

FINAL REPORT

Focus on Energy Evaluated Deemed Savings Changes

November 26, 2013

Public Service Commission of Wisconsin

The Cadmus Group, Inc.

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Deemed Savings Analysis: Residential

This report contains the measure-specific findings from the evaluation of the 2012 Focus on Energy programs. These findings are the result of individual project level evaluation activities that leverage site visits, phone interviews, documentation reviews, independent calculations of savings and data from secondary sources.

Over the course of the 2012 evaluation effort, the Evaluation Team[1] (the Team) reviewed each of the active programs in 2012, many of the projects that were completed under the programs, and many of the measures that were installed through the programs. Because there are thousands of individual projects that have been completed, the Evaluation Team uses a sampling approach to select a random population of projects and measures to evaluate in greater detail. The projects are sampled on a random and stratified basis. The stratification of projects/measures sorts participants into groups based upon the savings that are being reported. This approach ensures that the random sampling process does not result in an evaluation that, by random chance, misses the largest projects and measures.

The results in this report are for the calendar year 2012 (CY 2012) evaluation of Focus on Energy's *ex ante* savings assumptions in the SPECTRUM database. The values used by the Administrator and Implementers may have been established through previous evaluations or developed through other resources.

The Evaluation Team identified key measures and assumptions that need to be updated to reflect a changing market, incorrect assumptions, or a lack of data for specific measures. The measures are listed in Table 1.

[1] The Evaluation Team is made up of Cadmus, Nexant, St. Norbert College Strategic Research Institute, and TecMarket Works.

Table 1. Measures Requiring an Update

Measure Category	SPECTRUM Name	Calculation Page
Residential		
Ground Source Heat Pump	Ground Source Heat Pump, NG Back-up	13
Furnace with ECM Motor[1]	LP or Oil Furnace with ECM, 90%+ AFUE (Existing) NG Furnace with ECM, 95%+ AFUE (Existing) NG Furnace with ECM, 90%+ AFUE (Existing)	NA
Water Heater	Water Heater, NG, EF of 0.67 or greater	15
	Water Heater, Electric, EF of 0.93 or greater	16
	Water Heater, Indirect	17
Tankless Water Heater	Tankless Water Heater, NG, EF of 0.82 or greater	19
Clothes Washer	Clothes Washer, Common Area, Electric, ENERGY STAR	20
	Clothes Washer, Common Area, NG, ENERGY STAR	22
	Clothes Washer, In Unit, ENERGY STAR	24
Dishwasher	Dishwasher, Electric, ENERGY STAR	26
Showerhead	Showerhead, Non PI Direct Install, 1.5 gpm, Electric Showerhead, Non PI Direct Install, 1.5 gpm, NG Showerhead, Direct Install, 1.5 gpm, Electric Showerhead, Direct Install, 1.5 gpm, NG	27
Kitchen and Bathroom Aerators	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, NG Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, NG Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Electric Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, NG Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, Electric Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, NG	30
Direct Install, Compact Fluorescent Lights (CFLs)	CFL, Non PI Direct Install, 9 Watt CFL, Non PI Direct Install, 14 Watt CFL, Non PI Direct Install, 19 Watt CFL, Non PI Direct Install, 23 Watt CFL, Direct Install, 9 Watt CFL, Direct Install, 14 Watt CFL, Direct Install, 19 Watt CFL, Direct Install, 23 Watt	34
Nonresidential		
Steam Trap Repair, < 50 psig, General Heating		37
T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO		39
LED, 8-12 Watts		41

[1] Furnace ECMs are currently being investigated through a metering study. Findings on this measure, including recommendations for deemed savings, will be presented in a separate memo at the conclusion of that study.

Overview

The SPECTRUM database provides deemed savings for the Focus on Energy Administrator and Implementers; these savings values were then used to create the 2012 *ex ante* savings estimates. Focus on Energy leveraged many sources over the years—including past evaluations—to create an expansive deemed savings database.

Data Collection

Many of the deemed savings values in SPECTRUM were developed data from other jurisdictions. Some do not have adequate information to allow the Evaluation Team to assess the values used to create them. While several studies have been conducted for Focus on Energy, the savings values gained from some of those studies may no longer be accurate because of changes in codes or changes in the marketplace. While some workpapers were created for the measures listed, evaluated data captured was used to create the savings values presented below.

2012 Deemed Savings Values

The deemed savings values that were applied during CY 2012 are listed in Table 2.

Table 2. Residential Deemed Savings Values

Measure		Deemed	Units
Ground Source Heat Pump, NG Back-up		270.00	kWh per year
		0.50	kW
		192.50	therms per year
Water Heater, NG, EF of 0.67 or greater		-	kWh per year
		-	kW
		30.96	therms per year
Water Heater, Electric, EF of 0.93 or greater		154.03	kWh per year
		-	kW
		-	therms per year
Water Heater, Indirect		-	kWh per year
		-	kW
		32.00	therms per year
Tankless Water Heater, NG, EF of 0.82 or greater		-	kWh per year
		-	kW
		66.50	therms per year
Clothes Washer, Common Area, Electric, ENERGY STAR		625.30	kWh per year
		-	kW
		-	therms per year
Clothes Washer, Common Area, NG, ENERGY STAR		62.50	kWh per year
		-	kW
		21.30	therms per year
Clothes Washer, In Unit, ENERGY STAR		163.00	kWh per year
		-	kW
		5.50	therms per year
Dishwasher, Electric, ENERGY STAR		90.00	kWh per year
		-	kW
		5.00	therms per year
Showerhead		726.20	kWh per year
		-	kW
		36.20	therms per year
Kitchen Aerators		224.50	kWh per year
		-	kW
		11.10	therms per year
Bathroom Aerators		127.00	kWh per year
		-	kW
		6.30	therms per year
Direct Install, Compact Florescent Lights (CFLs)	9 Watt	25.79	kWh per year
		0.002	kW
	14 Watt	38.25	kWh per year
		0.003	kW
	19 Watt	46.52	kWh per year
		0.004	kW
	23 Watt	64.04	kWh per year
		0.006	kW

Deemed Savings Analysis: Non-Residential

Overview

The SPECTRUM database contains deemed savings values that are used by the Focus on Energy Administrator and Implementers. These deemed savings values were used to create the 2012 *ex ante* savings estimates. This database was created from numerous sources, including past Focus on Energy evaluations, other jurisdictions' regional and statewide technical reference manuals (TRMs), as well as privately and publicly funded research papers.

The Evaluation Team recommends updating several key measures and assumptions to improve the estimates of project savings. The Team's recommendations described in this report are based on the results of a database review, project audits, on-site measurement and verification, engineering analyses, and customer surveys. For each sampled measure, the Team used data from project audits and on-site measurement and verification to estimate verified savings. The Team then compared the verified savings with deemed values from SPECTRUM.

Data Collection

Many of the measures reviewed during the 2012 Impact Evaluation are not included in the Public Service Commission of Wisconsin—Focus on Energy Evaluation—Business Programs: Deemed Savings Manual V1.0[2]. Current deemed savings values were most likely developed from historic data, evaluation of project-to-project savings, as well as leveraging TRM data from other jurisdictions. As a result, it is necessary to revisit some of the measures and to improve upon the transparency of the calculations of saving claimed by the Focus on Energy programs.

[2] Public Service Commission of Wisconsin, Business Programs: Deemed Savings Manual V1.0 (Evaluation Contractor: PA Consulting Group, Inc.) Update Date: March 22, 2010.

2012 Deemed Savings Values

The deemed savings values applied during the 2012 program year are listed in Table 3.

Table 3. Nonresidential Deemed Savings Values

Measure	Category	Deemed	Units
Steam Trap Repair, < 50 psig, General Heating (Commercial/Schools & Government)		-	kWh per year
		-	kW
		910	therms per year
T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO	Agriculture	560	kWh per year
		0.0797	kW
		-	therms per year
	Industrial	287	kWh per year
		0.0593	kW
		-	therms per year
	Commercial	366	kWh per year
		0.0593	kW
		-	therms per year
	Schools & Government	250	kWh per year
		0.0493	kW
		-	therms per year
T8 4L 4', HPT8, CEE, replacing 8' 2L T12VHO	Agriculture	1175	kWh per year
		0.1675	kW
		-	therms per year
	Industrial	933	kWh per year
		0.1925	kW
		-	therms per year
	Commercial	1186	kWh per year
		0.1925	kW
		-	therms per year
	Schools & Government	810	kWh per year
		0.1600	kW
		-	therms per year
LED, 8-12 Watts	Agriculture	165	kWh per year
		.0235	kW
		-	therms per year
	Industrial	166	kWh per year
		0.0270	kW
		-	therms per year
	Commercial	131	kWh per year
		0.0270	kW
		-	therms per year
	Schools & Government	113	kWh per year
		0.0224	kW
		-	therms per year

Evaluation Savings Analysis: Residential

Methodology

During CY 2012, the Evaluation Team used engineering reviews, surveys, supplemental studies, and metering to create *ex post* savings assumptions. The methodology for each of these activities is explained below.

- ***Engineering Reviews.*** Through these reviews, the Team calculated *ex post* savings, using observed baseline conditions to inform adjustments to the engineering algorithm inputs. The Team used this approach for measures with small per-unit energy savings or when isolated savings could be measured using reliable data.
- ***Surveys.*** The Team conducted participant and nonparticipant surveys to understand usage patterns better. Depending on the measure, the Team conducted contractor or trade ally interviews to gather supplementary data that, in addition to the participant surveys, provided context for the results.
- ***Supplemental Studies.*** The Team relied on recent studies to obtain the current variables relevant to the Wisconsin population. These studies included previous research and fieldwork that members of the Evaluation Team have conducted within the Midwest.
- ***In Situ Metering.*** For use in the multivariate regression model, the Team measured the energy consumption of a sample of Program refrigerators and freezers. The Team also used data from a recent metering study in Michigan.

Calculation of Evaluated Savings Values

The algorithms provided in this section show how the Evaluation Team applied the data collected to create evaluated deemed savings values.

Ground Source Heat Pump, NG Back-Up

It appears that the SPECTRUM database does not contain references to any sources or methodologies for calculating the savings achieved by ground source heat pumps with natural gas backup. Additionally, at the time of the evaluation, a workpaper had not yet been created for this measure. In evaluating the savings for this measure, the Team has decided to use an electric air source heat pump as the baseline and to leverage federal standards and the Ohio TRM for variable inputs. Additionally, the Evaluation Team has not found any secondary or other documentation, regarding the natural gas furnace usage in this type of system. Consequently, the Evaluation Team is assuming no natural gas savings.

To develop detailed assumptions that will account for both gas and electric savings, the Team recommends using data from Wisconsin-specific studies, and information regarding typical usage patterns of the furnace and heat pump in this installation scenario.

- If the baseline is a heat pump with 80 AFUE gas backup, the consumer would experience less kWh savings than the Ground Source Heat Pump with electric backup and much less gas savings than the 90%+ AFUE measure.
- If the baseline is a heat pump with electric back-up, the consumer would experience electric savings, but negative gas savings.
- If the baseline is an 80 AFUE gas furnace, the consumer would experience large negative electric savings with the appropriate gas savings.

$$\Delta kWh\ Cooling\ Season = FLHCool * BtuHCool/1{,}000 * (1/SEERBase - (1/(EEReff * GSER)))$$

$$\Delta kWh\ Heating\ Season = (FLH_Heat * BtuHheat * ((1/HSPFBase - (1/(COPEFF * 3.412))/1{,}000))$$

$$\Delta kW = BTUhcool * (1/EERBase - 1/(((EEREE * GSER) * 0.37) + 6.43)) * CF / 1000$$

Table 4 provides the suggested description of variables for the ground source heat pump, natural gas back-up.

Table 4. Description of Variables for Ground Source Heat Pump, NG Back-up

Variable Name	Inputs	Units	Description	Source
FLH_cool	337.00	Hours	Full Load Hours Cooling	Adjusted full load hours from Ohio TRM.
FLH_heat	1,816.00	Hours	Full Load Hours Heating	Adjusted full load hours from Ohio TRM.
$BtuH_{Cool}$	40,089.02	Btu/Hr	Cooling Capacity of equipment	Tracking data model look-ups of AHRI certifications
$BtuH_{Heat}$	30,579.02	Btu/Hr	Heating Capacity of equipment	Tracking data model look-ups of AHRI certifications
EER_{Eff}	22.43	kBtu/kWh	Energy Efficiency Ratio Cooling	Tracking data model look-ups of AHRI certifications
COP_{Eff}	4.18	kWh/kWh	Coefficient of Performance Heating	Tracking data model look-ups of AHRI certifications
$SEER_{Base}$	13.00	kBtu/kWh	Seasonal Energy Efficiency Ratio Cooling	Federal Standard
$HSPF_{Base}$	7.70	kBtu/kWh	Heating Season Performance Factor	Federal Standard
EER_{Base}	11.00	EER	Baseline EER	2010 Ohio TRM
GSER	1.02	Ratio	Factor to determine the SEER of a GSHP based on its EERg	2011 Proposed Pennsylvania TRM Update
CF	0.50	Ratio	Coincidence Factor	2010 Ohio TRM

Table 5 provides the final recommended evaluated savings for ground source heat pumps, natural gas back-up.

Table 5. Final Recommended Evaluated Savings for Ground Source Heat Pump, NG Back-up

Unit Energy Savings	Evaluation Results	Units
kWh savings	3,739	kWh per year
kW savings	0.477	kW
therm savings	0	therms per year

Water Heater, NG, EF of 0.67 or greater

The natural gas water heater with an efficiency factor (EF) of 0.67 or greater does not have an existing Focus on Energy paper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim. In addition, the Evaluation Team did not locate the algorithm used to calculate the original savings claim. The value listed below of 27.7 therms, closely reflects the recommendation given within the workpaper. Table 6 provides the suggested description of variables for the natural gas water heater with an efficiency factor (EF) of 0.67 or greater.

- A difference in assumed annual hot water usage could cause a variation between deemed and evaluated savings. Recommend using baseline usage from the 2009 Residential Energy Consumption Survey data (unless specific metered data is available).

$$\Delta Therm = ThermStd\ x\ (1 - EFStd\ /\ EFEff)$$

Table 6. Description of Variables for Water Heater, NG, EF of 0.67 or greater

Variable Name	Inputs	Units	Description	Source
$Therm_{Std}$	223	Therm	Water heating energy use in standard house in WI	2009 RECS
EF_{Std}	0.586	EF	Federal energy factor EF =0.67 (0.0019 x Volume)	Federal Register: Energy Conservation Standards for Water Heaters; Final Rule
EF_{Eff}	0.67	EF	Average measure energy factor	Tracking data
Tank Volume	44	Gallons	Average volume from program tracking data	Tracking data

Table 7 provides the final recommended evaluated savings for a natural gas water heater with an efficiency factor (EF) of 0.67 or greater.

Table 7. Final Recommended Evaluated Savings for Water Heater, NG, EF of 0.67 or greater

Unit Energy Savings	Evaluation Results	Units
kWh savings	0	kWh per year
kW savings	0	kW
therm savings	27.7	therms per year

Water Heater, Electric, EF of 0.93 or greater

This section applies to only the single-family sector in SPECTRUM. The electric water heater with an EF of 0.93 or greater does not have an existing Focus on Energy paper, and the Evaluation Team did not locate the algorithm used to calculate the original savings claim.

- A difference in assumed annual hot water usage could cause a variation between deemed and evaluated savings. Recommend using baseline consumption from the 2009 Residential Energy Consumption Survey data (unless specific metered data is available).
- Heat pump water heaters were included in the evaluated savings, significantly increasing savings. Recommend developing separate measure for heat pump water heaters.

$$\Delta\, kWh \;=\; kWhStd\; x\; (1 \;-\; EFStd \;/\; EFEff)$$

$$\Delta\, kW \;=\; \Delta\, kWh \;/\; 8760$$

Table 8 provides the suggested description of variables for the single family water heater, electric, EF of 0.93 or greater.

Table 8. Description of Variables for Water Heater, Electric, EF of 0.93 or greater

Variable Name	Inputs	Units	Description	Source
kWh_{Std}	2,327	kWh	Water heating energy use in standard house in WI	2009 RECS
EF_{Std}	0.9064	EF	Federal energy factor EF = 0.97-(0.00132*Vol)	Federal Register: Energy Conservation Standards for Water Heaters; Final Rule
EF_{Eff}	1.45	EF	Average measure energy	Tracking data model look-ups of AHRI certifications
Tank Volume	48.2	Gallons	Average Volume from program tracking data	Tracking data

Table 9 provides the final recommended evaluated savings for a single family water heater, electric, EF of 0.93 or greater.

Table 9. Final Recommended Evaluated Savings for Water Heater, Electric, EF of 0.93 or greater

Unit Energy Savings	Evaluation Results	Units
kWh savings	871	kWh per year
kW savings	0.099	kW
therm savings	0	therms per year

Water Heater, Indirect

The Evaluation Team believes that the source for indirect water heater values is inaccurate, so the Team has used an alternative source, which has resulted in a changed deemed savings value. The workpaper provided by the implementer for this measure has not been updated to reflect the algorithm used for the savings assumption.

- A difference in assumed annual hot water usage could cause a variation between deemed and evaluated savings. The Team recommends using baseline usage from the 2009 Residential Energy Consumption Survey data (unless specific metered data are available).
- As indicated below, the temperature loss per hour is greater for high efficiency models than for standard models. However, because the volume of the efficient tank is typically lower than for the standard tank, the overall heat loss of the efficient tank is less. Heat loss is proportional to volume x ^{o}F/hr

$$.\Delta Therm = ThermStd - ThermEff$$

$$ThermOut = EFStd\ x\ ThermStdTank$$

$$ThermStd = StandbyStd\ x\ 8760\ x\ 1/100000/AFUEStd + ThermOut\ x\ 1/AFUEStd$$

$$ThermEff = StandbyEff\ x\ 8760\ x\ 1/100000/AFUEEFF + ThermOut\ x\ 1/AFUEEff$$

$$StandbyEff = Vol\ x\ oF/hr\ x\ 8.33$$

Table 10 provides the suggested description of variables for indirect water heaters.

Table 10. Description of Variables for Water Heater, Indirect

Variable Name	Inputs	Units	Description	Source
Therm	29	Therms	Saved Therms from measure	Equation
$Therm_{StdTank}$	223	Therms	Therms used by standard tank	RECS Data
$Therm_{Std}$	206			
$Therm_{Eff}$	177.52	Therms	Calculated	Equation
$EF_{StdTank}$	0.58	%	Federal standard energy factor EF =0.67 - (0.0019 x Volume)	Federal Register: Energy Conservation Standards for Water Heaters; Final Rule
Storage Tank Volume	45	Gallon	Assumes 45 gallon tank size average for standard water heater	http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
$Standby_{Std}$	434	Btu/hr	Standby loss from standard water heater	AHRI Database
$Standby_{Eff}$	397	Btu/hr	Standby loss from efficient water heater	Tracking data model look-ups of AHRI certifications
Vol_{Std}	63.50	Gallon	Volume	Model look-ups of AHRI certifications
Vol_{Eff}	51.2	Gallon	Volume	Tracking data model look-ups of AHRI certifications
$^{o}F/hr_{Std}$	0.8	^{o}F/hr	Heat lost per hour from tank	Model look-ups of AHRI certifications
$^{o}F/hr_{Eff}$	0.93	^{o}F/hr	Heat lost per hour from tank	Tracking data model look-ups of AHRI certifications
$AFUE_{Std}$	80%	%	Annual Fuel Utilization Ratio: % of fuel converted to heated water	State code (IECC 2009)
$AFUE_{Eff}$	93%	%	Annual Fuel Utilization Ratio: % of fuel converted to heated water	Tracking data model look-ups of AHRI certifications

Table 11 provides the final recommended evaluated savings for indirect water heaters.

Table 11. Final Recommended Evaluated Savings for Water Heater, Indirect

Unit Energy Savings	Evaluation Results	Units
kWh savings	0	kWh per year
kW savings	0.000	kW
therm savings	29	therms per year

Tankless Water Heater, NG, EF of 0.82 or greater

The tankless natural gas water heater with an EF of 0.82 or greater does not have an updated workpaper in the current Focus on Energy format. The Evaluation Team did not locate the algorithm used to calculate the original savings claim.

- A difference in assumed annual hot water usage could cause a variation between deemed and evaluated savings. Recommend using baseline consumption from the 2009 Residential Energy Consumption Survey data (unless specific metered data is available).

$$\Delta Therm = ThermStd\ x\ (1 - EFStd\ /\ EFEff)$$

Table 12 lists the characteristics of tankless water heater variables.

Table 12. Description of Variables for Tankless Water Heater, NG, EF of 0.82 or greater

Variable Name	Inputs	Units	Description	Source
$Therm_{Std}$	223	Therm	Water heating energy use in standard house in WI	2009 RECS Data: Mirco data for WI for fuel type and building type http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=consumption
EF_{Std}	0.5845	EF	Federal standard energy factor EF =0.67 - (0.0019 x Volume)	Federal Register: Energy Conservation Standards for Water Heaters; Final Rule
Tank Volume	45	Gallons	Assumes 45 gallon tank size average for standard water heater	http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
EF_{Eff}	0.88	EF	Average measure energy factor	Tracking data model look-ups of AHRI certifications for assumed average tank size

Table 13 provides the final recommended evaluated savings for tankless water heaters.

Table 13. Final Recommended Evaluated Savings for Tankless Water Heater, NG, EF of 0.82 or greater

Unit Energy Savings	Evaluation Results	Units
kWh savings	0	kWh per year
kW savings	0.000	kW
therm savings	74.5	therms per year

Clothes Washer, Common Area, Electric, ENERGY STAR

The ENERGY STAR electric clothes washer does not have an existing Focus on Energy workpaper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim.

- A difference in assumed cycles per year and savings per cycle could cause a variation between deemed and evaluated savings. Evaluated savings are from a 2009 Cadmus metering study. Recommend using 1,241 cycles/year based on ENERGY STAR assumptions (unless specific metered data is available).
- Assumed dryers are installed at all common area clothes washers locations.
- Evaluated values include savings from reduced washer, water heater, and dryer use. Recommend developing savings on multiple dryer fuel configurations.

$$\Delta kWh = [\Delta kWh(GE)\ x\ \%GE + \Delta kWh(EG)\ x\ \%EG + \Delta kWh(EE)\ x\ \%EE + \Delta kWh(EnD)\ x\ \%EnD]\ x\ Cycles/year$$

$$\Delta Therm = [\Delta Therm(GG)\ x\ \%GG + \Delta Therm(GE)\ x\ \%GE + \Delta Therm(EG)\ x\ \%EG + \Delta Therm(EnD)\ x\ \%EnD\ ]\ x\ Cycles/year$$

$$\Delta kW = \Delta kWh/Hours\ x\ CF$$

Table 14 lists the characteristics of variables for clothes washer, common area, electric, ENERGY STAR.

Table 14. Description of Variables for Clothes Washer, Common Area, Electric, ENERGY STAR

Variable Name	Inputs	Units	Description	Source
Gas Dryer	8%		Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
Elec Dryer	92%		Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%None	0%		No Dryer	RECs Database - Wisconsin Multifamily unit counts
ElecDHW	100%		ElecDHW	RECs Database - Wisconsin Multifamily unit counts
GasDHW	0%		GasDHW	RECs Database - Wisconsin Multifamily unit counts
%EE	92%		Elec DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%EG	8%		Elec DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%EnD	0.0%		Elec DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
%GE	0.0%		Gas DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%GG	0.0%		Gas DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%GnD	0.0%		Gas DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
Hours	1,241	Hours	Hours of Clothes Washer Use	Based on number of cycles per year (indirectly from Ohio TRM)
CF	4.5%		Summer Peak Coincidence Factor	Ohio TRM
Cycles/year	1,241	Cycles	Wash cycles/year	ENERGY STAR Appliance Calculator

Table 15 provides the final recommended evaluated savings for clothes washer, common area, electric, ENERGY STAR.

Table 15. Final Recommended Evaluated Savings for Clothes Washer, Common Area, Electric, ENERGY STAR

Unit Energy Savings	Evaluation Results	Units
kWh savings	1,971	kWh per year
kW savings	0.071	kW
therm savings	5.3	therms per year

Clothes Washer, Common Area, NG, ENERGY STAR

The ENERGY STAR natural gas clothes washer, does not have an existing Focus on Energy workpaper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim.

- A difference in assumed cycles per year and savings per cycle could cause a variation between deemed and evaluated savings. Evaluated savings are from a 2009 Cadmus metering study. Recommend using 1,241 cycles/year based on ENERGY STAR assumptions (unless specific metered data is available).
- Assumed dryers are installed at all common area clothes washer locations.
- Evaluated values include savings from reduced washer, water heater, and dryer use. Recommend developing savings on multiple dryer fuel configurations.

$$\Delta kWh = [\Delta kWh(GE)\ x\ \%GE + \Delta kWh(EG)\ x\ \%EG + \Delta kWh(EE)\ x\ \%EE + \Delta kWh(EnD)\ x\ \%EnD]\ x\ Cycles/year$$

$$\Delta Therm = [\Delta Therm(GG)\ x\ \%GG + \Delta Therm(GE)\ x\ \%GE + \Delta Therm(EG)\ x\ \%EG + \Delta Therm(EnD)\ x\ \%EnD\ ]\ x\ Cycles/year$$

$$\Delta kW = \Delta kWh/Hours\ x\ CF$$

Table 16 lists the characteristics of variables for common area, NG, ENERGY STAR clothes washers.

Table 16. Description of Variables for Clothes Washer, Common Area, NG, ENERGY STAR

Variable Name	Inputs	Units	Description	Source
Gas Dryer	26.5%		Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
Elec Dryer	74.5%		Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%None	0%		No Dryer	RECs Database - Wisconsin Multifamily unit counts
ElecDHW	0%		ElecDHW	RECs Database - Wisconsin Multifamily unit counts
GasDHW	100%		GasDHW	RECs Database - Wisconsin Multifamily unit counts
%EE	0%		Elec DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%EG	0%		Elec DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%EnD	0%		Elec DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
%GE	73.9%		Gas DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%GG	26.1%		Gas DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%GnD	0%		Gas DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
Hours	1,241	Hours	Hours of Clothes Washer Use	Based on number of cycles per year (indirectly from Ohio TRM)
CF	4.5%		Summer Peak Coincidence Factor	Ohio TRM
Cycles/year	1,241	Cycles	Wash cycles/year	ENERGY STAR Appliance Calculator

Table 17 provides the final recommended evaluated savings for common area, NG, ENERGY STAR clothes washers.

Table 17. Final Recommended Evaluated Savings for Clothes Washer, Common Area, NG, ENERGY STAR

Unit Energy Savings	Evaluation Results	Units
kWh savings	1,331	kWh per year
kW savings	0.048	kW
therm savings	31.9	therms per year

Clothes Washer, In-Unit, ENERGY STAR

This ENERGY STAR clothes washer Focus on Energy workpaper produced savings that were lower than evacuated savings. The algorithm and variables used are listed below.

- A difference in assumed savings per cycle could cause a variation between deemed and evaluated savings. Evaluated savings are from a 2009 Cadmus metering study. Evaluated values include savings from reduced washer, water heater, and dryer use.
- Recommend developing multiple savings values on installed dryer and water heater fuel configurations.

$$\Delta kWh = [\Delta kWh(GE) \times \%GE + \Delta kWh(EG) \times \%EG + \Delta kWh(EE) \times \%EE + \Delta kWh(EnD) \times \%EnD] \times Cycles/year$$

$$\Delta Therm = [\Delta Therm(GG) \times \%GG + \Delta Therm(GE) \times \%GE + \Delta Therm(EG) \times \%EG + \Delta Therm(GnD) \times \%GnD\ ] \times Cycles/year$$

$$\Delta kW = \Delta kWh/Hours \times CF$$

Table 18 lists the characteristics of variables for in unit, ENERGY STAR clothes washers.

Table 18. Description of Variables for Clothes Washer, In Unit, ENERGY STAR

Variable Name	Inputs	Units	Description	Source
Gas Dryer	18%		Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
Elec Dryer	77%		Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%None	5%		No Dryer	RECs Database - Wisconsin Multifamily unit counts
ElecDHW	44%		ElecDHW	RECs Database - Wisconsin Multifamily unit counts
GasDHW	56%		GasDHW	RECs Database - Wisconsin Multifamily unit counts
%EE	34%		Elec DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%EG	0%		Elec DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%EnD	2%		Elec DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
%GE	43%		Gas DHW/Elec Dryer	RECs Database - Wisconsin Multifamily unit counts
%GG	18%		Gas DHW/Gas Dryer	RECs Database - Wisconsin Multifamily unit counts
%GnD	3%		Gas DHW/No Dryer	RECs Database - Wisconsin Multifamily unit counts
Hours	276	Hours	Hours of Clothes Washer Use	Assume one hour per cycle. Based on number of cycles per year (indirectly from Ohio TRM)
CF	5%		Summer Peak Coincidence Factor	Ohio TRM
Cycles/year - Multi Family	276	Cycles	Wash cycles/year	RECs Database - Wisconsin Multifamily unit counts
ΔkWh(GE)	1.45	kWh	Electric Savings/Cycle	CPUC Res Retro HIM Evaluation Report - Weighted by quantity of each efficiency level from MESP Spectrum[3]
ΔkWh(EG)	0.25	kWh		
ΔkWh(EE)	1.70	kWh		
ΔkWh(EnD)	1.70	kWh		
ΔTherm(GG)	0.066	therm	Gas Savings/Cycle	
ΔTherm(GE)	0.011	therm		
ΔTherm(EG)	0.055	therm		
ΔTherm(GnD)	0.011	therm		

Table 19 provides the final recommended evaluated savings for in unit, ENERGY STAR clothes washers.

Table 19. Final Recommended Evaluated Savings for Clothes Washer, In Unit, ENERGY STAR

Unit Energy Savings	Evaluation Results	Units
kWh savings	335	kWh per year
kW savings	0.055	kW
therm savings	4.7	therms per year

[3] *Residential Retrofit High Impact Measure Evaluation Report. Prepared For The California Public Utilities Commission Energy Division*. Prepared by The Cadmus Group. February 8, 2010.
Values from this report are converted to a per cycle savings value and then weighted by the verified MEF efficiency levels from the Spectrum tracking data for MESP: 130 qty of MEF 2-2.19 and 16 qty of MEF 2.46+.

Dishwasher, Electric, ENERGY STAR

The ENERGY STAR dishwasher does not have an existing Focus on Energy workpaper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim. The Evaluation Team believes the source for the ENERGY STAR dishwasher value is inaccurate, so the Team has used an alternative source, resulting in a changed deemed savings value.

- A difference in assumed cycles per year could cause a variation between deemed and evaluated savings. Recommend using 215 cycles/year based on ENERGY STAR assumptions (unless specific metered data is available).
- Evaluated values include savings from reduced dishwasher and water heater use. Recommend developing savings on multiple water heater fuel configurations.

$$\Delta kWh = \left(kWh_{Std} - kWh_{Eff}\right) * (1 - \%\,DHW) + (kWh_Std - kWh_Eff) * \%\,DHW * \%DHW\ Elec$$

$$\Delta Therms = \left(kWh_{Std} - kWh_{Eff}\right) * \%\,DHW * \%\,DHW\ Gas * \frac{3412}{100000}/RE$$

$$\Delta kW = \Delta kWh/Hours * CF$$

Table 20 lists the characteristics of variables for electric ENERGY STAR dishwashers.

Table 20. Description of Variables for Dishwasher, Electric, ENERGY STAR

Variable Name	Inputs	Units	Description	Source
kWh_Std	355	kWh/year	kWh of Federal Standard dishwasher	DOE Test Procedure
EFdwnew	273	kWh/year	kWh of average participant dishwasher	From ENERGY STAR Calculator
% DHW	56%		% of Energy From Water Heat	From ENERGY STAR Calculator
% Elec DHW	44%		ElecDHW	RECs Database - Wisconsin Multifamily unit counts
% Gas DHW	56%		GasDHW	RECs Database - Wisconsin Multifamily unit counts
Cycles	215		Cycles/year	DOE Test Procedure
Hours	215	Hours		
CF	4.5%		Coincidence Factor	Ohio TRM
RE	78%		Gas DHW Recovery Efficiency	AHRI Directory Review of Tank Water Heaters

Table 21 provides the final recommended evaluated savings for electric ENERGY STAR dishwashers.

Table 21. Final Recommended Evaluated Savings for Dishwasher, Electric, ENERGY STAR

Unit Energy Savings	Evaluation Results	Units
kWh savings	56	kWh per year
kW savings	0.012	kW
therm savings	1.1	therms per year

Showerhead

Although direct install showerheads have a Focus on Energy specific workpaper, the Evaluation Team calculated alternative results, based on evaluation findings and updated algorithm calculations.

This section applies to these Master Measure Names from SPECTRUM:

- Showerhead, Non PI Direct Install, 1.5 gpm, Electric
- Showerhead, Non PI Direct Install, 1.5 gpm, NG
- Showerhead, Direct Install, 1.5 gpm, Electric
- Showerhead, Direct Install, 1.5 gpm, NG

The Evaluation Team value is ~50% of SPECTRUM value for Home Performance with ENERGY STAR due to the following:

- The Team assumes 0.61 showers per person per day, vs. SPECTRUM's assumption of 1 (SPECTRUM value is based on engineering assumption).

$$\Delta kWh = (GPMbase - GPMmeas_adj) * (t * Nppl * Daysyear * Nshowers/person) / Nfixtures * Lbsconv * kWhconv * Cenglish * (Tpou - Tin) * 1 / REbase_ehw$$

$$\Delta Therms = (GPMbase - GPMmeas_adj) * (t * Nppl * Daysyear * Nshowers/person) / Nfixtures * Lbsconv * Thermsconv * Cenglish * (Tpou - Tin) * 1 / REbase_ghw$$

$$\Delta kW = \Delta kWh * CF / (Nppl * t * Daysyear * Nshowers/person / Minhour / Nfixtures)$$

Table 22 lists the characteristics of variables for showerheads.

Table 22. Description of Variables for Showerheads

Variable Name	Inputs	Units	Description	Source
GPM_{base}	2.45	GPM	Baseline flowrate of shower	2010 ACES Deemed Savings Desk Review, measurements from 160 Wisconsin sites, collected from the Existing Building forms
GPM_{meas}	1.5	GPM	Measure flowrate of low-flow shower	SPECTRUM Database
FF - Flow Factor	0.9	%	Factor adjusting for actual flowrate vs. rated flow rate	Regional Technical Forum's (RTF) value, based off results shown on (p. 19) of "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008. They compared the In-situ mean flow rate of 1.82 gpm and to the rated flow rate of 2.0 gpm - 1.82 / 2.0 = 0.91. RTF chose 90%.
GPM_{meas_adj}	1.35	GPM	Adjusted measure flowrate of low-flow shower	Measure flowrate adjusted to account of actual flowrate compared to the rated (or listed) flow rate
t	7.83	min/shower	Length of individual shower	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
N_{ppl}	2.44	people/home	Number of people living in the home	2011 American Community Survey, 1 year estimate, WI statewide average household size
$Days_{year}$	365	days/year	Days per year	Assumed
$N_{showers/person}$	0.61	showers/ person/day	Number of showers per person per day	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
$N_{fixtures}$ SF	1.64	showerheads /home	Number of showerheads per single family home	RECs 2009 Wisconsin data, number of full bathrooms for single-family home
Lbs_{conv}	8.33	lb/gal	Convert gallons of water to lbs of water	Assumed
kWh_{conv}	0.00029	kWh/Btu	Convert Btus to kWh	Assumed
$C_{english}$	1	Btu/lb°F	Specific heat of water (English units)	Assumed
T_{pou}	101	°F	Temperature of water at point of use	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
T_{in}	52.3	°F	Temperature of water entering water heater	DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
RE_{base_ehw}	0.98	%	Baseline recovery efficiency of electric water heater	NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
$Therms_{conv}$	0.00001	therms/Btu	Convert Btus to Therms	Assumed
RE_{base_ghw}	0.76	%	Baseline recovery efficiency of gas water heater	NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
CF	0.00371	%	Coincidence Factor	Ohio TRM 2010
Min_{hour}	60	minutes/ hour	Minutes per hour	Assumed

Table 23 provides the final recommended evaluated savings for showerheads.

Table 23. Final Recommended Evaluated Savings for Showerheads

Unit Energy Savings	Evaluation Results	Units
Electric Hot Water Heater		
kWh savings	346.5	kWh per year
kW savings	0.030	kW
therm savings	0	therms per year
Natural Gas Hot Water Heater		
kWh savings	0	kWh per year
kW savings	0	kW
therm savings	15.2	therms per year

Kitchen and Bathroom Aerators

Although direct install kitchen and bathroom aerators have a Focus on Energy specific workpaper, based on evaluation findings alternative results were calculated.

This section applies to these Master Measure Names from SPECTRUM:

- Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric
- Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, NG
- Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric
- Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, NG
- Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Electric
- Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, NG
- Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, Electric
- Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, NG

The evaluated value is ~50% and ~40% for kitchen and bathroom aerators, respectively, greater than SPECTRUM value.

- For kitchen aerators, the Evaluation Team assumes 4.51 minutes/person/day, vs SPECTRUM's assumption of 3 (SPECTRUM value is based on engineering assumption made 4 years ago).
- For bathroom aerators, the Evaluation Team assumes 1.65 minutes/person/day, vs. SPECTRUM's assumption of 2 (SPECTRUM value is based on engineering assumption made 4 years ago).
- The Evaluation Team assumes 86°F temp at point of use for bathroom faucets, vs. SPECTRUM's assumption of 105°F (SPECTRUM value is based on shower temperatures).
- The Evaluation Team assumes 93°F temp at point of use for kitchen facuets, vs. SPECTRUM's assumption of 105°F (SPECTRUM value is based on shower temperatures).

$$\Delta kWh = (GPMbase - GPMmeas_adj) * (t * Nppl * Daysyear) / Nfixtures * Lbsconv * kWhconv * Cenglish * (Tpou - Tin) * 1 / REbase_ehw$$

$$\Delta Therms = (GPMbase - GPMmeas_adj) * (t * Nppl * Daysyear) / Nfixtures * Lbsconv * Thermsconv * Cenglish * (Tpou - Tin) * 1 / REbase_ghw$$

$$\Delta kW = \Delta kWh * CF / (Nppl * t * Daysyear / Minhour / Nfixtures)$$

Table 24 lists the characteristics of variables for kitchen and bathroom aerators.

Table 24. Description of Variables for Kitchen and Bathroom Aerators

Variable Name	Inputs	Units	Description	Source
GPM_{base} Kitchen Aerator	2.15	GPM	Baseline flowrate of kitchen aerator	2010 ACES Deemed Savings Desk Review, measurements from 152 Wisconsin sites, collected from the Existing Building forms
GPM_{base} Bathroom Aerator	2.05	GPM	Baseline flowrate of bathroom aerator	2010 ACES Deemed Savings Desk Review, measurements from 152 Wisconsin sites, collected from the Existing Building forms
GPM_{meas} Kitchen Aerator	1.5	GPM	Measure flowrate of kitchen aerator	SPECTRUM Database
GPM_{meas} Bathroom Aerator	1	GPM	Measure flowrate of bathroom aerator	SPECTRUM Database
FF - Flow Factor	0.9	%	Factor adjusting for actual flowrate vs. rated flow rate	Regional Technical Forum's (RTF) value, based off results shown on (p. 19) of "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008. They compared the In-situ mean flow rate of 1.82 gpm and to the rated flow rate of 2.0 gpm - 1.82 / 2.0 = 0.91. RTF chose 90%.
GPM_{meas_adj} Kitchen Aerator Adjusted	1.35	GPM	Adjusted measure flowrate of kitchen aerator	Measure flowrate adjusted to account of actual flowrate compared to the rated (or listed) flow rate
GPM_{meas_adj} Bathroom Aerator Adjusted	0.9	GPM	Adjusted measure flowrate of bathroom aerator	Measure flowrate adjusted to account of actual flowrate compared to the rated (or listed) flow rate
t Kitchen Aerator	4.51	min/day/ person	Time the kitchen aerator is used per day per person	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
t Bathroom Aerator	1.65	min/day/ person	Time the bathroom aerator is used per day per person	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
N_{ppl}	2.44	people/ home	Number of people living in the home	2011 American Community Survey, 1 year estimate, WI statewide average household size
$Days_{year}$	365	days/ year	Days per year	Assumed
$N_{fixtures}$ Kitchen	1	faucets/ home	Number of faucets per home for single	Engineering judgment

Variable Name	Inputs	Units	Description	Source
Aerator SF			family homes	
$N_{fixtures}$ Bathroom Aerator SF	2.96	faucets/ home	Number of faucets per home for single family homes	RECs 2009 Wisconsin data, calculated assuming 1.5 faucets per full bath and 1 faucet per half bath
Lbs_{conv}	8.33	lb/gal	Convert gallons of water to lbs of water	Assumed
kWh_{conv}	0.0002931	kWh/Btu	Convert Btus to kWh	Assumed
$C_{english}$	1	Btu/lb°F	Specific heat of water (english units)	Assumed
T_{pou} Kitchen Aerator	93	°F	Temperature of water at point of use	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
T_{pou} Bath Aerator	86	°F	Temperature of water at point of use	Michigan showerhead and faucet aerator meter study, Cadmus, 2013
T_{in}	52.3	°F	Temperature of water entering water heater	DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
RE_{base_ehw}	0.98	%	Baseline recovery efficiency of electric water heater	NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
$Therms_{conv}$	0.00001	therms/ Btu	Convert Btus to Therms	Assumed
RE_{base_ghw}	0.76	%	Baseline recovery efficiency of gas water heater	NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
CF	0.00262	%	Summer peak coincidence factor	Ohio TRM 2010
Min_{hour}	60	minutes/ hour	Minutes per hour	Assumed

Table 25 provides the final recommended evaluated savings for kitchen and bathroom aerators.

Table 25. Final Recommended Evaluated Savings for Kitchen and Bathroom Aerators

Unit Energy Savings	Evaluation Results	Units
Kitchen - Electric Hot Water Heater		
kWh savings	325.9	kWh per year
kW savings	0.013	kW
therm savings	0	therms per year
Bathroom - Electric Hot Water Heater		
kWh savings	47.9	kWh per year
kW savings	0.015	kW
therm savings	0	therms per year
Kitchen - Natural Gas Hot Water Heater		
kWh savings	0	kWh per year
kW savings	0	kW
therm savings	14.3	therms per year
Bathroom - Natural Gas Hot Water Heater		
kWh savings	0	kWh per year
kW savings	0	kW
therm savings	2.1	therms per year

Direct Install, Compact Fluorescent Lights (CFLs)

Although Non PI Direct Install CFLs have a Focus on Energy specific workpapers, papers could not be found for Direct Install 9-23 watt. Based on evaluation findings alternative results were calculated.

This section applies to these Master Measure Names from SPECTRUM:

- CFL, Non PI Direct Install, 9 Watt
- CFL, Non PI Direct Install, 14 Watt
- CFL, Non PI Direct Install, 19 Watt
- CFL, Non PI Direct Install, 23 Watt
- CFL, Direct Install, 9 Watt
- CFL, Direct Install, 14 Watt
- CFL, Direct Install, 19 Watt
- CFL, Direct Install, 23 Watt

Which fall into these Programs: Express Energy Efficiency (EEE), Home Performance with ENERGY STAR (HPwES), Assisted Home Performance with ENERGY STAR (AHPwES), and Multifamily Energy Savings Program (MESP).

Evaluated values are slightly greater than SPECTRUM values due to the following:

- The Evaluation Team assumes a direct install HOU of 2.60, vs. SPECTRUM's assumption of 2.28 (SPECTRUM value is not cited).
  - The Evaluation Team modeled both weekday and weekend daily HOU as a function of room type, the presence of children in the home, and CFL saturations in the home. This was done using two analyses of covariance (ANCOVA) models, one for each day type. The HOU from this model was then weighted using CFL distribution by room data from residential field visits in Wisconsin in 2013. Based on the Assisted Home Performance with ENERGY STAR program manual requiring that bulbs be installed in high usage areas, it is assumed that the direct install bulbs are only installed in the following areas of the home: living space (living room, dining room, office, hallways) and kitchen. This assumption leads to a greater HOU when compared to the Residential Lighting and Appliance Program.

$$\Delta kWh = (CFLwattage * \Delta WM) / 1000 * ISR * HOU$$

$$\Delta kW = (CFLwattage * \Delta WM) / 1000 * ISR * CF$$

Table 26 provides characteristics of the variables for direct install CFLs.

Table 26. Description of Variables for Direct Install, Compact Fluorescent Lights (CFLs)

Variable Name	Inputs	Units	Description	Source
$CFL_{wattage}$	9	watts	CFL wattage	Wattage of CFL in AHPwES Program
$CFL_{wattage}$	14	watts	CFL wattage	Wattage of CFL in AHPwES Program
$CFL_{wattage}$	19	watts	CFL wattage	Wattage of CFL in AHPwES Program
$CFL_{wattage}$	23	watts	CFL wattage	Wattage of CFL in AHPwES Program
Equivalent incandescent baseline wattage for 9 W	40	watts	Incandescent baseline wattage	Calculated using equivalent lumens method
Equivalent incandescent baseline wattage for 14 W	60	watts	Incandescent baseline wattage	Calculated using equivalent lumens method
Equivalent incandescent baseline wattage for 19 W	75	watts	Incandescent baseline wattage	Calculated using equivalent lumens method
Equivalent incandescent baseline wattage for 23 W	100	watts	Incandescent baseline wattage	Calculated using equivalent lumens method
ΔWM (Delta Watts Multiplier) for 9 W	3.44	-	Delta watts multiplier	Calculation
ΔWM (Delta Watts Multiplier) for 14 W	3.29	-	Delta watts multiplier	Calculation
ΔWM (Delta Watts Multiplier) for 19 W	2.95	-	Delta watts multiplier	Calculation
ΔWM (Delta Watts Multiplier) for 23 W	3.35	-	Delta watts multiplier	Calculation
HOU	2.60	hours/ day	Hours of use per bulb per day	Evaluation Team analysis, used light metering data from the following programs to determine an average HOU value: Efficiency Maine, Ameren Missouri, EmPOWER, Dayton Power & Light, and Consumers Energy[4].
$Days_{year}$	365	days/ year	Days per year	Assumed
CF	0.11	percent	Coincidence Factor	Ohio TRM 2010

[4] The Evaluation Team modeled both weekday and weekend daily HOU as a function of room type, the presence of children in the home, and CFL saturations in the home. This was done using two analyses of covariance (ANCOVA) models, one for each day type. The HOU from this model was then weighted using CFL distribution by room data from residential field visits in Wisconsin in 2013. Based on the AHPwES program manual requiring that bulbs be installed in high usage areas, it is assumed that the direct install bulbs are only installed in the following areas of the home: living space (living room, dining room, office, hallways) and kitchen.

Table 27 provides the final recommended evaluated savings for direct install CFLs.

Table 27. Final Recommended Evaluated Savings for Direct Install, Compact Fluorescent Lights (CFLs)

Unit Energy Savings	Evaluation Results	Units
kWh savings		
9 watt	29	kWh per year
14 watt	44	kWh per year
19 watt	53	kWh per year
23 watt	73	kWh per year
kW savings		
9 watt	0.003	kW
14 watt	0.005	kW
19 watt	0.006	kW
23 watt	0.008	kW
therm savings		
All wattages	0	therms per year

Evaluation Savings Analysis: Non-Residential

Methodology

Within the SPECTRUM database deemed savings are provided to the Focus on Energy Administrator and Implementers. These deemed savings values were used to create the 2012 ex ante savings estimates. Many sources have been leveraged over the years to create this expansive database, including past Focus on Energy evaluations.

Evaluation activities that informed the impact findings included a database review, project audits, on-site measurement and verification data, engineering analyses, and customer surveys. For each sampled project, the Evaluation Team used data from project audits and on-site measurement and verification to calculate verified savings. The validity of deemed savings assumptions were evaluated based upon the findings of our evaluation. The Evaluation Team has identified several key measures and assumptions that we believe need to be updated in order to better estimate project savings.

Calculation of Evaluated Savings Values

The Evaluation Team's algorithms show how the collected data were applied to create evaluated deemed savings values.

Steam Trap Repair, < 50 psig, General Heating

The steam trap repair does not have an updated workpaper in the current Focus on Energy format and the Evaluation Team did not locate the algorithm used to calculate the original savings claim.

- Savings are currently deemed on a per trap basis at 910 therms per trap. This deemed value is based upon several assumptions including the common range of orifice diameters for both float and thermostatic (F&T)and thermostatic steam traps.
- The range of orifice diameters is 7/32 of an inch to 5/16 of an inch. During the 2012 Evaluation the Team encountered several projects where steam traps were encountered with orifice diameters exceeding 5/16 of an inch (reaching up to 3/8 of an inch).
- Given the fact that this circumstance was encountered on multiple projects it is recommended that orifice diameters be requested in the steam trap incentive application forms so as to better estimate project savings.
- Savings tend to be underestimated using the current market prevalence assumptions. The savings algorithm used to estimate savings resulting from steam trap replacements has been included below.

$$W = 24.24 * P_abs * (OD)\text{^}2 \quad (Napier's\ Formula)$$

$$Q\ (therms) = (W * Hours * hfg * DF)/100{,}000/BE$$

$$therms = 24.24\ x\ OD\text{^}2\ x\ (Pg + 14.7)\ x\ hfg\ x\ Hours\ x\ DF\ /\ 100{,}000\ /\ BE$$

Table 28 list characteristics of variables for steam trap repair,< 50 psig.

Table 28. Description of Variables for Steam Trap Repair, < 50 psig, General Heating

Variable Name	Inputs	Units	Description	Source
$Days_{year}$	365	days/year	Days per year	Assumed
OD (7/32")	0.21875	Inches	Pipe Diameter	Measure Description
OD (1/4")	0.25	Inches	Pipe Diameter	Measure Description
OD (5/16")	0.3125	Inches	Pipe Diameter	Measure Description
OD (3/8")	0.375	Inches	Pipe Diameter	2012 Evaluation, Recommended
Pg	8.25	psi	Pounds per square inch	Steam Tables[5]
Patm	14.7	psi	Pounds per square inch	Typical at sea level
hfg	955	Btu/lb	British thermal unit per pound	Steam Tables[6]
Hours	4,706	Hours/year	Hours per year	Calculated[7]
100,000	100,000	Btu/therm	Conversion Factor	
BE	0.8	percent	Boiler Efficiency	Typical
DF	0.5	percent	Derating Factor	Enbridge Steam Saver Program 2005

Table 29 provides evaluated savings for steam trap repair,< 50 psig.

Table 29. Final Recommended Evaluated Savings for Steam Trap Repair, < 50 psig, General Heating

Unit Energy Savings	Results	Units
kWh savings	0	kWh per year
kW savings	0	kW
therm savings (7/32")	690	therms per year
therm savings (1/4")	901	therms per year
therm savings (5/16")	1,408	therms per year
therm savings (3/8")	2,027	therms per year

[5] Calculated using Steam Tables and weighted average of system steam pressures per State of Wisconsin Public Service Commission– Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
5 psi – 45%,
10 psi – 45%
15 psi – 10%

[6] Ibid.

[7] Calculated based on weighted average between F&T and thermostatic steam trap types per State of Wisconsin Public Service Commission– Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0

T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO and T12VHO

At the time of the evaluation the T8 4 lamp, 4 foot linear fluorescent, does not have an existing Focus on Energy workpaper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim.

This section applies to these Master Measure Names from SPECTRUM:

- T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO
- T8 4L 4', HPT8, CEE, replacing 8' 2L T12VHO

Suggested baseline values provided below[8].

- 8-ft 2 lamp T12 High Output – 207 Watts per fixture.
- 8-ft 2 lamp T12 Very High Output – 380 Watts per fixture.

$$\Delta kWh\ for\ T12HO = \left(T12HO_{wattage} - NewT8_{\frac{Low}{NormalBFwatts}}\right) * Qty\ /\ 1{,}000\ *\ Operating\ Hours$$

$$\Delta kWh\ for\ T12VHO = \left(T12VHO_{wattage} - NewT8_{\frac{Low}{NormalBFwatts}}\right) * Qty\ /\ 1{,}000\ *\ Operating\ Hours$$

$$\Delta kW\ \ for\ T12HO\ = \left(T12HO_{wattage} - NewT8_{Low/NormalBFwatts}\right) * Qty/1{,}000\ *\ CF$$

$$\Delta kW\ \ for\ T12VHO\ = \left(T12VHO_{wattage} - NewT8_{Low/NormalBFwatts}\right) * Qty/1{,}000\ *\ CF$$

[8] New York Device Codes and Rated Lighting System Wattage Table – 2010 Energy Initiative – Retrofit Program, dated March 5, 2010

Table 30 lists characteristics of variables for T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO and T12VHO.

Table 30. Description of Variables for T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO and T12VHO

Variable Name	Inputs	Units	Description	Source
$T12HO_{wattage}$	207	watts	Old High Output	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
$T12VHO_{wattage}$	380	watts	Old Very High Output	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
$NewT8_{LowBFwatts}$	100	watts	New T8 Low Ballast Factor	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
$NewT8_{NormalBFwatts}$	107	watts	New T8 Normal Ballast Factor	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Operating Hours				
Agriculture	4,698	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Commercial	3,720	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Industrial	4,745	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Schools & Government	3,239	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Coincidence Factor (CF)				
Agriculture	67%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Commercial	77%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Industrial	77%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Schools & Government	64%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0

Table 31 provides recommended savings for T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO and T8 4L 4', HPT8, CEE, replacing 8' 2L T12VHO.

Table 31. Final Recommended Evaluated Savings for T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO; and T8 4L 4', HPT8, CEE, replacing 8' 2L T12VHO

Unit Energy Savings	T12HO → LOW_BF	T12VHO → NORM_BF	Units
kWh savings (Ag.)	503	1,282.6	kWh per year
kW savings (Ag.)	0.0717	0.1829	kW
kWh savings (Com.)	398	1,015.6	kWh per year
kW savings (Com.)	0.0824	0.2102	kW
kWh savings (Ind.)	508	1,395	kWh per year
kW savings (Ind.)	0.0824	0.2102	kW
kWh savings (Gov.)	347	884	kWh per year
kW savings (Gov.)	0.0685	0.1747	kW
therm savings (all sectors)	0		therms per year

LED, 8-12 Watts

At the time of the evaluation the LED 8-12watts, does not have an existing Focus on Energy workpaper, and the Evaluation Team did not locate the methodology used to calculate the original savings claim.

- The deemed baseline wattage values being used to estimate savings for this measure are unknown.
- The program requires that new LED lamps replace baseline 40 to 100 watt incandescent lamps. Specific lamp watts for the new and old lighting systems are requested in the application form; however, this information is not currently being used to estimate project-level savings. It is recommended that project-specific information be used when requested and provided by the participant.

Deemed Approach (Actual Baseline Wattage Unknown):

$$\Delta kWh = \left(NewLED_{wattage} * \Delta WM\right) * Qty / 1{,}000 * Operating\ Hours$$
$$\Delta kW = \left(NewLED_{wattage} * \Delta WM\right) * Qty / 1{,}000 * CF$$

Custom Approach (Actual Baseline Wattage Known):

$$\Delta kWh = \left(NewLED_{wattage} - Old_{Incan_{wattage}}\right) * Qty / 1{,}000 * Operating\ Hours$$
$$\Delta kW = \left(NewLED_{wattage} - Old_{Incan_{wattage}}\right) * Qty / 1{,}000 * CF$$

Table 32 list characteristics of variables for 8-12 watt LEDs.

Table 32. Description of Variables for LED, 8-12 Watts

Variable Name	Inputs	Units	Description	Source
$NewLED_{wattage}$	8	watts	LED wattage	Wattage of LED in Spectrum
$NewLED_{wattage}$	12	watts	LED wattage	Wattage of LED in Spectrum
Equivalent incandescent baseline wattage for 8 W LED (Deemed Approach)	60	watts	Deemed Incandescent baseline wattage	Calculated using equivalent lumens method
Equivalent incandescent baseline wattage for 12 W LED (Deemed Approach)	90	watts	Deemed Incandescent baseline wattage	Calculated using equivalent lumens method
$Old_Incan_{wattage}$	40-100	Watts	Incandescent baseline wattage	Provided by participant in application form
Operating Hours				
Agriculture	4,698	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Commercial	3,720	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Industrial	4,745	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Schools & Government	3,239	hours	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Coincidence Factor (CF)				
Agriculture	67%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Commercial	77%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Industrial	77%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0
Schools & Government	64%	%	N/A	State of Wisconsin Public Service Commission of Wisconsin – Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0

Table 33 provides the final recommended savings for 8-12 Watt LEDs.

Table 33. Final Recommended Evaluated Savings for LED, 8-12 Watts

Unit Energy Savings	Results - 8W	Results – 12W	Units
kWh savings (Ag.)	244	366	kWh per year
kW savings (Ag.)	0.035	0.052	kW
kWh savings (Com.)	194	291	kWh per year
kW savings (Com.)	0.040	0.06	kW
kWh savings (Ind.)	247	370	kWh per year
kW savings (Ind.)	0.040	0.06	kW
kWh savings (Gov.)	168	253	kWh per year
kW savings (Gov.)	0.033	0.05	kW
therm savings (all sectors)	0		therms per year

Final Recommendations

Results

Due to the fact that the assumptions used to calculate ex ante saving are either unknown, market conditions have changed, or new data has become available, the Evaluation Team is recommending the aforementioned measures have updated savings values. Tables 35 and 36, below, are a comparison between the deemed and evaluated savings, showing the difference between the savings values.

Residential

Table 34. Deemed and Evaluated Savings Results for Residential Measures

Measure		Evaluated	Deemed	Difference	Units
Ground Source Heat Pump, NG Back-up		3,739	270	3469	kWh per year
		0.477	0.5	-0.023	kW
		-	192.5	-192.5	therms per year
Water Heater, NG, EF of 0.67 or greater		-	-	-	kWh per year
		-	-	-	kW
		27.7	30.96	-3.26	therms per year
Water Heater, Electric, EF of 0.93 or greater		871	154.03	716.97	kWh per year
		0.099	-	0.099	kW
		-	-	-	therms per year
Water Heater, Indirect		-	-	-	kWh per year
		-	-	-	kW
		29	32	-3	therms per year
Tankless Water Heater, NG, EF of 0.82 or greater		-	-	-	kWh per year
		-	-	-	kW
		74.5	66.5	8	therms per year
Clothes Washer, Common Area, Electric, ENERGY STAR		1971	625	1346	kWh per year
		0.071	-	0.071	kW
		5.3	-	5.3	therms per year
Clothes Washer, Common Area, NG, ENERGY STAR		1331	63	1269	kWh per year
		0.048	-	0.048	kW
		31.9	21.3	10.6	therms per year
Clothes Washer, In Unit, ENERGY STAR		335	163	172	kWh per year
		0.055	-	0.055	kW
		4.7	5.5	-0.8	therms per year
Dishwasher, Electric, ENERGY STAR		56	90	-34	kWh per year
		0.012	-	0.012	kW
		1.1	5	-3.9	therms per year
Showerhead		346.5	726.2	-379.7	kWh per year
		0.03	-	0.03	kW
		15.2	36.2	-21.7	therms per year
Kitchen Aerators		325.9	224.5	-221.58	kWh per year
		0.013	-	0.013	kW
		14.3	11.1	3.2	therms per year
Bathroom Aerator		47.9	127	-79.1	kWh per year
		0.015	-	0.015	kW
		2.1	6.3	-4.2	therms per year
Direct Install, Compact Florescent Lights (CFLs)	9 Watt	25.79	29	3.21	kWh per year
		0.002	0.003	0.001	kW
	14 Watt	38.25	44	5.75	kWh per year
		0.003	0.005	0.002	kW
	19 Watt	46.52	53	53.00	kWh per year
		0.004	0.006	0.002	kW
	23 Watt	64.04	73	8.96	kWh per year
		0.006	0.008	0.002	kW

Non-Residential

Table 35. Deemed and Evaluated Savings Results for Non-Residential Measures

Measure		Evaluated		Deemed	Difference		Units
Steam Trap Repair, < 50 psig, General Heating	All Sizes	-		-	-		kWh per year
		-		-	-		kW
	7/32”	690		910	-220		therms per year
	1/4”	901		910	-9		therms per year
	5/16”	1,408		910	498		therms per year
	3/8”	2,027		910	1,117		therms per year
T8 4L 4', HPT8, CEE, replacing 8' 2L T12HO	Agriculture	503		560	-57		kWh per year
		0.0717		0.0797	-0.008		kW
		-		-	-		therms per year
	Commercial	398		287	111		kWh per year
		0.0824		0.0593	0.0231		kW
		-		-	-		therms per year
	Industrial	508		366	142		kWh per year
		0.0824		0.0593	0.0231		kW
		-		-	-		therms per year
	Schools & Government	347		250	97		kWh per year
		0.0685		0.0493	0.0192		kW
		-		-	-		therms per year
T8 4L 4', HPT8, CEE, replacing 8' 2L T12VHO	Agriculture	1,282.60		1175	107.6		kWh per year
		0.1829		0.1675	0.0154		kW
		-		-	-		therms per year
	Commercial	1,015.60		933	82.6		kWh per year
		0.2102		0.1925	0.0177		kW
		-		-	-		therms per year
	Industrial	1,395		1186	209		kWh per year
		0.2102		0.1925	0.0177		kW
		-		-	-		therms per year
	Schools & Government	884		810	74		kWh per year
		0.1747		0.16	0.0147		kW
		-		-	-		therms per year
LED, 8-12 Watts		60W → 8W LED	90W → 12W LED		60W → 8W LED	90W → 12W LED	
	Agriculture	244	366	165	79	201	kWh per year
		0.035	0.052	0.0235	0.012	0.029	kW
		-	-	-	-	-	therms per year
	Commercial	194	291	131	63	160	kWh per year
		0.04	0.06	0.027	0.013	0.033	kW
		-	-	-	-	-	therms per year
	Industrial	247	370	166	81	204	kWh per year
		0.04	0.06	0.027	0.013	0.033	kW
		-	-	-	-	-	therms per year
	Schools & Government	168	253	113	55	140	kWh per year
		0.033	0.05	0.0224	0.011	0.028	kW
		-	-	-	-	-	therms per year