OAK RIDGE
NATIONAL LABORATORY
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# WEATHERIZATION ASSISTANCE PROGRAM TECHNICAL MEMORANDUM BACKGROUND DATA AND STATISTICS

**March 2010**

**Prepared by**
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**Program Manager**

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Energy and Transportation Science Division

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Prepared by
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**SUMMARY DATA SHEET**

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| Households eligible for the Low Income Home Energy Assistance Program (LIHEAP) | 38.6 million |
| Average site annual energy consumption for LIHEAP-Eligible Households | 84 MBtu |
| LIHEAP-Eligible households annual energy consumption per square foot | 90.2 Btu |
| Average LIHEAP-Eligible household energy expenditure for FY 2010 | $1,800 |
| Average first-year Weatherization energy savings | 29 MBtu |
| Average first-year heating and cooling bill reduction (2010 prices) | $436.64 |
| Range of potential annual base-load savings | $104–$174 |
| Average annual $CO_2$ reduction per weatherized home | 2.65 metric ton |
| Benefit/cost ratio for energy savings | 1.8 |
| Societal benefit/cost ratio | 2.5 |

# WEATHERIZATION ASSISTANCE PROGRAM
# BACKGROUND DATA AND STATISTICS

## INTRODUCTION

This technical memorandum is intended to provide readers with information that may be useful in understanding the purposes, performance, and outcomes of the Department of Energy's (DOE's) Weatherization Assistance Program (Weatherization). Weatherization has been in operation for over thirty years and is the nation's largest single residential energy efficiency program. Its primary purpose, established by law, is

*"…to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, the handicapped, and children."*[1]

The American Reinvestment and Recovery Act PL111-5 (ARRA), passed and signed into law in February 2009, committed $5 Billion over two years to an expanded Weatherization Assistance Program. This has created substantial interest in the program, the population it serves, the energy and cost savings it produces, and its cost-effectiveness. This memorandum is intended to address the need for this kind of information.

Statistically valid answers to many of the questions surrounding Weatherization and its performance require comprehensive evaluation of the program. DOE is undertaking precisely this kind of independent evaluation in order to ascertain program effectiveness and to improve its performance. Results of this evaluation effort will begin to emerge in late 2010 and 2011, but they require substantial time and effort.

In the meantime, the data and statistics in this memorandum can provide reasonable and transparent estimates of key program characteristics. The memorandum is laid out in three sections. The first deals with some key characteristics describing low-income energy consumption and expenditures. The second section provides estimates of energy savings and energy bill reductions that the program can reasonably be presumed to be producing. The third section deals with estimates of program cost-effectiveness and societal impacts such as carbon reduction and reduced national energy consumption.

Each of the sections is brief, containing statistics, explanatory graphics and tables as appropriate, and short explanations of the statistics in order to place them in context for the reader. The companion appendices at the back of the memorandum explain the methods and sources used in developing the statistics.

[1] Title 42 of the U.S. Code, Chapter 81, Subchapter III, Part A, 6861.

## SECTION 1
## ENERGY-RELATED CHARACTERISTICS OF LOW-INCOME HOUSEHOLDS

### DEFINING THE LOW-INCOME POPULATION

There are a number of ways to define the households that can be described as low-income. Most of these are based on household income standards defined by various federal programs. For example, eligibility for many programs at the Department of Housing and Urban Development (HUD) is defined as household income at or below 80 percent of the local area median. The Department of Health and Human Services (HHS) Low Income Home Energy Assistance Program (LIHEAP) has historically defined eligibility to be household income at or below 150 percent of the Federal Poverty Income Guidelines or 60 percent of state median income, whichever is higher. The DOE Weatherization Assistance Program now defines eligibility as household income at or below 200 percent of the Poverty Income Guidelines or HHS LIHEAP eligibility. For purposes of this analysis, the LIHEAP guidelines are employed because they are consistent with the most reliable energy data regarding household energy use, the DOE Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS)[2]. According to the latest RECS, there are 38.6 million households in the United States that are federally eligible for LIHEAP out of 111 million households nationwide.[3] Within this low-income population, 16.6 million households are categorized as having income below the poverty level. The low-income household population is generally distributed around the United States in roughly the same proportions as the non-low-income population, with approximately 21 percent in the Northeast, 24 percent in the Midwest, 36 percent in the South, and 19 percent in the West.

This large eligible population is composed of a broad range of households in terms of income levels, housing characteristics, and program participation. According to the 2005 RECS, more than 58 percent of the households contained at least one paid worker while approximately 21 percent received food stamps. Nearly 66 percent of the eligible households lived in single-family or mobile homes and more than half owned their own homes.

### FUEL TYPES AND EFFICIENCY CHARACTERISTICS

Low-income consumers have a similar profile to other consumers in terms of the primary heating fuel they use, with a slightly higher proportion than the general population using propane for this purpose. The largest single heating fuel type is natural gas, with approximately 48 percent of low-income households employing this fuel. Electricity is used for heating by 32 percent of these households. Home heating oil is the heating fuel of 8 percent of low-income families, and propane is employed for heating by 5 percent.

As the following graph demonstrates, the concentration of heating fuel usage varies substantially by region. Most of the home heating oil is used by households in the Northeast whereas electricity is the dominant heating source in the South, and natural gas predominates in the Midwest. These concentrations are found among both low-income and non-low-income households. This has important implications for the average level of residential expenditures and energy burdens in the various parts of the country because home heating oil and propane prices per million British thermal units (MBtu) are higher and have risen more sharply than those of other fuels. Furthermore,

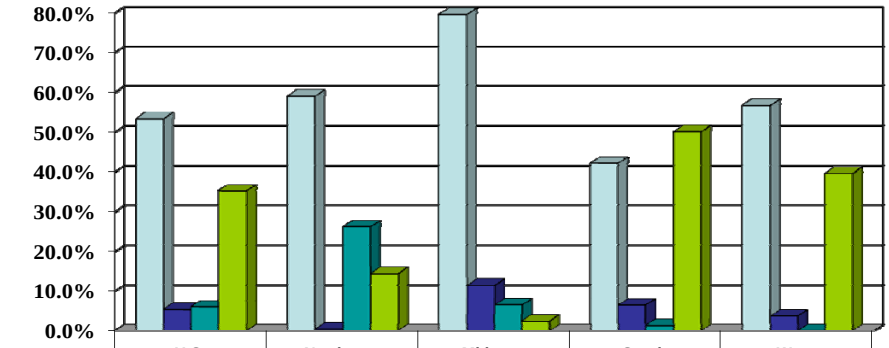
[2] Energy expenditure statistics in this memorandum are based on the public use files of the 2005 RECS, weather-normalized, and adjusted for FY 2010 prices as projected by EIA.

[3] Special tabulations from the American Community Survey, 2005-2007, which has more precise income data, indicate that there were approximately 32.8 million households at or below 200 percent of the federal poverty income guidelines and 34.9 million households at or below 60 percent of state median income.

residential electricity prices in the northeastern part of the country also tend to be well above the national average. The overwhelming predominance of natural gas as the primary heating fuel in the Midwest makes low-income households in that part of the United States extremely sensitive to events in the natural gas markets.

## PRIMARY HEATING FUEL FOR LOW-INCOME HOUSEHOLDS

**By Region**




| | U.S. | Northeast | Midwest | South | West |
|---|---|---|---|---|---|
| Natural Gas | 53.4% | 59.1% | 79.6% | 42.2% | 56.7% |
| Propane | 5.4% | 0.4% | 11.4% | 6.4% | 3.7% |
| Fuel Oil | 6.0% | 26.2% | 6.5% | 1.3% | 0.0% |
| Electricity | 35.2% | 14.4% | 2.4% | 50.1% | 39.6% |

Source: DOE/EIA Residential Energy Consumption Survey for 2001

Average annual weather-adjusted energy consumption for low-income households in 2005 was 84 MBtu compared to 102 MBtu for the non-low-income households. On the other hand, energy intensity, that is to say, Btu consumption per square foot of heated space, showed the reverse pattern. For eligible households, annual consumption per square foot averaged 90.2 Btu whereas for non-low-income households the average was 69 Btu per square foot. This reflects the relative inefficiency of the low-income housing stock compared to that of other households. Where 24 percent of low-income households reported inadequate insulation in their homes, 15 percent of non-low-income households reported this condition.

A review of the average MBtu consumption for low-income households by housing type reveals that households living in large apartment buildings have lower average annual consumption than those in most other building types (56.4 MBtu compared to 99 MBtu for those in single-family homes). It important to note that average consumption per square foot is far higher in the small multifamily housing stock than it is in other building types. The average consumption was 139 Btu per square foot for these homes compared to 81 Btu per square foot for single-family homes and 83 Btu per square foot for apartments in large buildings. This highlights a potential efficiency opportunity in the small multifamily housing stock.

The RECS data indicate substantial energy efficiency opportunities in the low-income housing stock in terms of both heating systems and refrigerators if one uses the age of the equipment as a

rough proxy for inefficiency. Nearly 40 percent of the refrigerators in the low-income households were original installations or more than 10 years old compared to 32 percent for the non-low-income households. The contrast is comparable for heating systems, with 65 percent of low-income heating units being either original equipment or 10 or more years old. This compares to 53 percent for non-low-income households. Please see the table below for details.

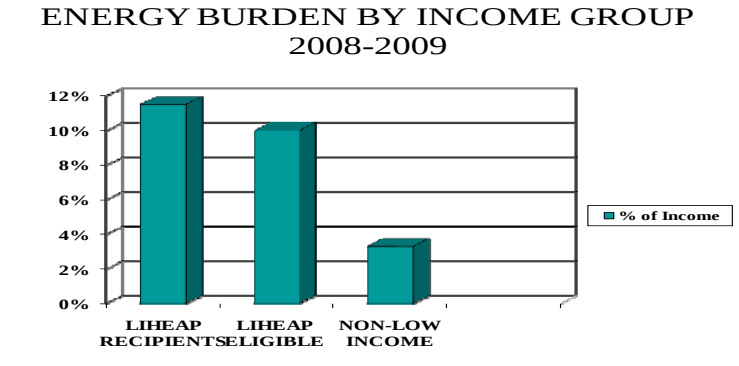
**AGE OF HEATING SYSTEMS AND REFRIGERATORS, BY INCOME CATEGORY**

| Age of Equipment | Refrigerators | | Heating Systems | |
|---|---|---|---|---|
| | Low-Income | Non-Low-Income | Low-Income | Non-Low-Income |
| Under 2 Years | 16.5% | 17.4% | 9.7% | 11.4% |
| 2–4 Years | 19.3% | 21.1% | 10.9% | 13.8% |
| 5–9 Years | 24.6% | 29.5% | 14.3% | 21.7% |
| 10–19 Years | 22.9% | 23.3% | 19.2% | 25.4% |
| 20 Years or more | 6.1% | 5.2% | 25.6% | 19.7% |
| As old as home | 10.6% | 3.5% | 20.3% | 8.0% |

## ENERGY EXPENDITURES AND BURDEN

The estimated average annual expenditure for low-income households for FY 2010 (October 2009–September 2010) is $1,800, of which $747 (41.5%) is estimated to be for primary heating and cooling expenses. This compares to estimated residential energy expenditures of $2,231 for non-low-income households, of which $863 (38.7%) was for primary heating and cooling.

Low-income households have lower average residential energy usage and lower residential energy bills than the non-low-income population, but this difference is not in proportion to household income. The average income of low-income households as provided in the 2005 RECS and adjusted for inflation was estimated at $18,624 compared to $71,144 for non-low-income households. In 2009 the group energy burden of low-income households, defined as average residential energy expense divided by average income, was estimated to be 10 percent of income for low-income households compared to 3.3 percent for non-low-income households as shown in the graph below. Households that actually received energy payment assistance, estimated at just over 5 million in 2005, had an even higher energy burden of 11.5 percent of income.



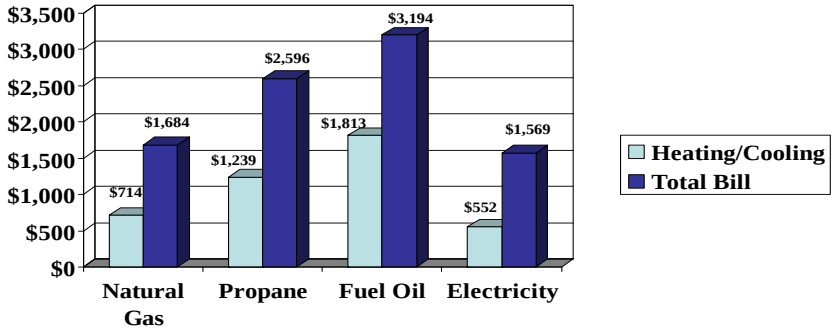

Source: RESIDENTIAL ENERGY CONSUMPTION SURVEY 2005

As one examines the energy bills of eligible low-income households, several features stand out. Households that employ fuel oil as their primary heat source have the highest energy bills, followed by those that heat with propane. The average energy bill for the former was estimated at $3,194 for FY 2010 while that of the latter was $2,596. This compares with $1,684 for low-income households heating with natural gas and $1,569 for those heating with electricity. Please see the following graph for details of heating and total residential energy expenditures by primary heating fuel.

Given the concentration of low-income households heating with fuel oil in the Northeast it is no wonder that the average energy expenditure projected for low-income households for FY 2010 is higher there than elsewhere at $2,341. This compares to $1,745 for such households in the Midwest, where less-expensive natural gas predominates, and $1,770 for those in the South, where heating loads are lower. Those low-income households living in the West have a projected average expenditure of $1,328. The lower average expenditure in the West is caused primarily by lower average heating and cooling needs in that region.

**EXPECTED ENERGY EXPENDITURES**
**FOR 2009-2010**
**Low-Income Households**

**By Primary Heating Fuel**




Source: ORNL Tabulation from EIA November 2009 STEO & 2005 RECS

## SECTION 2
## ENERGY SAVINGS AND BILL REDUCTION ESTIMATES

### ESTIMATED ENERGY SAVINGS

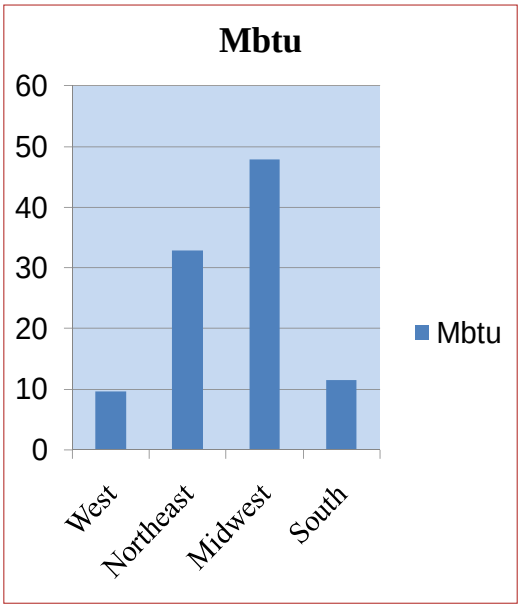
Oak Ridge National Laboratory (ORNL) has employed engineering estimates derived from the Weatherization Assistant residential audit package to estimate annual energy savings resulting from the installation of cost-effective measures in low-income residential dwellings under the new parameters established for the Weatherization Program under the ARRA. The estimated annual savings per low-income household for heating and cooling are 29 MBtu. For comparison purposes, the most recent metaevaluation of Weatherization savings based on state-level evaluations using energy billing data was 30.5 MBtu (Schweitzer 2005).

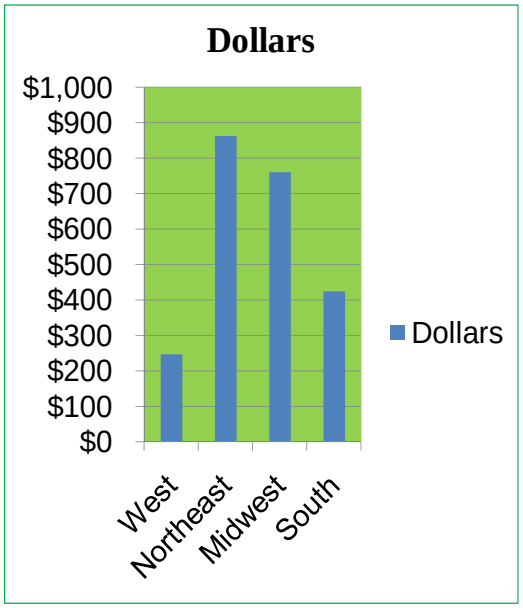
The ARRA legislation modified the Weatherization Assistance Program in significant ways. Most important for purposes of this analysis, the average cost ceiling for investment per unit was set at $6,500, a substantial increase from the previously authorized ceiling of $3,000. Accordingly, the investment level per unit should increase, resulting in greater savings. However, the higher funding levels were accompanied by a shift in formula allocation, resulting in proportionally more funding flowing toward hot-climate states, which might act to reduce average savings. This study takes these factors into account, as explained in Appendix B, by running audits on typical low-income homes in each state, adjusting for housing types, and weighting for revenue allocation. Though the results below provide a reasonable examination of the issue of Weatherization energy savings and regional variations in them, it is important to keep in mind that input data on local weatherization costs and housing characteristics is presently limited and that the estimates below are exactly that, and not valid statistical representations of actual program performance.

The weighted average national per-household expenditure savings, based on regional energy prices provided by EIA in its Annual Energy Outlook for 2010 and weighted by fuel use and housing type by state, is estimated at $436.64 in 2010. This figure represents the estimated annual savings only for heating and cooling measures. There is substantial uncertainty regarding savings resulting from base-load electric measures such as compact fluorescent bulb (CFL) change-outs and refrigerator replacements. A reasonable estimate for the savings resulting from those baseload measures is $104 to $174 per household. This is an audit-based estimate; the relatively broad range reflects the uncertainty that comes from a lack of hard data on the extent to which these measures are applied.

These data mask significant variations in both energy savings and expenditure reductions based on weather conditions, housing type, and energy costs. For example one large state in the Northeast had estimated energy savings of 32.93 MBtu compared to 47.92 MBtu in a large Midwest state for comparable homes. The higher MBtu savings were largely driven by differences in the weather conditions in the two locations. The estimated dollar savings, however, were higher in the Northeast state by more than $100 per year because of the higher energy prices in that location. Similarly, while two states in the South and West had comparable energy savings, the dollar savings per year in the South were estimated to be higher because of the higher energy prices in that particular location. Please see Chart for details.

# VARIATIONS IN SAVINGS
## SELECTED STATES




Sources: ORNL Weatherization Assistant Tabulations, EIA Annual Energy Outlook 2010

**SECTION 3**
**BENEFIT/COST RATIOS**

Traditionally, the benefit/cost ratio for Weatherization has been expressed in terms of estimated national energy cost savings per dollar of investment for homes heated with natural gas, with cost savings based on national average residential natural gas prices. The estimates provided below reflect a somewhat different approach because they are based on state-by-state energy savings and investment numbers used to generate the savings estimates given in the previous section. As a consequence, the dollar savings estimates vary by region, by fuel type, by housing type, and with the adjusted average cost ceiling provided under ARRA. The estimated non-energy benefits are derived using the same methodology described above and, once again, the societal benefit/cost ratio is the combination of the energy and non-energy benefits divided by the estimated weighted average cost. Unlike the cost estimates that were derived from the metaevaluation, these estimates contain no assumed leveraged funding. The benefit/cost ratio estimated for energy benefits alone is 1.80 with total costs estimated at $5,704 and discounted energy benefits estimated at $10,253 in 2008 dollars. Non-energy benefits are estimated at $4,082 per household, also in 2008 dollars. The combined total benefit is estimated at $14,335, and the estimated societal benefit/cost ratio (all benefits divided by all costs) is 2.51. This is almost identical to the societal benefit/cost ratio of 2.53 computed in the most recent metaevaluation (Schweitzer 2005).

Estimated $CO_2$ savings, measured in metric tons per year of annual reduction, is estimated at 2.65 metric tons per unit weatherized and 53.1 metric tons over the life of the measures.

It is interesting to note that the estimated weighted average annual energy savings per household weatherized is slightly lower under this estimation methodology (29 MBtu) than the estimate in the previous metaevaluation (30.5 MBtu), although the dollar energy savings are substantially higher ($437 vs about $350). The former is partly the result of the fact that the new savings estimates are weighted for housing type variations under this method whereas the previous method provided estimates only for single-family homes, as in the metaevaluation. Perhaps even more important is the fact that the savings estimate in the metaevaluation was based on an assumed preweatherization energy consumption of 133 MBtu, which is much greater than the 84 MBtu found in this study. The dollar energy savings in this study, on the other hand, are substantially higher than those reported in the metaevaluation for two reasons. First, there is an attempt in this study to estimate energy bill reductions from the implementation of base-load electric measures such as CFLs and refrigerator replacement. For purposes of this effort, these base-load savings are estimated at 870 KWh per household. Second, by taking fuel type and cost into account (varied by region), the estimation methodology captures high fuel prices and expenditures in parts of the country that receive a substantial amount of weatherization funding and have relatively high fuel prices (e.g., the Northeast). This was not possible using the more simple methodology that was previously employed.

The methods used here are more complex and hopefully better at reflecting current reality than those used in previous years. Nonetheless, one needs to keep in mind the limitations of available input data that constrain an analysis such as this. There is no nationally available data on energy-related housing characteristics of weatherized households, nor is there data on the variations in the cost of measures installed from one locale to another. There is also no way of knowing at this point the exact characteristics of the housing stock and housing types that will actually get weatherized with the greatly expanded revenues available. Making these estimates more precise requires populating the methodology with more accurate data that will flow from the National Evaluation effort.

## APPENDIX A

## METHOD FOR ESTIMATING LOW-INCOME ENERGY EXPENDITURES

The method used to estimate the impact of projected price increases for residential energy on low-income households is based on the integration of two products from the Department of Energy's Energy Information Administration (EIA)—the Residential Energy Consumption Survey (RECS) for 2005 and the Short Term Energy Outlook (STEO) for November 2009. The former is the most recent EIA survey of U.S. households in an occasional series dating back to 1978 that provides detailed data on housing and energy characteristics, demographics, and energy consumption and expenditures verified through billing data. There are records on 4,382 individual household records in the data base. The STEO provides EIA's monthly estimate of energy prices in the 18-month period immediately ahead.

The RECS public-use files identify the location of each household by census region, of which there are four, and by census division, of which there are nine. Heating and cooling degree days are provided for each household for 2005 based on the population-weighted data for each census division; the poverty status of each household is also provided. The survey provides actual fuel bills for each household and uses statistical techniques to allocate the usage and expenditures among major usage categories such as heating, cooling, hot water heating, and refrigeration. Long-range climate normals for heating and cooling degree days for each of the census divisions were calculated using statistics provided by the National Climatic Data Center of the National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service. These data were employed to calculate an adjustment factor for each division so that RECS data on heating and cooling expenditures for 2005 could be adjusted to reflect normal conditions.

Price adjustment factors were similarly calculated using quarterly price projections by division for natural gas and electricity and by region for propane and heating oil as provided by the STEO for November, 2009. The quarterly prices were weighted by consumption for each quarter to calculate an annual price adjustment factor for the historical record for 2009 and for the price projections for 2010. The baseline energy prices used to calculate multipliers were derived from the historical STEO database. This methodology provides a conservative and internally consistent approach to the estimation problem.

The estimate of an individual household's expenditure for a given year (n) was then calculated using the following formula in SPSS:

(((Dolngsph * hddfact) + Dolngwth + Dolngapl) * pmngd) + (((Dollpsph * hddfact) + Dollpwth + Dollpapl)*pmlp r) + (((Dolkrsph*hddfact+Dolkrwth+Doldrapl)*pmfo r) + (((Dolfosph*hddfact)+ Dolfowth + Dolfoapl)*pmfo r) + (((Dolelsph * hddfact) + (Dolelcol * cddfact)+dolelapl+ dolelrfg + dolelwth)* pmel d)

where

'Dol' signifies the expenditure for 2001,
'ng' represents natural gas
'lp' represents propane
'kr' represents kerosene
'fo' represents fuel oil
'el' represents electricity
'hddfact' is the heating degree day adjustment factor for normalization
'cddfact' is the cooling degree day adjustment factor for normalization

‘sph’ is space heating
‘wth’ is water heating
‘apl’ is appliances
‘col’ is cooling,
‘rfg’ is refrigerator
‘pm’ is price multiplier year ‘n’
‘r’ is census region
‘d’ is census division.

Regional estimates were then made using the sort functions of SPSS to select households by region and qualification of eligibility for Low Income Home Energy Assistance Program and the ‘Explore’ statistical function to derive means, medians, and standard deviations by primary heating fuel type for total expenditures as well as heating and cooling expenditures for each year. Statistics were generated on a weather-normalized projected basis for FY 2010 (October 2009–September 2010).

## APPENDIX B

## METHODOLOGY FOR ESTIMATING ENERGY SAVINGS AND BILL REDUCTIONS

Certain metrics have been used in recent years to express the performance of the Weatherization Assistance Program. These include annual energy savings per household weatherized, expressed in million British thermal units (MBtu), first-year annual energy expenditure reductions expressed in dollars, the ratio of household life-time expenditure benefits to the cost of weatherization expressed as a benefit/cost ratio, and the ratio of total benefits, both energy and non-energy, to the cost of weatherization, expressed as the societal benefit cost ratio. In addition, the energy savings estimate has been used to derive estimated annual and lifetime $CO_2$ reductions. These estimates have been based on the energy savings and cost estimates found in the most recent Oak Ridge National Laboratory (ORNL) metaevaluation of the Weatherization Assistance Program with prices and costs updated for inflation (Schweitzer 2005) and the ORNL analysis of non-energy benefits, also updated for inflation (Schweitzer and Tonn 2002).

The estimates in this memorandum are a methodological departure from this recently used procedure. There are several reasons that a change was needed. First, the metaevaluation estimates are dated and do not reflect recent changes in program operations that materially impact household savings. These include a major change in the program's average cost ceiling, from $3,000 to $6,500, an expansion in allowable measures to include electricity measures such as refrigerator replacement and lighting changeout, and a major increase in program funding impacting the allocation of resources among different regions and climate zones. Second, the metaevaluation results describe only homes heated with natural gas and do not reflect the diversity of heating fuels used in treated homes nor do they reflect potential cooling savings. The previous method reflected only savings in single-family homes and were never adjusted for variations in the treated housing stock. Finally, the previous estimates were based on national average energy prices and were not varied to reflect the diversity of energy prices weighted by the location of the weatherization work being performed.

The methodology used to prepare statistics for this memorandum and described below corrects for many of these deficiencies. Nonetheless, it does not represent a statistically valid representation of the Weatherization Assistance Program's performance and results. There are too many assumptions and uncertainties incorporated in it to allow that to be the case. Much of this is the result of a lack of up-to-date information on program operations, particularly regarding measures installed and their cost as well as the energy-related characteristics of the homes weatherized. Rather, the results should be treated as the best currently available estimate that can serve until more rigorous results are provided by the new National Evaluation.

The estimate is based on state-by-state projections of energy-efficiency investments, savings, and costs for a standard single-family home in moderate condition. Many states have very different weather conditions within their own borders, and in these cases, multiple assessments were made to take this into account, and an average result was derived. Census-division-level price projections were used to determine dollar savings and cost-effectiveness for individual measures. The prices were taken from the Energy Information Administration's Short Term Energy Outlook for September 2009.

The estimates were made using the Weatherization Assistant residential audit tool, version 8.4, and employing the measure installation costs contained in the Sample Supply Library provided by the audit. The home is a typical one-story wood-frame ranch home with 1,300 square feet of living space. There is some existing insulation in the attic but none in the wall cavities. The windows are moderately leaky and the foundation is an uninsulated slab. The air leakage rate as measured by a blower door test is 4,000 cfm at a house pressure difference of 50 pascals. The refrigerator is more

than 15 years old and the heating system is in fair condition with a steady-state efficiency of 74 percent.

Information regarding the characteristics of actual homes weatherized is not available at the federal level, and this house cannot be confirmed as representative. For comparison purposes, the average heating and cooling consumption calculated for this house on a national basis is 83.3 MBtu. This compares to average low-income heating and cooling consumption of 47.1 MBtu for low-income homes in the 2005 Residential Energy Consumption Survey (RECS) and average pre-weatherization consumption for weatherized natural gas heated homes of 133 MBtu in the 1993 National Evaluation (Brown et.al. 2003).

The single-family energy-savings results were adjusted for the relative proportional consumption levels for manufactured homes and multifamily homes as provided in the RECS of 2005 and weighted for the proportion of each housing stock that was weatherized in a given state as reported to DOE for the 2008 Program Year. Primary heating fuel was adjusted to reflect regional fuel concentrations, such as home heating oil in New England and electricity in the Southeast. In the vast majority of cases, the average total of cost-effective investments in a home did not exceed the $6,500 average cost ceiling, but in the handful of cases where this was the case, the least cost-effective measures were eliminated until the ceiling was met.

There is a well-known history of actual realized results from weatherization activity yielding smaller savings than predicted by computerized audits. To take this effect into account the audit-predicted heating and cooling savings were adjust downward by 20 percent so as not exaggerate program performance. In addition, it was assumed that only 60 percent of the homes actually received a new refrigerator. There are no data indicating the proportion of weatherized homes that receive new refrigerators, so the 60 percent assumption was derived from a review of a recent evaluation of the Weatherization Assistance Program in Ohio.

The energy bill reductions were calculated by deriving a fuel mix for each state's weatherized homes as reported for the 2008 Program Year and deriving a weighted average price per MBtu using census-division-level prices from the Energy Information Administration's (EIA's) Annual Energy Outlook 2010 Early Release, (EIA AEO 2009).

A weighted average national cost for weatherization was derived by dividing the audit-generated state cost into the state's ARRA allocation in order to develop a total number of state units weatherized and dividing this figure into the sum of all weatherized units to develop a state weighting factor. This weighting factor was then used to develop weighted average national weatherization per-unit costs, energy savings, and bill reductions.

The benefit/cost ratios were calculated assuming a 20-year life of the measures as was the case in the original 1993 National Evaluation. Energy prices over the 20-year period were provided by the EIA AEO in 2008 constant dollars and savings were discounted at 3 percent per Office of Management and Budget (OMB) Circular. A-94 Appendix C (OMB 1992).

Carbon dioxide reductions were calculated for each state by weighting the carbon content of the heating and cooling energy saved by the carbon content of the fuels used in weatherized homes in that state. Reductions from base-load measures were calculated from a national average content of carbon per kilowatt-hour consumed. Total reductions were also calculated based on an assumed 20-year life of the measures. These reductions were calculated for each state and then weighted by the proportion of all homes weatherized as described earlier for the calculation of national average energy savings.

## APPENDIX C

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