
# Connecticut C2117 RCx Persistence Study

Final Results

June 19, 2023

# Introduction

# Study Objectives

- Characterize the types of RCx measures and their savings installed in CT in past 5-10 years
- Develop effective life estimates for 4-6 RCx measures expected to be installed in CT over the next 5 years
- Recommend 3-5 RCx measures for field study to better estimate persistence

# Background / Definitions

## Retro-Commissioning (RCx)

- The systematic process that identifies and implements operational & maintenance and control strategy improvements to increase the energy performance of existing buildings.
- RCx targets malfunctioning and outdated control logic that causes a building's energy management system (EMS) to use more energy and prevent it from operating at peak performance.

## RCx Persistence

- The median length of time that equipment control strategies are in place and operational
- Operational = functioning as originally intended and with energy savings ≥50% of the original savings

# **Key Recommendations**
# Effective Useful Life (EUL)

1. Update the EUL values in the Program Savings Document (PSD) based on the findings from this study
   a. 5 years for AHU scheduling and optimization
   b. 7 years for all other non-lighting, non-refrigeration, and non-process retro-commissioning measures
2. Continue to use the existing EUL values in the 2022 PSD for lighting, refrigeration, and process equipment retro-commissioning measures.

# **Key Recommendations**
# Effective Useful Life (EUL)

| | Mean EUL from Literature Review | Mean EUL from Market Actor Interviews | 2022 PSD EUL | Recommended Value | PSD HVAC Controls Measures Covered |
|---|---|---|---|---|---|
| AHU Scheduling and Optimization | 5.5 | 3.4 | 6/8* | 5 | Adjust scheduling, controls to eliminate simultaneous heating and cooling, and reset set-points |
| CAV to VAV AHU Conversion | 5.8 | 7.7 | 8 | 7 | Not included in PSD |
| HVAC Occupancy Sensors | 6.3 | 9.0 | 8 | 7 | Demand control ventilation, Modify HVAC controls |
| ChW Controls | 5.3 | 9.8 | 8 | 7 | Modify HVAC controls |
| Exhaust Fan Controls | 7.3 | 9.8 | 8 | 7 | Modify HVAC controls |
| Non-Specific HVAC RCx Measures | 6.6 | 8.1 | 8 | 7 | |

*The PSD EUL values for adjust scheduling and reset set-points are 6 years while the EUL value for controls to eliminate simultaneous heating and cooling is 8 years.

# **Key Recommendations**
# Guidance for Future Studies

3. To improve measure life estimates, conduct a field study to measure the persistence of common RCx measures
    a. Develop RCx EUL values for broad measures where there may be a distinction in persistence

<u>Specific Suggestions</u>

- Use multiple modes, including:
    - In-person site visits to review measure trends or control logic in facilities' BAS, supplemented by functional testing
    - Virtual site visits with remote BAS access
    - Surveys
- Consider coordinating with other Northeast utilities or organizations
- Clearly define persistence and measure failure to maintain consistency across responses

# **Key Recommendations**
# Increasing RCx Persistence

4. To remedy persistence issues, programs may consider implementing or continuing a variety of best practices, including:
    a. Requiring RCx Service Providers (RSPs) to conduct follow-up visits to check for persistence issues
    b. Conducting post-RCx training with building operations staff
    c. Encouraging measures that are more difficult to change or overwrite when there are multiple options with similar savings

# Methodology

# Utility Data Review

- Analyzed program tracking data from 2015-2020
- Reviewed a random sample of 25 of 76 projects
- Identified most implemented measures/groups
- Grouped detailed measures of similar intent into common categories
  - E.g., "Implement an optimal start program for RTUs 1 & 2" became "Air Handling Unit Scheduling"
- Identified participating vendors and market actors

- Priority measures
  - AHU Scheduling and Optimization
  - CAV to VAV AHU Conversion
  - HVAC Occupancy Sensors
  - ChW Controls
  - Exhaust Fan Controls
- These measures represent 85% of electric (kWh) and 75% of natural gas (CCF) savings of sampled projects

CAV = constant air volume
ChW = Chilled water
VAV = variable air volume
AHU = Air handling unit

# Selected Measures

- **CAV to VAV AHU Conversion** – Adding variable speed controls to allow central units to slow down and match the load, which saves both fan energy and heating and cooling energy
- **AHU Scheduling and Optimization** – Turning off equipment during unoccupied times or periods with load loads. Optimizations include allowing the equipment to operate more efficiently at part-load conditions
- **Occupancy Sensors** – Only providing ventilation, space conditioning, or lighting to occupied spaces

# Selected Measures

- **ChW Controls** – Changing how chillers are operated to allow them to most efficiently meet the load by slowing down pumps, properly staging equipment, or maximizing heat transfer in the system
- **Exhaust Fan Controls** – Eliminates fan energy and space conditioning energy by avoiding exhausting conditioned air during unoccupied periods

# Data Collection

- Three main sources:
  - CT Utility staff interviews
  - RCx Service providers (n=2) and Controls vendors and other Market Actors (n=7)
  - Extensive literature review (n=43 studies – regional, national, utility evaluation & retention studies, conference papers)
- To inform on:
  - Past program offerings/ measures / context, future changes
  - Future measures, patterns
  - In-field information on failures, reasons, persistence factors (training, turnover, etc.), best methods for retention of measures & savings
  - Estimated measure lifetimes, field study needs
  - Covid and baseline issues

# Results

# Literature Review Findings on Lifetimes

| RCx Measure | Number of Studies | Minimum EUL (Years) | Maximum EUL (Years) | Mean EUL (Years) |
|---|---|---|---|---|
| AHU Scheduling and Optimization | 5 | 1 | 9 | 5.5 |
| CAV to VAV AHU Conversion | 5 | 3 | 8.5 | 5.8 |
| HVAC Occupancy Sensors | 5 | 3 | 11 | 6.3 |
| ChW Controls | 5 | 2 | 8.5 | 5.3 |
| Exhaust Fan Controls | 5 | 3 | 12.5 | 7.3 |
| Non-Specific RCx Measures | 9 | 3 | 10 | 6.6 |

# Market Actor Interview Findings

- EUL estimates varied by market actor AND average was higher than literature value.
  - May reflect difference in definition, or interviewed actors may be more engaged with customers, resulting in higher persistence
  - Evaluation team considered interview values as the high end of estimates

| RCx Measure | Number of Respondents | Minimum EUL (Years) | Maximum EUL (Years) | Mean EUL (Years) |
|---|---|---|---|---|
| AHU Scheduling and Optimization | 5 | 1 | 10 | 3.4 |
| CAV to VAV AHU Conversion | 3 | 5 | 10 | 7.7 |
| HVAC Occupancy Sensors | 5 | 5 | 10 | 9.0 |
| ChW Controls | 6 | 8 | 15 | 9.8 |
| Exhaust Fan Controls | 6 | 5 | 12 | 9.8 |

# Recommended EUL Values

| | Mean EUL from Literature Review | Mean EUL from Market Actor Interviews | 2022 PSD EUL | Recommended Value | PSD HVAC Controls Measures Covered |
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# Reasons for Poor RCx Persistence

| AHU Scheduling and Optimization | Chilled Water Controls | CAV to VAV AHU Conversion | HVAC Occupancy Sensors | Exhaust Fans |
|---|---|---|---|---|
| • Actual occupancy is different than assumed occupancy<br>• Lack of operating training around scheduling<br>• Need to coordinate scheduling with other groups (e.g., Registrar's office in Higher Education)<br>• Building renovations<br>• Lack of proper maintenance | • Failures due to programming changes<br>• User does not understand or trust new control strategy<br>• Equipment failure<br>• Actual occupancy is different than assumed occupancy<br>• Lack of proper maintenance | • VFDs failing<br>• Volume control issues<br>• Poor sensor calibration<br>• Aggregation of issues with individual spaces<br>• Programming changes<br>• Drives locked at 100%<br>• Building renovations<br>• Poor sequencing | • Overriding by facility staff due to poor understanding<br>• Bad application, location, or setup<br>• Equipment failure | • Airflow sensors out of calibration<br>• Poor application/ building pressure issues<br>• Poor scheduling<br>• Equipment failures<br>• Changes to the space<br>• Lack of proper maintenance |

*Occupancy deviations, programming / setting changes, overrides, lack of training, poor maintenance, equipment failure, poor application/calibration/sequencing/ scheduling, renovations, and some equipment-specific items.*

# Best Practices to Increase RCx Persistence **Programmatic Remedies**

- **Follow-up services**: Require adequate RCx follow-up services
- **Hold back $**: Consider holding back a portion of the incentives for a period of time after implementation and perform a persistence review
- **Required Training**: Require RCx providers to conduct post-RCx building operator training and create videos of training for later use
- **Performance Tracking**: Include performance tracking in the program
- **On-going Outreach**: Consider conducting ongoing outreach to RCx participants to understand changes to facility that may affect RCx savings
- **Difficult Measures**: Consider encouraging cost-effective measures that are difficult to change
- Continue to require RCx Providers to:
  - involve facility operators in the RCx process
  - work with operations staff to thoroughly document RCx measures and new operating procedures

# Best Practices to Increase RCx Persistence **Other Remedies**

- **Work Environment for Savings**: Encourage RCx participants to create a work environment for building operations staff that support savings persistence
- **Robust Measures**: Promote RCx measures that are simple and robust
- **Tech Transfer with staff turnover**: When there is staff turnover, encourage sharing of knowledge from outgoing staff
- **On-going Cx to Keep Performance**: Encourage ongoing commissioning to identify non-functional parts of systems or setpoint changes
- **Vendor Service Contracts**: Encourage service contracts with equipment or controls vendors
- **Operations Staff/Vendor Meetings**: Promote quarterly or annual meetings between building operations staff and vendors
- **Automation**: Encourage building persistence into automation
- **Fault detection diagnostics**: Encourage use of fault detection diagnostics (FDD)

# Future Studies

- Few rigorous RCx persistence studies – small programs / technical
- Field study would improve EULs for CT, but:
  - Consider joint / regional study
  - Consider methods beyond traditional review of BAS measure trends or control logic:  consider cost-effective alternatives
    - Virtual site visits with remote BAS access
    - Surveys

# Questions?

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