Focus on Energy
Evaluated Deemed Savings
Changes

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Deemed Savings Analysis

This report contains measure-specific findings from evaluating the CY 2017 Wisconsin Focus on Energy programs. These findings are the result of individual project-level evaluation activities, such as billing analyses, supporting research, and engineering reviews.

The CY 2017 evaluation activities revealed the following values and practices for key input variables and algorithms (specific details regarding these inputs are described further in this document):

1. Retail markdown LED lamps:
    a. In-service rate (ISR): 87%
    b. Effective useful life (EUL) for long-lifetime measures: 17 years
2. Appliance recycling:
    a. Part-use factor: 0.86 for refrigerators, 0.76 for freezers
    b. Unit energy consumption: 962 for refrigerators, 926 for freezers

The Evaluation Team[1] recommends updating the savings calculations for retail markdown LED lamps and appliance recycling measures to reflect these assumptions and algorithm changes. This report identifies the affected measures, the *ex ante* savings assumptions for those measures in the SPECTRUM database during CY 2017, 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.

[1] The Evaluation Team comprises Cadmus, Apex Analytics, and St. Norbert College Strategic Research Institute.

Table 1. Measures Requiring an Update

Measure Category	SPECTRUM Name and MMID
LED Retail Store Markdown	LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown, 3553 LED, Omnidirectional, 310-749 Lumens, Long Lifetime, Retail Store Markdown, 4307 LED, Omnidirectional, 750-1,049 Lumens, Retail Store Markdown, 4308 LED, Omnidirectional, 750-1,049 Lumens, Long Lifetime, Retail Store Markdown, 4309 LED, Omnidirectional, 1,050-1,489 Lumens, Retail Store Markdown, 4310 LED, Omnidirectional, 1,050-1,489 Lumens, Long Lifetime, Retail Store Markdown, 4311 LED, Omnidirectional, 1,490-2,600 Lumens, Retail Store Markdown, 4312 LED, Omnidirectional, 1,490-2,600 Lumens, Long Lifetime, Retail Store Markdown, 4313 LED, Reflector, 12 Watt, Retail Store Markdown, 3557 LED, Reflector, 12 Watt, Retail Store Markdown, Long Lifetime, 4306
Appliance Recycling	Refrigerator Recycling, 2955 Freezer Recycling, 2956

Throughout the CY 2017 evaluation, the Team—through workpaper review and other non-evaluation activities—also determined other measures with variables and algorithms in need of revision. Because these issues were not discovered through the CY 2017 evaluation, they are included in *Appendix A: Non-Evaluation Findings*.

The CY 2017 deemed savings values (or adjusted gross savings values per unit) and the evaluated savings values are listed in Table 2.

Table 2. Deemed and Evaluated Savings Values

SPECTRUM Name and MMID	Deemed/ Evaluated	kW	kWh per Year	Lifetime kWh
Retail Markdown LED Lamps				
LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown, 3553	Deemed	0.0027	23	345
	Evaluated	0.0023	25	375
LED, Omnidirectional, 310-749 Lumens, Long Lifetime, Retail Store Markdown, 4307	Deemed	0.0027	23	460
	Evaluated	0.0023	25	425
LED, Omnidirectional, 750-1,049 Lumens, Retail Store Markdown, 4308	Deemed	0.0037	32	480
	Evaluated	0.0032	29	435
LED, Omnidirectional, 750-1,049 Lumens, Long Lifetime, Retail Store Markdown, 4309	Deemed	0.0037	32	640
	Evaluated	0.0032	29	493
LED, Omnidirectional, 1,050-1,489 Lumens, Retail Store Markdown, 4310	Deemed	0.0045	39	585
	Evaluated	0.0039	36	540
LED, Omnidirectional, 1,050-1,489 Lumens, Long Lifetime, Retail Store Markdown, 4311	Deemed	0.0045	39	780
	Evaluated	0.0039	36	612
LED, Omnidirectional, 1,490-2,600 Lumens, Retail Store Markdown, 4312	Deemed	0.0064	55	825
	Evaluated	0.0056	49	735

SPECTRUM Name and MMID	Deemed/ Evaluated	kW	kWh per Year	Lifetime kWh
LED, Omnidirectional, 1,490-2,600 Lumens, Long Lifetime, Retail Store Markdown, 4313	Deemed	0.0058	55	1,100
	Evaluated	0.0051	49	833
LED, Reflector, 12 Watt, Retail Store Markdown, 3557	Deemed	0.0058	50	750
	Evaluated	0.0051	46	690
LED, Reflector, 12 Watt, Retail Store Markdown, Long Lifetime, 4306	Deemed	0.0058	50	1,000
	Evaluated	0.0051	46	782
Appliance Recycling				
Refrigerator, Recycling and Replacement, 2955	Deemed	0.1150	997	9,970
	Evaluated	0.0954	827	8,270
Freezer, Recycling and Replacement, 2956	Deemed	0.0970	786	7,860
	Evaluated	0.0868	704	7,040

Evaluation Savings Analysis

The algorithms presented in this section show how the Team applied evaluation results to generate deemed savings values for specific measures.

Retail Markdown LED Lamps

For LED lamp retail markdown measures, the Evaluation Team observed two issues affecting deemed savings. First, the Team observed a first-year ISR for LED lamps of 56% during CY 2017 in-home audits, and by assuming an Energy Independence and Security Act (EISA) backstop effective date of 2020, the Team used an 87% net present value for ISR.[2] Second, the Team recommends using an EUL of 17 years for long-lifetime retail markdown measures.

In addition, the Team recommends updating delta watt values to reflect findings from the delta watts analysis in the *CY 2017 Evaluation Report*.[2]

In-Service Rate

The Evaluation Team recruited participants from the general population survey for in-home audits to inventory lighting and appliances, in order to track bulb purchases, installations, and failure and removal rates over time. In the summer of CY 2015, the Evaluation Team made the first of several annual visits, completing 124 audits. In the summer of CY 2016, the Team revisited 120 of the original sites, then in CY 2017 conducted final visits to 116 of these same homes.

In the CY 2017 audits, the Team observed a first-year LED lamp ISR of 56%. This ISR can be projected forward using protocols laid out in the *Uniform Methods Project*,[3] which assume that 24% of bulbs in storage are installed each subsequent year. Projecting this from 2017 (year one) to 2022 (year 6) produces the ISRs shown in Table 3 The Evaluation Team recommends that Focus on Energy capture the likelihood of future installations by using the net present value ISR of 87%. This allows two years for potential sell-through, lack of enforcement, and political uncertainty, and aligns with a common halogen lifetime, which would likely be installed December 31, 2019, and last through CY 2022.

Table 3. CY 2017 LED Lifetime In-Service Rate

First-Year ISR	Second-Year ISR	Third-Year ISR	Fourth-Year ISR	Fifth-Year ISR	Sixth-Year ISR	Net Present Value ISR
56%	67%	75%	81%	85%	89%	87%

[2] Cadmus. *Focus on Energy Calendar Year 2017 Evaluation Report: Volume II.* May 22, 2018. https://focusonenergy.com/sites/default/files/WI%20FOE%20CY%202017%20Volume%20II%20FINAL.pdf

[3] National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. Chapter 6: Residential Lighting Evaluation Protocol. October 2017. https://www.nrel.gov/docs/fy17osti/68562.pdf

Effective Useful Life

Long-lifetime versions of the LED retail markdown measures were introduced in the fall of CY 2017. These are restricted to products with ENERGY STAR–rated lifetimes of 20,000 hours or greater,[4,5] and they are allowed EULs of up to 20 years, rather than the 15-year cap normally in place for residential lamps. Their EUL was calculated by dividing the rated lifetime by the hours of use. The weighted hours of use ($HOU_{WEIGHTED}$) was calculated to be 996, based on the residential and commercial population splits shown in Table 4.[6] The corresponding calculation is $HOU_{WEIGHTED}$ = (2.2 * 93.4% + 10.2 * 6.6%) * 365 = 996. Therefore, the deemed rated lifetime was 20,000 / 996 = 20 years.

Table 4. Cross-Sector Sales Hour of Use and Confidence Factor Weighting

Sector	Weighting	HOU per Day	CF
Residential	**93.4%**	**2.20**	**0.0699**
Multifamily	25.3%	2.01	0.0550
Single Family	74.7%	2.27	0.0075
Commercial	**6.6%**	**10.20**	**0.7700**

This calculation assumes that EUL is directly dependent on the residential and commercial sector *population quantity* splits, which are 93.4% and 6.6%, respectively. However, in cases like this—where savings are split across two populations with different EULs—the overall EUL is in fact directly dependent on the residential and commercial sector *annual savings* splits, which are 75.3% and 24.7%, respectively. The overall EUL can be properly calculated using the following algorithm:

$$kWh_{ANNUAL} = kWh_{RES,ANNUAL} * f_{POP,RES} + kWh_{COMM,ANNUAL} * f_{POP,COMM}$$

$$= \frac{HOU_{RES} * \Delta W}{1{,}000} * f_{POP,RES} + \frac{HOU_{COMM} * \Delta W}{1{,}000} * f_{POP,COMM}$$

$$= \frac{\Delta W}{1{,}000}\left(HOU_{RES} * f_{POP,RES} + HOU_{COMM} * f_{POP,COMM}\right)$$

$$kWh_{LIFECYCLE} = kWh_{RES,LIFECYCLE} * f_{POP,RES} + kWh_{COMM,LIFECYCLE} * f_{POP,COMM}$$

$$= kWh_{RES,ANNUAL} * EUL_{RES} * f_{POP,RES} + kWh_{COMM,ANNUAL} * EUL_{COMM} * f_{POP,COMM}$$

4 ENERGY STAR. *ENERGY STAR Program Requirements for Lamps (Light Bulbs)*. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

5 ENERGY STAR. "ENERGY STAR Certified Light Bulbs" https://www.energystar.gov/productfinder/product/certified-light-bulbs/results

6 Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. September 12, 2016. https://www.focusonenergy.com/sites/default/files/FoE_Deemed%20Savings%20Report_%20CY%2016_v1%207.pdf

$$= \frac{HOU_{RES} * \Delta W}{1{,}000} * EUL_{RES} * f_{POP,RES} + \frac{HOU_{COMM} * \Delta W}{1{,}000} * EUL_{COMM} * f_{POP,COMM}$$

$$= \frac{\Delta W}{1{,}000} * \left(HOU_{RES} * EUL_{RES} * f_{POP,RES} + HOU_{COMM} * EUL_{COMM} * f_{POP,COMM}\right)$$

EUL $= kWh_{LIFECYCLE} / kWh_{ANNUAL}$

$$= \frac{\frac{\Delta W}{1{,}000} * \left(HOU_{RES} * EUL_{RES} * f_{POP,RES} + HOU_{COMM} * EUL_{COMM} * f_{POP,COMM}\right)}{\frac{\Delta W}{1{,}000}\left(HOU_{RES} * f_{POP,RES} + HOU_{COMM} * f_{POP,COMM}\right)}$$

$$= \frac{HOU_{RES} * EUL_{RES} * f_{POP,RES} + HOU_{COMM} * EUL_{COMM} * f_{POP,COMM}}{HOU_{RES} * f_{POP,RES} + HOU_{COMM} * f_{POP,COMM}}$$

Where:

- kWh_{ANNUAL} = Total annual energy savings
- f_{POP} = Population quantity fraction (= 93.4% for residential; = 6.6% for commercial)[6]
- HOU = Hours of use (= 2.2 * 365 = 803 for residential; = 10.2 * 365 = 3,723 for commercial)[6]
- ΔW = Delta watts (= varies)
- $kWh_{LIFECYCLE}$ = Total lifecycle energy savings

The average rated life of lamps meeting the 20,000-hour rated life requirement for long lifetime measures delivered between January 2017 and May 2018 is 23,819 hours.[7,5] The corresponding residential EUL calculation is 23,819 / 803 = 29.66 years, and the residential EUL is capped at 20 years. The corresponding commercial EUL calculation is 23,819 / 3,723 = 6.4 years, which rounds to six years. Therefore, the weighted EUL for long-lifetime retail markdown measures is 17 years:

$$EUL = \frac{803 * 20 * 93.4\% + 3{,}723 * 6 * 6.6\%}{803 * 93.4\% + 3{,}723 * 6.6\%} = 16.545, \text{ which rounds to 17 years.}$$

As mentioned above, another way to view this is to calculate the weighted sector *annual savings* splits. The annual savings fraction from the residential sector, $f_{ANNSAV,RES}$, is:

$$f_{ANNSAV,RES} = \frac{kWh_{RES,ANNUAL} * f_{POP,RES}}{kWh_{RES,ANNUAL} * f_{POP,RES} + kWh_{COMM,ANNUAL} * f_{POP,COMM}}$$

[7] Wisconsin Focus on Energy. Historical project data, obtained from SPECTRUM. There were 7,156 lamps delivered from January 2018 through June 2018, with known models.

$$= \frac{\frac{HOU_{RES} * \Delta W}{1{,}000} * f_{POP,RES}}{\frac{HOU_{RES} * \Delta W}{1{,}000} * f_{POP,RES} + \frac{HOU_{COMM} * \Delta W}{1{,}000} * f_{POP,COMM}}$$

$$= \frac{HOU_{RES} * f_{POP,RES}}{HOU_{RES} * f_{POP,RES} + HOU_{COMM} * f_{POP,COMM}}$$

$$= \frac{803 * 93.4\%}{803 * 93.4\% + 3723 * 6.6\%} = 75.32\%$$

The commercial annual savings fraction, $f_{ANNSAV,COMM}$, is therefore 1 – 75.32% = 24.68%. This means that, although only 6.6% of the retail markdown lamp population goes to the commercial sector, those lamps make up 24.68% of the savings because of their higher HOU value. That higher HOU value also plays into the overall EUL for retail markdown bulbs, and the final EUL is:

EUL = $f_{ANNSAV,RES}$ * EUL_{RES} + $f_{ANNSAV,COMM}$ * EUL_{COMM}

= 75.32% * 20 + 24.68% * 6 = 16.545, which rounds to 17 years.

Note that while the sector annual savings splits are what weigh the overall EUL because of its interaction with HOU and annual savings, it is correct to weight the overall HOU by the sector population splits, producing 996 hours.

Annual Energy-Savings Algorithm

kWh_{SAVED} = ΔWatts * HOU / 1,000 * ISR

Where:

- ΔWatts = Change in wattage, calculated by subtracting efficient bulb wattage from baseline wattage as determined from its lumen bin (= varies by lumen bin; see Table 5)
- HOU = Hours of use (= 996, or (2.20 * 93.4% + 10.2 * 6.6%) * 365)[6]
- 1,000 = Kilowatt conversion factor
- ISR = In-service rate (= 87%)[2]

Table 5. Delta Watts Values

Lifetime Group	Measure Name	MMIDs	Evaluated Gross ΔWatts[2]
Standard, Long	LED, Omnidirectional, Retail Store Markdown, 310-749 Lumens	3553, 4307	29
	LED, Omnidirectional, Retail Store Markdown, 750-1,049 Lumens	4308, 4309	34
	LED, Omnidirectional, Retail Store Markdown, 1,050-1,489 Lumens	4310, 4311	41
	LED, Omnidirectional, Retail Store Markdown, 1,490-2,600 Lumens	4312, 4313	57
	LED, Reflector, 12 Watt, Retail Store Markdown	3557, 4306	53

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = ΔWatts * CF / 1,000

Where:

CF = Coincidence factor (= 0.1162, or (0.0699 * 93.4% + 0.77 * 6.6%))[6]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 15 years for standard measures;[8] = 17 years for long lifetime measures)

Evaluated Savings

The evaluated savings are shown in Table 6.

Table 6. Deemed Savings per Lumen Bin

Lifetime Group	Bulb Type	Lumen Bin	MMID	Annual Energy Savings (kWh)	Lifecycle Energy Savings (kWh)	Coincident Peak Demand Reduction (kW)
Standard	Omnidirectional	310-749	3553	25	375	0.0029
		750-1,049	4308	29	435	0.0034
		1,050-1,489	4310	36	540	0.0041
		1,490-2,600	4312	49	735	0.0058
	Reflector	N/A	3557	46	690	0.0054
Long	Omnidirectional	310-749	4307	25	425	0.0029
		750-1,049	4309	29	493	0.0034
		1,050-1,489	4311	36	612	0.0041
		1,490-2,600	4313	49	833	0.0058
	Reflector	N/A	4306	46	782	0.0054

[8] The average rated life of omnidirectional LEDs with a rated life above 20,000 hours is generally 15,000 to 20,000 hours. With an HOU of 996, the EUL is 15 to 20 years. However, a 15-year EUL cap has been deemed for standard retail markdown residential screw-base LED measures as a result of measure persistence concerns (http://www.neep.org/sites/default/files/resources/ResLightingDeeperDiveFINAL1.pdf) and LED lifetime cap practices of other programs (in Connecticut, Illinois, Massachusetts, Minnesota, Rhode Island, Vermont, and Washington DC).

Appliance Recycling

For the CY 2017 evaluation, the Team estimated the unit energy consumption for recycled refrigerators and freezers using the same meter data and multivariate regression models as in previous years, with updated characteristics of participating appliances as captured in the Program Administrator's program database.[2,9] The Team also derived updated part-use factors from CY 2017 participant survey data.

Annual Energy-Savings Algorithm

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

Wisconsin Focus on Energy's evaluation work for CY 2017 provides data to update both variables in the annual energy-savings equation. First, a modeling update in the CY 2017 report provides an estimate of the Wisconsin-specific gross annual savings, which results in a slight decrease in the assumed savings for refrigerators and freezers. Second, the determined part-use factor for refrigerators is decreased from 0.875 to 0.86, and that for freezers is increased from 0.73 to 0.76.[2]

Table 7. Refrigerator and Freezer Variables

Metric	Refrigerators		Freezers	
	Deemed	Evaluated	Deemed	Evaluated
Unadjusted gross annual kWh savings/unit	1,139	962	1,077	926
Part-use factor	0.875	0.86	0.73	0.76

The annual energy savings is a deemed value based on an evaluation, measurement, and verification analyses conducted by the Evaluation Team,[2] with adjustments for the envisioned Wisconsin conditions as noted below.

Summer Coincident Peak Savings Algorithm

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

Where:

- HOURS = Annual operating hours (= 8,760)
- P = Peak intensity factor; this captures the increase in compressor cycling time in summer peak conditions relative to average annual conditions (= 1.01 for refrigerators; = 1.08 for freezers)[2]
- Part_Use = Part-use factor determined by Evaluation Team (= 0.86 for refrigerators; = 0.76 for freezers)

[9] Cadmus. *Focus on Energy Calendar Year 2017 Evaluation Report*. Appendices. May 22, 2018. https://www.focusonenergy.com/sites/default/files/WI%20FOE%20CY%202017%20Appendices%20FINAL.pdf

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life of replaced refrigerator or freezer (= 10 years)[10]

For this technology, 10 years is technically the *remaining useful life* of the equipment; however, for consistency it is represented as the EUL.

Evaluated Savings

Table 8 shows the deemed savings for refrigerators and freezers.

Table 8. Deemed Savings by Measure

	Refrigerator (MMID 2955)	Freezer (MMID 2956)
Annual Energy Savings (kWh)	827	704
Peak Demand Reduction (kW)	0.0954	0.0868
Lifecycle Energy Savings (kWh)	8,270	7,040

[10] Southern California Edison. *SCE's 2010-2012 Energy Efficiency Proposed Program Plan Workpapers (Amended)*. July 2, 2009. https://www.sce.com/wps/wcm/connect/d6b04314-457c-4338-8b0c-213d9a1ed779/A0807021EE_PP_PPP_Workpapers.pdf?MOD=AJPERES&ContentCache=NONE

Appendix A: Non-Evaluation Findings

The algorithms presented in this appendix show how the Evaluation Team applied findings originating from a general workpaper and technical reference manual (TRM) review processes to generate updated deemed savings values for specific measures. These activities revealed the following values for key input variables and algorithms (specific details regarding these inputs are described further in this appendix):

1. Aerators
    a. Drain factor: 90% for bathrooms, 75% for kitchens
2. Domestic hot water
    a. Gallons per day: 42.75
3. Boilers
    a. Equations adjusted
    b. Effective full-load hours (EFLH) values adjusted
4. Furnaces and single package vertical HVAC units
    a. Equations adjusted
5. Air-source heat pumps and air conditioner split systems
    a. EFLH values adjusted

Table 9 lists the current measures affected by these recommendations. The Evaluation 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 using these measures.

Table 9. Measures Requiring an Update

Measure Category	SPECTRUM Name and MMID
Aerator Measures	Faucet Aerator, Kitchen, 1.5 GPM, Electric, 4384 Faucet Aerator, Kitchen, 1.5 GPM, NG, 4385 Faucet Aerator, Kitchen, 1.0 GPM, Electric, 4386 Faucet Aerator, Kitchen, 1.0 GPM, NG, 4387 Faucet Aerator, Kitchen, 0.5 GPM, Electric, 4388 Faucet Aerator, Kitchen, 0.5 GPM, NG, 4389 Faucet Aerator, Kitchen, 0.5/1.0/1.5 Variable GPM, Electric, 4390 Faucet Aerator, Kitchen, 0.5/1.0/1.5 Variable GPM, NG, 4391 Faucet Aerator, Kitchen, Pack Based, 1.5 GPM, 3862 Faucet Aerator, Bath, 1.5 GPM, Electric, 4392 Faucet Aerator, Bath, 1.5 GPM, NG, 4393 Faucet Aerator, Bath, 1.0 GPM, Electric, 4394 Faucet Aerator, Bath, 1.0 GPM, NG, 4395 Faucet Aerator, Bath, 0.5 GPM, Electric, 4396 Faucet Aerator, Bath, 0.5 GPM, NG, 4397 Faucet Aerator, Bath, Pack Based, 1.0 GPM, 3863

Measure Category	SPECTRUM Name and MMID
Domestic Hot Water Measures	Condensing Water Heater, Natural Gas, 90%+, 1986 Condensing Water Heater, Natural Gas, 90%+, Claim Only, 3584 DHW Plant Replacement, 2760 Water Heater, Indirect, 95% or greater, 1988 Water Heater, Indirect, Claim Only, 3585 Water Heater, Indirect, 95% or greater, 3784
Boiler Measures	Boiler, 95%+ AFUE, with DHW, NG, 3559 Boiler, Tier 2, 95%+ AFUE, with DHW, NG, 3778 Hot Water Boiler, 95%+ AFUE, 1983 Hot Water Boiler, Tier 2, 95%+ AFUE, 3780 Communicating Thermostat, Existing Natural Gas Boiler, 4298 Boiler Control - Outside Air Reset/Cutout, 2221 Boiler, Hot Water, Modulating, ≥90% AFUE, ≤300 MBh, 2743 Boiler, Hot Water, Modulating, ≥90% AFUE, < 300 MBh, 2218 Boiler, Hot Water, Condensing, ≥90% AFUE, ≥300 MBh, 3276 Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh, 3275 Boiler, Hot Water, Near Condensing, ≥85% AFUE, ≥300 MBh, 3277
Furnace Measures	Natural Gas Furnace with ECM, 95+ AFUE (Existing), 1981 Natural Gas Furnace with ECM: 96%+ AFUE, 3868 Natural Gas Furnace with ECM, 97%+ AFUE, 3440 Natural Gas Furnace with ECM: 98%+ AFUE, 3869 Natural Gas Furnace with ECM, Tier 2, 95%+ AFUE (Existing), 3782 Natural Gas Furnace, Tier 2, 95%+ AFUE, 3783 Natural Gas Furnace with ECM: Tier 2, 96%+ AFUE, 3870 Natural Gas Furnace with ECM: Tier 2, 97%+ AFUE, 3871 Natural Gas Furnace with ECM: Tier 2, 98%+ AFUE, 3872
Single Package Vertical HVAC Unit Measures	Single Package Vertical HVAC Unit, ≥90%+ Thermal Efficiency, ≥10.0 EER Cooling, NG, 3693 Single Package Vertical HVAC Unit, ≥90%+ Thermal Efficiency, NG, 3694
Air-Source Heat Pump Measures	Air-Source Heat Pump, ≥ 16 SEER, 2992
Split System Air Conditioner Measures	A/C Split System < 65 MBh SEER 14, 2194* A/C Split System < 65 MBh SEER 15, 2192* A/C Split System < 65 MBh SEER 16 or greater, 2193*

* Due to updates in SEER code, for CY 2019 MMIDs 2192 and 2193 are being replaced by MMIDs 4364 and 4365, and MMID 2194 is being removed. Their replacements will generally follow the updates outlined here.

CY 2017 Deemed and Evaluated Savings Values, Non-Evaluation

The CY 2017 deemed savings values and evaluated savings values for aerator measures are listed in Table 10. These savings updates derive from findings obtained through the general workpaper and TRM review processes.

Table 10. Deemed and Evaluated Savings Values, Aerator Measures

SPECTRUM Name and MMID	Deemed / Evaluated	kW	Annual kWh	Annual Therms
Aerator Measures				
Faucet Aerator, Kitchen, 1.5 GPM, Electric, 4384	Deemed	0.0147	240	0
	Evaluated	0.0111	180	0
Faucet Aerator, Kitchen, 1.5 GPM, NG, 4385	Deemed	0	0	10
	Evaluated	0	0	8
Faucet Aerator, Kitchen, 1.0 GPM, Electric, 4386	Deemed	0.0253	411	0
	Evaluated	0.0190	308	0
Faucet Aerator, Kitchen, 1.0 GPM, NG, 4387	Deemed	0	0	17
	Evaluated	0	0	13
Faucet Aerator, Kitchen, 0.5 GPM, Electric, 4388	Deemed	0.0358	582	0
	Evaluated	0.0269	437	0
Faucet Aerator, Kitchen, 0.5 GPM, NG, 4389	Deemed	0	0	24
	Evaluated	0	0	18
Faucet Aerator, Kitchen, 0.5/1.0/1.5 Variable GPM, Electric, 4390	Deemed	0.0253	411	0
	Evaluated	0.0190	308	0
Faucet Aerator, Kitchen, 0.5/1.0/1.5 Variable GPM, NG, 4391	Deemed	0	0	17
	Evaluated	0	0	13
Faucet Aerator, Kitchen, Pack Based, 1.5 GPM, 3862 (SF)	Deemed	0.0016	33	6
	Evaluated	0.0012	25	5
Faucet Aerator, Kitchen, Pack Based, 1.5 GPM, 3862 (MF)	Deemed	0.0011	18	5
	Evaluated	0.0008	14	3
Faucet Aerator, Bath, 1.5 GPM, Electric, 4392	Deemed	0.0043	49	0
	Evaluated	0.0039	44	0
Faucet Aerator, Bath, 1.5 GPM, NG, 4393	Deemed	0	0	2
	Evaluated	0	0	2
Faucet Aerator, Bath, 1.0 GPM, Electric, 4394	Deemed	0.0074	85	0
	Evaluated	0.0067	76	0
Faucet Aerator, Bath, 1.0 GPM, NG, 4395	Deemed	0	0	4
	Evaluated	0	0	3
Faucet Aerator, Bath, 0.5 GPM, Electric, 4396	Deemed	0.0105	120	0
	Evaluated	0.0095	108	0
Faucet Aerator, Bath, 0.5 GPM, NG, 4397	Deemed	0	0	5
	Evaluated	0	0	5
Faucet Aerator, Bath, Pack Based, 1.0 GPM, 3863 (SF)	Deemed	0.0008	8	2
	Evaluated	0.0007	7	1
Faucet Aerator, Bath, Pack Based, 1.0 GPM, 3863 (MF)	Deemed	0.0006	6	2
	Evaluated	0.0005	6	1

Table 11 and Table 12 outline the deemed and evaluated savings by sector for the affected measures.

Table 11. Deemed and Evaluated Therms Savings Values for Measures with Therm Savings Affected by Gallons per Day, Effective Full-Load Hours, and Equation Adjustments

SPECTRUM Name and MMID	Sector	Annual Therms	
		Deemed	Evaluated
Domestic Hot Water Measures			
Condensing Water Heater, Natural Gas, 90%+, 1986*	SF	46	35
Condensing Water Heater, Natural Gas, 90%+, Claim Only, 3584*			
DHW Plant Replacement, 2760	MF	324**	147
Water Heater, Indirect, 1988	SF	93	88
Water Heater, Indirect, Claim Only, 3585	SF	93	88
Water Heater, Indirect, Tier 2, 3784	SF	93	88
Boiler Measures			
Boiler, 95%+ AFUE, With DHW, NG, 3559	SF	277	296
Boiler, Tier 2, 95%+ AFUE, With DHW, NG, 3778	SF	277	296
Hot Water Boiler, 95%+ AFUE, 1983	SF	151	202
Hot Water Boiler, Tier 2, 95%+ AFUE, 3780	SF	151	202
Communicating Thermostat, Existing Natural Gas Boiler, 4298*	SF	34	36
	MF	18	19
Boiler Control - Outside Air Reset/Cutout, 2221	MF, Nonres	1.675	1.80
Boiler, Hot Water, Modulating, ≥90% AFUE, ≤300 MBh, 2743***	MF, Nonres	5.22	5.22
Boiler, Hot Water, Modulating, ≥90% AFUE, < 300 MBh, 2218***	MF, Nonres	6.5	6.5
Boiler, Hot Water, Condensing, ≥90% AFUE, ≥300 MBh, 3276***	MF, Nonres	3.42	3.42
Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh, 3275***	MF, Nonres	1.43	1.43
Boiler, Hot Water, Near Condensing, ≥85% AFUE, ≥300 MBh, 3277	MF, Nonres	1.77	1.61
Furnace Measures			
Natural Gas Furnace with ECM, 95+ AFUE (Existing), 1981*	SF	21	20
Natural Gas Furnace with ECM: 96%+ AFUE, 3868*	SF	30	29
Natural Gas Furnace with ECM, 97%+ AFUE, 3440*	SF	39	38
Natural Gas Furnace with ECM: 98%+ AFUE, 3869*	SF	48	47
Natural Gas Furnace with ECM, Tier 2, 95%+ AFUE (Existing), 3782*	SF	165	156
Natural Gas Furnace, Tier 2, 95%+ AFUE, 3783*	SF	165	156
Natural Gas Furnace with ECM: Tier 2, 96%+ AFUE, 3870*	SF	174	167
Natural Gas Furnace with ECM: Tier 2, 97%+ AFUE, 3871*	SF	183	177
Natural Gas Furnace with ECM: Tier 2, 98%+ AFUE, 3872*	SF	191	188

SPECTRUM Name and MMID	Sector	Annual Therms	
		Deemed	Evaluated
Single Package Vertical HVAC Unit Measures			
Single Package Vertical HVAC Unit, ≥90%+ Thermal Efficiency, ≥10.0 EER Cooling, NG, 3693*	MF	58	52
Single Package Vertical HVAC Unit, ≥90%+ Thermal Efficiency, NG, 3694*	MF	58	52

* These measures have kilowatt-hour savings and kilowatt reduction, but the values are unaffected by the changes discussed in this report.
** This measure's savings are hybrid and depend on user inputs. Savings listed are TRM example savings only.
*** These measures have savings that are fixed in place by billing analysis results. While EFLH values and equations change, their oversize factors are adjusted so that savings are unchanged.

Table 12. Deemed and Evaluated kWh Savings Values for Measures with Electric Savings Affected by Gallons per Day, Effective Full-Load Hours, and Equation Adjustments

SPECTRUM Name and MMID	Sector	Annual kWh	
		Deemed	Evaluated
Air Source Heat Pump, ≥ 16 SEER, 2992	SF	933	928
A/C Split System < 65 MBh SEER 14, 2194*	MF	60.8	66
A/C Split System < 65 MBh SEER 15, 2192*	MF	113.4	122
A/C Split System < 65 MBh SEER 16 or greater, 2193*	MF	159.5	172

* Due to updates in SEER code, for CY 2019 MMIDs 2192 and 2193 are being replaced by MMIDs 4364 and 4365, and MMID 2194 is being removed. Their replacements will generally follow the updates outlined here.

The algorithms presented in the rest of this appendix show how the Evaluation Team applied findings from the general TRM and workpaper review processes to generate deemed savings values for specific measures.

Aerator Measures

While rewriting and grouping many residential aerator measures into a single workpaper, it was noted that no aerator measures' calculations make use of a drain factor. The volume of water being used to fill vessels—such as for drinking glasses or pots for cooking—is unaffected by the presence of an aerator, since the consumer simply waits longer for the vessel to be filled. In calculating aerator savings, the drain factor accounts for only the volume of water that freely flows down the drain—for washing, rinsing, etcetera—being reduced by the aerator.

Two programs have independently applied drain factors. First, the Illinois TRM[11] uses values of 75% for kitchen usage and 90% for bathroom usage. These values were agreed to by the Illinois Technical Advisory Group, as no studies of drain factor are known. Second, the Ontario Energy Board[12] uses values of 50% for bathrooms and 70% for kitchens, citing a 2008 study. Because the citation used by the Ontario Energy Board to produce these numbers cannot be found, and because the Illinois TRM values are more recent and for a region that likely more closely reflects Wisconsin, the Evaluation Team recommends using the Illinois TRM values for Wisconsin, as shown below.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = Gallons_{SAVED} * 8.33 * 1* (T_{POINT\ OF\ USE} – T_{ENTERING}) / (EF_{ELECTRIC} * 3{,}412)$

$Therm_{SAVED} = Gallons_{SAVED} * 8.33 * C * (T_{POINT\ OF\ USE} – T_{ENTERING}) / (EF_{GAS} * 100{,}000)$

Aerators

$Gallon_{SAVED} = (GPM_{EXISTING} – GPM_{NEW}) * (PH / FH) * FLU * 365 * IR * DF$

Showerheads

$Gallon_{SAVED} = (GPM_{EXISTING} – GPM_{NEW}) * (PH * SPD / FH) * SLU * 365 * IR * DF$

Where:

$Gallons_{SAVED}$	=	First-year water savings in gallons
8.33	=	Density of water, lbs/gallon
$T_{POINT\ OF\ USE}$	=	Temperature of water at point of use (= 93°F for kitchen aerators; = 86°F for bathroom aerators; = 101°F for showerheads)[13]
$T_{ENTERING}$	=	Temperature of water entering water heater (= 52.3°F)[14]

[11] Illinois Energy Efficiency Stakeholder Advisory Group. *Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 6.0*. Volume 3: Residential Measures. February 8, 2017. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_3_Res_020817_Final.pdf

[12] Navigant Consulting. *Measures and Assumptions for Demand Side Management (DSM) Planning. Appendix C: Substantiation Sheets.* April 16, 2009. https://www.oeb.ca/oeb/_Documents/EB-2008-0346/Navigant_Appendix_C_substantiation_sheet_20090429.pdf

[13] Cadmus. *Showerhead and Faucet Aerator Meter Study*. Memo prepared for Michigan Evaluation Working Group. June 2013.

[14] U.S. Department of Energy. "Domestic Hot Water Scheduler." http://energy.gov/eere/buildings/downloads/dhw-event-schedule-generator (The Evaluation Team took the average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.)

$EF_{ELECTRIC}$	=	Energy factor of electric water heater (= 94% for single family; = 92% for multifamily)[15]
3,412	=	Conversion from Btu to kilowatt-hours
C	=	Specific heat of water (= 1 Btu/lb °F)
EF_{GAS}	=	Energy factor of natural gas water heater (= 61% for single family; = 75% for multifamily)[15]
100,000	=	Conversion from Btu to therms
$GPM_{EXISTING}$	=	Baseline flow rate (= 2.2 GPM for kitchen and bathroom aerators; = 2.5 GPM for showerheads)[16]
GPM_{NEW}	=	Efficient flow rate (= 0.5, 1.0, or 1.5 GPM for kitchen and bathroom aerators; = 1.25 or 1.5 GPM for showerheads)
PH	=	Persons per house (= 2.52 for single family homes; = 1.93 for multifamily units)[17]
FH	=	Fixtures per house (for single family homes = 1.0 for kitchen aerators, = 2.04 for bathroom aerators, and = 1.5 for showerheads; for multifamily units = 1.0 for kitchen aerators, = 1.43 for bathroom aerators, and = 1.0 for showerheads)[13]
FLU	=	Fixture length of use in minutes per person per day (= 4.5 for kitchen aerators; = 1.6 for bathroom aerators)[13]
365	=	Conversion from days to years

[15] Cadmus. 2016 Potential Study for Focus on Energy.
Data maintained by Cadmus and Wisconsin PSC.

[16] Alliance Water Efficiency. "National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances." Updated August 2011. http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/codes_and_standards/US-Water-Product-Standard-Matrix-Aug-2011.pdf

[17] U.S. Energy Information Administration. *Residential Energy Consumption Survey*. 2009. https://www.eia.gov/consumption/residential/index.php

IR	=	Installation rate (= 1.0 for prescriptive aerators, = 1.0 for prescriptive showerheads, = 0.54 for pack-based aerators,[18, 19] and = 0.65 for pack-based showerheads)[19, 20]
DF	=	Drain factor (= 0.75 for kitchen aerators, = 0.90 for bathroom aerators)
SPD	=	Showers per person per day (= 0.6)[13]
SLU	=	Shower length of use (= 7.8 minutes per shower)[13]

Summer Coincident Peak Savings Algorithm

Aerators

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * LU * 365 / 60 / FH)$

$CF = \%Peak_{AERATOR} * LU / 180$

Showerheads

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * SPD * SLU * 365 / 60 / FH)$

$CF = \%Peak_{SHOWER} * SLU * SPD / 180$

Where:

kWh_{SAVED}	=	Calculated savings per faucet
CF	=	Coincidence factor (= 0.0033 for kitchen aerators, = 0.0012 for bathroom aerators, = 0.0023 for showerheads)
60	=	Conversion from minutes to hours
$\%Peak_{AERATOR}$	=	Amount of time faucet aerator is used during peak period (= 13%)[21]
180	=	Number of minutes during peak period
$\%Peak_{SHOWER}$	=	Amount of time shower is used during peak period (= 9%)[21]

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18 Cadmus. *Ameren Missouri Efficient Products Impact and Process Evaluation: Program Year 2014*. May 15, 2015. https://www.efis.psc.mo.gov/mpsc/commoncomponents/viewdocument.asp?DocId=935933383

19 Cadmus. *Colorado Energy Savings Kits Program Evaluation*. August 28, 2012. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/CO-2012-Energy-Savings-Kits-Final-Evaluation.pdf

20 Cadmus. *Colorado Showerhead Program Evaluation*. December 7, 2011. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/2011-CO-Showerhead-Program-Evaluation.pdf

21 DeOreo, William B. and P.W. Mayer. *The End Uses of Hot Water in Single Family Homes from Flow Trace Analysis.* Figure 2, p. 10. http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 10 years)[22]

Evaluated Savings

Table 13 shows the evaluated savings for various aerator measures.

Table 13. Evaluated Savings, Prescriptive Multifamily

Description	MMID	Water Saved (Gallons)	kW Saved	kWh Saved		Therms Saved	
				Annual	Lifecycle	Annual	Lifecycle
Kitchen, Electric							
0.5/1.0/1.5 Variable GPM	4390	2,853	0.0190	308	3,080	0	0
0.5 GPM	4388	4,042	0.0269	437	4,370	0	0
1.0 GPM	4386	2,853	0.0190	308	3,080	0	0
1.5 GPM	4384	1,664	0.0111	180	1,800	0	0
Kitchen, Natural Gas							
0.5/1.0/1.5 Variable GPM	4391	2,853	0	0	0	13	130
0.5 GPM	4389	4,042	0	0	0	18	180
1.0 GPM	4387	2,853	0	0	0	13	130
1.5 GPM	4385	1,664	0	0	0	8	80
Bathroom, Electric							
0.5 GPM	4396	1,206	0.0095	108	1,080	0	0
1.0 GPM	4394	851	0.0067	76	760	0	0
1.5 GPM	4392	497	0.0039	44	440	0	0
Bathroom, Natural Gas							
0.5 GPM	4397	1,206	0	0	0	5	50
1.0 GPM	4395	851	0	0	0	3	30
1.5 GPM	4393	497	0	0	0	2	20

Gallons Per Day Values, Effective Full-Load Hour Values, and Equation Adjustments

While reviewing a multitude of workpapers during CY 2017 and CY 2018, the Evaluation Team observed a few issues affecting multiple measures. First, the gallons per day value used by domestic hot water

[22] GDS Associates, Inc. and Summit Blue Consulting. "Natural Gas Energy Efficiency Potential in Massachusetts: Final Report." Table B-2a, measure C-WH-15. April 22, 2009. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

measures was updated for a recent measure, and it was noted that this update should be applied to all measures also using the previous value. Second, it was noted that heating and cooling EFLH values throughout the Wisconsin TRM are often slightly out of alignment with each other and, in some cases, follow a source that could be improved. Third, many HVAC unit upgrade measures in the Wisconsin TRM use an equation that is incorrect for the type of capacity variable the measure calls for.

Several measures are affected by more than one of these three issues. The following sections describe each issue in turn, list the affected measures, and show in general how the algorithm for each measure is affected.

Gallons Per Day Value Adjustment

Previously, domestic hot water measures used a gallons-per-day (GPD) value of 51.5. This was derived by fitting a linear equation to data from Table 3 of a Florida Solar Energy Center study[23] that showcases water usage versus occupancy: GPD = 16.286 * x + 13, with 'x' representing the number of occupants per home. A value of 2.361 occupants per home—from 2009 Residential Energy Consumption Survey data[24]—is used with this polynomial fit to produce a value of 51.5 GPD.

While reviewing a recent domestic hot water measure, the value for occupants per home was updated to 2.43, based on 2010 U.S. Census data.[25] Also, the Florida Energy Center Study was examined more closely, and a new polynomial equation was derived: GPD = -0.0089 * x^2 + 16.277 * x + 3.25. This equation differs from the previous one, which may have had an incorrect intercept. The resulting GPD value is 42.75. This updated value should be applied to all domestic hot water measures using a GPD value.

The GPD value for multifamily sites should follow the same fit, but using the multifamily value of 1.9 persons per residence, for a GPD value of 34.14 rather than the previous value of 43.9. This affects only MMID 2760, which is hybrid measure.

This issue affects the measures shown in Table 14. Each measure has its savings reduced by this adjustment, although two are also affected by the EFLH adjustment discussed in the following section.

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[23] Florida Solar Energy Center. *Estimating Daily Domestic Hot-Water Use in North American Homes*. June 30, 2015. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-464-15.pdf

[24] U.S. Energy Information Administration. "2009 RECS Survey Data." Accessed August 2018. http://www.eia.gov/consumption/residential/data/2009/

[25] U.S. Census Bureau. "Demographic Profile for Wisconsin." May 12, 2011. https://www.census.gov/newsroom/releases/archives/2010_census/cb11-cn137.html

Table 14. Measures Affected by Gallons per Day Adjustment

MMID	Measure Master Name	Note
1986	Condensing Water Heater, Natural Gas, 90%+	Savings decrease 24%
3584	Condensing Water Heater, Natural Gas, 90%+, Claim Only	
2760	DHW Plant Replacement	Savings decrease slightly
1988	Water Heater, Indirect, 95% or greater	Savings decrease 5%
3585	Water Heater, Indirect, Claim Only	
3784	Water Heater, Indirect, 95% or Greater	
3559	Boiler, 95%+ AFUE, with DHW, Natural Gas	Savings decrease slightly (also affected by EFLH adjustment, described in the next section)
3778		

EFLH Value Adjustments

Measures throughout the Wisconsin TRM use several values for EFLH, for both heating and cooling. Several of these values come from arithmetic averages—rather than weighted population averages—and other values are based on extrapolations from an older, non-specific source, using an inappropriate assumption and older program data.

Several measures use a heating EFLH value of 1,909 hours and a cooling EFLH value of 380 hours. These are the arithmetic averages of EFLH values for four Wisconsin cities, derived from an ENERGY STAR savings calculator.[26] The values from the calculator are reduced by approximately 25% for use in the Wisconsin TRM because previous Cadmus metering studies revealed that these values are often overestimated—a phenomenon also discussed in a recent ACEEE paper.[27]

The EFLH values are displayed in Table 15 by city, showing area population splits.[28] The 380 hour and 1,909 hour values reflect an arithmetic average, but the values of 410 hours and 1,890 hours shown in the table incorporate population weights, including the weight of the Wisconsin population not in the named cities, and are more appropriate. This adjustment affects several measures, including nonresidential boilers, single family air-source heat pumps, and single family split-system air conditioners.

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[26] ENERGY STAR. "Energy- and Cost-Savings Calculators for Energy-Efficient Products." Accessed August 2018. https://www.energy.gov/eere/femp/energy-and-cost-savings-calculators-energy-efficient-products General EFLH values are shown in the air-source heat pump savings calculator.

[27] Korn, Dave, and J. Walczyk. "Exactly What is a Full Load Cooling Hour and Does Size Really Matter?" ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, August 21–26, 2016. https://aceee.org/files/proceedings/2016/data/papers/1_1168.pdf

[28] Cadmus. *Focus on Energy Evaluated Deemed Savings Changes.* November 14, 2014. https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

Table 15. Equivalent Full-Load Cooling and Heating Hours by City

Location	$EFLH_{COOL}$	$EFLH_{HEAT}$	Weighting by Participant
Green Bay	344	1,852	22%
La Crosse	323	1,966	3%
Madison	395	1,934	18%
Milwaukee	457	1,883	48%
Wisconsin Average	380	1,909	9%
Weighted Average	**410**	**1,890**	**100%**

Residential boiler measures also currently use EFLH values that can be updated. Single family boilers use a heating EFLH value of 1,000 hours, derived from the following line of reasoning: A 2003 study[29] examining the electricity use of new furnaces estimated that a typical older home in Wisconsin consumes 800 therms per year. This estimate stems from an earlier study[30] examining older homes with condensing furnaces. Since the average furnace is 90% efficient, the yearly furnace output for a typical home is estimated to be 720 therms. This value was combined with 2012 Focus on Energy program data showing an average furnace size of 72 MBh to produce a heating EFLH of 1,000 hours. Multifamily boilers use a value of 1,720 hours for heating EFLH, citing the same line of reasoning.

These assumptions are not clearly justified and rely on outdated estimates, and it is also unclear exactly how the multifamily value was derived. It is therefore recommended that single family boiler measures use the single family furnace heating EFLH value of 1,158 hours, derived from a 2015 metering study,[28] and that multifamily boiler measures use the nonresidential heating EFLH value of 1,890 hours.

As discussed in the 2016 ACEEE paper,[27] actual EFLH values depend heavily on the sizing practices for HVAC equipment, which can vary widely across location, sector, and equipment type. Therefore, it is better to use values derived from billing analyses or metering studies when possible. However, it is sensible that multifamily and nonresidential units have higher EFLH values, since these larger and more expensive units tend to be more appropriately sized.

Many measures are affected by these updates, as outlined in Table 16 and Table 17.

[29] Pigg, Scott. *Electricity Use by New Furnaces: A Wisconsin Field Study*. October 2003. https://www.seventhwave.org/publications/electricity-use-new-furnaces-wisconsin-field-study

[30] Pigg, Scott, and M. Nevius. *Energy and Housing in Wisconsin: A Study of Single-Family Owner-Occupied Homes*. November 2000. https://www.seventhwave.org/publications/energy-and-housing-wisconsin-study-single-family-owner-occupied-homes

Table 16. Measures Affected by Heating EFLH Adjustment

MMID	Measure Master Name	$EFLH_{HEAT}$		Note
		Old	Updated	
3559	Boiler, 95%+ AFUE, with DHW, Natural Gas	1,000	1,158	Also affected by GPD adjustment (described below)
3778				
1983	Hot Water Boiler, 95%+ AFUE			Also affected by equation alteration (described below)
3780				
4298	Communicating Thermostat, Existing Natural Gas Boiler			N/A
2221	Boiler, Outside Temperature Reset/Cutout Control	1,759 for MF	1,890 for MF	Nonresidential values are unchanged
2992	Air Source Heat Pump, ≥ 16 SEER	1,909	1,890	N/A
2743	Boiler, Hot Water, Modulating, ≥ 90% AFUE, ≤ 300 MBh			Also affected by equation alteration (described below); however, savings are fixed by billing analysis results and the oversize factor is adjusted to compensate
2218	Boiler, Hot Water, Modulating, ≥ 90% AFUE, < 300 MBh			
3276	Boiler, Condensing, ≥ 90% AFUE, ≥ 300 MBh			
3275	Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh			
3277	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, ≥ 300 MBh			Also affected by equation alteration (described below).

Table 17. Measures Affected by Cooling EFLH Adjustment

MMID	Measure Master Name	$EFLH_{COOL}$	
		Old	Updated
2194	A/C Split System, ≤ 65 MBh, SEER 14*	380	410
2192	A/C Split System, ≤ 65 MBh, SEER 15*		
2193	A/C Split System, ≤ 65 MBh, SEER 16+*		

* Due to updates in SEER code, for CY 2019 MMIDs 2192 and 2193 are being replaced by MMIDs 4364 and 4365, and MMID 2194 is being removed. Their replacements will generally follow the updates outlined here.

Equation and Capacity Input Adjustments

Savings for HVAC upgrade measures come from increasing the efficiency of HVAC equipment, and depend on the size of that increase and on the capacity of the affected equipment. There are three capacities that might be used for that calculation—output, baseline input, and efficient output. As

outlined in the Chapter 5 of the *Uniform Methods Project*,[31] a different equation applies for each of these capacities:

$Therm_{SAVED} = CAP_{IN,EE} * EFLH * (AFUE_{EE} / AFUE_{BASE} - 1)$ (Equation 1)

$= CAP_{OUT} * EFLH * (1/AFUE_{BASE} - 1 / AFUE_{EE})$ (Equation 2)

$= CAP_{IN,BASE} * EFLH * (1 - AFUE_{BASE} / AFUE_{EE})$ (Equation 3)

In addition, tune-up and add-on measures should use the following equation:

$Therm_{SAVED} = CAP_{IN} * EFLH / AFUE_{BASE} * SavingsFactor$ (Equation 4)

Where:

$CAP_{IN,EE}$ = Efficient input capacity

$AFUE_{EE}$ = Efficient AFUE (or other measure of efficiency)

$AFUE_{BASE}$ = Baseline AFUE (or other measure of efficiency)

CAP_{OUT} = Output capacity

$CAP_{IN,BASE}$ = Baseline input capacity

CAP_{IN} = Input capacity (fixed for upgrade measures)

The savings equations for many measures call for the *rated capacity* or the *capacity*, implying the rated capacity of the equipment being installed—the efficient input capacity. This means that they should use Equation 1 above, but many use Equation 2. This discrepancy should be remedied in the Wisconsin TRM, along with other related issues outlined in Table 18.

Table 18. Measures Affected by Equation/Capacity Adjustment

MMID	Measure Master Name	Equation Update	Notes
1983	Hot Water Boiler, 95%+ AFUE	Calls for *capacity* but uses Equation 3. Switch to Equation 1.	Also affected by EFLH adjustment (described above)
3780	Hot Water Boiler, 95%+ AFUE		
2743	Boiler, Hot Water, Modulating, ≥ 90% AFUE, ≤ 300 MBh	Calls for *rated capacity* but uses Equation 2. Switch to Equation 1.	Also affected by EFLH adjustment (described above); however, savings are fixed by billing analysis results and oversize factor is adjusted to compensate
2218	Boiler, Hot Water, Modulating, ≥ 90% AFUE, < 300 MBh		
3276	Boiler, Condensing, ≥ 90% AFUE, ≥ 300 MBh		
3275	Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh		

[31] National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* Chapter 5: Residential Furnaces and Boilers Evaluation Protocol. September 2017. https://www.nrel.gov/docs/fy17osti/68561.pdf

MMID	Measure Master Name	Equation Update	Notes
3277	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, ≥ 300 MBh		Savings decrease 9%. Also affected by EFLH adjustment (described above)
1981	Natural Gas Furnace with ECM, 95%+ AFUE (Existing)	Calls for *capacity* but uses Equation 2. Switch to Equation 1.	Therm savings decrease 5%
3868	Natural Gas Furnace with ECM, 96%+ AFUE		Therm savings decrease 4%
3440	Natural Gas Furnace with ECM, 97%+ AFUE		Therm savings decrease 3%
3869	Natural Gas Furnace with ECM, 98%+ AFUE		Therm savings decrease 2%
3782	Natural Gas Furnace with ECM, Tier 2, 95%+ AFUE (Existing)		Therm savings decrease 5%
3873	Natural Gas Furnace, Tier 2, 95%+ AFUE		Therm savings decrease 5%
3870	Natural Gas Furnace with ECM, Tier 2, 96%+ AFUE		Therm savings decrease 3%
3871	Natural Gas Furnace with ECM, Tier 2, 97%+ AFUE		Therm savings decrease 3%
3872	Natural Gas Furnace with ECM, Tier 2, 98%+ AFUE		Therm savings decrease 2%
3693	Single Package Vertical HVAC Unit, ≥ 90%+ Thermal Efficiency, ≥ 10.0 EER Cooling, Natural Gas	Uses efficient input capacity with Equation 2. Switch to Equation 1.	Therm savings decrease 10%
3694	Single Package Vertical HVAC Unit, ≥ 90%+ Thermal Efficiency, Natural Gas		

Because the three issues outlined above affect many measures, and some measures are affected by more than one issue, full algorithms for each are not presented here. They may be found for each of these measures in the Wisconsin Focus on Energy *2019 Technical Reference Manual*.[32] (Overall differences between deemed and evaluated savings for each were shown in Table 11 and Table 12).

[32] Available online, January 2019.