
• Annual household income	-0.00941	0.0001
Gas Heating Jobs		
Positive Relationship:		
• Change in energy usage from pre to post	2.38567	<0.0001
• Annual household income	0.00423	0.0081
Negative Relationship:		
• Number of residents in household	-21.10043	0.0001

Table D-14
Results of Basic Regression Model for Reduction in Utility Bill Arrearage
For Households that Reduce Energy Consumption
And Households that Do Not

	Parameter Estimate	Level of Significance
Households that Have No Change or Increase their Energy Consumption		
Positive Relationship:		
• Change in energy usage from pre to post	3.52386	0.0113
Negative Relationship:		
• Number of Residents in Household	-23.2528	0.0006
• Age of dwelling	-0.01523	0.0501
Households that Reduce Their Energy Consumption		
Positive Relationship:		
• Change in energy usage from pre to post	5.27378	<0.0001
• Education costs	0.67142	<0.0001
Negative Relationship:		
• Number of residents in household	-22.42562	<0.0001
• Age of dwelling	-0.04633	<0.0001
• Amount of heated space	-0.02377	0.0110

Table D-15
Results of Regression Model for Energy Conservation Education And Changes in Energy Consumption

	Parameter Estimate	Level of Significance
Positive Relationship:		
• Remedial in-home educational visits	3.68905	0.0002
Negative Relationship:		
• Pre in-home educational visits	-4.72308	<0.0001

Table D-16
Results of Regression Model for Energy Conservation Education And Changes in Energy Bill Arrearage

	Parameter Estimate	Level of Significance
Positive Relationship:		
• Remedial in-home educational visits	4.76040	0.0003
Negative Relationship:		
• Pre in-home educational visits	-5.73279	<0.0001