CT X1931-8 Commercial Advanced Thermostats Phase 1 Memo

Summary of Literature Review and Recommendations

Memo To: CT Energy Efficiency Board (EEB)

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OVERVIEW

The objective of this study is to create entry for a new commercial advanced thermostat measure to be incorporated into the 2022 Connecticut Program Savings Document (CT PSD). In Phase 1 of this study, this new measure was developed through literature review and discussion with experts. The primary source of information for the development of this new measures was the literature review. The team reviewed over 25 sources published between 2012– 2021, including the following Technical Reference Manuals (TRMs): IL, MA, Mid-Atlantic, NY, and WI.

The commercial advanced thermostat measure is for replacing an existing manual or programmable thermostat with an ENERGY STAR® certified smart thermostat. A smart thermostat is a thermostat that can be controlled remotely with a phone, tablet, or other internet-connected devices. Using features like learning, scheduling, geofencing, by diagnosing problems with the HVAC system, and by reminding users of when it's time to perform HVAC system maintenance, a smart thermostat ensures that the HVAC system runs efficiently and that the controlled space is heated or cooled only as much as needed, reducing heating and cooling energy consumption.

As explained in the measure definition above, the measure is for installing ENERGY STAR certified smart thermostats – it is recommended that the programs consider ENERGY STAR certification of the installed thermostats as a measure eligibility requirement. The commercial advanced thermostats measure developed for Phase 1 of this study are applicable to all CT programs, including Energy Opportunities (EO), Upstream, Midstream, and SBDI.

The sections below describe the measure savings methodology, the selection of the measure savings factors, and the topics that will be investigated in Phase 2. See Appendix A for complete measure write-up for entry into the PSD.

NEW MEASURE SAVINGS METHODOLOGY

The team developed the energy and demand savings methodologies and inputs based on the TRMs reviewed as part of the literature review.

The energy savings methodology formulas below are included in the measure write-up:

$$Energy\ Savings = Heating\ savings + Cooling\ savings$$

$$If\ existing\ gas\ heating, heating\ savings = 0.0178\ \left(\frac{ccf}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

$$If\ existing\ oil\ heating, heating\ savings = 0.0134\ \left(\frac{gallons}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

$$If\ existing\ propane\ heating, heating\ savings = 0.0201\ \left(\frac{gallons}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

$$If\ existing\ electric\ ressistance\ heating, heating\ savings = 0.4561\ \left(\frac{kWh}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

$$If\ existing\ heat\ pump\ heating, heating\ savings = 0.1425\ \left(\frac{kWh}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

$$Cooling\ savings\ (only\ if\ existing\ cooling\ system\ present) = 0.0234\ \left(\frac{kWh}{ft^2}\right) \times building\ conditioned\ area\ (ft^2)$$

Where, building conditioned area refers to building area served by the installed thermostat.

As seen with the TRMs (IL, MA, Mid-Atlantic, and WI) reviewed in this study, energy savings for commercial smart thermostats measures are typically expressed in terms of heating and cooling savings factors, meaning savings are expressed in terms of percentage of building heating and cooling energy usage. The measure energy savings algorithms reported above also follow a similar methodology – the per square feet energy savings reported above were estimated by multiplying the building heating and cooling energy intensities with the respective energy savings factors for installing smart thermostats.

From the Commercial Buildings Energy Consumption Survey data[1] (CBECS), the team estimated gas heating and electric cooling energy intensities of 40.7 kBtu/square feet and 1.17 kWh/square feet, respectively for commercial buildings in New England. The heating and cooling energy intensities were then multiplied with the respective savings factors (reported in the next section) to estimate per square feet heating gas savings and cooling electric savings. The heating electric savings were estimated based on conversion of gas (ccf) savings to electric (kWh) savings multiplied by the equipment efficiencies (assumed 85% for gas furnace, 100% for electric resistance, COP of 3.2 for heat pumps).

The reviewed TRMs do not report peak demand savings for commercial smart thermostat measures. As such, the measure demand savings is assumed to be zero until additional information is available.

SAVINGS FACTORS

The savings factors utilized in the energy savings calculations were determined based on the literature review. The team selected the commercial smart thermostats savings factors in Table 1 below from the following reference:

- Navigant. *Wi-Fi Thermostat Impact Evaluation--Secondary Research Study, prepared for Massachusetts Program Administrators and EEAC Consultants,* September 20, 2018.
    - This source looked at advanced thermostat studies conducted from 2015 – 2018 in climate zones similar to the New England. The reviewed studies all reported energy savings in terms of percentage of annual heating and cooling energy usages (savings factors). The savings factors from the reviewed studies were averaged to calculate values applicable to New England.

Table 1. Commercial savings factors developed from literature review

End Use	Savings Factor	Source
Heating	4.5%	Navigant, 2018
Cooling	2%	Navigant, 2018

[1] US Energy Information Administration Commercial Buildings Energy Consumption Survey (CBECS), 2012 CBECS Data End-Use Consumption, Table E4 and Table E7. https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption

EFFECTIVE USEFUL LIFE

The effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. For smart thermostats, the team recommends using an EUL of 9.1 years.[2]

PHASE 2 AREAS OF INTEREST

Based on the literature review and the discussions during the presentation of the Phase 1 results, the team identified the following topics to be investigated further during Phase 2 of this study.

- Update CBECS heating and cooling energy intensities with CT specific energy intensities from the x1931- 6 Hours of Use/ Full Load Hour Update study.
- Potential data collection and metered/billing analysis in small businesses to develop CT specific savings factors for smart thermostats.
- Update measure savings algorithms based on phase 2 findings.

To investigate these topics, the team will request any available, applicable data from the utilities and will develop questions to include in the expert interview and market actor interview guides that address the aforementioned topics.

[2] https://www.caetrm.com/media/reference-documents/SWHC039-01_A8_-_EUL_Analysis.pdf

Appendix A

Commercial Advanced Thermostats

Description of Measure

This measure involves replacement of an existing manual or programmable thermostats with an ENERGY STAR® certified smart thermostat. This measure applies to small commercial buildings.

A smart thermostat is a thermostat that can be controlled remotely with a phone, tablet, or other internet-connected devices. It allows users to create automatic and programmable temperature settings based on daily schedules, weather conditions, and heating and cooling needs. Using features like learning, scheduling, geofencing, by diagnosing problems with the HVAC system, and by reminding users of when it's time to perform HVAC system maintenance, a smart thermostat ensures that the HVAC system runs efficiently and that the controlled space is heated or cooled only as much as needed, reducing heating and cooling energy consumption.

Savings Methodology

The measure energy savings are calculated using deemed energy savings factors based on study results **[1].** Building space heating and space cooling energy intensities (Btu/square foot **Note [1])** were estimated for based on Commercial Buildings Energy Consumption Survey [2]. The estimated energy intensities were then multiplied with deemed savings factors to estimate per square foot heating and cooling savings (**Note [2]).**

Inputs

Table 3-S: Inputs

Symbol	Description	Units
A	Building conditioned area in square feet	ft^2

Nomenclature

Table 3-T: Nomenclature

Symbol	Description	Units	Value	Comment
$AKWH_{H\text{-}ER}$	Annual gross electric energy savings – heating (electric	kWh		
$AKWH_{H\text{-}}$	Annual gross electric energy savings – heating (heat pump)	kWh		
$AKWH_C$	Annual gross electric energy savings - cooling	kWh		
ACCF	Annual natural gas savings	ccf		
AOG	Annual oil savings	gallons		
APG	Annual propane savings	gallons		
A	Building conditioned area served by thermostat	ft^2		Input

Retrofit Gross Energy Savings, Electric

Heating (applicable only if the facility has an existing electric resistance heating system) **Note [3]**:

$$AKWH_H = 0.4561 \left(\frac{kWh}{ft^2}\right) \times A\ (ft^2)$$

Heating (applicable only if the facility has an existing heat pump heating system) **Note [3]**:

$$AKWH_H = 0.1425 \left(\frac{kWh}{ft^2}\right) \times A\ (ft^2)$$

Cooling (applicable only if the facility has an existing cooling system):

$$AKWH_C = 0.0234 \left(\frac{kWh}{ft^2}\right) \times A\ (ft^2)$$

Retrofit Gross Energy Savings, Fossil Fuel

Heating (applicable only if the facility has an existing natural gas heating system):

$$ACCF = 0.0178 \left(\frac{ccf}{ft^2}\right) \times A\ (ft^2)$$

Heating (applicable only if the facility has an existing oil heating system):

$$AOG = 0.0134 \left(\frac{gallons}{ft^2}\right) \times A\ (ft^2)$$

Heating (applicable only if the facility has an existing propane heating system):

$$APG = 0.0201 \left(\frac{gallons}{ft^2}\right) \times A\ (ft^2)$$

If site-specific building conditioned area per thermostat information is not available, the following deemed savings values should be used for direct install **Note [4]**:

	$AHWH_c$	$AHWH_{H\text{-}ER}$	$AHWH_{H\text{-}HP}$	ACCF	AOG	APG
When heating fuel and cooling system is known (Direct Install)	58.6	1,140.3	356.4	44.5	33.5	50.1

For midstream programs, the following savings values should be used **Note [5]**:

	AKWH	ACCF	AOG	APG
When heating fuel and cooling system is unknown (Midstream, E-commerce, etc)	181.1	12.6	11.8	11.0

Retrofit Gross Seasonal Peak Demand Savings, Electric (winter and summer)

Assumed to be zero until additional information is available.

Effective Useful Life (EUL)

The measure EUL is 9.1 years **[3].**

References

[1] Navigant. *Wi-Fi Thermostat Impact Evaluation--Secondary Research Study, prepared for Massachusetts Program Administrators and EEAC Consultants,* September 20, 2018.

[2] US Energy Information Administration Commercial Buildings Energy Consumption Survey (CBECS), 2012 CBECS Data End-Use Consumption, Table E4 and Table E7.

https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption

[3] Cadmus, Memorandum: EUL analysis of Residential Smart Communicating Thermostat—Vendor A and B, February 1, 2019.
https://www.caetrm.com/media/reference-documents/SWHC039-01_A8_-_EUL_Analysis.pdf

Notes

[1] Energy intensities in 2012 CBECS Data End-Use Consumption, Table E7 are based on commercial buildings located in New England.

[2] Energy savings factors of 4.5% and 2% are used for heating and cooling, respectively based on **Ref [1]**.

[3] Heating electric savings are derived based on conversion of natural gas heating savings to electric heating savings (therm to kWh) multiplied by the equipment efficiency.

For electric resistance heating, $kWh_{savings} = \frac{(therm_{savings} \times 29.3 \times 0.85)}{1}$, where 29.3 is therm to kWh conversion factor, 0.85 is the natural gas furnace efficiency and 1 is the electric resistance heating efficiency.

For heat pump heating, $kWh_{savings} = \frac{(therm_{savings} \times 29.3 \times 0.85)}{3.2}$, where 29.3 is therm to kWh conversion factor, 0.85 is the natural gas furnace efficiency and 3.2 is the heat pump COP.

[4] Estimated based on deemed building conditioned area of 2,500 square feet per thermostat.

[5] Heating primary fuel type for midstream savings calculation was estimated to be 14% electric (37% of the 14% was estimated to be heat pump heating and 63% of the 14% was estimated to be electric resistance heating), 28% natural gas, 35% fuel oil, and 22% propane, based on **Ref [2]** Table B38, heating equipment, number of buildings for New England.