Focus on Energy Evaluated Deemed Savings Changes

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The Cadmus Group, Inc.

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Deemed Savings Analysis

This report contains measure-specific findings from evaluating the 2014 Wisconsin Focus on Energy programs. Some of these findings are the result of individual project-level evaluation activities such as analysis of site visits, phone interviews, documentation reviews, independent calculations of savings, and data from secondary sources.

Over the 2014 evaluation effort, the Evaluation Team reviewed each active 2014 program, many of the projects completed under those programs, and many of the measures installed through those programs. Because thousands of individual projects have been completed, the Evaluation Team used a sampling approach to select a random population of projects and measures to evaluate in greater detail. All projects were sampled on a random and stratified basis. This stratification of projects/measures sorts participants into groups based on the savings reported. This approach ensures that the random sampling process results in not missing, by random chance, the largest projects and measures.

The Evaluation Team completed three main studies in calendar year (CY) 2014 that impact deemed savings values: (1) part-use factor surveys for the Appliance Recycling Program, (2) in-service rate surveys for direct install showerheads, and (3) metering and trend data analysis of guest room energy management controls (GREM). The results of those studies revealed the following values for key input variables (specific details regarding these inputs are described further in this document):

1. Appliance recycling measure part-use factors:
    a. Refrigerators= 0.82
    b. Freezers= 0.79
2. Direct install showerheads in-service rate: 90%
3. GREM controls:
    a. Weighted average cooling design load: 9,285 Btu/hr
    b. Energy efficiency ratio for air conditioner: 10.8
    c. Cooling degree days: 582
    d. Heating degree days: 7,501
    e. Design temperature difference for cooling (ΔTc): 76°F
    f. Design temperature difference for heating (ΔTc): 17°F

The Evaluation Team recommends that savings calculations for Appliance Recycling Program measures, direct install showerheads, and GREM controls measures be updated in CY 2016 to reflect these assumptions. This report identifies the measures affected; the *ex ante* savings assumptions in place for those measures in the SPECTRUM database during CY 2014; and the revised savings values calculated based on those recommended savings updates.

Table 1 lists the current measures affected by the Evaluation Team's recommendations. The Team also recommends using these updated assumptions for any new similar measures proposed by Program Implementers as well as for any custom and hybrid projects where these measures are used.

Table 1. Measures Requiring an Update

Measure Category	SPECTRUM Name and MMID
Residential	
Appliance Recycling	Refrigerator Recycling, 2955 Freezer Recycling, 2956
Direct Install Showerheads	Showerhead, Direct Install, 1.5 GPM, NG, 2123 Showerhead Direct Install, 1.5 GPM, Electric, 2129
Nonresidential	
Guest Room Energy Management Controls	Guest Room Energy Management Controls, Electric Heat PTAC Systems, 2373

2014 Deemed and Evaluated Savings Values

The deemed savings values, or adjusted gross savings values per unit, during CY 2014 and the evaluated savings values are listed in Table 2.

Table 2. Deemed and Evaluated Savings Values

Measure Category	SPECTRUM Name and MMID	Deemed	Evaluated	Units
Appliance Recycling	Refrigerator Recycling, 2955	1,071	886	kWh per year
		0.1230	0.1020	kW
		-	-	Therms per year
	Freezer Recycling, 2956	1,155	962	kWh per year
		0.1420	0.1190	kW
		-	-	Therms per year
Direct Install Showerheads	Showerhead, Direct Install, 1.5 GPM, NG, 2123; and Showerhead Direct Install, 1.5 GPM, Electric, 2129,	318	360	kWh per year
		0.0167	0.009	kW
		14	16	Therms per year
		2,625	2,967	Water Savings (gal/yr)
Guest Room Energy Management Controls	Guest Room Energy Management Controls, Prescriptive, 2373	1,507	1,568	kWh per year
		0.1000	-	kW
		-	-	Therms per year

Evaluation Savings Analysis

Methodology

During CY 2014, the Evaluation Team used engineering reviews, supporting research and fieldwork, and metering to create *ex post* savings assumptions, using the following methodology:

- ***Engineering Reviews.*** Through these reviews, the Evaluation Team calculated *ex post* savings using observed baseline conditions to inform adjustments to the engineering algorithm inputs, and applied this approach to measures with small per-unit energy savings or when isolated savings could be measured using reliable data.
- ***Supporting Research and Fieldwork.*** The Evaluation Team relied on recent studies to obtain current variables relevant to the Wisconsin population. These studies included previous research and fieldwork that members of the Evaluation Team have conducted in the Midwest.
- ***Metering.*** The Evaluation Team installed data loggers in guest rooms at two hotel sites. Metering and trend data analysis revealed the need for updating the GREM savings algorithm.

Calculation of Evaluated Savings Values

The algorithms presented in this section show how the Evaluation Team applied savings analysis data to generate evaluated deemed savings values for specific measures. Additional measures, not defined here, may require the same algorithms or updates based on using revised assumptions from the studies mentioned above.

Appliance Recycling Measures

The Evaluation Team surveyed 70 Appliance Recycling Program participants, and used the survey results to estimate an updated part-use factor. Part-use is an adjustment factor used to convert the annual unit energy consumption of a refrigerator or freezer into an average per-unit gross savings value. The adjusted savings apply to these two measures in SPECTRUM:

- Refrigerator Recycling, 2955
- Freezer Recycling, 2956

An increasing part-use factor is likely expected over the first several years of program implementation because new appliance recycling programs tend to clear out a backlog of unwanted and seldom-used appliances that may have been sitting in customer homes for many years. An increase in part-use factor will result in increased per-unit gross energy savings. The per-unit savings for appliance recycling measures will likely increase as the program matures, partly based on the following:

- The part-use adjustment accounts for the fact that not all recycled appliances would have operated year-round if not decommissioned through the program.
- As appliance recycling programs mature, the characteristics of the recycled appliances tend to change. For example, a newly launched appliance recycling program is more likely to collect

many older, unwanted appliances that may not be in use prior to recycling, which result in a low part-use factor. As the program matures, there is less of a backlog of unwanted appliances, typically resulting in an increased part-use factor and higher savings.

To estimate part-use based on current industry standards, the Evaluation Team followed the detailed methodology documented in Chapter 7 of the U.S. DOE *Uniform Methods Project.*[1] The Evaluation Team asked participants a series of questions about how they used their appliance prior to recycling. Their responses contributed to the estimate of a historic part-use factor, or the average portion of the year during which a participating appliance was plugged in and running prior to recycling. Next, the Evaluation Team asked participants how they would have used the appliance if they had not recycled it through the program. This information allowed the Evaluation Team to estimate a prospective part-use factor, using a weighted average of historic part-use factors and the participants' likely actions in absence of the Appliance Recycling Program. Table 3 shows the results of CY 2014 analysis.

Table 3. CY2014 Part-Use Factor Data

Use Prior to Recycling	Likely Use Independent of Recycling	Refrigerator		Freezer	
		Part-Use Factor	Percentage of Participants	Part-Use Factor	Percentage of Participants
Primary	Kept (as primary unit)	1.00	1%		
	Kept (as secondary unit)	0.71	17%		
	Discarded	0.88	33%		
Secondary	Kept	0.71	20%	0.79	44%
	Discarded	0.88	29%	0.79	56%
Overall		**0.82**	**100%**	**0.79**	**100%**

The CY 2014 part-use factor was 0.82 for refrigerators (MMID 2955) and 0.79 for freezers (MMID 2956). There was no statistically significant change between the CY 2013 and CY 2014 results, but the CY 2014 part-use factor for refrigerators is nominally 4% higher than the CY 2013 value.

Table 4 shows the CY 2014 part-use results compared to prior years' results. Although the differences are not large, the trend over time indicates that the part-use factor for refrigerators may be increasing.

Table 4. Part-Use Factor Yearly Trends

Appliance	Part-Use Factor		
	CY 2012	CY 2013	CY 2014
Refrigerators	0.67	0.78	0.82
Freezers	0.81	0.80	0.79

[1] National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. April 2013.

An increasing part-use factor is expected over the first several years of program implementation, because new appliance recycling programs tend to clear out a backlog of unwanted and seldom-used appliances that may have been sitting in customer homes for many years.

Annual Energy-Savings Algorithm

kWh_{SAVED}= Unadjusted gross annual kWh savings/unit * Part_Use

The unadjusted annual energy savings in the current Focus on Energy TRM is a deemed value based on evaluation, measurement, and verification analyses conducted by Cadmus in other jurisdictions.[2] The TRM also assumes a part-use factor of 0.90 for both kWh and kW.

Focus on Energy's evaluation work in CYs 2013 and 2014 provides data to update both factors. First, modeling present in the CY 2013 report provides an updated estimate of gross annual savings specific to Wisconsin's jurisdiction, which results in a slight reduction in assumed savings for both refrigerators and freezers. Second, the determined part-use factors for both refrigerators and freezers are lower than the assumed factor of 0.90. Applying the updated part-use factors to the updated gross savings assumptions yields an evaluated-adjusted per-unit gross savings less than the CY 2014 deemed savings. The evaluated annual energy savings are presented in Table 5.

Table 5. Evaluated Annual Energy Savings

Metric	Refrigerators	Freezers
Unadjusted gross annual kWh savings/unit*	1,081	1,215
Part-use factor	0.82	0.79
Adjusted gross annual kWh savings/unit	**886**	**962**

* Cadmus. *Focus on Energy Calendar Year 2013 Evaluation Report,* Volume II, Table 24. May 15, 2014.

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = [(kWh savings/unit) / HOURS] * P *Part_Use

[2] Cadmus. *EM&V Report.* Prepared for Dayton Power & Light. March 15, 2011.

Where:

HOURS	=	Annual operating hours (= 8,760)
P	=	Peak intensity factor, captures the increase in compressor cycling time in summer peak conditions relative to average annual conditions (= 1.01 for refrigerators; = 1.08 for freezers)[3]
Part_Use	=	Part-use factor determined by Evaluation Team (= 0.82 for refrigerators; = 0.79 for freezers)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL	=	Effective useful life of replaced refrigerator and freezer (= 8 years)[4]

For this technology, the remaining useful life of the equipment is technically eight years; however, for consistency it is represented as the EUL.

Evaluated Savings

Table 6 shows the annual and lifecycle savings, along with peak demand reduction, for refrigerators and freezers.

Table 6. Evaluated Savings

	Refrigerator (MMID 2955)	Freezer (MMID 2956)
Annual Energy Savings (kWh)	886	962
Peak Demand Reduction (kW)	0.102	0.119
Lifecycle Energy Savings (kWh)	7,088	7,696

[3] Cadmus. *Appliance Recycling Measure Savings Study*. Memo prepared for Michigan Evaluation Working Group. August 20, 2012.

[4] KEMA. Residential refrigerator recycling ninth year retention study. For Southern California Edison. 2004.http://www.calmac.org/startDownload.asp?Name=RARP_report_to_SCE_040726ES.pdf&Size=289KB

Direct Install Showerheads

The Evaluation Team surveyed 100 participants from three Focus on Energy programs: Home Performance with ENERGY STAR, Assisted Home Performance with ENERGY STAR, and Express Energy Efficiency. Based on the results of the surveys, the Evaluation Team adjusted the savings for the following measures (listed by their Master Measure Names from SPECTRUM):

- Showerhead, Direct Install, 1.5 GPM, NG, 2123
- Showerhead Direct Install, 1.5 GPM, Electric, 2129

These measures apply to standard 1.5 and 1.0 GPM low-flow aerators. The baseline equipment is assumed to be a higher flow rate aerator.

The primary goal of the surveys was to determine the rate at which program showerheads were installed, and remained installed, up to the date of the survey. Using these data, the Evaluation Team calculated a residential direct-install in-service rate (ISR) for CY 2014 energy-efficient showerheads. The results of the survey are shown in Table 7.

Table 7. In-Service Rate

Programs	Showerheads Received	Showerheads Persisted	Overall In-Service Rate
Home Performance, Assisted Home Performance, and Express Energy Efficiency	208	187	90%

Table 8 shows the historic ISRs that have been applied to showerhead savings for the three programs. The findings from the surveys are consistent with the previous ISRs applied.

Table 8. Historical In-Service Rates

Program	Historic Showerhead In-Service Rate Applied	
	CY 2012	CY 2013
Home Performance with ENERGY STAR	93%	NA
Assisted Home Performance with ENRGY STAR	93%	93%
Express Energy Efficiency	93%	87%

The Evaluation Team suggests updating the ISR to 0.90 for direct-install showerhead measures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{electric})/3,412) * ISR$

$Therms_{SAVED} = (((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{gas})/100,000) * ISR$

$Gallons_{SAVED} = ((GPM_{EXISTING} - GPM_{NEW}) * ((PH * SPD)/FH) * SLU * 365) * ISR$

- Where:

ΔGallons	=	First-year water savings, gallons
8.33	=	Density of water, lbs/gallon
1	=	Specific heat of water, Btu/lb °F
$T_{POINT\ OF\ USE}$	=	Temperature of water at point of use (= 101°F for showerheads)[5]
$T_{ENTERING}$	=	Temperature of water entering water heater (= 52.3°F)[5]
$RE_{ELECTRIC}$	=	Recovery efficiency of electric water heater (= 98%)[6]
3,412	=	Conversion from Btus to kWhs
RE_{GAS}	=	Recovery efficiency of natural gas water heater (= 76%)[6]
100,000	=	Conversion from Btus to therms
$GPM_{EXISTING}$	=	Baseline flow rate (== 2.5 GPM for showerheads)[7]
GPM_{NEW}	=	Efficient flow rate (= 1.5 GPM for showerheads)
PH	=	Multifamily persons per house (= 1.93)[8]
FH	=	Multifamily fixtures per house (= 1.0 for showerheads)[8]
365	=	Conversion from days to years
SPD	=	Showers per person per day (= 0.6)[5]
SLU	=	Shower length of use (= 7.8 minutes/shower)[5]
ISR	=	0.90

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * LU * 365 \text{ days} / (60 \text{ mins/hr}) / FH) * ISR$

Where:

CF = Coincidence factor (= 0.0023 for showerheads)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

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5 Cadmus. Michigan Water Meter Study. 2012

6 NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf.

7 Federal minimum at 80 psi.

8 Residential Energy Consumption Survey, Micro Survey Data. Structural and Geographic Characteristics, Wisconsin. 2009. Based on average of single-family units (single-family detached and single-family attached).

Where:

EUL = Effective useful life (= 10 years)[9]

Evaluated Savings

Table 9 shows the annual and lifecycle savings, along with peak demand reduction, and annual water savings for direct install showerhead measures.

Table 9. Evaluated Savings

Type of Savings	Showerhead
Annual Energy Savings (kWh)	360
Peak Demand Reduction (kW)	0.009
Annual Therm Savings (Therms)	15.83
Lifecycle Energy Savings (kWh)	3,600
Lifecycle Therm Savings (Therms)	158
Water Savings (gal/yr)	2,967

Guest Room Energy Management

As part of the CY 2014 impact evaluation, the Evaluation Team conducted metering and trend data analysis at two hotel sites to provide recommendations for updating the Guest Room Energy Management (GREM) savings algorithm. GREM controls are typically installed on packaged terminal air conditioning or packaged terminal heat pumps serving individual hotel guest rooms. They can also be installed on water-source heat pumps or fan coils. Based on the results of the metering and trend data analysis, the Evaluation Team adjusted the savings for the following measures:

- Guest Room Energy Management Controls, Electric Heat PTAC Systems, 2373

GREM controls are retrofit thermostat products capable of monitoring occupancy status using an integrated, passive infrared sensor or remote ceiling-mounted sensor. These sensors are designed to search for an occupant via motion detection or operation of the guest room door. When the thermostat senses the room is occupied, the guest has control over the thermostat and room temperature. When the system senses that the room is unoccupied, it sets the HVAC system to a default energy conservation mode consisting primarily of setpoint temperature setbacks.

As part of the CY 2014 impact evaluation, the Evaluation Team conducted metering and trend data analysis at two hotel sites (out of six participating sites in 2014) to provide recommendations for updating the GREM savings algorithm. The studies intent was to evaluate the validity of the 30% energy reduction factor used to estimate claimed savings. A secondary goal of this study was to evaluate the

[9] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Selected Residential & Small Commercial Gas Measures; March 2009. New York Department of Public Service. http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/$FILE/60_DAy_Gas_TecMarket_Energy_Savings_Manual_Final_1-0.pdf

measure-specific values for heating degree day (HDD), cooling degree day (CDD), heating correction factor, and design temperature difference used in the savings algorithm.

The Evaluation Team evaluated the GREM energy savings factor by comparing trended equipment run times and duty cycles for periods of active room occupancy versus known vacancy. The Evaluation Team concludes that the deemed GREM savings factor (30%) is reasonable and that the research does not conclusively support a change to the GREM savings factor (deemed= 31%). Hotels with high occupancy may have lower potential savings. The Program Implementer should collect occupancy rates (whole hotel, monthly, or annually) for future GREM measure applicants.

The GREM savings algorithm uses heating hours (based on HDD and design temperature difference) with a heating correction factor and over-sized factor. The focus of the study was the GREM savings factor, which is unaffected by these parameters. By setting these parameters constant, the Evaluation Team was able to focus only on the difference between occupied room energy consumption and un-occupied energy consumption – which represents the GREM savings factor. The Evaluation Team reviewed the parameters to determine whether they align with the values and methods used in the TRM. The Evaluation Team metered HVAC systems for several months which shows the difference in energy consumption during occupied and unoccupied modes.

The algorithm and inputs in the GREM savings calculation measure workbook differ slightly from TRM algorithms and inputs for similar measures. The values in the savings algorithm do not affect the estimate of the GREM savings factor but these values could be refined to align with values in the TRM. The Evaluation Team recommends revising the following parameters and the GREM algorithm:

Design Load & EER Ratings: The GREM work paper assumes a weighted average cooling design load of 9,750 Btu/hr and a 9.6 EER rating for guest room PTAC units. The verified weighted averages from this study were 9,285 Btu/hr and 10.8 EER, respectively. The stipulated cooling capacity and efficiencies used in the GREM measure workbook seem reasonable, but any increase in the stipulated EER value in the future should be carefully considered as older equipment gets phased out and newer, more efficient equipment is installed.

Weather Related Savings Parameters: The Wisconsin TRM provides guidance on HDD, CDD, and design temperature, but the GREM savings calculation uses different inputs. The Evaluation Team recommends updating the algorithm for the GREM measure to ensure that parameter inputs match values provided by the TRM. Inputs for HDD and CDD should match the TRM population-weighted statewide average. Using a base temperature of 65°F and the TRM-defined population weighted statewide average design temperatures, the GREM heating and cooling design temperatures should be changed to 80°F and 20°F, respectively and should use the TRM HDD and CDD values (Table 10. Differences between TRM and Measure Specific Inputs

Table 10. Differences between TRM and Measure Specific Inputs

Parameter	Wisconsin TRM Value	GREM Algorithm Value
Cooling Degree Days (CDD)	565	582
Heating Degree Days (HDD)	7,616	7,501
Design Temperature Difference – Cooling (ΔT_c) in °F	80	76
Design Temperature Difference – Heating (ΔT_h) in °F	20	17

Heating Correction Factor (HCF): The average verified HCF from the equipment surveyed was dependent on equipment type and ranged from 94% to 184%, as shown in Table 11. The GREM measure workbook currently assumes an HCF value of 75%. Currently, all available data indicates unitary HVAC systems eligible for the GREM measure are PTACs with electric auxiliary heat.

Table 11. Verified HCF by System Type for Sample Population

System Type	Weighted Avg. HCF
Packaged Terminal Heat Pump (PTHP)	0.94
Packaged Terminal Heat Pump with Electric Auxiliary Heating	1.84
Packaged Terminal Air Conditioner with Electric Auxiliary Heating	1.33

Annual Energy-Savings Algorithm

The Evaluation Team calculated annual energy savings for each guest room and solved for a room-specific GREM energy-savings factor using a modified version of the algorithm from the Wisconsin TRM. This algorithm is:

$$GREM\ savings\ factor =$$

$$\frac{Annual\ kWh\ Savings}{\left[\left(\frac{DL\ \times\ OLF\ \times\ HDD\ \times\ 24\ \times\ HCF}{\Delta Th\ \times\ 3{,}413}\right) + \left(\frac{DL\ \times\ OLF\ \times\ CDD\ \times\ 24}{\Delta Tc\ \times\ 12{,}000} \times \frac{12}{EER}\right)\right]}$$

Where:

- *Annual kWh Savings = room specific annual savings*
- *DL = actual room-specific cooling capacity of the PTAC unit in Btu/hr*
- *HDD = number of heating degree days, deemed 7,501*
- *CDD = number of cooling degree days, deemed 582*
- *ΔTh = design temperature difference for heating, deemed 76°F*
- *ΔTc = design temperature difference for cooling, deemed 17°F*
- *HCF = Heating Correction Factor, deemed 0.75*
- *OLF = oversized factor for design load, deemed 85%*
- *EER = actual room-specific Energy Efficiency Ratio for PTAC unit*
- *12,000 = conversion factor, Btu per ton*
- *12 = conversion factor based on the definition of EER, converts EER to kW/ton*
- *24 = number of hours in a day*
- *3,413 = conversion factor, Btu per kWh*

The annual kWh savings, design load (DI), and energy efficiency ratio (EER) are all recommended to be modified, as shown in the algorithm above.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years for Guest Room Energy Management Controls, Electric Heat PTAC Systems)[10]

[10] Average of Cadmus database 2013 and Focus Business Program Measure Life Study. PA Consulting Group. 2009.https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf.

Deemed Savings

Table 12 shows the annual and lifecycle savings, along with peak demand reduction for GREM measures.

Table 12. Evaluated Savings

Type of Savings	Guest Room Energy Management Controls, Electric Heat PTAC Systems
Annual Energy Savings (kWh)	1,568
Peak Demand Reduction (kW)	-
Annual Therm Savings (Therms)	-
Lifecycle Energy Savings (kWh)	15,680
Lifecycle Therm Savings (Therms)	-

Final Recommendations:

Results

The Evaluation Team recommends updating the savings values for several measures: refrigerator and freezer recycling, direct install showerheads, and guest room energy management controls. Table 13 compares the evaluated and deemed savings and shows the changes to final savings.

Table 13. CY 2014 Deemed and Evaluated Savings Results

Measure Category	SPECTRUM Name and MMID	Deemed	Evaluated	Difference	Units
Appliance Recycling	Refrigerator Recycling, 2955	1,071	886	185	kWh per year
		0.1230	0.1020	0.0210	kW
		-	-	-	Therms per year
	Freezer Recycling, 2956	1,155	962	193	kWh per year
		0.1420	0.1190	0.0230	kW
		-	-	-	Therms per year
Direct Install Showerheads	Showerhead, Direct Install, 1.5 GPM, NG, 2123and Showerhead Direct Install, 1.5 GPM, Electric, 2129,	318	360	-42	kWh per year
		0.0167	0.0090	0.0077	kW
		14	16	-2	Therms per year
		2,625	2,967	-342	Water Savings (gal/yr)
Guest Room Energy Management Controls	Guest Room Energy Management Controls, Prescriptive, 2373	1,507	1,568	-61	kWh per year
		0.1000	-	-	kW
		-	-	-	Therms per year