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ComEd Smart Energy Design Assistance Center Public Sector Enhanced Building Optimization IPA Program Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Plan Year 9 (PY9)

Presented to
ComEd

DRAFT

March 28, 2018

Prepared by:

Jennifer Ma
Navigant Consulting, Inc

Lorraine Renta
Navigant Consulting, Inc

www.navigant.com

Submitted to:

ComEd
Three Lincoln Centre
Oakbrook Terrace, IL 60181

Submitted by:

Navigant Consulting, Inc.
150 N. Riverside, Suite 2100
Chicago, IL 60606

Contact:

Randy Gunn, Managing Director	Jeff Erickson, Director	Patricia Plympton, Associate Director
312.583.5714	608.497.2322	202-253-9356
Randy.Gunn@Navigant.com	Jeff.Erickson@Navigant.com	Partricia.Plympton@Navigant.com

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1. Introduction

This report presents the results of the impact evaluation of ComEd's PY9 Smart Energy Design Assistance Center Public Sector Enhanced Building Optimization IPA (SEDAC) program. It presents a summary of the energy and demand impacts for the total program and broken out by relevant measure and program structure details. Section 6 (Appendix 1) presents the impact analysis methodology. PY9 covers June 1, 2016 through December 31, 2017.

2. Program Description

The aim of the SEDAC program was to provide public sector customers with customized HVAC optimization as an expansion of the Illinois Department of Commerce and Economic Opportunity (DCEO) program. The program provided HVAC tune-ups, direct installation measures, and HVAC optimization assessments. The program was implemented by 360 Energy Group (360EG).

Targeted participants were public sector ComEd customers with demand < 100 kW with Package Rooftop Unit (RTU) or Split Systems with capacity greater than five tons that have not had preventative maintenance performed in the last three years. The program leveraged a network of qualified and pre-approved mechanical contractors who performed the tune-ups and direct install measures, and implemented the customer-desired HVAC optimization strategies.

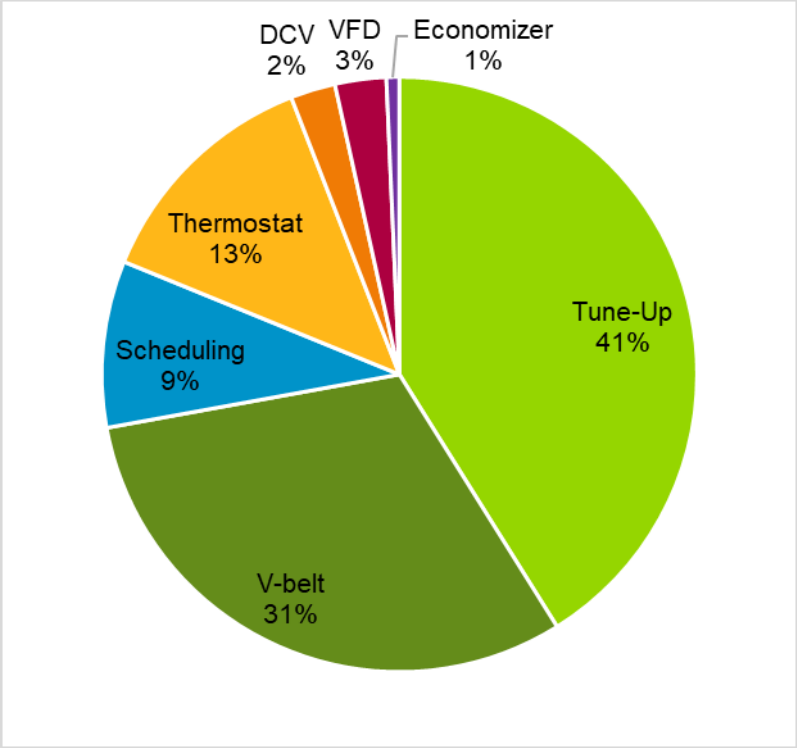
The program had 79 participants in PY9 and distributed 287 measures as shown in the following table and graph.

Table 2-1. PY9 Volumetric Findings Detail

Participation	PY9 Results
Participants	79
Projects	79
Measures Installed	287
Units/Project	3.6
Enhanced HVAC Tune-up	118
Notched V Belt for Supply Fan	89
HVAC Scheduling/Setbacks	26
Install Programmable Thermostat	37
Demand Controlled Ventilation (DCV) on Rooftop Unit (RTU)	7
Dynamic Cycle Management (Variable-frequency Drive)	8
Enthalpy Economizer Optimization	2

Source: ComEd tracking data and Navigant team analysis.

Figure 2-1. Percent of Measures Installed by Type



Source: Evaluation Analysis

3. Program Savings

Table 3-1 summarizes the incremental energy and demand savings the SEDAC Program achieved in PY9.

Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings*	2,254,315	NR	NR
Program Gross Realization Rate	99%	NA	NA
Verified Gross Savings	2,230,330	620	310
Program Net-to-Gross Ratio (NTGR)	0.95	0.95	0.95
Verified Net Savings	2,118,813	589	295

NR = Not Reported

* Ex ante savings summed from "PY9 Data – Project Savings.xlsx"

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The program includes seven measures as shown in the following table. The programmable thermostats and enhanced HVAC Tune-ups contributed the most savings. Navigant calculated the total technical measure life, total persistence, and total effective useful life (EUL) by doing a weighted average of the measures' verified gross savings.

Table 4-1. PY9 Energy Savings by Measure

End Use Type	Research Category	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTGR*	Verified Net Savings (kWh)	Technical Measure Life	Persistence	Effective Useful Life (EUL)†
HVAC	Enhanced HVAC Tune-up	683,059	100%	683,056	0.95	648,903	NA	NA	3
HVAC	Notched V Belt for Supply Fan	46,503	100%	46,507	0.95	44,181	NA	NA	3
HVAC	HVAC Scheduling/Setbacks	471,990	100%	471,989	0.95	448,390	8	25%	2
HVAC	Install Programmable Thermostat	844,644	97%	820,629	0.95	779,597	8	50%	4
HVAC	Demand Controlled Ventilation on RTU	20,562	100%	20,562	0.95	19,534	NA	NA	10
HVAC	Dynamic Cycle Management (VFD)	142,354	100%	142,354	0.95	135,236	NA	NA	15
HVAC	Enthalpy Economizer Optimization	45,203	100%	45,233	0.95	42,971	NA	NA	5
	Total‡	2,254,315	99%	2,230,330	0.95	2,118,813	NA	NA	4

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-frameworkhtml.
† EUL is a combination of technical measure life and persistence.
Source: ComEd tracking data and Navigant team analysis.
‡ Totals may not sum exactly due to rounding.

Table 4-2. PY9 Demand Savings by Measure

End Use Type	Research Category	Ex Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTGR*	Verified Net Demand Reduction (kW)
HVAC	Enhanced HVAC Tune-up	NR	NA	592	0.95	563
HVAC	Notched V Belt for Supply Fan	NR	NA	7	0.95	6
HVAC	HVAC Scheduling/Setbacks	NR	NA	0	0.95	0
HVAC	Install Programmable Thermostat	NR	NA	0	0.95	0
HVAC	Demand Controlled Ventilation on RTU	NR	NA	0	0.95	0
HVAC	Dynamic Cycle Management (VFD)	NR	NA	21	0.95	20
HVAC	Enthalpy Economizer Optimization	NR	NA	0	0.95	0
	Total†	NR	NA	620	0.95	589

NR = Not Reported
* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html
† Totals may not sum exactly due to rounding.
Source: ComEd tracking data and Navigant team analysis.

Table 4-3. PY9 Peak Demand Savings by Measure

End Use Type	Research Category	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (kW)	NTGR*	Verified Peak Net Demand Reduction (kW)
HVAC	Enhanced HVAC Tune-up	NR	NA	283	0.95	269
HVAC	Notched V Belt for Supply Fan	NR	NA	7	0.95	6
HVAC	HVAC Scheduling/Setbacks	NR	NA	0	0.95	0
HVAC	Install Programmable Thermostat	NR	NA	0	0.95	0
HVAC	Demand Controlled Ventilation on RTU	NR	NA	0	0.95	0
HVAC	Dynamic Cycle Management (VFD)	NR	NA	21	0.95	20
HVAC	Enthalpy Economizer Optimization	NR	NA	0	0.95	0
	Total†	NR	NA	310	0.95	295

NR = Not Reported
Values may not add due to rounding
* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† Totals may not sum exactly due to rounding.
Source: ComEd tracking data and Navigant team analysis.

5. Impact Analysis Findings and Recommendations

5.1 Impact Parameter Estimates

The implementer provided project calculators and final project trackers. The evaluation team analyzed all the program's project calculators and verified that savings and measure counts reported in the project calculators were consistent with the implementer's final trackers. Navigant relied on the following files for ex ante savings:

- Final PY9 tracking file: "PY9 Data – Project Savings.xlsx"
- Final PY9 Value Earned Report: "360EG-SEDAC_HVACBldgOptimization_PY9-YTD- Value Earned Report_01.07.2018.V1.xlsx"
- Project calculators: "Calculators.zip"

Navigant followed algorithms outlined in the Illinois Technical Reference Manual, version 5.0 to calculate verified gross savings for the SEDAC program. The evaluation team verified that these algorithms and appropriate deemed input parameters were correctly applied and validated any custom parameters that were used. Navigant calculated verified net savings by multiplying gross savings by a net-to-gross ratio (NTGR). The Illinois Stakeholder Advisory Group (IL SAG) reviewed and deemed a NTGR value for the SEDAC program.

Table 5-1 shows the key parameters and references used to calculate gross and net savings.

Table 5-1. PY9 Verified Gross Savings Parameters

Gross Savings Input Parameters	Value	Deemed or Evaluated?	Source
Quantity	Varies	Evaluated	SEDAC program project files
NTGR	0.95	Deemed	IL SAG Consensus*
Enhanced HVAC Tune-up	Varies	Deemed	IL TRM v5.0, Section 4.4.1 Air Conditioner Tune Up†
Notched V Belt for Supply Fan	Varies	Deemed	IL TRM v5.0, Section 4.4.30 Notched V Belts for HVAC Systems†
HVAC Scheduling/Setbacks	Varies	Deemed	IL TRM v5.0, Section 4.4.25 Small Commercial Programmable Thermostat Adjustments†
Install Programmable Thermostat	Varies	Deemed	IL TRM v5.0, Section 4.4.18 Small Commercial Programmable Thermostats†
Demand Controlled Ventilation on Rooftop Unite	Varies	Deemed	IL TRM v5.0, Section 4.4.19 Demand Controlled Ventilation†
Dynamic Cycle Management (Variable Frequency Drive)	Varies	Deemed	IL TRM v5.0, Section 4.4.26 Variable Speed Drive†
Enthalpy Economizer Optimization	Varies	Deemed	IL TRM v5.0, Section 4.4.35 Economizer Repair and Optimization†

* Source ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html
† State of Illinois Technical Reference Manual version 5.0 from http://www.ilsag.info/technical-reference-manual.html.

5.2 Other Impact Findings and Recommendations

Verified Gross Impacts and Realization Rate

Finding 1. The PY9 SEDAC Program achieved 2,230,330 kWh of verified gross energy savings, 620 kW of verified gross demand reduction, and 310 kW of verified gross peak demand reduction. The reported ex ante gross savings were 2,254,315 kWh and the overall verified gross program realization rate for energy savings was 99 percent. The implementer did not track gross demand reduction or gross peak demand reduction.

Recommendation 1. Navigant recommends that the implementer track gross demand and gross peak demand reduction.

Verified Net Impacts and NTGR

Finding 2. The evaluation used a deemed net-to-gross (NTG) value of 0.95 to calculate verified net savings of 2,118,813 kWh, verified net demand reduction of 589 kW and verified net peak demand reduction of 295 kW.

Tracking System Review

Finding 3. Navigant compared the reported gross savings and installed measure quantities in the final project tracking spreadsheet "PY9 Data – Project Savings.xlsx" with individual project calculators. Navigant found four projects with inconsistent installed quantities. For example, one project completed in November 2017 reported seven thermostat units and seven DCV units in the tracking spreadsheet but its project file listed one thermostat and one DCV unit. Navigant found two projects with inconsistent gross energy savings. For example, one project completed in November 2017 reported 37,756 kWh of gross savings for an economizer measure but its project file calculated 37,786 kWh gross savings for the same measure.

Recommendation 2. Navigant recommends that the implementer put in place quality control measures to ensure that savings and installed quantities are properly entered into the tracking system from individual project calculators.

Finding 4. Navigant compared reported gross savings in the final project tracking spreadsheet "PY9 Data – Project Savings.xlsx" with the implementer's Value Earned Report dated 01.07.2018, "360EG-SEDAC_HVACBldgOptimization_PY9-YTD- Value Earned Report_01.07.2018.V1.xlsx." Navigant found that "YTD NET" savings reported in the Value Earned Report did not factor in NTGR and were in fact gross, not net savings. Comparing gross savings, Navigant found a major discrepancy between year-to-date savings for scheduling. Scheduling savings in the project savings sheet summed to 471,990 kWh while scheduling savings in the value earned report summed to 454,823 kWh. Navigant found smaller differences under 500 kWh between the two spreadsheets for v belt and HVAC tune-up. Navigant treated savings reported in "PY9 Data – Project Savings.xlsx" as final ex ante savings.

Recommendation 4. Navigant recommends that the implementer put in place quality control measures to ensure that savings between the project tracker and Value Earned Report spreadsheets are consistent.

Finding 5. For two thermostat projects, the implementer employed the energy use equation for a continuous fan in a low-rise office building for baseline energy use and the equation for intermittent fan for proposed energy use. This shows that the implementer changed the building thermostat from continuous fan mode to intermittent fan mode during the occupied period, which is against commercial mechanical code according to the TRM. Therefore, Navigant set the verified gross savings for these two projects at 0. Navigant also found two other errors. The implementer did not properly adjust climate zone coefficient (CZ) value based on Fo and used the value for intermittent fan mode during occupied period for both the baseline and proposed case. Lastly, the implementer accounted for Cooling Capacity (Tons) twice in the baseline energy use.

Recommendation 5. Navigant recommends the implementer follow commercial mechanical code which advises against changing thermostats from continuous to intermittent during occupied periods to meet ventilation requirements.

Program Participation

Finding 6. The program installed 287 measures across 79 projects in PY9. A municipality was the program's largest client with 61 projects followed by a county's park districts and another's county buildings each with five projects. Libraries made up the largest type of project with 27 projects followed by emergency response buildings such as fire departments with 24 projects.

6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

Energy and demand savings were estimated using Illinois TRM v5.0. The Illinois TRM deems most input parameters for program measures and are provided below.

6.1 Installed Programmable Thermostats

Thermostat savings represent 37 percent of the total verified gross savings and have a realization rate of 96 percent. The realization rate was reduced due to two projects. The equation for thermostat savings from TRM v5.0 Section 4.4.18 is as follows:

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

where the TRM provides equations for energy use based on building type and a continuous or intermittent fan mode during the occupied period (Fo). The equations for energy use are functions of the climate zone coefficient (CZ), degrees of cooling setback (Tc), degrees of heating setback (Th), fan mode during unoccupied period (Fu) and weekly hours during occupied mode (Ws). The TRM also makes the following note: "Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirement"[1].

6.2 Enthalpy Economizer Optimization

Economizer savings represent two percent of the total verified gross savings and have a realization rate of 100%. The implementer provided data and calculators for the two economizer projects. Navigant verified the method as reasonable.

6.3 HVAC Tune-Up

$$\Delta kWh = \frac{kBtu}{hr} * \left(\frac{1}{EER_{before}} - \frac{1}{EER_{after}}\right) * EFLH$$

$$\Delta kW = \frac{kBtu}{hr} * \left(\frac{1}{EER_{before}} - \frac{1}{EER_{after}}\right) * CF$$

Where:

kBtu/hr	*= Capacity of cooling equipment*
EER_{before}	*= Energy efficiency ratio of equipment prior to tune-up*
EER_{after}	*= Energy efficiency ratio of equipment after tune-up*
EFLH	*= Equivalent full load hours for cooling*
CF	*= Summer peak coincidence factor*

[1] Page 231 of Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0, available at: http://www.ilsag.info/technical-reference-manual.html.

Table 6-1. HVAC Tune-up Custom and Deemed Values Comparison

Value	Variable	Source	Deemed/Custom
Actual	kBtu/hr	*Program Tracking Data*	Custom
Actual	EER_{before}	*Program Tracking Data*	Custom
Actual	EER_{after}	*Program Tracking Data*	Custom
Varies by Climate Zone	EFLH	*IL TRM v5.0, 4.4.1*	Deemed
47.8%	CF	*IL TRM v5.0, 4.4.1*	Deemed

6.4 Notched V Belt for Supply Fan

$$\Delta kWh = kW_{connected} * Hours * ESF$$

$$\Delta kW = kW_{connected} * ESF$$

$$kW_{connected} = HP * 0.746 * \frac{LF}{Motor\ Efficiency}$$

Where:

$kW_{connected}$ = *Electrical demand of HVAC equipment*
Hours = *Annual hours of operation*
ESF = *Energy savings factor*
HP = *Nominal horsepower*
0.746 = *kWh/Btu conversion factor*
LF = *Load factor*
Motor Efficiency = *Motor efficiency*

Table 6-2. V-Belts Custom and Deemed Values Comparison

Value	Variable	Source	Deemed/ Custom
Actual	$kW_{connected}$	*Calculated*	Custom
Varies by Building Type	Hours	*IL TRM v5.0, 4.4.30*	Deemed
2%	ESF	*IL TRM v5.0, 4.4.30*	Deemed
Actual	HP	*Program Tracking Data*	Custom
80%	LF	*IL TRM v5.0, 4.4.30*	Deemed
Varies by Motor Size	Motor Efficiency	*IL TRM v5.0, 4.4.30*	Deemed

6.5 HVAC Scheduling/Setbacks and Install Programmable Thermostat

$$\Delta kWh = [Baseline\ Usage - Proposed\ Usage] * Capacity$$

$$\Delta kW = 0$$

Where:

Baseline Usage = *Per-ton baseline energy usage, kWh/ton*
Proposed Usage = *Per-ton proposed energy usage, kWh/ton*
Capacity = *Cooling system capacity, tons*
CZ = *Climate zone coefficient*
Fu = *Fan mode during unoccupied period*
Fo = *Fan mode during occupied period*
Th = *Degrees of heating setback, °F*
Tc = *Degrees of cooling setback, °F*
Ws = *Weekly hours thermostat is in occupied mode*

Table 6-3. Thermostat Custom and Deemed Values

Value	Variable	Source	Deemed/ Custom
Varies by building type and Fo	Baseline Usage	IL TRM v5.0, Section 4.4.18 and 4.4.25	Calculated
Varies by building type and Fo	Proposed Usage	IL TRM v5.0, Section 4.4.18 and 4.4.25	Calculated
Actual	Capacity	Program Tracking Data	Custom
Varies	CZ	*Program Tracking Data*	Custom
Actual	Fu	*Program Tracking Data*	Custom
Actual	Fo	*Program Tracking Data*	Custom
Actual	Th	*Program Tracking Data*	Custom
Actual	Tc	*Program Tracking Data*	Custom
Actual	Ws	*Program Tracking Data*	Custom

6.6 Demand Controlled Ventilation on Rooftop Unit

$$kWh = Conditioned\ Space/1000 * SF_{cooling}$$

$$\Delta kW = 0$$

Where:

Conditioned Space = *Square footage of conditioned space controlled by sensor*
$SF_{cooling}$ = *Cooling savings factor*

Table 6-4. Demand Controlled Ventilation Custom and Deemed Values

Value	Variable	Source	Deemed/ Custom
Actual	Conditioned Space	*Program Tracking Data*	Custom
Actual	$SF_{cooling}$	*Program Tracking Data*	Custom

6.7 Variable-Frequency Drive

$$\Delta kWh = \Delta kWh_{fan} \times (1 + IE_{energy})$$

$$kWh_{Base} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{Base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Base})$$

$$kWh_{Retrofit} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times RHRS_{base} \times \sum_{0\%}^{100\%} (\%FF \times PLR_{Retrofit})$$

$$\Delta kWh_{fan} = kWh_{Base} - kWh_{Retrofit}$$

$$\Delta kW = \Delta kW_{fan} \times (1 + IE_{energy})$$

$$kW_{Base} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Base}$$

$$kW_{Retrofit} = \left(0.746 \times HP \times \frac{LF}{\eta_{motor}}\right) \times PLR_{Retrofit}$$

$$\Delta kW_{fan} = kW_{Base} - kW_{Retrofit}$$

Where:

kWh_{Base}	= *Baseline annaul energy consumption*
$kWh_{Retrofit}$	= *Retrofit annual energy consumption*
ΔkWh_{fan}	= *Fan-only annual energy savings*
HP	= *Nominal hosepower of controlled motor*
LF	= *Load Factor*
η_{motor}	= *Installed motor efficiency*
$RHRS_{Base}$	= *Annual operating hours for fan motor*
%FF	= *Percentage of run-time spent within a given flor fraction rate*
PLR	= *Part load ratio for given flow fraction range*
IE_{energy}	= *HVAC interactive effects factor*

Table 6-5. Variable-Frequency Drive Custom and Deemed Values

Value	Variable	Source	Deemed/ Custom
Actual	kWh_{Base}	IL TRM v5.0, Section 4.4.35	Calculated
Actual	$kWh_{Retrofit}$	IL TRM v5.0, Section 4.4.35	Calculated
Actual	ΔkWh_{fan}	IL TRM v5.0, Section 4.4.35	Calculated
Actual	HP	*Program Tracking Data*	Custom
0.65	LF	IL TRM v5.0, Section 4.4.35	Deemed
Actual	η_{motor}	Program Tracking Data	Custom
Varies by building type	$RHRS_{Base}$	IL TRM v5.0, Section 4.4.35	Deemed
Varies by control type	$\sum_{0\%}^{100\%}(\%FF \times PLR_{Base})$	IL TRM v5.0, Section 4.4.35	Deemed
Varies by control type	$\sum_{0\%}^{100\%}(\%FF \times PLR_{Retrofit})$	IL TRM v5.0, Section 4.4.35	Deemed
15.7%	IE_{energy}	IL TRM v5.0, Section 4.4.35	Deemed

6.8 Economizer Repair and Optimization

$$\Delta kWh = [Baseline\ Usage - Proposed\ Usage] * Capacity$$

$$\Delta kW = 0$$

Where:

Baseline Usage = *Per-ton baseline energy usage, kWh/ton*
Proposed Usage = *Per-ton proposed energy usage, kWh/ton*
Capacity = *Cooling system capacity, tons*
CZ = *Climate zone coefficient*
Fu = *Fan mode during unoccupied period*
Fo = *Fan mode during occupied period*
Th = *Degrees of heating setback, °F*
Tc = *Degrees of cooling setback, °F*
Ws = *Weekly hours thermostat is in occupied mode*

Table 6-6. Economizer Custom and Deemed Values

Value	Variable	Source	Deemed/ Custom
Varies by building type and changeover type	Baseline Usage	IL TRM v5.0, Section 4.4.35	Calculated
Varies by building type and changeover type	Proposed Usage	IL TRM v5.0, Section 4.4.35	Calculated
Actual	Capacity	*Program Tracking Data*	Custom
Varies	CZ	*Program Tracking Data*	Custom
Actual	Fu	*Program Tracking Data*	Custom
Actual	Fo	*Program Tracking Data*	Custom
Actual	Th	*Program Tracking Data*	Custom
Actual	Tc	*Program Tracking Data*	Custom
Actual	Ws	*Program Tracking Data*	Custom