ET Summit 2024

Presented by

Residential Integrated HVAC Controls

CEE Research and Resources

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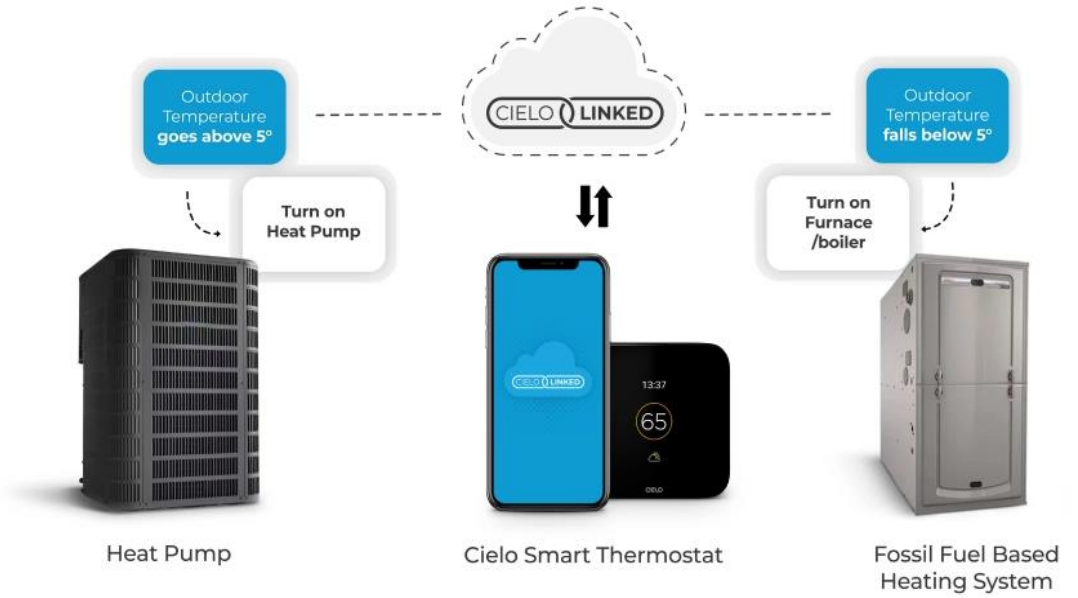
Overview



Source: Cielo

- Integrated HVAC controls systems connect and coordinate operations of multiple disparate space conditioning units
- Usually consists of
  - A heat pump and a supplemental or backup heating system
  - A mini-split heat pump with a central space cooling system

- Goal: Optimizing the space conditioning system for maximum efficiency, load shifting, and/or cost-effectiveness

CEE ASHP Education and Guidance Project

- Two-year sponsored project, launched January 2022
- Aimed at developing shared resources through a coordinated approach with industry partners to help:
  - Optimize HVAC solution selection for a given application
  - Ensure equipment performance and delivery of savings
  - Prevent negative customer experience
- Currently in Phase 2.1
- Link to the project resources can be found here:

https://cee1.org/news/details/collaboration-with-hvac-industry-produces-final-deliverables-on-efficient-heat-pump-installations

System Design with Existing Heating

SYSTEM DESIGN WITH
EXISTING HEATING

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Who: Heat pump installers | **Why:** Learn how to install a heat pump in a home that has existing heating

Heat pumps provide efficient heating and cooling for homes in all climates. When sized to be the sole source of heating and cooling, a heat pump is capable of doing so. However, not every project is a perfect match to be heated and cooled only by a heat pump.

PARTIAL LOAD APPLICATIONS

1. **Sized for Cooling - Heat pump that provides all cooling and some of the heating to the home.**
   - Adding or replacing air conditioning to a home with existing high efficiency heating.
   - A heat pump sized for cooling in a heating driven climate.
2. **New Addition - A heat pump providing heating and cooling to a zone that was not previously conditioned.**
   - Conditioning and adding dehumidification to a basement or sunroom.
   - Heating and cooling a new addition.
3. **Partial Coverage - A heat pump that provides part of the heating or cooling in part of the home.**
   - Supplements heating and cooling in an area of the home that the existing system struggles with.
   - Increases zoning and customizability of the home's heating and cooling.

Even in a partial load application, a heat pump provides clean and efficient heating and cooling.

BENEFITS OF A HEAT PUMP IN A PARTIAL LOAD APPLICATION

- **Maximum cooling efficiency**: Inverter driven and multiple capacity heat pumps typically have higher seasonal efficiencies than standard central air conditioners and most heating systems. These high levels of efficiency result in reduced summer electricity expenses and winter fuel bill savings.
- **Climate friendly**: For an average home heated by natural gas, switching to a heat pump reduces your carbon footprint by an amount comparable to not driving a gas car for 9 months of the year. A heat pump can lower carbon production by reducing the use of fossil fuel heating.
- **Better dehumidification**: Some inverter driven or multi-stage heat pumps' ability to control fan and compressor speed allows the heat pump to run efficiently at low speeds for long periods of time which wicks more moisture from the air than a standard air conditioning system.
- **Year-round comfort**: A heat pump can take the place of an air conditioner in cold climates and provide heating when temperatures are mild, keeping you warm in the winter and cool in the summer.
- **Increased indoor air quality**: Most heat pumps provide constant air flow with options to add an enhanced filtration system to clean the air of pollutants, dust, pollen, and allergens.
- **Affordability**: Installing a heat pump in a partial load situation can be a cost-effective alternative for homeowners who can't afford a full installation immediately, potentially making it more appealing during home sales.
- **Correcting existing heating and cooling issues**: Homes with heating and cooling problems can address these issues with a heat pump to ensure year-round comfort.

Oversizing Operational Issues

Low-load Cycling
Low-load cycling arises when the HVAC system's minimum capacity exceeds the home's heating or cooling requirement, causing frequent on-off cycling that lead to inefficiency, elevated energy costs, and added strain on mechanical components.

Comfort
An oversized system can push hot/cold air towards the thermostat or ductless head's temperature sensors before mixing evenly into the space. In these cases, the thermostat may falsely sense that the room's temperature setting is satisfied and turn off the equipment

Dehumidification
Heat pumps and air conditioners dehumidify the air as they cool. In theory, a larger system would be able to wick more moisture from the air than a smaller system would. However, the process of dehumidification requires the equipment to run for an extended

…ized systems have …mes and may fail to …e space.

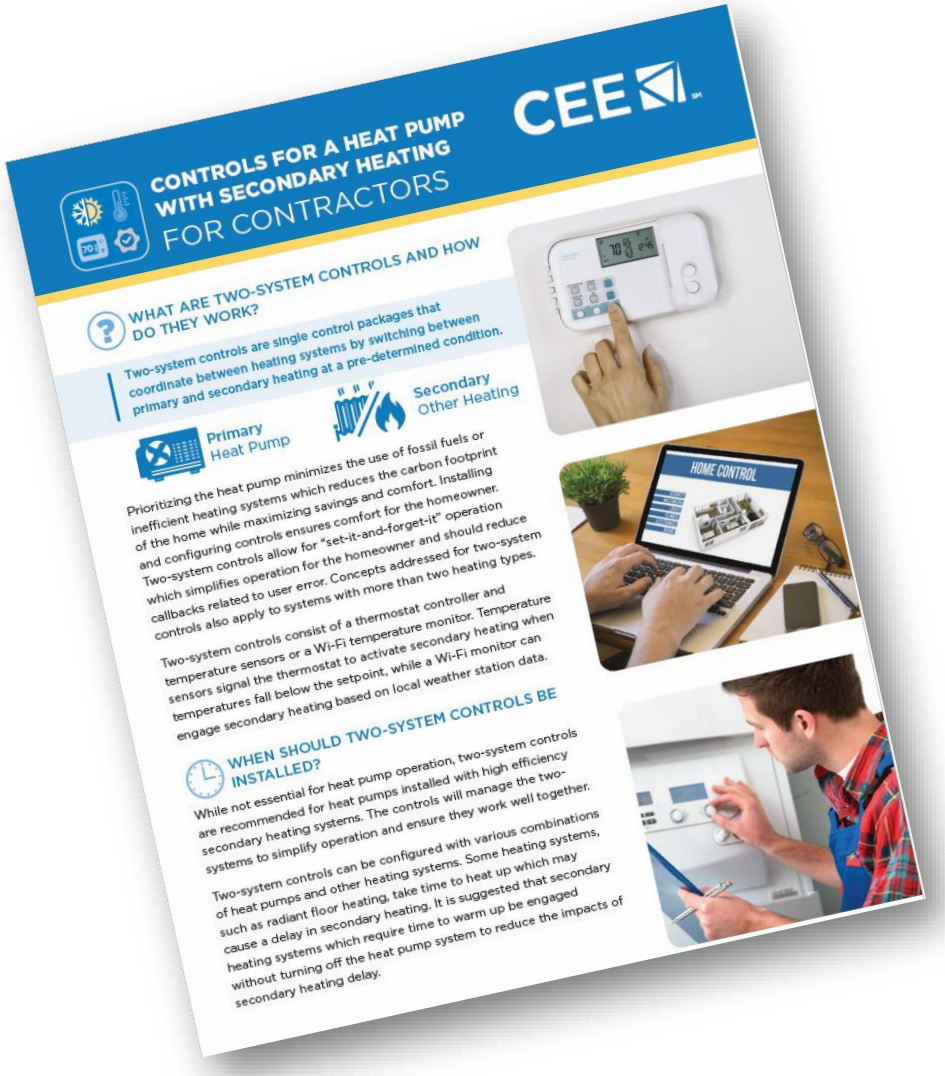
Heating Cost Savings

Use the past year's fuel bills to find what it should cost to heat your home with a heat pump this year.

Annual Heat Load = Amount of Fuel Used x Heating Density of Fuel x Efficiency

Cost of Operating a Whole Home Heat Pump = Annual Heat Load (Btu) x $/kWh ÷ 3.412 ÷ 1000 ÷ COP

"Two System" Controls Guide


CONTROLS FOR A HEAT PUMP WITH SECONDARY HEATING
FOR CONTRACTORS
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WHAT ARE TWO-SYSTEM CONTROLS AND HOW DO THEY WORK?

Two-system controls are single control packages that coordinate between heating systems by switching between primary and secondary heating at a pre-determined condition.

Primary Heat Pump
Secondary Other Heating

Prioritizing the heat pump minimizes the use of fossil fuels or inefficient heating systems which reduces the carbon footprint of the home while maximizing savings and comfort. Installing and configuring controls ensures comfort for the homeowner. Two-system controls allow for "set-it-and-forget-it" operation which simplifies operation for the homeowner and should reduce callbacks related to user error. Concepts addressed for two-system controls also apply to systems with more than two heating types.

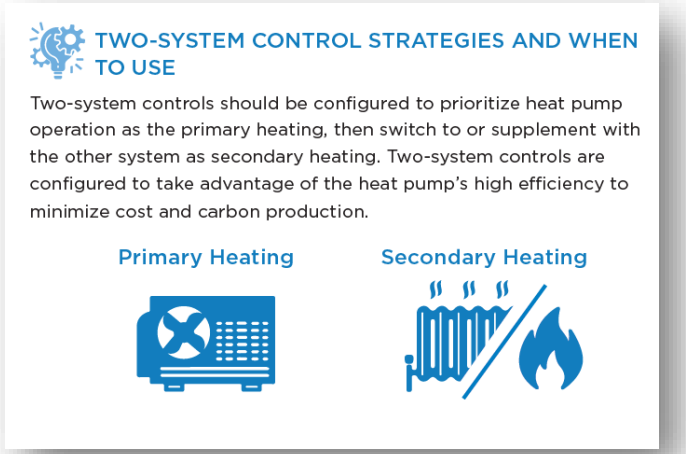
Two-system controls consist of a thermostat controller and temperature sensors or a Wi-Fi temperature monitor. Temperature sensors signal the thermostat to activate secondary heating when temperatures fall below the setpoint, while a Wi-Fi monitor can engage secondary heating based on local weather station data.

WHEN SHOULD TWO-SYSTEM CONTROLS BE INSTALLED?

While not essential for heat pump operation, two-system controls are recommended for heat pumps installed with high efficiency secondary heating systems. The controls will manage the two-systems to simplify operation and ensure they work well together.

Two-system controls can be configured with various combinations of heat pumps and other heating systems. Some heating systems, such as radiant floor heating, take time to heat up which may cause a delay in secondary heating. It is suggested that secondary heating systems which require time to warm up be engaged without turning off the heat pump system to reduce the impacts of secondary heating delay.

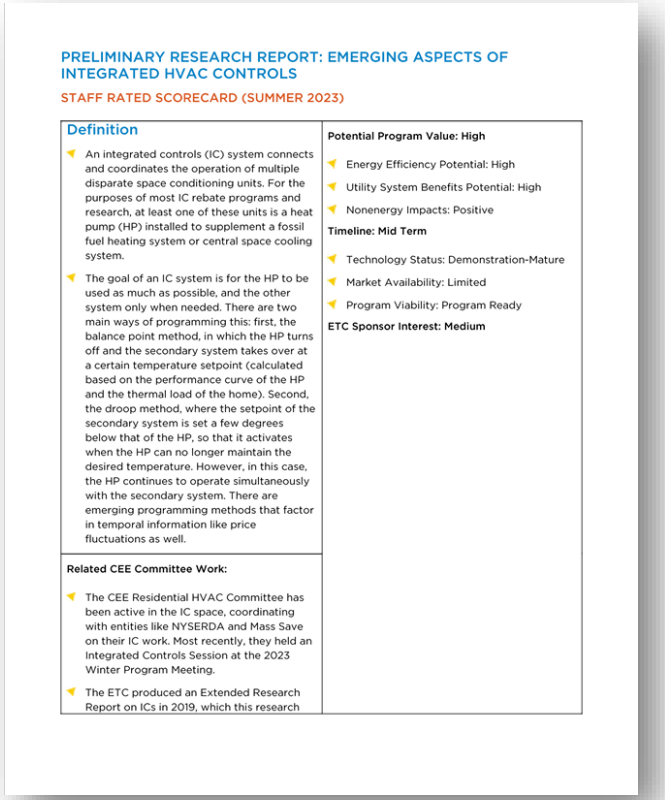
- Formally known as "integrated controls"
- Both contractor and homeowner versions


TWO-SYSTEM CONTROL STRATEGIES AND WHEN TO USE

Two-system controls should be configured to prioritize heat pump operation as the primary heating, then switch to or supplement with the other system as secondary heating. Two-system controls are configured to take advantage of the heat pump's high efficiency to minimize cost and carbon production.

Primary Heating
Secondary Heating

CEE ETC Preliminary Research



PRELIMINARY RESEARCH REPORT: EMERGING ASPECTS OF INTEGRATED HVAC CONTROLS

STAFF RATED SCORECARD (SUMMER 2023)

Definition

- An integrated controls (IC) system connects and coordinates the operation of multiple disparate space conditioning units. For the purposes of most IC rebate programs and research, at least one of these units is a heat pump (HP) installed to supplement a fossil fuel heating system or central space cooling system.
- The goal of an IC system is for the HP to be used as much as possible, and the other system only when needed. There are two main ways of programming this: first, the balance point method, in which the HP turns off and the secondary system takes over at a certain temperature setpoint (calculated based on the performance curve of the HP and the thermal load of the home). Second, the droop method, where the setpoint of the secondary system is set a few degrees below that of the HP, so that it activates when the HP can no longer maintain the desired temperature. However, in this case, the HP continues to operate simultaneously with the secondary system. There are emerging programming methods that factor in temporal information like price fluctuations as well.

Related CEE Committee Work:

- The CEE Residential HVAC Committee has been active in the IC space, coordinating with entities like NYSERDA and Mass Save on their IC work. Most recently, they held an Integrated Controls Session at the 2023 Winter Program Meeting.
- The ETC produced an Extended Research Report on ICs in 2019, which this research

Potential Program Value: High

- Energy Efficiency Potential: High
- Utility System Benefits Potential: High
- Nonenergy Impacts: Positive

Timeline: Mid Term

- Technology Status: Demonstration-Mature
- Market Availability: Limited
- Program Viability: Program Ready

ETC Sponsor Interest: Medium

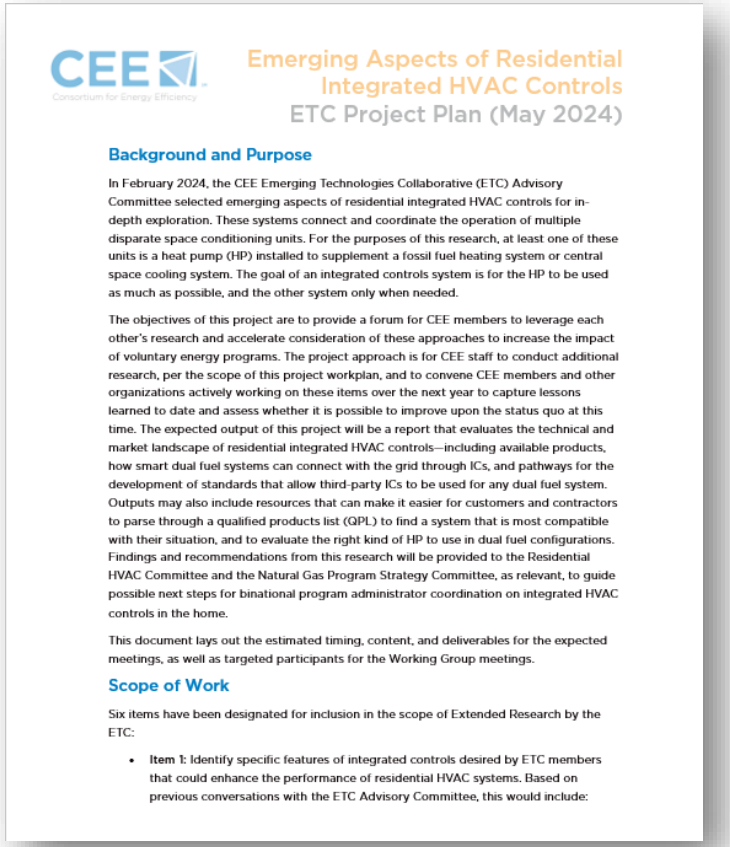
Benefits

- Enables integration of new heat pump appliances with legacy ducted systems
- Can aid in determining optimal switchover points between primary and supplemental heat sources
- Potential to contribute substantially to grid flexibility
- Particularly relevant in extreme climates

Barriers

- Relatively nascent market
- Customer and contractor confusion around integrated controls
- Ensuring that, once installed, integrated controls systems will be used correctly by the customer
- Limited programming capabilities, system interoperability, and remote configurability in many existing systems
- Currently limited capability for grid flexibility

CEE ETC Extended Research



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Emerging Aspects of Residential Integrated HVAC Controls
ETC Project Plan (May 2024)

Background and Purpose

In February 2024, the CEE Emerging Technologies Collaborative (ETC) Advisory Committee selected emerging aspects of residential integrated HVAC controls for in-depth exploration. These systems connect and coordinate the operation of multiple disparate space conditioning units. For the purposes of this research, at least one of these units is a heat pump (HP) installed to supplement a fossil fuel heating system or central space cooling system. The goal of an integrated controls system is for the HP to be used as much as possible, and the other system only when needed.

The objectives of this project are to provide a forum for CEE members to leverage each other's research and accelerate consideration of these approaches to increase the impact of voluntary energy programs. The project approach is for CEE staff to conduct additional research, per the scope of this project workplan, and to convene CEE members and other organizations actively working on these items over the next year to capture lessons learned to date and assess whether it is possible to improve upon the status quo at this time. The expected output of this project will be a report that evaluates the technical and market landscape of residential integrated HVAC controls—including available products, how smart dual fuel systems can connect with the grid through ICs, and pathways for the development of standards that allow third-party ICs to be used for any dual fuel system. Outputs may also include resources that can make it easier for customers and contractors to parse through a qualified products list (QPL) to find a system that is most compatible with their situation, and to evaluate the right kind of HP to use in dual fuel configurations. Findings and recommendations from this research will be provided to the Residential HVAC Committee and the Natural Gas Program Strategy Committee, as relevant, to guide possible next steps for binational program administrator coordination on integrated HVAC controls in the home.

This document lays out the estimated timing, content, and deliverables for the expected meetings, as well as targeted participants for the Working Group meetings.

Scope of Work

Six items have been designated for inclusion in the scope of Extended Research by the ETC:

- **Item 1:** Identify specific features of integrated controls desired by ETC members that could enhance the performance of residential HVAC systems. Based on previous conversations with the ETC Advisory Committee, this would include:

Scope of Work

- **Identify** specific features of integrated controls
- **Conduct further research** into available residential integrated controls products
- **Describe** common installation practices, archetypes, and configuration options
- **Identify additional programs** in the US and Canada that currently include integrated controls measures
- **Identify and develop resources** that can make it easy for customers and contractors to parse through a QPL to find a system that is most compatible with their situation
- **Determine a pathway to adoption** of universal standards for residential integrated HVAC controls

Integrated Controls Features: Systems Integration

- Integration between different HVAC makes/models
- Integration with smart thermostats
- Managing variable-speed heat pumps

- Managing systems that utilize multiple pieces of HVAC equipment
  - Integration of heat pumps and electric resistance systems
  - Integration with ductless heat pumps and secondary systems
  - Managing multiple zones from a single device
  - Managing smart dampers/correlation with home's existing distribution system
  - Functionality with other components that provide HVAC services

Integrated Controls Features: Controls Strategies

- Based on:
  - Outdoor air temperature
  - Indoor air temperature/droop
  - Non-dynamic price calculations
  - Decarbonization calculations
  - Manual J-based calculations

- To bring a space up to temperature:
  - Allow secondary system to bring space up to temperature more rapidly than a heat pump alone
  - Allow the heat pump to ramp up temperature in advance
- Allow for concurrent operation of disparate pieces of HVAC equipment, or disable secondary system(s)
- Automatic setback option
- Adjust internal temperature to account for temperature stratification

Integrated Controls Features: Communicability

- Network system(s) utilized for local communicability
- Grid connectivity options

Insights From Vendors and Program Administrators

- Broad interest in grid-level networking
- Interoperability and future-proofing would be helped by universal, open standards, however:
  - Not always practical for manufacturers to share their control schemes
  - The process can be complex and redundant
  - Protocols like CTA-2045 may not be an ideal solution for heat pumps for HVAC
- Smart thermostats could help to solve the problem of integrating control of mini-split systems with ducted heating systems

Insights From Vendors and Program Administrators

- System sizing is a concern manufacturers hear from utilities
  - ACCA's Manual S offers contractors sizing recommendations for various archetypes
- Incentive programs are seeing low uptake, due in part to greater incentives for full decommissioning
- It would be beneficial to have an integrated controls system be aware of marginal grid emissions

Thank You!

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Residential Integrated HVAC Controls

Appendix: Strategies from the CEE ASHP Education and Guidance Project

Partial Load Configurations

Sized for Cooling

- Dual fuel configuration most common but can be configurations of HPs and other heating systems
- Prioritize HP as the primary stage of heating (only engage secondary heating source when necessary)
- Homeowner should be aware of how the two systems interact

New Addition

- Typically ductless or compact ducted HP system
- HP will provide all heating and cooling necessary to the space (but should have minimal interaction with home's other systems)
- Homeowner should be informed on how to operate the system independently of existing system.

Partial Coverage

- Can be ductless or ducted HP with separate duct system
- Ideal for spaces far from the existing air handler, or have large windows
- Size HP to add to existing system to make the space comfortable
- Configure controls to operate both systems at the same time

Controls Strategies By Focus

Ease Of Use, Energy Efficiency, Carbon Footprint Focus

- Prioritize HP by running it at all times. Secondary heating system should be used only when the HP cannot maintain temperature.
- Engage the secondary heating system to return the space to the indoor temperature setpoint, then disengage secondary heating system (HP will continue running throughout this time)

Cost Focus

- Configured to switch from the heat pump to the secondary heating system when it is calculated that the secondary heating system is deemed cheaper to operate at a certain temperature (switchover temperature)
- Calculating switchover temperature manually is difficult and constantly changing with the prices of fuel and electricity. Savings are usually small.

Controls Strategies: Indoor Temperature Controls

Use this method when

- Homeowner priority is ease of use, energy efficiency, and carbon reduction.
- A HP is sized for 100% of the heating load.
- The thermostat is capable, or if it is a two thermostat system

Benefits

- Maximizes HP use
- Only employs secondary heating when needed
- Does not require annual re-calculation
- Temperature should not drop enough for homeowner to notice
- Reduces effect of mismatched zoning, excess cycling, and secondary heating delay

Controls Strategies: Outdoor Temperature Controls

Capacity Balance Point: Use When

- Indoor temperature method is unable to be used
- Homeowner priority is carbon reduction and ease of use
- Installed HP is not sized to 100% of the heating load
- The system and thermostat allow for temperature switchover

Economic Balance Point: Use When

- Homeowner's priority is cost reduction
- Operating cost of the HP is higher than the secondary heating at temperatures well above the design temperature

Signs Integrated Controls are Not Optimized

- High bills or excess fossil fuel use
- Frequent on/off cycling
- Secondary heating engaging at high outdoor temperatures
- Delays in secondary heating
- Uneven temperature or hot and cold zones throughout the home