DCEO
Energy Efficiency/Demand Response Plan
Plan Year 1 (6/1/2008-5/31/2009)
Evaluation Report:
Low Income Residential Retrofit Energy Efficiency Program
ComEd Service Territory

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Final Report

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E EXECUTIVE SUMMARY

This evaluation report covers the two residential retrofit programs run by the Illinois Department of Commerce and Economic Opportunity (DCEO): Low Income Weatherization and Low Income Home Improvement. Together, these programs are referred to as the Residential Retrofit Energy Efficiency program.

Evaluation of these two programs, Low Income Weatherization and Low Income Home Improvement, is combined into a single report because they both provide incentives for a similar set of retrofit measures that improve electric efficiency in existing homes. The major difference between the two programs is whether or not Low Income Weatherization work is also done on the home.

The installation of weatherization measures and other home improvements are generally focused on gas savings which are not part of this evaluation. However, this report does look at the energy savings achieved from the extra funding for electric efficiency measures that are installed in tandem with the weatherization and home improvement work.

Evaluation Questions

The objective of this evaluation report is to provide a basic verification of electric savings impacts during program year 1 (PY1) which covers June 1, 2008 through May 31, 2009. As the evaluation budget expands for program years 2 and 3, process evaluations will be added along with more in-depth investigation into the program impacts.

For this report on PY1, a review of the program tracking data will be done to answer these basic impact evaluation questions:

1. What are the gross impacts from this program?

2. Did the program meet its energy goals? If not, why not?

Analytical Methods

For this first year effort, an algorithm review was done to verify reasonable assumptions and methods were used for assigning ex-ante gross kWh and kW savings per measure.

DCEO used the Energy Star calculator for all of their measure savings estimates, except for the furnace measure. EPA and DOE data was the source of the information used by DCEO in the Energy Star calculators. The furnace information came from the Gas Appliance Manufacturers Association.

Several additional sources were used by Summit Blue to verify the reasonableness of the DCEO savings estimates:

1. The most current California Database for Energy Efficiency Resources (DEER) reports
2. Efficiency Vermont's Technical Reference User Manual (TRM) No. 2006-4
3. Summit Blue's own measure studies.

Impact Evaluation Results

Most of the measure-specific ex ante gross savings estimates were reasonable when compared to other authoritative sources. The EM&V team recommends that adjustments be made to improve the energy savings estimates for the lighting and programmable thermostat measures. For the lighting measures, we recommend a reduction in savings based on the reduction of hours of operation from three to 2.33 hours per day. Savings for programmable thermostats should be adjusted from 16% to 6%.

In general, the evaluation found that verified gross savings were slightly lower than claimed gross savings.

Process Evaluation

Process evaluations are planned for PY2 and PY3 for these programs when there is a sufficient evaluation budget to cover these tasks. This was not an immediate priority for PY1 since the electric energy efficiency measures are an add-on to other well-established programs.

Recommendations

Improve ex ante and ex post estimates of measure savings per unit. It is recommended that efforts be made by both DCEO and Summit Blue to find up-to-date measure savings data sources for areas closer to the Illinois region. Some of these may come from evaluation work currently being done on other portfolio programs. If this information is not available, then continued use of the Energy Star calculators is the next best option. It is important that the most recent Energy Star calculators be used each year as these calculators are continually updated with the most recent studies.

Use billing analysis in PY2 to estimate savings for the Weatherization program. We recommend that a billing analysis be done to estimate electric savings for the Weatherization program in PY2. This was found to be a feasible and cost-effective evaluation technique that is worth trying. Since the savings in the Weatherization program come primarily from the CFL installation measure, this method should produce sound estimates of overall savings from that measure. Knowing the overall impacts of the CFL installation measure takes the place of doing additional research on the components of the savings calculations. It will not be necessary to perform research studies to estimate in-service rates, hours of use, or average wattage savings per bulb if we are able to estimate the combined impact of all those factors from the billing analysis.

Re-assess the feasibility of using billing analysis for the Home Improvement program in PY3. We plan to use the billing analysis results from the Weatherization program in PY2 to re-assess the feasibility of getting reliable and cost-effective savings estimates for the Home Improvement program in PY3. We will have better information on the expected population variability and the required sample size for getting reliable electric savings estimates after the billing analysis for the Weatherization program is completed. This experience will help in determining the likely success of a billing analysis for the Home Improvement program.

1 INTRODUCTION TO THE PROGRAM

This evaluation report covers the two residential retrofit programs run by the Illinois Department of Commerce and Economic Opportunity (DCEO): Low Income Weatherization and Low Income Home Improvement. Together, these programs are referred to as the Residential Retrofit Energy Efficiency program.

In previous evaluation planning work, the Low Income Weatherization program was referred to as the Low Income Energy Efficiency Single Family Remodeling program, and the Low Income Home Improvement program was referred to as the Low Income Energy Efficiency Direct Install program. This evaluation will refer to the two programs using their current names.

1.1 Program Description

Each year the DCEO administers a grant application and acceptance process that provides extra funding for electric energy efficiency measures installed in low income residential homes. They award these grants to state agencies, local governments, lending institutions, affordable housing developers and other entities that administer low income weatherization programs or other low income home improvement programs in the Illinois electric service territories of Commonwealth Edison or Ameren. The objective of the grant process is to leverage existing energy efficiency programs to maximize electricity savings in low income residences. This program delivery mechanism will provide a cost-effective means to meet annual electric savings targets.

Evaluation of these two programs, Low Income Weatherization and Low Income Home Improvement, is combined into a single report because they both provide incentives for a similar set of retrofit measures that improve electric efficiency in existing homes. The major difference between the two programs is whether or not Low Income Weatherization work is also done on the home.

The installation of weatherization measures is focused on gas savings which are not part of this evaluation. However, this report does look at the energy savings achieved from the extra funding for electric efficiency measures that are installed in tandem with the weatherization work. It also looks at the energy savings achieved from the extra funding for electric efficiency measures given to organizations that run home improvement programs that are not part of the Low Income Weatherization program.

When funding is provided to Low Income Weatherization programs, grants are more likely to cover 100% of the cost of the approved electric efficiency measures for each home but fewer measures are covered. When funding is provided to organizations with Home Improvement programs that promote home repair and rehab in low-income neighborhoods, grants are more likely to cover only the incremental costs for the electric efficiency measures but more measures are eligible for funding .

Table 1 compares the electric efficiency measures which are part of each program and the associated incentive levels.

Table 1. Energy Efficiency Measures and Incentives for LI Residential Retrofit

		Weatherization		Home Improvement	
	Measure	**Incentive per Unit**	**Incentive Type**	**Incentive per Unit**	**Incentive Type**
1	Energy Star Refrigerator	$500	Full Cost	$500	Full Cost
2a	CFL Installation	$45	Full Cost		
2b	Energy Star Advanced Lighting Package			$300	Full Cost
3	Energy Star rated bathroom exhaust fan	$200	Full Cost	$200	Full Cost
4	High SEER central air conditioner w/ programmable thermostat	$2,500 (SEER 14)	Full Cost	$500 (SEER 16)	Incremental
5	Energy Star rated room air conditioner	$275	Full Cost	$75	Incremental
6	90% AFUE furnace with efficient air handler	$200	Incremental	$200	Incremental
7	Energy Star Dishwasher			$250	Full Cost
8	Reduce required AC tonnage as a result of thermal envelope improvements			$1,500	Estimated Grant

1.2 Evaluation Questions

The objective of this evaluation report is to provide a basic verification of electric savings impacts during program year 1 (PY1) which covers June 1, 2008 through May 31, 2009. As the evaluation budget expands for program years 2 and 3, process evaluations will be added along with more in-depth investigation into the program impacts.

For this report on PY1, a review of the program tracking data will be done to answer these basic impact evaluation questions:

- What are the gross impacts from this program?
- Did the program meet its energy goals? If not, why not?

2 EVALUATION METHODS

This section will discuss the analytical methods, data sources used, and sampling plan for this evaluation report.

2.1 Analytical Methods

For this first year effort, an algorithm review was done to verify reasonable assumptions and methods for assigning ex-ante gross kWh and kW savings per measure.

The first step was a verification of the mathematical soundness of the savings calculations for each measure. The measure algorithm's components were verified with the savings assumptions provided by DCEO. The calculations were checked to ensure that the same numbers could be replicated.

Once the calculation methods were verified, the reasonableness of the calculation was assessed. The assessment of reasonableness of the savings estimates was based on reputable measure savings evaluations from other sources and Summit Blue's own engineering calculations for similar measures.

In future years, a billing analysis may be the best method for verifying program impacts. It is assumed that this program would be a good candidate for using billing analysis as the impact evaluation method for two reasons – the expected savings are high enough and both pre- and post- billing data will be available for participants. However, since the DCEO programs cover the entire state, including both ComEd and Ameren Illinois, and multiple market actors, it is unknown if sufficient data is available in a usable form to make billing analysis a feasible option. For that reason, the impact evaluation effort in this first year report will include a Focused Evaluability Assessment.

The Focused Evaluability Assessment will assess the feasibility of performing a cost-effective billing analysis in future years. It will investigate the suitability of the program tracking data by researching the answers to these questions:

- Is the program tracking data in a standardized format across all participating market actors?
- Is it a centralized electronic database or is it paper-based?
- Does it have the necessary information to link to customer data in utility billing systems?
- Do utilities have access to sufficient historical billing data to supply what is needed for analysis?
- Does turnover in the units under analysis appear to cause difficulty in obtaining results?

If the Focused Evaluability Assessment determines that billing analysis is a feasible impact evaluation option, billing analysis will be completed annually for PY2 and PY3 since it is a valuable, reliable and relatively low cost impact evaluation method.

2.2 Data Sources

Data used to prepare this evaluation came from several sources. Program documentation, tracking information and energy savings calculation algorithms were received from DCEO. The tracking information was at a summary level for each participating organization that receives a grant from DCEO. Savings were disaggregated by measure and by utility service territory.

DCEO used the Energy Star calculator for all of their measure savings estimates, except for the furnace measure. EPA and DOE data was the source of the information used by DCEO in the Energy Star calculators. The furnace information came from the Gas Appliance Manufacturers Association.

Several additional sources were used by Summit Blue to verify the reasonableness of the DCEO savings estimates:

- The most current California Database for Energy Efficiency Resources (DEER) reports
- Efficiency Vermont's Technical Reference User Manual (TRM) No. 2006-4
- Summit Blue's own measure studies.

2.3 Sampling Plan

No samples were needed for the evaluation work included in this report.

3 PROGRAM LEVEL RESULTS

This section will present the program level evaluation results for the Low Income Residential Retrofit programs in PY1.

3.1 Impact

The impact evaluation will cover verification and due diligence issues, program tracking system review, and verification of gross and net savings for the program. The program tracking system review will include an Evaluability Feasibility Assessment that looks at the potential for performing billing analysis to verify impact results in PY2 and PY3.

3.1.1 Verification and Due Diligence

There was no additional field verification work done for these programs as part of this evaluation since there are already tight verification requirements for both programs. Every site in the Weatherization program receives a follow-up on-site inspection. For the Home Improvement program, grantees have to provide receipts for all installations to collect their grant money.

Grantees are responsible for ensuring that funded measures meet program requirements and are properly installed. The DCEO program manager monitors Grantee compliance with the terms of the grant agreement.

3.1.2 Tracking System Review

The tracking system data reviewed for this program was summary-level data prepared by DCEO. Since DCEO administers the program by providing grants to specific agencies, the focus of their tracking system is energy savings achievements for each agency. The number of installations is recorded for each measure within each agency. Deemed savings per measure are used to estimate total program savings. Care is taken to identify which installations are in ComEd service territory and which are in Ameren since funding is tied back to these two different sources.

The summary data is based on quarterly reports from each grantee which provide addresses of all installations completed over the quarter, the number of occupants meeting the income qualifications, and documentation on the electric service provider (ComEd or Ameren).

Evaluability Feasibility Assessment

Since this is a retrofit program, it may be possible to verify electric savings by looking at individual customer electric bills before and after their participation in this program. A billing analysis like this would require that program tracking data be available for individual customers Data is needed on when installation was done and what measures were installed for each individual customer. This customer-level data is maintained by each participating agency. The agencies do not have individual customer billing data. Billing data would have to be supplied by the appropriate electric utility. Given these complications, this section of the report will look at the availability of individual customer data and assess the feasibility of doing billing analysis evaluation in PY2 and PY3.

Table 2 summarizes responses to the evaluation questions identified as important to the Evaluability Feasibility Assessment. The situation is different for the Weatherization program and the Home Improvement program.

Table 2. Summary of Evaluability Feasibility Assessment

Evaluation Question	Weatherization Program	Home Improvement Program
Is the program tracking data in a standardized format across all participating agencies?	Yes	No
Is it a centralized electronic database or is it paper-based?	Centralized Electronic	Individual Agencies Mixed electronic & paper-based
Does it have the necessary information to link to customer data in utility billing systems?	Utility Account Numbers – Yes Fuel Bill Release Forms - Yes	Utility Account Numbers - Yes Fuel Bill Release Forms - Yes
Do utilities have access to sufficient historical billing data to supply what is needed for analysis?	Yes	Yes
Does turnover in the units under analysis appear to cause difficulty in obtaining reliable results?	No	Unknown

As shown in the previous table, the answers to the research questions are very different for the two programs. For the Weatherization program, program tracking data is available in a centralized, standardized electronic format for all participants across the state. The situation is different for the Home Improvement program where each participating agency has their own program tracking system. Some are electronic and some are paper-based. Collecting this information into a standardized dataset would require additional time and effort.

Both programs collect information on the utility account numbers of their participants. This is necessary information for linking to the correct billing data. They also collect Fuel Bill Release Forms from each participant. The participant signs these forms to give permission to the utility to provide their billing information to a third party for evaluation purposes. Having both the account numbers and the release forms are key items for performing billing analysis. These two items are already in place because evaluation of gas savings is regularly done for these programs.

The utilities do have the capability to provide the electric billing data required for a billing analysis. This type of data has been supplied for the evaluation of other programs. Generally, at least two years of monthly billing data is available for most homes and this is sufficient for analysis.

Some data quality issues may arise because of turnover in occupancy of the participant homes. To get good savings estimates from billing analysis, it is important to have a full year of pre-installation data and a full year of post-installation data for the same occupant. A full year of data is needed before and after because measures tend to respond to seasons in different ways.

If the occupant changes during this two year study period, the overall electric use often changes, too, since the new occupant brings different usage patterns and behavioral characteristics into the home.

Usage changes from a new occupant make it difficult for a billing analysis to identify the usage changes directly related to the program. For this reason, it is good practice to drop homes with turnover in occupants from the study. Dropping them will only cause a problem for the analysis if the total number of homes left in the study is too small to create reliable savings estimates.

Using PY1 activity as an indicator of PY2 activity, the data shows that 4,919 buildings received electric savings measures within the Weatherization program.[1] This number should be even greater in PY2 as total funding increases. Even if a large share of buildings need to be removed from the analysis because of turnover, there should still be a sufficiently large number of cases available with good data to provide reliable results in a billing analysis.

Looking at the Home Improvement program, there were 1,174 homes that received electric savings measures in PY1. If turnovers were a large percentage of this group, it is possible that the reliability of results from a billing analysis could be compromised. It would depend on the variability in the data.

Considering all of these factors, we recommend that a billing analysis be done to estimate electric savings for the Weatherization program in PY2, but not for the Home Improvement program. The cost of collecting and standardizing the data for analysis and the overall smaller number of participants makes billing analysis more problematic for the Home Improvement program.

After the experience of performing a billing analysis for the Weatherization program in PY2, this decision will be re-evaluated for PY3. Increasing participation in the Home Improvement program may warrant the additional effort to perform a billing analysis in PY3. We will also have better information on the expected population variability and the required sample size for getting reliable electric savings estimates after the billing analysis for the Weatherization program is completed. This experience will help in determining the likely success of a billing analysis for the Home Improvement program.

3.1.3 Gross Program Impact Parameter Estimates

A technical review of the gross savings assumptions for each measure included in either the Weatherization program or the Home Improvement program will be presented here. The review will assess the reasonableness of the algorithms, technology assumptions and the calculated savings on a per unit basis.

Energy Star Refrigerator

DCEO assumes annual savings of 554 kWh per unit for their Energy Star Refrigerator measure.

DCEO uses an Energy Star calculator to calculate gross savings for program refrigerators. The calculator has several adjustable options. For this application, DCEO assumes that the standard refrigerator being replaced and the replacement refrigerator are both “Top Mount Freezer without through-the-door ice”.

[1] In the Weatherization program tracking system, the reported unit is the building. For multi-family housing, one building can have many dwelling units. That is why the number of CFL installation measures for the Weatherization program is greater than the number of reported units (buildings). Each dwelling unit within the building can receive one CFL measure.

EM&V team verified the savings estimate using the Energy Star calculator. Savings were calculated taking the conventional refrigerator that uses 1000 kWh per year and comparing it to the Energy Star replacement which uses 450 kWh per year. Total annual savings per unit from this calculation is 550 kWh.[2] This re-calculation is very close to the 554 kWh used for ex ante estimates by DCEO.

EM&V team also compared this value to savings estimates for refrigerators from other sources. The ex ante refrigerator savings look reasonable when compared to data from the Association of Home Appliance Manufactures (AHAM) database for all current refrigerators. According to AHAM, the average new refrigerator uses 417 kWh per year. This is lower than the 450 kWh number used by DCEO, indicating the program's ex ante estimate is conservative. One of the seminal studies on refrigeration replacement programs reports savings of 593 kWh, another indication that the DCEO value is a conservative estimate.[3]

Given that the per unit savings of 550 kWh is verified in the Energy Calculator and is consistent with savings estimates from other authoritative sources, we recommend using 550 kWh per unit for the calculation of verified gross program impacts.

CFL Installation

DCEO assumes annual savings of 594 kWh per unit for their CFL Installation measure. One CFL Installation is twelve 15-watt CFL bulbs installed in the home for the customer.

DCEO uses an Energy Star calculator to calculate the gross savings from this measure. DCEO assumed each unit would have twelve conventional light bulbs replaced with CFLs. DCEO assumed that these light bulbs would be used for 3 hours a day. The average of the conventional light bulb was set to 60 watts per hour. The size of the new CFL was 15 watts. This is a savings of 45 watts per hour. The EM&V team verified this calculation to estimate that total annual savings per household is 591 kWh (365 days x 3 hours/day x 45 watts/hour x 12 bulbs = 591 kWh). This re-calculation, 591, is very close to the original estimate of 594.

While the DCEO assumptions used in the above algorithm are consistent with the Energy Star calculator's baseline numbers, there are several key assumptions where other sources present alternative values that could have a large influence on the overall savings estimate for this program. We will now look at these three key assumptions.

In-service Rate. DCEO assumed an in-service rate of 100%. An in-service rate of 67% is reported in the 2008 DEER database. However, in this program the bulbs are installed for the customer while other energy efficiency work is being done on the home. This justifies the use of the 100% service rate for this program. If the bulbs were distributed to the customer but not installed for them a lower in-service rate would be appropriate.

Hours of Use. DCEO assumed that the bulbs would be on 3 hours per day, using data from the Energy Star calculator. The DEER estimation of hours of use is 2.33 hours per day, taken from a California metering study. The EM&V team recommends using the 2.33 hours per day estimate since that number

[2] See Appendix A for the detailed assumptions used in the Energy Star calculators for this and the other measures.

[3] "Refrigerator Replacement in the Weatherization Program: Putting a Chill on Energy Waste", Larry Kinney and Rana Belshe, E Source, 2001.

comes from metered data. However, average hours of use depends on the number of bulbs per home and their room placement. It is unknown how this may be different for the California study group vs. the DCEO program participants. It is also unknown if low income customers use lighting differently than the general population. On the one hand, they may be more likely to be at-home because they are retired or not employed outside of the home. This could lead to greater use of lighting. On the other hand, they may be more budget-conscious because of their limited funds and keep a closer eye on their use of lighting. This could lead to a lower use of lighting. It is also true for this program that it is standard practice to install the CFL bulbs in the areas of the home where lighting is used the most. This practice could lead to a higher average daily hours of use than what was found in the California study. Since hours of use is a key input, additional investigation into verification of hours of use for this program would be beneficial for improving the savings estimate in PY2. It is possible that some helpful information will come from evaluation work being done currently on other lighting programs in the state of Illinois and that information can be applied to this program for the PY2 evaluation, or primary research could be performed for this program if sufficient evaluation budget dollars are available. These options will be considered in the evaluation plan for PY2.

Saved Watts per Bulb. DCEO assumed that the average replaced light bulb was a 60 Watt bulb and it was replaced with a 15 Watt CFL bulb. It is known that all of the installed bulbs were 15 watt bulbs for this program, however, this is only half of the equation. The wattage of the replaced light would be needed to improve the estimate of saved watts per bulb. The EM&V team does not recommend changing the assumption of 45 saved watts per bulb at this time. However, this is a key input and information on replacement wattages from other lighting programs in Illinois will be considered in PY2 for improving the estimated savings for this program.

Based on the recommendation to use 2.33 hours per day for lighting use instead of 3 hours per day, the EM&V team's final estimate of annual savings per home for CFLs in PY1 is 459 kWh (365 days x 2.33 hours/day x 45 watts/hour x 12 bulbs = 459 kWh).

Energy Star Advanced Lighting Package

DCEO estimated annual savings of 663 kWh per unit for their Energy Star Advanced Lighting Package program. Two outdoor fixtures and eight indoor fixtures were installed at each dwelling as part of an Advanced Lighting Package.

DCEO used the Energy Star calculator for Residential Lighting Fixtures to calculate the ex ante gross savings for eight indoor lighting fixtures and two outdoor lighting fixtures. DCEO assumed all lighting fixtures were on for 3 hours a day. All per unit savings assumptions came from the Energy Star default values.

DCEO total ex ante annual savings per household from this calculation is 663 kWh, as shown in Table 3**Error! Reference source not found.**. Similar to our discussion of savings from CFL bulbs, all of these fixtures were installed for the customer so the in-service rate is 100%. The EM&V team also recommends using an estimate of 2.33 hours of use per day for the indoor fixtures since the 2.33 value comes from metered data in residential homes. We do not have comparable estimates of hours for outdoor lighting, so we do not recommend any changes to that value. Table 3 shows that reducing the indoor fixture savings to reflect 2.33 hours of use instead of 3 hours reduces the estimate of overall savings per home from 663 to 548 kWh.

Table 3. Savings per Home from Energy Star Advanced Lighting Package

	DCEO Savings Estimates			Recommended Savings Estimates		
	Outdoor Fixtures	Indoor Fixtures	Total	Outdoor Fixtures	Indoor Fixtures	Total
Conventional use per year	140 kWh	100 kWh		140 kWh	78 kWh	
Energy Star use per year	70 kWh	35 kWh		70 kWh	27 kWh	
Energy Savings per year per fixture	70 kWh	65 kWh		70 kWh	51 kWh	
Number of fixtures per home	2	8		2	8	
Annual kWh savings per home	140 kWh	523 kWh	663 kWh	140 kWh	408 kWh	548 kWh

The EM&V team recommends using the estimate of annual savings of 548 kWh per home for this measure in PY1. However, similar to the discussion of underlying assumptions presented for the CFL measure, consideration should be given to applying results from evaluation work on other Illinois residential lighting programs to improve this estimate of savings in PY2. It is particularly important for this measure to look at the differentiation between indoor and outdoor use of the bulbs related to hours of use and saved watts per bulb.

Energy Star rated Bathroom Exhaust Fan

DCEO assumes annual savings of 89 kWh per unit for their Energy Star rated Bathroom Exhaust Fan measure.

Energy Star bathroom exhaust fan ratings were used for the DCEO calculation. It was assumed that the fans would be run for two hours per day. The conventional fan was rated to use 150 watts an hour while the Energy Star fan was rated to use 28 watts an hour. This is a difference of 122 watts per hour. Total annual savings per unit from this calculation is 89 kWh (365 days x 2 hours/day x 122 watts/hour = 89 kWh).

The EM&V team examined the Home Ventilating Institute's (HVI) bathroom fan ratings and verified the reasonableness of the conventional and replacement bathroom fan wattages used by DCEO.

The EM&V team does not recommend any changes to the ex ante estimate of savings for Energy Star rated Bathroom Exhaust Fans.

SEER=16 Central Air Conditioner with Programmable Thermostat

DCEO assumes annual savings of 1,643 kWh per unit for their SEER=16 Central Air Conditioner with Programmable Thermostat measure.

DCEO used an Energy Star calculator to calculate the ex ante gross savings for this measure. This measure is part of the Weatherization program which looks at savings from replacing an existing unit. The conventional existing central AC unit was assumed to have a SEER rating of 9 and no programmable thermostat. The low SEER value used for this savings estimation is appropriate given that this is for the Weatherization program where an older central air conditioning model is being replaced before its normal

end of life, as opposed to the Home Improvement program that is installing a new central air conditioning unit in a home that does not have one. The Energy Star calculator estimates that the conventional central AC unit for this measure will use 2,400 kWh per year. The new installed unit has a SEER rating of 16 and a programmable thermostat. The Energy Star central AC unit was estimated to use 756 kWh per year. Total annual savings per unit from this calculation is 1,644 kWh (2,400 – 756). This is very close to the 1,643 kWh estimate that comes directly from the Energy Star calculator worksheets. The difference is due to rounding.

The EM&V team compared this savings estimate to other sources. The updated 2008 DEER study showed less savings than the Energy Star calculator accounts for. The main issue was the Energy Star calculator's use of 16% savings for a programmable thermostat. A current study of several thousand homes found that a savings of 6% was achieved.[4] This is a significant difference for savings. Accounting for this difference, the revised estimate of savings from the Energy Star calculator would be 1,287 kWh instead of 1,644 kWh.

The EM&V team recommends using 1,287 kWh per unit for the estimation of verified gross savings.

SEER=14 Central Air Conditioner with Programmable Thermostat

DCEO assumes annual savings of 366 kWh per unit for their SEER=14 Central Air Conditioner with Programmable Thermostat measure.

DCEO used an Energy Star calculator to calculate the gross savings for this measure. This measure is part of the Home Improvement program which looks at incremental savings compared to installation of a baseline new unit with a lower SEER. The conventional baseline unit was assumed to have a SEER rating of 13 and no programmable thermostat. This conventional unit was estimated to use 1,662 kWh per year. The Energy Star central AC unit was assumed to have a SEER rating of 14 and have a programmable thermostat. The Energy Star central AC unit was estimated to use 1,296 kWh per year. Total annual savings per unit from this calculation is 366 kWh.

The EM&V team compared this savings estimate to other sources. The updated 2008 DEER study showed less savings than the Energy Star calculator accounts for. The main issue was the Energy Star calculator's use of 16% savings for a programmable thermostat. A current study of several thousand homes found that a savings of 6% was achieved.[5] This is a significant difference for savings. Accounting for this difference, the revised estimate of savings from the Energy Star calculator would be 240 kWh instead of 366 kWh.

The EM&V team recommends using 240 kWh per unit for the estimation of verified gross savings.

Energy Star rated Room Air Conditioner

DCEO assumes annual savings of 176 kWh per unit for their Energy Star rated Room Air Conditioner measure.

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[4] ibid

[5] "Validating the Impact of Programmable Thermostats", RLW Analytics, 2007.

DCEO uses an Energy Star calculator to calculate gross savings for this measure. As part of the Home Improvement program, it is assumed that the Energy Star rated room air conditioner would be installed instead of a conventional new room air conditioner. DCEO assumes the conventional room AC unit has a EER rating of 8.8, while the Energy Star room AC has an EER rating of 11.5. Based on these values, the Energy Star calculator estimates an annual kWh usage of 750 for the conventional unit and 574 for the efficient unit. The total annual savings per unit from this calculation is 176 kWh.

The EM&V team went to other sources to verify the SEER assumptions that were used, and found that they are reasonable when compared to data from the Association of Home Appliance Manufactures (AHAM) database of SEER levels for all current room air conditioner models.

The EM&V team recommends using 176 kWh per unit.

90% AFUE Furnace with efficient air handler

DCEO assumes annual savings of 400 kWh per unit for their 90% AFUE Furnace with efficient air handler measure. Since these are electric savings, they come from the efficiency of the air handler (furnace fan) and are not directly related to the AFUE rating on the furnace.

DCEO used the Gas Appliance Manufacturers Association ratings to calculate the gross electric savings from this measure. The typical furnace was assumed to be 90% AFUE without an Electronically Commutated Motor (ECM). The typical furnace is estimated to use 625 kWh per year. The more efficient furnace had a 90% AFUE with an ECM. The more efficient furnace is estimated to use 225 kWh per year. DCEO assumes the total annual savings per unit from this calculation is 400 kWh.[6]

The EM&V team searched for additional sources to verify the savings estimates for an ECM used in this region of the country. Results from a field study conducted by the Energy Center of Wisconsin were found.[7] This study concluded that a savings of 465 kWh per year could be attributed to an ECM. This leads us to accept the 400 kWh per year assumption by the DCEO.

The EM&V team recommends using 400 kWh per unit as a reasonable estimate of savings from an efficient air handler on a furnace.

Energy Star Dishwasher

DCEO assumes annual savings of 62 kWh per unit for their Energy Star Dishwasher program.

DCEO used an Energy Star calculator to calculate gross savings for this measure. Conventional dishwashers were rated as using 211 kWh per year. Energy Star dishwashers were rated as using 149 kWh per year. DCEO assumes total annual savings per unit from this calculation is 62 kWh.[8]

The EM&V team verified this savings estimate by comparing it to other sources. An examination of AHAM's and the California Energy Commission's databases shows power consumption kWh per cycle to be very close to the Energy Star calculator number. The calculator shows 1.54 kWh per cycle for an

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[6] Additional detail on these savings assumptions can be found in Appendix B.

[7] "Electricity Use by New Furnaces", Energy Center of Wisconsin, 2003.

[8] Additional detail on these savings assumptions can be found in Appendix A.

Energy Star rated dishwasher. The California Energy Commission shows an average of 1.47 kWh per cycle for efficient units.

The EM&V team recommends using 62 kWh per unit.

Reduce required AC tonnage as a result of weatherization improvements

DCEO assumes annual savings of 216 kWh per unit when a new air conditioner is installed in a home that also received weatherization improvements. This savings is attributed to the fact that the size (tonnage) of the unit can be reduced because the cooling requirements of the home have been lowered.

The DCEO estimate of savings for this measure is based on several assumption. They assumed the weatherization improvements to the home were sidewall insulation, roof cavity insulation, and improved window thermal efficiency. They then made an engineering judgment that this would contribute to a ½ ton reduction in cooling requirements for the home. This judgment was based on their knowledge that homes being rehabbed under the Home Improvement program are old. It is likely they had no or poor insulation in the sidewalls and attic, giving an overall low effective R-value. If windows were being replaced, it was assumed the old windows were single-pane or single-pane with storms. This situation was expected to create a cooling load reduction of ½ ton after the sidewalls and attics were insulated. This was considered a broad assumption given that homes in the program are spread across the state and vary in size. The ½ ton reduction in capacity led to an estimate of 216 kWh of savings per year.

The EM&V team believes that more information would be needed before making an adjustment to these savings estimates. It would be helpful to have a detailed breakdown of the type of weatherization measures that were installed in each dwelling. An initial examination of Oak Ridge National Laboratory and Green Builders databases on insulation and window improvement savings suggest that DCEO's savings estimates are possible depending on the amount of weatherization measures installed.

The EM&V team recommends using 216 kWh per unit this year. Additional detailed modeling of savings should be done for PY2 after looking at typical weatherization measures being installed in homes that receive this measure.

Summary of Energy Savings Assessment

Most of the measure-specific ex ante gross savings estimates were reasonable when compared to other authoritative sources. The EM&V team recommends that adjustments be made to improve the energy savings estimates for the lighting and programmable thermostat measures.

For the lighting measures, we recommend a reduction in savings based on the reduction of hours of operation from three to 2.33 hours per day. Savings for programmable thermostats were adjusted from 16% to 6%. For the Energy Star Refrigerator, there was a small discrepancy between the ex ante gross savings per unit values and the verified gross savings per unit values as estimated by the Energy Calculator. We recommend that the verified values be used for the calculation of ex post gross savings from these measures.

Table 4 compares the original estimates of ex ante gross savings per unit to the final recommended verified values for each program measure.

Table 4. Summary of Verified Gross Energy Savings per Unit

	Measure	Ex Ante kWh per unit	Verified kWh per unit	Difference
1	Energy Star Refrigerator	554	550	-4
2a	CFL Installation	594	459	-135
2b	Energy Star Advanced Lighting Package	663	548	-115
3	Energy Star rated bathroom exhaust fan	89	89	0
4a	SEER 16 replacement central air conditioner w/ programmable thermostat	1,643	1,287	-356
4b	SEER 14 new central air conditioner w/ programmable thermostat	366	240	-126
5	Energy Star rated room air conditioner	176	176	0
6	90% AFUE furnace with efficient air handler	400	400	0
7	Energy Star Dishwasher	62	62	0
8	Reduce required AC tonnage as a result of thermal envelope improvements	216	216	0

Estimates of Peak Demand Savings

Peak demand savings were estimated for each measure in addition to annual energy savings. For this evaluation, the peak period is defined as 1:00 to 6:00 p.m. on the hottest summer weekday.

DCEO's estimates of peak demand savings for most measures were based on the assumption of uniform use over all hours of the year. That is, annual energy savings estimates were divided by 8760 hours to get an estimate of peak demand savings for the measure.

The exceptions to this were the three air conditioning measures (Central AC, Room AC and Reduce required AC tonnage). In these three cases, DCEO assumed that energy was used uniformly over 600 hours.

The EM&V team concurs that a uniform load shape based on 8760 hours is an appropriate assumption to use for peak contributions for most of the measures until more detailed load shape data is available. However, we believe the hours of use should be modified for several of the measures as detailed in the following discussion.

90% AFUE furnace with efficient air handler.

The EM&V team recommends modifying the peak contribution for the 90% AFUE furnace with efficient air handler.

The energy savings estimates for this measure assume all savings come from winter operation of the furnace. The corresponding estimate of summer peak savings from this measure would be zero since it is not expected to be in use during the summer.

While it is possible that some furnace air handlers will be running during the summer peak if central air conditioning is in use, the saturation of central air conditioners in this group is considered to be low. Additional investigation into the saturation of central air conditioning for this group could warrant a change in the estimated peak demand savings, but given the absence of this information at the current time the EM&V team recommends zero peak savings per unit for this measure in PY1.

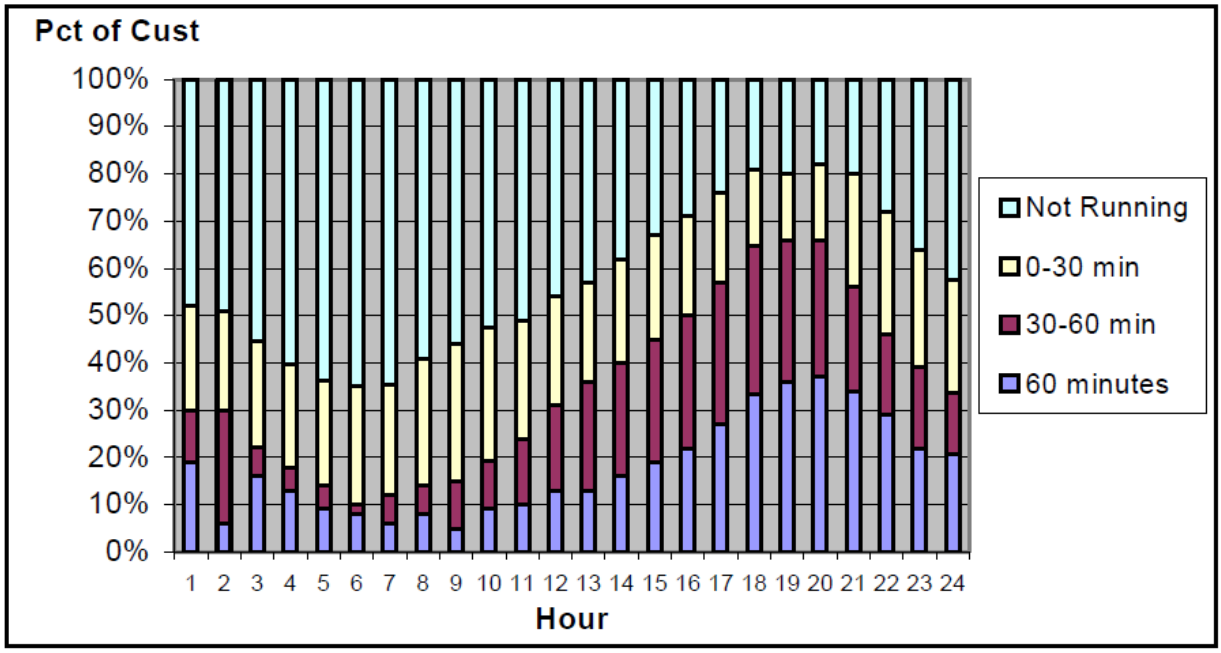
Air conditioning measures.

As stated previously, DCEO's estimates of ex ante peak savings from air conditioning measures assumes that energy use occurs uniformly over 600 hours of use. This assumption comes from the Energy Star calculator and reflects the expected number of full load hours for air conditioning in the Illinois area. Using this value to estimate peak savings from energy savings is equivalent to saying that all air conditioners will be running at full load, or 100% of their capacity, for the entire summer peak period. We do not have access to Chicago-specific capacity factors, but we do have information from two different Wisconsin studies that can be used to help inform an estimate of the capacity factor during the peak hour.

In 2005, Wisconsin Public Service (WPS) installed communicating programmable thermostats on 86 homes with central air conditioning as part of a pilot study. The thermostats recorded the hourly run times for each unit throughout the summer. The summer of 2005 had a typical number of days that reached a cumulative temperature-humidity index (CTHI) greater than 10 (approximately 87 degrees and very humid). What was atypical, however, was that there were several occurrences of persistently high CTHI levels that lasted throughout the night. This created several long, unbroken spells of high heat lasting for 24 hours or more.

Figure 1 illustrates the average run times found from the thermostat data on the four hottest non-control days of the summer. Looking at the hours which correspond to the definition of peak for this report, it shows that only 15% percent of air conditioners are at full load (run times of 60 minutes) at the beginning of the peak period (1:00 p.m.) and this grows to only 33% by the end of the peak period (6:00 p.m.) This data indicates it is unrealistic to expect an average capacity factor of 100% over all customers at peak time.

Figure 1. Percent of Customers with Different AC Run Times on the Four Hottest Non-Control Days of Summer 2005, Wisconsin Public Service[9]



It is of interest to note that even during the hours of maximum use, at least 20% of the air conditioners were not running at all. This is attributable to people being on vacation or not home at the time, or foregoing air conditioning for some other reason.

The second Wisconsin study comes from the Energy Center of Wisconsin. When looking at the question of peak demand from air conditioning during summer peak hours, they report the following:

> *In terms of system operation at time of utility peak, we assume a diversified peak demand factor of 0.75 +/- 0.10, representing the average fraction of full system output at system peak. This factor reflects both the likelihood that not all air conditioners will be operating during system peak as well as the duty cycle of those that are operating. We have derived this estimate from unpublished data from the Energy Center's 2003 Appliance Sales Tracking survey that asked respondents about how they had operated their air conditioner in the previous 24 hours. These data suggest that about 70 to 80 percent of households will be operating their air conditioner on a hot weekday afternoon with the temperature above 90°F.* [10]

This survey data for the state of Wisconsin corroborates what was seen in the thermostat data collected by Wisconsin Public Service. Both estimate that only 80% of air conditioners were in use at peak time on the

9 "Switches vs. Stats: Who Wants What?: A Comparison of Load Control Switches and Web-enabled Programmable Thermostats", Mary Klos, presentation at the 2007 Association of Energy Services Professionals (AESP) Conference, February 2007.

[10] Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015, Volume II: Technical Appendix, Energy Center of Wisconsin, ECW Report Number 236-2, November 2005, page

hottest summer days. This provides us with an upper bound on the run time, or capacity factor, that we should assume for air conditioner use.

However, not all of the air conditioners that were in use were running at 100% of capacity, so we know the average capacity factor should be something less than 80%. Taking a weighted average of the capacity factors shown in the Wisconsin Public Service data, the expected capacity factor over the peak period of 1:00 to 6:00 p.m. is approximately 50% to 60%.[11] Since Illinois is farther south than Wisconsin, summers are warmer and air conditioning is used more. We would expect this to increase the capacity factor beyond the Wisconsin value. The EM&V team believes that 70% would be a reasonable capacity factor to use for Illinois based on the available data. Additional work should be done in the PY2 evaluation to adjust these factors in more detail for the Illinois market, particularly for differences between the northern and southern areas of the state. It is expected that more data on air conditioning use specifically for the Illinois market will be available in the future to take the place of the Wisconsin data being relied on in this PY1 evaluation.

The correct application of this capacity factor would be to apply it to the full load peak savings values used as ex ante estimates for this program. For example, the 240 kWh of annual savings estimated for the SEER=14 Central Air Conditioner with Programmable Thermostat measure can be divided by the 600 full load hours, and then adjusted by the 70% capacity factor for peak hours (240 kWh / 600 hours * 70% = 0.28 kW). This adjustment for capacity factor should be applied to all of the air conditioning measures.

In addition to applying an adjustment factor of zero for furnaces with efficient air handlers, and an adjustment factor of 70% for all air conditioning measures, it is necessary to re-calculate many of the kW savings estimates based on recommended changes to the energy savings values. Table 5 presents the calculation of the verified peak savings estimates for each measure based on all of the recommended changes from the EM&V team.

The table starts by showing the results of applying the new verified kWh savings to the original DCEO estimates of hours of use per year. This creates an initial set of new kW savings estimates based only on the changes that were made to the energy estimates. Then the recommended adjustments from the EM&V team regarding peak savings calculations are shown and applied to create the final verified kW savings estimates on a per unit basis.

Table 6 compares the ex ante peak savings estimates from DCEO to the verified estimates from the EM&V team. Peak savings for two measures, bathroom fans and dishwashers, did not change. All other peak savings estimates were reduced in some way.

[11] An estimated range is presented because there is not sufficient detail in the chart to determine this number with more accuracy, and the source data is not available.

Table 5. Calculation of Verified Gross Demand Savings

	Measure	Verified kWh per unit	Hours	Unadjusted kW per unit	Adjustment Factor	Verified kW per unit
1	Energy Star Refrigerator	550	8760	0.0628	1	0.0628
2a	CFL Installation	459	8760	0.0524	1	0.0524
2b	Energy Star Advanced Lighting Package	548	8760	0.0626	1	0.0626
3	Energy Star rated bathroom exhaust fan	89	8760	0.0102	1	0.0102
4a	SEER 16 replacement central air conditioner w/ programmable thermostat	1,287	600	2.1450	70%	1.5015
4b	SEER 14 new central air conditioner w/ programmable thermostat	240	600	0.4000	70%	0.2800
5	Energy Star rated room air conditioner	176	600	0.2933	70%	0.2053
6	90% AFUE furnace with efficient air handler	400	8760	0.0457	0	0
7	Energy Star Dishwasher	62	8760	0.0071	1	0.0071
8	Reduce required AC tonnage as a result of thermal envelope improvements	216	600	0.3600	70%	0.2520

Table 6. Summary of Verified Gross Demand Savings

	Measure	Ex Ante kW per unit	Verified kW per unit	Difference
1	Energy Star Refrigerator	0.0632	0.0628	-0.0004
2a	CFL Installation	0.0678	0.0524	-0.0154
2b	Energy Star Advanced Lighting Package	0.0757	0.0626	-0.0131
3	Energy Star rated bathroom exhaust fan	0.0102	0.0102	0
4a	SEER 16 replacement central air conditioner w/ programmable thermostat	2.7383	1.5015	-1.2368
4b	SEER 14 new central air conditioner w/ programmable thermostat	0.6100	0.2800	-0.3300
5	Energy Star rated room air conditioner	0.2933	0.2053	-0.0880
6	90% AFUE furnace with efficient air handler	0.0457	0	-0.0457
7	Energy Star Dishwasher	0.0071	0.0071	0
8	Reduce required AC tonnage as a result of thermal envelope improvements	0.3600	0.2520	-0.1080

3.1.4 Gross Program Impact Results

The verified gross savings per unit for energy and demand savings can be used with the actual number of installations for each measure to show the overall gross program impact results for PY1.

Weatherization Program

Table 7 presents the ex ante and ex post gross MWh savings for the Weatherization program. Table 8 presents the companion MW savings. The ex post energy savings for the Weatherization program are somewhat lower than the ex ante energy savings. The same is true for the demand savings.

Table 7. Weatherization Program Ex Ante and Ex Post Gross MWH Savings

ComEd	Ex Ante			Ex Post		
Measure	**kWh/Unit**	**Units**	**Total MWH**	**kWh/Unit**	**Units**	**Total MWH**
Energy Star Refrigerator	554	948	525	550	948	521
CFL Installation (12 bulbs)	594	6,546	3,888	459	6,546	3,005
Energy Star Bathroom Exhaust Fan	89	461	41	89	461	41
TOTAL			4,455			3,567

Table 8. Weatherization Program Ex Ante and Ex Post Gross KW Savings

ComEd	Ex Ante			Ex Post		
Measure	**kW/Unit**	**Units**	**Total kW**	**kW/Unit**	**Units**	**Total kW**
Energy Star Refrigerator	0.0632	948	60	0.0628	948	59
CFL Installation (12 bulbs)	0.0678	6,546	444	0.0524	6,546	343
Energy Star Bathroom Exhaust Fan	0.0102	461	5	0.0102	461	5
TOTAL			508			407

Note: These tables only include the electric efficiency measures actually installed through the Weatherization program in PY1.

Home Improvement Program

Table 9 presents the ex ante and ex post gross MWh savings for the Home Improvement program. Table 10 presents the companion MW savings. For this program, the ex post savings are slightly lower than the ex ante savings. This is true for both energy and demand.

Table 9. Home Improvement Program Ex Ante and Ex Post Gross MWH Savings

ComEd	Ex Ante			Ex Post		
Measure	**kWh/Unit**	**Units**	**Total MWH**	**kWh/Unit**	**Units**	**Total MWH**
Energy Star Refrigerator	554	1022	566	550	1022	561
Energy Star Advanced Lighting Package	663	30	20	548	30	16
Energy Star Bathroom Exhaust Fan	89	5	0.4	89	5	0.4
Energy Star Dishwasher	62	5	0.3	62	5	0.3
SEER 14 Central AC with programmable thermostat (new installation)	366	5	2	240	5	1
Energy Star Room AC	176	25	4	176	25	4
Reduce required tonnage as a result of thermal envelope improvements	216	57	12	216	57	12
90% AFUE furnace with EE air handler	400	1	0.4	400	1	0.4
CFL Installation (12 bulbs)	594	202	120	459	202	93
TOTAL			726			690

Table 10. Home Improvement Program Ex Ante and Ex Post Gross KW Savings

Com Ed	Ex Ante			Ex Post		
Measure	**kW/Unit**	**Units**	**kW**	**kW/Unit**	**Units**	**kW**
Energy Star Refrigerator	0.0632	1022	65	0.0628	1022	64
Energy Star Advanced Lighting Package	0.0757	30	2	0.0626	30	2
Energy Star Bathroom Exhaust Fan	0.0102	5	0	0.0102	5	0
Energy Star Dishwasher	0.0071	5	0	0.0071	5	0
SEER 14 Central AC with programmable thermostat (new installation)	0.6100	5	3	0.2800	5	2
Energy Star Room AC	0.2933	25	7	0.2053	25	5
Reduce required tonnage as a result of thermal envelope improvements	0.3600	57	21	0.2520	57	14
90% AFUE furnace with EE air handler	0.0457	1	0	0	1	0
CFL Installation (12 bulbs)	0.0678	202	14	0.0524	202	11
TOTAL			112			98

Note: These tables only include the electric efficiency measures actually installed through the Home Improvement program in PY1.

3.1.5 Net Program Impact Parameter Estimates

DCEO assumed a Net-to-Gross adjustment of 80% when they prepared their budget estimates. Since these programs specifically target customers of limited income it is likely that the customers would not

have funded new energy efficiency measures on their own. As a result, the EM&V team believes the Net-to-Gross factor should be 100%. This is the practice in other jurisdictions, such as Wisconsin.[12]

3.1.6 Net Program Impact Results

Table 11 presents the final gross and net program impact results for the Weatherization program. The summary of final gross and net savings for the Home Improvement program can be found in Table 12.

Table 11. Summary of Gross and Net Savings for Low Income Weatherization

ComEd Low Income Weatherization Program PY1	MWh Savings		KW Savings	
	DCEO Claimed	Evaluation Verified	DCEO Claimed	Evaluation Verified
Gross Savings	4,455	3,567	508	407
Net-to-Gross Ratio	0.80	1	0.80	1
Net Savings	3,564	3,567	406	407

Table 12. Summary of Gross and Net Savings for Low Income Home Improvement

ComEd Low Income Home Improvement Program PY1	MWh Savings		KW Savings	
	DCEO Claimed	Evaluation Verified	DCEO Claimed	Evaluation Verified
Gross Savings	726	690	112	98
Net-to-Gross Ratio	0.80	1	0.80	1
Net Savings	581	690	90	98

3.2 Process

Process evaluations are planned for PY2 and PY3 for these programs when there is a sufficient evaluation budget to cover these tasks. This was not an immediate priority for PY1 since the electric energy efficiency measures are an add-on to other well-established programs.

[12] Telephone conversation with Oscar Bloch, DSM Evaluation Supervisor, Public Service Commission of Wisconsin, 10-29-2009. Mr. Bloch verified that Wisconsin has always used a net-to-gross ratio of 1 for evaluation of programs targeted to limited income customers. However, there is no current documentation stating this. It can be seen by looking at program evaluation reports, such as "Focus on Energy Evaluation, Semiannual Report (First Half of 2009)", PA Consulting Group, Revised Final October 19, 2009, p. 4-21, and noting that programs targeted at limited income customers are only required to report verified gross savings, not verified net savings.

3.3 Cost Effectiveness

This section addresses the cost effectiveness of the DCEO Residential Retrofit programs. Cost effectiveness is assessed through the use of the Total Resource Cost (TRC) test. The TRC test is defined in the Illinois Power Agency Act SB1592 as follows:

> *" 'Total resource cost test' or 'TRC test' means a standard that is met if, for an investment in energy efficiency or demand-response measures, the benefit-cost ratio is greater than one. The benefit-cost ratio is the ratio of the net present value of the total benefits of the program to the net present value of the total costs as calculated over the lifetime of the measures. A total resource cost test compares the sum of avoided electric utility costs, representing the benefits that accrue to the system and the participant in the delivery of those efficiency measures, to the sum of all incremental costs of end-use measures that are implemented due to the program (including both utility and participant contributions), plus costs to administer, deliver, and evaluate each demand-side program, to quantify the net savings obtained by substituting the demand-side program for supply resources. In calculating avoided costs of power and energy that an electric utility would otherwise have had to acquire, reasonable estimates shall be included of financial costs likely to be imposed by future regulations and legislation on emissions of greenhouse gases."*[13]

Table 13 summarizes the unique inputs used in a spreadsheet model to assess the TRC ratio for the Residential Retrofit Weatherization program in PY1. Most of the unique inputs come directly from the evaluation results presented previously in this report. DCEO administration, implementation and other costs come from the budgets filed as part of the 2008 DCEO Energy Efficiency Plan.[14] Incentive costs come from the DCEO program tracking data . The participant contribution to incremental measure costs is zero for this program. Avoided costs for both demand and energy match what was used by ComEd in DSMore™ for assessing the TRC ratio of their own energy efficiency projects.

Table 13. Inputs to TRC Assessment for Residential Retrofit Weatherization Program

Item	Value Used
Measure Life (varies by measure)	9 to 15 years
Annual Gross Energy Savings	3,567 MWh
Gross Coincident Peak Savings	0.407 MW
Net-to-Gross Ratio	100%
DCEO Administration Costs	$23,888
DCEO Implementation Costs	$0
DCEO Other Costs	$0
DCEO Incentive Costs	$860,770
Participant Contribution to Incremental Measure Costs	$0

[13] Illinois Power Agency Act SB1592, pages 7-8.

[14] Exhibits 1.2 through 1.10 in DCEO testimony filed in Docket Nos. 07-0539 and 07-0540.

Based on these inputs, the TRC for this program is 1.97 and the program passes the TRC test.

Table 14 summarizes the unique inputs used in a spreadsheet model to assess the TRC ratio for the Residential Retrofit Home Improvement program in PY1. Most of the unique inputs come directly from the evaluation results presented previously in this report. DCEO administration, implementation and other costs come from the budgets filed as part of the 2008 DCEO Energy Efficiency Plan.[15] Incentive costs come from the DCEO program tracking data . The participant contribution to incremental measure costs is zero for this program. Avoided costs for both demand and energy match what was used by ComEd in DSMore™ for assessing the TRC ratio of their own energy efficiency projects.

Table 14. Inputs to TRC Assessment for Residential Retrofit Home Improvement Program

Item	Value Used
Measure Life (varies by measure)	9 to 20 years
Annual Gross Energy Savings	690 MWh
Gross Coincident Peak Savings	0.098 MW
Net-to-Gross Ratio	100%
DCEO Administration Costs	$14,333
DCEO Implementation Costs	$0
DCEO Other Costs	$0
DCEO Incentive Costs	$621,415
Participant Contribution to Incremental Measure Costs	$0

Based on these inputs, the TRC for this program is 0.80 and the program does not pass the TRC test.

Since most individual measures within this program do pass the TRC test, a shift of funding across the measures could raise the program TRC to a value greater than one. Also, it must be remembered that at this time, additional benefits related to reduction of greenhouse gas emissions have not been quantified in the calculation of the TRC. These additional benefits would increase the given TRC benefit/cost ratio and it is likely that this adjustment would make the current measure mix of the program pass the TRC test.

[15] Exhibits 1.2 through 1.10 in DCEO testimony filed in Docket Nos. 07-0539 and 07-0540.

4 CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this report is an evaluation of gross and net impacts from the Weatherization and Home Improvement programs in PY1. In general, the evaluation found that verified gross savings were slightly lower than claimed gross savings.

Recommendations

Improve ex ante and ex post estimates of measure savings per unit. It is recommended that efforts be made by both DCEO and Summit Blue to find measure savings data sources for areas closer to the Illinois region that are up-to-date. Some of these may come from evaluation work currently being done on other portfolio programs. If this information is not available, then continued use of the Energy Star calculators is the next best option. It is important that the most recent Energy Star calculators be used each year as these calculators are continually updated with the most recent studies.

Use billing analysis in PY2 to estimate savings for the Weatherization program. We recommend that a billing analysis be done to estimate electric savings for the Weatherization program in PY2. This was found to be a feasible and cost-effective evaluation technique that is worth trying. Since the savings in the Weatherization program come primarily from the CFL installation measure, this method should produce sound estimates of overall savings from that measure. Knowing the overall impacts of the CFL installation measure takes the place of doing additional research on the components of the savings calculations. It will not be necessary to perform research studies to estimate in-service rates, hours of use, or average wattage savings per bulb if we are able to estimate the combined impact of all those factors from the billing analysis.

Re-assess the feasibility of using billing analysis for the Home Improvement program in PY3. We plan to use the billing analysis results from the Weatherization program in PY2 to re-assess the feasibility of getting reliable and cost-effective savings estimates for the Home Improvement program in PY3. We will have better information on the expected population variability and the required sample size for getting reliable electric savings estimates after the billing analysis for the Weatherization program is completed. This experience will help in determining the likely success of a billing analysis for the Home Improvement program.

5 APPENDICES

5.1 Appendix A: Energy Star Calculators

These calculators show the assumptions and calculations used to create the ex ante estimates of savings.

Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy.
www.energystar.gov

CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for 1 ENERGY STAR Qualified Residential Refrigerator(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

Number of units	1
Electricity Rate ($/kWh)	$ 0.101

Choose the type of refrigerator: 3-Top Mount Freezer without through-the-door ice

	ENERGY STAR Qualified Unit	Conventional Unit
Initial cost per unit (estimated retail price)	$1,100	$1,070
Refrigerator Fresh Volume (ft^3)	18	18
Refrigerator Freezer Volume (ft^3)	5	5
Refrigerator Total Volume (ft^3)	23	23

Annual and Life Cycle Costs and Savings for 1 Residential Refrigerator(s)

	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs*			
Energy costs	$45	$101	$55
Total	**$45**	**$101**	**$55**
Life Cycle Costs*			
Energy costs	$453	$1,007	$554
Energy consumption (kWh)	*5,850*	*13,000*	*7,150*
Purchase Price for 1 unit(s)	$1,100	$1,070	-$30
Total	**$1,553**	**$2,077**	**$524**
Simple payback of initial additional cost (years)†			**0.5**

* *Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount*

† *A simple payback period of zero years means that the payback is immediate.*

Summary of Benefits for 1 Residential Refrigerator(s)

Initial cost difference	**$30**
Life cycle savings	**$554**
Net life cycle savings (life cycle savings - additional cost)	**$524**
Simple payback of additional cost (years)	**0.5**
Life cycle energy saved (kWh)	**7,150**
Life cycle air pollution reduction (lbs of CO_2)	**10,975**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**0.96**
Air pollution reduction equivalence (acres of forest)	**1.36**
Savings as a percent of retail price	**48%**

Assumptions for Residential Refrigerators			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Initial cost per unit	$1,100		DOE 2004
Refrigerator Fresh Volume	18	ft^3	DOE 2004
Refrigerator Freezer Volume	5	ft^3	DOE 2004
Adjusted Volume	26.15	ft^3	DOE 2004
Lifetime	13	years	DOE 2004
Annual Unit Energy Consumption			
For Selected Refrigerator Type	450	kWh	Calculated.
1-Manual Defrost Refrigerators	407	kWh	DOE 2004
2-Partial Automatic Defrost Refrigerators	407	kWh	DOE 2004
3-Top Mount Freezer without through-the-door ice	450	kWh	DOE 2004
4-Side Mount Freezer without through-the-door ice	541	kWh	DOE 2004
5-Bottom Mount Freezer without through-the-door ice	492	kWh	DOE 2004
6-Top Mount Freezer with through-the-door ice	529	kWh	DOE 2004
7-Side Mount Freezer with through-the-door ice	570	kWh	DOE 2004
Conventional Unit (New Unit)			
Initial cost per unit	$1,070		DOE 2004
Refrigerator Fresh Volume	18	ft^3	DOE 2004
Refrigerator Freezer Volume	5	ft^3	DOE 2004
Adjusted Volume	26.15	ft^3	DOE 2004
Lifetime	13	years	DOE 2004
Annual Unit Energy Consumption			
For Selected Refrigerator Type	1,000	kWh	Calculated.
1-Manual Defrost Refrigerators	479	kWh	DOE 2004
2-Partial Automatic Defrost Refrigerators	479	kWh	DOE 2004
3-Top Mount Freezer without through-the-door ice	1000	kWh	DOE 2004
4-Side Mount Freezer without through-the-door ice	636	kWh	DOE 2004
5-Bottom Mount Freezer without through-the-door ice	579	kWh	DOE 2004
6-Top Mount Freezer with through-the-door ice	623	kWh	DOE 2004
7-Side Mount Freezer with through-the-door ice	670	kWh	DOE 2004
Usage			
Number of operating hours per day	24	hours/day	DOE 2004
Number of operating days per year	365	days/year	DOE 2004
Number of operating hours per year	8,760	hours/year	Calculated.
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Energy Prices			
2006 Commercial Electricity Price	$ 0.0912	$/kWh	EIA 2006
2006 Residential Electricity Price	$ 0.1008	$/kWh	EIA 2006
Carbon Emissions Factors			
Electricity Carbon Emission Factors	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2004
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2004

For more information, please contact Bill McNary, D&R International, Contractor to the U.S. DOE, (301) 588-9387, bmcnary@drintl.com
Calculator last updated: 2/15/05
Constants updated 05/07

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CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for 12 ENERGY STAR Qualified Compact Fluoresecent Lamp(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

Number of units	12
Electricity Rate ($/kWh)	$ 0.101
Hours used per day	3

	ENERGY STAR Qualified Unit	Conventional Unit
Initial cost per unit (estimated retail price)	$3.50	$0.50
Wattage (watts)	15 *	60
Lifetime (hours)	10,000	1,000

**ENERGY STAR wattage is calculated based on the wattage selected for the incandescent unit, user can entire an alternative value if desired*

Annual and Life Cycle Costs and Savings for 12 CFLs

	12 ENERGY STAR Qualified Units	12 Conventional Units	Savings with ENERGY STAR
Annual Operating Costs*			
Energy cost	$20	$79	$60
Energy consumption (kWh)	*194*	*788*	*594*
Maintenance cost	$0	$46	$46
Total	**$20**	**$125**	**$106**
Life Cycle Costs*			
Operating cost (energy and maintenance)	$147	$944	$797
Energy costs (lifetime)	$147	$598	$451
Energy consumption (kWh)	*1,773*	*7,200*	*5,427*
Maintenance costs (lifetime)	$0	$346	$346
Purchase price for 12 unit(s)	$42.00	$6.00	-$36.00
Total	**$189**	**$950**	**$761**
		Simple payback of initial additional cost (years)†	**0.3**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Summary of Benefits for 12 CFLs

Initial cost difference	**$36**
Life cycle savings	**$797**
Net life cycle savings (life cycle savings - additional cost)	**$761**
Simple payback of additional cost (years)	**0.3**
Life cycle energy saved (kWh)	**5,427**
Life cycle air pollution reduction (lbs of CO_2)	**8,330**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**0.73**
Air pollution reduction equivalence (acres of forest)	**1.03**
Savings as a percent of retail price	**1812%**

Assumptions for CFLs			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Initial Cost per Unit	$3.50		Industry Data 2006
Wattage	10	watts	EPA 2007
	15	watts	EPA 2007
	18	watts	EPA 2007
	25	watts	EPA 2007
	37	watts	EPA 2007
Bulb Life	6,000	hours	EPA 2007
	8,000	hours	EPA 2007
	10,000	hours	EPA 2007
	12,000	hours	EPA 2007
Lifetime			
For 6,000 hour CFL	5	years	calculated
For 8,000 hour CFL	7	years	calculated
For 10,000 hour CFL	9	years	calculated
For 12,000 hour CFL	11	years	calculated
Conventional Unit			
Initial Cost per Unit	$0.50		Industry Data 2007
Wattage	40	watts	EPA 2007
	60	watts	EPA 2007
	75	watts	EPA 2007
	100	watts	EPA 2007
	150	watts	EPA 2007
Bulb Life	750	hours	EPA 2007
	1,000	hours	EPA 2007
Lifetime			
For 750 hour incadescent bulb	0.7	years	calculated
For 1,000 hour incadescent bulb	0.9	years	calculated
Maintenance			
Labor cost (per hour)	$20		EPA 2004
Installation labor hours	0.15	hours	Assumption
Usage			
Hours used per day	3	hours/day	EPA 2007
Number of days per year	365	days/year	Assumption
CFL annual bulb replacements			
6,000 hours	0.18	bulbs/year	Calculated
8,000 hours	0.14	bulbs/year	Calculated
10,000 hours	0.11	bulbs/year	Calculated
12,000 hours	0.09	bulbs/year	Calculated
Incandescent annual bulb replacements			
750 hours	1.46	bulbs/year	Calculated
1,000 hours	1.10	bulbs/year	Calculated
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Energy Prices			
2006 Commercial Electricity Price	0.0912	$/kWh	EPA 2006
2006 Residential Electricity Price	0.1008	$/kWh	EPA 2006
Carbon Emissions Factors			
Electricity Carbon Emission Factors	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2004
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2004

For questions or comments, please send your email to: Escalcs@cadmusgroup.com
Constants Update 05/07
Calculator Updated 06/07

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CHANGE FOR THE BETTER WITH ENERGY STAR

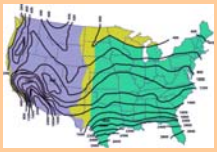
Life Cycle Cost Estimate for 1 ENERGY STAR Qualified Central Air Conditioner(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray box using the map.

Full-Load Cooling Hours for Selected Location	600

Follow the link and click on your location to display your cooling load hours, enter this value in the box on the left.



Enter your own values in the gray boxes or use our default values.

Number of units	1
Electric Rate ($/kWh)	$0.101

	ENERGY STAR Qualified Unit	Conventional Unit
Initial Cost per Unit (estimated retail price with installation)	$3,800	$3,300
Seasonal Energy Efficiency Ratio (SEER) rating	16	9
Cooling Capacity of Air Conditioner (Btu/hr)	24,000	36,000
Use with programmable Thermostat (Yes/No)	Yes	No

Annual and Life Cycle Costs and Savings for 1 Central Air Conditioner(s)

	1 ENERGY STAR Qualified Units	1 Conventional Units	Savings with ENERGY STAR
Annual Operating Costs*			
Energy cost	$76	$242	$166
Energy consumption (kWh)	*756*	*2,400*	1,644
Maintenance cost	$0	$0	$0
Total	**$76**	**$242**	**$166**
Life Cycle Costs*			
Operating costs (energy and maintenance)	$805	$2,555	$1,750
Energy costs	$805	$2,555	$1,750
Energy consumption (kWh)	*10,584*	*33,600*	*23,016*
Maintenance costs	$0	$0	$0
Purchase price for 1 unit(s)	$3,800	$3,300	-$500
Total	**$4,605**	**$5,855**	**$1,250**
		Simple payback of initial additional cost (years)†	**3.0**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Summary of Benefits for 1 Central Air Conditioner(s)

Initial cost difference	**$500**
Life cycle savings	**$1,750**
Net life cycle savings (life cycle savings - additional cost)	**$1,250**
Simple payback of additional cost (years)	**3.0**
Life cycle energy saved (kWh)	**23,016**
Life cycle air pollution reduction (lbs of CO_2)	**35,330**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**3**
Air pollution reduction equivalence (acres of forest)	**4**
Savings as a percent of retail price	**33%**

Assumptions for Central Air Conditioners			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Initial Cost Per Unit	$3,800		Industry Data 2007
Seasonal Energy Efficiency Ratio(SEER) rating	14		EPA 2007
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	Btu/hr	EPA 2004
Use with programmable Thermostat (Yes/No)	No		Cadmus Assumption 05-07
Lifetime	14	years	EPA 2006
Conventional Unit			
Initial Cost Per Unit	$3,300		Industry Data 2007
Seasonal Energy Efficiency Ratio(SEER) rating	9		EPA 2007
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	Btu/hr	EPA 2004
Use with programmable Thermostat (Yes/No)	No		EPA 2004
Lifetime	14	years	EPA 2006
Maintenance			
Labor cost (per hour)	$20		EPA 2004
Labor time (hours)	0		EPA 2004
Usage			
Full-Load Cooling Hours			
Full-Load Cooling Hours for Selected Location	600		ARI Unitary Directory, August 1, 1992 - January 31, 1993
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Programable Thermostat Discount Rate	16%		LBNL 2005 (Based on minimum estimated savings)
Energy and Water Prices			
Commercial Electricity Price	$0.0912	$/kWh	EIA 2006
Residential Electricity Price	$0.1008	$/kWh	EIA 2006
Carbon Dioxide Emissions Factors			
Electricity Carbon Emission Factor	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2006
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2006
For questions or comments, please send your email to Escalcs@cadmusgroup.com			
Calculator last updated: 6/07			
Constants updated 05/07			

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CHANGE FOR THE BETTER WITH ENERGY STAR

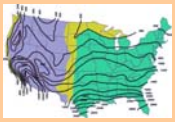
Life Cycle Cost Estimate for 1 ENERGY STAR Qualified Room Air Conditioner(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own value in the gray box using the map.

Full-Load Cooling Hours for Selected Location: 600

Follow the link and click on your location to display your cooling load hours, enter this value in the box on



Enter your own values in the gray boxes or use our default values.

Number of units	1
Electricity Rate ($/kWh)	$0.101
Cooling Capacity of Air Conditioner (Btu/hr)	8,000 - 13,999

	ENERGY STAR	Conventional Unit
Initial Cost per Unit (estimated retail price)	$300	$300
Energy Efficiency Ratio (EER)	11.5	8.8

Annual and Life Cycle Costs and Savings for 1 Room Air Conditioner(s)

	1 ENERGY STAR	1 Conventional	Savings with
Annual Operating Costs*			
Energy cost	$58	$76	$18
Energy consumption (kWh)	*574*	*750*	*176*
Maintenance cost	$0	$0	$0
Total	**$58**	**$76**	**$18**
Life Cycle Costs*			
Operating costs (energy and maintenance)	$578	$755	$177
Energy costs	$578	$755	$177
Energy consumption (kWh)	*7,461*	*9,750*	*2,289*
Maintenance costs	$0	$0	$0
Purchase price for 1 unit(s)	$300	$300	$0
Total	**$878**	**$1,055**	**$177**
Simple payback of initial additional cost (years)†			**0.0**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Summary of Benefits for 1 Room Air Conditioner(s)

Initial cost difference	**$0**
Life cycle savings	**$177**
Net life cycle savings (life cycle savings - additional cost)	**$177**
Simple payback of additional cost (years)	**0.0**
Life cycle energy saved (kWh)	**2,289**
Life cycle air pollution reduction (lbs of CO_2)	**3,514**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**0**
Air pollution reduction equivalence (acres of forest)	**0**
Savings as a percent of retail price	**59%**

Assumptions for Room Air Conditioners			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Initial Cost Per Unit	$300		Industry Data 2006
Energy Efficiency Ratio (EER)			
< 6000	10.7		DOE 2005
6,000 - 10000	10.8		DOE 2005
14,000 - 19,999	10.7		DOE 2005
≥ 20000	9.4		DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	≤ 7,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	8,000 - 13,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	14,000 - 19,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	≥ 20000	Btu/hr	DOE 2005
Lifetime	13	years	EPA 2006
Conventional Unit (Manufactured After 1994)			
Initial Cost Per Unit	$300		Industry Data 2006
Energy Efficiency Ratio (EER)			
< 6000	9.7		DOE 2005
10,000	9.8		DOE 2005
14,000 - 19,999	7.7		DOE 2005
≥ 20000	8.5		DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	≤ 7,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	8,000 - 13,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	14,000 - 19,999	Btu/hr	DOE 2005
Cooling Capacity of Air Conditioner (Btu/hr)	≥ 20000	Btu/hr	DOE 2005
Lifetime	13	years	EPA 2006
Maintenance			
Labor cost (per hour)	$20		EPA 2004
Labor time (hours)	0		EPA 2004
Usage			
Full-Load Cooling Hours			
Full-Load Cooling Hours for Selected Location	600		ARI Unitary Directory, August 1, 1992 - January 31, 1993
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Energy Prices			
Commercial Electricity Price	$0.0912	$/kWh	EIA 2006
Residential Electricity Price	$0.1008	$/kWh	EIA 2006
Carbon Dioxide Emissions Factors			
Electricity Carbon Emission Factor	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2006
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2006
For questions or comments, please send your email to:	Escalcs@cadmusgroup.com		
Constants updated: 5/07			
Last updated: 7/07			

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CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for 10 ENERGY STAR Qualified Lighting Fixture(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

		ENERGY STAR Unit Cost	Conventional Unit Cost
Electricity Rate ($/kWh)	$0.101		
Indoor Lighting Fixtures	8	$65.00	$40.00
Outdoor Lighting Fixtures	2	$40.00	$40.00

Annual and Life Cycle Costs and Savings for 10 Light Fixture(s)

	10 ENERGY STAR Qualified Unit(s)	10 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs*			
Energy cost	$42	$109	$67
Maintenance cost	$0	$0	$0
Total	**$42**	**$109**	**$67**
Life Cycle Costs*			
Life cycle operating cost (energy + maintenance)	$575	$1,479	$904
Purchase price for 10 unit(s)	$600	$400	-$200
Total	**$1,175**	**$1,879**	**$704**
		Simple payback of initial additional cost (years)†	**3.0**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Summary of Benefits for 10 Light Fixture(s)

Initial cost difference	**$200**
Life cycle savings	**$904**
Net life cycle savings (life cycle savings - additional cost)	**$704**
Simple payback of additional cost (years)	**3.0**
Life cycle energy saved (kWh)	**13,200**
Life cycle air pollution reduction (lbs of CO_2)	**20,262**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**1.77**
Air pollution reduction equivalence (acres of forest)	**2.51**
Savings as a percent of retail price	**176%**

Assumptions for Residential Lighting Fixtures			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Indoor Lighting Fixtures unit energy consumption			
High use (3+ hr/day)	35	kWh/yr	EPA 2007
Initial Cost	$65.00		Industry Data 2007
Outdoor Lighting Fixtures unit energy consumption	70	kWh/yr	EPA 2007
Initial Cost	$40.00		Industry Data 2007
Conventional Unit			
Indoor Lighting Fixtures unit energy consumption			
High use (3+ hr/day)	100	kWh/yr	EPA 2007
Initial Cost	$40.00		Industry Data 2007
Outdoor Lighting Fixtures unit energy consumption	140	kWh/yr	EPA 2007
Initial Cost	$40.00		Industry Data 2007
Usage			
Fixture Lifetime	20	years	EPA 2007
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Energy Prices			
Commercial Electricity Price	0.0912	$/kWh	EIA 2006
Residential Electricity Price	0.1008	$/kWh	EIA 2006
Carbon Emissions Factors			
Electricity Carbon Emission Factor	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EIA 2004
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EIA 2004
Last updated: 7/07			
Constants updated: 5/07			
If you have any questions, please contact: ESCalcs@cadmusgroup.com.			

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CHANGE FOR THE BETTER WITH ENERGY STAR

Life Cycle Cost Estimate for 1 ENERGY STAR Qualified Dishwasher(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray boxes or use our default values.

Number of units	1
Electric Rate ($/kWh)	$0.101
Water Rate ($/1000 gallons)	$4.158
Gas Rate ($/therm)	$0.880
Number of Cycles (Loads) per Week	7
Type of Water Heating	Gas Water Heating

	ENERGY STAR Qualified Unit	Conventional Unit
Initial Cost per Unit (estimated retail price)	$545	$645
Energy Factor (EF)	0.65	0.46
Unit Electricity Consumption (kWh/year)	149	211
Unit Water Consumption (gal/year)	1,456	2,184

Annual and Life Cycle Costs and Savings for 1 Dishwasher(s)

	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs*			
Electricity cost	$15	$21	$6
Electricity consumption (kWh)	*149*	*211*	*2*
Water cost	$6	$9	$3
Water consumption (gal)	*1,456*	*2,184*	*728*
Gas cost	$20	$28	$8
Gas consumption (therm)	*23*	*32*	*9*
Maintenance cost	$0	$0	$0
Total	**$41**	**$59**	**$18**
Life Cycle Costs*			
Operating costs (electricity, water, and maintenance)	$361	$515	$154
Electricity costs	$132	$186	$55
Water costs	$53	$80	$27
Gas costs	$176	$249	$73
Maintenance costs	$0	$0	$0
Purchase price for 1 unit(s)	$545	$645	$100
Total	**$906**	**$1,160**	**$254**
		Simple payback of initial additional cost (years)†	**0.0**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Summary of Benefits for 1 Dishwasher(s)

Initial cost difference	**-$100**
Life cycle savings	**$154**
Net life cycle savings (life cycle savings - additional cost)	**$254**
Simple payback of additional cost (years)	**0.0**
Life cycle electricity saved (kWh)	**681**
Life cycle air pollution reduction (lbs of CO_2)	**1,045**
Air pollution reduction equivalence (number of cars removed from the road for a year)	**0**
Air pollution reduction equivalence (acres of forest)	**0**
Savings as a percent of retail price	**47%**

Assumptions for Dishwashers			
Category	**Value**		**Data Source**
Power & Water			
ENERGY STAR Qualified Unit			
Initial Cost Per Unit	$545		Industry Research 2007
Energy Factor	0.65		DOE 2007
Lifetime	11	years	DOE 2007
Water Consumption per Cycle	4	gallons/cy	DOE 2007
Annual Unit Water Consumption	1,456	gallons/yr	Calculated
Electric Water Heating			
Electricity Consumption per Cycle	1.54	kWh/Cycle	Calculated
Unit Electricity Consumption (UEC)	560	kWh/yr	Calculated
Gas Water Heating			
Percent improvement	0		Calculated
Electricity Consumption per Cycle	0.41	kWh/cy	EPA 2006
Unit Electricity Consumption	149	kWh/yr	Calculated
Gas Consumption per Cycle	0.063	Therms/cy	EPA 2006
Unit Gas Consumption	23	Therms/yr	Calculated
Conventional Unit			
Initial Cost Per Unit	$545		Assume same price as ENE
Energy Factor	0.46		DOE 2007
Lifetime	11	years	DOE 2007
Water Consumption per Cycle	6	gallons/cy	DOE 2007
Annual Unit Water Consumption	2,184	gallons/yr	Calculated
Electric Water Heating			
Electric Consumption per Cycle	2.17	kWh/Cycle	Calculated
Unit Electricity Consumption	791	kWh	Calculated
Gas Water Heating			
Percent improvement	0		Calculated
Electric Consumption per Cycle	0.58	kWh/Cycle	EPA 2006
Unit Electricity Consumption	211	kWh	Calculated
Gas Consumption per Cycle	0.089	Therms/Cycle	EPA 2006
Unit Gas Consumption	32	Therms	Calculated
Maintenance			
Labor cost (per hour)	$20		EPA 2004
Labor time (hours)	0		EPA 2004
Usage			
Average number of cycles per year (CPY)	364	Cycles/year	Calculated
Number of Cycles per week (CPW)	4	Cycles/week	EPA 2006
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Energy and Water Prices			
Commercial Electricity Price	$0.091	$/kWh	EIA 2006
Residential Electricity Price	$0.101	$/kWh	EIA 2006
Water Rate per 1000 Gallons	$4.158	$/1000 gal	DOE 2004
Commercial Gas Price	$1.07	$/therm	EIA 2006
Residential Gas Price	$1.25	$/therm	EIA 2006
Carbon Dioxide Emissions Factors			
Electricity Carbon Emission Factors	1.535	lbs CO_2/kWh	EPA 2006
Carbon Dioxide Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2004
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2004
For questions or comments, please send your email to Escalcs@cadmusgroup.com			
Last updated: 8/07			

Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy.
www.energystar.gov

CHANGE FOR THE BETTER WITH ENERGY STAR

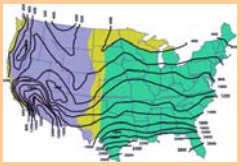
Life Cycle Cost Estimate for
1 ENERGY STAR Qualified Central Air Conditioner(s)

This energy savings calculator was developed by the U.S. EPA and U.S. DOE and is provided for estimating purposes only. Actual energy savings may vary based on use and other factors.

Enter your own values in the gray box using the map.

Full-Load Cooling Hours for Selected Location	600

Follow the link and click on your location to display your cooling load hours, enter this value in the box on the left.



Enter your own values in the gray boxes or use our default values.

Number of units	1
Electric Rate ($/kWh)	$0.101

	ENERGY STAR Qualified Unit	Conventional Unit
Initial Cost per Unit (estimated retail price with installation)	$3,500	$3,300
Seasonal Energy Efficiency Ratio (SEER) rating	14	13
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	36,000
Use with programmable Thermostat (Yes/No)	Yes	No

Annual and Life Cycle Costs and Savings for 1 Central Air Conditioner(s)

	1 ENERGY STAR Qualified Units	1 Conventional Units	Savings with ENERGY STAR
Annual Operating Costs*			
Energy cost	$131	$167	$37
Energy consumption (kWh)	*1,296*	*1,662*	366
Maintenance cost	$0	$0	$0
Total	**$131**	**$167**	**$37**
Life Cycle Costs*			
Operating costs (energy and maintenance)	$1,380	$1,769	$389
Energy costs	$1,380	$1,769	$389
Energy consumption (kWh)	*18,144*	*23,262*	*5,118*
Maintenance costs	$0	$0	$0
Purchase price for 1 unit(s)	$3,500	$3,300	-$200
Total	**$4,880**	**$5,069**	**$189**
		Simple payback of initial additional cost (years)†	**5.4**

** Annual costs exclude the initial purchase price. All costs, except initial cost, are discounted over the products' lifetime using a real discount rate of 4%. See "Assumptions" to change factors including the discount rate.*

† A simple payback period of zero years means that the payback is immediate.

Assumptions for Central Air Conditioners			
Category	**Value**		**Data Source**
Power			
ENERGY STAR Qualified Unit			
Initial Cost Per Unit	$3,500		Industry Data 2007
Seasonal Energy Efficiency Ratio(SEER) rating	14		EPA 2007
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	Btu/hr	EPA 2004
Use with programmable Thermostat (Yes/No)	No		Cadmus Assumption 05-07
Lifetime	14	years	EPA 2006
Conventional Unit			
Initial Cost Per Unit	$3,300		Industry Data 2007
Seasonal Energy Efficiency Ratio(SEER) rating	13		EPA 2007
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	Btu/hr	EPA 2004
Use with programmable Thermostat (Yes/No)	No		EPA 2004
Lifetime	14	years	EPA 2006
Maintenance			
Labor cost (per hour)	$20		EPA 2004
Labor time (hours)	0		EPA 2004
Usage			
Full-Load Cooling Hours			
Full-Load Cooling Hours for Selected Location	600		ARI Unitary Directory, August 1, 1992 - January 31, 1993
Discount Rate			
Commercial and Residential Discount Rate (real)	4%		A real discount rate of 4 percent is assumed, which is roughly equivalent to the nominal discount rate of 7 percent (4 percent real discount rate + 3 percent inflation rate).
Programable Thermostat Discount Rate	16%		LBNL 2005 (Based on minimum estimated savings)
Energy and Water Prices			
Commercial Electricity Price	$0.0912	$/kWh	EIA 2006
Residential Electricity Price	$0.1008	$/kWh	EIA 2006
Carbon Dioxide Emissions Factors			
Electricity Carbon Emission Factor	1.535	lbs CO_2/kWh	EPA 2006
CO_2 Equivalents			
Annual CO_2 sequestration per forested acre	8,066	lbs CO_2/year	EPA 2006
Annual CO_2 emissions for "average" passenger car	11,470	lbs CO_2/year	EPA 2006
For questions or comments, please send your email to Escalcs@cadmusgroup.com			
Calculator last updated: 6/07			
Constants updated 05/07			

5.2 Appendix B: Furnace Data from Gas Appliance Manufacturers Association (GAMA)

This data was used for the ex ante estimate of savings.

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Model Number	Configu-ration	Footnotes	Heat Cap MBTUH Input MBTUH	Eae kWh/yr PE Watts	Ef MMBTU/yr	AFUE %
AIRTEMP PRODUCTS						
Trade Name(s): Airtemp						
NATURAL OR PROPANE GAS						**NON-WEATHERIZED**
ABA100NH5RX	U D H	2,4,7,8	100	81 83 1,111	95.1	80.2
ADA100NH5R	U D H	2,4,7,8	100	81 83 1,111	95.1	80.2
ADA120NH4RH	U D H	2,4,7,8	108	88 82 1,335	114.1	80.2
ADA120NH5RH	U D H	2,4,7,8	108	88 88 1,226	114.6	80.2
CCA108NH5R	D H	2,4,5,6,7,8	108	97 103 909	102.9	90.4
CSA108NH5R	D H	2,4,5,6,7,8	108	97 103 909	102.9	90.4
CSA108NH5RX	D H	2,4,5,6,7,8	108	97 103 909	102.9	90.4
VCA108NH5R	U	2,4,5,6,7,8	108	99 103 1,089	101.6	90.9
VSA108NH5R	U	2,4,5,6,7,8	108	99 103 1,089	101.6	90.9
VSA108NH5RX	U	2,4,5,6,7,8	108	99 103 1,089	101.6	90.9
CCA126NH5RH	D H	2,4,5,6,7,8	113	103 102 962	120.4	90.4
VCA126NH5RH	U	2,4,5,6,7,8	113	104 102 1,262	118.6	90.9
ABA120NH4R	U D H	2,4,7,8	120	98 82 1,335	114.1	80.2
ABA120NH4RX	U D H	2,4,7,8	120	98 82 1,335	114.1	80.2
ADA120NH4R	U D H	2,4,7,8	120	98 82 1,335	114.1	80.2
ABA120NH5R	U D H	2,4,7,8	120	98 88 1,226	114.6	80.2
ABA120NH5RX	U D H	2,4,7,8	120	98 88 1,226	114.6	80.2
ADA120NH5R	U D H	2,4,7,8	120	98 88 1,226	114.6	80.2
ADA140NH4RH	U D H	2,4,7,8	126	102 77 1,340	134.1	80.2

Model Number	Configu-ration	Footnotes	Heat Cap MBTUH Input MBTUH	Eae kWh/yr PE Watts	Ef MMBTU/yr	AFUE %
GUCA070*X40	U H	1,3,4,5,7,8	69	63 123	627	67.3 92.1
GULA070*X40	U H	1,3,4,5,7,8	69	63 123	627	67.3 92.1
ACS90704CX	U H	1,3,4,5,8	69	64 115	370 e	68.3 93.0
ACS90703BX	U H	1,3,4,5,8	69	64 123	690	67.1 93.0
AMS90703BX	U H	1,3,4,5,8	69	64 123	743	66.9 93.0
AMS90704CX	U H	1,3,4,5,8	69	64 123	627	67.3 93.0
DCS90703BX	U H	1,3,4,5,8	69	64 123	690	67.1 93.0
DMS90703BX	U H	1,3,4,5,8	69	64 123	743	66.9 93.0
DMS90704CX	U H	1,3,4,5,8	69	64 123	627	67.3 93.0
GUCA070*X30	U H	1,3,4,5,7,8	69	64 123	743	66.9 92.1
GULA070*X30	U H	1,3,4,5,7,8	69	64 123	743	66.9 92.1
GUSA070*X35	U H	1,3,4,7,8,9	69	65 89	510	66.3 92.1
ACV90704CX	U H	1,3,4,5,8,9,11	69	65 100	225 e	64.9 93.3
GCVA070**40	D H	1,3,4,5,7,8,9	69	65 100	225 e	64.9 93.3
GCCA070*X30	D H	1,3,4,5,7,8	69	65 117	690	67.1 92.1
GCLA070**30	D H	1,3,4,5,7,8	69	65 117	690	67.1 92.1
AMV90704CX	U H	1,3,4,5,8,9,11	69	67 86	275 e	64.0 95.5
GUVA070*X40	U H	1,3,4,7,8,9	69	67 86	275 e	64.0 95.5
ADS80703AN	D	1,3	70	56 75	449	58.1 80.0
ADS80703AX	D	1,3	70	56 75	449	58.1 80.0
AMS80703AN	U H	1,3	70	56 75	449	58.1 80.0
AMS80704BN	U H	1,3	70	56 75	559	58.1 80.0
AMS80704BX	U H	1,3	70	56 75	559	58.1 80.0