MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

FROM: CHERYL JENKINS, PROJECT MANAGER and SAM DENT, TECHNICAL LEAD - VEIC

SUBJECT: V5.0 ERRATA MEASURES EFFECTIVE 06/01/2016

DATE: 01/25/2018

Cc: ANNETTE BEITEL, SAG

This memo documents five errata changes to version 5.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 06/01/2016.

VEIC has provided a summary table showing the errata measures and a brief summary of what was changed, followed by the measures themselves.

TRM Policy Document, Section 3.2.1, states that,

> "TAC participants should notify the TAC when a TRM mistake or omission is found. If a significant mistake or omission is found in the TRM that results in an unreasonable savings estimate, the Program Administrators, Evaluators, TRM Administrator, and TAC will strive to reach consensus on a solution that will result in a reasonable savings estimate. For example, an unreasonable savings estimate may result from an error or omission in the TRM.
>
> "In these limited cases where consensus is reached, the TRM Administrator shall inform the Evaluators to use corrected TRM algorithms and inputs to calculate energy and capacity savings, in addition to using the Commission-approved TRM algorithms and inputs to calculate savings. If the corrected TRM algorithms and inputs are stipulated for acceptance by all the parties in the Program Administrator's savings docket, then the corrected TRM savings verification values may be used for the purpose of measuring savings toward compliance with the Program Administrator's energy savings goals. Errors and omissions found in the TRM will be officially corrected through the annual TRM Update proceeding."

It is our belief and understanding that the following measures have consensus errata by the Program Administrators, Evaluators and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with the TRM Policy Document, the Evaluators may use this version of the measures during evaluation of the current program year (in addition to the measures currently in Version 5.0 of the TRM).

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change
4.2.16	Kitchen Demand Ventilation Controls	CI-FSE-VENT-V03-160601	Fixed cost and savings assumptions to be per HP of fan, not just per fan.
4.4.35	Economizer Repair and Optimization	CI-HVC-ECRP-V02-160601	Fixed alignment of algorithms to building types. Clarity on applicability of algorithms.
4.5.3	High Performance and Reduced Wattage T8 Fixtures and Lamps	CI-LTG-T8FX-V06-160601	Fixing multiple fixture baseline wattage assumptions and therefore savings.
5.4.6	Water Heater Temperature Setback	RS-HWE-TMPS-V05-160601	Adding In Service Rate for KIT applications.
6.1.1	Adjustments to Behavior Savings	CC-BEH-BEHP-V02-160601	Addition of text to clarify persistence calculations and weather adjustments. Update of electric persistence factors. Update the effective date of measure applicability from 6-1-17 to 1-1-18, specifying that all residential HERs-type programs implemented prior to 1-1-18 will assume a one-year measure life.

4.2.16 Kitchen Demand Ventilation Controls

DESCRIPTION

Installation of commercial kitchen demand ventilation controls that vary the ventilation based on cooking load and/or time of day.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a control system that varies the exhaust rate of kitchen ventilation (exhaust and/or makeup air fans) based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a new temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed accordingly.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is kitchen ventilation that has constant speed ventilation motor.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[1]

DEEMED MEASURE COST

The incremental capital cost for this measure is[2]

Measure Category	Incremental Cost , $/HP of fan
DVC Control Retrofit	$1,988
DVC Control New	$1,000

LOADSHAPE

Loadshape C23 - Commercial Ventilation

COINCIDENCE FACTOR

The measure has deemed peak kW savings therefore a coincidence factor does not apply

[1] PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004 - 2005

[2] Ibid.

Algorithm

Calculation of Savings

Annual energy use was based on monitoring results from five different types of sites, as summarized in PG&E Food Service Equipment work paper.

Electric Energy Savings

kWh savings are assumed to be 4966 kWh per horsepower of the fan[3]

THE FOLLOWING TABLE PROVIDES THE KWH SAVINGS

Measure Name	Annual Energy Savings Per Unit (kWh/fan)
DVC Control Retrofit	4,486
DVC Control New	4,486

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Summer Coincident Peak Demand Savings

kW savings are assumed to be 0.68 kW per horsepower of the fan[4]

THE FOLLOWING TABLE PROVIDES THE KW SAVINGS

Measure Name	Coincident Peak Demand Reduction (kW)
DVC Control Retrofit	0.76
DVC Control New	0.76

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Natural Gas Energy Savings

ΔTherms = CFM * HP* Annual Heating Load /(Eff(heat) * 100,000)

Where:

CFM = the average airflow reduction with ventilation controls per hood

= 611 430 cfm/HP[5]

HP = actual if known, otherwise assume 7.75 HP[6]

Annual Heating Load = Annual heating energy required to heat fan exhaust make-up air, Btu/cfm

[3] Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details.

[4] Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details.

[5] Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details., 4,734 cfm reduction on average , with 7.75 fan horsepower on average.

[6] Average of units in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009.

dependent on location[7]:

Zone	Annual Heating Load, Btu/cfm
1 (Rockford)	154,000
2-(Chicago)	144,000
3 (Springfield)	132,000
4-(Belleville)	102,000
5-(Marion)	104,000

Eff(heat) = Heating Efficiency

= actual if known, otherwise assume 80%[8]

100,000 = conversion from Btu to Therm

EXAMPLE

For example, a kitchen hood in Rockford, IL with a 7.75 HP ventilation motor

ΔTherms = ~~611~~ 430 * 7.75*154,000 / (0.80 * 100,000)

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: CI-FSE-VENT-V0~~2~~3-1~~6~~40601

[7] Food Service Technology Center Outside Air Load Calculator, http://www.fishnick.com/ventilation/oalc/oac.php, with inputs of one cfm, and hours from Commercial Kitchen Demand Ventilation Controls (Average 17.8 hours a day 4.45 am to 10.30 pm). Savings for Rockford, Chicago, and Springfield were obtained from the calculator; values for Belleview and Marion were obtained by using the average savings per HDD from the other values.

[8] Work Paper WPRRSGNGRO301 CLEAResult"Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

4.4.35 Economizer Repair and Optimization

DESCRIPTION

Economizers are designed to use unconditioned outside air (OSA) instead of mechanical cooling to provide cooling when exterior conditions permit. When the OSA temperature is less than the changeover temperature (determined by a static setpoint or a reference return air sensor) up to 100% OSA is supplied to help meet the facility's cooling needs, thus reducing mechanical cooling energy and saving energy. An economizer that is not working or is not properly adjusted can waste energy and cause comfort issues. This HVAC Economizer Optimization measure involves the repair and optimization of common economizer problems such as adjusting changeover setpoint, repairing damper motors & linkages and replacing non-working sensors and/or controllers. These repairs and adjustments result in proper operation which maximizes both occupant comfort and energy savings.

This measure is only appropriate for single zone packaged rooftop units. Custom calculations are required for savings for multi-zone systems.

In general the HVAC Economizer Optimization measure may involve both repair and/or optimization;

Economizer Repair – The Economizer repair work is preformed to ensure that the existing economizer is working properly. This allows the system to take advantage of free cooling and ensure that the system is not supplying an excess amount of outside air (OSA) during non-economizing periods.

- **Replace Damper Motor** – If the existing damper motor is not operational, the unit will be replaced with a functioning motor to allow proper damper modulation.
- **Repair Damper linkage** – If the existing linkage is broken or not adjusted properly, the unit will be replaced or adjusted to allow proper damper modulation.
- **Repair Economizer Wiring** – If the existing economizer is not operational due to a wiring issue, the issue will be repaired to allow proper economizer operation.
- **Reduce Over Ventilation** – If the unit is supplying excess OSA, the OSA damper position will be adjusted to meet minimum ventilation requirements.
- **Economizer Sensor Replacement** – If the unit is equipped with a nonadjustable dry bulb (i.e. snapdisk) or malfunctioning analog sensor, the sensor is replaced with a new selectable sensor.
- **Economizer Control Replacement** – If the existing economizer controller is not operational, the unit will be replaced or upgraded to allow for proper economizer operation.

Economizer Optimization- The economizer optimization work is preformed to ensure that the existing economizer system is set up properly to maximize use of free cooling for units located in a particular climate zone.

- **Economizer Changeover Setpoint Adjustment** – If the unit is equipped with a fully operational economizer, the controller is adjusted to the appropriate changeover setpoint based on ASHRAE 90.1 (Figure 1 - *Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)* for the corresponding climate zone.
- **Enable Integrated Operation** – If the unit is equipped with a fully operational economizer and is not set up to allow a minimum of two stages of cooling (1st stage – Economizer Only & 2nd Stage – Economizer & Mechanical cooling), the unit will be wired to allow two stage cooling

This measure was developed to be applicable to the following program types: RF, DI.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment condition is defined by fully functional economizer that is programmed to meet ASHRAE 90.1 economizer changeover setpoint requirements for the facility's climate zone and changeover control type

(Figure 1 - Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)[9].

Figure 1 – Baseline ASHRAE High-Limit Shutoff Control Settings

TABLE 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers[b]

Control Type	Allowed Only in Climate Zone at Listed Setpoint	Required High-Limit Setpoints (Economizer Off When):	
		Equation	Description
Fixed dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
	5a, 6a	$T_{OA} > 70°F$	Outdoor air temperature exceeds 70°F
	1a, 2a, 3a, 4a,	$T_{OA} > 65°F$	Outdoor air temperature exceeds 65°F
Differential dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperature	All	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb[a] of dry air[a] or outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds 75°F

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50% RH. As an example, at approximately 6000 ft elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.
b. Devices with selectable rather than adjustable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

Figure 2 – ASHRAE Climate Zone Map

NORMATIVE APPENDIX B
CLIMATE ZONES FOR U.S. STATES AND COUNTIES

This normative appendix provides the climate zones for U.S. states and counties. Figure B-1 contains the county-level climate zone map for the United States. Table B-1 lists each state and major counties within the state and shows the climate number and letter for each county listed.

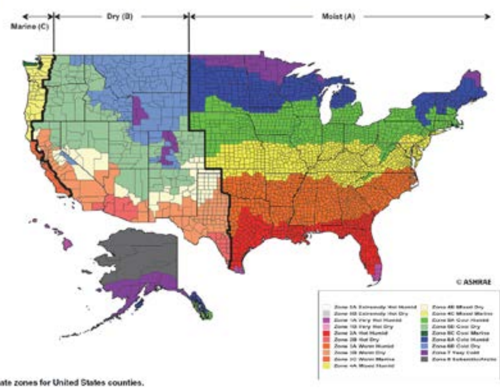

FIGURE B-1 Climate zones for United States counties.

DEFINITION OF BASELINE EQUIPMENT

The baseline for this measure is an existing economizer installed on a packaged single zone rooftop HVAC unit. The existing economizer system is currently not operating as designed due to mechanical and/or control problems, and/or is not optimally adjusted.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 5 years[10].

DEEMED MEASURE COST

The cost for this measure can vary considerably depending upon the existing condition of the economizer and the

[9] ASHRAE, Standard 90.1-2013 - https://www.ashrae.org/resources--publications/bookstore/standard-90-1
[10] California Public Utilities Commission, DEER 2014 EUL Table D08 v2.05

work required to achieve the required efficiency levels. Measure cost should be determined on a site-specific basis.

LOADSHAPE
Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF ENERGY SAVINGS
The savings calculation methodology uses a regression equation to calculate the energy savings for a variety of common situations[11]. The equation variables are limited to the ranges listed; if the actual conditions fall outside of these ranges custom calculations are required.

ELECTRIC ENERGY SAVINGS

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use[12].

Electric Energy Use Equations (kWh / ton)

~~Building Type~~	~~Changeover Type~~	~~Equation~~
~~Assembly~~	~~Fixed Dry-Bulb (DB)~~	~~cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13~~
	~~Dual Temperature Dry-Bulb (DTDB)~~	~~cz+EL*-11.5+OAn*1.635+OAx*-2.817~~
	~~Dual Temperature Enthalpy (DTEnth)~~	~~cz+EL*-17.772+OAn*1.853+OAx*-3.044~~
	~~Fixed Enthalpy (Enth)~~	~~cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003~~
	~~Analog ABCD Economizers (ABCD)~~	~~cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01~~
~~Convenience Store~~	~~DB~~	~~cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13~~
	~~DTDB~~	~~cz+EL*-11.5+OAn*1.635+OAx*-2.817~~
	~~DTEnth~~	~~cz+EL*-17.772+OAn*1.853+OAx*-3.044~~
	~~Enth~~	~~cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003~~
	~~ABCD~~	~~cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01~~
~~Office – Low Rise~~	~~DB~~	~~cz+CSP*-3.982+EL*-27.508+OAn*2.486+OAx*-4.684~~
	~~DTDB~~	~~cz+EL*-20.798+OAn*2.365+OAx*-3.773~~
	~~DTEnth~~	~~cz+EL*-30.655+OAn*2.938+OAx*-4.461~~
	~~Enth~~	~~cz+CSP*-8.648+EL*-25.678+OAn*2.092+OAx*-3.754~~
	~~ABCD~~	~~cz+CSP*-3.64+EL*-24.927+OAn*2.09+OAx*-3.788~~
~~Religious Facility~~	~~DB~~	~~cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047~~
	~~DTDB~~	~~cz+OAn*2.968+OAx*-0.943~~
	~~DTEnth~~	~~cz+EL*-9.799+OAn*3.106+OAx*-1.085~~
	~~Enth~~	~~cz+CSP*-2.773+EL*-7.392+OAn*2.941+OAx*-0.974~~

[11] For more information on methodology, please refer to workpaper submitted by CLEAResult titled "CLEAResult_Economizer Repair_151020_Finalv2.doc". Note that the original ComEd eQuest models were used in the analysis, rather than the VEIC developed models used elsewhere. VEIC do not consider this a significant issue as adjustments from the ComEd models were focused on calibrating EFLH values, not to overall energy use metrics. We also believe using the ComEd models is likely more conservative. It may be appropriate to update the analysis with the updated models at a later time.

[12] This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Building Type	Changeover Type	Equation
	ABCD	cz+CSP*-1.234+EL*-7.229+OAn*2.936+OAx*-0.995
Restaurant	DB	cz+CSP*-1.131+OAn*3.542+OAx*-1.01
	DTDB	cz+EL*-10.198+OAn*4.056+OAx*-1.279
	DTEnth	cz+OAn*3.775+OAx*-1.031
	Enth	cz+CSP*-2.13+OAn*3.317+OAx*-0.629
	ABCD	cz+CSP*-0.95+OAn*3.313+OAx*-0.647
Retail - Department Store	DB	cz+CSP*-2.243+EL*-21.523+OAx*-1.909
	DTDB	cz+EL*-14.427+OAn*0.295+OAx*-1.451
	DTEnth	cz+EL*-25.99+OAn*0.852+OAx*-1.951
	Enth	cz+CSP*-4.962+EL*-16.868+OAn*-0.12+OAx*-1.418
	ABCD	cz+CSP*-2.115+EL*-16.15+OAn*-0.125+OAx*-1.432
Retail - Strip Mall	DB	cz+CSP*-1.003+OAn*3.765+OAx*-0.938
	DTDB	cz+OAn*3.688+OAx*-0.676
	DTEnth	cz+OAn*4.081+OAx*-1.072
	Enth	cz+CSP*-2.545+OAn*3.725+OAx*-0.788
	ABCD	cz+CSP*-1.175+OAn*3.708+OAx*-0.809

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13
	Dual Temperature Dry-Bulb (DTDB)	cz+EL*-11.5+OAn*1.635+OAx*-2.817
	Dual Temperature Enthalpy (DTEnth)	cz+EL*-17.772+OAn*1.853+OAx*-3.044
	Fixed Enthalpy (Enth)	cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003
	Analog ABCD Economizers (ABCD)	cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01
Convenience Store	DB	cz+CSP*-3.982+EL*-27.508+OAn*2.486+OAx*-4.684
	DTDB	cz+EL*-20.798+OAn*2.365+OAx*-3.773
	DTEnth	cz+EL*-30.655+OAn*2.938+OAx*-4.461
	Enth	cz+CSP*-8.648+EL*-25.678+OAn*2.092+OAx*-3.754
	ABCD	cz+CSP*-3.64+EL*-24.927+OAn*2.09+OAx*-3.788
Office - Low Rise	DB	cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
	DTDB	cz+OAn*2.968+OAx*-0.943
	DTEnth	cz+EL*-9.799+OAn*3.106+OAx*-1.085
	Enth	cz+CSP*-2.773+EL*-7.392+OAn*2.941+OAx*-0.974
	ABCD	cz+CSP*-1.234+EL*-7.229+OAn*2.936+OAx*-0.995
Religious Facility	DB	cz+CSP*-1.131+OAn*3.542+OAx*-1.01
	DTDB	cz+EL*-10.198+OAn*4.056+OAx*-1.279
	DTEnth	cz+OAn*3.775+OAx*-1.031

Building Type	Changeover Type	Equation
	Enth	cz+CSP*-2.13+OAn*3.317+OAx*-0.629
	ABCD	cz+CSP*-0.95+OAn*3.313+OAx*-0.647
Restaurant	DB	cz+CSP*-2.243+EL*-21.523+OAx*-1.909
	DTDB	cz+EL*-14.427+OAn*0.295+OAx*-1.451
	DTEnth	cz+EL*-25.99+OAn*0.852+OAx*-1.951
	Enth	cz+CSP*-4.962+EL*-16.868+OAn*-0.12+OAx*-1.418
	ABCD	cz+CSP*-2.115+EL*-16.15+OAn*-0.125+OAx*-1.432
Retail - Department Store	DB	cz+CSP*-1.003+OAn*3.765+OAx*-0.938
	DTDB	cz+OAn*3.688+OAx*-0.676
	DTEnth	cz+OAn*4.081+OAx*-1.072
	Enth	cz+CSP*-2.545+OAn*3.725+OAx*-0.788
	ABCD	cz+CSP*-1.175+OAn*3.708+OAx*-0.809
Retail - Strip Mall	DB	cz+CSP*-1.192+EL*-5.62+OAn*3.353+OAx*-1.142
	DTDB	cz+OAn*3.355+OAx*-0.915
	DTEnth	cz+EL*-9.202+OAn*3.642+OAx*-1.215
	Enth	cz+CSP*-2.997+EL*-5.938+OAn*3.312+OAx*-0.964
	ABCD	cz+CSP*-1.36+EL*-5.884+OAn*3.3+OAx*-0.987

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changover Type (see table below)

		Electric Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	874.07	886.73	1043.38	1071.48	1072.20
	DTDB	698.45	711.89	870.13	899.51	903.10
	DTEnth	702.06	715.42	873.43	902.76	906.50
	Enth	851.95	865.43	1020.65	1047.10	1053.32
	ABCD	884.19	897.63	1053.12	1080.58	1086.35
Convenience Store	DB	1739.12	1787.09	2128.78	2206.65	2245.93
	DTDB	1389.28	1436.30	1780.99	1863.45	1904.89

Building Type	Changeover Type	Electric Climate Zone Coefficients CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
	DTEnth	1398.42	1446.82	1789.71	1869.89	1912.59
	Enth	1643.51	1691.34	2032.83	2112.21	2157.63
	ABCD	1692.80	1740.62	2082.35	2162.73	2207.68
Office - Low Rise	DB	674.06	687.17	899.17	993.84	989.16
	DTDB	583.62	597.02	811.39	907.61	903.58
	DTEnth	588.94	602.11	816.02	912.49	908.26
	Enth	668.83	682.23	893.61	987.52	986.59
	ABCD	690.27	703.52	915.27	1009.94	1008.59
Religious Facility	DB	613.26	630.50	853.53	923.99	931.74
	DTDB	518.40	535.45	760.76	832.57	840.72
	DTEnth	513.59	531.20	756.26	829.13	837.26
	Enth	576.94	594.17	817.64	888.37	897.18
	ABCD	593.78	611.04	834.69	905.83	914.27
Restaurant	DB	1397.27	1430.45	1763.21	1837.63	1872.18
	DTDB	1191.82	1225.12	1558.32	1633.95	1669.13
	DTEnth	1192.84	1226.77	1559.41	1635.13	1671.11
	Enth	1343.56	1377.52	1710.11	1783.66	1821.67
	ABCD	1373.72	1407.70	1740.43	1814.74	1852.55
Retail - Department Store	DB	717.89	730.07	968.85	1034.78	1035.06
	DTDB	628.83	641.70	883.37	951.09	951.33
	DTEnth	629.35	641.90	882.84	951.33	951.44
	Enth	705.06	717.99	956.42	1020.57	1024.45
	ABCD	728.60	741.47	980.19	1045.30	1048.57
Retail - Strip Mall	DB	800.69	818.68	1070.39	1129.87	1133.84
	DTDB	692.97	711.31	965.63	1026.68	1030.41
	DTEnth	698.12	716.34	970.06	1031.78	1035.72
	Enth	784.54	803.35	1054.37	1112.72	1120.74
	ABCD	810.10	828.86	1080.11	1139.39	1146.95

CSP = Economizer Changeover Setpoint (°F or Btu/lb) (actual in ranges below)

Economizer Control Type		Economizer Changeover Setpoint
Dry-Bulb		60°F - 80°F
Dual Temperature Dry-Bulb		0°F -5°F delta
Dual Temperature Enthalpy		0 Btu/lb -5 Btu/lb delta
Enthalpy		18 Btu/lb – 28 Btu/lb
Analog ABCD Economizers	A	73°F
	B	70°F
	C	67°F
	D	63°F
	E	55°F

EL = Integrated Economizer Operation (Economizer Lockout)

= 0 for Economizer w/ Integrated Operation (Two Stage Cooling)

= 1 for Economizer w/ out Integrated Operation ~~fan that runs intermittently~~ (One Stage Cooling)

Oan = Minimum Outside Air (% OSA)[13]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 30%
Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) - 30% (Assume Minimum Ventilation (Three Fingers)[14])

Oax = Maximum Outside Air (%)[i]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 70%
Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) –– 30% (Assume Minimum Ventilation (Three Fingers))

[13] DNV GL, "HVAC Impact Evaluation Final Report WO32 HVAC – Volume 1: Report," California Public Utilities Commission, Energy Division, HVAC Commercial Quality Maintenance (CQM) (1/28/14)
[14] Technician rule of thumb taken from CPUC 'HVAC Impact Evaluation Final Report', WO32, 28Jan 2015, p18.

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found that the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+62*-0.967+0*-6.327+30*2.87+30*-1.047
= 668.8 kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+70*-0.967+0*-6.327+ 30*2.87+70*-1.047
= 619.2 kWh/Ton

ΔkWh = [668.8 (kWh/Ton) – 619.2 (kWh/Ton)] * 5 Tons
= 49.6 kWh/Ton * 5 Tons
= 248.08 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A - It is assumed that repair or optimization of the economizer will not typically have a significant impact summer peak demand.

NATURAL GAS SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use (Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed electric energy use.

Natural Gas Energy Use Equations (therms / kbtu output)

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+OAn*0.0853
	Dual Temperature Dry-Bulb (DTDB)	cz+OAn*0.0866
	Dual Temperature Enthalpy (DTEnth)	cz+OAn*0.0866
	Fixed Enthalpy (Enth)	cz+OAn*0.0855
	Analog ABCD Economizers (ABCD)	cz+OAn*0.0855
Convenience Store	DB	cz+OAn*0.26
	DTDB	cz+OAn*0.263

Building Type	Changeover Type	Equation
	DTEnth	cz+OAn*0.263
	Enth	cz+OAn*0.261
	ABCD	cz+OAn*0.261
Office - Low Rise	DB	cz+OAn*0.3
	DTDB	cz+OAn*0.301
	DTEnth	cz+OAn*0.301
	Enth	cz+OAn*0.3
	ABCD	cz+OAn*0.3
Religious Facility	DB	cz+OAn*0.35
	DTDB	cz+OAn*0.348
	DTEnth	cz+OAn*0.348
	Enth	cz+OAn*0.349
	ABCD	cz+OAn*0.349
Restaurant	DB	cz+OAn*0.0867
	DTDB	cz+OAx*-0.038+OAn*OAx*0.00149
	DTEnth	cz+OAx*-0.038+OAn*OAx*0.00149
	Enth	cz+OAn*0.0878
	ABCD	cz+OAn*0.0878
Retail - Department Store	DB	cz+OAn*0.319
	DTDB	cz+OAn*0.318
	DTEnth	cz+OAn*0.318
	Enth	cz+OAn*0.318
	ABCD	cz+OAn*0.318
Retail - Strip Mall	DB	cz+OAn*0.215
	DTDB	cz+OAn*0.216
	DTEnth	cz+OAn*0.216
	Enth	cz+OAn*0.215
	ABCD	cz+OAn*0.215

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changover Type (see table below)

		Natural Gas Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	-0.03	-0.55	-1.06	-1.28	-1.71
	DTDB	-0.02	-0.57	-1.11	-1.34	-1.79
	DTEnth	-0.02	-0.57	-1.11	-1.34	-1.79
	Enth	-0.03	-0.55	-1.06	-1.29	-1.72
	ABCD	-0.03	-0.55	-1.06	-1.29	-1.72
Convenience Store	DB	2.95	0.50	-1.48	-2.96	-5.56
	DTDB	3.06	0.52	-1.56	-3.11	-5.81
	DTEnth	3.06	0.52	-1.56	-3.11	-5.81

Building Type	Changeover Type	Natural Gas Climate Zone Coefficients				
		CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
	Enth	2.96	0.50	-1.49	-2.98	-5.59
	ABCD	2.96	0.50	-1.49	-2.98	-5.59
Office - Low Rise	DB	5.83	3.02	0.46	-0.92	-4.13
	DTDB	5.98	3.08	0.41	-1.03	-4.36
	DTEnth	5.98	3.08	0.41	-1.03	-4.36
	Enth	5.85	3.03	0.46	-0.93	-4.16
	ABCD	5.85	3.03	0.46	-0.93	-4.16
Religious Facility	DB	9.23	6.71	3.75	2.40	-0.80
	DTDB	9.41	6.83	3.77	2.39	-0.86
	DTEnth	9.41	6.83	3.77	2.39	-0.86
	Enth	9.25	6.73	3.75	2.40	-0.80
	ABCD	9.25	6.73	3.75	2.40	-0.80
Restaurant	DB	8.30	6.54	4.94	4.00	1.95
	DTDB	10.51	8.71	7.07	6.10	4.00
	DTEnth	10.51	8.71	7.07	6.10	4.00
	Enth	8.28	6.51	4.91	3.96	1.90
	ABCD	8.28	6.51	4.91	3.96	1.90
Retail - Department Store	DB	8.20	5.86	3.19	1.25	-2.59
	DTDB	8.35	5.94	3.18	1.18	-2.75
	DTEnth	8.35	5.94	3.18	1.18	-2.75
	Enth	8.21	5.87	3.18	1.24	-2.61
	ABCD	8.21	5.87	3.18	1.24	-2.61
Retail - Strip Mall	DB	6.40	4.35	2.07	0.49	-2.18
	DTDB	6.51	4.38	2.03	0.39	-2.34
	DTEnth	6.51	4.38	2.03	0.39	-2.34
	Enth	6.41	4.35	2.06	0.48	-2.20
	ABCD	6.41	4.35	2.06	0.48	-2.20

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

ΔTherms = [14.8(Therms/kBtuh output) – 14.8 (Therms/kBtuh output)] * 92kBtuh output
= 0.0 (Therms/kBtuh output) * 92kBtuh output
= 0 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ECRP-V0~~1~~2-160601

4.5.3 High Performance and Reduced Wattage T8 Fixtures and Lamps

DESCRIPTION

This measure applies to "High Performance T8" (HPT8) lamp/ballast systems that have higher lumens per watt than standard T8 systems. This measure applies to the installation of new equipment with efficiencies that exceed that of the equipment that would have been installed following standard market practices and is applicable to time of sale as well as retrofit measures. Retrofit measures may include new fixtures or relamp/reballast measures. In addition, options have been provided to allow for the "Reduced Wattage T8 lamps" or RWT8 lamps that result in re-lamping opportunities that produce equal or greater light levels than standard T8 lamps while using fewer watts.

If the implementation strategy does not allow for the installation location to be known, a deemed split of 99% Commercial and 1% Residential should be used[15].

This measure was developed to be applicable to the following program types: TOS, RF, DI.

If applied to other program types, the measure savings should be verified.

The measure applies to all commercial HPT8 installations excluding new construction and major renovation or change of use measures (see lighting power density measure). Lookup tables have been provided to account for the different types of installations. Whenever possible, actual costs and hours of use should be utilized for savings calculations. Default new and baseline assumptions have been provided in the reference tables. Default component costs and lifetimes have been provided for Operating and Maintenance Calculations. Please see the Definition Table to determine applicability for each program. HPT8 configurations not included in the TRM may be included in custom program design using the provided algorithms as long as energy savings is achieved. The following table defines the applicability for different programs

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
This measure relates to the installation of new equipment with efficiency that exceeds that of equipment that would have been installed following standard market practices. In general, the measure will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables. High-bay applications use this system paired with qualifying high ballast factor ballasts and high performance 32 w lamps. Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms.	This measure relates to the replacement of existing equipment with new equipment with efficiency that exceeds that of the existing equipment. In general, the retrofit will include qualifying high efficiency low ballast factor ballasts paired with high efficiency long life lamps as detailed in the attached tables. Custom lighting designs can use qualifying low, normal or high ballast factor ballasts and qualifying lamps in lumen equivalent applications where total system wattage is reduced when calculated using the Calculation of Savings Algorithms. High efficiency troffers (new/or retrofit) utilizing HPT8 technology can provide even greater savings. When used in a high-bay application, high-performance T8 fixtures can provide equal light to HID high-bay fixtures, while using fewer watts; these systems typically utilize high ballast factor ballasts, but qualifying low and normal ballast factor ballasts may be used when appropriate light levels are provided and overall wattage is reduced.

[15] Based on weighted average of Final ComEd's BILD program data from PY5 and PY6. For Residential installations, hours of use assumptions from '5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture' measure should be used.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient conditions for all applications are a qualifying HP or RWT8 fixture and lamp/ballast combinations listed on the CEE website under qualifying HP T8 products[16] and qualifying RWT8 products[17].

The definition of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
High efficiency troffers combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output. High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts. High bay fixtures must have fixture efficiencies of 85% or greater. RWT8 lamps: 2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table. This measure assumes a lamp only purchase.	High efficiency troffers (new or retrofit kits) combined with high efficiency lamps and ballasts allow for fewer lamps to be used to provide a given lumen output. High efficiency troffers must have a fixture efficiency of 80% or greater to qualify. Default values are given for a 2 lamp HPT8 fixture replacing a 3 lamp standard efficiency T8 fixture, but other configurations may qualify and the Calculation of savings algorithm used to account for base watts being replaced with EE watts. High bay fixtures will have fixture efficiencies of 85% or greater. RWT8: 2', 3' and 8' lamps must meet the wattage requirements specified in the RWT8 new and baseline assumptions table.

DEFINITION OF BASELINE EQUIPMENT

The definition of baseline equipment varies based on the program and is defined below:

[16] http://library.cee1.org/content/cee-high-performance-t8-specification
[17] http://library.cee1.org/content/reduced-wattage-t8-specification

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
The baseline is standard efficiency T8 systems that would have been installed. The baseline for high-bay fixtures is pulse start metal halide fixtures, the baseline for a 2 lamp high efficiency troffer is a 3 lamp standard efficency troffer.	The baseline is the existing system. In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. Therefore the timing of the sunsetting of T-12s as a viable baseline has been pushed back in v5.0 until 6/1/2018 and will be revisited in future update sessions. There will be a baseline shift applied to all measures installed before 6/1/2018. See table C-1.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed lifetime of efficient equipment varies based on the program and is defined below:

Time of Sale (TOS)	Retrofit (RF) and Direct Install (DI)
Fixture lifetime is 15 years[18]. Fixture retrofits which utilize RWT8 lamps have a lifetime equivalent to the life of the lamp, capped at 15 years. There is no guarantee that a reduced wattage lamp will be installed at time of burnout, but if one is, savings will be captured in the RWT8 measure below. RWT8 lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "RWT8 Component Costs and Lifetime"), capped at 15 years.19	Fixture lifetime is 15 years. As per explanation above, for existing T12 fixtures, a mid life baseline shift should be applied in 6/1/2018 as described in table C-1. Note, since the fixture lifetime is deemed at 15 years, the replacement cost of both the lamp and ballast should be incorporated in to the O&M calculation.

[18] 15 years from GDS Measure Life Report, June 2007
[19] ibid

DEEMED MEASURE COST

The deemed measure cost is found in the reference table at the end of this characterization.

LOADSHAPE

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

Loadshape C11 - Retail Indoor Lighting

Loadshape C12 - Warehouse Indoor Lighting

Loadshape C13 - K-12 School Indoor Lighting

Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)

Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)

Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)

Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)

Loadshape C18 - Industrial Indoor Lighting

Loadshape C19 - Industrial Outdoor Lighting

Loadshape C20 - Commercial Outdoor Lighting

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing system which depends on the baseline fixture configuration (number and type of lamp) and number of fixtures. Value can be selected from the appropriate reference table as shown below, or a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

Program	Reference Table
Time of Sale	A-1: HPT8 New and Baseline Assumptions
Retrofit	A-2: HPT8 New and Baseline Assumptions
Reduced Wattage T8, time of sale or retrofit	A-3: RWT8 New and Baseline Assumptions

$Watts_{EE}$ = New Input wattage of EE fixture which depends on new fixture configuration (number of lamps) and ballast factor and number of fixtures. Value can be selected from the appropriate reference table as shown below, of a custom value can be entered if the configurations in the tables is not representative of the exisitng system.

Program	Reference Table
Time of Sale	A-1: HPT8 New and Baseline Assumptions
Retrofit	A-2: HPT8 New and Baseline Assumptions
Reduced Wattage T8, time of sale or retrofit	A-3: RWT8 New and Baseline Assumptions

Hours = Average hours of use per year as provided by the customer or selected from the Reference Table in Section 4.5, Fixture annual operating hours. If hours or building type are unknown, use the Miscellaneous value.

WHF_e = Waste heat factor for energy to account for cooling energy savings from efficient lighting is selected from the Reference Table in Section 4.5 for each building type. If building is un-cooled, the value is 1.0.

ISR = In Service Rate or the percentage of units rebated that get installed.

=100%[20] if application form completed with sign off that equipment is not placed into storage

[20] Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.

If sign off form not completed assume the following 3 year ISR assumptions:

Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
98%[21]	0%	0%	98.0%[22]

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{23} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

SUMMER COINCIDENT DEMAND SAVINGS

$$\Delta kW = ((Watts_{base}-Watts_{EE})/1000) * WHF_d * CF * ISR$$

Where:

WHF_d = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is selected from the Reference Table in Section 4.5 for each building type. If the building is not cooled WHFd is 1.

CF = Summer Peak Coincidence Factor for measure is selected from the Reference Table in Section 4.5 for each building type. If the building type is unknown, use the Miscellaneous value of 0.66.

[21] 1st year in service rate is based upon review of PY5-6 evaluations from ComEd's commercial lighting program (BILD) (see 'IL Commercial Lighting ISR_2014.xls' for more information

[22] The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

[23]Negative value because this is an increase in heating consumption due to the efficient lighting.

Other factors as defined above

NATURAL GAS SAVINGS

ΔTherms[24] = (((WattsBase-WattsEE)/1000) * ISR * Hours *- IFTherms

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Please select from the Reference Table in Section 4.5 for each building type.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Actual operation and maintenance costs will vary by specific equipment installed/replaced. See Reference tables for Operating and Maintenance Values;

Program	Reference Table
Time of Sale	B-1: HPT8 Component Costs and Lifetime
Retrofit	B-2: HPT8 Component Costs and Lifetime
Reduced Wattage T8, time of sale or retrofit	B-3: HPT8 Component Costs and Lifetime

REFERENCE TABLES

See following page

[24] Negative value because this is an increase in heating consumption due to the efficient lighting.

A-1: Time of Sale: HPT8 New and Baseline Assumptions[25]

EE Measure Description	Nominal Watts	$Watts_{EE}$	Baseline Description	Nominal Watt	$Watts_{BASE}$	Incremental Cost	$Watts_{SAVE}$
4-Lamp HPT8 w/ High-BF Ballast High-Bay	128190	147.2218.5	200 Watt Pulse Start Metal-Halide	200	232	$75	84.8013.50
4-Lamp HPT8 w/ High-BF Ballast High-Bay	128190	147.2218.5	250 Watt Metal Halide	250	295	$75	147.8076.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	192287	220.8330.05	320 Watt Pulse Start Metal-Halide	320	348.8	$75	128.0018.75
6-Lamp HPT8 w/ High-BF Ballast High-Bay	192287	330.05220.8	400 Watt Pulse Start Metal Halide	400	455	$75	234.20124.95
8-Lamp HPT8 w/ High-BF Ballast High-Bay	256364	294.4418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	320	476	$75	181.6057.40
8-Lamp HPT8 w/ High-BF Ballast High-Bay	256364	292.4418.6	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal Halide	400	618	75	323.60199.40
1-Lamp HPT8-high performance 32 w lamp	32	24.64	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	3.52
1-Lamp HPT8-high performance 28 w lamp	289	21.5622.33	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	6.605.83
1-Lamp HPT8-high performance 25 w lamp	25	19.25	1-Lamp Standard F32T8 w/ Elec. Ballast	32	28.16	$15	8.91
2-Lamp HPT8 -high performance 32 w lamp	64	49.28	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	7.04
2-Lamp HPT8-high performance 28 w lamp	56	43.12	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	13.20
2-Lamp HPT8-high performance 25 w lamp	5045	38.534.65	2-Lamp Standard F32T8 w/ Elec. Ballast	64	56.32	$18	17.8221.67
3-Lamp HPT8-high performance 32 w lamp	964	73.9272.38	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	12.1010.56
3-Lamp HPT8-high performance 28 w lamp	845	64.6865.45	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	19.8019.03
3-Lamp HPT8-high performance 25 w lamp	75	57.75	3-Lamp Standard F32T8 w/ Elec. Ballast	96	84.48	$20	26.73
4-Lamp HPT8 -high performance 32 w lamp	1282	93.9498.56	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	18.7014.08
4-Lamp HPT8-high performance 28 w lamp	112	86.24	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	26.40
4-Lamp HPT8-high performance 25 w lamp	100	77	4-Lamp Standard F32T8 w/ Elec. Ballast	128	112.64	$23	35.64
2-lamp High-Performance HPT8 Troffer	64	49.28	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	$100	35.20

Table developed using a constant ballast factor of .77 for troffers/linear HPT8 and 1.15 for HPT8 highbay, 1.0 for all MH/MHPS, and 0.95 for T12 and 0.88 for

[25] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment.

standard T8. Input wattages are an average of manufacturer inputs that account for ballast efficacy

A-2: Retrofit HPT8 New and Baseline Assumptions[26]

EE Measure Description	Nominal Watts	Ballast Factor	Watts$_{EE}$	Baseline Description	Nominal Watts	Watts$_{BASE}$	Watts$_{SAVE}$	Full Measure Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	128~~190~~	1.15	~~218.5~~147.2	200 Watt Pulse Start Metal-Halide	200	232	~~13.50~~84.80	$200
4-Lamp HPT8 w/ High-BF Ballast High-Bay	128~~190~~	1.15	~~218.5~~147.2	250 Watt Metal Halide	250	295	~~76.50~~147.80	$200
6-Lamp HPT8 w/ High-BF Ballast High-Bay	192~~287~~	1.15	~~330.05~~220.8	320 Watt Pulse Start Metal-Halide	320	348.8	~~18.75~~128.00	$225
6-Lamp HPT8 w/ High-BF Ballast High-Bay	192~~287~~	1.15	~~330.05~~220.8	400 Watt Pulse Start Metal Halide	400	455	~~124.95~~234.20	$225
8-Lamp HPT8 w/ High-BF Ballast High-Bay	256~~364~~	1.15	~~418.6~~294.4	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	320	476	~~57.40~~181.60	$250
8-Lamp HPT8 w/ High-BF Ballast High-Bay	~~364~~256	1.15	~~418.6~~294.4	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 400 W Metal Halide	400	618	~~199.40~~323.60	$250
1-Lamp Relamp/Reballast T12 to HPT8	~~34~~32	0.77	~~26.18~~24.64	1-Lamp F34T12 w/ EEMag Ballast	34	42	~~15.82~~17.36	$50
2-Lamp Relamp/Reballast T12 to HPT8	~~68~~64	0.77	~~52.36~~49.28	2-Lamp F34T12 w/ EEMag Ballast	68	67	~~14.64~~17.72	$55
3-Lamp Relamp/Reballast T12 to HPT8	~~102~~96	0.77	~~78.54~~73.92	3-Lamp F34T12 w/ EEMag Ballast	102	104	~~25.46~~30.08	$60
4-Lamp Relamp/Reballast T12 to HPT8	~~136~~128	0.77	~~104.72~~98.56	4-Lamp F34T12 w/ EEMag Ballast	136	144	~~39.28~~45.44	$65
1-Lamp Relamp/Reballast T12 to HPT8	~~40~~32	0.77	24.64~~30.8~~	1-Lamp F40T12 w/ EEMag Ballast	40	41	~~10.20~~16.36	$50
2-Lamp Relamp/Reballast T12 to HPT8	~~80~~64	0.77	49.28~~61.6~~	2-Lamp F40T12 w/ EEMag Ballast	80	87	~~25.40~~37.72	$55
3-Lamp Relamp/Reballast T12 to HPT8	~~120~~96	0.77	73.92~~92.4~~	3-Lamp F40T12 w/ EEMag Ballast	120	141	~~48.60~~67.08	$60
4-Lamp Relamp/Reballast T12 to HPT8	~~160~~128	0.77	98.56~~123.2~~	4-Lamp F40T12 w/ EEMag Ballast	160	172	~~48.80~~73.44	$65
1-Lamp Relamp/Reballast T12 to HPT8	~~40~~32	0.77	24.64~~30.8~~	1-Lamp F40T12 w/ Mag Ballast	40	51	~~20.20~~26.36	$50
2-Lamp Relamp/Reballast T12 to HPT8	~~80~~64	0.77	49.28~~61.6~~	2-Lamp F40T12 w/ Mag Ballast	80	97	~~35.40~~47.72	$55

[26] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, Xcel Energy Lighting Efficiency Input Wattage Guide and professional judgment.

EE Measure Description	Nominal Watts	Ballast Factor	Watts$_{EE}$	Baseline Description	Nominal Watts	Watts$_{BASE}$	Watts$_{SAVE}$	Full Measure Cost
3-Lamp Relamp/Reballast T12 to HPT8	~~120~~96	0.77	73.92~~92.4~~	3-Lamp F40T12 w/ Mag Ballast	120	135	~~42.60~~61.08	$60
4-Lamp Relamp/Reballast T12 to HPT8	~~160~~128	0.77	98.56~~123.2~~	4-Lamp F40T12 w/ Mag Ballast	160	175	~~51.80~~76.44	$65
1-Lamp Relamp/Reballast T8 to HPT8	32	0.77	24.64	1-Lamp F32T8 w/ Elec. Ballast	32	28.16	3.52	$50
2-Lamp Relamp/Reballast T8 to HPT8	64	0.77	49.28	2-Lamp F32T8 w/ Elec. Ballast	64	56.32	7.04	$55
3-Lamp Relamp/Reballast T8 to HPT8	96	0.77	73.92	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	10.56	$60
4-Lamp Relamp/Reballast T8 to HPT8	128	0.77	98.56	4-Lamp F32T8 w/ Elec. Ballast	128	112.64	14.08	$65
2-lamp High-Performance HPT8 Troffer or high efficiency retrofit troffer	64	0.77	49.28	3-Lamp F32T8 w/ Elec. Ballast	96	84.48	35.20	$100

Table developed using a constant ballast factor of 0.77 for troffers/linear HPT8 and 1.15 for HPT8 highbay, 1.0 for all MH/MHPS, and 0.95 for T12 and 0.88 for standard T8. Input wattages are an average of manufacturer inputs that account for ballast efficacy.

A– 3: RWT8 New and Baseline Assumptions

EE Measure Description	Nominal Watts	$Watts_{EE}$	EE Lamp Cost	Baseline Description	Base Lamp Cost	Nominal Watts	$Watts_{BASE}$	$Watts_{SAVE}$	Measure Cost
RW T8 - F28T8 Lamp	28	24.64	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	3.52	$2.00
RWT8 F2T8 Extra Life Lamp	28	24.64	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	3.52	$2.00
RWT8 - F32/25W T8 Lamp	25	22.00	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	6.16	$2.00
RWT8 - F32/25W T8 Lamp Extra Life	25	22.00	$4.50	F32 T8 Standard Lamp	$2.50	32	28.16	6.16	$2.00
RWT8 F17T8 Lamp - 2 ft	16	14.08	$4.80	F17 T8 Standard Lamp - 2ft	$2.80	17	14.96	0.88	$2.00
RWT8 F25T8 Lamp - 3 ft	23	20.24	$5.10	F25 T8 Standard Lamp - 3ft	$3.10	25	22.00	1.76	$2.00
RWT8 F30T8 Lamp - 6' Utube	30	26.40	$11.31	F32 T8 Standard Utube	$9.31	32	28.16	1.76	$2.00
RWT8 F29T8 Lamp - Utube	29	25.52	$11.31	F32 T8 Standard Utube	$9.31	32	28.16	2.64	$2.00
RWT8 F96T8 Lamp - 8 ft	65	57.20	$9.00	F96 T8 Standard Lamp - 8 ft	$7.00	70	61.60	4.40	$2.00

Table developed using a constant ballast factor of 0.88 for RWT8 and Standard T8.

B-1: Time of Sale T8 Component Costs and Lifetime[27]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	200 Watt Pulse Start Metal-Halide	$21.00	10000	$6.67	$87.75	40000	$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	320 Watt Pulse Start Metal-Halide	$21.00	20000	$6.67	$109.35	40000	$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	Lamp HPT8 Equivalent to 320 PSMH	$21.00	20000	$6.67	$109.35	40000	$22.50
1-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp Standard F32T12 w/ Elec Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00
2-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp Standard F32T12 w/ Elec Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00
3-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00
4-Lamp HPT8 – all qualifying lamps	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp Standard F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00
				$32.50									
2-lamp High-Performance HPT8 Troffer	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00

[27] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment

B-2: T8 Retrofit Component Costs and Lifetime[28]

EE Measure Description	EE Lamp Cost	EE Lamp Life (hrs)	EE Lamp Rep. Labor Cost per lamp	EE Ballast Cost	EE Ballast Life (hrs)	EE Ballast Rep. Labor Cost	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost	Base Ballast Cost	Base Ballast Life (hrs)	Base Ballast Rep. Labor Cost
4-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	200 Watt Pulse Start Metal-Halide	$29.00	12000	$6.67	$87.75	40000	$22.50
6-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	320 Watt Pulse Start Metal-Halide	$72.00	20000	$6.67	$109.35	40000	$22.50
8-Lamp HPT8 w/ High-BF Ballast High-Bay	$5.00	24000	$6.67	$32.50	70000	$15.00	Proportionally Adjusted according to 6-Lamp HPT8 Equivalent to 320 PSMH	$17.00	20000	$6.67	$109.35	40000	$22.50
1-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
2-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
3-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
4-Lamp Relamp/Reballast T12 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp F34T12 w/ EEMag Ballast	$2.70	20000	$2.67	$20.00	40000	$15.00
1-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	1-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20.00	70000	$15.00
2-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	2-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20.00	70000	$15.00
3-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20.00	70000	$15.00
4-Lamp Relamp/Reballast T8 to HPT8	$5.00	24000	$2.67	$32.50	70000	$15.00	4-Lamp F32T8 w/ Elec. Ballast	$2.70	20000	$2.67	$20.00	70000	$15.00
2-lamp High-Performance HPT8 Troffer	$5.00	24000	$2.67	$32.50	70000	$15.00	3-Lamp F32T8 w/ Elec. Ballast	$2.50	20000	$2.67	$15.00	70000	$15.00

[28] Cost assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment

B-3: Reduced Wattage T8 Component Costs and Lifetime[29]

EE measure description	EE Lamp Cost	EE Lamp Life (hrs)	Baseline Description	Base Lamp Cost	Base Lamp Life (hrs)	Base Lamp Rep. Labor Cost
RW T8 - F28T8 Lamp	$4.50	30000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 F2T8 Extra Life Lamp	$4.50	36000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp	$4.50	30000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 - F32/25W T8 Lamp Extra Life	$4.50	36000	F32 T8 Standard Lamp	$2.50	15000	$2.67
RWT8 F17T8 Lamp - 2 ft	$4.80	18000	F17 T8 Standard Lamp - 2ft	$2.80	15000	$2.67
RWT8 F25T8 Lamp - 3 ft	$5.10	18000	F25 T8 Standard Lamp - 3ft	$3.10	15000	$2.67
RWT8 F30T8 Lamp - 6' Utube	$11.31	24000	F32 T8 Standard Utube	$9.31	15000	$2.67
RWT8 F29T8 Lamp - Utube	$11.31	24000	F32 T8 Standard Utube	$9.31	15000	$2.67
RWT8 F96T8 Lamp - 8 ft	$9.00	24000	F96 T8 Standard Lamp - 8 ft	$7.00	15000	$2.67

[29] Cost assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline and efficient measure cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment.

C-1: T12 Baseline Adjustment:

For measures installed up to 6/1/2018, the full savings (as calculated above in the Algorithm section) will be claimed up to 6/1/2018. A savings adjustment will be applied to the annual savings for the remainder of the measure life. The adjustment to be applied for each measure is listed in the reference table below.

Savings Adjustment Factors

EE Measure Description	Savings Adjustment T12 EEmag ballast and 34 w lamps to HPT8	Savings Adjustment T12 EEmag ballast and 40 w lamps to HPT8	Savings Adjustment T12 mag ballast and 40 w lamps to HPT8
1-Lamp Relamp/Reballast T12 to HPT8	47%	30%	20%
2-Lamp Relamp/Reballast T12 to HPT8	53%	30%	22%
3-Lamp Relamp/Reballast T12 to HPT8	42%	38%	21%
4-Lamp Relamp/Reballast T12 to HPT8	44%	29%	23%

Measures installed in 2016 will claim full savings for two years and 2017 for one year,. Savings adjustment factors will be applied to the full savings for savings starting in 6/1/2018 and for the remainder of the measure life. The savings adjustment is equal to the ratio between wattage reduction from T8 baseline to HPT8 and wattage reduction from T12 EE ballast with 40 w lamp baseline from the table 'T8 New and Baseline Assumptions'.[30]

Example: 2 lamp T8 to 2 lamp HPT8 retrofit saves 10 watts, while the T12 EE with 40 w lamp to HPT8 saves 33 watts. Thus the ratio of wattage reduced is 30%.

MEASURE CODE: CI-LTG-T8FX-V06~~5~~-160601

[30] See "HPRWT8_reference.xlsx" for more information.

EPE Program Downloads. Web accessed http://www.epelectricefficiency.com/downloads.asp?section=ci download Copy of LSF_2012_v4.04_250rows.xls.

Kuiken et al, Focus on Energy Evaluation. Business Programs: Deemed Savings Manual v1.0, Kema, march 22, 2010 available at http://www.focusonenergy.com/files/Document_Management_System/Evaluation/bpdeemedsavingsmanuav10_evaluationreport.pdf Based on ComEd's BILD program data from PY4 and PY5. For Residential installations, hours of use assumptions from '5.5.6 LED Downlights' should be used for LED fixtures and '5.5.8 LED Screw Based Omnidirectional Bulbs' should be used for LED bulbs.

5.4.6 Water Heater Temperature Setback

DESCRIPTION

This measure was developed to be applicable to the following program types: NC, RF, DI, KITS.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

High efficiency is a hot water tank with the thermostat reduced to no lower than 120 degrees.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a hot water tank with a thermostat setting that is higher than 120 degrees, typically systems with settings of 130 degrees or higher. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the measure is 2 years.

DEEMED MEASURE COST

The incremental cost of a setback is assumed to be $5 for contractor time, or no cost if the measure is self-installed.

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 1.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For homes with electric DHW tanks:

ΔkWh[31] = (U * A * (Tpre – Tpost) * Hours * ISR) / (3412 * RE_electric)

Where:

U = Overall heat transfer coefficient of tank (Btu/Hr-°F-ft^2).

= Actual if known. If unknown assume R-12, U = 0.083

A = Surface area of storage tank (square feet)

[31] Note this algorithm provides savings only from reduction in standby losses. The TAC considered avoided energy from not heating the water to the higher temperature but determined that dishwashers are likely to boost the temperature within the unit (roughly canceling out any savings), faucet and shower use is likely to be at the same temperature so there would need to be more lower temperature hot water being used (cancelling any savings) and clothes washers will only see savings if the water from the tank is taken without any temperature control. It was felt the potential impact was too small to be characterized.

= Actual if known. If unknown use table below based on capacity of tank. If capacity unknown assume 50 gal tank; A = 24.99ft^2

Capacity (gal)	A (ft^2)[32]
30	19.16
40	23.18
50	24.99
80	31.84

Tpre = Actual hot water setpoint prior to adjustment

Tpost = Actual new hot water setpoint, which may not be lower than 120 degrees

Default Hot Water Temperature Inputs	
Tpre	135
Tpost	120

Hours = Number of hours in a year (since savings are assumed to be constant over year).

= 8766

ISR = In service rate of showerhead

= Dependant on program delivery method as listed in table below

Delivery method	ISR
Instructions provided in a Kit	To be determined through evaluation
All other	1.0

3412 = Conversion from Btu to kWh

RE_electric = Recovery efficiency of electric hot water heater

= 0.98 [33]

A deemed savings assumption, where site specific assumptions are not available would be as follows:

[32] Assumptions from PA TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation.

[33] Electric water heaters have recovery efficiency of 98%: http://www.ahridirectory.org/ahridirectory/pages/home.aspx

ΔkWh = (U * A * (Tpre – Tpost) * Hours) / (3412 * RE_electric)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (3412 * 0.98)

= 81.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

Hours = 8766

CF = Summer Peak Coincidence Factor for measure

= 1

A deemed savings assumption, where site specific assumptions are not available would be as follows:

ΔkW = (81.6/ 8766) * 1

ΔkW default = 0.00931 kW

NATURAL GAS SAVINGS

For homes with gas water heaters:

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (100,000 * RE_gas)

Where

100,000 = Converts Btus to Therms (btu/Therm)

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[34]

= 67% For MF homes[35]

A deemed savings assumption, where site specific assumptions are not available would be as follows:

For Single Family homes:

[34] DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 78%.

[35] Water heating in multi-family buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multi-family buildings.

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (RE_gas)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (100,000 * 0.78)

= 3.5 Therms

For Multi Family homes:

ΔTherms = (U * A * (Tpre – Tpost) * Hours) / (RE_gas)

= (((0.083 * 24.99) * (135 – 120) * 8766) / (100,000 * 0.67)

= 4.1 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION
N/A

DEEMED O&M COST ADJUSTMENT CALCULATION
N/A

MEASURE CODE: RS-HWE-TMPS-V0~~4~~5-1~~5~~60601

REVIEW DEADLINE: 6/1/2021

1.1.16.1.1 6.1.1 Adjustments to Behavior Savings to Account for Persistence

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DESCRIPTION

Energy efficiency program administrators are increasingly including behavior programs as part of their portfolios. These programs are characterized by various kinds of outreach, education, and customer engagement designed to motivate increases in conservation and energy management behaviors, and most commonly include participant-specific energy usage information. Savings impacts are evaluated by ex-post billing analysis comparing consumption before and after (or with and without) program intervention, and require M&V methods that include customer-specific energy usage regression analysis and randomized controlled trial (RCT) experimental designs, among others (see Behavioral protocol set forth in the IL-TRM Attachment A: Illinois Statewide Net-to-Gross Methodologies for more information). As such, initial calculation of savings is treated as a custom protocol[36].

An important issue for many stakeholders is whetherbwhether energy savings from behavior programs continue over time (i.e., whether they persist beyond the initial program year). Behavior programs have now been delivered for a number of years in many jurisdictions. The weight of evaluation evidence indicates that the energy-saving behaviors influenced through these programs can persist beyond the initial period of program intervention, even without continued program participation[37]. This post-treatment savings persistence has implications for calculations of first-year savings, measure life, and cost-effectiveness testing. Accounting for persistence will yield savings and cost-effectiveness estimates that more accurately reflect the true benefits of these programs. Because annual goals are based on first-year savings, programs should only count savings attributable to first-year spending. The effect of persistence of savings beyond the first year should be included in lifetime savings calculations and cost-effectiveness testing.

The protocol below was developed to outline the adjustments that should be made to account for the persistence of savings beyond the year of program delivery. This protocol is applicable to behavior programs of any type, delivered to residential or C&I customers, that has evaluated evidence of program persistence.; however, the persistence values in this version of the protocol are specific to residential home energy reports (HERs)-type programs[38]. This general protocol should be used for any type of behavior program once supportable assumptions for persistence exist as measured by multi-year, rigorous evaluation studies; persistence factors for those behavioral programs may differ from the specific factors provided in this measure for HERs-type programs.

-Currently, evaluations calculate a custom value on an annual basis to estimate yearly savings. Evaluators typically use a regression analysis to estimate program effects. These regression analyses provide what is called an average treatment effect on the treated (ATT) estimate of program savings. The ATT approach takes advantage of the presence of a randomly assigned control group for each cohort that received reports in the service territory. These regressions use various methods to account for household-specific usage patterns[39]. Because of the experimental design, we can assume that the treatment and control groups experienced similar historical, political, economic, and other events that had comparable effects on their energy use. Moreover, because these groups experienced generally similar weather conditions, it is not necessary to measure or include weather in the RCT model specification to calculate initial annual savings related to the program.

[36] The protocol outlined here assumes that adjustments to remove the effects of savings from program lift (participation in other utility programs), including legacy uplift, to account for move-outs and opt-outs, to normalize for effects of weather, and any other appropriate adjustments, have been made as part of the custom calculation of savings – this final savings value is referred to as "Measured Savings" in the calculations below.

[37] Long-Run Savings and Cost-Effectiveness of Home Energy Reports Programs, Cadmus, October 2014. Also see additional sources in the REFERENCE TABLE below.

[38] Residential HERs-type programs: programs that regularly deliver home energy reports to residential customers through direct mail or email channels using a random control trial (RCT) experimental design. At a minimum, the reports include customer-specific usage information used for a comparison to similar households and individualized energy savings tips.

[39] For example, a linear fixed-effects regression (LFER) model includes a household-specific intercept to account for time-invariant, household-level factors affecting energy use, and a post program regression (PPR) model uses energy use lags to account for household-specific usage in the year prior to the program.

However, in the case of comparing and summing savings year over year, exogenous factors, such as weather, are likely to make annual estimates non-equivalent. In particular, weather ~~can~~is likely to play an important role in driving behavioral effects, affecting savings magnitude (e.g., a constant percentage change in consumption will result in more cooling savings during a hotter-than-average summer), as well as savings rate (e.g., the percentage change in consumption is likely to be higher during hotter-than-average summers).[40] As such, for this framework, evaluators will adjust for effects related to weather as part of the custom inputs to this protocol. ~~This adjustment will~~Each evaluator will choose the most appropriate method for weather normalization. For example, one method would be to provide savings using a model specification that incorporates standard weather year inputs (e.g., HDD and CDD), to be used ~~in~~as the initial input into the calculation of annual savings, as well as inputs for cost effectiveness, as outlined below. This input will approximate average savings for a ~~given~~standard weather year based upon historical data.[41] ~~This approach~~Adjusting savings to a standard weather year is consistent with how other weather-sensitive TRM measures are specified, and will remove weather risk from performance goals ~~are developed, as well as other inputs for~~and cost-effectiveness testing.[42]

The protocol will become effective for residential ~~Home Energy Reports (~~HERs~~)~~ -type programs~~[43]~~ as of ~~June~~January 1, ~~2017 (program year~~ 2018~~) - it is provided here for program planning purposes~~. All ongoing programs will undergo a "reset" upon institution of this protocol[44]. Regardless of any previous history of behavior program delivery, the program year ending ~~May~~December 31, 2018 will be assumed to be Year 1 for all HERs-type programs underway at that time for the purpose of the incorporation of multiyear measure life/savings persistence into cost-effectiveness calculations and for the application of the adjustments to annual savings as outlined below. Should any additional new programs (referred to as "waves" in the calculations below) be established in 2018 or in subsequent years, their first year will be assumed to be Year 1 for that wave – that is, each wave is tracked separately and savings are calculated separately using the approach outlined here. Waves that existed prior to the program year ending December 31, 2018 will continue to be tracked separately for each wave. All residential HERs-type programs implemented prior to ~~June~~January 1, ~~2017~~2018 will assume a ~~1~~one-year measure life; the assumptions and protocols outlined below will not be applied retrospectively to any utility programs. Updates to persistence factors from future evaluations, once incorporated into the IL-TRM, will be used when available for calculation of annual savings values for applicable program years but will not be applied retrospectively to previous years' first-year savings calculations. All other types of behavior programs will continue to use a ~~1~~one-year measure life until supportable evidence exists for savings persistence, at which time this adjustment protocol can be used with appropriate persistence factors.

DETERMINATION OF EFFICIENT BEHAVIOR

Behavior programs focus primarily on reducing electricity and natural gas consumption through behavioral changes; this reduction is generally measured through ex-post billing analysis after program intervention. Specific energy conservation and management behaviors are not usually directly observable. The specific definition of the efficient case is part of the design of behavioral programs and is included as part of the custom saving protocol, which will

[40] ~~We acknowledge that this approach is a proxy for estimating actual savings to allow for prospective calculation of lifetime savings. However, a substantial limitation to this approach is the issue of unobserved behavioral ramp-up that is likely to occur for future waves of participants.~~ An analysis to confirm that cross-year effects of weather are material, and therefore should be included as outlined here, is planned.

[41] In the future, this approach could be empirically tested by comparing actual savings calculated in future program years against standard weather year results, producing a 'realization rate' between planned and actual savings results. Standard weather years could potentially be enhanced to better reflect these differences.

[42] We acknowledge that this approach is a proxy for estimating actual savings to allow for prospective calculation of lifetime savings. However, a substantial limitation to this approach is the issue of unobserved behavioral ramp-up that is likely to occur for future waves of participants.

~~[43] Residential HERs-type programs: programs that deliver Home Energy Reports to homeowners using a random control trial (RCT) experimental design. Behavior change is motivated by customer-specific usage information with individualized analysis, comparisons, and tips for energy savings.~~

[44] It is understood that this approach does not accurately take into account that programs have been in place prior to this date, and the fact that customers at that time will have been receiving reports for variable amounts of time, with varied associated actual savings persistence from these earlier program efforts. The difficulties of trying to "phase in" persistence adjustments to reflect this history have been recognized, and the approach outlined here has been recommended by the Illinois TAC members as a reasonable approximation.

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include any adjustment necessary to remove effects of program-related investments in efficient equipment.

DETERMINATION OF BASELINE BEHAVIOR

The ideal baseline for behavior programs is the energy usage without the program intervention. Various types of experimental, quasi-experimental, and/or regression-based EM&V approaches are used to present statistically valid approximations to this without-program baseline[45]. The specific definition of the baseline case is part of the design of behavioral programs and is included as part of the custom saving protocol.

DEEMED LIFETIME/PERSISTENCE OF SAVINGS

Evaluations in Illinois have shown that savings from residential HERs-type behavior programs can persist into at least the first and second year following discontinuation of program delivery[46], though on-going savings levels decay in the second year. For other residential RCT programs evaluated to date, savings have been shown to persist for at least 3 years year following program delivery[47], and industry expectations are that savings likely persist beyond that. We assume here that savings persist at some level for 5 years[48]. ~~Savings~~On-going savings over those 5 years are not equal, however; it is preferable that actual levels of ongoing savings should be calculated by future year as outlined below (see Application of Persistence for Cost-effectiveness) and used in cost-effectiveness and lifetime savings calculations[49]. ~~Measure life is assumed = 1 year for~~For other behavior program types without evaluations that quantify levels of persistence, measure life is assumed = 1 year.

DEEMED MEASURE COST

It is assumed that- most behavior changes in residential settings can be accomplished with homeowner labor only and without investment in new equipment; therefore, without evidence to the contrary, measure costs in such residential programs focused on motivating changes in customer behavior may be defined as $0[50]. Costs for C&I programs may include additional staffing, software purchases, etc. Cost for such programs is therefore program specific and is determined on a custom basis.

LOADSHAPE AND COINCIDENCE FACTOR

While there is evidence from analysis of AMI data that the savings loadshape for residential HERs-type programs mirrors the whole-house electric energy load pattern, there are not yet enough data to develop a behavior-specific

[45] See the Illinois Behavioral protocol set forth in the IL-TRM Attachment A: IL-NTG Methods for more information concerning randomized control trials and quasi-experimental evaluation methods for non-randomized designs for behavior programs.

[46] ComEd Home Energy Report Opower Program Decay Rate and Persistence Study DRAFT~~.~~-Navigant, presented to Commonwealth Edison Company, January 29, 2016; ComEd Home Energy ~~Efficiency/Demand Response Plan: Plan~~Report Program Decay Rate and Persistence Study, Year ~~7 (6/1/2014-5/31/2015).~~Two DRAFT - Navigant, Presented to Commonwealth Edison Company, ~~January 29~~July 20, 2016; Behavioral Energy Savings Programs: Home Energy Reports Persistence Study Part 2 – April 2015 to September ~~2015Nicor Behavioral Energy Savings Programs,~~2015 FINAL – Navigant, ~~January~~Prepared for Nicor Gas, September 21, 2016.

[47] Long-Run Savings and Cost-Effectiveness of Home Energy Reports Programs, Cadmus, October 2014. Also see additional sources in the REFERENCE TABLE below. Given the limited persistence studies available, we acknowledge that using an average of these studies by fuel type may be the best approximation of persistence rates. However, moving forward, the TAC will incorporate additional study values and develop the most appropriate persistence ~~factor~~factors, taking into account participant characteristics, such as the duration of exposure, the frequency of reports, baseline usage, as well as the amount of time that has persisted since receiving their final report, and the shape of the persistence curve.

[48] Determined as a reasonable preliminary assumption by Illinois TAC members. This assumption should be updated as additional research is conducted on these types of programs, and additional evaluation should be undertaken to assess the reasonableness of this assumption for Illinois-specific programs.

[49] This method of applying calculated values for future year benefits is preferred. Alternatively, an effective measure life can be calculated as Effective Measure Life = Total Discounted Lifetime Savings / First Year Savings.

[50] Future evaluation of costs of behavior change is encouraged to help clarify this assumption. In addition, as noted earlier in this measure characterization, in order to ensure double counting of savings does not occur, the protocol outlined here assumes that adjustments to remove the effects of program lift have been made as part of the custom calculation of savings. In a similar manner, given the savings accounted for by other utility programs are removed from the savings claims and cost-effectiveness for the behavior program, the incremental costs associated with such utility program incentivized measures should also be excluded from the behavior program cost-effectiveness analysis, so as to help ensure double counting of costs does not occur in the utility portfolio cost-effectiveness analysis.

loadshape. Indications from several unpublished analyses[51] show that these behavior savings occur in a general pattern most closely approximated by the Residential Electric Heating and Cooling Loadshape (R10) than any other current residential measure loadshape; this is therefore recommended as the most reasonable approximation for use until more-specific data are available. Loadshapes and coincidence factors will need to be determined for other types of behavior programs once sufficient data are in hand.

Algorithm

CALCULATION OF SAVINGS

Throughout these protocols, Year T refers to the current reporting year for which annual savings are being determined[52].

ELECTRIC ENERGY SAVINGS

The algorithm shown below for this measure was developed to calculate the annual persistence-adjusted electric savings in to be reported in year T after adjustment to account for the proportion of the measured savings for that program year that actually reflects any persistent savings from prior years' program activities (Years T-1, T-2, T-3, and T-4)[53].

$$\Delta kWh_{T\ Adjusted} = \Delta kWh_{T\ Measured} - (\Delta kWh_{T-1\ Adjusted} * RR_{T-1,T} * PFE_1) - (\Delta kWh_{T-2\ Adjusted} * RR_{T-2,T} * PFE_2) - (\Delta kWh_{T-3\ Adjusted} * RR_{T-3,T} * PFE_3) - (\Delta kWh_{T-4\ Adjusted} * RR_{T-4,T} * PFE_4)$$

Where:

$\Delta kWh_{x\ Adjusted}$ = total program annual savings for year X after adjustments to account for persistence (calculated value)

$\Delta kWh_{x\ Measured}$ = measured kWh savings: total program savings as determined from custom calculation/billing analysis[54] of participants in program during year X (input value)

$RR_{Y,X}$ = Program retention rate in year X from year Y participation

= % of program participants in year Y that are still in program in year X (input value: calculated as # participants still in program in year X / # participants in year Y))

PFE_Z = Persistence factor - electric (deemed value)

= % savings that persist Z years after savings were initially measured, where Z is a number

[51] Based on communication from Mathias Bell based on (currently unpublished) studies done by Opower, Cadmus, and LBNL. Also see DTE Energy: Behavior Program Measures for Submission to 2015 MEMD - Year Three Energy Savings - Demand Savings. Energy Optimization, April 15, 2014. http://www.michigan.gov/documents/mpsc/memd_2015_453673_7.pdf

[52] Calculation algorithms account for ~~program~~ attrition of customers out of the service territory, as well as persistence decay. It has been noted that there may also be a need to adjust for cross-year effects of large differences in weather conditions or economic impacts. Custom savings inputs therefore are adjusted for standard year weather. Further studies are needed to help determine the magnitude of such effects and if this is the appropriate way to account for them.

[53] This calculation should be carried out separately for each "wave" of behavior programs, where a wave is defined as a newly launched program. For simplicity, any new wave is assumed to start at the beginning of a program year (Year 1) and may include multiple different treatment types such as usage groups, report frequency, etc. For example, any wave added after 2018, will be considered Year 1 in the year they are launched.

[54] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for standard year ~~X~~ weather terms.

from 1 - 4

= use table below to select the appropriate value

Electric Persistence Factors[55]

Program Type	Program Year T - record 100% of adjusted savings ($\Delta kWh_{TAdjusted}$ above)	Percent adjusted savings from Year T activities that persist 1 year after year T	Percent adjusted savings from Year T activities that persist 2 years after year T	Percent adjusted savings from Year T activities that persist 3 years after year T	Percent adjusted savings from Year T activities that persist 4 years after year T
		PFE_1	PFE_2	PFE_3	PFE_4
Residential HERs-type (RCT)	100%	~~82~~80%	~~68~~54%	~~56~~31%	~~46~~15%

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55 See REFERENCE ~~TABLE~~TABLES below for sources.

Example of Adjusted Annual Savings Calculations:

Assume the following information on participation and measured savings for the following program years (all adjustments have been made to remove effects of program lift, weather, etc. within the custom savings calculations). Assume 2018 is the first year of all programs (or is the "reset" year).

	Reporting Year					
	2018	2019	2020	2021	2022	2023
Input data from program information and custom savings analysis						
# Participants (households)	120,000	109,000	103,000	99,000	94,000	90,000
kWh per participant (household)	200	250	245	250	250	265
Measured kWh savings (custom)	24,000,000	27,250,000	25,235,000	24,750,000	23,500,000	23,850,000

Calculation of Retention Rates:

For use in 2019:

$RR_{2018, 2019}$ = 109,000/120,000 = 0.908

For use in 2020:

$RR_{2018, 2020}$ = 103,000/120,000 = 0.858

$RR_{2019, 2020}$ = 103,000/109,000 = 0.945

For use in 2021:

$RR_{2018, 2021}$ = 99,000/120,000 = 0.825

$RR_{2019, 2021}$ = 99,000/109,000 = 0.908

$RR_{2020, 2021}$ = 99,000/103,000 = 0.961

For use in 2022:

$RR_{2018, 2022}$ = 94,000/120,000 = 0.783

$RR_{2019, 2022}$ = 94,000/109,000 = 0.862

$RR_{2020, 2022}$ = 94,000/103,000 = 0.913

$RR_{2021, 2022}$ = 94,000/99,000 = 0.949

For use in 2023:

$RR_{2019, 2023}$ = 90,000/109,000 = 0.826

$RR_{2020, 2023}$ = 90,000/103,000 = 0.874

$RR_{2021, 2023}$ = 90,000/99,000 = 0.909

$RR_{2022, 2023}$ = 90,000/94,000 = 0.957

Calculation of Adjusted Annual Savings:

$\Delta kWh_{2018\ Adjusted}$ = 24,000,000 kWh

$\Delta kWh_{2019\ Adjusted}$ = 27,250,000 – (24,000,000 * 0.908 * 0.82)
= 9,380,560 kWh

$\Delta kWh_{2020\ Adjusted}$ = 25,235,000 – (9,380,560 * 0.945 * 0.82) – (24,000,000 * 0.858 * 0.68)
= 3,963,444 kWh

$\Delta kWh_{2021\ Adjusted}$ = 24,750,000 – (3,963,444 * 0.961 * 0.82) – (9,380,560 * 0.908 * 0.68) – (24,000,000 * 0.825 * 0.56)
= 4,746,794 kWh

$\Delta kWh_{2022\ Adjusted}$ = 23,500,000 – (4,746,794 * 0.949 * 0.82) – (3,963,444 * 0.913 * 0.68) – (9,380,560 * 0.862 * 0.56) – (24,000,000 * 0.783 * 0.46)
= 4,172,971 kWh

$\Delta kWh_{2023\ Adjusted}$ = 23,850,000 – (4,172,971 * 0.957 * 0.82) – (4,746,794 * 0.909 * 0.68) – (3,963,444 * 0.874 * 0.56) – (9,380,560 * 0.826 * 0.46)
= 12,137,109 kWh

Example of Adjusted Annual Savings Calculations:

Assume the following information on participation and measured savings for the following program years (all adjustments have been made to remove effects of program lift, weather, etc. within the custom savings calculations). Assume 2018 is the first year of all programs (or is the "reset" year).

	Reporting Year					
	2018	**2019**	**2020**	**2021**	**2022**	**2023**
Input data from program information and custom savings analysis						
# Participants (households)	120,000	109,000	103,000	99,000	94,000	90,000
kWh per participant (household)	200	250	245	250	250	265
Measured kWh savings (custom)	24,000,000	27,250,000	25,235,000	24,750,000	23,500,000	23,850,000

Calculation of Retention Rates:

For use in 2019:

$RR_{2018,\ 2019} = 109{,}000/120{,}000 = 0.908$

For use in 2020:

$RR_{2018,\ 2020} = 103{,}000/120{,}000 = 0.858$

$RR_{2019,\ 2020} = 103{,}000/109{,}000 = 0.945$

For use in 2021:

$RR_{2018,\ 2021} = 99{,}000/120{,}000 = 0.825$

$RR_{2019,\ 2021} = 99{,}000/109{,}000 = 0.908$

$RR_{2020,\ 2021} = 99{,}000/103{,}000 = 0.961$

For use in 2022:

$RR_{2018,\ 2022} = 94{,}000/120{,}000 = 0.783$

$RR_{2019,\ 2022} = 94{,}000/109{,}000 = 0.862$

$RR_{2020,\ 2022} = 94{,}000/103{,}000 = 0.913$

$RR_{2021,\ 2022} = 94{,}000/99{,}000 = 0.949$

For use in 2023:

$RR_{2019,\ 2023} = 90{,}000/109{,}000 = 0.826$

$RR_{2020,\ 2023} = 90{,}000/103{,}000 = 0.874$

$RR_{2021,\ 2023} = 90{,}000/99{,}000 = 0.909$

$RR_{2022,\ 2023} = 90{,}000/94{,}000 = 0.957$

Calculation of Adjusted Annual Savings:

$\Delta kWh_{2018\ Adjusted} = 24{,}000{,}000$ kWh

$\Delta kWh_{2019\ Adjusted} = 27{,}250{,}000 - (24{,}000{,}000 * 0.908 * 0.80)$

$= 9{,}816{,}400$ kWh

$\Delta kWh_{2020\ Adjusted} = 25{,}235{,}000 - (9{,}816{,}400 * 0.945 * 0.80) - (24{,}000{,}000 * 0.858 * 0.54)$

$= 6{,}694{,}122$ kWh

$\Delta kWh_{2021\ Adjusted} = 24{,}750{,}000 - (6{,}694{,}122 * 0.961 * 0.80) - (9{,}816{,}400 * 0.908 * 0.54) - (24{,}000{,}000 * 0.825 * 0.31)$

$= 8{,}652{,}382$ kWh

$\Delta kWh_{2022\ Adjusted} = 23{,}500{,}000 - (8{,}652{,}382 * 0.949 * 0.80) - (6{,}694{,}122 * 0.913 * 0.54) - (9{,}816{,}400 * 0.862 * 0.31)$
$- (24{,}000{,}000 * 0.783 * 0.15)$

$= 8{,}188{,}837$ kWh

$\Delta kWh_{2023\ Adjusted} = 23{,}850{,}000 - (8{,}188{,}837 * 0.957 * 0.80) - (8{,}652{,}382 * 0.909 * 0.54) - (6{,}694{,}122 * 0.874 * 0.31)$
$- (9{,}816{,}400 * 0.826 * 0.15)$

$= 10{,}303{,}561$ kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Coincident peak demand savings in year T should also be adjusted to account for persistence from previous years using a similar algorithm[56].

[56] While there are no current studies that evaluate the persistence of peak savings, without more-specific information on the actual behaviors undertaken by program participants and their corresponding peak savings, it seems reasonable to assume that peak savings will also persist in a similar pattern; both of the approaches given assume persistence in peak savings. Further evaluation should be undertaken to clarify this point and determine appropriate peak-specific persistence values.

If peak demand is measured directly by the custom savings analysis:

$$\Delta kW_{T} kW_{T\ Adjusted} = \Delta kW_{T\ Measured} - (\Delta kW_{T-1\ Adjusted} * RR_{T-1,T} * PFE_1) - (\Delta kW_{T-2\ Adjusted} * RR_{T-2,T} * PFE_2) - (\Delta kW_{T-3\ Adjusted} * RR_{T-3,T} * PFE_3) - (\Delta kW_{T-4\ Adjusted} * RR_{T-4,T} * PFE_4)$$

Where:

$\Delta kW_{X\ Adjusted}$ = total program demand savings for year X after adjustments to account for persistence (calculated value)

$\Delta kW_{X\ Measured}$ = total program demand savings as determined from custom calculation /billing analysis[57] of participants in program during year X (input value)

Other variables as defined above

If peak demand is not measured directly by the custom savings analysis, peak demand should be calculated as follows:

$$\Delta kW_{T\ Adjusted} = (\Delta kWh_{T\ Adjusted\ Summer} / \#summer\ hours) * peak\ adjustment\ factor$$

Where:

$\Delta kWh_{T\ Adjusted\ Summer}$ = average adjusted electric energy savings (calculated above) for peak summer months

$= \Delta kWh_{T\ Adjusted} * 0.42 * (3/5)$

$= \Delta kWh_{T\ Adjusted} * 0.25$

Where:

0.42 = Summer Loadshape % for May – Sept

3/5 = proportion of May-Sept hours that fall in June, July, and Aug

summer hours = # hours in June, July, and Aug

= 8760 / 4

Where: 8760 = Hours per year

peak adjustment factor = adjustment for peak k/w over average kW for these hours

[57] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for standard year X weather terms.

= 1.5[58]

NATURAL GAS ENERGY SAVINGS

The algorithm shown below for this measure was developed to calculate the annual persistence-adjusted Therm savings in to be reported in year T after adjustment to account for the proportion of the measured savings for that program year that actually reflects any persistent savings from prior years' program activities (Years T-1, T-2, T-3, and T-4).[59]

$\Delta Therms_{T\ Adjusted} = \Delta Therms_{T\ Measured} – (\Delta Therms_{T-1\ Adjusted} * RR_{T-1,T} * PFG_1) – (\Delta Therms_{T-2\ Adjusted} * RR_{T-2,T} * PFG_2) – (\Delta Therms_{T-3\ Adjusted} * RR_{T-3,T} * PFG_3) – (\Delta Therms_{T-4\ Adjusted} * RR_{T-4,T} * PFG_4)$

Where:

$\Delta Therms_{x\ Adjusted}$ = total program annual savings for year X after adjustments to account for persistence (calculated value)

$\Delta Therms_{x\ Measured}$ = total program savings as determined from custom calculation/billing analysis[60] of participants in program during year X (input value)

PFG_Z = Persistence factor - gas (deemed value)

= % savings that persist Z years after savings were initially measured, where Z is a number from 1 - 4

= use table below to select the appropriate value

Other variables as defined above

Gas Persistence Factors[61]

Program Type	Program Year T - record 100% of calculated savings ($\Delta Therms_{TAdjusted}$ above)	Percent adjusted savings from Year T activities that persist 1 year after year T	Percent adjusted savings from Year T activities that persist 2 years after year T	Percent adjusted savings from Year T activities that persist 3 years after year T	Percent adjusted savings from Year T activities that persist 4 years after year T
		PFG_1	PFG_2	PFG_3	PFG_4
Residential HERs-type (RCT)	100%	45%	20%	9%	4%

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[58] Based on an approach used in Michigan that gives resulting values supported by evaluation claims. Also see DTE Energy: Behavior Program Measures for Submission to 2015 MEMD - Year Three Energy Savings - Demand Savings. Energy Optimization, April 15, 2014. http://www.michigan.gov/documents/mpsc/memd_2015_453673_7.pdf

[59] This calculation should be carried out separately for each "wave" of behavior programs, where a wave is defined as a newly launched program. For simplicity, any new wave is assumed to start at the beginning of a program year (Year 1) and may include multiple different treatment types such as usage groups, report frequency, etc.

[60] All appropriate adjustments to remove effects of participation in other utility programs, move-outs, opt-outs, to normalize for effects related to weather, and other adjustments as determined by the program experimental design, are assumed to have been made to result in this value for "measured savings". This value has been adjusted for standard year X weather terms.

[61] See REFERENCE TABLETABLES below for sources.

APPLICATION OF PERSISTENCE FOR COST-EFFECTIVENESS

For determination of cost effectiveness (or lifetime savings) of programs in year T, future years' savings related to the current year activities should be recorded for this measure as savings for each specific year using the table below[62]. Because of the potentially confounding effects of differences in weather in future years, the savings inputs used ($\Delta kWh_{TAdjusted}$, $\Delta kW_{TAdjusted,}$ $\Delta Therms_{TAdjusted}$) for these future-year savings calculations have been ~~developed using inputs that are provided from a custom model specification that incorporates standard~~ weather ~~year inputs (HDD and CDD).~~normalized. This input (to be provided by program evaluators) will approximate average savings for a ~~given~~standard weather year based upon historical data.[63]

Program Year T - record 100% of adjusted annual savings as calculated above	Percent savings from Year T activities that persist 1 year after year T	Percent savings from Year T activities that persist 2 years after year T	Percent savings from Year T activities that persist 3 years after year T	Percent savings from Year T activities that persist 4 years after year T
$\Delta kWh_{TAdjusted}$ $\Delta kW_{TAdjusted}$ $\Delta Therms_{TAdjusted}$	$\Delta kWh_{TAdjusted}$ * PFE_1 $\Delta kW_{TAdjusted}$ * PFE_1 $\Delta Therms_{TAdjusted}$ * PFG_1	$\Delta kWh_{TAdjusted}$ * PFE_2 $\Delta kW_{TAdjusted}$ * PFE_2 $\Delta Therms_{TAdjusted}$ * PFG_2	$\Delta kWh_{TAdjusted}$ * PFE_3 $\Delta kW_{TAdjusted}$ * PFE_3 $\Delta Therms_{TAdjusted}$ * PFG_3	$\Delta kWh_{TAdjusted}$ * PFE_4 $\Delta kW_{TAdjusted}$ * PFE_4 $\Delta Therms_{TAdjusted}$ * PFG_4

62 These cost-effectiveness calculations assume a retention rate of 100% after the first program year. Move-out rates and other attrition factors continue to occur and fluctuate year over year, ~~and, to~~although customers moving within the service territory would continue to produce savings. To be accurate, the value of this persistence for lifetime cost and cost-effectiveness calculations should adjust for ~~this~~ attrition through the application of ~~a~~an additional deemed ~~estimate~~factor. At this time, we do not have sufficient data for such an adjustment and recommend further evaluation to develop appropriate values.

63 In the future, this approach could be empirically tested by comparing actual savings calculated in future program years against standard weather year results, producing a 'realization rate' between planned and actual savings results. Standard weather years could potentially be enhanced to better reflect these differences.

Example of Calculation of Cost-effectiveness Inputs – for Electric Savings:

Assume the same information as was used in the Example of Adjusted Annual Savings Calculations (first row below). However, within each year of calculation, evaluators will adjust custom evaluation input (e.g., $\Delta kWh_{2018WeatherAdj}$) by modeling estimated savings using the standard weather year for prospective application. Assume these custom inputs provide the values in the second row below.

	Reporting Year T					
	2018	2019	2020	2021	2022	2023
Adj. kWh savings (previously calculated) $\Delta kWh_{TAdjusted}$	24,000,000	10, 252, 240	5,116,954	5,731,923	5,024,404	11,556,551

In 2018:

2018 annual savings = $\Delta kWh_{2018\ Adjusted}$ = 24,000,000 kWh

Cost-effectiveness benefit in 2019 = $\Delta kWh_{2018\ Adjusted}$ * PFE_1 = 24,000,000 * 0.82 = 19,680,000 kWh

Cost-effectiveness benefit in 2020 = $\Delta kWh_{2018\ Adjusted}$ * PFE_2 = 24,000,000 * 0.68 = 16,320,000 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2018\ Adjusted}$ * PFE_3 = 24,000,000 * 0.56 = 13,440,000 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2018\ Adjusted}$ * PFE_4 = 24,000,000 * 0.46 = 11,040,000 kWh

In 2019:

2019 annual savings = $\Delta kWh_{2019\ Adjusted}$ = 10,252,240 kWh

Cost-effectiveness benefit in 2020 = $\Delta kWh_{2019\ Adjusted}$ * PFE_1 = 10,252,240 * 0.82 = 8,406,837 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2019\ Adjusted}$ * PFE_2 = 10,252,240 * 0.68 = 6,971,523 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2019\ Adjusted}$ * PFE_3 = 10,252,240 * 0.56 = 5,741,254 kWh

Cost-effectiveness benefit in 2023 = $\Delta kWh_{2019\ Adjusted}$ * PFE_4 = 10,252,240 * 0.46 = 4,716,030 kWh

In 2020:

2020 annual savings = $\Delta kWh_{2020\ Adjusted}$ = 5,116,954 kWh

Cost-effectiveness benefit in 2021 = $\Delta kWh_{2020\ Adjusted}$ * PFE_1 = 5,116,954 * 0.82 = 4,195,902 kWh

Cost-effectiveness benefit in 2022 = $\Delta kWh_{2020\ Adjusted}$ * PFE_2 = 5,116,954 * 0.68 = 3,479,529 kWh

Cost-effectiveness benefit in 2023 = $\Delta kWh_{2020\ Adjusted}$ * PFE_3 = 5,116,954 * 0.56 = 2,865,494 kWh

Cost-effectiveness benefit in 2024 = $\Delta kWh_{2020\ Adjusted}$ * PFE_4 = 5,116,954 * 0.46 = 2,353,799 kWh

Etc.

Apply the same approach to calculate cost-effectiveness inputs for kW and for Therms.

Example of Calculation of Cost-effectiveness Inputs – for Electric Savings:

Assume the same information as was used in the Example of Adjusted Annual Savings Calculations.

	Reporting Year T					
	2018	2019	2020	2021	2022	2023
Annual Savings = Adj. kWh savings (previously calculated) = $\Delta kWh_{TAdjusted}$	24,000,000	9,816,400	4,634,922	5,384,166	4,683,858	11,741,354

For calculating cost effectiveness in 2018:

Cost-effectiveness benefit of 2018 savings in 2019 = $\Delta kWh_{2018\ Adjusted}$ * PFE_1 = 24,000,000 * 0.80 = 19,200,000 kWh

Cost-effectiveness benefit of 2018 savings in 2020 = $\Delta kWh_{2018\ Adjusted}$ * PFE_2 = 24,000,000 * 0.54 = 12,960,000 kWh

Cost-effectiveness benefit of 2018 savings in 2021 = $\Delta kWh_{2018\ Adjusted}$ * PFE_3 = 24,000,000 * 0.31 = 7,440,000 kWh

Cost-effectiveness benefit of 2018 savings in 2022 = $\Delta kWh_{2018\ Adjusted}$ * PFE_4 = 24,000,000 * 0.15 = 3,600,000 kWh

For calculating cost effectiveness in 2019:

Cost-effectiveness benefit of 2019 savings in 2020 = $\Delta kWh_{2019\ Adjusted}$ * PFE_1 = 9,816,400 * 0.80 = 7,853,120 kWh

Cost-effectiveness benefit of 2019 savings in 2021 = $\Delta kWh_{2019\ Adjusted}$ * PFE_2 = 9,816,400 * 0.54 = 5,300,856 kWh

Cost-effectiveness benefit of 2019 savings in 2022 = $\Delta kWh_{2019\ Adjusted}$ * PFE_3 = 9,816,400 * 0.31 = 3,043,084 kWh

Cost-effectiveness benefit of 2019 savings in 2023 = $\Delta kWh_{2019\ Adjusted}$ * PFE_4 = 9,816,400 * 0.15 = 1,472,460 kWh

For calculating cost effectiveness in 2020:

Cost-effectiveness benefit of 2020 savings in 2021 = $\Delta kWh_{2020\ Adjusted}$ * PFE_1 = 6,694,122 * 0.80 = 5,355,297 kWh

Cost-effectiveness benefit of 2020 savings in 2022 = $\Delta kWh_{2020\ Adjusted}$ * PFE_2 = 6,694,122 * 0.54 = 3,614,826 kWh

Cost-effectiveness benefit of 2020 savings in 2023 = $\Delta kWh_{2020\ Adjusted}$ * PFE_3 = 6,694,122 * 0.31 = 2,075,178 kWh

Cost-effectiveness benefit of 2020 savings in 2024 = $\Delta kWh_{2020\ Adjusted}$ * PFE_4 = 6,694,122 * 0.15 = 1,004,118 kWh

Etc.

Apply the same approach to calculate cost-effectiveness inputs for kW and for Therms

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WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE ~~TABLE~~TABLES

Persistence studies done to date for HERs-type programs capture effects only through a limited time frame and only for the specific program characteristics of the programs studied. They may not accurately represent conditions in Illinois or those for all Illinois programs. The Illinois TAC has determined that an average annual persistence rate across the studies done to date (Table 1 below) is the best currently available data to approximate persistence for the first year for the general class of residential HERs-type programs. Additional information about the rate of decay in the following years is limited. Most studies done to date that assess decay after more than one year do not specifically evaluate after each individual year and instead just calculate an average annual decay across the years studied. This is true of persistence studies for gas HERs-type programs. For them, this protocol assumes a linear ongoing rate of decay for five years based on the average annual persistence in Table 1.

Navigant has recently undertaken an evaluation of the ComEd electric HERs program specifically designed to determine the first and second year persistence rate separately for each individual year. The results, shown in Table 2 below, indicate an average increase in the year-over-year persistence factor from year 1 to year 2 of 15%. This level of non-linear increase in the persistence factor is assumed to hold for the five years of electric savings persistence for HERs-type programs and is used to calculate persistence factors used in this protocol. The average annual persistence rate from Table 1 is used for the first year.

It is recommended that the persistence values and the shape of the decay function used in this protocol continue to be updated as further longer term and Illinois-specific evaluations are undertaken.

Table 1: Annual Persistence Rate for Residential HERs-type (RCT) Programs: Reference Studies[64]

Utility/Location	Frequency of Reports when in program	Number of Months in Program Before Terminated	Number of Post-Treatment Savings Analysis Months	Average Annual savings decay	Persistence (= 100% - decay)	Source	Electric or Gas
Upper Midwest	Monthly & quarterly	24-25	26	21%	79%	1	Electric
West Coast	Monthly & quarterly	24	29	18%	82%	1	Electric
West Coast	Monthly & quarterly	25-28	34	15%	85%	1	Electric
SMUD	Monthly & quarterly	27	12	32%	68%	1	Electric
Puget Sound Energy	Monthly & quarterly	24	36	11%	89%	1	Electric
MASS	Monthly & quarterly	26	15	33%	67%	2	Electric
Illinois (ComEd)): First Year	Bimonthly	16-52	12	410%	9690%	3	Electric
Illinois (ComEd)	Bimonthly	30	12	2%	98%	3	Electric
Illinois (ComEd)	Bimonthly	16	12	22%	78%	3	Electric
Average Annual Electric Savings Persistence:					**8280%**		
MASS	Monthly & quarterly	15	17	64%	36%	2	Gas
Illinois (Nicor)	Bimonthly	12	12	46%	54%	4	Gas
Average Annual Gas Savings Persistence:					**45%**		

Sources:
1: http://www.cadmusgroup.com/wp-content/uploads/2014/11/Cadmus_Home_Energy_Reports_Winter2014.pdf
2: http://ma-eeac.org/wordpress/wp-content/uploads/Home-Energy-Report-Savings-Decay-Analysis-Final-Report1.pdf
3:http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Sources/Nicor_Gas_HER_Persistence_Study_Part_2_DRAFT_2016-01-28.pdf
43:http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Sources/ComEd_HER_Opower_Persistence_and_Decay_Study_DRAFT_2016-01-28.pdf

4:http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Evaluation_Documents/Nicor_Gas_HER_Persistence_Study_Part_2_Final_2016-09-21.pdf

[64] These persistence studies done to date capture effects only through a limited time frame and only for the specific program characteristics of the study programs. They may not accurately represent conditions in Illinois or those for all Illinois programs. It is recommended that this protocol continue to be updated as further longer term and Illinois-specific evaluations are undertaken.

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Table 2: Year-over-Year Persistence Factors for ComEd Residential HERs Programs						
	Annual Persistence Factor				Implied Year-over-Year Persistence	Change in Year-over-Year Persistence
	Wave 1	Wave 3	Wave 5 Non-AMI	Average		
Year 1: 11/2013-10/2014	96%	98%	78%	90%	90%	
Year 2: 11/2014-10/2015	85%	83%	40%	69%	77%	15%

Source: http://ilsagfiles.org/SAG_files/Evaluation_Documents/Draft%20Reports%20for%20Comment/ComEd_EPY7/ComEd_HER_Year_Two_Persistence_and_Decay_Study_2016-07-20_Draft.pdf This evaluation extends the analysis of the ComEd program waves reviewed in the 2016 study (#3 above) to the second year after reports were terminated. The study shows an increased rate of decay in year two, indicating that a linear decay rate assumption may not be accurate, at least for the first two years. This assessment of a non-liner decay rate will be reviewed, and the rate as it extends beyond the first two years, will be revisited when there have been additional studies designed to explicitly assess the shape of the decay curve across several years.

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REVIEW DEADLINE: 6/1/2020