176

DUKE ENERGY OHIO EXHIBIT________

BEFORE

THE PUBLIC UTILITIES COMMISSION OF OHIO

FILE

In the Matter of the Application of Duke Energy Ohio, Inc., for Recovery of Program Costs, Lost Distribution Revenue and Performance Incentives Related to its Energy Efficiency and Demand Response Programs.	)))))	Case No. 13-753-EL-RDR

DIRECT TESTIMONY OF

ASHLIE J. OSSEGE

ON BEHALF OF

DUKE ENERGY OHIO, INC.

VOLUME 1 OF 3

March 28, 2013

TABLE OF CONTENTS

PAGE

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Ashlie J. Ossege, and my business address is 139 East Fourth Street, Cincinnati, Ohio 45202.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Duke Energy Business Services LLC, (DEBS) as Manager, Energy Efficiency (EE) Analytics for residential customers. DEBS provides various administrative and other services to Duke Energy Ohio, Inc., (Duke Energy Ohio or Company) and other affiliated companies of Duke Energy Corporation (Duke Energy).

Q. PLEASE SUMMARIZE YOUR EDUCATION AND PROFESSIONAL EXPERIENCE.

A. I graduated from the University of Cincinnati with a Bachelor's Degree in Marketing and Real Estate. I have completed additional course work at the graduate level in quantitative analysis. I am an Instructor in the Graduate Economics Department at the University of Cincinnati, teaching Applied Statistical Programming Methods for Economists.

From 1994 to 1997, I was employed by various real estate brokers, including Comey & Shepherd Realtors as a certified Realtor in Ohio. From 1997 to 2006, I worked for Cinergy and Duke Energy Ohio as a Lead Market Analyst developing and managing product/program design activities as well as market research projects. Since 2006, I have been employed by Duke Energy Business Services, currently in the role of Manager, Energy Efficiency Analytics supporting energy efficiency research, analytics and evaluation.

Q. PLEASE DESCRIBE YOUR DUTIES AS MANAGER OF EE ANALYTICS.

A. As Manager, EE Analytics, I have responsibilities for a variety of analytical functions including market research data collection and analysis, marketing design testing, energy load analysis, energy efficiency cost effectiveness analysis, impact evaluation studies, and product design research. In this role, I provide services for Duke Energy affiliates, including Duke Energy Ohio. Additionally, I participated on behalf of the Company at public forums held at the Public Utilities Commission of Ohio (Commission) wherein the Commission, its Staff and interested stakeholders developed the Technical Reference Manual (TRM) which is the subject of the Commission's docket in Case No. 09-512-GE-UNC.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO?

A. Yes. I have provided testimony in this case and in other energy efficiency related proceedings before the Public Utilities Commission of Ohio.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. My testimony supports the Duke Energy Ohio's Application to update its Energy Efficiency cost recovery rider, EE-PDRR. In particular, my testimony: (1) provides an overview of the programs on which Evaluation, Measurement and Verification (EM&V) activities occurred or for which EM&V results were applied in 2012, (2) provides the current findings from the Company's EM&V

work, and (3) demonstrates how the results from the EM&V process will be used in the true-up.

II. OVERVIEW OF EVALUATION, MEASUREMENT, AND VERIFICATION

Q. WHAT PROGRAMS RECEIVED EVALUATION, MEASUREMENT & VERIFICATION THAT APPLY TO THIS TRUE-UP?

A. AJO Attachments 1 through 9 provide the detailed, completed EM&V reports that apply to this true-up:

AJO Attachment	Program	Evaluation Type	Report Date	Effective Date
1	Low Income Services: Refrigerators	Impact	12/20/2011	1/1/2012
2	Residential Energy Assessments: Personalized Energy Report (PER)®	Impact	12/22/2011	1/1/2012
3	Residential Energy Assessments: Mass Market Energy Assessments Online (OHEC)	Impact	12/22/2011	1/1/2012
4	Energy Efficiency Education Program for Schools	Impact	12/22/2011	1/1/2012
5	2010 Smart Saver® Residential: HVAC	Impact	1/2/2012	1/1/2012
6	2011 Power Manager	Demand Response Impact	2/19/2012	1/1/2011
7	2009-2011 Non-Res Smart Saver, Custom	Impact	9/17/2012	10/1/2012
8	2011 Smart $aver® Residential: CFLs	Process and Impact	9/28/2012	10/1/2012
9	2011 PowerShare®	Demand Response Impact	11/12/2012	1/1/2011
10	2012 Power Manager	Process	2/22/2013	N/A

Q. HAVE THESE REPORTS BEEN REVIEWED BY THE COMMISSION'S INDEPENDENT THIRD-PARTY EVALUATOR?

A. Rule 4901:1-39-05, Ohio Administrative Code (O.A.C.), sets forth specific energy efficiency and demand reduction targets with which electric utilities must comply. The Commission is charged with ensuring that utilities meet these targets and therefore must have a rational method with which to do so. The Company provided several reports as appendices to its May 15, 2012 filing in compliance with Rule 4901:1-39-05(C), O.A.C. These reports covered the following programs: Low Income Refrigerator, Personalized Energy Report, Mass Market Energy Assessments Online, K12 Curriculum, Residential Smart Saver, and Power Manager. The Residential CFL, The Non-Residential Custom Incentive, the 2011 program year Power Share and 2012 Power Manager demand response reports provided as AJO Attachments 7 through 10 respectively, will also be provided in the Rule 4901:1-39-05(C), O.A.C, Annual Energy Efficiency Portfolio Status Report, May 15, 2013.

Q. HOW WERE THE EVALUATION, MEASUREMENT, AND VERIFICATION RESULTS UTILIZED IN DEVELOPING ESTIMATES OR TRUE-UPS FOR THE EE RIDER?

A. The EM&V process produces results on two main concepts: actual customer participation and prospective load impact estimations. The reason these are important to the proposed rider is that the original evaluation of program cost-effectiveness utilized projected numbers for participants in the programs and estimates of the load impacts. The participant and initial load impact information is used to develop estimates of the achievement level that is subsequently used to determine the incentive amounts included in the rider. The Company has measured actual participation as an input into the EM&V process and uses this actual participation information as the basis for annual true-ups of estimated incentives for the rider by multiplying this participation by the initial estimates or updated EM&V results. For those programs on which EM&V has been conducted and finalized, the estimates of energy efficiency impacts and free ridership levels (which are an output of this EM&V process) have been applied prospectively to adjust subsequent impact assumptions. Once the EM&V load impact estimates have been received, they are applied to the rider in the following month. These results will also be used to estimate future target achievement levels for development of estimated incentives and in future cost-effectiveness evaluations[1].

Q. WHAT DATA WAS USED IN THE CALCULATION OF THE REVENUE REQUIREMENT PROVIDED BY DUKE ENERGY OHIO WITNESS JAMES E. ZIOLKOWSKI?

A. The revenue requirement was calculated using both data inputs and outputs from the DSMore™ model, including initial estimates or estimated energy savings from EM&V, program costs and avoided costs. In addition, measurement and verification costs, which are not part of the DSMore™ model, are also included in

[1] For demand response programs, the contracted amounts of kW reduction capability from participants are considered to be components of actual participation.

the calculation of revenue requirements.

III. CONCLUSION

Q. WERE ATTACHMENTS AJO 1 – 9 PREPARED BY YOU OR AT YOUR DIRECTION?

A. Yes, they were. Specifically, at my direction, the evaluation reports were prepared by the Company's independent third party evaluator.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

COLLibrary 0106219.0591612 365771v1

Case No. 13-753-EL-RDR
Attachment AJO 1

Final Report

Evaluation of Duke Energy's Low Income Refrigerator Replacement Program In Ohio

An Impact Evaluation

Prepared for
Duke Energy
139 East Fourth Street
Cincinnati, OH 45201

December 20, 2011

Submitted by

Nick Hall and Brian Evans

TecMarket Works
165 West Netherwood Road
2nd Floor, Suite A
(608) 835-8855

Pete Jacobs
BuildingMetrics, Inc.

TABLE OF CONTENTS

Executive Summary

Key Findings and Recommendations

The key findings and recommendations identified through this evaluation are presented below.

Impact Evaluation

1. Average annual consumption of old and new refrigerators was 1,576 kWh and 394 kWh respectively, an average savings of 1,182 kWh.
2. A total of 569[1] refrigerators were replaced for a total program savings of 672,671 kWh.
3. Only 6% of old refrigerators were replaced with a 15 cubic foot model.
4. Average cubic footage of old vs. new models was very close, 18.92 vs. 19.3 cubic feet.
5. In special cases, a refrigerator with a bad seal may be replaced at the discretion of the auditor even if the meter wattage is below the program requirement. There were four such exceptions made in Ohio. In descending order, these units consumed 1304 kWh, 1243 kWh, 475 kWh, and 471 kWh. These installations, especially the latter two, should be reviewed by Duke Energy to assure that protocols that provide energy savings are being followed by all auditors.
6. Units were replaced only after an inspection of the old unit and a participant-specific offer by the program to have it replaced. Most participants were made aware of the Refrigerator Replacement Program offerings only after they had applied for another low income program (such as the weatherization program) and were subsequently informed that they were eligible for the Refrigerator Replacement Program as well. Survey data indicates that participants were not considering replacing their units at the time of the program offering. Hence, program freeridership is set at zero percent.

Engineering Impact Estimates: Key Findings

Table 1. Summary of Program Savings by Measure

Measure	Participation Count	Verified Per unit kWh impact	Gross Verified kWh Impact	Gross Verified kW Savings	Verified Per unit kW Savings
Frigidaire: 15 cubic feet	29	1,132	32,836	5.1	0.175
Frigidaire: 18 cubic feet	230	1,211	278,482	43.0	0.187
Frigidaire: 21 cubic feet	253	1,164	294,481	45.3	0.179
Whirlpool: 15 cubic feet	5	1,093	5,465	0.8	0.169
Whirlpool: 18 cubic feet	24	1,180	28,329	4.4	0.182
Whirlpool: 21 cubic feet	28	1,181	33,078	5.1	0.182
TOTAL	**569**	**1,182** [1]	**672,671**	**104**	**0.182**[2]

[1]total gross kwh impact divided by 569 participants

[2]total gross kW savings divided by 569 participants

[1] The number of participants for the impact evalution is based upon the base rates and stipulated agreement program, and from the Energy Efficiency Portfolio program.

Introduction and Purpose of Study

Summary Overview

This document presents the evaluation report for Duke Energy's Low Income Refrigerator Replacement Program as it was administered in Ohio.

Summary of the Evaluation

The evaluation was conducted by TecMarket Works and BuildingMetrics.

The impacts are based on engineering analysis of the data collected through the use of a power meter installed directly to refrigerators in customers' homes. This report is structured to provide energy impact estimations per unit as well as total program savings. The impact tables reporting total savings are based on the savings identified from the 569 participants that replaced a refrigerator. Note that these savings do not include spillover or market effects savings from taking the old refrigerator off the secondary market.

Evaluation Objectives

This evaluation's objective is to determine the savings achieved by Duke Energy's Low Income Refrigerator Replacement Program through the replacement of customers' old, inefficient refrigerators with newer, more efficient, Energy Star qualified refrigerators.

Researchable Issues

- In special cases, a refrigerator with a bad seal may be replaced at the discretion of the auditor even if the meter wattage is below the program requirement. There were four such exceptions made in Ohio. In descending order, these units consumed 1304 kWh, 1243 kWh, 475 kWh, and 471 kWh. These installations, especially the latter two, should be reviewed by Duke Energy to assure that the minimum energy-saving-focused protocols are being followed by all auditors. However, in view that there were only two units with already low levels of consumption, this is not a serious issue for the program as a whole.

Methodology

Overview of the Evaluation Approach

This impact evaluation is based on engineering estimates using in-situ monitored data collected from customers' homes.

Study Methodology

Power meters were installed directly to the old refrigerators in the customers' homes. Impact estimations were calculated by subtracting the new refrigerator's energy consumption, provided by the manufacturer, from the energy consumed by the customer's existing refrigerator as measured by the power meter.

Data collection methods, sample sizes, and sampling methodology

Power meters were installed directly to the refrigerators in the customers' homes. Low income homes were targeted. There were 569 participants in Ohio. All participants' units were pre-metered.

Number of completes and sample disposition for each data collection effort

Data was collected from the power meters that were installed directly to the refrigerators in all 569 of the customers' homes.

Expected and achieved precision

Not applicable. A census of participants was used in the study.

Description of baseline assumptions, methods and data sources

The existing (replaced) refrigerator is the baseline. Baseline energy consumption is obtained from in-situ metering.

Description of measures and selection of methods by measure(s) or market(s)

The low income residential market was targeted. Six refrigerator models were available as replacements. They can be seen in the table below.

Brand	Model Number	Size (Cubic ft.)	Energy Usage (kWh)
Frigidaire	FFHT1513LW	15	355
Frigidaire	FFHT1826LW	18	383
Frigidaire	FFHT2126LW	21	408
Whirlpool	ET5WSEXVQ	15	354
Whirlpool	ET8WTEXVQ	18	388
Whirlpool	ET1FTEXVQ	21	416

Use of TRM values and explanation if TRM values not used

The TRM uses a dual baseline approach to calculate lifecycle savings. The remaining useful life of the existing unit is deemed to be eight years. As a result, savings for the first eight years calculated against the existing unit. Savings for the remaining nine years of the 17 year effective useful life of the new refrigerator are calculated against a new baseline unit. In this case we are deeming the effective useful life to be eight years.

Demand reduction was estimated as a function of energy savings as outlined in the following formula taken from the TRM:

$$\Delta kW = (\Delta kWh/8760) * TAF * LSAF$$

Where TAF (Temperature Adjustment Factor) is deemed at 1.3 and LSAF (Load Shape Adjustment Factor) is deemed at 1.074 for an existing unit and 1.18 for a new unit.

Threats to validity, sources of bias and how those were addressed

The baseline energy consumption is based on in-situ monitoring over a two-hour period. The monitoring period was selected to obtain a number of operating cycles. In-situ monitoring accounts for the location and condition of the refrigerator in terms of refrigerant charge, door gaskets, and so on. The doors remained closed during the test. The two hour test results were extrapolated to annual kWh usage. There is a potential engineering bias in the in-situ testing and extrapolation procedure, but this is expected to underestimate baseline use relative to a longer-period in-situ test that includes door openings, food loading, and so on. As a result, the actual achieved savings may be larger than the evaluated savings.

Snapback and Persistence

Both persistence and technical degradation are included in the calculation of a refrigerator's effective useful life shown in Appendix C: DSMore Table.

The theoretical additional energy and capacity used by customers that may occur from implementing an energy efficiency product, often called "snapback" if it occurs, by design will be captured in the impact evaluation through the billing analysis approach (due to be completed in 2012 after sufficient time has passed since the new refrigerator was installed).

The billing analysis approach will use actual energy use between the pre and post condition compared to what would occur without the program (control). All market or program effects conditions, including snapback, will be accounted for with this evaluation method. Further, there is little to no literature or snapback analysis within the evaluation industry that has been able to identify a snapback condition. The so-called snapback that has recently been referenced in the press has been the impact of normal electric demand growth that shows up in all customers as new products, services, and technologies are acquired and used. However, as noted above, any snapback that does occur would be captured in the evaluation design because of the use of pre and post billing analysis.

Evaluation Findings

Impact Evaluation

There were 569 refrigerators replaced through the Low Income Refrigerator Replacement program in Ohio from January 2010 to June 2011. All units were tested in the customers' homes using a power meter installed directly to the refrigerator. The meters collected energy consumption data for a minimum of two hours, allowing enough time for the unit to stabilize and cycle. Two hours has been shown to be sufficient time to determine a poorly operating unit that needs to be replaced.[2,3] Three sizes and two brands of replacement units were available: 15, 18, or 21 cubic foot Frigidaire or Whirlpool Energy Star top-freezer models. In Ohio, 90% of replacements were Frigidaire and 10% were Whirlpool. Of the 569 units replaced, 6% were 15 cubic feet, 45% were 18 cubic feet, and 49% were 21 cubic feet. A breakdown of the individual numbers can be seen in Table 2.

In general, the size of the customer's existing refrigerator and that of the unit chosen to replace it are as close as possible while still being restricted to the three available sizes. The average size of a replacement unit is 19.3 cubic feet while the average size of the replaced units was 18.92 cubic feet. A detailed comparison of refrigerator sizes and their replacements can be seen in Table 3.

Table 2. Replacement Unit Size and Brand Prevalence

Size of new unit	Count Frigidaire	Count Whirlpool	TOTAL
15 cubic feet	29	5	34
18 cubic feet	230	24	254
21 cubic feet	253	28	281
TOTAL	512	57	**569**

Table 3. Average Replaced Unit Size by Size and Brand of Replacement

Size of new unit	Frigidaire	Whirlpool	AVERAGE
15 cubic feet	15.14	15.00	15.12
18 cubic feet	17.80	18.00	17.81
21 cubic feet	20.37	21.82	20.52
AVERAGE	18.88	19.30	**18.99**

The power meter installed on the unit calculates the annual kWh consumption based on the watts used over the period of the test. If the refrigerator was calculated by the meter to consume over 1,315 kWh per year, it is eligible to be replaced at no charge to the customer. If a unit shows abnormally high peak wattage during the test, 325 watts or higher, this indicates that it was in defrost mode. In this case, the kWh per year must equal 1,565 kWh or more to be replaced. In special cases, a refrigerator with a bad seal may be replaced at the discretion of the auditor even

[2] Mapp, Jim. "Selection of High Usage Refrigerators and Freezers," Wisconsin Energy Bureau. April 16, 1998.
[3] Mapp, J., R Morgan, and K Schroder (2001). *Low-Income Refrigerator Replacement – Selection Criteria for High Usage Refrigerator Replacement,* August 21 – 24, 2001, Salt Lake City. International Energy Program Evaluation Conference.

if the meter wattage is below the program requirement. There were four such exceptions made in Ohio. In descending order, these units consumed 1304 kWh, 1243 kWh, 475 kWh, and 471 kWh. These installations, especially the latter two, should be reviewed by Duke Energy to assure that the replacement protocols, which focus on making sure all units provide savings, are being followed by all auditors.

Table 4. Annual kWh Consumed by Replaced Refrigerators

Size Replaced	Quantity	Average kWh/yr
12 cubic feet	1	1,418
13 cubic feet	1	2,133
14 cubic feet	24	1,626
15 cubic feet	29	1,503
16 cubic feet	19	1,560
17 cubic feet	23	1,594
18 cubic feet	225	1,562
19 cubic feet	16	1,500
20 cubic feet	28	1,701
21 cubic feet	141	1,547
22 cubic feet	36	1,634
23 cubic feet	1	1,572
24 cubic feet	7	1,627
25 cubic feet	12	1,733
26 cubic feet	6	1,768
TOTAL/AVG.	569	1,576

From Table 4, the average annual kWh consumed by replaced units was 1,576 kWh compared to the average annual kWh used by the replacement units of 394 kWh. This provides an average annual savings of 1,182 kWh per unit and results in a total savings of 672,671kWh across the entire program in Ohio. Savings per unit ranged from a minimum of 55 kWh to a maximum of 3,110 kWh. The manufacturer provided energy guides associated with the replacement units can be seen in Appendix B: Energy Guides. A breakdown of the energy savings by unit size and brand can be seen in Table 5. Per-unit savings can be found in Table 6. Program kW reduction can be seem in Table 7 and Table 8.

Table 5. Total Program kWh Savings by Unit Size and Brand

New Refrigerator Size	Frigidaire	Whirlpool	TOTAL
15 cubic feet	32,836	5,465	38,301
18 cubic feet	278,482	28,329	306,811
21 cubic feet	294,481	33,078	327,559
TOTAL	605,799	66,872	**672,671**

Table 6. Per-Unit kWh Savings by Unit Size and Brand

New Refrigerator Size	Frigidaire	Whirlpool	TOTAL
15 cubic feet	1,132	1,093	1,127
18 cubic feet	1,211	1,180	1,208
21 cubic feet	1,164	1,181	1,166
Savings Per Unit	1,183	1,173	**1,182**

Table 7. Total Program kW Reduction by Unit Size and Brand

New Refrigerator Size	Frigidaire	Whirlpool	TOTAL
15 cubic feet	5.1	0.8	6
18 cubic feet	43.0	4.4	47
21 cubic feet	45.3	5.1	50
TOTAL	93	10	**104**

Table 8. Per-Unit kW Reduction by Unit Size and Brand

New Refrigerator Size	Frigidaire	Whirlpool	TOTAL
15 cubic feet	0.175	0.169	0.174
18 cubic feet	0.187	0.182	0.186
21 cubic feet	0.179	0.182	0.179
Reduction per unit	0.182	0.181	**0.182**

Appendix A: Required Savings Tables

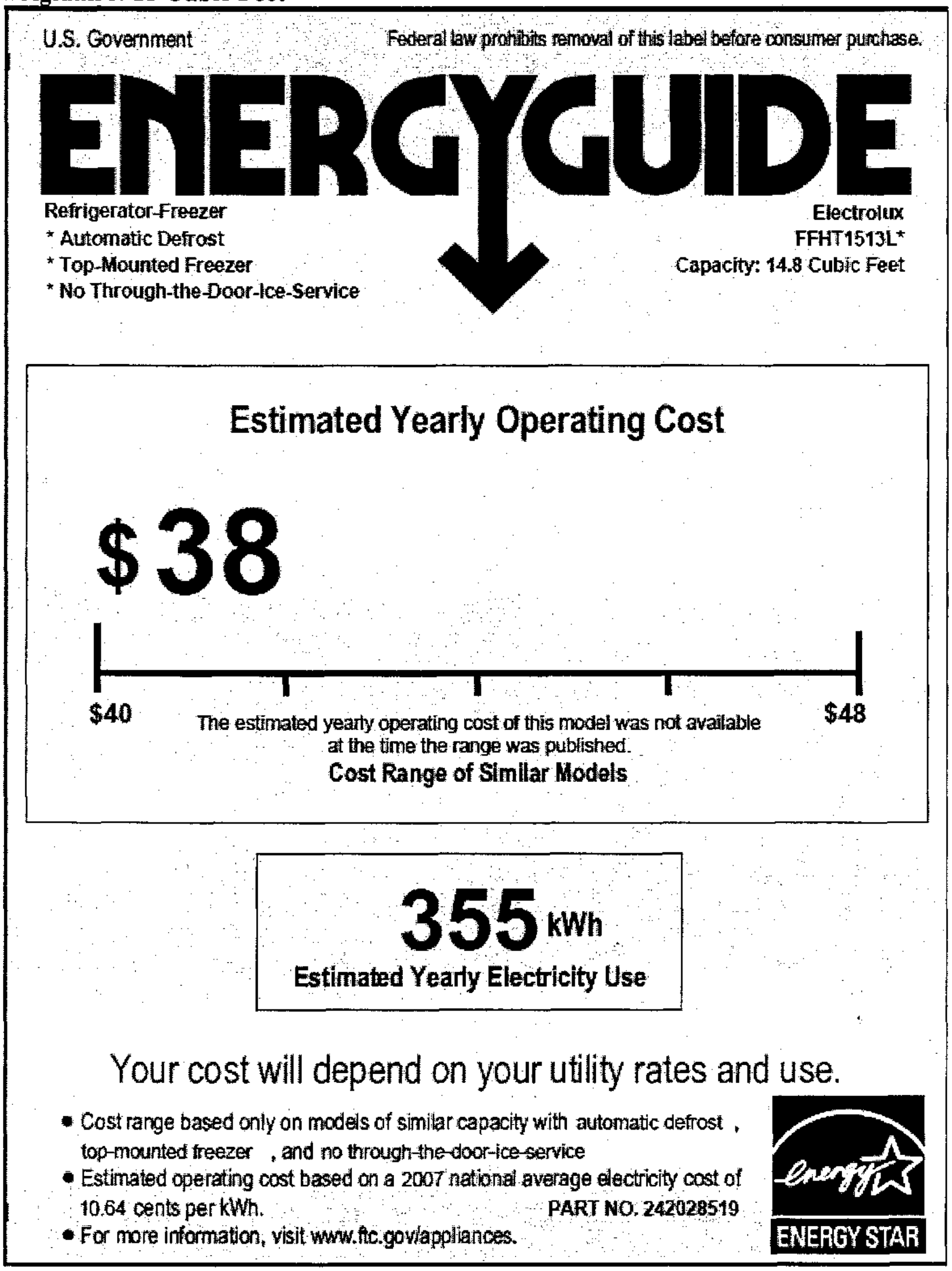
The required table showing measure-level participation counts and savings for each program is below.

Measure	Participation Count	Verified Per unit kWh impact	Gross Verified kWh Impact	Gross Verified kW Savings	Verified Per unit kW Savings
Frigidaire: 15 cubic feet	29	1,132	32,836	5.1	0.175
Frigidaire: 18 cubic feet	230	1,211	278,482	43.0	0.187
Frigidaire: 21 cubic feet	253	1,164	294,481	45.3	0.179
Whirlpool: 15 cubic feet	5	1,093	5,465	0.8	0.169
Whirlpool: 18 cubic feet	24	1,180	28,329	4.4	0.182
Whirlpool: 21 cubic feet	28	1,181	33,078	5.1	0.182
TOTAL	**569**	**1,182** [1]	**672,671**	**104**	**0.182** [2]

[1]total gross kwh impact divided by 569 participants

Appendix B: Energy Guides

Frigidaire: 15 Cubic Feet



U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
* Automatic Defrost
* Top-Mounted Freezer
* No Through-the-Door-Ice-Service

Electrolux
FFHT1513L*
Capacity: 14.8 Cubic Feet

Estimated Yearly Operating Cost

$38

$40 $48

The estimated yearly operating cost of this model was not available at the time the range was published.

Cost Range of Similar Models

355 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost , top-mounted freezer , and no through-the-door-ice-service
- Estimated operating cost based on a 2007 national average electricity cost of 10.64 cents per kWh. PART NO. 242028519
- For more information, visit www.ftc.gov/appliances.

ENERGY STAR

Frigidaire: 18 Cubic Feet

Case No. 13-753-EL-RDR
Attachment AJO 1

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
* Automatic Defrost
* Top-Mounted Freezer
* No Through-the-Door-Ice-Service

Electrolux
FFHT1826L*
Capacity: 18.2 Cubic Feet

Estimated Yearly Operating Cost

$41

$42 $52

The estimated yearly operating cost of this model was not available at the time the range was published.

Cost Range of Similar Models

383 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost , top-mounted freezer , and no through-the-door-ice-service
- Estimated operating cost based on a 2007 national average electricity cost of 10.64 cents per kWh. PART NO. 242028537
- For more information, visit www.ftc.gov/appliances.

ENERGY STAR

Frigidaire: 21 Cubic Feet

U.S. Government

Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
* Automatic Defrost
* Top-Mounted Freezer
* No Through-the-Door-Ice-Service

Electrolux
FFHT2126L*
Capacity: 20.5 Cubic Feet

Estimated Yearly Operating Cost

$43

$44 — $56

The estimated yearly operating cost of this model was not available at the time the range was published.

Cost Range of Similar Models

408 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost , top-mounted freezer , and no through-the-door-ice-service
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh.   PART NO. 242028524
- For more information, visit www.ftc.gov/appliances.

ENERGY STAR

Whirlpool: 15 Cubic Feet

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
•Automatic Defrost
•Top Mounted Freezer
•Without Through-the-Door-Ice Service

Whirlpool Corporation
Model(s): ET5WSE*V*0*
Capacity: 14.6Cubic Feet

Estimated Yearly Operating Cost

$38

$40 $48

Cost Range of Similar Models

The estimated yearly operating cost of this model was not available at the time the range was published.

354 kWh
Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost, Top mounted freezer, and without through the door ice service.
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh.
- For more information, visit www.ftc.gov/appliances. (P/N W10185762A)

ENERGY STAR

Frigidaire: 18 Cubic Feet

U.S. Government

Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
- Automatic Defrost
- Top-Mounted Freezer
- Without Through-The-Door-Ice Service

Whirlpool Corporation
Model: ET8WTE*V*0*
Capacity: 18.3 Cubic Feet

Estimated Yearly Operating Cost

$41

$42 $52

Cost Range of Similar Models

The estimated yearly operating cost of this model was not available at the time the range was published.

388 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost, top-mounted freezer, and without through-the-door ice.
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh.
- For more information, visit www.ftc.gov/appliances. (P/N W10178118 Rev. A)

ENERGY STAR

Frigidaire: 21 Cubic Feet

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer
- Automatic Defrost
- Top-Mounted Freezer
- Without Through-The-Door-Ice

Whirlpool Corporation
Model(s): ET1CHE*V*0*,
ET1FTE*V*0*
Capacity: 21.0 Cubic Feet

Estimated Yearly Operating Cost

$44

$44 $56

Cost Range of Similar Models

416 kWh
Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

- Cost range based only on models of similar capacity with automatic defrost, top-mounted freezer, and without through-the-door ice.
- Estimated operating cost based on a 2007 national average electricity cost of 10.65 cents per kWh.
- For more information, visit www.ftc.gov/appliances. (P/N W10206565 Rev. A)

ENERGY STAR

Appendix C: DSMore Table

Impacts ⇨ / Technology ⇩	Product code	State	EM&V gross savings (kWh/unit)	EM&V gross kW (customer peak/unit)	EM&V gross kW (coincident peak/unit)	Unit of measure	Combined spillover less freeridership adjustment	EM&V net savings (kWh/unit)	EM&V net kW (customer peak/unit)	EM&V net kW (coincident peak/unit)	EM&V load shape (yes/no)	EUL (whole number)
Refrigerator Replacement		OH	1,182	0.182	0.182	Refrigerator	0.00%	1,182	0.182	0.182	no	8
Program wide			1,182	0.182	0.182			1,182	0.182	0.182		

Energy Impact Evaluation of the Personalized Energy Report (PER)® Program in Ohio

Final Report

Prepared for
Duke Energy
139 East Fourth Street
Cincinnati, OH 45201

December 22, 2011

Submitted by:

Nick Hall and Brian Evans

TecMarket Works
165 West Netherwood Road
Oregon, Wisconsin 53575
(608) 835-8855

Subcontractors:
Pete Jacobs
BuildingMetrics, Inc

Michael Ozog
Integral Analytics

Table of Contents

Executive Summary

Key Findings and Recommendations

This section presents the key findings and recommendations identified through this impact evaluation[1]. Table 1 presents the estimated overall impacts of both the Personalized Energy Report (PER)® and the online version (OHEC) for Ohio. Note that Kentucky is not included in these figures. Kentucky is included in the engineering estimates, but not in the billing analysis.

Table 1. Estimated Overall Impacts

	Gross Savings	Net Savings
Per Participant Annual Savings		
kW	0.0291	0.0223
kWh	332	253
Therms	-0.031	-0.023

The kWh impacts in this table are from the statistical analysis of participants' monthly electricity billing data. Since the billing data cannot provide estimates of either demand (kW) or gas (therms) savings as well as the net to gross ratio, those impact estimates were based upon the engineering analysis impacts, adjusted by the ratio of the overall kWh savings between the billing analysis and the engineering analysis (127%). The engineering analysis also provides insight into impacts by measures (the billing analysis only produces an overall number). Therefore, while the overall result is driven by the billing analysis, an engineering analysis is required as well, so both approaches will be discussed in the report.

Significant Impact Evaluation Findings

- Both the mailed (PER) and online (OHEC) aspects of the program result in statistically significant savings.
- The results from the PER provide higher savings than the OHEC, though the difference is not statistically significant.
- The billing data results for the both the PER and OHEC components are larger than the engineering estimate, which may be due to differences between the survey sample and the population on recommended measure uptake.
- CFLs make up 98% of total program savings.

[1] The PER® Process Evaluation was completed December 2, 2010 for Ohio and Kentucky. References are made throughout this report to this Process Evaluation. In addition, impacts based on the engineering analysis for both states are referenced in this report.

- On average, the 13-watt CFL replaced a 60-watt load; the 20-watt CFL replaced a 77-watt load.

- Kentucky participants reported lower installation rates when the PER survey was completed by mail. However, the evaluation team is not able to find any reason for this difference.

Free Ridership and Spillover

Free ridership was calculated for CFLs distributed to customers who filled out a Personalized Energy Report survey. The level of free ridership was determined by using the responses to two questions in the survey (found in Appendix C: Ohio Participant Survey Instrument). Respondents were asked if they had any CFLs installed in their home prior to completing the Personalized Energy Report survey, and, if so, how many. The amount of pre-installed CFLs determined the level of free ridership applied to energy savings according to Table 2 below.

Table 2. Free Ridership Factors for Energy Efficiency Kit CFLs

Did you have any CFLs installed before you completed your PER survey?	If yes, how many?	% Free Ridership
No	n/a	0%
Yes	1 to 3	0%
	4 to 6	25%
	7 to 9	50%
	10 to 12	75%
	More than 12	100%

The percentages of survey respondents in each range of free ridership for pre-installed CFLs are presented in Figure 1 below. These percentages multiplied by the free ridership levels are then presented in Table 3 to arrive at the unadjusted free ridership for CFLs in the Personalized Energy Report programs. These numbers amount to free ridership of 24.4 percent in Ohio and 31.1 percent in Kentucky.

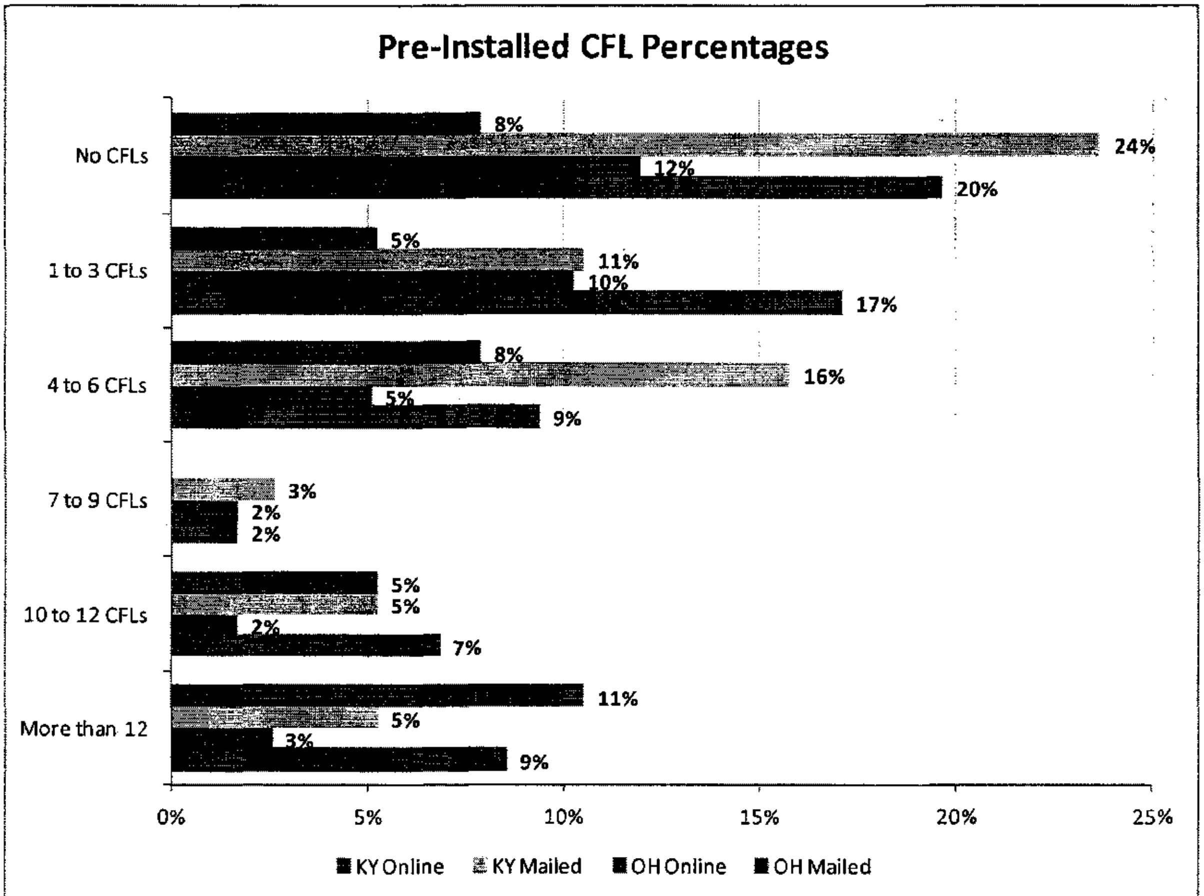


Figure 1. Percentage of Respondents by number of CFLs pre-installed

Table 3. Free Ridership in Ohio and Kentucky

State	Type	Pre-installed CFL range	Percentage in range	Free ridership Level	Free ridership
OH	Mailed	0 to 3	36%	0	0%
		4 to 6	9%	25	2.3%
		7 to 9	2%	50	1%
		10 to 12	7%	75	5.3%
		More than 12	9%	100	9%
	Online	0 to 3	22%	0	0%
		4 to 6	5%	25	1.3%
		7 to 9	2%	50	1%
		10 to 12	2%	75	1.5%
		More than 12	3%	100	3%
Sum of OH Free Ridership					**24.4%**
KY	Mailed	0 to 3	34%	0	0%
		4 to 6	16%	25	4%
		7 to 9	3%	50	1.5%
		10 to 12	5%	75	3.8%
		More than 12	5%	100	5%
	Online	0 to 3	13%	0	0%

		4 to 6	8%	25	2%
		7 to 9	0%	50	0%
		10 to 12	5%	75	3.8%
		More than 12	11%	100	11%
Sum of KY Free Ridership					**31.1%**

Impact Estimates for Personalized Energy Report Audit Recommendations
The participants of the Personalized Energy Report Program each received a customized report with specific recommendations for improvements to their home that would increase their home's energy efficiency. In this report, we present the recommendations as they were reported to us by the random sample of 154 participants from Ohio and Kentucky contacted during the telephone survey. We first asked them what, if any, improvements they had made to their home. We then ask if this was a recommendation that was in the Personalized Energy Report report. If they said that yes, (it was in the Personalized Energy Report report) we ask how influential the recommendation in the PER report was to their decision to install the item on a scale of 1 to 10.

Savings were calculated using engineering algorithms that can be found in Appendix E: Impact Algorithms. Self-selection bias and false response bias are then factored in to calculate the final estimated net impact for engineering estimates only.

Program Impact Recommendations

- As part of ongoing research related to program marketing effectiveness, Duke Energy has been exploring whether some programs are gateways that potentiate other offers. Research on follow on offer uptake for PER indicates that customers that first participate in PER are approximately twice as likely to respond to an offer to participate in Power Manager® as compared to those that did not first participate in PER. The reverse correlation does appear strong. This suggests that customers participating in PER should be offered additional opportunities to participate. Perhaps especially in simple offers like Power Manager. Duke Energy's research on this type of offer progression focuses on the 2009 period, as eventually the universe of participants that *first* received PER and *then* a Power Manager offer is reduced, as the total number of Power Manager offers mailed increases over time. It may be that the ability to migrate customers through programming experiences, e.g. PER to Power Manager could drive additional value for Duke Energy, by keeping customers engaged and continuing to offer relevant programming. It may be that engagement programming like PER drives additional dividends beyond the measurement year. Here for example follow on Demand Response program offer uptake was described. In light of the need to find new ways to get more participation to meet ramping goals, Duke Energy should consider exploring whether this gateway effect exists for other programming types.

Introduction and Purpose of Study

Summary Overview

This document presents the evaluation report for Duke Energy's Personalized Energy Report (PER) Program and the Mass Market Energy Assessments Online Program (OHEC) as it was administered in Ohio and Kentucky.

Summary of the Evaluation

These customers received the PER offer by mail, and either returned the paper PER survey, or completed the OHEC survey online as directed in the cover letter. An impact analysis was performed for the CFLs and for the measures that were installed as a result of the Personalized Energy Report and OHEC's recommendations. The impacts are based on engineering analysis of the impacts associated with the self-reported measure installs identified through a participant survey. To increase the reliability of the study findings, additional confirmative analysis was performed using a billing analysis comparing the pre and post program energy consumption levels of program participants.

This report is structured to provide program energy savings impact estimations per measure via the engineering analysis, and program savings based on the billing analysis results. The engineering impact tables reporting total savings are based on the savings identified from 154 surveyed participants extrapolated to the program's total participants. The study includes participants from both Ohio and Kentucky from August 2009 through August of 2010 (n=20,845). The billing analysis impact tables are based on Ohio participants only between August 2009 and March 2011 (n=14,719).

	OH	KY
Completed Online Survey	3,095	355
Completed Mail Survey	8,921	8,474

This impact evaluation of the measures with the kits is based on surveys conducted with customers who participated in the Personalized Energy Report program and who have received the kits mailed by the program. The impact of the Personalized Energy Report recommendations that were implemented is based on survey responses of the actions they have taken that, according to the customer, were at least in part caused by the PER report. The impact analysis conducted for this study was systematically adjusted downward to account for self-selection bias and potential false response bias sometimes associated with survey research of socially acceptable behaviors documented via telephone surveys. As a result, the evaluation consultants consider this study a reasonable estimate of program-induced savings.

The evaluation was conducted by TecMarket Works and BuildingMetrics with assistance from Integral Analytics. The survey instruments were developed by TecMarket Works and BuildingMetrics. The survey was administered by TecMarket Works. Integral Analytics performed the billing analysis. BuildingMetrics developed the engineering algorithms to estimate energy impacts based on the survey responses.

Researchable Issues

In addition to the objectives noted above, there were a number of researchable issues for this evaluation. These were:

1. To determine the actual energy savings achieved from the program.

2. To determine if there is any statistically significant difference between participants who used the written survey and those that used the online version.

Description of Program

The Personalized Energy Report (PER) is a customized energy report offered to Duke Energy's residential customers to help them identify ways to save energy in their homes. The Personalized Energy Report is offered both via mail and via Duke Energy's website. The online energy report is called the Online Home Energy Calculator (OHEC). The online version is identical in content to the mailed Personalized Energy Report and has the benefit of being accessible to Duke Energy's customer service representatives. The mailed Personalized Energy Report includes a cover letter that informs customers of the availability of the OHEC if they wish to respond online. Customers channeled from the Personalized Energy Report to OHEC are given a promotion code to use if they wish to respond online.

Through both the mailed version and online versions of the program, customers complete a survey about their home and energy use, and in return receive the customized energy report. As an incentive for participating in the PER and OHEC programs, customers are also offered a free package of 6 CFLs. The PER/OHEC participation survey can be found in Appendix F: Personalized Energy Report/OHEC Survey.

Program Participation

Engineering Estimates

The results from 154 surveyed participants are extrapolated to a total of 20,845 program participants from Ohio and Kentucky between August 2009 and August 2010.

Billing Analysis

The results from the billing analysis are the result of the entire population of participants with usable billing data in Ohio, North and South Carolina, and Kentucky.[2] However, only Ohio customers are represented in the billing analysis savings tables in this report.

[2] Including all the data from all the states into a regression equation increases the number of data points, which in turn makes increases the efficiency of the estimated savings as well as the statistical precision of all estimated coefficients.

Methodology

Overview of the Evaluation Approach

This impact evaluation has two components: billing analysis and engineering estimates.

Study Methodology

Engineering Estimates

A combination of engineering algorithms and building energy simulations were used. The engineering algorithms were used to estimate savings from lighting measures. Building energy simulations models of prototypical residential buildings were used to develop unit energy and demand savings estimates for building shell and HVAC measures. These unit energy savings values were applied to customers in the engineering analysis sample.

Billing Analysis

Program tracking data was used to pull billing data from all participants in all states. The billing data was combined with information on participation date and whether the customer completed the mail or online version. This was in turn linked to weather data (temperature) to form the dataset used in the regression analysis.

Data collection methods, sample sizes, and sampling methodology

Engineering Estimates

TecMarket Works and Building Metrics developed a customer survey for the Personalized Energy Report (PER) Program participants to be implemented after they have had time to install at least some of the CFLs and to follow the recommendations offered. The survey asked the customer for information specific to each of the measures included in the Energy Efficiency Starter Kit.

A telephone survey was conducted with a random sample of 154 Personalized Energy Report program participants. These participants were surveyed by TecMarket Works. To help focus the survey, the questions asked were based on key results of an earlier study employing an identical approach for similar measures. The experience from the previous study for the Personalized Energy Report program allowed this study to use those questions that were most informative to the energy impact estimation process and eliminate those questions that were found to have little impact on the results of the energy savings calculations. This allowed the Personalized Energy Report survey to be shorter and more focused, yet still provide the information needed to estimate savings. The surveys can be found in Appendix C: Ohio Participant Survey Instrument and Appendix D: Kentucky Participant Survey Instrument.

	Ohio	Kentucky
Participants		
Online	3,095	355
Mail	8,921	8,474
Surveyed		
Online	76	23
Mail	40	15

Billing Analysis

The results from the billing analysis represent the entire population of participants with usable billing data.

Number of completes and sample disposition for each data collection effort

Engineering Estimates

Surveys were conducted with a random sample of participants. Data were collected from a total of 154 program participants. Energy savings achieved as a result of self-installations were attributed to the program if it was indicated that the improvement was suggested by the home energy report provided to the customer through the program.

Billing Analysis

Program tracking data was used to pull billing data from all participants in all states. The billing data was combined with information on participation date and whether the customer completed the mail or online version. This was in turn linked to weather data (temperature) to form the dataset used in the regression analysis.

Expected and achieved precision

Engineering Estimates

Engineering Estimates rely on participant survey responses. Sampling procedures for the participant survey had an expected and achieved precision of 90% ± 10%.

Billing Analysis

All savings estimates from the billing analysis were statistically significant at the 95% confidence level.

Description of baseline assumptions, methods and data sources

Engineering Estimates

Baseline assumptions for CFLs were taken from the Draft Ohio TRM. Impact analysis for the recommendations is based on DOE-2.2 simulations of a set of prototypical residential buildings. Building shell measure baselines were selected based on typical construction practices by building vintage, using data from the US EIA Residential Energy Consumption Survey (RECS). HVAC baselines assumed normal end-of life replacement of the HVAC system, and used Federal appliance standards (NAECA) to establish the baseline efficiency.

Description of measures and selection of methods by measure(s) or market(s)

Engineering Estimates

The measures and methods are shown below. All customers are in the residential market.

Measure	Method
CFLs	Draft Ohio TRM
Double Pane Windows	DOE-2.2 simulation
Energy Star Doors	DOE-2.2 simulation

Energy Star Dishwasher	DOE-2.2 simulation
Energy Star Clothes Washer	DOE-2.2 simulation
Energy Star Freezer	DOE-2.2 simulation

Billing Analysis

The billing analysis computed the overall savings associated with the program. There was no measure-level investigation.

Use of TRM values and explanation if TRM values not used

Engineering Estimates

The Draft Ohio TRM was used for CFLs, but not for recommendations. Savings calculations for recommendations often require detailed information about customers' homes that would not be collected through a typical phone survey. Without this information, accurate savings calculations using engineering algorithms are impossible. Instead, DOE-2.2 simulations were performed, adding the indicated improvement to a set of prototypical residential buildings, and attributing equal savings to each incidence.

Billing Analysis

The billing analysis provides an estimate of the savings that were actually achieved by participating households, thus there was no need to use Draft Ohio TRM values.

Threats to validity, sources of bias and how those were addressed

Engineering Estimates

Customers were sampled at random for the survey and subsequent engineering analysis. Measure adoptions were self-reported by the customer. There is a potential for self response bias, but the customer has no vested interest in the reported measure adoptions, so this bias is expected to be minimal. There is a potential for bias in the engineering algorithms, which was minimized through the use of building energy simulation models, which are considered to be state of the art for building shell and HVAC system analysis.

Billing Analysis

The specification of the model used in the billing analysis was designed specifically to avoid the potential of omitted variable bias[3] by including monthly variables that capture any non-program effects that affect energy usage. The model did not correct for self-selection bias because there is no reason to as long as the program remains voluntary.

Snapback and Persistence

The theoretical additional energy and capacity used by customers that may occur from implementing an energy efficiency product, often called "snapback" if it occurs, is by design already captured in the impact evaluation through the billing analysis approach. The billing analysis approach uses actual energy use between the pre and post condition compared to what would occur without the program (control). All market or program effects conditions, including

[3] See Appendix I: Omitted Variable Bias Memo for information on omitted variable bias

snapback, are already accounted for in this evaluation method. Further, there is little to no literature or snapback analysis within the evaluation industry that has been able to identify a snapback condition. The so-called snapback that has recently been referenced in the press has been the impact of normal electric demand growth that shows up in all customers as new products, services, and technologies are acquired and used. However, as noted above, any snapback that does occur would be captured in the evaluation design because of the use of pre and post billing analysis.

The billing data analysis, by using usage data from customers who participated as long as over two years ago, indicates that the impacts of the PER program are likely to persist for at least two years. However, the evaluation did not address how long these savings are likely to persist over time because the time span of the available data was not sufficient to address this issue. Both persistence and technical degradation are included in the calculation of each measure's effective useful life shown in Appendix B: DSMore Table.

Engineering Estimates

The Personalized Energy Report provides a six pack of CFLs and a list of energy-saving recommendations, when applicable, to each participant. Phone surveys, which can be found in Appendix C: Ohio Participant Survey Instrument and Appendix D: Kentucky Participant Survey Instrument, were conducted with a random sample of participants that completed the Personalized Energy Report survey either online or through the mail and received the six pack of CFLs. The results of this survey with the associated energy impact estimations and recommendations are presented below. Survey responses were received from 154 of the 20,845 participants from August 2009 to August 2010, 115 participants from Ohio, and 39 from Kentucky. The responses and estimated energy savings of these 154respondents have been extrapolated to the full population of 20,845 participants for the purpose of calculating overall savings estimates. All algorithms used in the calculation of the savings estimates herein can be found in Appendix E: Impact Algorithms. A summary can be seen in Table 10.

Energy Savings: Engineering Estimates

The CFLs provided through the Personalized Energy Report (PER) program, when installed and used, provide energy savings to the participants and to Duke Energy. For the Ohio and Kentucky participants, the installation of the CFLs supplied in the kit to the 20,845 participants provides an estimated net annual energy savings of -3,110 therms, 2,080,770 kWh and reduces peak load by 176.9 kW.

Table 4. Program Impact Summary

	Gross Savings	Net Savings
ANNUAL SAVINGS FOR CFL INSTALLATIONS		
kW	411.7	176.9
kWh	4,843,243	2,080,770
Therms	-7,239	-3,110
ANNUAL SAVINGS FOR RECOMMENDATION INSTALLATIONS		
kW	20.6	14.4
kWh	96,726	67,805
Therms	7,552	5,294
TOTAL ANNUAL SAVINGS FOR CFLs AND RECOMMENDATIONS		
kW	432.3	191.3
kWh	4,939,969	2,148,575
Therms	313	2,184
LIFECYCLE SAVINGS FOR CFL INSTALLATIONS		
kWh		10,403,852
Therms		-15,551
LIFECYCLE SAVINGS FOR RECOMMENDATION INSTALLATIONS		
kWh		1,188,792

Therms		99,075
TOTAL LIFECYCLE SAVINGS FOR CFLs AND RECOMMENDATIONS		
kWh		11,592,644
Therms		83,524

On a per-participant basis, this equals first year annual gross energy savings of 232 kWh and .02 kW, with a net savings of 99.8 kWh and .008 kW for the CFLs. The total first year net energy savings for the CFLs and the recommendations are 191.3 kW, 2,148,575 kWh and 2,184 therms. The total net lifetime savings for the Personalized Energy Report is 556 kWh and 4.01 therms per participant.

The impact estimates are based on survey responses of what actions were taken and the use conditions associated with these actions for the weather zone in which the participants reside. The energy savings estimates for the recommended actions taken are based on DOE-2 simulations of measure impact in residential buildings. This type of modeling and assessment approach is an industry standard and can be expected to provide accurate estimates of program impact that are consistent with the accuracy of the survey information provided by the program participants.

Energy Savings Distributions: Engineering Estimates

The tables below present a summary of the total CFL savings from the program participants. Table 5 presents the gross energy savings based on the randomly sampled participant survey responses extrapolated to the program population of 20,845. Table 6 presents the expected savings after the false-response and self-selection biases are factored into the calculations. Table 7 presents the net savings, which factors in the estimated program free ridership.

Table 5. First Year Gross Energy Savings of CFLs, All Program Participants (n=20,845)

State and Wattage	kW	kWh	Therms
OH 13-watt CFL	126.2	1,589,913	-2,376
OH 20-watt CFL	138.5	1,517,323	-2,268
OH Total	**264.7**	**3,107,236**	**-4,644**
KY 13-watt CFL	76.6	964,165	-1,441
KY 20-watt CFL	70.4	771,843	-1,154
KY Total	**147.0**	**1,736,007**	**-2,595**

Table 6. First Year Energy Savings of CFLs, Net of False-Response and Self-Reporting Bias, All Program Participants (n=20,845)

Kit Measures	kW	kWh	Therms
OH 13-watt CFL	73.5	925058.87	-1382.71
OH 20-watt CFL	80.6	882824.04	-1319.58
OH Total	**154.0**	**1,807,883**	**-2,702**
KY 13-watt CFL	44.5	560979.88	-838.51
KY 20-watt CFL	41.0	449081.23	-671.26
KY Total	**85.5**	**1,010,061**	**-1,510**

Table 7. First Year Net Energy Savings of CFLs, Net of False-Response, Self-Reporting Bias and Free ridership, All Program Participants (n=20,845)

Kit Measures	kW	kWh	Therms
OH 13-watt CFL	56.3	708595.09	-1059.16
OH 20-watt CFL	61.7	676243.22	-1010.80
OH Total	**118.0**	**1,384,838**	**-2,070**
KY 13-watt CFL	30.7	386515.14	-577.74
KY 20-watt CFL	28.2	309416.97	-462.50
KY Total	**58.9**	**695,932**	**-1,040**

The tables below present a summary of the total recommendation savings from the program participants. Table 8 presents the gross energy savings based on the randomly sampled participant survey responses extrapolated to the program population in both Ohio and Kentucky combined of 20,845. Table 9 presents the net savings, which factors in the estimated program self-reporting bias.

Table 8. First Year Gross Energy Savings of Recommendations, All Program Participants (n=20,845)

Recommendation	Total Times Recommended	ΔkW	ΔkWh	Δtherms
Double Pane Windows	130	15.40	48,320	4,024
Energy Star Doors	130	5.21	21,887	2,449
Energy Star Dishwasher	130	0.00	4,612	294
Energy Star Clothes Washer	130	0.00	12,683	784
Energy Star Freezer	130	0.00	9,224	0
TOTAL	**650**	**20.61**	**96,726**	**7,552**

Table 9. First Year Net Energy Savings of Recommendations, Net of Self-Reporting Bias, All Program Participants (n=20,845)

Recommendation	Total Times Recommended	ΔkW	ΔkWh	Δtherms
Double Pane Windows	130	10.8	33,872	2,821
Energy Star Doors	130	3.7	15,343	1,717
Energy Star Dishwasher	130	0.0	3,233	206
Energy Star Clothes Washer	130	0.0	8,891	550
Energy Star Freezer	130	0.0	6,466	0
TOTAL	**650**	**14.4**	**67,805**	**5,294**

Table 10. Total Program Savings by Measure

Measure	kW	kWh	therms
CFLs	411.68	4,843,243	-7,239
Double Pane Windows	15.40	48,320	4,024
Energy Star Doors	5.21	21,887	2,449
Energy Star Dishwasher	0.00	4,612	294
Energy Star Clothes Washer	0.00	12,683	784
Energy Star Freezer	0.00	9,224	0
TOTALS	**432.28**	**4,939,969**	**313**

Personalized Energy Report CFL Impacts

The phone surveys asked the respondents to state whether or not they used each CFL in the six pack and, if not, whether or not they plan to use them in the future. Those that indicated that they plan to use them are reported separately and should be interpreted as future potential savings rather than achieved savings. A summary of both achieved and potential savings from the CFLs can be seen in Table 11. A total of 4,843,243 kWh was achieved along with an additional 2,968,275 kWh in potential savings. The savings from CFL installations is responsible for 98% of the total program kWh savings.

Table 11. Total Achieved and Planned Savings from CFLs by State

	Ohio			Kentucky		
	ΔkW	ΔkWh	Δtherms	ΔkW	ΔkWh	Δtherms
Installed 13-Watt	126.24	1,589,913	-2,376	76.56	964,165	-1,441
Installed 20-Watt	138.45	1,517,323	-2,268	70.43	771,843	-1,154
Total Achieved	**264.69**	**3,107,236**	**-4,644**	**146.98**	**1,736,007**	**-2,595**
Potential 13-Watt	41.90	527,657	-789	53.47	673,385	-1,007
Potential 20-Watt	73.22	802,430	-1,199	88.04	964,803	-1,442
Total Potential	**115.12**	**1,330,087**	**-1,988**	**141.50**	**1,638,188**	**-2,449**

The CFL six packs included three 13-watt CFLs and three 20-watt CFLs. As presented in Table 12, the survey revealed that in Ohio, a total of 229 of the13-watt and 208 of the 20-watt CFLs were installed, which equates to 22,931 of the13-watt and 20,828 of the 20-watt CFLs total, or about 61% of the amount distributed. Survey participants indicated that they plan to install an additional 76 of the13-watt and 110 of the 20-watt CFLs, which equates to 7,610 of the 13-watt and 11,015 of the 20-watt CFLs total. If all of these potential installs are actualized, 87% of the total amount distributed would be in use. In Kentucky, the survey showed that a total of 63 of the 13-watt and 48 of the 20-watt CFLs were installed, which equates to 13,906 of the 13-watt and 10,595 of the 20-watt CFLs total, or about 46% of the amount distributed. Survey participants indicated that they plan to install an additional 44 of the 13-watt and 60 of the 20-watt CFLs, which equates to 9,712 of the 13-watt and 13,244 of the 20-watt CFLs total. If all of these potential installs are actualized, 90% of the total amount distributed would be in use.

Table 12. Total number of CFLs installed by state

	Ohio			Kentucky		
	Survey	%	Total	Survey	%	Total
Installed 13-Watt	229	64%	**22,931**	63	53%	**13,906**
Installed 20-Watt	208	58%	**20,828**	48	40%	**10,595**
Potential 13-Watt	76	21%	**7,610**	44	37%	**9,712**
Potential 20-Watt	110	31%	**11,015**	60	50%	**13,244**

In the calculation of the installation rates from the surveys, the responses from the online and by-mail participants were mixed together. However, there were some notable behavior differences between the two survey groups. Figure 1 shows the differences in installation rates between the two survey populations in both Ohio and Kentucky. Interestingly, Ohio participants that completed the survey by mail indicated slightly higher installation rates while Kentucky participants exhibited the exact opposite, a sharp decrease in installation rates when the survey was sent in by mail.

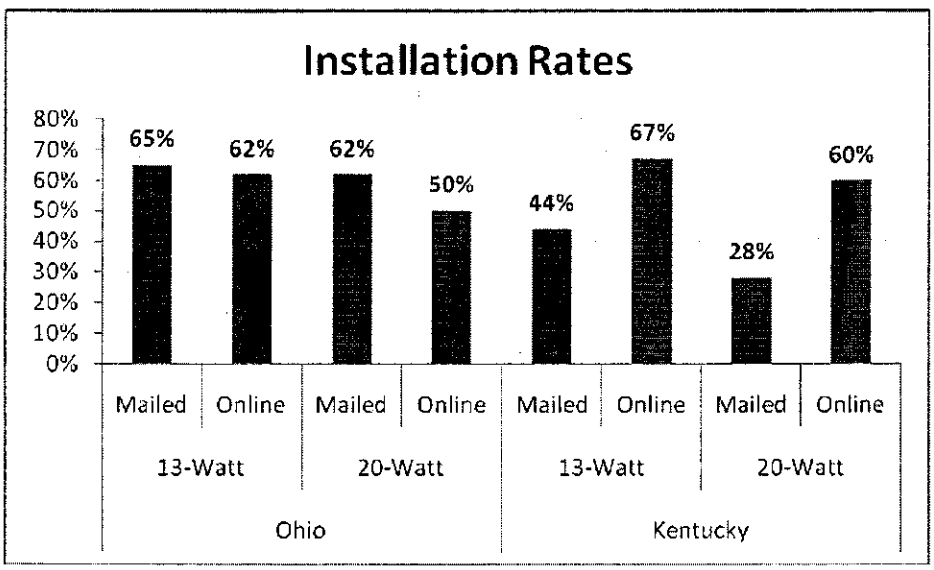


Figure 1. CFL Installation Rates Survey Group and State

From the survey, it was determined that, on average, participants use the 13-watt CFL to replace a 60-watt incandescent bulb and the 20-watt CFL to replace a 77-watt incandescent bulb. The savings from installing the CFLs are presented in Table 11. Using only the savings estimates based on those that said that they took the action, and extrapolating these estimates to the full population of program participants, the Personalized Energy Report participants reduced their annual kWh consumption by 4,843,243 kWh, or 321 kWh per person per year. Of the total savings, 2,554,077 kWh (53%) is from 13-watt CFLs and the other 2,289,166 kWh (47%) comes from 20-watt CFLs. This results in per-installation savings achievements of 69.34 kWh and 72.85 kWh respectively. Mean values for all participants in Ohio and Kentucky combined are shown in Table 13. The slight increase in therm consumption occurs because incandescent bulbs burn much hotter than CFLs and consequently, homeowners must use a little bit more gas heating their homes in the winter.

Table 13. Mean Estimates per Install from Participants Installing CFLs

	kW	kWh	therms
Installed 13-Watt	0.0055	69.34	-0.1036
Installed 20-Watt	0.0066	72.85	-0.1089

Just as with the installation rate calculations, the replaced wattage and operating hour calculations were carried out on aggregate data across both Ohio and Kentucky. State dependent calculations were not performed. Figure 2 and Figure 3 show that survey participants that submit their survey by mail tend to use CFLs to replace higher wattage incandescent bulbs, but also that they have their lights turned on less often.

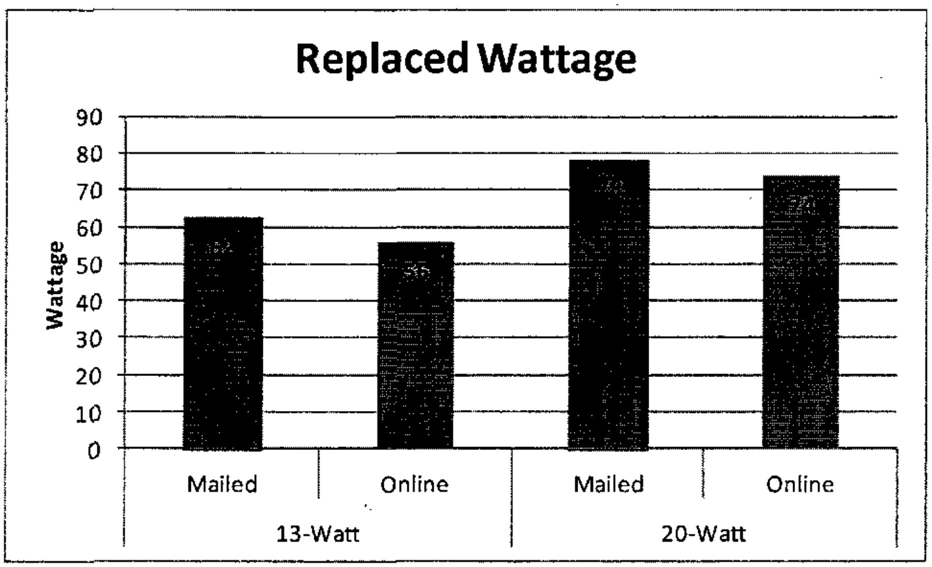


Figure 2. CFL Replaced Wattages by Survey Group

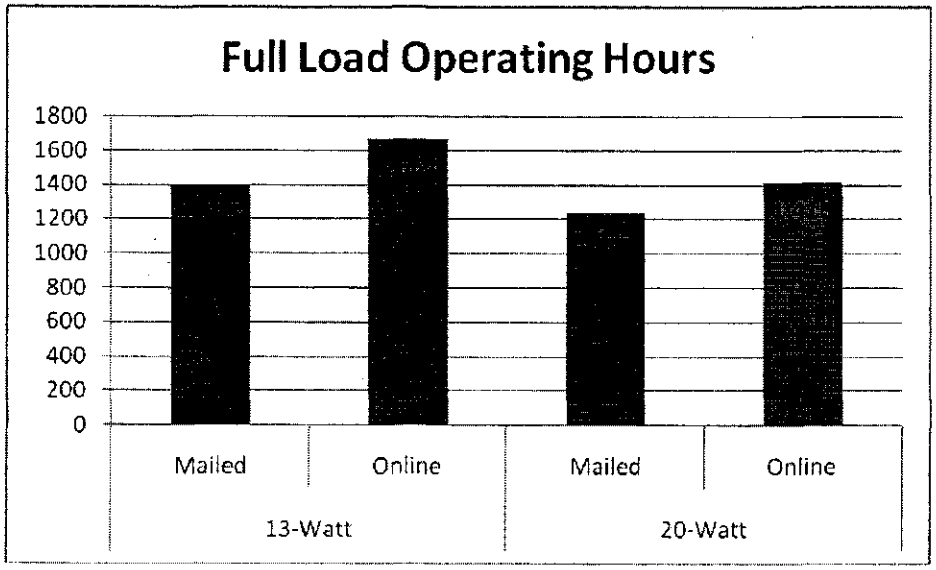


Figure 3. CFL Operating Hours by Survey Group

Personalized Energy Report Recommendation Impacts

There were a total of five different recommendations that were taken by program participants in Ohio and Kentucky combined. Table 14 lists each recommendation along with how many times the recommendation was followed and the total estimated savings acquired from the measure taken. The evaluation phone survey did not allow participants to indicate whether or not they plan to take recommendations they have not yet taken as it did for the CFLs, so there are no planned or potential future savings presented for the recommendations provided by the Personalized Energy Report.

Table 14. All Recommendations with Savings Estimates

Recommendation	Times Recommendation Taken In Survey	Percent of Total	Total Times Recommendation Taken	kW	kWh	therms
Double Pane Windows	1	0.63%	130	15.40	48,320	4,024
Energy Star Doors	1	0.63%	130	5.21	21,887	2,449
Energy Star Dishwasher	1	0.63%	130	0.00	4,612	294
Energy Star Clothes Washer	1	0.63%	130	0.00	12,683	784
Energy Star Freezer	1	0.63%	130	0.00	9,224	0
TOTAL	**5**	**3.13%**	**651**	**20.61**	**96,726**	**7,552**

All five of the recommendations were taken only once and therefore all have an implementation rate of 0.63% and were followed by 130 participants out of the entire population of 20,845. Due to this very low implementation rate, the energy savings from the recommendations is quite low when compared to the savings from the CFLs, accounting for just 2% of the total program kWh savings. Mean savings estimates are shown in Table 15.

Table 15. Mean Savings Estimates for All Recommendations

	kW	kWh	therms
Double Pane Windows	0.1184	371.7	30.95
Energy Star Doors	0.0401	168.4	18.84
Energy Star Dishwasher	0.0000	35.5	2.26
Energy Star Clothes Washer	0.0000	97.6	6.03
Energy Star Freezer	0.0000	71.0	0.00

Inter-State Comparison

The Personalized Energy Report program was evaluated in four states, with Ohio and Kentucky results being presented in this report, and North Carolina and South Carolina being reported together in another report. However, for this section, we present the results across all four states.

Figure 4 and Figure 5 show the distribution of CFLs across Ohio, Kentucky, North Carolina, and South Carolina. There were more Personalized Energy Report participants in North Carolina than in the other three states combined. It follows that North Carolina also achieves more kWh savings than the other three states combined.

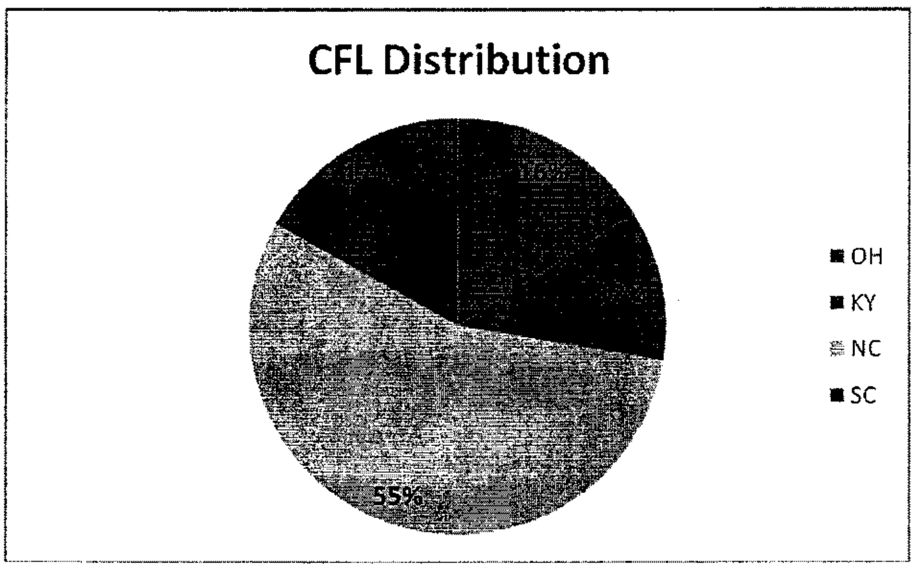


Figure 4. Percent of CFLs Distributed by State

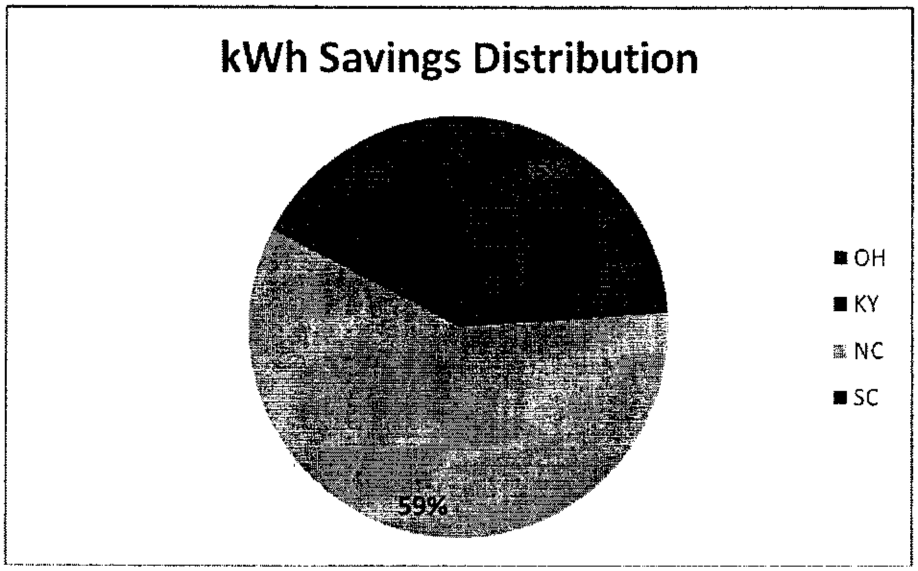


Figure 5. Percent of kWh Savings by State

Figure 6 and Figure 7 illustrate the differences in CFL installation rates between online and by-mail survey participants as well as by all four states. For the most part, the installation rates hover steadily in the 60 to 70% range, with one glaring exception. Participants in Kentucky that submitted their survey by mail reported drastically lower installation rates for both 13 and 20-watt CFLs than any other survey group and state combination, 44% and 28% respectively. The second lowest combination is Ohio participants submitting their surveys online. Their by-mail and online survey results for 20-watt CFLs disagree by 12%, 62% and 50% respectively. Also of interest to note are North Carolina's 20-watt CFL installation rates. Online survey takers reported the highest installation rate of any survey group and state combination, 73% while the by-mail survey takers reported below average installation rates, 60%, a difference of 13%, the largest difference of any state save Kentucky.

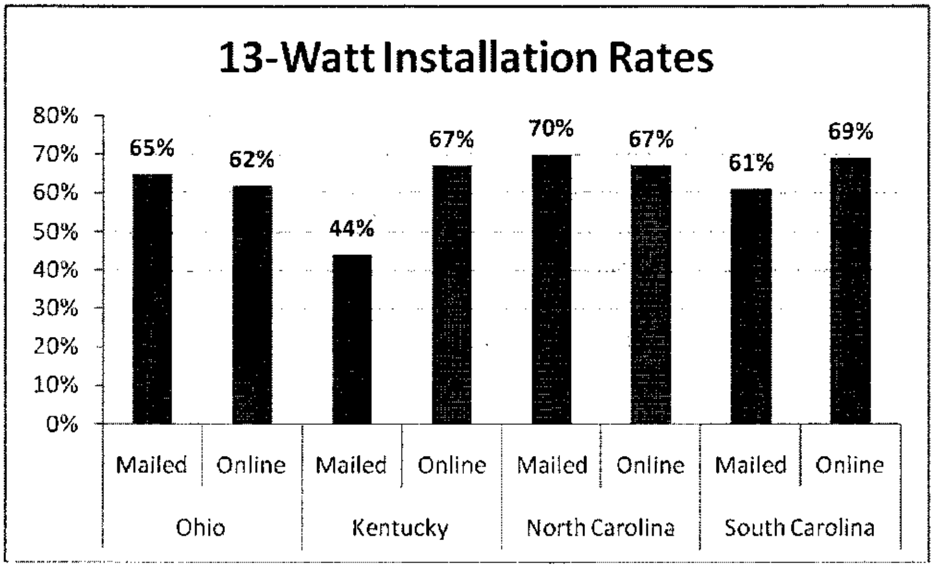


Figure 6. 13-watt CFL Installation Rates by Survey Group and State

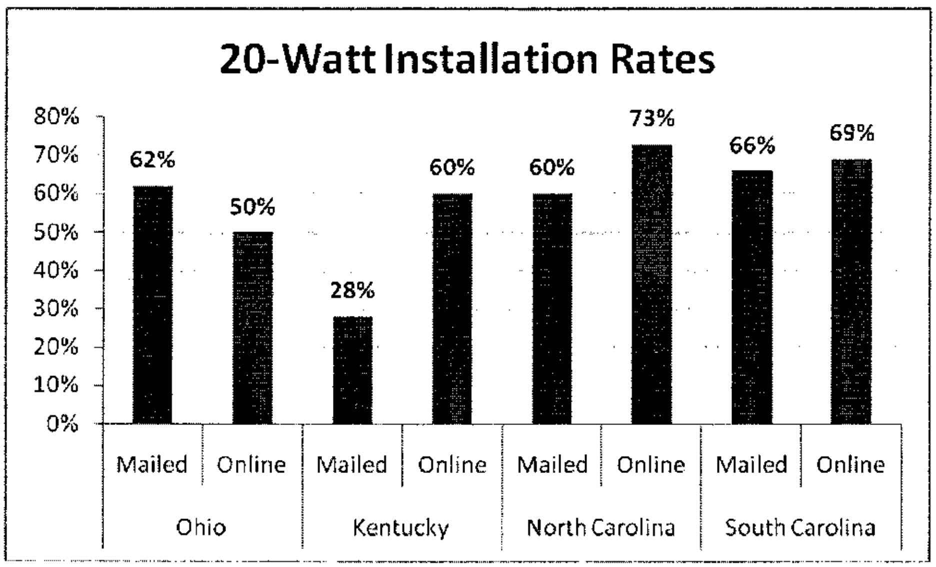


Figure 7. 20-watt CFL Installation Rates by Survey Group and State

Figure 8 and Figure 9 represent the replaced wattages and operating hours of the installed CFLs. Survey participants that submitted their survey by mail indicated that they were using the CFLs from the six-pack to replace a higher wattage incandescent bulb than their online counterparts. This is true regardless of state. Reported operating hours, however, do vary with state. By-mail survey takers in Ohio and Kentucky report using their lights less often than the online survey takers. Conversely, North and South Carolina participants that submitted their survey by mail reported using their lights more often than the online survey takers.

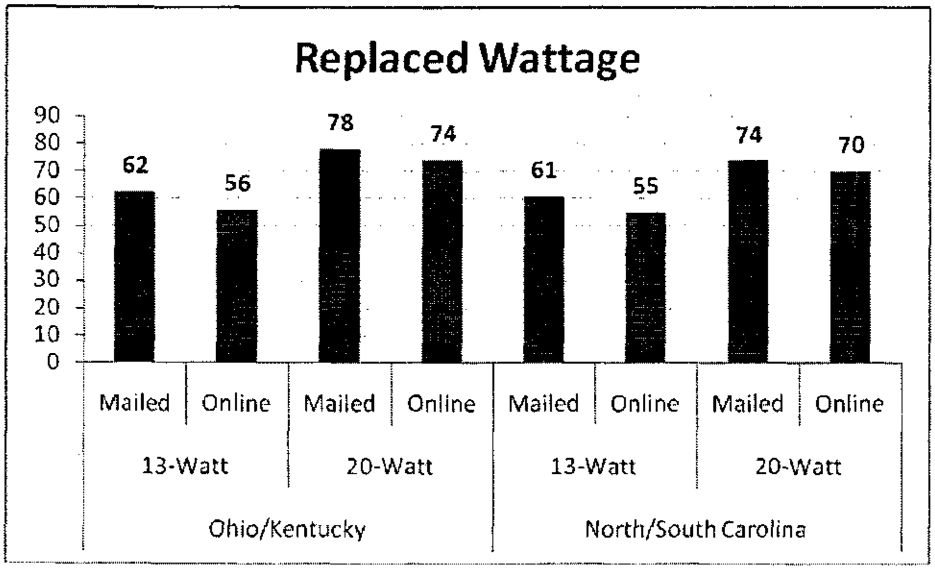


Figure 8. CFL Replaced Wattages by Survey Group and State

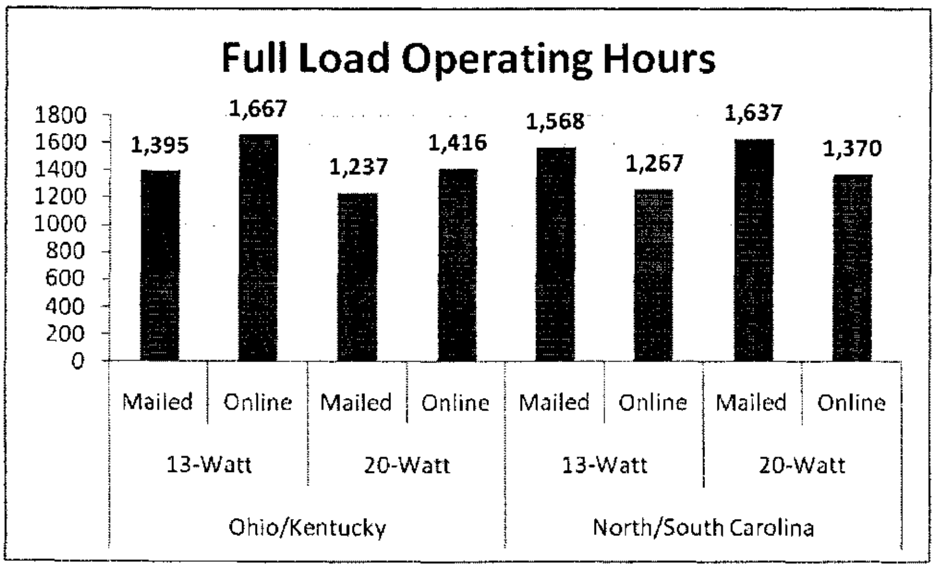


Figure 9. CFL Operating Hours by Survey Group and State

Billing Analysis

This section of the report presents the results of a billing analysis conducted over the participants in the Ohio PER program. All data presented in impact tables relating to the billing analysis are exclusive of Kentucky participants. Since the customer has a choice of either the mail or online version (OHEC), separate billing analyses were conducted for the mail version (referred below as PER) and the online version (referred to as OHEC). For both analyses, billing data was obtained for all participants in the program between August, 2009 and March, 2011. For the written PER, there were a total of 8,638 usable accounts after processing[4], and for OHEC there were a total of 6,081.[5] For each program, a panel model was used to determine program impacts, where the dependent variable was monthly electricity consumption from January 2009 to March 2011. The results of the billing analysis are presented in Table 16.

Table 16. Estimated Ohio PER Impacts: Billing Analysis

	95% Confidence Interval		
	Lower Bound	Estimate	Upper Bound
Per Participant Annual Savings (Gross) – PER	224.7	387.6	550.3
Per Participant Annual Savings (Gross) - OHEC	59.1	173.5	287.8

This table shows that both the written and online aspects of the PER program produced statistically significant savings for participants in Ohio. In both cases, the 95% confidence interval includes the engineering estimate, so there is no statistically significant difference between the billing data estimate and the engineering estimate. The appropriate impact estimate for both aspects is assumed to be the one based on the billing analysis because:

- The billing analysis is more likely to capture adoption of recommended measures as well as behavioral responses.
- The billing analysis was estimated over nearly all 2009-2011 participants (over 60,000 customers) while the engineering analysis relied upon the surveyed sample (154 customers).

For this analysis, data are available both across households (i.e., cross-sectional) and over time (i.e., time-series). With this type of data, known as "panel" data, it becomes possible to control, simultaneously, for differences across households as well as differences across periods in time through the use of a "fixed-effects" panel model specification. The fixed-effect refers to the model specification aspect that differences across homes that do not vary over the estimation period (such as square footage, heating system, etc.) can be explained, in large part, by customer-

[4] Useable accounts are those accounts which have billing data for both a portion of the pre- and post-participation period. It was not required that the data covers the complete evaluation period, only that there is at least one observation in each period.

[5] In order to maximize the use of the data, a single model for PER and OHEC were estimated that included households from across all states (Ohio, North Carolina, South Carolina and Kentucky). Therefore, the actual sample size in the PER model included 39,851 houses in the Carolinas and 8,451 in Kentucky, in addition to the 8,638 in Ohio, for a total sample size of 56,940 households, and the OHEC model included 12,962 from the Carolinas and 1,021 from Kentucky, in addition to the 6,081 from Ohio, for a total sample of 19,821.

specific intercept terms that capture the net change in consumption due to the program, controlling for other factors that do change with time (e.g., the weather).

Because the consumption data in the panel model includes months before and after the installation of measures through the program, the period of program participation (or the participation window) may be defined specifically for each customer. This feature of the panel model allows for the pre-installation months of consumption to effectively act as controls for post-participation months. In addition, this model specification, unlike annual pre/post-participation models such as annual change models, does not require a full year of post-participation data. Effectively, the participant becomes their own control group, thus eliminating the need for a non-participant group. We know the exact month of participation in the program for each participant, and are able to construct customer specific models that measure the change in usage consumption immediately before and after the date of program participation, controlling for weather and customer characteristics.

The fixed effects model can be viewed as a type of differencing model in which all characteristics of the home, which (1) are independent of time and (2) determine the level of energy consumption, are captured within the customer-specific constant terms. In other words, differences in customer characteristics that cause variation in the level of energy consumption, such as building size and structure, are captured by constant terms representing each unique household.

Algebraically, the fixed-effect panel data model is described as follows:

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it},$$

where:

y_{it} = energy consumption for home i during month t
α_i = constant term for site i
β = vector of coefficients
x = vector of variables that represent factors causing changes in energy consumption for home i during month t (i.e., weather, time, and participation)
ε = error term for home i during month t.

With this specification, the only information necessary for estimation is those factors that vary month to month for each customer, and that will affect energy use, which effectively are weather conditions and program participation. Other non-measurable factors can be captured through the use of monthly indicator variables (e.g., to capture the effect of potentially seasonal energy loads).

The effect of the written and online aspects of the PER® program are captured by including a variable which is equal to one for all months after the household participated in the program. The coefficient on this variable is the savings associated with the program. In order to account for differences in billing days, the usage was normalized by days in the billing cycle. The estimated electric model for the written aspect of PER and OHEC are presented in Table 17 and Table 18, respectively.[6]

Table 17. Estimated Savings Model for PER – dependent variable is daily kwh usage, January 2009 through March 2011 (savings are negative).

Independent Variable	Coefficient (kWh Savings/day)	t-value
PER participation – Ohio	-1.062	-4.67
PER participation – Carolina	-0.432	-3.41
PER participation – Kentucky	-0.5153	-1.25
Sample Size	1,490,567 observations (56,940 homes)	
R-Squared	79%	

Table 18. Estimated Savings Model for OHEC – dependent variable is daily kwh usage, January 2009 through March 2011 (savings are negative).

Independent Variable	Coefficient (kWh Savings/day)	t-value
OHEC participation – Ohio	-0.475	-2.97
OHEC participation – Carolina	-1.639	-12.04
OHEC participation – Kentucky	-1.157	-2.72
Sample Size	457,836 observations (19,821 homes)	
R-Squared	78%	

The complete estimate model, showing the weather and time factors, is presented in Appendix H: Estimated Statistical Model.

[6] As stated previously, for each aspect of PER, a single model was estimated over participants in all states. Thus, the tables present the impacts for the Carolinas and Kentucky in addition to the impacts for Ohio.

Appendix A: Required Savings Table

Based upon reconciled billing and engineering analyses. Billing analysis data is based on Ohio participants only between August 2009 and March 2011 (n=14,719).

Measure	Participation Count	Ex Post Per unit kWh impact	Ex Post Per unit kW impact	Gross Ex Post kWh Savings	Gross Ex Post kW Savings
CFL	7,330	322.4	0.275	2,363,168	2,013
Double Pane Windows	76	5.014	0.002	380	0.121
Energy Star Doors	76	2.271	0.001	172	0.041
Energy Star Dishwasher	76	0.479	0.000	36	0.000
Energy Star Clothes Washer	76	1.316	0.000	100	0.000
Energy Star Freezer	76	0.957	0.000	72	0.000

Appendix B: DSMore Table

SAE

Per Measure Impacts Summary for PER Ohio

Impacts ⇨ / Technology ⇩	Product code	State	EM&V gross savings (kWh/unit)	EM&V gross kW (customer peak/unit)	EM&V gross kW (coincident peak/unit)	Unit of measure	Combined spillover less freeridership and bias adjustment	EM&V net savings (kWh/unit)	EM&V net kW (customer peak/unit)	EM&V net kW (coincident peak/unit)	EM&V load shape (yes/no)	EUL (whole number)
CFLs		Ohio	326.6	0.278	0.028	customer	24.4%	246.9	0.2103	0.0210	no	5
Double Pane Windows		Ohio	2.928	0.001	0.001	customer	0.0%	2.9	0.0009	0.0009	no	20
Energy Star Doors		Ohio	1.326	0.000	0.000	customer	0.0%	1.3	0.0003	0.0003	no	20
Energy Star Dishwasher		Ohio	0.279	0.000	0.000	customer	0.0%	0.3	0.0000	0.0000	no	11
Energy Star Clothes Washer		Ohio	0.768	0.000	0.000	customer	0.0%	0.8	0.0000	0.0000	no	11
Energy Star Freezer		Ohio	0.559	0.000	0.000	customer	0.0%	0.6	0.0000	0.0000	no	11
Program wide			**332**	**0.2795**	**0.0291**		**24.0%**	**253**	**0.2116**	**0.0223**		**5**

Appendix C: Ohio Participant Survey Instrument

The questions below require mostly short, scaled replies from the interviewee, and not all questions will be asked of all participants. This interview should take approximately 10 to 15 minutes.

Personalized Energy Report (PER) Program

Participant Survey

SURVEY INTRODUCTION

Use five attempts at different times of the day and different days before dropping from contact list. Call times are from 10:00 a.m. to 8:00 p.m. EST or 9-7 CST Monday through Saturday. No calls on Sunday.

SURVEY

Introduction

Note: Only read words in bold type.

Hello, my name is ______. I am calling on behalf of Duke Energy to conduct a customer survey about the Personalized Energy Report Program. This was a survey someone in your home completed and you received a report and compact fluorescent light bulbs for your participation. May I speak with ____________ please?

If person talking, proceed. If person is called to the phone reintroduce.
If not home, ask when would be a good time to call and schedule the call-back:

Call back 1:	Date: __________,	Time: ____________	❑AM or ❑PM
Call back 2:	Date: __________,	Time: ____________	❑AM or ❑PM
Call back 3:	Date: __________,	Time: ____________	❑AM or ❑PM
Call back 4:	Date: __________,	Time: ____________	❑AM or ❑PM
Call back 5:	Date: __________,	Time: ____________	❑AM or ❑PM

❑ Contact dropped after fifth attempt.

We are conducting this survey to obtain your opinions about the Personalized Energy Report Program. Duke Energy's records indicate that you participated in the Personalized Energy Report Program by completing and mailing a paper survey or an online survey. We are not selling anything. The survey will take about 5 or 10 minutes and your answers will be confidential, and will help us to make improvements to the program to better serve others. May we begin the survey?

Note: If this is not a good time, ask if there is a better time to schedule a callback.

1. Do you recall participating in the Personalized Energy Report Program?

1. ❑ Yes, *begin* → *Skip to Q3.*
2. ❑ No,
99. ❑ DK/NS

This program was provided through Duke Energy. In this program, you completed a short survey about your home in <*month year*>, and then Duke Energy provided you with energy-saving recommendations for you and your home, and you were also provided with a free six-pack of CFLs.

Do you remember participating in this program?

1. ❑ Yes, *begin* → *Go to Q2.*
2. ❑ No,
99. ❑ DK/NS

If No or DK/NS terminate interview and go to next participant.

2. **How did you learn of the PER Program?**

a. ____ I visited Duke Energy's website (pop-up survey)
b. ____ I got the survey in the mail -- *Did you fill out the mailed PER survey or did you complete the survey online?*
  i. Paper ____
  ii. Online _____
c. ____ Other: ______________________

3. Please think back to the time when you were deciding to participate in the Personalized Energy Report program. What factors motivated you to participate? (*do not read list, place a "1" next to the response that matches best)*

1. ____ Six pack of CFL bulbs
2. ____ Recommendation of someone else (*Probe*: **Who?**__________)
3. ____ Wanted to reduce energy costs
4. ____ The information provided by the program
5. ____ Past experience with this program
6. ____ Because of past experience with another Duke Energy program

7. ____ Recommendation from other utility program
    i. (*Probe*: **What program?** ______________________)
8. ____ Recommendation of family/friend/neighbor
9. ____ Other (SPECIFY) ______________________________
10. ____ Don't know/don't remember/not sure (DK/NS)

If multiple responses: 3.a. **Were there any other reasons?** *(number responses above in the order they are provided - Repeat until 'no' response.)*

4. **Did you have any CFLs installed in your home before you completed your PER survey?**

❑ Yes ❑ No ❑ DK

If yes, 4a. **How many did you have installed before you completed the PER survey?**

Enter response: ________________

Please answer the following set of questions with a yes or no response.

5. **Do you have any cold drafts in your house during the winter?**

❑ Yes ❑ No ❑ DK

6. **Do your windows have water on them or look "sweaty" in the winter?**

❑ Yes ❑ No ❑ DK

7. **Does your cooling system keep your home comfortable?**

❑ Yes ❑ No ❑ DK ❑ Don't have a cooling system

8. **Does your heating system keep your home comfortable?**

❑ Yes ❑ No ❑ DK ❑ Don't have a heating system

9. **Does the temperature in your house stay even from room to room?**

❑ Yes ❑ No ❑ DK

10. I'd like to talk about the CFLs that you received for participating in the PER program. The kit came with 3 13-watt CFLs and 3 20-watt CFLs. How many of the 13-watt CFLs are you using?

- **a.** None of them
- **b.** 1 of the CFLs
- **c.** 2 of the CFLs
- **d.** 3 of the CFLs
- **e.** Don't know

11. **For the** <first, second, third> **How many watts was the old bulb that you took out?** (repeat for all installed out of the 3 provided)

❑<=44 ❑45-70 ❑71-99 ❑100+

4. **On average, approximately how many hours per day is this light used?** (repeat for all installed out of the 3 provided)

❑<=1 ❑1-2 ❑3-4 ❑5-10 ❑11-12 ❑13-24

If less than 3:

Do you plan on using the remaining 13-watt CFLs?

❑ Yes
❑ No **Why Not?** ______________________
❑ Maybe/DK

12. How many of the 20-watt CFLs are you using?

- **f.** None of them
- **g.** 1 of the CFLs
- **h.** 2 of the CFLs
- **i.** 3 of the CFLs
- **j.** Don't know

13. **For the** <first, second, third> **How many watts was the old bulb that you took out?** (repeat for all installed out of the 3 provided)

❑<=44 ❑45-70 ❑71-99 ❑100+

4. **On average, approximately how many hours per day is this light used?** (repeat for all installed out of the 3 provided)

❑<=1 ❑1-2 ❑3-4 ❑5-10 ❑11-12 ❑13-24

If less than 3:

14. **Do you plan on using the remaining 20-watt CFLs?**
    i. ❑ Yes
    ii. ❑ No **Why Not?** ____________________
    iii. ❑ Maybe/DK

15. **On a scale from 1-10, with 1 indicating that you were very dissatisfied, and 10 indicating that you were very satisfied, please rate your satisfaction with the kit's 13-watt CFL(s).**

very dissatisfied very satisfied
1 2 3 4 5 6 7 8 9 10

If 7 or less, 10a. **Why were you dissatisfied with the 13-watt CFLs?**

____

____

16. **On a scale from 1-10, with 1 indicating that you were very dissatisfied, and 10 indicating that you were very satisfied, please rate your satisfaction with the kit's 20-watt CFL.**

very dissatisfied very satisfied
1 2 3 4 5 6 7 8 9 10

If 7 or less, 11a. **Why were you dissatisfied with the 20-watt CFL?**

____

____

17. **Have you purchased any CFLs since receiving the kit from Personalized Energy Report?**

❑ Yes ❑ No ❑ DK

If yes, 12a. **How many?** ____________________

18. **Since you participated in the Personalized Energy Report Program,**
    a. **have you purchased and installed any energy efficiency equipment?**

        1. ❑ Yes
        2. ❑ No
        3. ❑ Don't Know

    b. **have you made energy efficiency improvements in your home?**

        a. ❑ Yes
        b. ❑ No
        c. ❑ Don't Know

    c. **Have you changed any of your habits related to energy use that were recommended by the PER report?**

        a. ❑ Yes
        b. ❑ No
        c. ❑ Don't Know

If any of the responses to questions 18a - 18c are "yes", continue. If all responses are "no" or "Don't Know", skip to question #23.

19. **What type and quantity of high efficiency equipment did you install on your own?**
    PROBE TO GET EXACT TYPE AND QUANTITY AND LOCATION

Type 1: ____________	Quantity 1: ______	Location 1:__________
Type 2: ____________	Quantity 2: ______	Location 2:__________
Type 3: ____________	Quantity 3: ______	Location 3:__________
Type 4: ____________	Quantity 4: ______	Location 4:__________

20. **Was this improvement suggested by the home energy report provided to you through the Personalized Energy Report program?**

Type 1: ____________	❑ Yes	❑ No	❑ DK
Type 1: ____________	❑ Yes	❑ No	❑ DK
Type 1: ____________	❑ Yes	❑ No	❑ DK
Type 1: ____________	❑ Yes	❑ No	❑ DK

21. **Was this improvement suggested through a different energy efficiency program?**

Type 1: ____________ ❑ Yes ❑ No ❑ DK
    If yes: **Which program?:**____________
Type 1: ____________ ❑ Yes ❑ No ❑ DK
    If yes: **Which program?:**____________

Type 1: ________________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?:**________________
Type 1: ________________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?:**________________

22. *For each type listed in 14 above,* **How do you know that this equipment is high efficiency? For example, was it Energy Star rated?**

Type 1: ________________________________
Type 2: ________________________________
Type 3: ________________________________
Type 4: ________________________________

I'm going to read a statement about this equipment that you purchased on your own. On a scale from 1-10, with 1 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statement.

23. **My experience with the Personalized Energy Report Program in** <2009, 2010> **influenced my decision to install** <Type 1/Type 2/Type 3/Type 4> **on my own.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

24. **What other actions, if any, have you taken in your home to save energy and reduce utility bills at least in part as a result of what you learned in this program?**

Response:1 ________________________________

Response:2 ________________________________

Response:3 ________________________________

Response:4 ________________________________

Now I am going to ask you some general satisfaction statements. On a scale from 1-10, with 1 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statements.

25. **The mailed survey was easy to understand.** (If an online participant: **The web site's survey was easy to understand.**)

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

26. **The energy report was easy to read and understand.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

27. **The recommendations in the PER report provided new ideas that I was not previously considering.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

28. **The recommendations in the report increased the likelihood that I would take recommended actions.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

29. **The kit I received met my expectations.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

30. I am satisfied with the amount of time it took to receive the kit and report after completing the PER survey.

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

31. **Overall I am satisfied with the program.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

32. What additional services would you like the program to provide that it does not now provide?

Response: ____

____

33. Are **there any other things that you would like to see changed about the program?**

Response: ____

34. **What do you think can be done to increase people's interest in participating in the Personalized Energy Report Program?**

Response:1 ____
Response:2 ____
Response:3 ____
Response:4 ____

35. **Have you recommended this program to others?**

If yes, **How many people did you recommend this program to?**

36. **What did you like most about this program?**

Response: ____

37. **What did you like least about this program?**

Response: ____

38. **What other services could Duke Energy provide to help improve home energy efficiency?**

Response: ____

That completes our survey, thank you for your time and feedback today! *(politely end call)*

Appendix D: Kentucky Participant Survey Instrument

The questions below require mostly short, scaled replies from the interviewee, and not all questions will be asked of all participants. This interview should take approximately 10 to 15 minutes.

Personalized Energy Report (PER) Program

Participant Survey

SURVEY INTRODUCTION

If PER participant, then contact for survey. Use five attempts at different times of the day and different days before dropping from contact list. Call times are from 10:00 a.m. to 8:00 p.m. EST or 9-7 CST Monday through Saturday. No calls on Sunday. (Sample size N =150)

SURVEY

Introduction

Note: Only read words in bold type.

Hello, my name is ______. I am calling on behalf of Duke Energy to conduct a customer survey about the Personalized Energy Report Program. This was a survey someone in your home completed and you received a report and compact fluorescent light bulbs for your participation. May I speak with ____________ please?

If person talking, proceed. If person is called to the phone reintroduce.
If not home, ask when would be a good time to call and schedule the call-back:

Call back 1:	Date: __________,	Time: _____________	❑AM or ❑PM
Call back 2:	Date: __________,	Time: _____________	❑AM or ❑PM
Call back 3:	Date: __________,	Time: _____________	❑AM or ❑PM
Call back 4:	Date: __________,	Time: _____________	❑AM or ❑PM
Call back 5:	Date: __________,	Time: _____________	❑AM or ❑PM

❑ Contact dropped after fifth attempt.

We are conducting this survey to obtain your opinions about the Personalized Energy Report Program. Duke Energy's records indicate that you participated in the Personalized Energy Report Program by completing and mailing a paper survey or an online survey. We are not selling anything. The survey will take about 5 or 10 minutes and your answers will be confidential, and will help us to make improvements to the program to better serve others. May we begin the survey?

Note: If this is not a good time, ask if there is a better time to schedule a callback.

1. **Do you recall participating in the Personalized Energy Report Program?**

1. ❑ Yes, *begin* → *Skip to Q3.*
2. ❑ No,
99. ❑ DK/NS

This program was provided through Duke Energy. In this program, you completed a short survey about your home in <*month year*>, and then Duke Energy provided you with energy-saving recommendations for you and your home, and you were also provided with a free six-pack of CFLs.

Do you remember participating in this program?

1. ❑ Yes, *begin* → *Go to Q2.*
2. ❑ No,
99. ❑ DK/NS

If No or DK/NS terminate interview and go to next participant.

2. **How did you learn of the PER Program?**

d. ____ I visited Duke Energy's website (pop-up survey)
e. ____ I got the survey in the mail -- *Did you fill out the mailed PER survey or did you complete the survey online?*
   i. Paper ____
   ii. Online ______
f. ____ Other: ____________________________

3. Please think back to the time when you were deciding to participate in the Personalized Energy Report program. What factors motivated you to participate? (*do not read list, place a "1" next to the response that matches best)*

11. ____ Six pack of CFL bulbs
12. ____ Recommendation of someone else (*Probe*: **Who?**___________)
13. ____ Wanted to reduce energy costs
14. ____ The information provided by the program
15. ____ Past experience with this program
16. ____ Because of past experience with another Duke Energy program

17. ____ Recommendation from other utility program
    i. (*Probe*: **What program?** ____________________________)
18. ____ Recommendation of family/friend/neighbor
19. ____ Other (SPECIFY) ____
20. ____ Don't know/don't remember/not sure (DK/NS)

If multiple responses: 3.a. **Were there any other reasons?** *(number responses above in the order they are provided - Repeat until 'no' response.)*

39. Did you have any CFLs installed in your home before you completed your PER survey?

❑ Yes ❑ No ❑ DK

If yes, 4a.
How many did you have installed before you completed the PER survey?

Enter response: ________________

Please answer the following set of questions with a yes or no response.

40. Do you have any cold drafts in your house during the winter?

❑ Yes ❑ No ❑ DK

41. Do your windows have water on them or look "sweaty" in the winter?

❑ Yes ❑ No ❑ DK

42. Does your cooling system keep your home comfortable?

❑ Yes ❑ No ❑ DK ❑ Don't have a cooling system

43. **Does your heating system keep your home comfortable?**

❑ Yes ❑ No ❑ DK ❑ Don't have a heating system

44. Does the temperature in your house stay even from room to room?

❑ Yes ❑ No ❑ DK

45. I'd like to talk about the CFLs that you received for participating in the PER program. The kit came with 3 13-watt CFLs and 3 20-watt CFLs. How many of the 13-watt CFLs are you using?

- **k.** None of them
- **l.** 1 of the CFLs
- **m.** 2 of the CFLs
- **n.** 3 of the CFLs
- **o.** Don't know

46. **For the** <first, second, third> **How many watts was the old bulb that you took out?** (repeat for all installed out of the 3 provided)

❑<=44 ❑45-70 ❑71-99 ❑100+

4. **On average, approximately how many hours per day is this light used?** (repeat for all installed out of the 3 provided)

❑<=1 ❑1-2 ❑3-4 ❑5-10 ❑11-12 ❑13-24

If less than 3:

Do you plan on using the remaining 13-watt CFLs?

❑ Yes
❑ No **Why Not?** ______________________________
❑ Maybe/DK

47. How many of the 20-watt CFLs are you using?

- **p.** None of them
- **q.** 1 of the CFLs
- **r.** 2 of the CFLs
- **s.** 3 of the CFLs
- **t.** Don't know

•

48. **For the** <first, second, third> **How many watts was the old bulb that you took out?** (repeat for all installed out of the 3 provided)

❑<=44 ❑45-70 ❑71-99 ❑100+

4. **On average, approximately how many hours per day is this light used?** (repeat for all installed out of the 3 provided)

☐<=1 ☐1-2 ☐3-4 ☐5-10 ☐11-12 ☐13-24

If less than 3:

49. **Do you plan on using the remaining 20-watt CFLs?**
    i. ☐ Yes
    ii. ☐ No **Why Not?** ______________________
    iii. ☐ Maybe/DK

50. **On a scale from 1-10, with 1 indicating that you were very dissatisfied, and 10 indicating that you were very satisfied, please rate your satisfaction with the kit's 13-watt CFL(s).**

very dissatisfied									very satisfied
1	2	3	4	5	6	7	8	9	10

If 7 or less, 10a. **Why were you dissatisfied with the 13-watt CFLs?**

____

____

51. **On a scale from 1-10, with 1 indicating that you were very dissatisfied, and 10 indicating that you were very satisfied, please rate your satisfaction with the kit's 20-watt CFL.**

very dissatisfied									very satisfied
1	2	3	4	5	6	7	8	9	10

If 7 or less, 11a. **Why were you dissatisfied with the 20-watt CFL?**

____

____

52. **Have you purchased any CFLs since receiving the kit from Personalized Energy Report?**

☐ Yes ☐ No ☐ DK

If yes, 12a. **How many?** ______________

53. **Since you participated in the Personalized Energy Report Program,**
    a. **have you purchased and installed any energy efficiency equipment?**

        4. ❑ Yes
        5. ❑ No
        6. ❑ Don't Know

    b. **have you made energy efficiency improvements in your home?**

        d. ❑ Yes
        e. ❑ No
        f. ❑ Don't Know

    c. **Have you changed any of your habits related to energy use that were recommended by the PER report?**

        d. ❑ Yes
        e. ❑ No
        f. ❑ Don't Know

If any of the responses to questions 18a - 18c are "yes", continue. If all responses are "no" or "Don't Know", skip to question #23.

54. **What type and quantity of high efficiency equipment did you install on your own?** *PROBE TO GET EXACT TYPE AND QUANTITY AND LOCATION*

Type 1: ____________ Quantity 1: ______ Location 1: ____________
Type 2: ____________ Quantity 2: ______ Location 2: ____________
Type 3: ____________ Quantity 3: ______ Location 3: ____________
Type 4: ____________ Quantity 4: ______ Location 4: ____________

55. **Was this improvement suggested by the home energy report provided to you through the Personalized Energy Report program?**

Type 1: ____________ ❑ Yes ❑ No ❑ DK
Type 1: ____________ ❑ Yes ❑ No ❑ DK
Type 1: ____________ ❑ Yes ❑ No ❑ DK
Type 1: ____________ ❑ Yes ❑ No ❑ DK

56. **Was this improvement suggested through a different energy efficiency program?**

Type 1: ____________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?**: ____________
Type 1: ____________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?**: ____________

Type 1: ________________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?:** ________________
Type 1: ________________ ❑ Yes ❑ No ❑ DK
If yes: **Which program?:** ________________

57. *For each type listed in 14 above,* **How do you know that this equipment is high efficiency? For example, was it Energy Star rated?**

Type 1: ________________
Type 2: ________________
Type 3: ________________
Type 4: ________________

I'm going to read a statement about this equipment that you purchased on your own. On a scale from 1-10, with 1 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statement.

58. **My experience with the Personalized Energy Report Program in** <2009, 2010> **influenced my decision to install** <Type 1/Type 2/Type 3/Type 4> **on my own.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

59. **What other actions, if any, have you taken in your home to save energy and reduce utility bills at least in part as a result of what you learned in this program?**

Response:1 ________________
Response:2 ________________
Response:3 ________________
Response:4 ________________

60. **How many weeks after you requested your Personalized Energy Report with the 6 pack of CFLs did you received your bulbs?**
    a. 1 week
    b. 2 weeks
    c. 3 weeks
    d. 4 weeks
    e. 5 weeks
    f. 6 weeks
    g. Over six weeks
    i. Don't Know

61. **How many weeks after you requested your Personalized Energy Report with the 6 pack of CFLs did you receive your report?**
    a. Instantly (on-line)
    b. 1 week
    c. 2 weeks
    d. 3 weeks
    e. 4 weeks
    f. 5 weeks
    g. 6 weeks
    h. Over six weeks
    i. Don't Know

Now I am going to ask you some general satisfaction statements. On a scale from 1-10, with 1 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statements.

62. **The mailed survey was easy to understand.** (If an online participant: **The web site's survey was easy to understand.**)

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**______________________________

____

30. **The time it took to fill out the PER survey was satisfactory.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**____________________________________

29. **Returning the survey was easy.**

1 2 3 4 5 6 7 8 9 10

☐ Don't Know

If 7 or less, **How could this be improved?**____________________________________

30. **The energy report was easy to read and understand.**

1 2 3 4 5 6 7 8 9 10

☐ Don't Know

If 7 or less, **How could this be improved?**____________________________________

31. **The recommendations in the PER report provided new ideas that I was not previously considering.**

1 2 3 4 5 6 7 8 9 10

☐ Don't Know

If 7 or less, **How could this be improved?**____________________________________

32. **The recommendations in the report increased the likelihood that I would take recommended actions.**

1 2 3 4 5 6 7 8 9 10

☐ Don't Know

If 7 or less, **How could this be improved?**____________________________________

33. The kit I received met my expectations.

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**____________________________________

35. I am satisfied with the amount of time it took to receive the kit after completing the PER survey.

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**____________________________________

35. I am satisfied with the amount of time it took to receive the report after completing the PER survey.

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**____________________________________

36. **Overall I am satisfied with the program.**

1 2 3 4 5 6 7 8 9 10

❑ Don't Know

If 7 or less, **How could this be improved?**________________________________

____

37. **What additional services would you like the program to provide that it does not now provide?**

Response: ____

____

38. Are **there any other things that you would like to see changed about the program?**

Response: ____

39. **What do you think can be done to increase people's interest in participating in the Personalized Energy Report Program?**

Response:1 ____
Response:2 ____
Response:3 ____
Response:4 ____

40. **Have you recommended this program to others?**

    If yes, **How many people did you recommend this program to?**

41. **What did you like most about this program?**

Response: ____

42. **What did you like least about this program?**

Response: ____

43. **What other services could Duke Energy provide to help improve home energy efficiency?**

Response: ____

That completes our survey, thank you for your time and feedback today! (*politely end call*)

Appendix E: Impact Algorithms

CFLs

General Algorithm

Gross Summer Coincident Demand Savings

$$\Delta kW_S = \text{units} \times \left[\frac{(Watts \times DF_s)_{base} - (Watts \times DF_s)_{ee}}{1000}\right] \times CF_S \times (1 + HVAC_{d,\,s})$$

Gross Annual Energy Savings

$$\Delta kWh = \text{units} \times \left[\frac{(Watts \times DF)_{base} - (Watts \times DF)_{ee}}{1000}\right] \times FLH \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \times HVAC_g$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
$\Delta therm$	= gross annual therm interaction
units	= number of units installed under the program
$Watts_{ee}$	= connected (nameplate) load of energy-efficient unit
$Watts_{base}$	= connected (nameplate) load of baseline unit(s) displaced
FLH	= full-load operating hours (based on connected load)
DF	= demand diversity factor
CF	= coincidence factor
$HVAC_c$	= HVAC system interaction factor for annual electricity consumption = 0.023625
$HVAC_d$	= HVAC system interaction factor for demand = 0.1628
$HVAC_g$	= HVAC system interaction factor for annual gas consumption = -0.0017

13 W CFL Measure

$Watts_{ee}$ = 13, which is the input power of program supplied CFL

$Watts_{base}$ - calculated from survey responses as shown below = 60.05395683

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 - 70	60	Lumen equivalent of 15 W CFL

71 - 99	75	Most popular size in range
>= 100	100	Most popular size in range

FLH - calculated from survey responses as shown below: = 1498.035461 for 13-watt, 1303.535 For the 20-watt bulb.

Hours of use per day	FLH	Notes
<1	183	Average value over range
1-2	548	Average value over range
3-4	1278	Average value over range
5-10	2738	Average value over range
11-12	4198	Average value over range
13-24	6753	Average value over range

DF = 1.0 and CF = 0.10

The coincidence factor for this analysis was taken as the average of the coincidence factors estimated by PG&E and SCE for residential CFL program peak demand savings. The PG&E and SCE coincidence factors are combined factors that consider both coincidence and diversity, thus the diversity factor for this analysis was set to 1.0

$HVAC_c$ - the HVAC interaction factor for annual energy consumption depends on the HVAC system, heating fuel type, and location. The HVAC interaction factors for annual energy consumption were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Heating Fuel	Heating System	Cooling System	HVACc	HVACg
Other	Any except Heat Pump	Any except Heat Pump	0	0
Any	Heat Pump	Heat Pump	-0.16	0
Gas Propane Oil	Central Furnace	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021
	Other	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021
Electricity	Central furnace	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0
	Electric baseboard	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0

	Other	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0

$HVAC_d$ - the HVAC interaction factor for demand depends on the cooling system type. The HVAC interaction factors for summer peak demand were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Cooling System	HVACd
None	0
Room/Window	.17
Central AC	.17
Heat Pump	.17

20W CFL Measure

$Watts_{ee}$ = 20, which is the input power of program supplied CFL

$Watts_{base}$ - calculated from survey responses as shown below: = 76.81624

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 - 70	60	Most popular size in range
71 - 99	75	Lumen equivalent of 20 W CFL
>= 100	100	Most popular size in range

Recommendations

	kW	kWh	therms	Units
Double Pane Windows	.101	317	26.4	100 SF of Window
Energy Star Doors	.02	84	9.4	Door
Energy Star Dishwasher	0	35.4	2.26	Unit
Energy Star Clothes Washer	0	97.35	6.02	Unit
Energy Star Freezer	0	70.8	0	Unit
14 SEER Central AC	.168	141	-2.3	Ton of AC

Appendix F: Personalized Energy Report/OHEC Survey

U142045

RECEIVE YOUR FREE, PERSONALIZED ENERGY REPORT (PER)™

[redacted]

FOR THE ADDRESS SHOWN ABOVE, PLEASE ANSWER THE FOLLOWING QUESTIONS RELATED TO YOUR HOME AND ENERGY USAGE. FILL IN THE CIRCLES COMPLETELY USING BLUE OR BLACK INK.

PROPERTY DETAILS

1. What type of home best describes your primary residence? (Select one only)
   - Detached single family
   - Duplex / 2 family
   - Townhouse
   - Apartment / Multi - Family (3 or more units)
   - Condominium
   - Manufactured home

2. How many levels does your home have, excluding the basement and unfinished attic?
   - 1
   - 2
   - 3

3. In what year was your home built?
   - Before 1959
   - 1960 - 1979
   - 1980 - 1989
   - 1990 - 1997
   - 1998 - 2000
   - 2001 - 2007
   - 2008

4. Does your home have an attic?
   - Yes
   - No

5. Does your home have a basement?
   - Yes, heated
   - Yes, unheated
   - No

6. Excluding bathrooms and hallways, how many rooms are in your home? (Include finished basement)
   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - More than 9

7. How would you describe the size of the rooms in your home?
   - Above average
   - Average
   - Below average

8. Approximate size (heated area) of your home? Your answers to questions 6 & 7 above will allow us to estimate the size of your home in square feet. Or, if you know the square footage of your home, you may choose it here and we will use your input.
   - < 500
   - 500-999
   - 1000-1499
   - 1500-1999
   - 2000-2499
   - 2500-2999
   - 3000-3499
   - 3500-3999
   - 4000 or more
   - Don't know

MAIN HEATING SYSTEM

9. What is the fuel used in your primary heating system?
   - Electric
   - Natural Gas
   - Oil
   - Propane
   - Other (solar, wood, etc)
   - No heat system

10. Which of the following bests describes your home's primary heating system?
    - Electric Baseboard or ceiling cable
    - Forced air furnace
    - Standard heat pump
    - Ground source heat pump
    - Water boiler
    - Steam boiler
    - Wood heating system
    - Heat pump with gas backup
    - Heat pump with propane backup
    - Heat pump with oil backup
    - No heat system

11. How old is your heating system?
    - 0 - 4 years
    - 5 - 9 years
    - 10 - 14 years
    - 15 - 19 years
    - 20 years or greater

COOLING SYSTEM

12. Do you have a central cooling system? (If you use window or room air conditioners, you will note this in question 14)
    - No central cooling system
    - Central air conditioning
    - Heat Pump

13. If you have any cooling system, how old is it?
    - 0 - 4 years
    - 5 - 9 years
    - 10 - 14 years
    - 15 - 19 years
    - 20 years or greater

14. Do you use room or window air conditioners?
    - Yes
    - No

15. How many room or window A/Cs?
    - 1
    - 2
    - 3

16. If you have a central heating and cooling system with air ducts, are any of these ducts located in the attic?
    - Yes
    - No
    - Not applicable

Duke Energy.

What is your thermostat setting for a typical heating day and a typical cooling day in the afternoon?

Heating

- < 67 °F
- 67 – 70 °F
- 71 – 73 °F
- 74 – 77 °F
- > 77 °F
- Thermostat off/ No thermostat

Cooling

- < 69 °F
- 69 – 72 °F
- 73 – 76 °F
- 77 – 78 °F
- > 78 °F
- Thermostat off/ No thermostat

Do you have any of the following comfort issues in your home?

a. *Cold drafts in the winter*
- Yes
- No

b. *Sweaty windows in the winter*
- Yes
- No

c. *Cooling system will not keep the home comfortable*
- Yes
- No

d. *Heating system will not keep the home comfortable*
- Yes
- No

e. *Uneven temperatures between rooms*
- Yes
- No

Please print your email address in the boxes below

How many people live in your home?
- 1
- 2
- 3
- 4
- 5
- 6
- 7 or more

Do you own or rent this home?
- Own
- Rent

What fuel is used by your water heater?
- Electric
- Natural Gas
- Propane
- Other
- None

What is the age of your water heater?
- 0 – 4 years
- 5 – 9 years
- 10 – 14 years
- 15 – 19 years
- 20 years or greater

What type of fuel do you use for clothes drying?
- Electric
- Natural Gas
- Other
- None

What type of fuel do you use for your cook top?
- Electric
- Natural Gas
- Other
- None

What type of fuel do you use for your oven?
- Electric
- Natural Gas
- Other
- None

26. a. Do you have a swimming pool?
- Yes
- No

b. *Do you have a pool heater?*
- Yes
- No

c. *What type of fuel do you use to heat your pool?*
- Electric
- Natural Gas
- Oil
- Propane
- Not applicable

a. Do you have a hot tub?
- Yes
- No

b. *What type of fuel do you use to heat your hot tub?*
- Electric
- Natural Gas
- Oil
- Propane

Would a two degree increase in your home's indoor temperature during summer weekday afternoons affect your family's comfort?
- Not at all
- A small impact
- A moderate impact
- A large impact

Are you planning to make any large purchases to improve the energy efficiency of your home within the next three years?
- Yes
- No
- Not sure

How many CFLs* do you have installed in your home?

* 0 1 4 2 0 4 5 *

*compact fluorescent light bulbs

Appendix G: Responses to Questions Repeated from the Personalized Energy Report Implementation Survey

Survey Respondents in Kentucky and Ohio were asked the following five questions:

1. Do you have any cold drafts in your house during the winter?
2. Do your windows have water on them or look sweaty in winter?
3. Does your cooling system keep your home comfortable?
4. Does your heating system keep your home comfortable?
5. Does the temperature in your house stay even from room to room?

These questions are on the PER™/OHEC Survey which can be found in Appendix F: Personalized Energy Report/OHEC Survey. TecMarket Works was asked to include these questions in the evaluation survey so that the results could be compared. TecMarket Works does not have the results for the initial survey, so only a summary of their most recent responses are presented in the table below.

Table 19. Kentucky OHEC

		Yes		No		Don't Know	
		N	Percent	N	Percent	N	Percent
Cold Drafts?	Mailed	5		19		0	
	Online	4		10		0	
	Total	**9**	**23.7%**	**29**	**76.3%**	**0**	**0%**
Sweaty Windows?	Mailed	5		19		1	
	Online	2		11		0	
	Total	**7**	**18.4%**	**30**	**78.9%**	**1**	**2.6%**
Cooling System Comfortable?	Mailed	22		2		0	
	Online	14		0		0	
	Total	**36**	**94.7%**	**2**	**5.3%**	**0**	**0%**
Heating System Comfortable?	Mailed	22		2		0	
	Online	12		2		0	
	Total	**34**	**89.5%**	**4**	**10.5%**	**0**	**0%**
Temperature Even?	Mailed	15		9		0	
	Online	8		6		0	
	Total	**23**	**60.5%**	**15**	**39.5%**	**0**	**0%**

Table 20. Ohio OHEC

		Yes		No		Don't Know	
		N	Percent	N	Percent	N	Percent
Cold Drafts?	Mailed	20		55		0	
	Online	15		24		1	
	Total	**35**	**30.4%**	**79**	**68.7%**	**1**	**0.9%**
Sweaty Windows?	Mailed	20		55		0	
	Online	13		26		1	
	Total	**33**	**28.7%**	**81**	**70.4%**	**1**	**0.9%**
Cooling	Mailed	68		6		1	

System Comfortable?	Online	35		4		1	
	Total	**103**	**89.6%**	**10**	**8.7%**	**2**	**1.7%**
Heating System Comfortable?	Mailed	67		7		1	
	Online	35		3		2	
	Total	**102**	**88.7%**	**10**	**8.7%**	**3**	**2.6%**
Temperature Even?	Mailed	47		28		0	
	Online	25		15		0	
	Total	**72**	**62.6%**	**43**	**37.4%**	**0**	**0%**

Appendix H: Estimated Statistical Model

This appendix show the complete model estimated for the billing analysis of PER® and OHEC. The model includes indicators for each month (the yearmonth variable), temperature, the state the participant resides, and the participation variables.

PER®

Variable	Coefficient	Std. Err.	t-value	P>|t|	[95% Conf.	Interval]
Ohio PER®	-1.061723	.2275592	-4.67	0.000	-1.507731	-.6157145
Carolina PER®	-.4318153	.1267935	-3.41	0.001	-.6803262	-.1833044
Kentucky PER®	-.5153296	.4109788	-1.25	0.210	-1.320834	.2901747
yearmonth- monthly indicators						
200902	.4266216	1.010806	0.42	0.673	-1.554524	2.407767
200903	1.214701	1.240542	0.98	0.327	-1.21672	3.646121
200904	-9.274887	1.621965	-5.72	0.000	-12.45388	-6.095892
200905	-46.04743	1.530528	-30.09	0.000	-49.04722	-43.04765
200906	-152.9098	2.173861	-70.34	0.000	-157.1705	-148.6491
200907	-165.0771	2.978928	-55.41	0.000	-170.9157	-159.2385
200908	-174.267	2.831219	-61.55	0.000	-179.8161	-168.7179
200909	-161.846	2.172825	-74.49	0.000	-166.1046	-157.5873
200910	-70.86816	1.265211	-56.01	0.000	-73.34794	-68.38839
200911	-19.43655	1.912648	-10.16	0.000	-23.18528	-15.68783
200912	10.43675	.9859776	10.59	0.000	8.504268	12.36923
201001	13.31447	1.187308	11.21	0.000	10.98738	15.64155
201002	6.056467	1.24992	4.85	0.000	3.606667	8.506268
201003	21.50042	1.162243	18.50	0.000	19.22247	23.77838
201004	-7.110179	1.365137	-5.21	0.000	-9.7858	-4.434557
201005	-94.58579	2.174196	-43.50	0.000	-98.84714	-90.32444
201006	-167.8692	2.085284	-80.50	0.000	-171.9563	-163.7821
201007	-209.1718	3.371102	-62.05	0.000	-215.7791	-202.5646
201008	-200.396	3.466054	-57.82	0.000	-207.1894	-193.6027
201009	-159.8892	2.277926	-70.19	0.000	-164.3538	-155.4245
201010	-104.0399	1.334106	-77.98	0.000	-106.6547	-101.4251
201011	-15.56738	1.256639	-12.39	0.000	-18.03035	-13.10441
201012	13.01914	.9093942	14.32	0.000	11.23676	14.80152
201101	2.593355	1.406553	1.84	0.065	-.1634416	5.350151
201102	17.50172	1.237131	14.15	0.000	15.07698	19.92645
201103	9.087197	1.358838	6.69	0.000	6.423922	11.75047
temperature interacted with monthly indicator						
200901	-.8448921	.0231028	-36.57	0.000	-.8901728	-.7996115
200902	-.8684181	.0217809	-39.87	0.000	-.9111078	-.8257284
200903	-.8756204	.0225642	-38.81	0.000	-.9198455	-.8313953
200904	-.6823165	.028334	-24.08	0.000	-.7378501	-.6267829
200905	-.0299153	.0215229	-1.39	0.165	-.0720994	.0122688
200906	1.610204	.0280663	57.37	0.000	1.555195	1.665213
200907	1.846985	.0413431	44.67	0.000	1.765954	1.928016
200908	1.910927	.0380102	50.27	0.000	1.836429	1.985426
200909	1.867457	.0310438	60.16	0.000	1.806612	1.928302
200910	.4744001	.0200308	23.68	0.000	.4351403	.5136598
200911	-.5401151	.037813	-14.28	0.000	-.6142272	-.4660029
200912	-1.270706	.019183	-66.24	0.000	-1.308304	-1.233108
201001	-1.288228	.033432	-38.53	0.000	-1.353754	-1.222702
201002	-1.134498	.03636	-31.20	0.000	-1.205762	-1.063234
201003	-1.295564	.0186343	-69.53	0.000	-1.332087	-1.259042
201004	-.6484281	.0191337	-33.89	0.000	-.6859294	-.6109267
201005	.7130788	.0307386	23.20	0.000	.6528322	.7733253
201006	1.7906	.0256551	69.79	0.000	1.740317	1.840884
201007	2.373414	.0427584	55.51	0.000	2.289609	2.457219
201008	2.288716	.044393	51.56	0.000	2.201707	2.375725
201009	1.837347	.0311476	58.99	0.000	1.776299	1.898395
201010	1.028331	.0193759	53.07	0.000	.9903547	1.066307
201011	-.6584072	.0228751	-28.78	0.000	-.7032416	-.6135729
201012	-1.499983	.0167263	-89.68	0.000	-1.532766	-1.4672
201101	-.9255145	.0431786	-21.43	0.000	-1.010143	-.8408859

201102	|	-1.228139	.0262677	-46.75	0.000	-1.279623	-1.176655
201103	|	-1.092089	.0248396	-43.97	0.000	-1.140774	-1.043405
state interacted with monthly indicator							
2 200901	|	-14.24384	.5474325	-26.02	0.000	-15.31679	-13.17089
2 200902	|	-13.54088	.518331	-26.12	0.000	-14.55679	-12.52497
2 200903	|	-16.25062	.4647394	-34.97	0.000	-17.16149	-15.33975
2 200904	|	-18.76405	.4715211	-39.79	0.000	-19.68822	-17.83989
2 200905	|	-19.30963	.4632841	-41.68	0.000	-20.21765	-18.40161
2 200906	|	-21.57624	.4973071	-43.39	0.000	-22.55095	-20.60154
2 200907	|	-25.5147	.5224062	-48.84	0.000	-26.5386	-24.4908
2 200908	|	-22.15775	.5028924	-44.06	0.000	-23.1434	-21.1721
2 200909	|	-32.42633	.5261241	-61.63	0.000	-33.45752	-31.39515
2 200910	|	-26.44687	.5309348	-49.81	0.000	-27.48749	-25.40626
2 200911	|	-17.17487	.5821393	-29.50	0.000	-18.31584	-16.0339
2 200912	|	-6.724921	.4933693	-13.63	0.000	-7.691907	-5.757934
2 201001	|	-6.855386	.4941245	-13.87	0.000	-7.823853	-5.886919
2 201002	|	-6.499494	.5447694	-11.93	0.000	-7.567223	-5.431765
2 201003	|	-17.73031	.3889161	-45.59	0.000	-18.49257	-16.96805
2 201004	|	-21.94704	.3813565	-57.55	0.000	-22.69448	-21.19959
2 201005	|	-18.90678	.3822114	-49.47	0.000	-19.6559	-18.15766
2 201006	|	-20.29665	.3830755	-52.98	0.000	-21.04746	-19.54583
2 201007	|	-23.06292	.4012778	-57.47	0.000	-23.84941	-22.27643
2 201008	|	-26.30591	.4283165	-61.42	0.000	-27.1454	-25.46643
2 201009	|	-32.79776	.4488772	-73.07	0.000	-33.67755	-31.91798
2 201010	|	-30.52598	.4351305	-70.15	0.000	-31.37882	-29.67314
2 201011	|	-14.44264	.4843888	-29.82	0.000	-15.39203	-13.49325
2 201101	|	-10.16058	.5146035	-19.74	0.000	-11.16919	-9.151975
2 201102	|	-16.37198	.3964678	-41.29	0.000	-17.14905	-15.59492
2 201103	|	-16.2204	.4099473	-39.57	0.000	-17.02389	-15.41692
3 200901	|	-2.719421	.4557286	-5.97	0.000	-3.612634	-1.826209
3 200902	|	-4.833738	.4596333	-10.52	0.000	-5.734604	-3.932873
3 200903	|	-2.1202	.4586602	-4.62	0.000	-3.019158	-1.221242
3 200904	|	-2.482411	.4517629	-5.49	0.000	-3.367851	-1.596971
3 200905	|	-1.926375	.4544875	-4.24	0.000	-2.817155	-1.035595
3 200907	|	-.766061	.4529398	-1.69	0.091	-1.653807	.1216853
3 200908	|	-1.251723	.4512852	-2.77	0.006	-2.136226	-.3672193
3 200909	|	-1.952124	.4520576	-4.32	0.000	-2.838141	-1.066106
3 200910	|	-1.832651	.4513288	-4.06	0.000	-2.71724	-.9480621
3 200911	|	-2.673984	.451699	-5.92	0.000	-3.559298	-1.78867
3 200912	|	-3.951661	.4600417	-8.59	0.000	-4.853326	-3.049995
3 201001	|	-3.513307	.475893	-7.38	0.000	-4.446041	-2.580573
3 201002	|	-2.760464	.5071023	-5.44	0.000	-3.754367	-1.766561
3 201003	|	-1.240512	.5077624	-2.44	0.015	-2.235709	-.2453155
3 201004	|	-2.562118	.5029819	-5.09	0.000	-3.547946	-1.576291
3 201005	|	-2.735408	.5035323	-5.43	0.000	-3.722314	-1.748502
3 201006	|	-1.480987	.5035467	-2.94	0.003	-2.467921	-.4940523
3 201007	|	-1.120872	.6074386	-1.85	0.065	-2.311431	.0696869
3 201008	|	-1.706594	.6428559	-2.65	0.008	-2.966569	-.4466181
3 201009	|	-1.13282	.6485791	-1.75	0.081	-2.404013	.1383728
3 201010	|	-1.975442	.6502539	-3.04	0.002	-3.249918	-.7009671
3 201011	|	-2.949383	.6507419	-4.53	0.000	-4.224815	-1.673952
3 201012	|	-4.499843	.6508389	-6.91	0.000	-5.775465	-3.224221
3 201101	|	-2.329826	.6518026	-3.57	0.000	-3.607337	-1.052316
3 201102	|	-1.289736	.653429	-1.97	0.048	-2.570434	-.0090371
3 201103	|	-1.724363	.6534582	-2.64	0.008	-3.005119	-.4436076

OHEC

Variable	Coefficient	Std. Err.	t-value	P>|t|	[95% Conf.	Interval]
Ohio OHEC	-.4752078	.1598156	-2.97	0.003	-.7884415	-.161974
Carolina OHEC	-1.639313	.1361068	-12.04	0.000	-1.906078	-1.372548
Kentucky OHEC	-1.156848	.4252654	-2.72	0.007	-1.990355	-.3233405
yearmonth- monthly indicators						
200902	6.1028	2.63925	2.31	0.021	.9299511	11.27565
200903	-2.973926	2.777778	-1.07	0.284	-8.418285	2.470433
200904	-28.67183	3.50644	-8.18	0.000	-35.54434	-21.79931
200905	-63.87458	3.371306	-18.95	0.000	-70.48224	-57.26693
200906	-178.4931	4.596679	-38.83	0.000	-187.5024	-169.4837
200907	-209.5281	7.25564	-28.88	0.000	-223.749	-195.3073
200908	-204.5421	6.464157	-31.64	0.000	-217.2117	-191.8726
200909	-174.9807	5.025815	-34.82	0.000	-184.8312	-165.1303
200910	-84.71277	3.19882	-26.48	0.000	-90.98236	-78.44318
200911	-45.71389	4.606562	-9.92	0.000	-54.74261	-36.68517
200912	16.12113	2.6609	6.06	0.000	10.90585	21.33641
201001	41.3951	3.073435	13.47	0.000	35.37126	47.41894
201002	27.33586	3.155435	8.66	0.000	21.15131	33.52042
201003	29.78945	2.51837	11.83	0.000	24.85352	34.72538
201004	-18.48318	2.952863	-6.26	0.000	-24.2707	-12.69566
201005	-136.32	4.33229	-31.47	0.000	-144.8111	-127.8288
201006	-194.0864	4.130382	-46.99	0.000	-202.1818	-185.9909
201007	-236.1339	7.18788	-32.85	0.000	-250.2219	-222.0458
201008	-211.5787	7.275538	-29.08	0.000	-225.8386	-197.3189
201009	-164.2715	5.105585	-32.17	0.000	-174.2783	-154.2647
201010	-120.3567	3.197601	-37.64	0.000	-126.6239	-114.0895
201011	-22.80084	3.209117	-7.11	0.000	-29.09062	-16.51107
201012	25.30604	2.464515	10.27	0.000	20.47567	30.13642
201101	66.20788	3.775215	17.54	0.000	58.80857	73.60718
201102	36.66786	2.833697	12.94	0.000	31.1139	42.22182
201103	9.462914	3.180452	2.98	0.003	3.229326	15.6965
temperature interacted with monthly indicator						
200901	-.7920264	.0458513	-17.27	0.000	-.8818935	-.7021594
200902	-.9218201	.0403026	-22.87	0.000	-1.000812	-.8428284
200903	-.760226	.0405027	-18.77	0.000	-.8396102	-.6808419
200904	-.338051	.0521215	-6.49	0.000	-.4402076	-.2358944
200905	.2580965	.0411678	6.27	0.000	.1774089	.3387841
200906	1.960164	.0577431	33.95	0.000	1.84699	2.073339
200907	2.356975	.0917796	25.68	0.000	2.17709	2.53686
200908	2.271226	.0791544	28.69	0.000	2.116085	2.426366
200909	1.881162	.0619722	30.35	0.000	1.759698	2.002625
200910	.5869888	.0384341	15.27	0.000	.5116592	.6623184
200911	-.0439493	.0737773	-0.60	0.551	-.1885505	.1006519
200912	-1.150471	.0367928	-31.27	0.000	-1.222583	-1.078358
201001	-1.783806	.0638012	-27.96	0.000	-1.908854	-1.658757
201002	-1.41811	.0645008	-21.99	0.000	-1.544529	-1.29169
201003	-1.490099	.0347189	-42.92	0.000	-1.558147	-1.422051
201004	-.4821425	.0367939	-13.10	0.000	-.5542573	-.4100276
201005	1.399267	.0585345	23.91	0.000	1.284541	1.513993
201006	2.172885	.0485893	44.72	0.000	2.077651	2.268118
201007	2.68543	.0865505	31.03	0.000	2.515793	2.855066
201008	2.35579	.0868163	27.14	0.000	2.185633	2.525947
201009	1.754277	.0611546	28.69	0.000	1.634416	1.874138
201010	1.134476	.0368492	30.79	0.000	1.062252	1.206699
201011	-.4310716	.0441303	-9.77	0.000	-.5175655	-.3445776
201012	-1.370989	.0326091	-42.04	0.000	-1.434902	-1.307076
201101	-2.537856	.0913773	-27.77	0.000	-2.716953	-2.358759
201102	-1.684399	.0496296	-33.94	0.000	-1.781671	-1.587126
201103	-1.039596	.0489464	-21.24	0.000	-1.135529	-.9436622
state interacted with monthly indicator						
2 200902	.7458418	.557853	1.34	0.181	-.3475329	1.839217
2 200903	-.8121234	.5531857	-1.47	0.142	-1.89635	.2721036
2 200904	-2.801436	.5491054	-5.10	0.000	-3.877666	-1.725206
2 200905	-3.36511	.546365	-6.16	0.000	-4.435969	-2.294251
2 200906	-4.325335	.5482618	-7.89	0.000	-5.399911	-3.250759
2 200907	-3.913752	.5729119	-6.83	0.000	-5.036641	-2.790862
2 200908	-3.161915	.5460493	-5.79	0.000	-4.232155	-2.091675

2	200909	-3.237897	.5430086	-5.96	0.000	-4.302177	-2.173616
2	200910	-2.628921	.5400286	-4.87	0.000	-3.687361	-1.570482
2	200911	-3.476591	.5446731	-6.38	0.000	-4.544134	-2.409049
2	200912	.024264	.5376477	0.05	0.964	-1.029509	1.078037
2	201001	4.398478	.5457061	8.06	0.000	3.328911	5.468045
2	201002	3.588498	.5471063	6.56	0.000	2.516187	4.66081
2	201003	2.051405	.5331268	3.85	0.000	1.006493	3.096318
2	201004	-1.954602	.5313711	-3.68	0.000	-2.996073	-.9131306
2	201005	-5.299274	.5384854	-9.84	0.000	-6.354689	-4.24386
2	201006	-4.655693	.5372707	-8.67	0.000	-5.708727	-3.602658
2	201007	-3.277058	.5478108	-5.98	0.000	-4.35075	-2.203366
2	201008	-1.67269	.5542155	-3.02	0.003	-2.758936	-.5864449
2	201009	-2.576074	.5475517	-4.70	0.000	-3.649259	-1.50289
2	201010	-3.263574	.5436797	-6.00	0.000	-4.32917	-2.197979
2	201011	-2.284696	.5407137	-4.23	0.000	-3.344478	-1.224913
2	201012	1.47561	.5432829	2.72	0.007	.4107921	2.540428
2	201101	6.170112	.5845433	10.56	0.000	5.024425	7.315799
2	201102	2.751435	.5495114	5.01	0.000	1.674409	3.82846
2	201103	-.9954718	.5540261	-1.80	0.072	-2.081346	.0904025
3	200901	-4.800005	.7892656	-6.08	0.000	-6.346941	-3.253068
3	200902	-8.255436	.6843585	-12.06	0.000	-9.596758	-6.914114
3	200903	-3.943258	.5398597	-7.30	0.000	-5.001367	-2.88515
3	200904	-.4013229	.5583763	-0.72	0.472	-1.495723	.6930776
3	200905	-.4390306	.5442348	-0.81	0.420	-1.505714	.6276529
3	200907	9.189895	.7675322	11.97	0.000	7.685555	10.69423
3	200908	4.292691	.6842789	6.27	0.000	2.951525	5.633857
3	200909	13.25935	.7441734	17.82	0.000	11.80079	14.71791
3	200910	7.464784	.7450409	10.02	0.000	6.004527	8.925041
3	200911	1.000552	.8762154	1.14	0.253	-.716803	2.717908
3	200912	-14.33377	.7421614	-19.31	0.000	-15.78838	-12.87915
3	201001	-18.37087	.7794767	-23.57	0.000	-19.89862	-16.84312
3	201002	-18.46548	.8850422	-20.86	0.000	-20.20014	-16.73083
3	201003	-2.171681	.5440646	-3.99	0.000	-3.238031	-1.105331
3	201004	-.1378551	.5283282	-0.26	0.794	-1.173362	.897652
3	201005	-5.336617	.532192	-10.03	0.000	-6.379697	-4.293537
3	201006	-3.836876	.538338	-7.13	0.000	-4.892002	-2.78175
3	201007	3.055561	.591153	5.17	0.000	1.89692	4.214203
3	201008	6.893369	.6588577	10.46	0.000	5.602028	8.184709
3	201009	11.38975	.7299049	15.60	0.000	9.959162	12.82034
3	201010	9.956821	.6898606	14.43	0.000	8.604716	11.30893
3	201011	-5.695116	.8066483	-7.06	0.000	-7.276122	-4.11411
3	201012	-21.35183	.7486924	-28.52	0.000	-22.81925	-19.88442
3	201101	-23.79701	.8934698	-26.63	0.000	-25.54819	-22.04584
3	201102	-6.114855	.5659414	-10.80	0.000	-7.224083	-5.005627
3	201103	-5.505351	.6004264	-9.17	0.000	-6.682168	-4.328533
4	200901	-5.861322	1.231562	-4.76	0.000	-8.275146	-3.447499
4	200902	-10.38068	1.172296	-8.86	0.000	-12.67834	-8.083015
4	200903	-3.243827	1.101798	-2.94	0.003	-5.403318	-1.084337
4	200904	-2.183546	1.08875	-2.01	0.045	-4.317463	-.0496286
4	200905	-2.393892	1.095938	-2.18	0.029	-4.541897	-.2458867
4	200907	6.828609	1.208247	5.65	0.000	4.460481	9.196737
4	200908	2.304797	1.158839	1.99	0.047	.0335076	4.576086
4	200909	9.570243	1.180024	8.11	0.000	7.257431	11.88305
4	200910	5.484633	1.198249	4.58	0.000	3.136101	7.833164
4	200911	-1.093537	1.264058	-0.87	0.387	-3.571052	1.383977
4	200912	-15.95889	1.191173	-13.40	0.000	-18.29355	-13.62423
4	201001	-19.01027	1.212553	-15.68	0.000	-21.38684	-16.6337
4	201002	-17.01281	1.278598	-13.31	0.000	-19.51882	-14.5068
4	201003	-1.210361	1.092289	-1.11	0.268	-3.351214	.9304931
4	201004	-1.443451	1.074951	-1.34	0.179	-3.550321	.6634191
4	201005	-7.14515	1.080256	-6.61	0.000	-9.262419	-5.02788
4	201006	-5.166153	1.085197	-4.76	0.000	-7.293106	-3.0392
4	201007	.5834876	1.106336	0.53	0.598	-1.584898	2.751873
4	201008	3.672043	1.124906	3.26	0.001	1.467262	5.876824
4	201009	9.13512	1.172299	7.79	0.000	6.837449	11.43279
4	201010	7.968857	1.160437	6.87	0.000	5.694436	10.24328
4	201011	-6.880328	1.225462	-5.61	0.000	-9.282195	-4.478461
4	201012	-22.25081	1.216083	-18.30	0.000	-24.6343	-19.86733
4	201101	-21.61695	1.289504	-16.76	0.000	-24.14434	-19.08957
4	201102	-3.931399	1.114829	-3.53	0.000	-6.11643	-1.746368
4	201103	-5.299288	1.130323	-4.69	0.000	-7.514686	-3.08389

Appendix I: Omitted Variable Bias Memo

There has been a lot of concern recently that our billing data analyses are somehow flawed because we do not adjust for measures that may have been installed through other energy efficiency programs. While this argument does make intuitive sense, it fails upon further examination. This memo presents a rather technical discussion of this issue. The first part of the memo presents a formal discussion of the issue, and the second part indicates what this need not be a concern given the approach we use in the billing data analysis.

Issue

Technically, the idea that the estimated savings for a program that is developed through a regression model may be incorrect if it does not account for participation in other program is a perfect example of what is termed in the literature omitted variable bias. It is straightforward to show that in a model with one included independent variable (X) and omitted independent variable (Z), the bias of the estimated coefficient $\hat{\beta}_x$ on the included variable can be stated as:

$$E(\widehat{\beta_x}) = \beta_x + \left[\frac{Cor(X,Z)\cdot\sigma_Z}{\sigma_X}\right]\beta_z ,$$

where β_x is the true effect of X on the dependent variable, β_z is the true effect of Z on the dependent variable, and σ_x and σ_z are the standard deviation of X and Z, respectively.[7]

This result shows that there is indeed a bias associated with not including a relevant variable. What is more noteworthy is that it is possible to estimate the sign and the magnitude of the bias. For this situation, where we expect both programs to produce savings (i.e., both β_x and β_z are negative), and the correlation between X and Z is positive, then the coefficient on the included variable will be biased downward (higher savings), consistent with the intuition.

Note however that the magnitude of the bias depends upon the true value for β_z (in the uninteresting case, if $\beta_z = 0$, there is no bias) as well as the correlation between X and Z (if the variables are uncorrelated, there is also no bias). In this sense, one can roughly view the amount of bias is a function of how much of the omitted variable is explained by the included variable.

We can now use this result to get an estimate on how pervasive the omitted variable bias might be our billing data analysis. This is addressed in the next section.

Extent of Bias

Based on the above discussion, the key to determining the extent of the bias in the estimated savings found through a model that does not incorporate participation in other programs is the correlation between the participation variable in the model and the omitted participation variable. The first critical thing to note is that this is not the same as the percentage of participants who enrolled in both programs. Since

[7] For the where there are more than one included independent variables (X_I) and more than one excluded variables (X_O), the equation becomes:

$$E(\hat{\beta}_I) = \beta_I + (X_I'X_I)^{-1}X_I'X_O$$

(See Green Econometric Analysis, Fifth Edition, 2003, page 148-149.

the billing analysis uses cross-section/time series data, the "temporal" difference between the dates that the customer participated in each program can have substantial impacts on the value for the correlation, even though the percentage of customers who participated in multiple programs is quite high.

This can perhaps be understood by some simple examples. First, assume that program participation is modeled through binary (1/0) variables, so the participation variables are zero for those months prior to the participation in a program, and one for all months after the participation date. Now consider a few extreme cases:

1. Suppose that every participant in the program in question also participated in another program, but they did so well in advance of their participation in the program being model, so far in the past that had the variable indicating participation in the first program (the omitted variable) is one for every customer. Aside from being collinear with the constant term (which indicates that this prior program is inherently incorporated in the baseline), the standard deviation for this variable (σ_z in the above equation) is zero, as there is no variation in this variable. The implication is that the bias associated with omitted variable goes to zero – there is no omitted variable bias.

2. At the opposite extreme, suppose again that all participants went on to participate in another program, but did so well after they participated in the program in question. In that situation, the omitted variable is primarily zero, and the standard deviation can be quite small, approaching zero. Again, the above equation indicates that the bias will thus approach zero, and there is no bias associated with omitting participation in the other program.

3. Finally, as before, all participants in one program also participated in another program, but this time at the very same time. In this case, the included participation variable and the omitted variable are identical (i.e., they are perfectly correlated), then the bias will be unity. In other words, the coefficient on the included variable will capture all of the effects of the omitted participation as well, and it is impossible to disentangle the separate savings from each program.

Of course, the in practice, none of the above cases are likely to be true. In general, only a fraction of participants in one program participate in another program, and if they do, there is usually a significant time difference between the participation dates. In such a case, there may indeed be some bias introduced, but it is likely to be small. For example, looking at the Duke Power's very successful CFL program, something on the order of 35% of all Duke's customers participated in the program. If we ignore the temporal variation, and assume that 35% of participants in any other Duke program will also have participated in the CFL program, then from the bias will be 35% *of the savings associated with CFLs*. If the monthly savings from the CFL program is, for illustration, around 30 kWh, the expected bias is around 10 kWh. This is relatively small effect is likely lost in the variation in usage across customers and over time.

Another aspect of the omitted bias issues relates to our use of the fixed-effect model. It can be shown that the fixed-effect specification will automatically eliminate the bias from omitted variables if these variables are either constant over time or constant across customers. For cases where these conditions do not hold (which is probably the case for multiple program participation), the fixed-effect approach does not eliminate the bias, but it does reduce the bias. To appreciate this result, the fixed-effect model:

$$y_{it} = \beta_i + \beta' x_{it} + \varepsilon_{it}$$

Can be estimated (assuming no serial correlations) using the first-difference:

$$\Delta y_i = \beta' \Delta x_i + \mu_i$$

The first difference the two participation variables (the included one X and the omitted one Z), this first difference will convert them from vectors of zeros and ones to a vector with many zeros and only a single value equal to one. This results in a substantial decrease in the correlation between the two variables, thus indicating a very small bias from omitting participation in other programs.

Final Report

Evaluation of Duke Energy's 2009-2011 "Get Energy Smart" Program in Ohio

An Impact Evaluation Report

Prepared for
Duke Energy
139 East Fourth Street
Cincinnati, OH 45201

December 22, 2011

Submitted by

Nick Hall and Brian Evans
TecMarket Works
165 West Netherwood Road
2nd Floor, Suite A
(608) 835-8855

Michael Ozog
Integral Analytics, Inc.

Pete Jacobs
BuildingMetrics, Inc.

TECMARKET Works

TABLE OF CONTENTS

Executive Summary

Key Findings and Recommendations

This section presents the key findings and recommendations identified through this evaluation. Table 1 presents the estimated overall impacts from the billing analysis

Table 1. Estimated Overall Impacts

	Gross Savings	Net Savings
Per Participant Annual Savings		
kWh	113	87
kW	0.010	0.007
Therms	4.10	3.14

The kWh impacts in this table are from the statistical analysis of participants' monthly electricity billing data. Since the billing data cannot provide estimates of either demand (kW) or gas (therms) savings as well as the net to gross ratio, these impact estimates were based upon the engineering analysis impacts, adjusted by the ratio of the overall kWh savings between the billing analysis and the engineering analysis (41%). The engineering analysis also provides insight into impacts by measures (the billing analysis only produces an overall number). Therefore, while the overall result is driven by the billing analysis, an engineering analysis is required as well, so both approaches will be discussed in the report.

The variance between the engineering estimates and the billing analysis can be explained by customer behavioral and psychological effects that are not accounted for in the engineering analysis. These effects include survey biases such as customers' inability to accurately estimate operating hours and imperfect recall regarding the wattage of the incandescent lamps replaced. For example, the Ohio Residential Smart $aver CFL study, dated June 29, 2010, compared customers' self reported hours of operation to the actual hours of operation, measured with lighting loggers, and discovered that customers responding to the survey overestimated their lighting usage by about 40%.

Significant Impact Evaluation Findings

- CFLs account for 70% of total program kWh savings
- These savings were statistically significant at the 95% level of confidence.
- While the realization rate was relatively low (41%), it is not reasonable given the measures involved and the characteristics of the program. Note however that the 95% confidence interval about the savings estimate extends from 76% to 6%.

Freeridership

CFL Freeridership for Duke Energy Customers

TecMarket Works utilized two questions from the student family survey to estimate CFL freeridership. The first question asked survey respondents whether or not they had installed CFLs prior to participating in the program, and if so, how many they had installed. The second question asked respondents if they had planned on buying any CFLs before participating in the program.

Quantities of pre-installed CFLs range from one to 40 among those respondents who indicated having pre-installed CFLs.

Freeridership ratios based on survey responses are assigned using a Bass curve based on diffusion of innovation product adoption concepts. Zero pre-installed CFLs correspond to an assigned freeridership score of zero percent. Fourteen or more CFLs correspond to a freeridership level of 100 percent. This allows higher credit for savings to participants with the lowest pre-existing use of CFLs and lower savings to those with a history of CFLs. The inflection point of the curve is seven CFLs, which is the typical level of CFL penetration among these participants. A graph of this curve is located in Figure 1 with the corresponding freeridership levels by CFL count shown in Table 2. This approach to estimating freeridership is consistent with the field of product adoption and diffusion research and represents a standard approach within the field of product adoption research. It also recognizes that the more CFLs a home has, the less likely the addition of new Duke Energy CFLs will have an impact on product adoption and use behaviors.

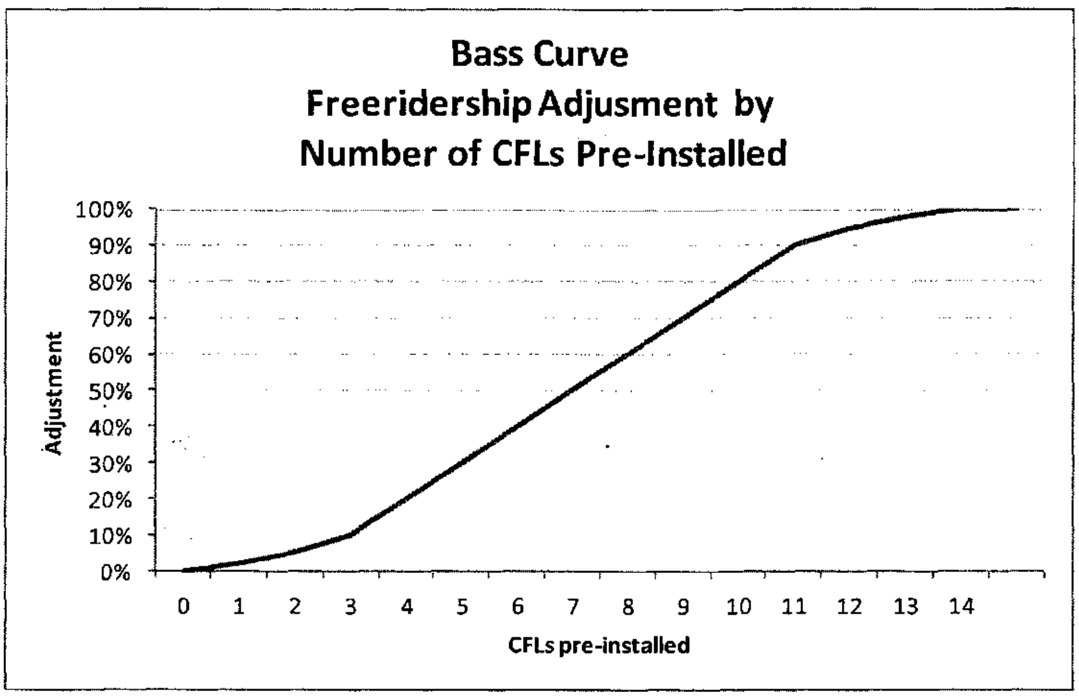


Figure 1. Bass Curve Freeridership Adjustment by Number of CFLs Pre-Installed

Table 2. CFL Freeridership Adjustment Determined by Bass Curve

Number of CFLs pre-installed	Freeridership pre-installation adjustment factor	Number of customers with number of pre-installed CFLs
0	0%	45
1	2%	6

2	5%	16
3	10%	6
4	20%	3
5	30%	4
6	40%	6
7	50%	6
8	60%	9
9	70%	0
10	80%	3
11	90%	0
12	95%	3
13	98%	2
14 or more	100%	11

In addition to the pre-installation adjustment factor, TecMarket Works applied a freeridership multiplier based on whether or not respondents indicated they had planned on purchasing measures before receiving the K-12 energy efficiency kit. These multipliers are shown in Table 3.

Table 3. Freeridership Multiplier Based on Measure Purchasing Plans

Did you plan on purchasing <measure> before receiving the K-12 kit?	Freeridership multiplier*
Yes	1.25 (result cannot exceed 100%) (reduces program savings)
Maybe	1
Don't Know	1
No	0.25 (results cannot be lower than 0%) (increases program savings)
No, already installed in all possible places	Automatic 100% freeridership score

*The values used to modify freeridership (1.25 and .25) represent best practices within the field of evaluation. They are consistant with standard practices requiring an adjustment approach that can reasonably be expected to reflect how technology innovation and diffusion algorithms are modified to compensate for customer preferences and intent as they relate to technology adoption rates.

Combining Table 2 with Table 3 produces Table 4.

Table 4. Number of Participants Cross-Referenced by Freeridership Adjustment and Multiplier

Number of CFLs pre-installed	Freeridership Pre-installation adjustment factor	Number of Participants per Freeridership Multiplier				
		1.25	**1**	**0.25**	**Automatic 0%**	**Automatic 100%**
0 (N=34)	0%	NA	NA	NA	45	0
1 (N=6)	2%	3	3	0	0	0
2 (N=9)	5%	7	7	2	0	0
3 (N=3)	10%	3	2	1	0	0
4 (N=3)	20%	2	1	0	0	0

5 (N=4)	30%	1	3	0	0	0
6 (N=6)	40%	4	2	0	0	0
7 (N=6)	50%	5	1	0	0	0
8 (N=9)	60%	7	1	0	0	1
9 (N=0)	70%	0	0	0	0	0
10 (N=3)	80%	2	0	1	0	0
11(N=0)	90%	0	0	0	0	0
12 (N=3)	95%	3	0	0	0	0
13 (N=2)	98%	2	0	0	0	0
14 or more (N=11)	100%	8	0	1	0	2

TecMarket Works then multiplied the freeridership adjustment factor by the freeridership multiplier for each survey respondent. An average of the resulting freeridership percentage across all 120 respondents that installed CFLs produced a freeridership level of 28.54% per participant.

Low-flow Showerhead Freeridership for Duke Energy Customers

Nineteen percent (14 out of 72) of the respondents who installed the low-flow showerhead indicated that they already had a low-flow showerhead installed in their home before receiving the K-12 kit.

The 54 respondents that indicated that they had not previously installed a low-flow showerhead were assigned a freeridership of zero. Two survey respondents did not answer the question and two indicated that they did not know.

Seven of the respondents who indicated that they already had a low-flow showerhead (but not that low-flow showerheads had been installed in all showers) also indicated that they had not been planning to purchase or use another low-flow shower head before receiving the K-12 kit. These respondents were assigned 25% freeridership. The other seven survey respondents who indicated pre-installed low-flow showerheads were assigned 100% freeridership.

An average of the resulting freeridership percentage across all 72 respondents with an installed kit low-flow showerhead produced a freeridership level of 12.15% per participant.

Faucet Aerator Freeridership for Duke Energy Customers

Twenty-eight percent (21 out of 75) of the respondents who installed the kitchen or bath aerators indicated that they already had an aerator installed in their home before receiving the K-12 kit.

The 54 respondents that indicated that they had not previously installed a faucet aerator were assigned a freeridership of zero.

Eighteen of the respondents who indicated that they already had an aerator (but not that aerators had been installed in all faucets) also indicated that they had not been planning to purchase or use another aerator before receiving the K-12 kit. These respondents were assigned 25%

freeridership. The other three survey respondents who indicated pre-installed aerators were assigned 100% freeridership.

An average of the resulting freeridership percentage across all 75 respondents with an installed kit aerators produced a freeridership level of 10.0% per participant.

Gasket Freeridership for Duke Energy Customers

Twenty-two percent (10 out of 46) of the respondents who installed outlet or switch gaskets to exterior walls indicated that they already had gaskets installed in their home before receiving the K-12 kit.

The 36 respondents that indicated that they had not previously installed any gaskets were assigned a freeridership of zero.

Two of the respondents who indicated that they already had installed gaskets (but not that gaskets had been installed in all available outlets or switches) also indicated that they had not been planning to purchase or use more gaskets before receiving the K-12 kit. These respondents were assigned 25% freeridership. The other eight survey respondents who indicated pre-installed gaskets were assigned 100% freeridership.

An average of the resulting freeridership percentage across all 46 respondents with installed kit gaskets produced a freeridership level of 18.48% per participant.

Introduction and Purpose of Study

Summary Overview

This document presents the evaluation report for Duke Energy's K-12 Curriculum, or "Get Energy Smart" Program as it was administered in Ohio.

Summary of the Evaluation

The Get Energy Smart Program provides energy efficiency informational and educational support and resources to 3rd and 4th grade teachers for them to incorporate into their lesson plans. Students are given Duke Energy's home energy audit survey to complete. These surveys can be returned to the teacher to be mailed back to Duke Energy in a large prepaid envelope or students can return them themselves in their own individual prepaid envelopes. The survey can also be taken online. Once the surveys are received and processed, Energy Efficiency Starter kits containing low-cost, energy efficiency measures are sent to the home. The kit also contains a business reply card that asks the family to indicate which of the measures in the kit were installed.

An impact analysis was performed for each of the measures in the Energy Efficiency Starter Kit. The impacts are based on a billing analysis comparing the pre and post program energy consumption levels of all program participants between July 2009 to March 2011. To increase the reliability of the study findings, additional confirmative analysis was performed using an engineering analysis of the impacts associated with the self-reported measure installs identified through a participant survey.

This report is structured to provide program energy savings impact estimations per measure via the engineering analysis, and program savings based on the billing analysis results. The impact tables reporting total savings are based on the savings identified from 134 surveyed participants extrapolated to the program's total participants. The engineering estimates include participants from June 2009 through mid-September of 2010 (n=5,002). The data for the billing analysis spans the time period from July 2009 to March 2011 and includes 6,271 participants.

Note that the participant sample size is larger for the billing analysis than it is for the engineering estimates. This is primarily because the analyses are performed at different times. The billing analysis was subsequent to the engineering estimates. As part of the process study, customer surveys are completed. Data from these surveys feed the engineering algorithms used to estimate savings. The billing analysis does not require survey data and, for this reason, can be completed at any time. Typically, the billing analysis is started as late as possible to allow for the largest possible number of participants to be included in the sample. Added participants yield more accurate results with higher statistical significance.

Description of Program

"The "Get Energy Smart" program goal is to educate children and their families about wise energy usage in their homes and personal choices they can make to save money, protect the environment and address climate change. The curriculum was designed to allow teachers to incorporate the materials into their existing math/science instructional schedules with supplemental activities on the Web.

The lessons are short, but relevant, and create opportunities for interactive, hands-on learning. Students and families can perform an on-line energy audit of their own homes, which creates an energy report for each participating family. After students perform the audit, those that live in Duke Energy territory receive a free energy efficiency starter kit containing information and the following items:

- 2 CFLs: a 13 Watt (60 Watt Equivalent), and a 20 Watt (100 Watt Equivalent)
- Efficient showerhead
- 2 low flow aerators: one kitchen and one bathrooom
- Weather stripping
- Duke Energy Labeled DOE Energy Savers Booklet
- Duke Energy Supplied Product Information and Instruction Sheet
- Personalized Energy Survey report
- Business reply card (BRC)
- Water flow meter bag
- 12 Outlet and light switch gasket insulators
- Refrigerator magnet
- Night light
- Duke Energy Supplied Toy (Glow Ring)
- Hot Water Temperature Guage Card
- Teflon Tape

Students that do not live in Duke Energy territory receive a kit containing the following Items:

- 13 Watt CFL (60 Watt Equivalent)
- Duke Energy Labeled DOE Energy Savers Booklet
- Water Flow Meter Bag
- Duke Energy Supplied Toy (Glow Ring)
- 8 Outlet Gasket Insulators
- Duke Energy Supplied Product Information and Instruction Sheet

Program Participation

Program	Impact Type	Participation Count
K-12 "Get Energy Smart"	Engineering	5,002
K-12 "Get Energy Smart"	Billing	6,271

Methodology

Overview of the Evaluation Approach

This impact evaluation has components: billing analysis and engineering estimates.

Study Methodology

Engineering Estimates

Engineering algorithms taken from the Draft Ohio TRM were used to estimate savings from all measures. Building energy simulation models of prototypical residential buildings were used to develop unit energy and demand savings estimates for outlet/switch gaskets. These unit energy savings values were applied to customers in the engineering analysis sample.

Billing Analysis

Program tracking data was used to pull billing data from all participants. The billing data was combined with information on participation date and whether the customer completed the mail or online version. This was in turn linked to weather data (temperature) to form the dataset used in the regression analysis.

Data collection methods, sample sizes, and sampling methodology

Engineering Estimates

Surveys were sent to 377 of the 3,619 K-12 participant families. Families in Duke territory returned a total of 126 surveys. Eight surveys were returned by non-Duke Energy customers. The survey asked the customer for information specific to each of the measures included in the Energy Efficiency Starter Kit.

Billing Analysis

The results from the billing analysis represent the entire population of participants in Duke territory with usable billing data, 6,271.

Number of completes and sample disposition for each data collection effort

Engineering Estimates

Families in Duke territory returned a total of 126 surveys. Eight surveys were returned by non-Duke Energy customers.

Billing Analysis

Program tracking data was used to pull billing data from all participants. The billing data was combined with information on participation date and whether the customer completed the mail or online version. This was in turn linked to weather data (temperature) to form the dataset used in the regression analysis.

Expected and achieved precision

Engineering Estimates

Engineering Estimates rely on participant survey responses. Sampling procedures for the participant survey had an expected and achieved precision of 90% ± 10%.

Billing Analysis

All savings estimates from the billing analysis were statistically significant at the 95% confidence level.

Description of baseline assumptions, methods and data sources

Baseline assumptions for all measures were taken from the Draft Ohio TRM. Impact analysis for the outlet/switch gaskets is based on unit energy savings derived from DOE-2.2 simulations of a set of prototypical residential buildings.

Description of measures and selection of methods by measure(s) or market(s)

The measures and methods are shown below. All customers are in the residential market.

Measure	Method
CFLs	Draft Ohio TRM
Low-flow showerheads	Draft Ohio TRM
Faucet aerators	Draft Ohio TRM
Outlet/switch gaskets	Draft Ohio TRM with DOE-2.2 simulation
Water temperature card	Draft Ohio TRM
Night light	Draft Ohio TRM

Billing Analysis

The billing analysis computed the overall savings associated with the program. There was no measure-level investigation.

Use of TRM values and explanation if TRM values not used

Engineering Estimates

The TRM was used for all measures. In the case of the outlet/switch gaskets, DOE-2.2 simulations were used to supplement the TRM. This was necessary because existing air leakage was not measured. The baseline condition of a building significantly impacts the opportunity for energy savings through air-sealing. Without this information, accurate savings calculations using engineering algorithms alone are impossible. Instead, DOE-2.2 simulations were performed, adding the indicated improvement to a set of prototypical residential buildings, and attributing equal savings to each incidence.

Billing Analysis

The billing analysis provides estimate of the savings that were actually achieved by participation households, thus there was no need to use TRM values.

Threats to validity, sources of bias and how those were addressed

Engineering Estimates

Measure adoptions were self-reported by the customers. There is a potential for social desirability bias[1] but the customer has no vested interest in their reported measure adoptions, so,

[1] Social desirability bias occurs when a respondent gives a false answer due to perceived social pressure to "do the right thing."

this bias is expected to be minimal. There is a potential for bias in the engineering algorithms, which was minimized through the use of building energy simulation models, which are considered to be state of the art for building shell and HVAC system analysis.

Billing Analysis

The specification of the model used in the billing analysis was designed specifically to avoid the potential of omitted variable bias by including monthly variables that capture any non-program effects that affect energy usage. The model did not correct for self-selection bias because there is no reason to as long as the program remains voluntary.

Snapback and Persistence

The theoretical additional energy and capacity used by customers that may occur from implementing an energy efficiency product, often called "snapback" if it occurs, is by design already captured in the impact evaluation through the billing analysis approach. The billing analysis approach uses actual energy use between the pre and post condition compared to what would occur without the program (control). All market or program effects conditions, including snapback, are already accounted for in this evaluation method. Further, there is little to no literature or snapback analysis within the evaluation industry that has been able to identify a snapback condition. The so-called snapback that has recently been referenced in the press has been the impact of normal electric demand growth that shows up in all customers as new products, services, and technologies are acquired and used. However, as noted above, any snapback that does occur would be captured in the evaluation design because of the use of pre and post billing analysis.

The billing data analysis, by using usage data from customers who participated as long as over two years ago, indicates that the impacts of the K-12 program are likely to persist for at least two years. However, the evaluation did not address how long these savings are likely to persist over time because the time span of the available data was not sufficient to address this issue. Both persistence and technical degradation are included in the calculation of each measure's effective useful life shown in Appendix D: DSMore Table.

Evaluation Findings

Billing Analysis

This section of the report presents the results of a billing analysis conducted over the participants in the Ohio K-12 program. Billing data was obtained for all participants in the K-12 program between July, 2009 and March, 2011 and that had accounts with Duke Energy. After processing, there were a total of 6,271 usable accounts.[2] A panel model was used to determine program impacts, where the dependent variable was monthly electricity consumption from January 2009 to March 2011. The results of the billing analysis are presented in Table 5.

Table 5. Estimated Ohio K-12 Impacts: Billing Analysis

	kWh	t-value
Per Participant Annual Savings (Gross)	113	2.33
Per Participant Annual Savings (Net)	87	

This table shows that the K-12 program produced statistically significant savings for participants in Ohio. The variance between the engineering estimates and the billing analysis can be explained by customer behavioral and psychological effects that are not accounted for in the engineering analysis. These effects include survey biases such as customers' inability to accurately estimate operating hours and imperfect recall regarding the wattage of the incandescent lamps replaced. For example, the Ohio Residential Smart $aver CFL study, dated June 29, 2010, compared customers' self reported hours of operation to the actual hours of operation, measured with lighting loggers, and discovered that customers responding to the survey overestimated their lighting usage by about 40%. The remainder of this section discusses the procedure used in the billing analysis.

For this analysis, data were available both across households (i.e., cross-sectional) and over time (i.e., time-series). With this type of data, known as "panel" data, it becomes possible to control, simultaneously, for differences across households as well as differences across periods in time through the use of a "fixed-effects" panel model specification. The fixed-effect refers to the model specification aspect that differences across homes that do not vary over the estimation period (such as square footage, heating system, etc.) can be explained, in large part, by customer-specific intercept terms that capture the net change in consumption due to the program, controlling for other factors that do change with time (e.g., the weather).

Because the consumption data in the panel model includes months before and after the installation of measures through the program, the period of program participation (or the participation window) may be defined specifically for each customer. This feature of the panel model allows for the pre-installation months of consumption to effectively act as controls for post-participation months. In addition, this model specification, unlike annual pre/post-participation models such as annual change models, does not require a full year of post-

[2] In order to maximize the use of the data, a single model was estimated over all states (Ohio, North Carolina, South Carolina and Kentucky). Therefore, the actual sample size in the model included 6,271 households in Ohio,10,503 in North Carolina, 3,251 in South Carolina and 398 in Kentucky, for a total sample size of 20,423 households.

participation data. Effectively, the participant becomes their own control group, thus eliminating the need for a non-participant group. We know the exact month of participation in the program for each participant, and are able to construct customer specific models that measure the change in usage consumption immediately before and after the date of program participation, controlling for weather and customer characteristics.

The fixed effects model can be viewed as a type of differencing model in which all characteristics of the home, which (1) are independent of time and (2) determine the level of energy consumption, are captured within the customer-specific constant terms. In other words, differences in customer characteristics that cause variation in the level of energy consumption, such as building size and structure, are captured by constant terms representing each unique household.

Algebraically, the fixed-effect panel data model is described as follows:

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it},$$

where:

y_{it} = energy consumption for home i during month t
α_I = constant term for site i
β = vector of coefficients
x = vector of variables that represent factors causing changes in energy consumption for home i during month t (i.e., weather and participation)
ε = error term for home i during month t.

With this specification, the only information necessary for estimation is those factors that vary month to month for each customer, and that will affect energy use, which effectively are weather conditions and program participation. Other non-measurable factors can be captured through the use of monthly indicator variables (e.g., to capture the effect of potentially seasonal energy loads).

The effect of the K-12 program is captured by including a variable which is equal to one for all months after the household participated in the program. The coefficient on this variable is the savings associated with the program. In order to account for differences in billing days, the usage was normalized by days in the billing cycle. The estimated electric model is presented in Table 6.[3]

Table 6. Estimated Savings Model – dependent variable is log (daily kwh usage), June 2009 through March 2011 (savings are negative)

[3] As stated previously, a single model was estimated over participants in all states. Thus, this table presents the impacts for the Carolinas and Kentucky in addition to the impacts for Ohio.

Independent Variable	Coefficient (percentage / 100)	t-value
K-12 participation – Ohio	-0.0067	-2.33
K-12 participation - Carolina	-0.0125	-6.00
K-12 participation - Kentucky	-0.0227	-1.79
Sample Size	478,093 observations (20,423 homes)	
R-Squared	74%	

Note that in this table, the dependent variable is the natural log of the monthly energy use. In this specification, the coefficient represents the savings as a percentage of the participant's usage. To derive the kWh savings, the coefficient in the table was multiplied by the average annual usage per participating household in Ohio (16,842 kWh/year) to give the 113.2 kWh/year savings estimate. The complete estimate model, showing the weather and time factors, is presented in Appendix B: Estimated Statistical Model.

Since some participating customers received an additional six-pack of CFLs, this analysis investigated both the effect of these additional CFLs on the overall impact estimates, as well as the impact associated with these additional CFLs. The results are presented in Appendix E: Effect of Additional CFLs. The finding that there is no statistical difference in the savings may be a result of the small sample size for the six-pack customers. These customers were such a small part of the population of customers that they essentially had no impact on the savings analysis.

Engineering Estimates

The K-12 program required participants to fill out and return a pre-participation questionnaire to Duke Energy before becoming eligible to participate. The K-12 program provided an Energy Efficiency Starter Kit to each participant that filled out and returned their questionnaire. Participation was not limited to Duke Energy customers, however, Non-Duke Energy customers received an abbreviated kit containing only one 13-watt CFL and four outlet and four switch gaskets. A mail-in survey was later mailed to a randomly selected sample of 395 participants, 377 Duke Energy customers and 18 Non-Duke Energy customers.

The results of this survey with the associated energy impact estimations for each of the kit items are presented below. Responses were received from 134 of the 395 participants, 126 from Duke Energy customers and eight from Non-Duke Energy customers. For the purpose of calculating overall savings estimates, the responses and estimated energy savings of these 134 respondents from the Ohio participants have been extrapolated to the full population of 5,002 participants that received an Energy Efficiency Starter Kit through the K-12 program between June 2009 and mid-September 2010. All algorithms used in the calculation of the savings estimates herein can be found in Appendix C: Impact Algorithms. The results are summarized in Table 7 and Table 8.

Table 7. Total Program Savings by Measure for Duke Energy Customers

Measure	kWh	kW	therms
CFLs	963,976	76.1	-1,643
Low-Flow Showerheads	314,413	34.5	43,437
Faucet Aerators	53,368	0.6	5,306
Outlet/Switch Gaskets	22,162	4.3	606
Water Temperature Card	13,502	1.5	1,865
Night Light	93	0.0	0
DUKE ENERGY	**1,367,514**	**117**	**49,570**

Table 8. Total Program Savings by Measure for Non-Duke Energy Customers

Measure	kWh	kW	therms
CFLs	6,452	0.5	-11
Outlet/Switch Gaskets	292	0.1	8
NON-DUKE ENERGY	**6,745**	**0.6**	**-3**

Table 9. Net Program Savings by Measure for Duke Energy Customers

Measure	NTG %	kWh	kW	therms
CFLs	28.54%	688,857	54.4	-1,174
Low-Flow Showerheads	12.15%	276,212	30.3	38,159
Faucet Aerators	10.00%	48,031	0.58	4,775
Outlet/Switch Gaskets	18.48%	18,066	3.54	494
Water Temperature Card	0.00%	13,502	1.54	1,865
Night Light	0.00%	93	0.00	0
DUKE ENERGY	**23.6%**	1,044,761	90	44,120

Table 10. Net Program Savings by Measure for Non-Duke Energy Customers

Measure	NTG %	kWh	kW	therms
CFLs	28.54%	4,611	0.356	-7.86
Outlet/Switch Gaskets	18.48%	238	0.047	6.51
NON-DUKE ENERGY	**28.1%**	**4,849**	**0.402**	**-1.35**

There were a total of 4,905 kits distributed to Duke Energy customers and 97 distributed to Non-Duke Energy customers. A net savings of 1,051,506 kWh was achieved, 1,044,761 kWh by Duke Energy customers and 4,849 kWh by Non-Duke Energy customers. The savings from CFL installations is responsible for the majority (66%) of the total program kWh savings. Low-flow showerheads contribute another 26% and are also the only measure supplying an appreciable amount of therm savings, 86% of the program total. Together, these two measures comprise 92% of the total program kWh savings.

Table 11. Net Program Savings Per Participant by Measure for All Duke Energy and Non-Duke Energy Participants

Measure	kWh	kW	therms
CFLs	138.6	0.0109	-0.2364
Low-Flow Showerheads	56.3	0.0062	7.7796
Faucet Aerators	9.79	0.0001	0.9735
Outlet/Switch Gaskets	3.66	0.0007	0.1000
Water Temperature Card	2.75	0.0003	0.3803
Night Light	0.02	0.0000	0.0000
TOTAL PER PARTICIPANT	**212**	**0.0183**	**9.07**

The combined net to gross percentage is 23.6% for Duke Energy customers and 28.1% for Non-Duke Energy customers. The comprehensive net to gross percentage is 23.62%. These percentages, along with net program savings, are broken down by measure in Table 9 and Table 10. Program-wide per-participant kWh savings with all Duke Energy and Non-Duke Energy customers combined is 212 kWh, as shown in Table 11.

CFLs

The standard Energy Efficiency Starter Kit included one 13-watt CFL and one 20-watt CFL. The kit received by Non-Duke Energy customers contained just the 13-watt CFL. Duke Energy customers that indicated that they had fewer than seven CFLs currently installed in their home when they filled out their pre-participation questionnaire and that had not exceeded the twelve CFL threshold within the CFL tracker, a database used by Duke to track CFL program participation, also received an additional six pack of CFLs[4] containing three 13-watt CFLs and three 20-watt CFLs; 1,142 such kits were given away. Non-Duke Energy customers were ineligible to receive this supplement.

A total of 224 13-watt CFLs and 180 20-watt CFLs were installed by 120 Duke Energy customers, an install rate of 87% and 70%, respectively. A total of 16,759 CFLs were given

[4] An analysis of the additional 6 pack is in "Appendix E: Effect of Additional CFLs".

away, 8,331 each of 13 and 20-watt CFLs to Duke Energy customers, and 97 13-watt CFLs to Non-Duke Energy customers. As presented in Table 12, a total of 7,233 13-watt and 5,812 20-watt CFLs were installed by Duke Energy customers. Another 84 13-watt CFLs were installed by Non-Duke Energy customers. To avoid inaccuracy due to insufficient sample size, the install rate for Duke Energy customers, 87%, was carried over to the non-customers.

Table 12. Total Number of CFLs Installed with Gross Annual Savings Estimates

	Total Installed	Install Rate	kWh	kW	therms
13W CFL	7,233	87%	554,172	42.7	-945
20W CFL	5,812	70%	409,804	33.4	-698
NON-DUKE ENERGY	84	87%	6,452	0.5	-11
TOTAL	13,130	78%	970,428	76.6	-1,654

From the mail-in survey, it was determined that, on average, participants use the 13-watt CFL to replace a 64-watt incandescent bulb and the 20-watt CFL to replace a 69-watt incandescent bulb. On average, customers reported that these bulbs are operated for 4.03 and 3.82 hours per day, respectively. The savings from installing each wattage of CFL are presented in Table 12. Extrapolating the data collected from the survey to the full population of program participants, K-12 participants reduced their gross annual kWh consumption by 970,428 kWh, or 203 kWh per household/participant per year. Mean values are shown in Table 13. Of the total savings, 554,172 kWh (58%) is from 13-watt CFLs and the other 409,804 kWh (42%) comes from 20-watt CFLs. This results in gross per-installation annual savings achievements of 76.6 kWh and 70.5 kWh, respectively. The slight increase in therm consumption occurs because incandescent bulbs burn much hotter than CFLs and consequently, homeowners must use a little more gas heating their homes in the winter.

Table 13. Mean Gross Annual Savings Estimates per Participant from Participants Installing CFLs

	kWh	kW	therms
13W CFL	122	0.009	-0.21
20W CFL	98	0.008	-0.17
COMBINED	203	0.016	-0.35

Outlet and Switch Gaskets

The standard Energy Efficiency Starter Kit contained 12 gaskets. The kit received by Non-Duke Energy customers contained only eight gaskets. Forty-one out of the 126 Duke Energy customers surveyed combined to install a total of 224 outlet and/or switch gaskets out of the 1,512 provided to them in the kit (15%) into exterior walls. Applying the same implementation rate to the Non-Duke Energy customers yields another 10 gaskets installed. Gasket installations in interior walls will realize zero savings and are therefore not counted. Projecting these numbers onto the entire participant base yields 8,720 gaskets installed by Duke Energy customers and 115 installations by Non-Duke Energy customers. Table 14 shows this installation information along with the savings estimates. From Table 15, each Duke Energy participant installed 5.46 gaskets and each Non-Duke Energy participant installed 3.59 gaskets in exterior walls. The outlet and switch gaskets installed by Duke Energy customers provided gross energy savings of 22,162 kWh, for an average of 13.9 kWh per participant per year. Non-Duke Energy customers saved 292 kWh, an average of 9.1 kWh per participant per year.

Table 14. Total Gaskets Installed in Exterior Walls with Gross Savings Estimates

	Total Installed	Install Rate	kWh	kW	Therms
DUKE ENERGY	8,720	15%	22,162	4.35	606
NON-DUKE ENERGY	115	15%	292	0.06	17
TOTAL	8,835	15%	22,454	4.41	623

Table 15. Mean Gaskets Installed in Exterior Walls with Mean Gross Savings Estimates

	Average Installed	kWh	kW	therms
DUKE ENERGY	5.46	13.9	0.003	0.38
NON-DUKE ENERGY	3.59	9.1	0.002	0.53
TOTAL	5.43	13.8	0.003	0.38

Low-Flow Showerheads

A total of 72 out of 126 (57%) low-flow showerheads were installed from the kits. Given that 57% of the participant population has installed their showerheads, it can be assumed that 2,803 have been installed in total. Low-flow showerheads were not provided to Non-Duke Energy customers. Participants that installed the showerhead lowered their daily hot water consumption for showers from 20.3 gallons before the installation to 9.8 gallons after the installation. Table 16 shows the installation figures along with estimates of their savings. An estimated gross 314,413 kWh is saved, an average of 112 kWh and 15.5 therms per installation per year, as seen in Table 17. In Ohio, 74% of participants have a gas water heater and 26% have an electric water heater.

Table 16. Total Low-Flow Showerheads Installed with Gross Savings Estimates

Total Installed	Install Rate	kWh[5]	kW	therms
2,803	57%	314,413	34.46	43,437

Table 17. Mean Gross Savings Estimates for Installed Low-Flow Showerheads

kWh	kW	therms
112	0.012	15.5

[5] All numbers and savings for water-related measures presented in the tables are program-wide. For example, participants with electric water heaters achieve electric and demand savings, while participants with gas heaters achieve only therm savings. This applies to low-flow showerheads, faucet aerators, and water temperature cards.

Faucet Aerators

One kitchen and one bathroom faucet aerator were given out in each Duke Energy customer kit. A total of 111 aerators were installed by 73 people with a 44% installation rate. Extrapolating this data to fit the participant population, 4,321 aerators are estimated to be installed. Faucet aerators were not provided to Non-Duke Energy customers. Table 18 shows that the aerators provided by the kit have saved 52,860 gross kWh. In Table 19, it is shown that per installation, this is about 12.35 kWh annually. In Ohio, 74% of participants have a gas water heater and 26% have an electric water heater.

Table 18. Total Faucet Aerators Installed with Gross Savings Estimates

Total Installed	Install Rate	kWh	kW	Therms
4,321	44%	53,368	0.64	5,306

Table 19. Mean Gross Savings Estimates for Installed Faucet Aerators

kWh	kW	therms
12.35	0.0001	1.228

Water Temperature Cards

A total of 48 out of the 126 participants (38%) reported using their water temperature card. However, only ten of these 48 people (21%) changed their water heater temperature based on the card's result. This means that approximately 8% of people have adjusted their water heater. Applying this number to the full population returns 389 adjustments made. Water temperature cards were not provided to Non-Duke Energy customers. For participants that made an adjustment, their average hot water temperature went from 135 degrees before the change to 124 degrees after the change. As shown in Table 20, an estimated 13,502 kWh per year was saved as a result of these changes, an average of 34.7 kWh per participant per year, as seen in Table 21. In Ohio, 74% of participants have a gas water heater and 26% have an electric water heater.

Table 20. Total Water Temperature Cards Used with Savings Estimates for Adjustments

Total Used	Usage Rate	kWh	kW	therms
389	8%	13,502	1.54	1,865

Table 21. Mean Savings Estimates for Water Temperature Adjustments

kWh	kW	therms
34.7	0.0040	4.792

LED Night Lights

Out of the 126 participants, 100 installed the LED night light, an installation rate of 79%. Just over half of these night lights, 54%, replaced an existing night light, meaning that the other 46% were used in a socket where there was previously no night light, this subtracts a small amount of savings from the measure. In all, there were 2,113 replacement night lights and 1,781 new night lights. Table 22 shows a total savings of 93 kWh per year. There were no kW or therm savings, and the LED night lights were not provided to Non-Duke Energy customers.

Table 22. Total LED Night Lights installed with Savings Estimates

Total Installed	Install Rate	kWh
3,893	79%	93

Appendix A: Required Savings Tables

The required table showing measure-level participation counts and savings for each program is below.

Measure	Participation Count	Verified Per unit kWh impact	Verified Per unit kW impact	Gross Verified kWh Savings	Gross Verified kW Savings
CFLs	5,002	79.79	0.0630	399,116	315
Low-Flow Showerheads	5,002	26.02	0.0071	130,177	35.7
Faucet Aerators	5,002	4.42	0.0001	22,096	0.62
Outlet/Switch Gaskets	5,002	1.83	0.0004	9,176	1.78
Water Temperature Card	5,002	1.12	0.0001	5,590	0.62
Night Light	5,002	0.01	0.0000	39	0.00

Appendix B: Estimated Statistical Model

This appendix show the complete model estimated for the billing analysis. The model includes indicators for each month (the yearmonth variable), temperature, the state the participant resides, and the participation variables.

Variable	Coefficient	Std. Err.	t-value	P>|t|	[95% Conf.	Interval]
Ohio Part	-.0067198	.00289	-2.33	0.020	-.0123841	-.0010555
Carolina Part	-.0124677	.0020794	-6.00	0.000	-.0165433	-.0083921
Kentucky Part	-.0227276	.0126868	-1.79	0.073	-.0475933	.0021381
yearmonth (time variables)						
200902	-.052312	.033756	-1.55	0.121	-.1184726	.0138487
200903	-.0715763	.0421097	-1.70	0.089	-.1541099	.0109574
200904	-.1556293	.0601211	-2.59	0.010	-.2734648	-.0377938
200905	-1.063964	.0581443	-18.30	0.000	-1.177925	-.9500025
200906	-3.438992	.0869149	-39.57	0.000	-3.609343	-3.268641
200907	-3.606707	.1163904	-30.99	0.000	-3.834829	-3.378586
200908	-3.965954	.1196231	-33.15	0.000	-4.200411	-3.731496
200909	-2.858674	.0768451	-37.20	0.000	-3.009288	-2.708059
200910	-1.481454	.0436092	-33.97	0.000	-1.566927	-1.395982
200911	-.3275281	.0653933	-5.01	0.000	-.455697	-.1993592
200912	.1987411	.033256	5.98	0.000	.1335604	.2639217
201001	.1349608	.0392585	3.44	0.001	.0580153	.2119063
201002	.1203595	.0412687	2.92	0.004	.0394741	.2012449
201003	.5782756	.0409695	14.11	0.000	.4979767	.6585745
201004	.1993842	.0500427	3.98	0.000	.1013021	.2974663
201005	-2.783248	.0815696	-34.12	0.000	-2.943122	-2.623374
201006	-3.55006	.0763178	-46.52	0.000	-3.699641	-3.40048
201007	-4.569939	.1307381	-34.95	0.000	-4.826182	-4.313697
201008	-3.825948	.1096061	-34.91	0.000	-4.040772	-3.611123
201009	-2.843417	.0753555	-37.73	0.000	-2.991111	-2.695722
201010	-2.341425	.0447405	-52.33	0.000	-2.429115	-2.253735
201011	-.0632438	.044417	-1.42	0.154	-.1502997	.0238121
201012	.1765302	.029746	5.93	0.000	.118229	.2348314
201101	.2212299	.0471835	4.69	0.000	.1287518	.313708
201102	.555201	.0426248	13.03	0.000	.4716578	.6387442
201103	.5683593	.047679	11.92	0.000	.47491	.6618087
temperature interacted with monthly indicator						
200901	-.0138686	.0007626	-18.19	0.000	-.0153632	-.0123739
200902	-.0143049	.0007527	-19.00	0.000	-.0157802	-.0128296
200903	-.0135311	.0007972	-16.97	0.000	-.0150937	-.0119686
200904	-.0127076	.0010832	-11.73	0.000	-.0148307	-.0105844
200905	.0039433	.0008611	4.58	0.000	.0022555	.0056311
200906	.0410536	.0011429	35.92	0.000	.0388135	.0432937
200907	.0456421	.0016258	28.07	0.000	.0424556	.0488285
200908	.0485673	.0016261	29.87	0.000	.0453803	.0517543
200909	.0363371	.0010932	33.24	0.000	.0341945	.0384798
200910	.0143571	.0006964	20.61	0.000	.0129921	.0157221
200911	-.0096781	.0012833	-7.54	0.000	-.0121934	-.0071629
200912	-.0224782	.0006526	-34.45	0.000	-.0237572	-.0211991
201001	-.0170185	.0011085	-15.35	0.000	-.019191	-.014846
201002	-.0198193	.0012126	-16.34	0.000	-.0221959	-.0174426
201003	-.0270605	.0006987	-38.73	0.000	-.0284299	-.0256911
201004	-.0167514	.0007344	-22.81	0.000	-.0181907	-.0153121
201005	.0289119	.0011713	24.68	0.000	.0266162	.0312077
201006	.0417506	.000957	43.63	0.000	.0398749	.0436262
201007	.0565541	.001666	33.95	0.000	.0532889	.0598194
201008	.0473564	.0013879	34.12	0.000	.0446361	.0500767
201009	.0368167	.0010226	36.00	0.000	.0348125	.038821
201010	.0286051	.0006504	43.98	0.000	.0273304	.0298798
201011	-.0166427	.0008261	-20.15	0.000	-.0182618	-.0150236
201012	-.0249429	.0005702	-43.75	0.000	-.0260605	-.0238254
201101	-.0209974	.0014676	-14.31	0.000	-.0238737	-.018121
201102	-.0273321	.0009304	-29.38	0.000	-.0291557	-.0255085
201103	-.0281919	.0008984	-31.38	0.000	-.0299527	-.0264311
state interacted with monthly indicator						
2 200901	.2404777	.0146982	16.36	0.000	.2116695	.2692858
2 200902	.3097867	.0141364	21.91	0.000	.2820798	.3374936

2	200903	.2506665	.0114111	21.97	0.000	.228301	.273032
2	200904	.1930738	.0116537	16.57	0.000	.1702328	.2159147
2	200905	.1268657	.011327	11.20	0.000	.104665	.1490663
2	200907	-.200628	.0153021	-13.11	0.000	-.2306198	-.1706363
2	200908	-.1056397	.0147499	-7.16	0.000	-.134549	-.0767304
2	200909	-.246503	.0145415	-16.95	0.000	-.2750039	-.2180021
2	200910	-.1033328	.0149927	-6.89	0.000	-.132718	-.0739476
2	200911	.1851111	.0165659	11.17	0.000	.1526424	.2175797
2	200912	.4145755	.014596	28.40	0.000	.3859679	.4431832
2	201001	.304861	.0152787	19.95	0.000	.2749152	.3348068
2	201002	.4098067	.0175765	23.32	0.000	.3753573	.4442562
2	201003	.2172948	.011091	19.59	0.000	.1955568	.2390328
2	201004	.1113218	.0107755	10.33	0.000	.0902021	.1324416
2	201005	.2296814	.0108011	21.26	0.000	.2085116	.2508512
2	201006	.055609	.0108398	5.13	0.000	.0343633	.0768547
2	201007	-.1511093	.012124	-12.46	0.000	-.174872	-.1273467
2	201008	-.1792477	.0123959	-14.46	0.000	-.2035433	-.1549521
2	201009	-.2885355	.0135805	-21.25	0.000	-.3151528	-.2619181
2	201010	-.2003509	.0132729	-15.09	0.000	-.2263653	-.1743364
2	201011	.3172147	.015395	20.61	0.000	.287041	.3473884
2	201012	.5328833	.0148749	35.82	0.000	.5037289	.5620377
2	201101	.3508014	.0162304	21.61	0.000	.3189903	.3826126
2	201102	.2363542	.0114875	20.57	0.000	.2138391	.2588694
2	201103	.2976398	.0121518	24.49	0.000	.2738228	.3214569
3	200901	-.0335729	.0287799	-1.17	0.243	-.0899807	.0228348
3	200902	.0026508	.0297882	0.09	0.929	-.0557332	.0610348
3	200903	-.0168359	.029722	-0.57	0.571	-.0750901	.0414184
3	200904	-.0211797	.0283686	-0.75	0.455	-.0767813	.0344219
3	200905	-.1413398	.0286474	-4.93	0.000	-.1974879	-.0851918
3	200907	-.0015518	.0282434	-0.05	0.956	-.0569081	.0538044
3	200908	.0572144	.0280412	2.04	0.041	.0022546	.1121742
3	200909	-.0861749	.0279939	-3.08	0.002	-.1410422	-.0313077
3	200910	-.0843118	.0279604	-3.02	0.003	-.1391133	-.0295103
3	200911	-.0351205	.0280048	-1.25	0.210	-.090009	.0197681
3	200912	.0872507	.0281925	3.09	0.002	.0319942	.1425072
3	201001	-.0360286	.0285158	-1.26	0.206	-.0919187	.0198614
3	201002	.0130815	.0287192	0.46	0.649	-.0432074	.0693703
3	201003	-.0435733	.0286941	-1.52	0.129	-.0998129	.0126662
3	201004	-.0587561	.0284881	-2.06	0.039	-.114592	-.0029202
3	201005	.0058591	.029481	0.20	0.842	-.0519228	.0636409
3	201006	.1033168	.0295559	3.50	0.000	.0453882	.1612453
3	201007	.0270181	.0294907	0.92	0.360	-.0307827	.0848188
3	201008	.0084112	.0295064	0.29	0.776	-.0494203	.0662427
3	201009	-.0501598	.0295561	-1.70	0.090	-.1080889	.0077693
3	201010	-.0750878	.0309838	-2.42	0.015	-.135815	-.0143606
3	201011	.0130509	.0310657	0.42	0.674	-.0478369	.0739386
3	201012	.1036032	.0310394	3.34	0.001	.042767	.1644394
3	201101	-.0131601	.0311165	-0.42	0.672	-.0741474	.0478272
3	201102	-.0180948	.0312241	-0.58	0.562	-.0792932	.0431035
3	201103	-.0268983	.0311963	-0.86	0.389	-.0880421	.0342456

Appendix C: Impact Algorithms

CFLs

General Algorithm

Gross Summer Coincident Demand Savings

$$\Delta kW_S = \text{units} \times \left[\frac{(Watts \times DF_s)_{base} - (Watts \times DF_s)_{ee}}{1000}\right] \times CF_S \times (1 + HVAC_{d,\,s})$$

Gross Annual Energy Savings

$$\Delta kWh = \text{units} \times \left[\frac{(Watts \times DF)_{base} - (Watts \times DF)_{ee}}{1000}\right] \times FLH \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \times HVAC_g$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
$\Delta therm$ = gross annual therm interaction
units = number of units installed under the program
$Watts_{ee}$ = connected (nameplate) load of energy-efficient unit
$Watts_{base}$ = connected (nameplate) load of baseline unit(s) displaced
FLH = full-load operating hours (based on connected load)
DF = demand diversity factor
CF = coincidence factor
$HVAC_c$ = HVAC system interaction factor for annual electricity consumption = 0.023625
$HVAC_d$ = HVAC system interaction factor for demand = 0.1628
$HVAC_g$ = HVAC system interaction factor for annual gas consumption = -0.0017

13 W CFL Measure

$Watts_{ee}$ = 13, which is the input power of program supplied CFL

$Watts_{base}$ - calculated from survey responses as shown below = 63.81696

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 – 70	60	Lumen equivalent of 15 W CFL
71 – 99	75	Most popular size in range
> = 100	100	Most popular size in range

FLH - calculated from survey responses as shown below: = 1472.887 for 13-watt bulb, 1396.088 For the 20-watt bulb.

Hours of use per day	FLH	Notes
<1	183	Average value over range
1-2	548	Average value over range
3-4	1278	Average value over range
5-10	2738	Average value over range
11-12	4198	Average value over range
13-24	6753	Average value over range

DF = 1.0 and CF = 0.10

The coincidence factor for this analysis was taken as the average of the coincidence factors estimated by PG&E and SCE for residential CFL program peak demand savings. The PG&E and SCE coincidence factors are combined factors that consider both coincidence and diversity, thus the diversity factor for this analysis was set to 1.0

$HVAC_c$ - the HVAC interaction factor for annual energy consumption depends on the HVAC system, heating fuel type, and location. The HVAC interaction factors for annual energy consumption were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Heating Fuel	Heating System	Cooling System	HVACc	HVACg
Other	Any except Heat Pump	Any except Heat Pump	0	0
Any	Heat Pump	Heat Pump	-0.16	0
Gas Propane Oil	Central Furnace	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021

	Other	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021
Electricity	Central furnace	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0
	Electric baseboard	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0
	Other	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0

$HVAC_d$ - the HVAC interaction factor for demand depends on the cooling system type. The HVAC interaction factors for summer peak demand were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Cooling System	HVACd
None	0
Room/Window	.17
Central AC	.17
Heat Pump	.17

20W CFL Measure

$Watts_{ee}$ = 20, which is the input power of program supplied CFL

$Watts_{base}$ - calculated from survey responses as shown below: = 69.33702

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 – 70	60	Most popular size in range
71 – 99	75	Lumen equivalent of 20 W CFL
> = 100	100	Most popular size in range

Outlet Gaskets

Gross Summer Coincident Demand Savings

ΔkW_S = units × $(\Delta cfm/unit) \times (kW / cfm)$ × $DF_S \times CF_S$

Gross Annual Energy Savings

ΔkWh = units × $(\Delta cfm/unit) \times (kWh / cfm)$

$$\Delta therm = units \times (\Delta cfm / unit) \times (therm / cfm)$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
units = number of buildings sealed under the program
$\Delta cfm/unit$ = unit infiltration airflow rate (ft^3/min) reduction for each measure
DF = demand diversity factor = 0.8
CF = coincidence factor = 1.0
kW/cfm = demand savings per unit cfm reduction = 0.000903
kWh/cfm = electricity savings per unit cfm reduction = 3.683335
therm/cfm = gas savings per unit cfm reduction = 0.10067

Unit cfm savings per measure

The cfm reductions for each measure were estimated from equivalent leakage area (ELA) change data taken from the ASHRAE Handbook of Fundamentals (ASHRAE, 2001). The equivalent leakage area changes were converted to infiltration rate changes using the Sherman-Grimsrud equation:

$$Q = ELA \text{ x } \sqrt{A \times \Delta T + B \times v^2}$$

where:

A = stack coefficient ($ft^3/min\text{-}in^4\text{-}°F$) = 0.015 for one-story house
ΔT = average indoor/outdoor temperature difference over the time interval of

interest (°F)

B = wind coefficient ($ft^3/min-in^4-mph^2$)
= 0.0065 (moderate shielding)

v = average wind speed over the time interval of interest measured at a local weather station at a height of 20 ft (mph)

The location specific data are shown below:

Location	Average outdoor temp	Average indoor/outdoor temp difference	Average wind speed (mph)	Specific infiltration rate (cfm/in^2)
Covington	33	35	22	1.92

Measure ELA impact and cfm reductions are as follows:

Measure	Unit	ELA change (in^2/unit)	ΔCfm/unit (KY)
Outlet gaskets	Each	0.357	0.69
Weather strip	Foot	0.089	0.17
Fireplace	Each	1.86	3.57

Unit energy and demand savings

The energy and peak demand impacts of reducing infiltration rates were calculated from infiltration rate parametric studies conducted using the DOE-2 residential building prototype models, as described at the end of this Appendix. The savings per cfm reduction by heating and cooling system type are shown below:

Heating Fuel	Heating System	Cooling System	kWh/cfm	kW/cfm	therm/cfm
Other	Any except Heat Pump	Any except Heat Pump	1.14	0.00000	0.000
Any	Heat Pump	Heat Pump	12.85	0.00248	0.000
Gas Propane Oil	Central Furnace	None	0	0	0.124
		Room/Window	1.14	0.00000	0.124
		Central AC	1.14	0.00000	0.124
	Other	None	0	0	0.124
		Room/Window	1.14	0.00000	0.124
		Central AC	1.14	0.00000	0.124
Electricity	Central furnace	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000
	Electric baseboard	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000

	Other	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000

Low-Flow Showerhead

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{3413_s} \times DF_x \times CF_s$$

Gross Annual Energy Savings

$$\Delta kWh = units \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{3413} \times 365$$

$$\Delta therm = units \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{\eta_{waterheater}} \times \frac{365}{100000}$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
units = number of units installed under the program
GPD_{base} = daily hot water consumption before installation
GPD_{ee} = daily hot water consumption after flow reducing measure installation
ΔT = average difference between entering cold water temperature and the shower use temperature
DF = demand diversity factor for electric water heating

CF = coincidence factor
8.33 = conversion factor (Btu/gal-°F)
3413 = conversion factor (Btu/kWh)
24 = conversion factor (hr/day)
365 = conversion factor (days/yr)
100000 = conversion factor (Btu/therm)

Showerhead

GPD_{base} = showers/week / 7 x 3.1 gpm x 5 minutes/shower

GPD_{ee} = showers/week / 7 x 1.5 gpm x 5 minutes/shower

ΔT

City	Average cold water temperature	Shower use temperature	Average ΔT
Covington	53.9°F	100°F	46.1°F

Water heater efficiency

Combustion efficiency for residential gas water heater = 0.70

Demand diversity factor = 0.1

Coincidence factor = 0.4

Showers/week = 9.16

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for the residential water heating end-use in a summer peaking utility.

Faucet Aerators

This measure used the Efficiency Vermont deemed savings (Efficiency Vermont, 2003) adjusted for entering water temperature:

Demand Savings
$\Delta kW = 0.0171\ kW \times \Delta T / \Delta T_{VT} \times DF \times CF$

Energy Savings
$\Delta kWh_i = 57\ kWh \times \Delta T / \Delta T_{VT}$
$\Delta therms = 2.0 \times \Delta T / \Delta T_{VT\,i}$

City	Average cold water temperature	Hot water use temperature	Average ΔT
Covington	53.9°F	100°F	46.1°F
Burlington VT	44.5	100°F	55.5

Demand diversity factor = 0.1

Coincidence factor = 0.4

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for the residential water heating end-use in a summer peaking utility.

Water Temperature Card

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times \frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3413} \times DF_s \times CF_s$$

Gross Annual Energy Savings

$$\Delta kWh = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{3413} \times 8760$$

$$\Delta therm = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{\eta_{waterheater}} \times \frac{8760}{100000}$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
units = number of water heaters installed under the program
UA_{base} = overall heat transfer coefficient of base water heater (Btu/hr-°F) =4.6817
UA_{ee} = overall heat transfer coefficient of improved water heater (Btu/hr-°F) =1.9217

ΔT = temperature difference between the tank and the ambient air (°F)
DF = demand diversity factor
CF = coincidence factor
3413 = conversion factor (Btu/kWh)
8760 = conversion factor (hr/yr)
100000 = conversion factor (Btu/therm)
$\eta_{waterheater}$ = water heater efficiency

Water heater tank UA

Water heater size (gal)	Electric		Gas	
	UAbase	UAee	UAbase	UAee
30	3.84	1.69	4.21	1.76
50	4.67	1.83	5.13	1.91
60	4.13	2.06	4.54	2.14
75	5.00	2.42	5.50	2.52
80+	5.72	2.53	6.28	2.64

ΔT = 140°F water setpoint temp – 65°F room temp = 75°F

DF = 1.0
CF= 1.0
$\eta_{waterheater} = 0.7$

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential water heaters meeting standby losses.

LED Night Lights

$Watts_{ee} = 0.6$
$Watts_{base} = 4$
Daily Operating Hours = 24

$\Delta kWh = units \times (Watts_{base} - Watts_{ee}) / (1000 \times DailyOH) \times 365$

Prototypical Building Model Description

The impact analysis for many of the HVAC related measures are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER) study (Itron, 2005), with adjustments make for local building practices and climate. The prototype "model" in fact contains 4 separate residential buildings; 2 one-story and 2 two-story buildings. The each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these 4 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures. A sketch of the residential prototype buildings is shown in Figure 2.

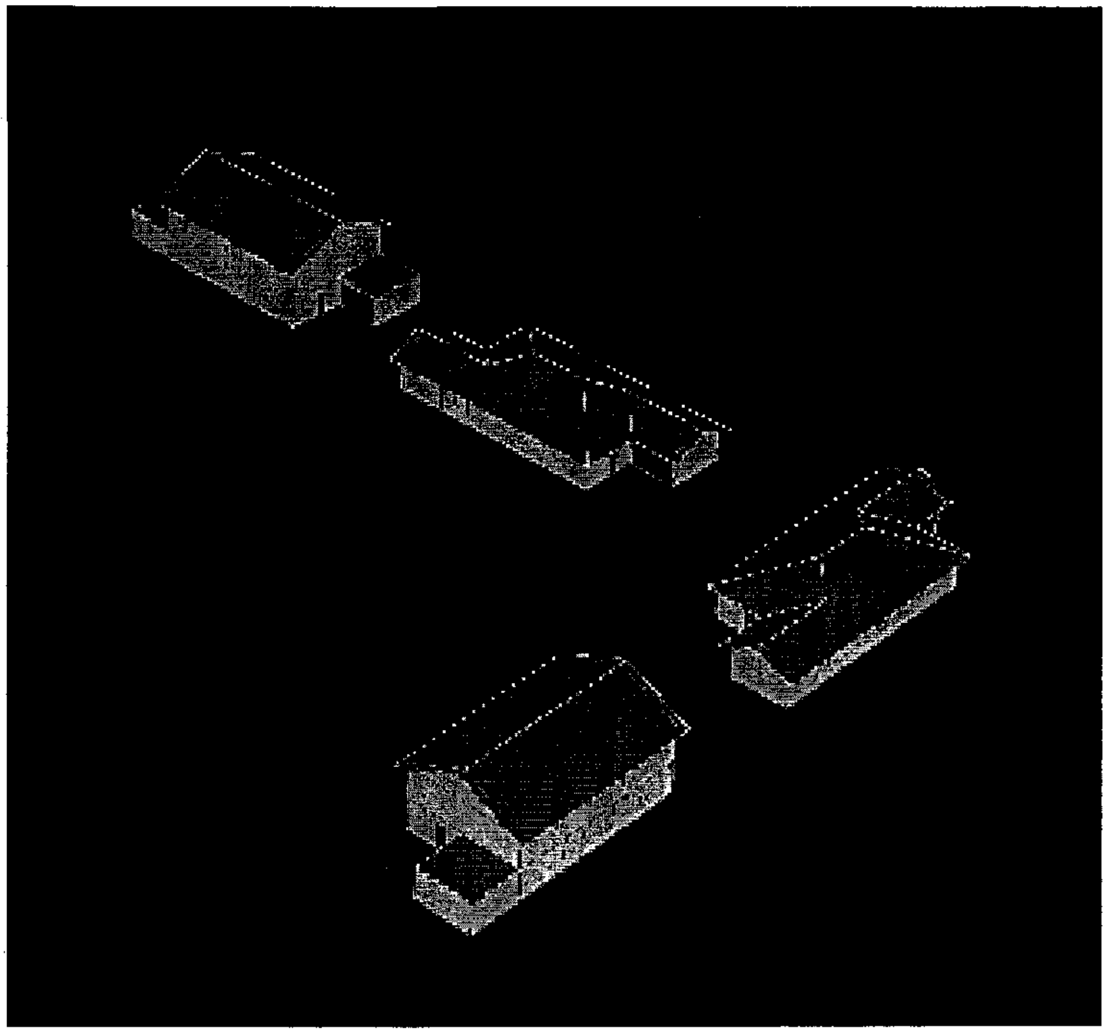


Figure 2. Computer Rendering of Residential Building Prototype Model

The general characteristics of the residential building prototype model are summarized below:

Residential Building Prototype Description

Characteristic	Value
Conditioned floor area	1 story house: 1465 SF 2 story house: 2930 SF

Characteristic	Value
Wall construction and R-value	Wood frame with siding, R-11
Roof construction and R-value	Wood frame with asphalt shingles, R-19
Glazing type	Single pane clear
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% oversizing. Average 640 SF/ton
HVAC system efficiency	SEER = 8.5
Thermostat setpoints	Heating: 70°F with setback to 60°F Cooling: 75°F with setup to 80°F
Duct location	Attic (unconditioned space)
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct insulation	Uninsulated
Duct leakage	26%; evenly distributed between supply and return
Cooling season	Charlotte – April 17 to October 6 Covington
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F. 3 air changes per hour

References

ASHRAE, 2001. ASHRAE Handbook of Fundamentals, American Society of Heating, Refrigeration and Airconditioning Engineers, Atlanta, GA, 2001.

Efficiency Vermont, 2003. Technical Reference Manual, Master Manual Number 4, Measure Savings Algorithms and Cost Assumptions, Efficiency Vermont, Burlington, VT. 2003.

EPRI, 1993. Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2: Fundamental Equations for Residential and Commercial End-Uses, EPRI TR-100984 V2., Electric Power Research Institute, Palo Alto, CA. 1993.

Itron, 2005. "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report," Itron, Inc., J.J. Hirsch and Associates, Synergy Consulting, and Quantum Consulting. December, 2005. Available at http://eega.cpuc.ca.gov/deer

Appendix D: DSMore Table

Per Measure Impacts Summary for K-12 Ohio Duke Energy Customers

Impacts Technology	Product code	State	EM&V gross savings (kWh/unit)	EM&V gross kW (customer peak/unit)	EM&V gross kW (coincident peak/unit)	Unit of measure	Combined spillover less freeridership adjustment	EM&V net savings (kWh/unit)	EM&V net kW (customer peak/unit)	EM&V net kW (coincident peak/unit)	EM&V load shape (yes/no)	EUL (whole number)
CFLs		Ohio	79.79	0.0630	0.0063	participant	28.54%	57.0	0.0450	0.0045	no	5
Low-Flow Showerheads		Ohio	26.02	0.0071	0.0029	participant	12.15%	22.9	0.0063	0.0025	no	10
Faucet Aerators		Ohio	4.42	0.0001	0.0000	participant	10.00%	4.0	0.0001	0.0000	no	10
Outlet/Switch Gaskets		Ohio	1.83	0.0004	0.0004	participant	18.48%	1.5	0.0003	0.0003	no	20
Water Temperature Card		Ohio	1.12	0.0001	0.0001	participant	0.00%	1.1	0.0001	0.0001	no	3
Night Light		Ohio	0.01	0.0000	0.0000	participant	0.00%	0.008	0.0000	0.0000	no	16
Program wide			**113**	**0.071**	**0.010**		**23.62%**	**87**	**0.052**	**0.007**		**7**

Appendix E: Effect of Additional CFLs

This appendix investigates the effect on the estimated program impacts from those customers who received the additional six-pack of CFLs as part of the K12 program relative to the other participants in K12. This is in response to concerns that the estimated K12 impacts (that did not differentiate between those customers who received the six-pack) may overstate the prospective savings from the program since the six-pack will not be used in future K12 implementations.

In order to investigate the impact of the six-pack customers on the estimated savings for K12, a variable denoting these customers was included in the prior K12 billing analysis model. The results are shown in Table 23 (the dependent variable is in log form, so the savings in this table represent percentage of usage):

Table 23. Estimated K12 impacts with and without accounting for the CFL six-pack

State	Savings (percent/100) from original model (t-value)	Savings (percent/100) account for six-pack CFLs (t-value)
K12 participation – Ohio	-0.0067 (-2.33)	-0.0055 (-1.82)
K12 participation - Carolinas	-0.0125 (-6.00)	-0.0124 (-5.95)
K12 participation - Kentucky	-0.0227 (-1.70	-0.0227 (-1.79)
Additional savings from six-pack CFLs		-0.0075 (-1.49)

These results show that:

1. There is no statistically significant difference between the savings found from the model that did not explicitly capture the effect of the CFL six-pack and one that does. Indeed, for all intents and purposes there is no impact on the savings estimates for the Carolinas and Kentucky, and the difference between the two estimates in Ohio is not statistically significant.

2. The CFL six-pack caused an incremental savings of 0.75% relative to those K12 participants who received only two CFLs, but this result is not statistically significant.

The finding that there is no statistical difference in the savings may be a result of the small sample size for the six-pack customers. These customers were such a small part of the population of customers that they essentially had no impact on the savings analysis.

Case No. 13-753-EL-RDR
Attachment AJO 5

Final Report

Evaluation of the 2009-2010 Residential Smart $aver® HVAC Program in Ohio

Results of an Impact Evaluation

Prepared for
Duke Energy
139 East Fourth Street
Cincinnati, OH 45201

January 2, 2012

Submitted By:

Pete Jacobs
BuildingMetrics, Inc

Michael Ozog
Integral Analytics

Nick Hall, Brian Evans, and
John Wiedenhoeft

TecMarket Works
165 West Netherwood Road
Oregon, Wisconsin 53575
(608) 835-8855

TECMARKET Works

Table of Contents

Executive Summary

Key Findings and Recommendations

An overview of the key findings identified through this evaluation is presented in this section.

Significant Impact Evaluation Findings

Table 1 presents the gross unit kWh and kW savings per ton associated with the Residential Smart $aver program. These results are obtained based on a model which uses the results of the engineering analysis within a statistical billing data analysis (the SAE approach).

Table 1. Energy Savings Per Ton Associated with the Residential Smart $aver Program in Ohio

Measure	Gross Energy and Demand Savings Per Ton		
	kWh/ton	kW/ton	Therm/ton
AC_seer14	147	0.14	-4
AC_seer15	176	0.12	-4
AC_seer16	282	0.1	-6
AC_seer17	301	0.13	-6
Hp_seer14	940	0.11	0
Hp_seer15	829	0.17	0
Hp_seer16	1,221	0.18	0
Hp_seer17	539	0.19	0
Hp_seer18	1,327	0.19	0

Program participation by HVAC system type, size, SEER, and location were applied to the savings per ton estimates from Table 1 above to compute the program savings, as shown in Table 2. These results are consistent with current evaluation results in Ohio.[1]

Table 2. Summary of Program Savings by Measure

Measure	Participation Count	Gross Ex Post kWh Savings	Gross Ex Post kW Savings	Gross Ex Post kWh Savings per unit	Gross Ex Post kW Savings per unit
Air conditioner	5,604	3,398,450	1,955	606	0.349
Heat Pump	5,670	14,729,349	2,598	2,628	0.464

[1] For example, see DP&L's 2010 Evaluation, Measurement and Verification Report, March 15, 2011, page 70.

- The electronically commutated (EC) motors required by the program caused very little change in occupant behavior relative to supply fan usage. Large increases in supply fan operating hours after system installation were not observed. The proportion of fan systems operating continuously decreased slightly after system installation.
- The EC motors provided substantial savings in fan power consumption, on the order of 46%.
- Future monitoring should capture fan, compressor and strip heat energy to provide full unit heating and cooling data for model development and calibration.
- Engineering modeling revealed energy and demand savings that are not proportional to the difference in SEER. The SEER, which is based on a standardized laboratory test, is not a reliable predictor of annual energy consumption under the more realistic operating conditions included in the building energy simulation models. Higher SEER air conditioners and heat pumps typically rely on multiple compressors to improve part-load performance, but may not provide proportional improvements in full-load efficiency. The results seen in this evaluation are consistent with results in other states.
- The billing analysis indicates that the participants realized 55.1% and 108.5% of the savings estimated by the engineering analysis for air conditioners and heat pumps, respectively.
- Participating dealers should record the make and model number of the replaced air conditioner and provide an assessment of the condition of the unit as part of the rebate application process. These data will allow the evaluation team to improve the estimate of the early replacement baseline efficiency.

Recommendation

- Duke Energy may wish to consider conducting an economic impact evaluation of key Duke Energy programs, including the Smart $aver Program, as previous studies suggest that job related impacts of energy efficiency programs may be substantial. Previous studies conducted on the economic impacts associated with energy efficiency programs show impacts in four job creation categories. These include: 1) Jobs created by helping businesses become more profitable by lowering their cost of operations, making them more competitive; 2) Lowering the energy cost of living for customers that increases their disposable income, which in turn supports jobs driven by expenditures other than energy; 3) Dollars spent more locally on non-energy expenditures keeps more dollars in the state being re-spent through the local economy creating more in-state jobs; and 4) Greater spending within non-energy economic streams leads to increased manufacturing, distribution and sales that require additional jobs to support consumer demand. Evaluations that assess economic effects of programs allow policy makers to understand a fuller range of program impacts. These evaluations can be conducted using secondary data (research conducted by others and applied to the Duke Energy programs) or use primary research depending on the reliability needs associated with the study findings.

Description of Program

The Duke Energy Residential Smart $aver program provides rebates for installations of higher efficiency heating and cooling measures in new or existing homes. Qualified purchases by residential customers are eligible for rebates of $200 to the homeowner, and $100 to the HVAC contractor/dealer. Home builders who install qualified equipment are eligible for rebates of $300 that they may choose to pass on to the home buyers.

There are two types of measures for which rebates are available: central air conditioners (CAC) with electronically commutated fan motors (ECM)s, and heat pumps with ECMs. Duke Energy provides rebates for measures that have higher efficiency performance levels that are above current federal standards.

To participate, Duke Energy customers work directly with a participating HVAC contractor, select the eligible equipment, and provide their Duke Energy account number. The contractor completes the application for the rebate, providing the necessary AHRI certificates. Duke Energy has contracted with a third party, program administrator (Wisconsin Energy Conservation Corporation, WECC) who then processes the rebates and sends incentives to the customer and/or the contractor.

Program Participation

The evaluation covers participants in the program spanning 2009 through 2010, with post customer data through June 2011. Engineering estimates were prepared for each program participant. The billing analysis included a near census of participants, as shown below:

Program	Impact Type	Participation Count for 2009-2010
Residential Smart $aver – Ohio	Engineering	11,274
Residential Smart $aver – Ohio	Billing	10,774

Methodology

The impact evaluation used an engineering approach combined with a statistical billing analysis in a Statistically Adjusted Engineering (SAE) model framework. The engineering-based approach to estimating program savings consisted of the following steps:

1. Analysis of contractor surveys
2. Analysis of program participation tracking system data
3. Development and calibration of prototypical building energy simulation models
4. Simulation of measure energy savings
5. True-up of engineering estimates with billing data using a Statistically Adjusted Engineering (SAE) approach
6. Calculation of gross program energy and demand savings

The engineering estimates were then combined with a billing analysis by comparing the engineering estimates of savings for each participant as the participation variable. In this manner, the coefficient on the participation variable becomes the percentage of the engineering savings realized by participants (i.e., the realization rate). This is the SAE approach.

This approach differs from most of the other evaluations of similar programs in that it combines both an engineering and a billing analysis. Other evaluations have either used one or the other. Those evaluations that use only engineering analysis (even if they calibrated using billing data), ignore changes in customer HVAC usage associated with the installation of higher efficiency units and other behavior changes. Evaluations that depend only upon a billing analysis can only capture the early replacement of equipment – they cannot capture the natural replacement savings (i.e., the baseline is not the actual efficiency of the existing HVAC system, but the current HVAC efficiency standards).

The Residential Smart $aver HVAC program is designed as a time of replacement program. Incentives are offered to encourage customers to upgrade from a standard efficiency new air conditioner or heat pump to a higher efficiency new system when the existing system is at the end of its service life. This is commonly referred to a "normal replacement" scenario. The baseline efficiency assumed for the program is a SEER 13 minimally code-compliant air conditioner or heat pump. In some cases, the customer may be encouraged by the program to replace their existing air conditioner or heat pump before the existing system is at the end of its service life. This is commonly referred to as an "early replacement" scenario. Under an early replacement scenario, the existing HVAC system is the baseline, and the life cycle savings accrue using the existing system baseline for the remaining useful life of the existing system. Once the existing system reaches the end of its service life, the baseline reverts to the normal replacement baseline, and the life cycle savings accrue until the end of the service life of the new equipment. This is commonly referred to as the "dual baseline" approach, which is shown in the equation below:

$$\text{Life cycle kWh savings} = (kWh_{ER} - kWh_{EE}) \times RUL + (kWh_{NR} - kWh_{EE}) \times (EUL - RUL)$$

where:

kWh_{ER} = kWh consumption of the existing system
kWh_{EE} = kWh consumption of the efficient (rebated) system
kWh_{NR} = kWh consumption of a minimally code compliant system
RUL = remaining useful life of the existing system
EUL = effective useful life of the efficient (rebated) system

Under the normal replacement scenario, the savings are simply:

$$\text{Life cycle kWh savings} = (kWh_{NR} - kWh_{EE}) \times EUL$$

As discussed above, it is reasonable for the program to claim the savings associated with early replacement. These savings can only be claimed for the remaining life of the replaced unit, after which the claimed savings revert to the normal replacement level. However, it is extremely difficult and expensive to derive accurate estimates of the replaced unit's remaining life, so this evaluation takes the conservative approach, where all replacements were considered to be normal replacements.

To convert the early replacement savings estimate obtained from the billing analysis, the estimated realization rate (using engineering estimates with a 10 SEER early replacement baseline), was multiplied by the engineering-based loss in savings associated with going from a 10 SEER to a 13 SEER (the normal replacement baseline). This represents approximately a 70% reduction in savings.

Finally, during the initial phase of this evaluation, it was discovered that there was a marked difference between the engineering analysis and billing analysis in the preliminary results. This difference was a result of using different participant samples for the engineering and billing analyses. (Please see Appendix C: November 23, 2011 Memo to Duke Energy for more information.) This disparity warranted further investigation and analysis, which resulted in the same participation group used for both the billing and the engineering analysis, the final results of which are presented in this report.

Data collection methods, sample sizes, and sampling methodology

Engineering Estimates

Smart $aver program participation records for all participants covering the period through December, 2010 were obtained from Duke Energy.

Billing Analysis

The results from the billing analysis represent the entire population of participants with usable billing data, so no sample design was necessary.

Number of completes and sample disposition for each data collection effort

Engineering Estimates

Smart $aver program participation records for all participants covering the period through December, 2010 were obtained from Duke Energy.

Billing Analysis

Program tracking data was used to pull billing data from all participants in Ohio. The billing data was combined with information on participation date and in turn linked to weather data (temperature) to form the dataset used in the regression analysis.

Expected and achieved precision

Engineering Estimates

Not applicable. Census of participants used in the study.

Billing Analysis

All savings estimates from the billing analysis were statistically significant at the 95% confidence level.

Description of baseline assumptions, methods and data sources

Engineering Estimates

Baseline assumptions are incorporated into the prototypical simulation models derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER) study, with adjustments made for local building practices and climate. A detailed description can be seen in Table 3.

Description of measures and selection of methods by measure(s) or market(s)

Engineering Estimates

DOE-2.2 simulations were used to estimate savings from all measures, air conditioners and heat pumps ranging from SEER 14 to SEER 18.

Billing Analysis

The billing analysis was used to true up the engineering estimates. The realization rate from the SAE model was used to adjust the engineering estimates of savings for air conditioners and heat pumps ranging from SEER 14 to SEER 18.

Threats to validity, sources of bias and how those were addressed

Engineering Estimates

Any potential for bias in the engineering estimates is minimized through the use of building energy simulation models, which are considered to be state of the art for building shell and HVAC system analysis. Seasonality in heating and cooling energy use, and the use of natural ventilation during mild weather in the cooling season is incorporated to reduce upward bias in the engineering estimates. The engineering models are informed by pre/post metered data on fan usage at a sample of sites, and trued up to the billing analysis described below.

Billing Analysis

The specification of the model used in the billing analysis was designed specifically to avoid the potential of omitted variable bias by including monthly variables that capture any non-program effects that affect energy usage. The model did not correct for self-selection bias because there is no reason to as long as the program remains voluntary.

Snapback and Persistence

The theoretical additional energy and capacity used by customers that may occur from implementing an energy efficiency product, often called "snapback" if it occurs, is by design already captured in the impact evaluation through the billing analysis approach. The billing analysis approach uses actual energy use between the pre and post condition compared to what would occur without the program (control). All market or program effects conditions, including snapback, are already accounted for in this evaluation method. This is contrasted to evaluations that primarily rely upon engineering calculations.

The billing data analysis, by using usage data from customers who participated as long as over two years ago, indicates that the impacts of the Smart $aver program are likely to persist for at least two years. However, the evaluation did not address how long these savings are likely to persist over time because the time span of the available data was not sufficient to address this issue. Both persistence and technical degradation are included in the calculation of each measure's effective useful life shown in Appendix B: DSMore Table.

Energy Impact Analysis and Findings

Program Tracking System Analysis

Smart $aver program participation records covering the period through December 2010 were obtained from Duke Energy. The data, delivered as an Excel spreadsheet, contained customer name and address, installing vendor contact information, system type and efficiency, unit make and model number, rebate amounts, and other information. These data were examined to identify the number and types of customers and HVAC systems in the program.

The distribution of equipment type listed in the program tracking database is shown in Figure 1.

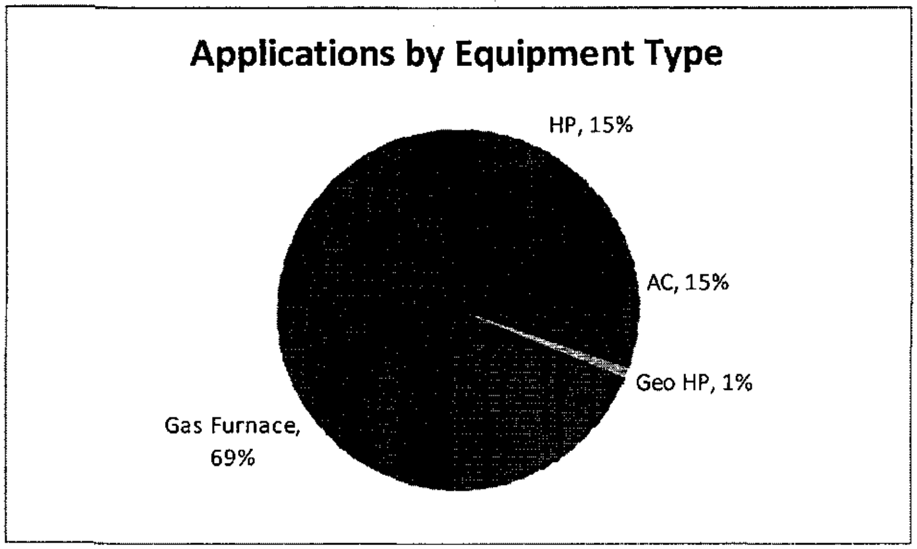


Figure 1. Applications by Equipment Type

Note, gas furnaces make up the majority of the applications listed in the program tracking database received from Duke Energy. Air conditioners and air source heat pump applications numbered about the same. A negligible number of geothermal heat pump applications were recorded. Air conditioners and some heat pumps were bundled with high efficiency furnaces, although they were recorded separately in the tracking database.

The frequency of rebated units and their efficiency is shown below.

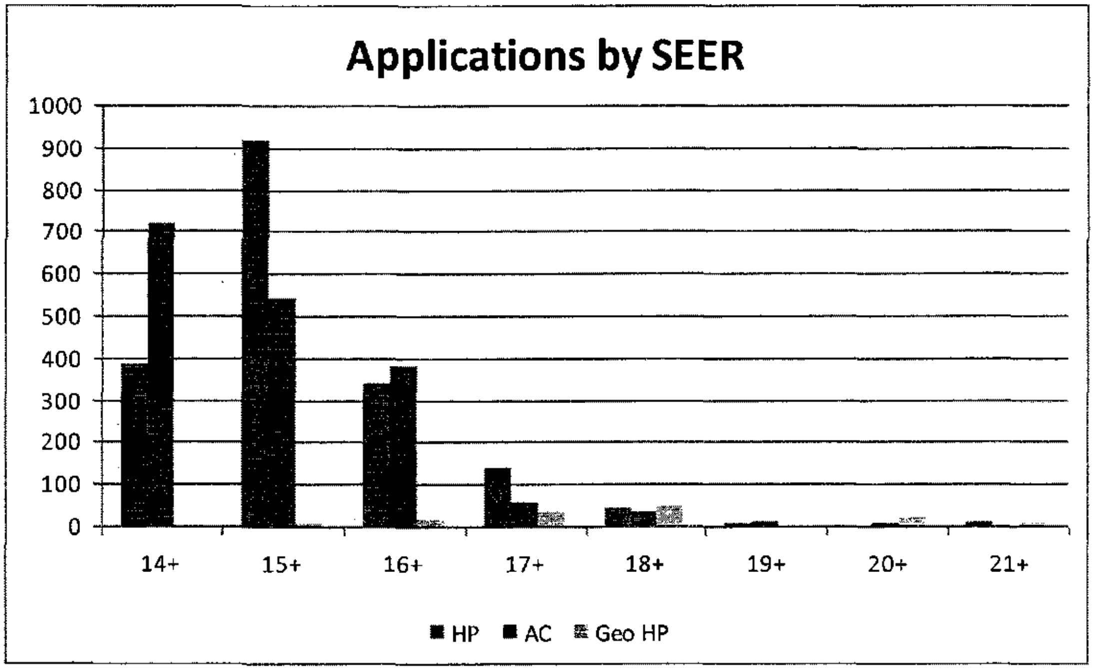


Figure 2. Heat Pump and Air Conditioner Applications by SEER[2]

Engineering-Based Analysis

The impact analysis for the Residential Smart $aver program is based on a combination of engineering estimates and billing data analysis. The engineering estimates are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER) study, with adjustments made for local building practices and climate. The prototype "model" in fact contains 4 separate residential buildings; 2 one-story and 2 two-story buildings. Each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these 4 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures. A sketch of the residential prototype buildings is shown in Figure 3.

[2] Note: Geothermal heat pumps are rated by EER

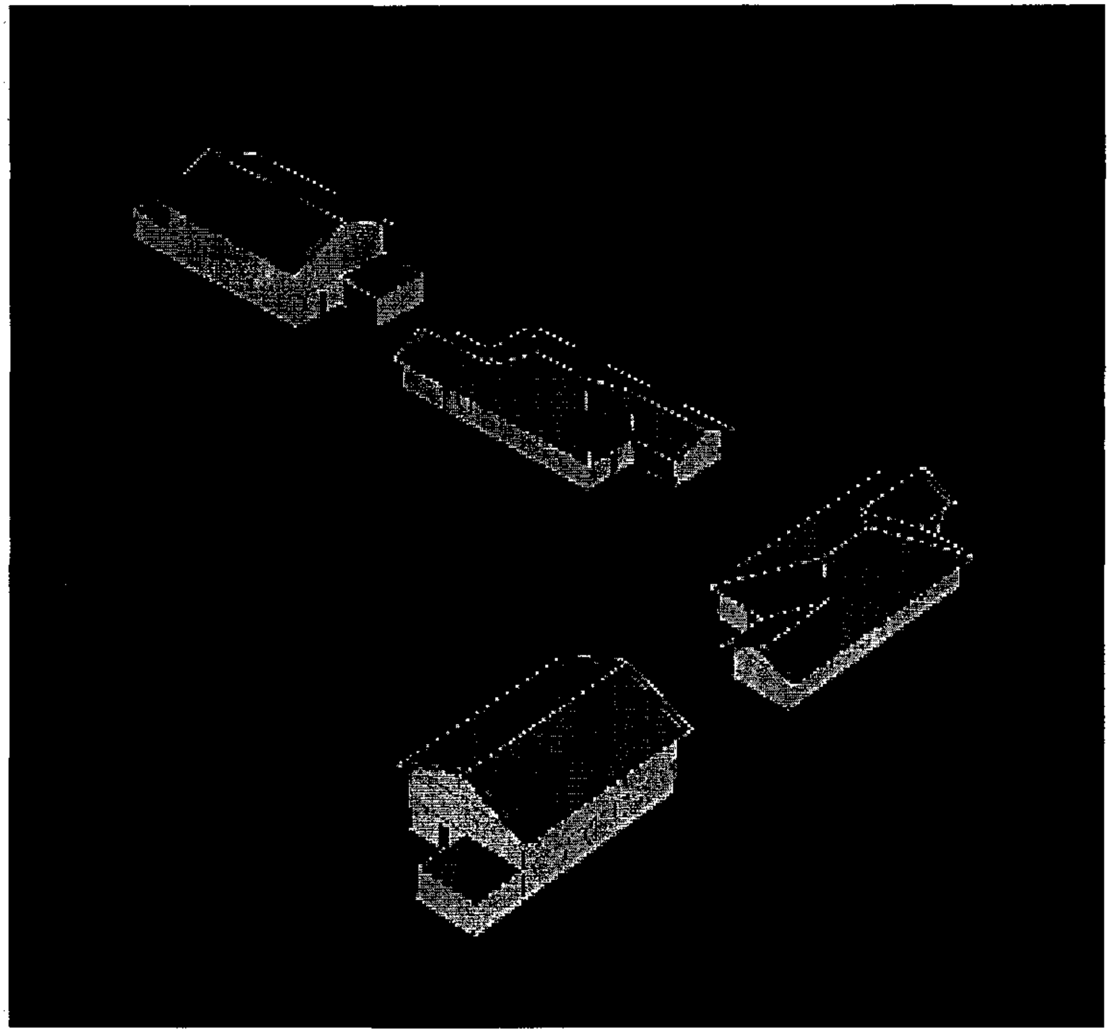


Figure 3. Computer Rendering of Residential Building Prototype Model

For this study, we added a basement to each building to create another set of 4 buildings, allowing us to simulate the impact of the energy efficiency measures on buildings with and without basements. Appliance saturation survey data collected in Indiana were used to refine the prototype models. An appliance saturation survey was not available for Ohio, so the Indiana data were used. These data were judged to be the best data available for the study. The general characteristics of the residential building prototype model are summarized in Table 3.

Table 3. Residential Building Prototype Description

Characteristic	Value
Vintage	Three vintages simulated: 1959 and older, 1960 – 1989, and 1990 and newer
Conditioned floor area	1 story house: 1465 SF (not including basement) 2 story house: 2930 SF (not including basement)
Wall construction and R-value	Wood frame with siding, R-value varies by system type and vintage
Roof construction and R-value	Wood frame with asphalt shingles, R-value varies by system type and vintage
Glazing type	Average of single and double pane; properties vary by system type and vintage
Lighting and appliance power density	0.51 W/SF average
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% oversizing.
HVAC system efficiency	Baseline SEER = 13 for normal replacement; SEER = 10 for early replacement Furnace efficiency = 0.78 AFUE
Thermostat setpoints	Heating setpoint = 70, cooling setpoint =75. Night setback/setup of 5 degrees in runs with setback thermostats.
Duct location	Buildings without basement: Unconditioned attic Buildings with basement: basement
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct leakage	20% total, evenly distributed between supply and return
Cooling season	Covington: April 29th – Oct 9th
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F. 3 air changes per hour

Several of the building characteristics were varied by vintage and HVAC system type to reflect the differences noted in the appliance saturation survey. These characteristics are described below.

Wall, Floor and Ceiling Insulation Levels

The appliance saturation survey contains questions about the presence of wall, floor and ceiling insulation. The penetration of wall, floor and ceiling insulation was tracked by building vintage and HVAC system type, and an average wall, floor and ceiling insulation level was established to represent the average insulation level in the population. In buildings with basements, the floor insulation levels shown below were applied to the basement walls. The assumed values for wall, floor and ceiling insulation and the assumed average R-value by vintage and HVAC system type is shown in Table 4 through Table 6.

Table 4. Insulation R-Value Assumptions by Vintage

Vintage	HVAC type	Assumed R-value of insulated wall	Average R-value of insulated and non-insulated walls
1959 and older	A/C w/ gas furnace	11	5.26

Vintage	HVAC type	Assumed R-value of insulated wall	Average R-value of insulated and non-insulated walls
	Heat pump	11	7.15
1960 - 1989	A/C w/ gas furnace	11	7.30
	Heat pump	11	8.54
1990 and newer	A/C w/ gas furnace	19	14.35
	Heat pump	19	16.05

Table 5. Ceiling Insulation R-Value Assumptions by Vintage and HVAC System Type

Vintage	HVAC type	Assumed R-value of insulated ceiling	Average R-value of insulated and non-insulated ceiling
1959 and older	A/C w/ gas furnace	19	14.71
	Heat pump	19	16.23
1960 - 1989	A/C w/ gas furnace	30	25.91
	Heat pump	30	25.48
1990 and newer	A/C w/ gas furnace	36	30.41
	Heat pump	36	34.09

Table 6. Floor Insulation R-Value Assumptions by Vintage and HVAC System Type

Vintage	HVAC type	Assumed R-value of insulated floor	Average R-value of insulated and non-insulated floor
1959 and older	A/C w/ gas furnace	11	2.19
	Heat pump	11	3.31
1960 - 1989	A/C w/ gas furnace	11	3.71
	Heat pump	11	4.03
1990 and newer	A/C w/ gas furnace	19	8.46
	Heat pump	19	5.91

Duct Insulation

The appliance survey asked a question about the presence of duct insulation. The fraction of the respondents that indicated the presence of duct insulation by building vintage and HVAC system type was used to establish baseline duct insulation levels. Note, the assumed R-value for insulated ductwork in the general population is R-4.9, corresponding to standard 1in. duct wrap or insulated flex duct.

Table 7. Duct Insulation R-Value Assumptions by Vintage and HVAC System Type

Vintage	HVAC type	Assumed R-value of insulated ducts
1959 and older	A/C w/ gas furnace	4.9
	Heat pump	4.9
1960 – 1989	A/C w/ gas furnace	4.9
	Heat pump	4.9
1990 and newer	A/C w/ gas furnace	4.9
	Heat pump	4.9

Windows

The appliance survey included questions about the presence of dual pane or storm windows, low-e windows and window film. The glazing U-value and solar heat gain coefficient (SHGC) assumptions for these systems are shown in Table 8. Note, the presence of window film was assumed to result in a 50% reduction in SHGC in the small number of buildings affected.

Table 8. Basic Glazing Property Assumptions

Property	Single	Double	Low e
U-value (Btu/hr-F-SF)	1.04	0.55	0.45
Solar heat gain coefficient	0.86	0.76	0.65

The penetration of dual pane, low-e and window film features by building vintage and HVAC system type were applied to the basic window properties to develop a set of glazing property assumptions, as shown in Table 9.

Table 9. Glazing Property Assumptions by Vintage and HVAC System Type

Vintage	HVAC type	U-value	SHGC
1959 and older	A/C w/ gas furnace	0.63	0.88
	Heat pump	0.66	0.89
1960 – 1989	A/C w/ gas furnace	0.62	0.87
	Heat pump	0.62	0.88
1990 and newer	A/C w/ gas furnace	0.65	0.87
	Heat pump	0.60	0.87

Model Calibration

The DOE-2 models were refined using monitored data supplied by Duke Energy on residential central air conditioners and heat pumps in Ohio and Indiana. Dent Elite Pro true electric power meters were installed on the furnace/air handler fans at a sample of sites. Time series measurements of fan power before and after the Residential Smart $aver system installations were made. The dataloggers were rotated from site to site, with some systems monitored during the heating season while other systems were monitored during the cooling season. Note, only the fan power was monitored; total unit power was not included in the monitoring activity. The purpose of the monitoring was to assess the fan power differences resulting from including an electronically-commutated (EC) motor as a program requirement. EC motors are much more efficient than standard motors, improving the SEER rating of an air conditioner or heat pump. The EC motor also allows for fan speed modulation, saving additional fan energy during part-load operation. Homeowners may elect to run their systems with continuous low speed fan operation regardless of heating or cooling needs to improve comfort and indoor air quality. Under this type of control, the energy savings from EC motor installation are reduced due to longer operating hours.

The monitored data were analyzed to determine the fan operation (continuous vs. cycling with call for heat/cool) and fan power per ton of cooling capacity in the pre and post installation case. The result of the monitored data analysis is shown in Table 10.

Table 10. Summary of Furnace Fan Motor Monitoring

Unit Monitored	Cycling Fan Fraction	Continuous Fan Fraction	Average Fan Power at Full Flow (W/cfm)
Existing	42%	58%	0.367
New	51%	49%	0.197

The existing units were more likely to operate with a continuous fan (58% of existing units vs. 49% of replacement units). While continuous fan operation is a feature of systems with EC motors, about half of the systems monitored used the feature.

The average fan power at full flow for the existing units was 0.365 W/cfm, while the average fan power at full flow for the replacement units was 0.197 W/cfm, representing a savings of 46% in full load fan power. Additional fan savings due to reduced speed operation were analyzed using the DOE-2.2 simulation models described in the next section.

The prototype model was simulated with a variety of efficiency measures to develop a series of savings estimates. The engineering analysis provided two sets of estimates. Separate estimates were generated for both normal replacement (replace on failure) and early replacement scenarios. Under the normal replacement scenario, air conditioning systems were simulated with a baseline SEER 13 air conditioner and with a series of high efficiency air conditioners ranging from SEER 14 to SEER 17. Heat pump systems were simulated with a baseline SEER 13 heat pump and with a series of high efficiency heat pumps ranging from SEER 14 to SEER 18. Under the early replacement scenario, the baseline unit efficiency was set at SEER 10, which is typical of units manufactured 20 years ago. The analysis required two sets of estimates. The early replacement baseline was used to compare the engineering analysis to the billing analysis. This comparison yielded an engineering adjustment factor. The adjustment factor was then applied to the engineering estimates developed under the normal replacement scenario. The adjusted, normal replacement engineering estimates were used to develop the final results.

The basic efficiency assumptions for each of the air conditioner and heat pump measures are shown in Table 11. These data were taken from an extensive study of residential air conditioners and heat pumps conducted for the California DEER update study.[3] Besides these basic efficiency parameters, an extensive set of performance curves were developed representing mean performance of production units in each SEER category. These performance curves describe unit efficiency as a function of outdoor temperature, part-load efficiency, and so on. Fan power data were taken directly from the metering study. These curves were also applied to air conditioner and heat pump measures in each SEER category.

[3] Itron, 2005. "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report," Itron, Inc., J.J. Hirsch and Associates, Synergy Consulting, and Quantum Consulting. December, 2005. Available at http://eega.cpuc.ca.gov/deer

Table 11. Baseline and Measure Performance Assumptions

Type	Efficiency	Fan Type	EER	Sensible Heat Ratio	Air flow (CFM/ton)	Heating COP
Air conditioner	SEER 10	Std 1-speed	9.3	0.74	396	
	SEER 13	Std 1-speed	11.1	0.75	376	
	SEER 14	EC motor	13.2	0.71	361	
	SEER 15	EC motor	12.7	0.7	320	
	SEER 16	EC motor	11.6	0.81	409	
	SEER 17	EC motor	12.3	0.8	422	
Heat pump	SEER 10	Std 1-speed	9.0	0.69	371	3.0
	SEER 13	Std 1-speed	11.1	0.73	337	3.28
	SEER 14	EC motor	12.2	0.73	352	3.52
	SEER 15	EC motor	12.7	0.81	436	3.74
	SEER 16	EC motor	12.1	0.78	400	3.48
	SEER 17	EC motor	12.5	0.81	430	3.26
	SEER 18	EC motor	13.0	0.78	404	3.18

This set of measures resulted in a simulation run matrix as follows:

Category	Number	Description
Building Vintage	3	1959 and older, 1960 – 1989, and 1990 and newer
Foundation type	2	With and without basement
HVAC systems	2	Air conditioner with gas furnace Standard heat pump with electric backup
Air conditioner efficiency levels	7	Base and 5 measures
Heat pump efficiency levels	8	Base and 6 measures
Furnace fan control	2	Continuous and intermittent
Tstat type	2	Setback and no setback

Evaluation Findings

The set of simulations described above were conducted for Covington, Kentucky, which is the closest weather data site to Cincinnati, Ohio. The results for each of the vintages were weighted according to the relative frequency of each vintage in the overall population. The simulated savings were normalized per ton of cooling capacity. A summary of the simulation results is shown in Table 12. Savings results are shown for each SEER class and air conditioner or heat pump type. Engineering estimates were provided using a normal replacement (SEER 13) baseline and an early replacement (SEER 10) baseline. The estimates for early replacement were prepared for consistency with the billing analysis, which observes the change in consumption as existing equipment is replaced with the efficient equipment.

Table 12. Normalized Measure Savings from Prototype Simulations for All Vintages[4]

Measure	Normal Replacement			Early Replacement[5]	
	kWh/ton	kW/ton	Therm/ton	kWh/ton	kW/ton
AC_seer14	288	0.14	-7	627	0.42
AC_seer15	343	0.12	-8	686	0.4
AC_seer16	405	0.1	-9	762	0.38
AC_seer17	431	0.13	-9	789	0.41
Hp_seer14	793	0.11	0	1333	0.34
Hp_seer15	699	0.17	0	1231	0.39
Hp_seer16	1051	0.18	0	1613	0.4
Hp_seer17	464	0.19	0	1031	0.41
Hp_seer18	1142	0.19	0	1706	0.42

The engineering analysis used detailed performance maps for air conditioners and heat pumps at each SEER level. The detailed performance maps were derived from engineering data published by the unit manufacturers, and were compiled by the California Database for Energy Efficiency Resources (DEER) project. The most recent version of the DEER performance maps were used for this evaluation[6]. The performance maps addressed unit full load efficiency and capacity over a range of outdoor and indoor temperature and humidity conditions and the effects of part-load operation on unit efficiency. The simulation models include the effect of duct leakage into return air systems on HVAC system performance, which in turn affects the temperature and humidity of the entering air conditions. The detailed simulation modeling formed the basis of the engineering estimates.

Note, the energy and peak demand savings derived from the simulations are not proportional to the difference in SEER. The SEER, which is based on a standardized laboratory test, is not a reliable predictor of annual energy consumption under the more realistic operating conditions included in the building energy simulation models. Peak demand savings across the SEER levels are due to different strategies used by manufacturers to achieve a particular SEER rating and the influence of those strategies on energy efficiency under peak conditions. For example, units using multiple compressors can have high SEER ratings, while having relatively poor efficiency under peak conditions. Heat pumps save energy for both heating and cooling, thus the overall annual energy savings are greater for heat pumps than air conditioners. Also, heat pumps have different performance characteristics than air conditioners, causing differences in the demand savings within each SEER class. Energy savings as a function of unit SEER are based on the performance of units under operating conditions representative of units in Ohio, especially when

[4] Normalized energy savings are a weighted average of the results for each of the building vintages.
[5] Billing analysis addressed electricity savings only, so no early replacement gas savings were estimated.
[6] See www.deeresources.com for DEER documentation. The HVAC performance maps are described in the Summary of Energy Analysis Changes in 2008 DEER versus 2005 DEER document, which is accessed from the DEER 2008 for 09-11 Planning/Reporting section under the DEER Database Contents heading.

considering the influence of warm moist air infiltration into the return air systems on system performance.

The savings per ton from the table above were applied to each participant in the program tracking system according to the installed cooling capacity (tons), location and the SEER of the rebated unit to create a customer specific estimate of savings. The customer specific estimates using the early replacement baseline (i.e., SEER 10) were then passed to billing analysis, as described in the next section. The resulting realization rate was then modified by the difference in the engineering-based savings associated with going from the early replacement baseline to the normal replacement baseline.

Billing Analysis

This section of the report presents the results of a billing analysis conducted over the participants in the Ohio Residential Smart $aver program. Billing data was obtained for all participants in the program between January, 2009 and March, 2011 that had accounts with Duke Energy (after processing, there were a total of 10,774 accounts from Ohio).[7] A panel model was used to determine program impacts, where the dependent variable was monthly electricity consumption from January 2009 to June 2011. Since engineering estimates were available for all these participants, a Statistically Adjusted Engineering (SAE) model was used for the analysis. The SAE model uses the customer-specific engineering savings estimate as the program variable, and the resulting estimated coefficient indicates the percentage of the engineering estimate realized on average by participants (i.e., the realization rate). The results of the billing analysis are presented in Table 13.[8]

Table 13. Estimated Ohio Residential Smart $aver Impacts: Billing Analysis

Program Component	Realization Rate	t-value
Air conditioners less than SEER 16	51.2%	8.02
Air conditioners SEER 16 and higher	69.8%	10.38
Heat Pumps less than SEER 16	118.6%	60.49
Heat Pumps SEER 16 and higher	116.2%	49.45

This table shows that the Residential Smart $aver program produced statistically significant savings for participants in Ohio. The realization rate indicates that the savings from this billing analysis is lower than the savings based upon the engineering analysis of air conditioners, and higher for heat pumps. This is often the case because the estimated realization rate captures several factors:

- Customer behavior. The engineering analysis assumes that there is no change in customer behavior with the installation of the new HVAC system. In practice, the addition of a new energy efficient system results in a decline in the cost of heating and cooling, so it is reasonable to assume that some customers will increase their heating/cooling.
- Actual home thermodynamics. The engineering analysis used a set of representative houses to develop the impact estimates. The billing analysis essentially captures the thermodynamics of specific to each house. Since some

[7] In order to maximize the use of the data, a single model was estimated over all states (Ohio, North Carolina, and South Carolina). Therefore, the actual sample size in the model also included 15,054 accounts from North Carolina and 3,213 from South Carolina, for a total sample size of 29,033 households.

[8] In order to insure an accurate separation between the pre and post participation periods, for each customer, the billing data for the period of time between the reported installation date (which may not accurately reflect when the new HVAC system installation was running) and the receipt of the rebate application was eliminated. In a vast majority of the cases this period was less than 2 months.

houses may vary significantly from the set of representative houses, their actual savings may therefore be significantly different as well.
- Status of pre-system. The billing analysis essentially compares the pre-installation usage to the post-installation usage. If some customer's pre-installation HVAC system was not functional, then the billing analysis will show an increase in electricity usage, and the overall estimated program savings will be lower than the case with functioning systems (which is the assumption in the engineering analysis).
- Actual baseline efficiency. The engineering analysis assumed that all customers had a fixed baseline efficiency. However, the billing analysis implicitly uses the actual efficiency of the customer's HVAC system, which may be higher or lower than the efficiency assumed in the engineering analysis.

The remainder of this section discusses the procedure used in the billing analysis.

For this analysis, data are available both across households (i.e., cross-sectional) and over time (i.e., time-series). With this type of data, known as "panel" data, it becomes possible to control, simultaneously, for differences across households as well as differences across periods in time through the use of a "fixed-effects" panel model specification. The fixed-effect refers to the model specification aspect that differences across homes that do not vary over the estimation period (such as square footage, heating system, etc.) can be explained, in large part, by customer-specific intercept terms that capture the net change in consumption due to the program, controlling for other factors that do change with time (e.g., the weather).

Because the consumption data in the panel model includes months before and after the installation of measures through the program, the period of program participation (or the participation window) may be defined specifically for each customer. This feature of the panel model allows for the pre-installation months of consumption to effectively act as controls for post-participation months. In addition, this model specification, unlike annual pre/post-participation models such as annual change models, does not require a full year of post-participation data. Effectively, the participant becomes their own control group, thus eliminating the need for a non-participant group.

The fixed effects model can be viewed as a type of differencing model in which all characteristics of the home, which (1) are independent of time and (2) determine the level of energy consumption, are captured within the customer-specific constant terms. In other words, differences in customer characteristics that cause variation in the level of energy consumption, such as building size and structure, are captured by constant terms representing each unique household.

Algebraically, the fixed-effect panel data model is described as follows:

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it},$$

where:

y_{it} = energy consumption for home i during month t

α_i = constant term for site i
β = vector of coefficients
x = vector of variables that represent factors causing changes in energy consumption for home i during month t (i.e., weather and participation)
ε = error term for home i during month t.

With this specification, the only information necessary for estimation is those factors that vary month to month for each customer, and that will affect energy use, which effectively are weather conditions and program participation. Other non-measurable factors can be captured through the use of monthly indicator variables (e.g., to capture the effect of potentially seasonal energy loads).

The effect of the Residential Smart $aver program is captured by including a variable which is equal to zero for the months prior to participation, and the engineering estimate (on a monthly basis) for all months after the household participated in the program. The coefficient on this variable is the realization rate, and indicates the relationship between the engineering estimate and the billing data estimate (if the estimate is greater than one, the billing data indicates a higher savings than the engineering estimate. If the coefficient is less than one, then the billing data indicates a smaller savings than the engineering models). In order to account for differences in billing days, the usage was normalized by days in the billing cycle. The estimated model is presented in Table 14.[9]

Table 14. Estimated Savings Model – dependent variable is (daily kWh usage), January 2009 through June 2011 (savings are negative).

Independent Variable	Coefficient (percentage / 100)	t-value
Ohio – AC Eng. Est.	-0.55	-11.89
Ohio – HP Eng. Est.	-1.09	-69.24
Carolina – AC Eng. Est.	-0.67	-40.12
Carolina – HP Eng. Est.	-0.56	-38.80
Sample Size	725,874 observations (29,033 homes)	
R-Squared	73%	

The complete estimate model, showing the weather and time factors, is presented in Appendix A: Estimated Statistical Model.

The billing analysis represents a pre/post comparison of energy consumption, using the existing air conditioner or heat pump as the "pre" equipment.

The realization rate from the billing analysis (based upon the early replacement engineering estimates) was applied to the ratio of the savings associated with the early replacement to normal replacement engineering estimates, to give an estimate of the normal replacement energy

[9] As stated previously, a single model was estimated over participants in all states. Thus, this table presents the impacts for the Ohio in addition to the impacts for the Carolinas.

savings. Since the billing analysis did not address demand savings, the engineering estimates of peak demand were not adjusted. The final billing analysis adjusted gross energy and demand savings per ton estimates are shown in Table 15.

Table 15. Adjusted Gross Energy and Demand Savings Per Ton

Measure	Gross Energy and Demand Savings Per Ton		
	kWh/ton	kW/ton	Therm/ton
AC_seer14	147	0.14	-4
AC_seer15	176	0.12	-4
AC_seer16	282	0.10	-6
AC_seer17	301	0.13	-6
Hp_seer14	940	0.11	0
Hp_seer15	829	0.17	0
Hp_seer16	1,221	0.18	0
Hp_seer17	539	0.19	0
Hp_seer18	1,327	0.19	0

Program participation by HVAC system type, size, and SEER were applied to the savings per ton estimates from Table 15 above to compute the program savings, as shown in Table 16.

Table 16. Summary of Program Savings by Measure

Measure	Participation Count	Gross Ex Post kWh Savings	Gross Ex Post kW Savings	Gross Ex Post kWh Savings per unit	Gross Ex Post kW Savings per unit
Air conditioner	5,604	3,398,450	1,955	606	0.349
Heat Pump	5,670	14,729,349	2,598	2,628	0.464

The kW savings estimated for the program are summer peak demand savings at the customer meter. Estimates of utility coincident peak savings were not included in the study. Coincidence factors are applied to the customer peak savings in the DSMore cost effectiveness tool to estimate coincident peak savings.

Net-to-Gross Analysis for Impact Estimates

The evaluation examined the extent to which customers would have taken the same actions without the Duke Energy incentive and the degree to which the program participation impacted the adoption of additional energy efficient measures. This analysis assessed the degree of the influence of the program and the program's rebate on the customer's decision to buy, and used self-reports of 54 surveyed program participants to estimate freeridership.

Participants were asked how important the program rebate was to their decision to purchase a more energy efficient model. The results are shown in Figure 4. One participant (1.9%) indicated that the rebate was the primary reason and five participants (9.3%) regarded the rebate as unimportant or minor in their consideration. Fifteen participants (27.3%) regarded the rebate as important, and thirty-three participants (61.1%) said that the rebate was one of the reasons, but not the most important.

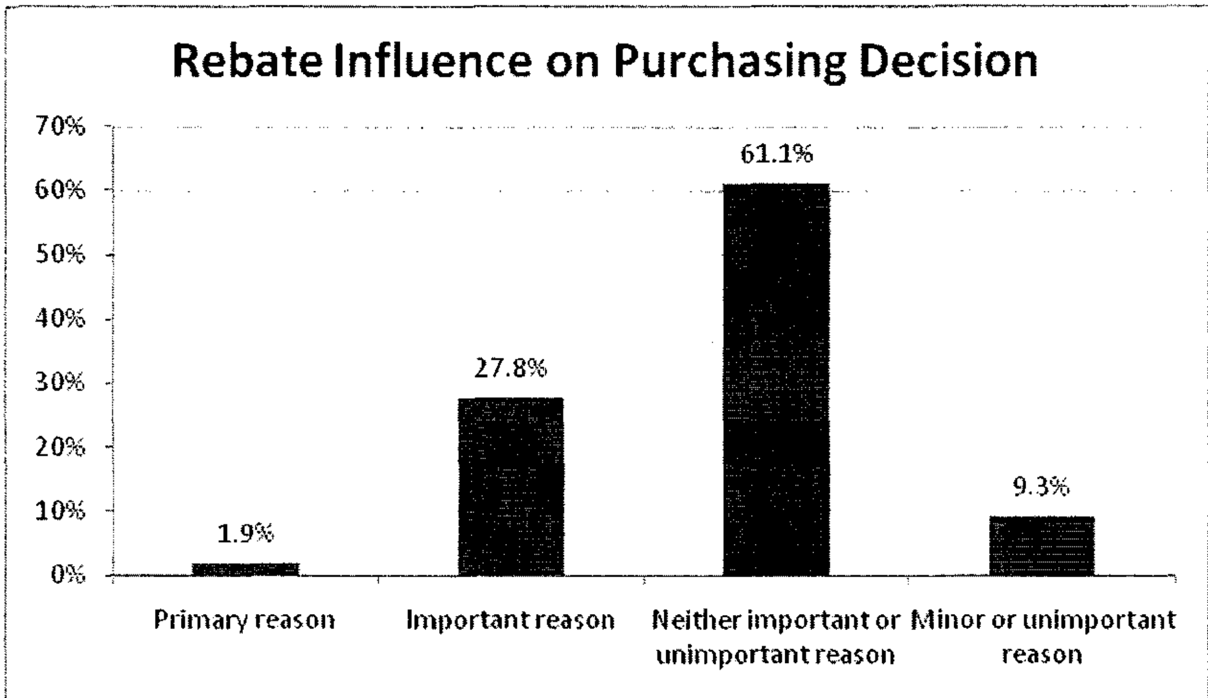


Figure 4. Rebate Influence on Purchasing Decision (n=54)

Surveyed participants were asked if the rebate had not been available whether they would have purchased the same measure or an equally energy efficient one. Customers were also asked about the timeline associated with their purchase to determine if the change would have been made, but at a later time. In addition, only two out of 54 surveyed participants indicated that they would have delayed the purchase of equipment without the program. One participant thought the delay would be three to four months and the other thought he or she would have waited six months to purchase new equipment.

Survey participants were read the following statement in order to rate the amount of influence the rebate had on their purchasing decision: "I would like to ask how important the program incentive was in your decision to buy the more energy efficient model. Would you say the incentive was..."

Possible responses were weighted for free ridership and included the following:

- The primary reason (no free ridership)

- An important reason (20 percent free ridership)
- Neither an important or unimportant reason (40 percent free ridership)
- An unimportant reason (80 percent free ridership)
- Not a reason at all (100 percent free ridership)

The free ridership multiplier from each rating is then multiplied by the percentage of respondents who chose that rating. The sum of the products of the percentages and multipliers is the unadjusted free ridership percentage.

The unadjusted free ridership percentage is calculated using Table 17. The overall free ridership is calculated to be 37.4 percent with a net to gross ratio of 62.6 percent (100 percent minus 37.4 percent.)

Table 17. Free Ridership Percentages

Amount of Rebate Influence	Free Ridership Multiplier	Number of Respondents	Percent of Respondents	Adjusted Free Ridership Ratio
Primary reason	0 percent	1	1.9%	0 %
Important reason	20 percent	15	27.8%	5.6%
Neither Important or Unimportant reason	40 percent	33	61.1%	24.4%
Unimportant reason	80 percent	5	9.3%	7.4%
Not a reason	**100 percent**	**0**	**0%**	**0%**
Sum			**100%**	**37.4%**

In a previous study of this program (TecMarket Works 2008) we estimated free ridership using a different approach. In the previous study we interviewed dealers and contractors and asked them to make estimates of their customer's free rider condition. That finding was almost identical (37.2% in 2008 versus the current study's 37.4%). Because these two different approaches that were conducted at different times yet for the same program provide almost identical findings, we are not adjusting the current study's free ridership score down to reflect the decision bias described in the evaluation literature. The fact that the two scores are essentially identical supports the findings of both studies.

Spillover

The participant survey asked customers if they had taken additional actions to save energy beyond the equipment discounted as a result of the Duke Energy program. Fourteen (25%) participants indicated that they had taken additional actions beyond those covered by the program. However, TecMarket Works is not crediting any additional savings to the program as a result of these actions because the customers did not understand that the Duke Energy program was responsible for the reduced price of the program-covered incentive, and because the participating dealers do not push additional products or behavior changes as a result of the Duke Energy program. This finding may change if future interviews with the participating dealers and surveys with customers identify that Duke Energy has in some way caused all or a portion of those actions to occur. This conclusion is supported by the majority of the interviewed dealers who indicated that their customers were not aware of the Duke Energy program at the time of the customer's decision to purchase.

Net to Gross Ratio

The net to gross ratio for this program is set at 0.626 and includes a downward adjustment in gross savings equal to 37.4% of the gross savings. There is no adjustment for spillover savings for this program until such time as the program can be found to be a cause of additional actions being taken by program participants. As a result, the final net-to-gross ratio for the program is set at 0.626.

Appendix A: Estimated Statistical Model

This appendix show the complete model estimated for the billing analysis. The model includes indicators for each month (the YYYYMM variable), temperature, and the participation variables.

kwhyear	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hp_oh_eng	-1.085192	.0156737	-69.24	0.000	-1.115912	-1.054473
ac_oh_eng	-.5513968	.0463747	-11.89	0.000	-.6422897	-.4605038
hp_cl_eng	-.5602956	.0139649	-40.12	0.000	-.5876664	-.5329248
ac_cl_eng	-.6728898	.0173447	-38.80	0.000	-.7068849	-.6388947
tme#c.atemp						
200901	-913.7671	6.085213	-150.16	0.000	-925.6939	-901.8403
200902	-343.6916	7.26964	-47.28	0.000	-357.9399	-329.4434
200903	-390.8604	12.29096	-31.80	0.000	-414.9503	-366.7706
200904	-271.3217	14.12966	-19.20	0.000	-299.0154	-243.6281
200905	38.25065	13.30942	2.87	0.004	12.16461	64.33668
200906	541.3495	14.65064	36.95	0.000	512.6347	570.0643
200907	-226.1684	15.70453	-14.40	0.000	-256.9488	-195.3881
200908	291.9479	12.93154	22.58	0.000	266.6025	317.2933
200909	422.4782	12.54466	33.68	0.000	397.8911	447.0653
200910	72.02099	8.661937	8.31	0.000	55.04387	88.9981
200911	-182.7167	12.81394	-14.26	0.000	-207.8316	-157.6018
200912	-384.9971	8.653933	-44.49	0.000	-401.9586	-368.0357
201001	-1207.315	9.643819	-125.19	0.000	-1226.216	-1188.413
201002	-236.4453	9.281978	-25.47	0.000	-254.6377	-218.2529
201003	-523.1728	8.899549	-58.79	0.000	-540.6156	-505.73
201004	-272.333	12.62213	-21.58	0.000	-297.072	-247.5941
201005	241.5872	13.89349	17.39	0.000	214.3565	268.818
201006	643.2156	15.28561	42.08	0.000	613.2563	673.1749
201007	632.6885	19.8788	31.83	0.000	593.7267	671.6503
201008	550.5609	20.72206	26.57	0.000	509.9463	591.1755
201009	499.6086	14.61731	34.18	0.000	470.9591	528.258
201010	296.6883	10.38808	28.56	0.000	276.328	317.0486
201011	-179.2051	10.95534	-16.36	0.000	-200.6772	-157.733
201012	-565.9388	8.366704	-67.64	0.000	-582.3373	-549.5403
201101	-673.5651	13.65525	-49.33	0.000	-700.3289	-646.8012
201102	-780.1368	9.999165	-78.02	0.000	-799.7348	-760.5388
201103	-580.2816	11.67736	-49.69	0.000	-603.1689	-557.3944
201104	-296.3959	13.40752	-22.11	0.000	-322.6742	-270.1176
201105	168.4322	16.95744	9.93	0.000	135.1961	201.6682
201106	623.2664	14.92664	41.76	0.000	594.0107	652.5221
tme						
200902	-25705.23	346.5428	-74.18	0.000	-26384.44	-25026.01
200903	-24840.03	588.0499	-42.24	0.000	-25992.59	-23687.47
200904	-32458.36	768.8295	-42.22	0.000	-33965.24	-30951.48
200905	-49999.84	862.4094	-57.98	0.000	-51690.13	-48309.54
200906	-82434.03	1051.236	-78.42	0.000	-84494.41	-80373.64
200907	-22183.3	1180.341	-18.79	0.000	-24496.73	-19869.87
200908	-61815.77	988.7357	-62.52	0.000	-63753.66	-59877.88
200909	-73287.39	933.2411	-78.53	0.000	-75116.51	-71458.26
200910	-51609.09	588.1439	-87.75	0.000	-52761.83	-50456.35
200911	-37437.37	722.1384	-51.84	0.000	-38852.73	-36022
200912	-25245.57	451.6399	-55.90	0.000	-26130.77	-24360.37
201001	9588.784	396.5249	24.18	0.000	8811.608	10365.96
201002	-27710.61	397.4397	-69.72	0.000	-28489.58	-26931.64
201003	-18321.73	432.9353	-42.32	0.000	-19170.26	-17473.19
201004	-31497	750.2375	-41.98	0.000	-32967.44	-30026.56
201005	-62780.79	909.432	-69.03	0.000	-64563.24	-60998.33

201006	-90085.7	1140.603	-78.98	0.000	-92321.24	-87850.15
201007	-88609.74	1575	-56.26	0.000	-91696.69	-85522.79
201008	-82419.24	1669.476	-49.37	0.000	-85691.36	-79147.12
201009	-79675.89	1129.434	-70.55	0.000	-81889.54	-77462.23
201010	-66272.66	731.0191	-90.66	0.000	-67705.43	-64839.88
201011	-36859.49	650.8755	-56.63	0.000	-38135.18	-35583.79
201012	-16006.69	426.1167	-37.56	0.000	-16841.87	-15171.52
201101	-11038.53	516.6781	-21.36	0.000	-12051.2	-10025.86
201102	-7096.302	447.7675	-15.85	0.000	-7973.912	-6218.693
201103	-15183.09	612.8344	-24.78	0.000	-16384.22	-13981.95
201104	-29628.96	765.9756	-38.68	0.000	-31130.25	-28127.67
201105	-57977.34	1106.54	-52.40	0.000	-60146.13	-55808.56
201106	-88967.22	1113.216	-79.92	0.000	-91149.09	-86785.36
_cons	61532.85	243.7272	252.47	0.000	61055.15	62010.54

Appendix B: DSMore Table

Per Measure Impacts Summary for Smart Saver Ohio

Impacts ⇨ / Technology ⇩	Product code	State	EM&V gross savings (kWh/unit)	EM&V gross kW (customer peak/unit)	EM&V gross kW (coincident peak/unit)*	Unit of measure	Combined spillover less freeridership adjustment	EM&V net savings (kWh/unit)	EM&V net kW (customer peak/unit)	EM&V net kW (coincident peak/unit)	EM&V load shape (yes/no)	EUL (whole number)
Air Conditioner		Ohio	606	0.349	N/A	unit	37.40%	379	0.218	N/A	no	18
Heat Pump		Ohio	2,628	0.464	N/A	unit	37.40%	1,645	0.290	N/A	no	18
Program wide			**1,623**	**0.407**	**NA**	**unit**	**37.40%**	**1,016**	**0.255**	**NA**		

Notes: Coincidence factors to be applied in DSMore using the residential HVAC load shape in the DSMore library.

Appendix C: November 23, 2011 Memo to Duke Energy

In using both engineering and billing analysis approaches for this evaluation, it was discovered that there was a marked difference between the engineering analysis and billing analysis in the preliminary results. This difference was due a result of using different participant samples for the engineering and billing analyses, as described in the memo below.

TecMarket Business Center
165 Netherwood Road
2^{nd} Floor, Suite A
Oregon, WI 53575

Memorandum

To: Ashlie Ossege, Duke Energy
From: Michael Ozog, Integral Analytics
Date: November 23, 2011
Subject: Status of Residential Smart Saver impact evaluation

This memo reviews the status of the impact evaluation of the residential Smart Saver program. The impact evaluation consists of both engineering and a billing data analyses. The engineering analysis consists of DOE-2 simulations of prototypical residential buildings combined with pre/post monitoring of HVAC system fans at a sample of participant sites. The DOE-2 simulations provide unit energy savings estimates (kWh/ton and kW/ton) for central air conditioners and heat pumps at various efficiency levels. Since the program requires electronically commutated (EC) motors on the supply fans of the rebated equipment, pre/post monitoring of HVAC system fans was used to improve the simulation models by observing how participants used this feature in their new systems. The billing analysis uses pre- and post-participation data of participants within a regression model to estimate program impacts.

Both the billing data and engineering analysis were initially completed in September. However, when the results were compared, there was a marked difference between the results from the engineering analysis and the billing analysis. To investigate this difference, the engineering estimates were combined into the regression model in a statistically adjusted engineering (SAE) framework. While constructing the SAE model, it was noted that the samples used for the engineering analysis did not match the sample used in the billing data analysis, with the engineering analysis having significantly fewer participants than the billing analysis.

Therefore, a new extract of the participation data for Smart Saver was conducted in order to insure that both samples were consistent and the SAE model could be run with the full set of program participants. Once this task was completed, new engineering and billing data analyses were conducted. This procedure was, naturally, time consuming, and was not completed until mid-November. The results are currently being reviewed internally and will be available once the internal review is completed.

Impact Evaluation and Review of the 2011 Power Manager® Program in Ohio

Final Report

Prepared for
Duke Energy
139 East Fourth Street
Cincinnati, OH 45201

February 19, 2012

Submitted by:

TecMarket Works
165 West Netherwood Road
Oregon, Wisconsin 53575
(608) 835-8855

Subcontractor:

Michael Ozog
Integral Analytics, Inc.

Table of Contents

Executive Summary

Summary of Findings

The approach used by Duke Energy for estimating the effect of the Power Manager program is very reasonable and defensible. One particularly noteworthy feature is that they use an extensive history to estimate the model, rather than relying on only a handful of days as is common in many utilities which use less rigorous approaches (i.e., approaches that compare average usages from a pre-event period, for example, rather than conducting a multivariate regression model, as Duke Energy is doing).

Overall, based on our review, Duke Energy's impact evaluation is a very complete and innovative approach, and should result in accurate estimates of event impacts and the summer load reduction capacity under peak normal weather conditions, as summarized in Table 15 on page 18.

Recommendation

- The behavior of some Cannon switches to deviate substantially from the shed times expected for the Target Cycle method is worrisome since it increases the uncertainty of the program impacts. While this is beyond the control of Duke Energy, we encourage Duke Energy to continue to work with Cooper Power Systems (Cannon) staff to determine the cause and extent of this issue.
    - See section titled "PM Load Control Strategies", specifically "Table 6. Percentage of Cannon Switches for Each Shed Pattern" on page 12.

Introduction and Purpose of Study

This document presents the evaluation report for Duke Energy's Power Manager Program as it was administered in Ohio.

The evaluation was conducted by Duke Energy and the TecMarket Works evaluation team. Duke Energy conducted the impact analysis, and Integral Analytics (a TecMarket Works subcontractor) conducted the review of the methodology and results.

Summary Overview

This document presents a review of the impact evaluation for the Power Manager (PM) program conducted by Duke Energy as it was administered in Ohio.

Summary of the Evaluation

Power Manager is a voluntary residential program, available to homeowners with central air conditioning (AC). On days where energy demand and/or energy costs are expected to be high, Power Manager participants have agreed to allow Duke Energy to cycle their air conditioning off for a period of time.

The impact evaluation conducted by Duke Energy developed an air conditioner (AC) duty cycle model based on information from a sample of PM participants in Ohio and Kentucky. This duty cycle was then used to simulate the expected natural duty cycle during the PM event days and under peak normal weather conditions for different PM program options and load control technologies to produce estimates of the potential load reduction. These estimates were then de-rated by the results of various operability studies to give estimates of the realized load reductions.

Evaluation Objectives

The purpose of this evaluation was two-fold. The first objective is to summarize the actual kW and expected peak normal kW impacts determined by Duke Energy for 2011. The second objective is to determine if the approach used by Duke Energy in estimating these impacts is consistent with commonly accepted evaluation principles.

Description of Program

Power Manager is a voluntary residential program, available to homeowners with central air conditioning (AC). On days where energy demand and/or energy costs are expected to be high, Duke Energy has permission from Power Manager participants to cycle their air conditioning off for a period of time.

There are two requirements that must be met for a customer to be eligible to participate in Power Manager. First, they need to own and live in their single family home. Second, they need to have a functional central air conditioner with an outside compressor that can be controlled. When customers enroll, Duke Energy installs a switch that allows the AC unit to be cycled off and on in response to signals sent over Duke Energy's paging system.

The Power Manager program allows customers to select which load reduction target they would be willing to provide, either 1.0 kW or 1.5 kW. During an event, customers in the 1.5 kW option would have their air conditioner cycled off for a few minutes longer in each half hour than the 1.0 kW customers. Events may be called on non-holiday weekdays during the months of May through September.

Within Duke Energy Ohio's portfolio, Power Manager is currently the only residential demand response program[1]. The Power Manager program plays a key role in capacity planning; every year, Power Manager provides an estimate as to how much capacity it can provide during the summer season, and this information is taken into account by the capacity planners.

Program Participation

Program	Participation Count for 2011
Power Manager Ohio	EOM Sept. 2011 – 37,612

[1] Not including pilot programs.

Methodology

Overview of the Evaluation Approach

The impact evaluation for the Power Manager (PM) program was conducted by Duke Energy staff. The complete evaluation included M&V sample from Duke Energy territory in the states of Ohio, Indiana, Kentucky, North Carolina, and South Carolina. The results presented in this report include a review by Integral Analytics of the impact evaluation methodology and results.

The impact evaluation developed an air conditioner (AC) duty cycle model based on information from a sample of PM participants in Ohio and Kentucky. This duty cycle was then used to simulate the expected natural duty cycle during the PM event days for estimates of event load reduction impacts and under peak normal weather conditions for different PM program options and load control technologies to produce estimates of the potential load reduction on a peak normal day. These estimates were then de-rated by the results of various operability studies to give estimates of the realized load reductions. Table 1 below summarizes the resulting estimated actual and the peak normal weather load impacts at the switch level for customers in Ohio.

Table 1. Ohio Load Impacts

Control Strategy	2011 Impacts	Peak Normal Weather Impacts
Target Cycle (TC) 1.5	1.24	1.40
Target Cycle (TC) 1.0	1.11	1.24

The approach used by Duke Energy staff is nearly identical to the approach used in the prior evaluations reviewed by the TecMarket team. Noteworthy additions include:

- The discovery that many Cannon switches deviate substantially from the shed times expected for the Target Cycle method, shedding more like an "inverted" pattern. This results in a significant difference between the Target Cycle shed and the actual shed. The reported estimated impacts incorporate this inverted shed.
- It appears that the peak normal impacts now include an adjustment for line losses. This is a commendable approach and is rarely done in other evaluations.

This general approach is well established in the industry and the actual analysis was very thorough and well thought out. The resulting impact estimates are reasonable and accurate. A potential alternative approach for future impact evaluations is to use the data from the M&V and the operability sample to directly estimate impacts via statistical models. This approach could use a time-series, cross-sectional analysis where the dependent variable is the actual AC load (or run-time), and the independent variables include weather conditions, time of day, day of week, and the PM control event. In essence, this would produce an overall duty-cycle model, and the coefficient on the PM control event variable(s) would estimate the actual load impacts during those events. This approach is very similar to the approach used by Duke Energy, but it reduces the need to model event days separately. It is not certain that the results would necessarily be more accurate, however it is a more efficient use of the data. In addition, the statistical significance of the estimated impacts are directly calculated.

Data collection methods, sample sizes, and sampling methodology

The 2011 Power Manager M&V sample in the Midwest consists of 144 households with 156 air conditioner (AC) units. This includes 56 households from Ohio, 16 households from Kentucky, and 72 households from Indiana, closely reflecting the relative numbers of PM participants in each state in February, 2011. The 2011 Ohio and Kentucky M&V sample is representative of the PM population within the two states and is designed to target at 10% relative precision at 90% confidence level. The OH/KY sample includes 47 new households randomly selected from the PM population in February, 2011, and 25 holdovers from the 2010 M&V sample that were randomly selected in either 2009 or 2010. The 2011 Indiana M&V sample has 39 new households randomly selected from the PM population in February, 2011, and 33 holdovers from the 2010 M&V sample that were randomly selected in either 2009 or 2010. The resulting stratification of PM M&V samples is shown in Table 2.

Table 2. M&V Sample Stratification

	Midwest		Indiana		Southeast	
	High	Low	High	Low	High	Low
Sample allocation	38	34	37	35	74	69
Population weight	34.7%	65.3%	34.7%	65.3%	37.3%	62.7%

Hourly run-time of AC units in the M&V samples was collected during the summer months of 2011 (May through September). This was accomplished with Cannon load control devices, which record hourly run-time (in minutes) of the AC unit to which they are attached. Three rounds of data collection from M&V Cannon devices were conducted in June, July, and October. In addition to hourly run-time, the Cannon device scan data includes hourly shed minutes and the contents of many device registers. Information about the AC unit is also recorded, including amp ratings for both the AC compressor and fan.

Households in the M&V samples were equipped with load research interval meters, and 15-minute premise interval usage (kWh) was collected for 2011 summer months.

Number of completes and sample disposition for each data collection effort

See "Table 2. M&V Sample Stratification" above.

Expected and achieved precision

The 2011 Ohio and Kentucky M&V sample is representative of the PM population within the two states and is designed to target at 10% relative precision at 90% confidence level.

The final sample sizes for OH & KY were adequate to produce estimates at 20% relative precision at 90% confidence level.

Description of baseline assumptions, methods and data sources

The baseline is developed from the duty-cycle of the sampled AC units based upon the observed AC usage during non-holiday, non-weekend, and non-control days.

Description of measures and selection of methods by measure(s) or market(s)

The PM program is an AC cycling program, so the only measure in question is the AC units.

Use of TRM values and explanation if TRM values not used

The analysis provides estimate of the savings that were achieved by participating households, thus there was no need to use TRM values.

Threats to validity, sources of bias and how those were addressed

The approach used in the evaluation relied upon actual measurement of AC usage, and is therefore not subject to any reporting or self-selection bias.

Evaluation Findings

Validation of AC Duty Cycle Data

Hourly air conditioner (AC) run-time collected from Cannon M&V devices is compared to corresponding premise interval kWh to verify that it accurately reflects the operations of the attached AC unit. The validation process is accomplished through a sequence of computer programs that: 1) convert the hourly AC run-time data into hourly duty cycle; 2) display time series plots of premise kWh and duty cycle with control over time resolution enabling visual comparison of plot detail; 3) calculate cross-correlation between hourly kWh and hourly duty cycle and display cross-plots of kWh versus duty cycle. Each run-time data file collected for an AC in the 2011 M&V sample is reviewed in this fashion, and the AC duty cycle is added to the model database when hourly premise kWh provides adequate confirmation.

For 5 ACs in the Midwest sample and 4 ACs in the Southeast sample, Duke Energy could not obtain the 2011 data needed to apply validation procedures. Reasons for this include customers leaving the PM program (3), no interval kWh (1), unable to retrieve scan data (5). In the validation process, run-time data was rejected for 4 ACs in the Indiana sample and 9 ACs in the Southeast sample. These cases appear to be due to sensitivity issues, where the AC is reported to have no run-time or to be always running. The remaining sample is statistically significant and provides better insight into AC usage profiles. Overall, hourly duty cycle data was added to the model database for 147 ACs from the Midwest sample and 165 ACs from the Southeast sample. The final sample sizes for OH & KY, IN, and the Southeast are still adequate to produce estimates at 20% relative precision at 90% confidence level. Table 3 summarizes the 2011 M&V sample.

Table 3. M&V Sample

	Midwest			Southeast	
	Ohio	Indiana	Kentucky	North Carolina	South Carolina
Households	56	72	16	104	39
Total AC Units	156			178	
Missing data	5			4	
Invalid Data	4			9	
Final AC Sample	147			165	
Duty Cycle Models (see below)	136			136	

AC Duty Cycle Models

Impact estimates during PM load control periods are based upon models developed for the natural duty cycle of M&V AC units. These models are developed from 2011 duty cycle data described above, and similar duty cycle data from the two prior summers (2009, 2010) for AC units that are holdovers from previous M&V samples. Weekends and holidays are not used in the models, and hours during load control and for the remainder of the day are not used. Duke

Energy staff was able to develop duty cycle models for AC units at 136 households in the Midwest M&V sample, and for AC units at 136 households in the Southeast M&V sample.

Natural duty cycle models are specified and estimated individually for M&V AC units to better capture the unique dependence of duty cycle on the temperature and humidity characteristics of each AC unit. A limited dependent variable model specification is adopted for hourly duty cycle, the independent variable in the models. Candidate specifications for dependent variables in the models include temperature averaged over the prior 2-hour, 4-hour, and 6-hour intervals, and a weighted temperature average with declining weights over the previous six hours. Candidate specifications also include similar sets of averages based on temperature-humidity index (THI) and heat index (16-element polynomial). Models are estimated with the SAS procedure QLIM[2]. The dependent variable specification selected for an AC unit is based on fit diagnostics from hourly model fits over the typical load control hours, 2:00–6:00 PM. For the selected model, distinct parameters are estimated in each hour of interest, resulting in a set of hourly natural duty cycle fits for each M&V AC.

PM Load Control Strategies

The PM program employs two generic types of load control devices which require somewhat different treatment for load impact evaluation. The newer switch types – Cannon LCR 4700 in OH, KY, NC, and SC, and the Cannon LCR 5200 in Indiana – operate with an adaptive control strategy called Target Cycle (TC). For each hour of load control, the Target Cycle switch calculates a unique shed time (or percentage) based on characteristics of the attached AC unit. The older switch type – CSE in Indiana and KY and Comverge in NC and SC – uses traditional fixed cycling control, where all devices on the same program shed the same amount of time during the control period. In the Midwest, the principal PM program options are 1.5 kW and 1.0 kW, and Target Cycle switches are configured with these load reduction targets constrained by the maximum shed time of 24 minutes per 30-minute control period. Fixed Cycling (FC) devices in the Midwest limit the AC run-time to 7.5 minutes (1.5 kW) or 15 minutes (1.0 kW) of each 30-minute control period. Equivalently, PM CSE devices in the Midwest are operated with fixed cycling percentages of 75% (FC 75%) for 1.5 kW, or 50% (FC 50%) for 1.0 kW. The third program option in the Midwest is 0.5 kW. Due to the limited number of participants on this option, we scale the impact estimate for it based on the results for 1.0 kW. Different program options are not offered in the Southeast. Cannon devices in NC and SC are configured with a load reduction target of 1.3 kW (TC 1.3) constrained by the maximum shed time of 22.5 minutes per 30-minute control period, and Comverge fixed cycling devices limit the AC run-time to 5 minutes of each 15-minute control period. Equivalently, PM Comverge devices in the Southeast are operated with a fixed cycling percentage of 67% (FC 67%). Another control strategy is full shed of the AC. The AC is completely turned off during the control periods. This strategy is only commonly employed in the Southeast for emergency load shed events. Table 4 summarizes PM load control technology and strategy used in different states.

[2] QLIM: qualitative and limited dependent variable model.

Table 4. PM Load Control Devices and Strategies

Device	Period	Strategy					
		OH		IN / KY		NC / SC	
	(min)	1.5 kW	1.0 kW	1.5 kW	1.0 kW	Cycling	Full Shed
Cannon	30	TC 1.5	TC 1.0	TC 1.5	TC 1.0	TC 1.3	FC 100%
CSE	30			FC 75%	FC 50%		
Comverge	15					FC 67%	FC 100%

The Target Cycle control strategy puts more functionality in the switch itself. Rated amps of the attached AC unit is entered into the switch at installation, and used to determine connected load for the unit. The switch also records hourly duty cycle of attached AC unit and builds a profile (historical profile) of the expected hourly duty cycle under weather conditions typical for load control. The historical profile can be scaled (globally) by adjusters included in the commands sent to switches for load control. The connected load and adjusted historical profile are used to calculate hourly cycling percentages for the attached AC unit expected to achieve the appropriate load reduction target (1.5 kW, 1.3 kW, or 1.0 kW).

Factors that determine Target Cycle shed percentages for M&V AC units during control periods are known, except for contents of hourly historical profile registers on those days. Values in these registers change frequently during the summer as they are updated with the AC hourly run-time on "saved" days, which are selected with weather conditions sufficiently close to a typical load control day. Hourly run-time profiles on 2011 control days for M&V AC units are determined from the contents at the start of the 2011 control season (when available), and the unit run-time on 2011 saved days.

Various factors contribute to small deviations of the switch shed minutes recorded hourly in the switch data log during PM load control hours from the expected Target Cycle shed times calculated with switch register values for the amp parameter, the hourly historical profile, and the load reduction target. Such factors include limited precision of switch processor arithmetic, and occasional hours with proper shed in only one of two 30-minute shed periods. Note that in our operability shed analysis, hours with zero shed time are incorporated into the operability shed factor and do not contribute to the shed adjustment results. By analysis of Cannon switch shed times during 2011 PM load control hours for Target Cycle switches from the operability samples in NC/SC and IN, and the special group collected in OH/KY, we have estimated average shed deviation in different states and for different program types. These results given in Table 5 are used to adjust Target Cycle shed percentages in the load impact simulation model.

Table 5. Target Cycle shed adjustment

State	Program	Shed deviation (min /hr)	Shed deviation (%)
NC / SC	TC 1.3 kW	-0.99	-1.66
IN	TC 1.5 kW	0.11	0.18
IN	TC 1.0 kW	1.14	1.90
OH / KY	TC 1.5 kW	-0.79	-1.32
OH / KY	TC 1.0 kW	-0.10	-0.16

Analysis of Cannon switch shed times during 2011 PM load control hours for operability samples in NC/SC and IN, and for a special group collected in OH/KY, has identified many Cannon switches that deviate substantially from the shed times expected for the Target Cycle method. Instead, these switches appear to shed more like an "inverted" pattern, relative to the pattern expected, defined as follows:

$$Inverted\ shed\ \% = 100 - 0.5 * Target\ Cycle\ shed\ \%$$

Table 6 gives our estimates of the proportion of Cannon switches that shed according to the inverted pattern. These proportions are used to determine the overall shed per switch attributable to Cannon switches in different states and for different program options. Results are given in Table 6. These results are used to adjust shed percentages for the inverted pattern in the load impact simulation model.

Table 6. Percentage of Cannon Switches for Each Shed Pattern

State	Target KW	Target Cycle shed	Inverted shed
OH/KY	1.5	58.5%	41.5%
OH/KY	1.0	75.2%	24.8%
IN	1.5	30.1%	69.9%
IN	1.0	22.2%	77.8%
NC/SC	1.3	60.5%	39.5%

For LCR 4700 switches in OH/KY and NC/SC, newer switches with higher serial numbers shed according to the inverted pattern. For LCR 5200 switches in Indiana, it is the older switches with lower serial numbers that shed according to the inverted pattern. This issue is currently being researched by Cooper Power Systems (Cannon) staff.

The inverted pattern is characterized in terms of the Target Cycle shed time, and it is reasonable to expect similar deviations for these switches. By analysis of Cannon switch shed times during 2011 PM load control hours for switches following the inverted shed pattern from the operability samples in NC/SC and IN, and the special group collected in OH/KY, we have estimated average shed deviation for the inverted pattern in different states and for different program types. Results are given in Table 7. These results are used to adjust shed percentages for the inverted pattern in the load impact simulation model.

Table 7. Shed adjustment for the inverted pattern

State	Program	Shed deviation (min /hr)	Shed deviation (%)
NC / SC	1.3 kW	-1.25	-2.09
IN	1.5 kW	-3.35	-5.59
IN	1.0 kW	-2.19	-3.65
OH / KY	1.5 kW	-0.09	-0.15
OH / KY	1.0 kW	-0.41	-0.69

AC Connected Load

Connected load is the average power demand (kW) of a running AC unit over a full cycle. It determines the load reduction (kWh) achieved when AC run-time is reduced. Connected load is specified for M&V AC units through the basic engineering formulas:

*Apparent Power (kVA) = (Compressor Amps + Fan Amps) * 230 Volts / 1000*

*Connected Load (kW) = Power Factor * Apparent Power*

Rated amps for the compressor (FLA) and fan (RLA) are typically listed on the AC faceplate.

Power factor in this formula is actually different for different AC units, and even varies somewhat for different cycles of the same unit, increasing at high temperature and humidity. Duke Energy has analyzed synchronous AC run-time and premise interval kWh collected for the M&V samples to determine an appropriate overall power factor within each sample. Results are 0.84 for the Midwest M&V sample, and 0.8 for the Southeast M&V sample. These power factor values are used to calculate connected loads for impact evaluation.

Simulation Method for PM Impact Evaluation

Simulation with M&V natural duty cycle models is used to determine average load reduction per household within high and low M&V strata during each hour of load control and for each PM cycling strategy. These strata results are combined with the population weights given in Table 2 to estimate average load reduction per household in the PM population (Midwest or Southeast). The potential load impacts estimated in this manner represent the load reduction which would be achieved if all switches controlled as expected. Impact results for PM load control in the Midwest are obtained by simulation with the Midwest M&V sample, and impact results for the PM load control in the Southeast are obtained by simulation with the Southeast M&V sample.

The simulation procedure is very similar for the three basic PM control strategies: Target Cycle, Fixed Cycling, and Full Shed. In a fixed cycling or full shed (100% cycling) simulation, the same specified shed percentage is applied to all ACs to evaluate load impact for a particular program option. Program options available in each state and the corresponding shed percentages are shown in Table 4. In a Target Cycle simulation for a particular program option, or load reduction target, and during a specified hour (and day) of load control, a customized shed percentage is calculated for each AC unit from information specific to that unit. The appropriate adjustment is applied to this shed percentage. The resulting unit-specific shed percentages remain fixed in all simulated realizations for that load reduction target and load control hour.

Load reduction corresponding to the inverted shed pattern is also calculated in a Target Cycle simulation. A unit-specific shed percentage for the inverted pattern is determined from the relationship to the Target Cycle shed percentage given in the section "PM Load Control Strategies" and the appropriate adjustment from Table 7. The same set of simulated duty cycles for an AC are used to evaluate load reduction with both the Target Cycle shed percentage and the inverted pattern shed percentage calculated for that AC.

A single realization in the simulation is generated by a random draw of residuals for each of the M&V natural duty cycle model fits, which are evaluated at the temperature and humidity of the control hour (and day). This gives a set of simulated natural duty cycles appropriate for the control hour. Load reduction for each M&V AC is calculated as follows:

Duty cycle reduction = MAX[Duty cycle - (1 – Shed percentage), 0]

*Load reduction = Connected load * Duty cycle reduction*

For households with multiple ACs, realized load reduction is aggregated to the household level by summing load reduction from all household ACs. These realized load reductions are averaged within the strata to produce single realizations of average load reduction per household within both high and low strata. These two sample averages constitute the result from one pass through the simulation corresponding to one draw of model residuals.

Two thousand passes through the simulation are performed to adequately capture the variation in average load reduction within strata that is consistent with our duty cycle models and M&V sample sizes. The results accumulate into distributions of sample averages for both high and low strata. The grand means of these distributions are the most significant output from a simulation run. They are the estimates of average load reduction per household in the high and low strata for the specified control hour and cycling strategy. The spread of these distributions (e.g., variance) characterizes the uncertainty in the load reduction estimates, and is very much affected by our M&V sample sizes.

Load Impact Results

Load impacts described in this section are computed with population estimates of load reduction per switch, rather than load reduction per household. Simulation results are converted to load reduction per switch using the factors 1.057 switches per household for Ohio and Kentucky results, 1.063 switches per household for Indiana results, and 1.178 switches per household for Southeast results. Population estimates of load reduction per household are divided by these factors to get corresponding population estimates of load reduction per switch. The estimates of switches per household are determined from the Midwest and Southeast M&V samples.

Table 8 through Table 10 illustrate the calculation of the load reduction on a PM event day in a state with 3 different load control technologies. Load impact from CSE devices are developed in Table 8, load impact from Cannon devices are developed in Table 9, and Table 10 gives the total PM load impact in the state. In Table 8, columns labeled shed kW/switch are the results of simulation runs, scaled as described above, for both 75% cycling (1.5 kW program) and 50% cycling (1.0 kW program) and for hours 16-18 on June 8, 2011. Potential load impacts for CSE devices (next to last column) are calculated from switch counts for each program option in the state on the event day. De-rated load impacts in the last column of Table 8 are the product of the potential impact with the de-rating factor (54.1%) applicable to Kentucky CSE devices. The appropriate de-rating factors for each switch technology are determined by separate operability studies. Table 9 for Cannon devices is structured in the same way as Table 8. The columns with shed kW/switch in Table 9 contain results from Target Cycle simulations, and the higher de-rating factor appropriate for Cannon devices (93.1%) is used to calculate de-rated impacts. Table 10 shows the PM hourly impact results in KY on June 8, 2011, which are obtained by adding corresponding hours in the last columns of Table 8 and Table 9.

PM load control devices do not start shedding load in unison at the top of the first control hour. Instead, each load control device computes a random time delay which determines when the first shed period begins for that device. For the population as a whole, this reduces the shed minutes in the first hour of a load control event by a factor that depends on the load control technology and program option. For CSE devices, these loss factors are 0.1875 for the 1.5 kW program with 75% shed percentage, and 0.125 for the 1.0 kW program with 50% shed percentage. Potential and de-rated impacts for hour 16 in Table 8 are reduced accordingly. Duke Energy approximated the reduction in shed minutes for Target Cycle 1.5 kW and 1.0 kW programs with these same factors, and the potential and de-rated impacts for hour 16 in Table 9 are similarly reduced.

Table 8. KY CSE Impact Results on 6/8/2011

									De-rate 54.1%
		Option 1.5 kW			Option 1.0 kW			Total	
Date	Hour (EDT)	shed kW/switch FC 75%	Switch Count	Potential Impact (MW)	shed kW/switch FC 50%	Switch Count	Potential Impact (MW)	Potential Impact (MW)	De-rated Impact (MW)
			1439			1243			
6/8/2011	16	1.53		2.39	0.86		1.07	3.27	1.77
	17	1.60		2.50	0.91		1.13	3.43	1.86
	18	1.63		2.54	0.94		1.17	3.51	1.90

Table 9. KY Cannon Impact Results on 6/8/2011

									De-rate 93.1%
		Option 1.5 kW			Option 1.0 kW			Total	
Date	Hour (EDT)	shed kW/switch FC 75%	Switch Count	Potential Impact (MW)	shed kW/switch FC 50%	Switch Count	Potential Impact (MW)	Potential Impact (MW)	De-rated Impact (MW)
			2974			3910			
6/8/2011	16	1.24		3.55	1.04		4.07	7.75	7.22
	17	1.29		3.70	1.05		4.11	7.94	7.39
	18	1.3		3.72	1.04		4.07	7.93	7.39

Table 10. KY PM Impact Results on 6/8/2011

Date	Hour	De-rated Impact (MW)
6/8/2011	16	9.0
	17	9.3
	18	9.3

PM hourly impact results have been computed as illustrated by Table 8 through Table 10 for all 2011 load control days in all states. Results for OH, KY, and IN are given in Table 12 and results for NC and SC are given in Table 13. Both Cannon and CSE load control devices are also installed in Indiana, so load impact results there are computed in the same way as for KY. Only Cannon devices are installed in OH, so these load impact results are computed similarly to Table 9 above. In NC and SC, older fixed cycling Comverge switches are installed along with newer Cannon devices, so load impact results are computed similarly to Table 8 through Table 10. But PM offers a single program in NC and SC, with fixed cycling at 67% and a Target Cycle load reduction target of 1.3 kW, so the calculations corresponding to Table 8 and Table 9 are simplified.

Table 11 shows de-rating factors used for the 2011 impact evaluation. The factors for Cannon in OH and KY were determined by an operability study conducted in 2010. The CSE factor in KY was determined by an operability study conducted in 2009. The factors for CSE in Indiana and Comverge in the Southeast were determined by operability studies conducted in 2010. Cannon factors in Indiana and the Southeast were determined by operability studies conducted in 2011.

Table 11. De-rating Factors for Impact Evaluation

Switch Type	OH	KY	IN	NC / SC
Cannon	0.931	0.931	0.803	0.945
CSE		0.541	0.396	
Comverge				0.399

Table 12. 2011 PM Impact Results for OH, KY, and IN

Event Date	Hour	PM Impact (MW)			Midwest Total
		OH	KY	IN	
5/31/2011	15	15.5	8.3	25.0	48.8
	16	16.3	9.2	29.9	55.4
	17		2.0	13.6	15.6
6/7/2011	15	15.3	8.4	27.7	51.4
	16	16.4	9.2	31.5	57.1
	17	16.9	9.6	35.0	61.6
6/8/2011	16	15.4	9.0	18.6	42.9
	17	15.6	9.3	20.7	45.5
	18	15.5	9.3	21.4	46.2
7/12/2011	16	17.2	10.3		27.5
	17	17.5	10.6		28.1

7/20/2011	16	17.1	10.2	33.0	60.3
	17	17.3	10.4	35.7	63.4
7/21/2011	16	16.9	10.6	45.0	72.5
	17	17.5	11.0	49.3	77.9
	18	17.9	11.3	49.4	78.7
7/29/2011	16	16.9	10.4		27.3
	17	17.4	10.7		28.1
8/1/2011	15	14.1			14.1
	16	14.8	8.9	35.5	59.2
	17	15.6	9.4	38.7	63.8
9/1/2011	16	16.1	9.5	39.1	64.6
	17	17.3	10.3	43.1	70.7
	18	18.2	10.9	45.1	74.2

PM load control was activated in OH and KY on 9 days during the summer of 2011, including both CSE and Cannon devices on all days. PM load control was activated in Indiana on 7 days during summer 2011, including Cannon devices on all days and CSE devices on all days except for June 8. Table 12 gives hourly impact results in OH, KY, and IN for each control day. The last column of Table 12 gives total PM impact in the Midwest. The highest hourly impact in the Midwest was 78.7 MW in hour 18 (5:00 – 6:00 pm EDT) on July 21, not adjusted for line losses.

Table 13. PM Impact Results for NC and SC

Event Date	Hour	PM Impact (MW)		Southeast Total
		NC	SC	
6/21/2011	16	63.6	26.4	90.0
	17	67.9	28.3	96.3
7/11/2011	16	62.3	25.7	88.0
	17	67.1	27.8	94.9
	18	69.3	28.7	97.9
7/13/2011	16	69.2	28.8	98.0
	17	67.2	28.0	95.2
	18	63.2	26.2	89.4
7/20/2011	16	68.9	28.4	97.3
	17	72.0	29.7	101.7
7/21/2011	16	73.5	30.4	103.9
	17	76.5	31.7	108.3
7/29/2011	16	71.2	29.3	102.7
	17	73.7	30.3	106.9
8/2/2011	17	75.0	30.6	101.8
	18	76.5	31.3	105.0
8/25/2011	16	126.4	43.3	169.7

PM cycling events were activated in NC and SC on 8 days during the summer of 2011. Both Cannon and Comverge devices were controlled on all days. Table 13 gives hourly impact results in NC and SC for each control day. The last column of Table 13 gives total PM impact in the Southeast. The highest hourly impact for cycling events in the Southeast was 108.3 MW in hour 17 (4:00 – 5:00 pm EDT) on July 21. A full shed test event was activated on August 25 from 3:00 to 4:00 pm in NC and SC and the total impact was 169.7 MW not adjusted for line losses and 183.3 MW after adjusting for line losses.

Table 14 gives estimated load reduction per switch under peak normal weather conditions for different PM program options and load control technologies. **Table 15 shows the summer monthly load reduction adjusted for line losses under peak normal weather conditions for each state.** Table 16 shows the peak normal weather conditions used to calculate the results in Table 14. The system peak is assumed to occur in the hour 5:00 – 6:00 pm EDT in the Midwest (identified as hour 18 in this report). The system peak in the Southeast is assumed to occur in the hour 4:00 – 5:00 pm EDT (identified as hour 17 in this report).

Table 14. Shed kW/switch with Peak Normal Weather

Switch Type	Control Strategy	Potential Impact			De-rated Impact		
		OH/KY	IN	NC/SC	OH/KY	IN	NC/SC
Cannon	TC 1.5	1.50	1.37		1.40	1.10	
	TC 1.0	1.33	1.48		1.24	1.19	
	TC 1.3			1.18			1.12
	Full Shed			2.22			2.10
CSE	FC 75%	1.77	1.74		0.96	0.69	
	FC 50%	1.05	1.00		0.57	0.40	
Comverge	FC 67%			1.29			0.51
	Full Shed			2.22			0.89

Table 15. Monthly Peak Normal Weather Load Reduction De-rated Impact by State adjusted for Line Losses for Cycling and Full Shed

State	Control Strategy	June	July	August	September
Ohio	**Cycling**	**48.9**	**48.8**	**49.4**	**50.5**
Kentucky	Cycling	11.8	12.2	12.1	12.1
Indiana	Cycling	42.8	43	43	43.6
Carolinas	Cycling	110.9	112.9	113.7	115
Carolinas	Full Shed	224.2	226.7	227.6	229.2

Table 16. Peak Normal Weather

Hour	OH / KY		IN		NC / SC	
	Temp	Dewpt	Temp	Dewpt	Temp	Dewpt
11	85.3	71.8	84.9	73.9	89.0	69.0
12	87.6	71.9	87.6	74.4	91.0	69.0
13	89.9	71.9	89.9	74.8	92.0	68.0
14	92.0	71.5	91.2	74.9	94.0	68.0
15	93.1	70.7	91.9	74.5	93.0	69.0
16	93.9	70.5	91.5	74.2	95.0	67.0
17	92.5	70.0	90.8	74.0	95.0	66.0
18	92.4	69.5	89.5	73.5	95.0	67.0