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

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Submitted To:

The Department of Commerce and Economic Opportunity



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TABLE OF CONTENTS

E	Execu	tive Summary	.1
1	Introd 1.1 1.2	Juction to the Program Program Description Evaluation Questions	.3 .3 .4
2	Evalu 2.1 2.2 2.3	ation Methods Analytical Methods Data Sources Sampling Plan	. 5 . 6 . 6
3	Progr 3.1 3.2 3.3	am Level ResultsImpact.3.1.1Verification and Due Diligence.3.1.2Tracking System Review.3.1.3Gross Program Impact Parameter Estimates.3.1.4Gross Program Impact Results3.1.5Net Program Impact Parameter Estimates.3.1.6Net Program Impact ResultsProcess.Cost Effectiveness.	.7 .7 .7 .9 20 23 23 24 24
4	Concl	usions and Recommendations	27
5	Apper 5.1 5.2	ndices Appendix A: Energy Star Calculators Appendix B: Furnace Data from Gas Appliance Manufacturers Association (GAMA	2 8 29 ()44

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.

<u>Use billing analysis in PY2 to estimate savings for the Weatherization program.</u> 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.

		Weather	Weatherization		provement
	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

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

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.

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

Table 2. Summary of Evaluability Feasibility Assessment

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. 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.

	DCEO	Savings Estim	ates	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	

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

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.

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

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 judgement that this would contribute to a $\frac{1}{2}$ ton reduction in cooling requirements for the home. This judgement 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 $\frac{1}{2}$ 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 $\frac{1}{2}$ 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

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

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.

	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

Table 4. Summary of Verified Gross Energy Savings per Unit

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.





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 &}quot;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.

	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 5. Calculation of Verified Gross Demand Savings

Table 6. Summary of Verified Gross Demand Savings

	Measure	Ex Ante	Verified	Difference
		kW per unit	kW per unit	
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.

Ameren		Ex Ante			Ex Post	
Measure	kWh/Unit	Units	Total MWH	kWh/Unit	Units	Total MWh
Energy Star Refrigerator	554	327	181	550	327	180
CFL Installation (12 bulbs)	594	2,903	1,724	459	2,903	1,333
Energy Star Bathroom Exhaust Fan	89	38	3	89	38	3
TOTAL			1,909			1,516

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

Table 8.	Weatherization	Program Ex	Ante and E	x Post Gross	KW Savings
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Ameren		Ex Ante			Ex Post	
Measure	kW/Unit	Units	Total kW	kW/Unit	Units	Total kW
Energy Star Refrigerator	0.0632	327	21	0.0628	327	21
CFL Installation (12 bulbs)	0.0678	2,903	197	0.0524	2,903	152
Energy Star Bathroom Exhaust Fan	0.0102	38	0	0.0102	38	0
TOTAL			218			173

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.

Ameren		Ex Ante			Ex Post	
Measure	kWh/Unit	Units	Total MWH	kWh/Unit	Units	Total MWH
Energy Star Refrigerator	554	67	37	550	67	37
Energy Star Advanced Lighting Package	663	88	59	548	88	48
Energy Star Bathroom Exhaust Fan	89	81	7	89	81	7
Energy Star Dishwasher	62	14	1	62	14	1
SEER 14 Central AC with programmable thermostat (new installation)	366	55	20	240	55	13
Energy Star Room AC	176	4	1	176	4	1
Reduce required tonnage as a result of thermal envelope improvements	216	108	23	216	108	23
90% AFUE furnace with EE air handler	400	47	19	400	47	19
CFL Installation (12 bulbs)	594	7	4	459	7	3
TOTAL			171			152

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

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

Ameren		Ex Ante			Ex Post	
Measure	kW/Unit	Units	Total kW	kW/Unit	Units	Total kW
Energy Star Refrigerator	0.0632	67	4	0.0628	67	4
Energy Star Advanced Lighting Package	0.0757	88	7	0.0626	88	6
Energy Star Bathroom Exhaust Fan	0.0102	81	1	0.0102	81	1
Energy Star Dishwasher	0.0071	14	0	0.0071	14	0
SEER 14 Central AC with programmable thermostat (new installation)	0.6100	55	34	0.2800	55	15
Energy Star Room AC	0.2933	4	1	0.2053	4	1
Reduce required tonnage as a result of thermal envelope improvements	0.3600	108	39	0.2520	108	27
90% AFUE furnace with EE air handler	0.0457	47	2	0	47	0
CFL Installation (12 bulbs)	0.0678	7	0	0.0524	7	0
TOTAL			88			54

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.

Ameren	Μ	Wh Savings		KW Savings
Low Income Weatherization Program PY1	DCEO Claimed	Evaluation Verified	DCEO Claimed	Evaluation Verified
Gross Savings	1,909	1,516	218	173
Net-to-Gross Ratio	0.80	1	0.80	1
Net Savings	1,527	1,516	174	173

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

Table 12. S	ummary of	Gross and	Net Savings f	for Low	Income Home	Improvement

Ameren	Μ	Wh Savings		KW Savings
Low Income Home Improvement Program PY1	DCEO Claimed	Evaluation Verified	DCEO Claimed	Evaluation Verified
Gross Savings	171	152	88	54
Net-to-Gross Ratio	0.80	1	0.80	1
Net Savings	137	152	70	54

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.

3.2 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.

3.3 Cost Effectiveness

This section addresses the cost effectiveness of the 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

For the DCEO Ameren programs, assessment of cost-effectiveness begins with a valuation of each conservation program's net "total resource" benefits, as measured by the electric avoided costs, total incremental costs of measures installed, and administrative costs associated with the program. A program is deemed cost-effective if its net "total resource" benefits are positive, i.e.,:

$$\frac{\text{Total Resource Benefits}}{\text{Total Resource Costs}} \ge 1$$

where,

$$Total Resource Benefits = PV \left(\sum_{year=1}^{measurelife} \left(\sum_{i=1}^{s=1}^{s=1} (impact_i \times avoidedcost_i) \right) \right)$$

and,

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

Benefits used in the TRC test calculation include the full value of time and seasonally differentiated generation, transmission and distribution, and capacity costs and also take into account avoided line losses. For each energy-efficiency measure included in a program, hourly (8,760) system-avoided costs were adjusted by the hourly load shape of the end use affected by the measure to capture the full value of time and seasonally-differentiated impacts of the measure. Evaluated impacts were provided to AIU for the DCEO program. End-use load shapes were also employed in calculating peak load impacts for energy-efficiency measures in AIU programs. To calculate the peak load impacts from energy-efficiency measures, end-use load shapes were used to identify the average reduction in demand over AIU's top hours defined as summer weekdays from 3 p.m. until 7 p.m. Non-energy benefits such as water savings were not factored into the calculation. Additionally, consistent with The State of Illinois Commerce Commission Order 07-0539 ("the Order") Section 12-103(f)(5), gas benefits were not accounted for under the program.

Future benefits for the TRC are discounted by 9% based on Ameren's weighted average cost of capital (WACC). Benefits are also adjusted for line losses. Annual avoided costs were adjusted to an hourly stream of costs using hourly system load data to capture seasonality and pricing differences. Consistent with the Order, avoided costs include estimates for financial costs associated with legislation and regulation related to greenhouse gas emissions. The carbon costs are introduced in the 2014 (Program Year 6) costs, valued at \$15 per ton.

The cost component of the analysis considered incremental measure costs and direct utility costs. Incremental measure costs are the incremental expenses associated with installation of energy-efficiency measures and ongoing operation and maintenance costs, where applicable. These costs include the incentive as well as the customer contribution. Utility costs include any customer payments and the expenses associated with program development, marketing, delivery, operation, and evaluation, or monitoring and verification (EM&V).

Table 13 and Table 14 summarize the unique inputs used to assess the TRC ratio for the Residential Weatherization and Residential Home Improvement programs 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. Avoided costs for both demand and energy match what was used by AIU for assessing the TRC ratio of their own energy efficiency projects. Avoided costs include estimates for financial costs associated with legislation and regulation related to greenhouse gas emissions. The carbon costs are introduced in the 2014 (Program Year 6) costs, valued at \$15 per ton.

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

Item	Value
Measure Life (years)	Varies by Measure
Participants	3,268
Annual Gross Energy Savings (MWh)	1,516
Gross Coincident Peak Savings (MW)	.173
Net-to-Gross Ratio	100%
DCEO Incentive Costs	\$301,735
Participant Contribution to Incremental Measure Costs	\$0
DCEO Administration Costs	\$8,370

Table 13. Inputs to TRC Assessment for Residential Weatherization Program

Based on these inputs, the TRC for this program is 2.44 and the program passes the TRC test.

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

Item	Value
Measure Life (years)	Varies by Measure
Participants	471
Annual Gross Energy Savings (MWh)	152
Gross Coincident Peak Savings (MW)	.054
Net-to-Gross Ratio	100%
DCEO Incentive Costs	\$279,115
Participants Contribution to Incremental Measure Costs	\$0
DCEO Administration Costs	\$5,022

Based on these inputs, the TRC for this program is 0.48 and it does not pass the TRC test.

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.

<u>Use billing analysis in PY2 to estimate savings for the Weatherization program.</u> 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.

meeting strict energy efficiency guidelines set Protection Agency and the U.S. Department of www.energystar.gov	greenhouse gas emissions by t by the U.S. Environmental f Energy.	energy	CHANGE FOR THE BETTER WITH ENERGY STAF
1.22	fa Cuala Caat Estim		
	P Ovelified Decider	ate for	*(a)
I ENERGI SIA	AR Qualified Resider	itial Keirigerato	
This energy savings calculator was developed b Actual energy savings may vary based on use a	y the U.S. EPA and U.S. DOE and other factors.	and is provided for estim	ating purposes only.
Enter your own val	ues in the gray boxes o	r use our default va	lues.
Number of units	1		
Electricity Rate (\$/kWh)	\$ 0.101		
	2 Top Mount Franzer without throu	ah tha daar isa	
Choose the type of retrigerator	5-Top Mount Preezer Without throu		
	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 Refrig	erator(s)
	1 ENERGY STAR	1 Conventional	Savings with
	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs	1 ENERGY STAR Qualified Unit(s) \$45_	1 Conventional Unit(s) \$101	Savings with ENERGY STAR \$55
Annual Operating Costs [*] Energy costs Total	1 ENERGY STAR Qualified Unit(s) \$45 \$45	1 Conventional Unit(s) 	Savings with ENERGY STAR \$55 \$55
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Annual Operating Costs [*] Energy costs Total Life Cycle Costs*	1 ENERGY STAR Qualified Unit(s) \$45 \$45	1 Conventional Unit(s) \$101 \$101	Savings with ENERGY STAR \$55 \$55
Annual Operating Costs [*] Energy costs Total Life Cycle Costs* Energy costs	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453	1 Conventional Unit(s) \$101 \$101 \$1,007	Savings with ENERGY STAR \$55 \$55 \$554
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh)	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s)	1 ENERGY STAR Qualified Unit(s) 	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$1,077	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total	1 ENERGY STAR Qualified Unit(s) 	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total	1 ENERGY STAR Qualified Unit(s) \$45 \$453 5,850 \$1,100 \$1,553 Simple payba	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co	Savings with <u>ENERGY STAR</u> <u>\$55</u> \$55 \$55 7,150 <u>-\$30</u> \$524 st (years) [†] 0.5
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payba	1 Conventional Unit(s) \$101 \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional consciunted over the products	Savings with <u>ENERGY STAR</u> <u>\$55</u> \$55 \$55 7,150 <u>-\$30</u> \$524 st (years) [†] 0.5 Ulfetime using a real discour
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payba All costs, except initial cost, are dis pat the payback is immediate.	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co	Savings with <u>ENERGY STAR</u> <u>\$55</u> \$55 \$55 7,150 <u>\$554</u> 7,150 <u>\$554</u> 7,150 <u>\$554</u> \$554 7,150 <u>\$554</u> \$554 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$55 \$5 \$55 \$ \$ \$ \$ \$ \$ \$ \$
Annual Operating Costs Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A t A simple payback period of zero years means th	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payba All costs, except initial cost, are dis pat the payback is immediate.	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co	Savings with ENERGY STAR
Annual Operating Costs Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A † A simple payback period of zero years means the	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payba All costs, except initial cost, are dis payback is immediate.	1 Conventional Unit(s) \$101 \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products	Savings with ENERGY STAR
Annual Operating Costs Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Asimple payback period of zero years means the Summary of hitigal cost difference	1 ENERGY STAR Qualified Unit(s) 	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products al Refrigerator(s)	Savings with <u>ENERGY STAR</u> <u>\$55</u> \$55 \$55 7,150 <u>-\$30</u> \$524 st (years) [†] 0.5 c' lifetime using a real discour
Annual Operating Costs Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A t A simple payback period of zero years means the Summary of Initial cost difference Life cycle savings	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payback New York State of the second	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with <u>ENERGY STAR</u> <u>\$55</u> \$55 7,150 <u>-\$30</u> \$524 st (years) [†] 0.5 'lifetime using a real discour \$30 \$554
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A * Annual c	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payback is immediate. Benefits for 1 Residentian phal cost)	1 Conventional Unit(s) \$101 \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A t A simple payback period of zero years means the Summary of Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost (years))	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payback is immediate. Benefits for 1 Residentian ponal cost)	1 Conventional Unit(s) \$101 \$101 \$100 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A t A simple payback period of zero years means the Summary of Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost (years)) Life cycle paprox saved (kWh)	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payback All costs, except initial cost, are distributed by the payback is immediate. Benefits for 1 Residential bonal cost)	1 Conventional Unit(s) \$101 \$101 \$100 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A † A simple payback period of zero years means the Summary of Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - addition Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lise of CO.)	1 ENERGY STAR Qualified Unit(s) 	1 Conventional Unit(s) \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR
Annual Operating Costs [*] Energy costs Total Life Cycle Costs [*] Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A † A simple payback period of zero years means the Summary of Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - addition Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lbs of CO ₂)	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$45 \$453 5,850 <u>\$1,100</u> \$1,553 Simple paybe All costs, except initial cost, are dis pat the payback is immediate. Benefits for 1 Residenti ponal cost)	1 Conventional Unit(s) \$101 \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR
Annual Operating Costs Energy costs Total Life Cycle Costs* Energy costs Energy consumption (kWh) Purchase Price for 1 unit(s) Total * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual costs exclude the initial purchase price. A * Annual cost difference Life cycle savings Net life cycle savings Net life cycle an engy saved (kWh) Life cycle air pollution reduction (lbs of CO ₂) Air pollution reduction equivalence (number of ca	1 ENERGY STAR Qualified Unit(s) \$45 \$45 \$453 5,850 \$1,100 \$1,553 Simple payback All costs, except initial cost, are distributed to the payback is immediate. Benefits for 1 Residential conal cost) ars removed from the road for a neth	1 Conventional Unit(s) \$101 \$101 \$101 \$1,007 13,000 \$1,070 \$2,077 ack of initial additional co scounted over the products ial Refrigerator(s)	Savings with ENERGY STAR

Α	ssumptior	s for Reside	ential Refrigerators
Casta manu		N-1	Data Dauma
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-Iop 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)	0 4 070		205 2001
Initial cost per unit	\$1,070	. 2	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).
Enorgy Bricos			
2000 Commercial Electricity Drice	¢ 0.0040	Ф/I-)А/Ь	FIA 2000
2006 Commercial Electricity Price	\$ 0.0912	\$/KVVN	
2006 Residential Electricity Price	\$ 0.1008	\$/KVVN	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 /vear	EPA 2004
	,	2. j	

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

Products that earn the ENERGY STAR prevent	greenhouse gas emissions by		CHANGE FOR THE
meeting strict energy efficiency guidelines se	t by the U.S. Environmental		RETTER W/ITH
Protection Agency and the U.S. Department of	f Energy.	energy	
www.energystar.gov			ENERGY 2 IAK
Li	fe Cycle Cost Estima	te for	
12 ENERGY STAR	Qualified Compact	Fluoresecent L	amp(s)
This energy savings calculator was developed b Actual energy savings may vary based on use a	y the U.S. EPA and U.S. DOE a and other factors.	and is provided for estim	nating purposes only.
Enter your own ya	ues in the gray boxes or	use our default va	
	des in the gray boxes of	use our delaur va	ilues.
Number of units	12		
Electricity Rate (\$/KWN)	\$ 0.101		
Hours used per day			
	Ouglified Unit	Conventional Unit	
			<u>.</u>
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 th	e wattage selected for the incande	escent unit, user can entir	re an alternative value if desired
Annual and I	Life Cycle Costs and Sav	rings for 12 CFLs	
	12 ENERGY STAR	12 Conventional	Savings with
	Qualified Units	Units	ENERGY STAR
Annual Operating Costs	\$ 20	0 =0	\$ 20
Energy cost	\$20	\$/9 700	\$6U
Maintenance cost	194 \$0	700 \$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
i otai	\$109	2920	\$/01

		S	imple p	bayba	ck o	f initial additiona	al co	st (yea	ars)†	0.3		
* Annual costs exclude the initial purchase price. Al	l costs,	except initial	cost, ai	e disc	ount	ted over the prod	ucts'	lifetim	e usii	ng a real d	iscou	nt
rate of 4%. See "Assumptions" to change factors inc	luding	the discount r	ate.									
[†] A simple payback period of zero years means that	t the pa	ayback is imn	nediate									

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%	

	Assumpt	ions for CFL	S
Catagory		/alua	Data Source
Bower	, v	aiue	Data Source
ENERGY STAR Qualified Unit			
Initial Cost per Unit	\$3.50		Industry Data 2006
Wattage	40.00 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
Lifetime	12,000	nours	EPA 2007
For 6 000 hour CEL	5	Vears	calculated
For 8,000 hour CEL	7	vears	calculated
For 10,000 hour CFL	9	vears	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
D # 17	150	watts	EPA 2007
Bulb Life	750	hours	EPA 2007
	1,000	hours	EPA 2007
Ener 750 hour incodes cont hulb	0.7	Vooro	aplaulated
For 1 000 hour incades cent hulb	0.7	years	
Tor 1,000 Hour incadescent build	0.3	years	Calculated
Maintenance			
l abor cost (per bour)	\$20		EPA 2004
Installation labor hours	0.15	hours	Assumption
	0.10	nouro	, loodinpilon
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 Data			
Discount Rate	404		
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			
		0 /1) A/2	
2006 Desidential Electricity Price	0.0912	ф/КVVh	EPA 2006
2006 Residential Electricity Price	0.1008	\$/KVVN	EPA 2006
Carbon Emissions Eactors			
	4 505		
Electricity Carbon Emission Factors	1.535	IDS CO2/kWh	EPA 2006
CO. Equivalents			
	0.00-	11 × 00 /	EDA 0004
Annual CO ₂ sequestration per forested acre	8,066	IDS CO ₂ /year	EPA 2004
Annual CO ₂ emissions for "average" passenger car	11,470	lbs CO ₂ /year	EPA 2004
F	E		
For questions or comments, please send your email to:	<u>⊏scalcs@c</u>	aamusgroup.cor	<u>n</u>
Calculator Lipdated 06/07			
Gardalator Opulator 00/07			

Products that earn the ENERGY STAR prevent	greenhouse gas emissions	s by	CHANGE FOR THE
meeting strict energy efficiency guidelines se Protection Agency and the U.S. Department o	t by the U.S. Environmental f Energy.	energy	BETTER WITH
www.energystan.gov			ENERGYSTAN
	Life Cycle Cost Estir	mate for	
1 ENERGY	STAR Qualified Centr	al Air Conditioner(s)	
This energy savings calculator was developed by the U.S. I on use and other factors.	EPA and U.S. DOE and is provide	ed for estimating purposes only. A	ctual energy savings may vary based
Enter yo	ur own values in the gray	box using the map.	
		N	
Full-Load Cooling Hours for Selected Location	600 to dis	w the link and click on your location play your cooling load hours, enter alue 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	
Use with programmable Thermostat (Yes/No)	Yes 🔻	No T	
Annual and Life C	rele Coate and Sovings (s	a 1 Control Air Conditioner	
Annual and Life C	1 ENERGY STAR	or i Central Air Conditioner	(S) Savings with
	Qualified Units	1 Conventional Units	ENERGY STAR
Annual Operating Costs	\$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 costs Energy consumption (kWh) Maintenance costs	\$805 1 <i>0,584</i> \$0	\$2,555 33, <i>600</i> \$0	\$1,750 <i>23,016</i> \$0
Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s)	\$805 <i>10,584</i> \$0 \$3,800	\$2,555 <i>33,600</i> \$0 \$3,300	\$1,750 <i>23,016</i> \$0 \$500
Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total	\$805 10,584 \$0 <u>\$3,800</u> \$4,605	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855	\$1,750 23,016 \$0 \$500 \$1,250
Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total	\$805 10,584 \$0 <u>\$3,800</u> \$4,605 Sin	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co	\$1,750 23,016 \$0 \$500 \$1,250 bst (years) [†] 3.0
Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over t	\$2,555 33,600 \$0 \$3,300 \$5,855 nple payback of initial additional co the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 out rate of 4%. See "Assumptions" to
Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the payback	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over t tok is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 bist (years) [†] 3.0 count rate of 4%. See "Assumptions" to
Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the payback	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over to tack is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 bist (years) [†] 3.0 count rate of 4%. See "Assumptions" to
Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the payback Summar	\$805 10,584 \$0 <u>\$3,800</u> \$4,605 Sin ept initial cost, are discounted over t tock is immediate.	\$2,555 33,600 \$0 \$3,300 \$5,855 nple payback of initial additional co the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 ext (years) [†] 3.0 count rate of 4%. See "Assumptions" to
Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the payback Summal Initial cost difference	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over to tock is immediate.	\$2,555 33,600 \$0 \$3,300 \$5,855 nple payback of initial additional cc the products' lifetime using a real dis the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 bist (years) [†] 3.0 count rate of 4%. See "Assumptions" to count rate of 4%. See "Assumptions" to \$500
Energy costs Energy costs Energy costsumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the paybac Summat Initial cost difference Life cycle savings	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over the tack is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional or the products' lifetime using a real dis I Air Conditioner(s)	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 bit (years) [†] 3.0 count rate of 4%. See "Assumptions" to count rate of 4%. See "Assumptions" to \$500 \$1,750
Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the payback Summar Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost)	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over t ack is immediate. by of Benefits for 1 Centra	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis the products' lifetime using a real dis	\$1,750 23,016 \$0 <u>-\$500</u> \$1,250 bost (years) [†] 3.0 count rate of 4%. See "Assumptions" to count rate of 4%. See "Assumptions" to \$500 \$1,750 \$1,250
Energy costs Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the paybac Summat Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost) Simple payback of additional cost (years) Life owned energy energy (kMb)	\$805 10,584 \$0 \$3,800 \$4,605 Sin ept initial cost, are discounted over the neck is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis I Air Conditioner(s)	\$1,750 23,016 \$0
Energy costs Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the paybac Summar Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost) Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lbs of CO ₂)	\$805 10,584 \$0 <u>\$3,800</u> \$4,605 Sin ept initial cost, are discounted over the ack is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis the products' lifetime using a real dis 1 Air Conditioner(s)	\$1,750 23,016 \$0 \$500 \$1,250 count rate of 4%. See "Assumptions" to \$500 \$1,750 \$1,250 \$1,250 3.0 23,016 35,330
Energy costs Energy costs Energy costs Energy consumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the paybac Summat Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost) Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lbs of CO ₂) Air pollution reduction equivalence (number of cars removed	\$805 10,584 \$0 <u>\$3,800</u> \$4,605 Sim ept initial cost, are discounted over to tack is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis I Air Conditioner(s)	\$1,750 23,016 \$0 \$500 \$1,250 count rate of 4%. See "Assumptions" to count rate of 4%. See "Assumptions" to \$500 \$1,750 \$1,250 3.0 23,016 35,330 3
Energy costs Energy costs Energy cossumption (kWh) Maintenance costs Purchase price for 1 unit(s) Total * Annual costs exclude the initial purchase price. All costs, exc change factors including the discount rate. * A simple payback period of zero years means that the paybac Summar Initial cost difference Life cycle savings Net life cycle savings Net life cycle savings (life cycle savings - additional cost) Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lbs of CO ₂) Air pollution reduction equivalence (acres of forest)	\$805 10,584 \$0 <u>\$3,800</u> \$4,605 Sim ept initial cost, are discounted over the tock is immediate.	\$2,555 33,600 \$0 <u>\$3,300</u> \$5,855 nple payback of initial additional co the products' lifetime using a real dis I Air Conditioner(s)	\$1,750 23,016 \$0 \$500 \$1,250 bit (years) [†] 3.0 count rate of 4%. See "Assumptions" to 5500 \$1,750 \$1,250 3.0 23,016 35,330 3 4

Assumptions for Central Air Conditioners							
Category	<u>۱</u>	/alue	Data Source				
Power	,	aiue					
ENERGY STAR Qualified Unit							
	\$3.800		Industry Data 2007				
Seasonal Energy Efficiency Ratio(SEER) rating	ψ3,000 14						
Cooling Capacity of Air Conditioner (Btu/br)	36,000	Btu/br	EPA 2004				
Use with programmable Thermostat (Yes/No)	00,000 No	Diam	Cadmus Assumption 05-07				
Lifetime	14	vears	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	\$0.0012	\$/k\//b					
Residential Electricity Price	\$0.0912	\$/k\/h					
	ψ0.1000	φ/κνντι					
Carbon Dioxide Emissions Factors							
Electricity Carbon Emission Factor	1.535	lbs CO ₂ /kWh	EPA 2006				
CO. Emilyelente							
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	Escales@c	admusaroup co	m				
Calculator last updated: 6/07							
Constants updated 05/07							

Products that earn the ENERGY STAR preve meeting strict energy efficiency guidelines Protection Agency and the U.S. Department www.energystar.gov	nt greenhouse gas emis set by the U.S. Environn t of Energy.	ssions by nental	energy	CHANGE FOR THE BETTER WITH ENERGY STAR
	Life Cycle Cost	Estimate	e for	
1 ENERGY	STAR Qualified	Room Air	Conditioner	s)
This energy savings calculator was developed by savings may vary based on use and other factors	the U.S. EPA and U.S.	DOE and is p	rovided for estimating	purposes only. Actual energy
Enter you	ur own value in the	gray box u	ising the map.	
Full-Load Cooling Hours for Selected Location	600 Fo	pliow the link an cation to displa purs, enter this v	id click on your yyour cooling load value in the box on	
Enter your own	values in the gray b	oxes or us	se our default va	lues.
Number of units Electricity Rate (\$/kWh) Cooling Capacity of Air Conditioner (Btu/hr)	1 \$0.101 8,000 - 13,999 -	Cor	ventional Unit	
Initial Cost per Unit (estimated retail price) Energy Efficiency Ratio (EER)	\$300 11.5		\$300 8.8	
Annual and Life Cu	cle Costs and Savi	ings for 1 F	Room Air Conditi	oner(s)
	1 ENERGY STAR	10	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)	¢200		COOO	¢0
		-	\$300	<u></u>
Total	\$878	-	\$300 \$1,055	\$177
Total	\$300 \$878 Simple	- payback of in	\$300 \$1,055 itial additional cost (y	\$177 ears) [†] 0.0
Total	\$300 \$878 Simple	payback of in	\$300 \$1,055 itial additional cost (y	ears) [†] 0.0
* Annual costs exclude the initial purchase price. Al 4%. See "Assumptions" to change factors including	\$300 \$878 Simple V costs, except initial cost, a the discount rate.	payback of in	\$300 \$1,055 itial additional cost (y over the products' lifetii	\$177 ears) [†] 0.0
* Annual costs exclude the initial purchase price. A 4%. See "Assumptions" to change factors including A simple payback period of zero years means the	\$300 \$878 Simple Il costs, except initial cost, a the discount rate. It the payback is immediat	payback of in are discounted ie.	\$300 \$1,055 itial additional cost (y over the products' lifeti	\$177 ears) [†] 0.0
Annual costs exclude the initial purchase price. An 4%. See "Assumptions" to change factors including the simple payback period of zero years means the sim	\$878 \$878 Il costs, except initial cost, a the discount rate. It the payback is immediat	payback of in are discounted e.	\$300 \$1,055 itial additional cost (y over the products' lifetin	\$177 ears) [†] 0.0
Annual costs exclude the initial purchase price. Annual costs exclude the initial purchase price. Annual costs exclude the initial purchase price. A simple payback period of zero years means the	\$300 \$878 Simple Il costs, except initial cost, a the discount rate.	payback of in are discounted	\$300 \$1,055 itial additional cost (y over the products' lifetin	ears) [†] 0.0
Annual costs exclude the initial purchase price. An 4%. See "Assumptions" to change factors including the A simple payback period of zero years means the Summar	\$300 \$878 Simple If costs, except initial cost, a the discount rate. at the payback is immediat y of Benefits for 1 F	payback of in are discounted le. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetin conditioner(s)	ears) [†] 0.0 me using a real discount rate of
Annual costs exclude the initial purchase price. An 4%. See "Assumptions" to change factors including to A simple payback period of zero years means the Summar Initial cost difference	\$878 \$878 Simple Il costs, except initial cost, a the discount rate. At the payback is immediat y of Benefits for 1 F	payback of in are discounted te. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetin conditioner(s)	\$177 ears) [†] 0.0 me using a real discount rate of \$0
Annual costs exclude the initial purchase price. Al Annual costs exclude the initial purchase price. Al See "Assumptions" to change factors including A simple payback period of zero years means that Summar Initial cost difference Life cycle savings	U costs, except initial cost, a the discount rate.	payback of in are discounted te. Room Air C	\$1,055 itial additional cost (y over the products' lifetin conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177
* Annual costs exclude the initial purchase price. Al 4%. See "Assumptions" to change factors including * A simple payback period of zero years means the Summar Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additio	sorrest s	payback of in are discounted le. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177
* Annual costs exclude the initial purchase price. A 4%. See "Assumptions" to change factors including * A simple payback period of zero years means that Summar Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additio Simple payback of additional cost (years)	source state	payback of in are discounted te. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 0.0
Annual costs exclude the initial purchase price. A 4%. See "Assumptions" to change factors including A simple payback period of zero years means the Summai Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additio Simple payback of additional cost (years) Life cycle energy saved (kWh)	source second tracks and the payback is immediat y of Benefits for 1 F nal cost)	payback of in are discounted te. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii conditioner(s)	\$00 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 \$177 0.0 \$2,289
Annual costs exclude the initial purchase price. A 4%. See "Assumptions" to change factors including A simple payback period of zero years means the Summai Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - addition Simple payback of additional cost (years) Life cycle air pollution reduction (lbs of CO ₂)	source state in the payback is immediate in the payback is immediated in the payback i	payback of in are discounted le. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 \$177 0.0 \$2,289 3,514
 Annual costs exclude the initial purchase price. Al 4%. See "Assumptions" to change factors including A simple payback period of zero years means the Summal Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - additional cost (years) Life cycle air pollution reduction (lbs of CO₂) Air pollution reduction equivalence (number of ca 	source	payback of in are discounted le. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetin conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 \$177 \$177 \$0.0 \$2,289 3,514 0
 Annual costs exclude the initial purchase price. Al 4%. See 'Assumptions' to change factors including A simple payback period of zero years means the Summan Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - addition Simple payback of additional cost (years) Life cycle are pollution reduction (lbs of CO₂) Life cycle in pollution reduction (lbs of CO₂) Life pollution reduction equivalence (acres of fore 	\$878 Simple Il costs, except initial cost, a the discount rate. at the payback is immediat y of Benefits for 1 F nal cost) rs removed from the road at)	payback of in are discounted te. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 \$177 0.0 \$2,289 3,514 0 0
 Annual costs exclude the initial purchase price. Al 4%. See "Assumptions" to change factors including A simple payback period of zero years means the Summar Initial cost difference Life cycle savings Net life cycle savings (life cycle savings - addition Simple payback of additional cost (years) Life cycle energy saved (kWh) Life cycle air pollution reduction (lbs of CO₂) Air pollution reduction equivalence (acres of fore: Savings as a percent of retail price 	\$878 Simple Il costs, except initial cost, e the discount rate. It the payback is immediat ry of Benefits for 1 F nal cost) rs removed from the road it)	payback of in are discounted te. Room Air C	\$300 \$1,055 itial additional cost (y over the products' lifetii conditioner(s)	\$0 \$177 ears) [†] 0.0 me using a real discount rate of \$0 \$177 \$177 \$177 \$177 0.0 \$2,289 3,514 0 0 \$9%

Assumptions for Room Air Conditioners								
Catagony	Volu	•	Data Source					
Category	vaiu	e	Data Source					
Power								
ENERGY STAR Qualified Unit	\$ 000		hadaataa Data 0000					
Initial Cost Per Unit	\$300		Industry Data 2006					
Energy Efficiency Ratio (EER)	40.7							
< 6000	10.7		DOE 2005					
6,000 - 10000	10.8		DOE 2005					
20000	10.7							
2 20000	9.4	D4/h.m						
Cooling Capacity of Air Conditioner (Btu/hr)	≥ 7,999	Btu/hr						
Cooling Capacity of Air Conditioner (Btu/hr)	8,000 - 13,999	Blu/nr Dtu/hr						
Cooling Capacity of Air Conditioner (Btu/hr)	14,000 - 19,999	Btu/hr						
Lifetime	2 20000	Btu/nr	DUE 2005					
Lieume	13	years	EPA 2006					
Conventional Unit (Manufacture d After 1004)								
Initial Cost Der Unit	\$200		Industry Data 2006					
Francis Efficiency Datia (EED)	\$300		Industry Data 2006					
Energy Elliciency Ratio (EER)	0.7		DOE 2005					
< 6000	9.7		DOE 2005					
10,000	9.8							
> 20000	1.1		DOE 2005					
2 20000	0.0	Dtu/br						
Cooling Capacity of Air Conditioner (Btu/hr)	≥ 7,999	Btu/hr						
Cooling Capacity of Air Conditioner (Btu/hr)	8,000 - 13,999	Blu/nr Dtu/hr						
Cooling Capacity of Air Conditioner (Btu/hr)	14,000 - 19,999	Btu/hr						
	20000	Dlu/III	DOE 2003					
Lieume	13	years	EFA 2000					
Maintonanco								
Labor cost (por bour)	\$20		EPA 2004					
Labor time (bours)	φ20		EPA 2004					
Labor time (nouis)	0		LFA 2004					
lisago								
Full-Load Cooling Hours								
Full-Load Cooling Hours for Selected Location	600		ARI Unitary Directory August 1, 1992 - January 31, 1993					
Tui-Load Cooling Hours for Delected Escation	000		Art officary 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	FIA 2006					
Residential Electricity Price	\$0.1008	\$/kWh	EIA 2006					
	\$0.1000	¢,						
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					
	.1,470							
For questions or comments, please send your email to:	Escalcs@cadmus	group.com						
Constants updated: 5/07								
Last updated: 7/07								

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Products that earn the ENERGY	STAR preve	nt greenhou	use gas e	emissions b	y	/				IAI	NOC	UN	INC
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				StEStin	ate	TO	- Insta	(2)					
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This energy savings calculator was	developed by	the U.S. FP.	A and U S	S DOF and	is prov	ided	for esti	mating p	irnose	s onl	v Ac	ual ene	erav
savings may vary based on use and	other factors.					naoa		mating p	aipoot	0 011	y. 7.0		Jigy
Enter	your own	values in	the gra	y boxes	or us	e ou	ır defa	ault val	ues.				
Electricity Rate (\$/kWb)	\$0 101	1											
	φ0.101		ENED	CV ST AD	Unit			Conv	ontic	nal	Unit		
				Cost	Unit	-		0111	C	n ai			
Indeer Lighting Fixtures	0	1		\$65.00	1				640	00	1		
Indoor Lighting Fixtures	8	l		\$65.0U					\$40	.00	l		
		1		0 40 00	1						1		
Outdoor Lighting Fixtures	2	l		\$40.00	J				\$40	.00			
Ann	ual and Lif	e Cvcle C	osts a	d Savinc	is for	10	Liaht	Fixture	(s)				
			10 FI	NERGY ST	TAR		10 C	onventi	onal		Sav	inas w	vith
			Qua	lified Unit	(s)			Unit(s)	onai		FNFR	GYS	TAR
Annual Operating Costs*						-		01111(0)		-		0.0	<u>.,</u>
Energy cost				¢10				¢100				¢67	
Energy cost				Φ4∠ ΦΩ			\$109				۲ ۵ Φ		
				\$U ¢40		-		\$U	\$0				
Total				⊅ 4∠				\$109				Ф0 7	
Life Cycle Costs													
Life cycle operating cost (energy + r	maintenance)		\$575					\$1,479			\$904		
Purchase price for 10 unit(s)			\$600			\$400				-	-\$200		
Total			\$1,175			\$1,879						\$704	
				Si	mple p	ayba	ck of in	itial addit	ional o	cost (years) [†]	3.0	
* Annual costs exclude the initial purc	hase price. All	costs, except	t initial cos	t, are discou	nted ov	/er the	e produ	cts' lifetim	e using	g a rea	al discou	int rate	of 4%.
See "Assumptions" to change factors i	including the d	iscount rate.											
A simple payback period of zero yea	ars means that	the payback	is immed	liate.									
						-							
	C	many of	Ronofit	for 10 L	abt 5	 							
	Juli		Senents		ynt r	ixtu	10(5)						
Initial cost difference												\$200	
Life cycle savings												\$904	
Net life cycle savings (life cycle savi	ings - addition	al cost)										\$704	
Simple payback of additional cost ()	/ears)											3.0	
Life cycle energy saved (kWh)											1	3,200	
Life cycle air pollution reduction (lbs	of CO ₂)										2	20,262	
Air pollution reduction equivalence (number of car	s removed fro	om the ro	ad for a vea	r)							1.77	
Air pollution reduction equivalence (acres of forest	:)										2.51	
Savings as a percent of retail price		,										176%	
samge de a persent er retair price													
	1	1	1	1	1		1	1	1		_		<u> </u>

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/vr	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. Equivalents							
Annual CO ₂ sequestration per forested acre	8 066	lbs CO ₂ /vear	FIA 2004				
Annual CO_2 sequestration per lorested acte Annual CO_2 emissions for "average" passenger car	11,470	lbs CO ₂ /year	EIA 2004				
Last updated: 7/07							
Constants updated: 5/07							
It was have any available places contact. ECCales@codmus							

If you have any questions, please contact: ESCalcs@cadmusgroup.com.

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



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.

Unit Water Consumption (gal/year)

Enter y	our own values i	in the gray box	es or use ou	r 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	Conventional Unit
	Qualified Unit	
Initial Cost per Unit (estimated retail price)	\$545	\$645
Energy Factor (EF)	0.65	0.46
Linit Electricity Concumption (k)//h/year)	140	211

1,456

2,184

1 E Qi	ENERGY STAR ualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs			
Electricity cost	\$15	\$21	\$6
Electricity consumption (kWh)	149	211	2
Nater cost	\$6	\$9	\$3
Water consumption (gal)	1,456	2,184	728
Gas cost	\$20	\$28	\$8
Gas consumption (therm)	23	32	9
Aaintenance cost	\$0	\$0	\$0
Гotal	\$41	\$59	\$18
Dperating 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
	\$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.

	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	to onlango laote	no mondanng aro aro	oounn nato.	
Α	simple pavbac	k period of zero	years means that t	ne pavback i	s immediate

S	umma	ary of Benefits	for 1	Dish	washe	er(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	V	alue	Data Source				
Bower & Water							
ENERGY STAR Qualified Unit							
Initial Cost Der Unit	¢e ie		Inductor Research 2007				
	۵ <u>۵</u>		DOE 2007				
Lifetime	0.05		DOE 2007				
	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/vr	Calculated				
Electric Water Heating	, -	J ()					
Electric Consumption per Cycle	2 17	kWh/Cycle	Calculated				
Unit Electricity Consumption	791	kWh	Calculated				
Gas Water Heating	101	KUT	Calculatou				
Percent improvement	0		Calculated				
Electric Consumption per Cycle	0.58	kWb/Cycle	EPA 2006				
Linit Electricity Consumption	211	kWh/Cycle	Calculated				
	211	KVVII Thomso/Outolo					
Gas Consumption per Cycle	0.089	Therms/Cycle	Coloulated				
	52	menns	Calculated				
Meintenenee							
	.		FDA 0004				
Labor cost (per nour)	\$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				
		Cyclos, Wook	21772000				
Discount Rate							
Commercial and Desidential Discount Data (real)	40/		A real discount rate of 4				
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	IDS CO2/kWh	EPA 2006				
Carbon Dioxide Equivalents							
Annual CO ₂ sequestration per forested acre	8.066	lbs CO ₂ /vear	EPA 2004				
	11 470		EBA 2004				
Annual CO2 emissions for average passenger car	11,470	IDS CO2/year	EFA 2004				
	Free L. C.						
For questions or comments, please send your email to	<u>⊨scalcs@c</u>	aamusgroup.c	om				
Last updated: 8/07							



* 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.

Ass	umptions	for Central	Air Conditioners
Catagony	1	/alua	Data Source
Bower	,	aiue	
Initial Cost Per Unit	¢2 500		Industry Data 2007
Seeconal Energy Efficiency Patio(SEED) rating	\$3,500 14		
Cooling Capacity of Air Conditioner (Btu/hr)	36,000	Btu/br	EPA 2004
Lise with programmable Thermostat (Ves/No)	50,000 No	Dtu/III	Cadmus Assumption 05-07
Lifetime	14	vears	EPA 2006
Liounio		youro	
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	FIA 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 Equivalante			
	0.000		
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@c	admusgroup.co	<u>m</u>
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.

May 2005		SEG	TION	1 - (GAS	FUR	INA	CES				\searrow						Page 15
Model Number	Configu- ration	Footnotes	He MI Input MBTUH	at Ca BTUI	ip] H kV PE Vatts	Eae Vh/yr MM	ef BTU	AFUE % /yr	Model Number	Cor ra	ıfigu- tion	Footnotes	H M Input MBTU	eat C BTL	ap JH 1 PE Watt	Eac Wh/y	r Ef MBTU	AFUE % J/yr
AIRTEMP PRODUCTS Trade Name(s): Airtemp NATURAL OR PROPANE GAS				NC	DN-W	EATH	IFRI	ZED	GULA070*X40 GULA070*X40 ACS90704CX	บ บ บ	H H H	1,3,4,5,7,8 1,3,4,5,7,8 1,3,4,5,8	69 69 69	63 63 64	123 123 115	627 627 370	67.3 67.3 e 68.3	92.1 92.1 93.0
ABA100NH5RX ADA100NH5R ADA120NH4RH	UDH UDH UDH	2,4,7,8 2,4,7,8 2.4,7.8	100 100	81 81 88	83 I 83 1 82 1	,111 ,111	95.1 95.1	80.2 80.2 80.2	AMS90703BX AMS90703BX AMS90704CX	บ บ บ	H H H	1,3,4,5,8 1,3,4,5,8 1,3,4,5,8	69 69 69	64 64	123 123 123	690 743 627	67.1 66.9 67.3	93.0 93.0 93.0
ADA120NH5RH CCA108NH5R CSA108NH5R	UDH DH DH	2,4,7,8 2,4,5,6,7,8 2,4,5,6,7,8	108 108	88 97 97	88 1 103	,226 1 909 1	14.6	80.2 90.4	DMS90703BX DMS90704CX	U U U	H H H	1,3,4,5,8 1,3,4,5,8 1,3,4,5,8	69 69 69	64 64 64	123 123 123	690 743 627	67.1 66.9 67.3	93.0 93.0 93.0
CSA108NH5RX VCA108NH5R VSA108NH5R	DH U U	2,4,5,6,7,8 2,4,5,6,7,8 2,4,5,6,7,8	108 108 108	97 99 99	103 103 1 103 1	0909 1 089 1	02.9	90.4 90.4 90.9	GULA070*X30 GULA070*X30 GUSA070*X35	U U U	H H H	1,3,4,5,7,8 1,3,4,5,7,8 1,3,4,7,8,9	69 69 69	64 64 65	123 123 89	743 743 510	66.9 66.9 66.3	92.1 92.1 92.1
VSA108NH5RX CCA126NH5RH VCA126NH5RH	U DH U	2,4,5,6,7,8 2,4,5,6,7,8 2,4,5,6,7,8	108 113 113	99 103 104	103 1 102 1	,089 1 962 1 262 1	01.6 20.4	90.9 90.9 90.4	GCVA070**40 GCCA070**30	1	H DH DH	1,3,4,5,8,9,11 1,3,4,5,7,8,9 1,3,4,5,7,8	69 69 69	65 65 65	100 100 117	225 e 225 e 690	64.9 67.1	93.3 93.3 92.1
ABA120NH4R ABA120NH4RX ADA120NH4R	UDH UDH UDH	2,4,7,8 2,4,7,8 2,4,7,8	120 120 120	98 98 98	82 1 82 1 82 1	,335 1 ,335 1 ,335 1	14.1	80.2 80.2	GCLA070**30 AMV90704CX GUVA070*X40	U U	H H H	1,3,4,5,7,8 1,3,4,5,8,9,11 1,3,4,7,8,9	69 69 69	65 67 67	117 86 86	690 275 e 275 e	67.1 64.0 64.0	92.1 95.5 95.5
ABA120NH5R ABA120NH5RX ADA120NH5R	UDH UDH UDH	2,4,7,8 2,4,7,8 2,4,7,8 2,4,7,8	120 120 120	98 98 98	88 1. 88 1. 88 1.	226 1 226 1	14.6 14.6	80.2 80.2 80.2	ADS80703AN ADS80703AX AMS80703AN	ו ע ע	D D H	1,3 1,3 1,3	70 70 70	56 56 56	75 75 75	449 449 449	58.1 58.1 58.1	80.0 80.0 80.0
ADA140NH4RH	UDH	2,4,7,8	126	102	77 1	340 1	34.1	80.2	AMS80704BN AMS80704BX	UU	H H	1,3 1,3	70 70	56 56	75	559	58.1 58.1	80.0