lighting design lab

Small Commercial Buildings – Controls and Other Helpful Tools from DOE

Presented by

Nora Hart, Energy Technology Researcher

Nathan McKenzie, Program Manager

Lawrence Berkeley National Laboratory

January 15, 2026

Seattle City Light

Webinar Procedures

- All attendees are on mute
- Submit questions at any time
- The webinar is being recorded
- Please take the after-class survey!

Look for the Questions icon in the menu bar

Chat icon – disabled for general use; webinar staff might use

React icon – click the arrow to “laugh,” “agree,” or “appreciate.”

Upcoming Events

Lab Events	Day	Time
Heat Pump Water Heaters: From Installation to Business Success	Wed Jan 28	7:30 – 10:00 a.m.
Snohomish County PUD – Lessons Learned From the Arlington Microgrid	Tue Feb 10	10:00 – 11:30 a.m.

Partner Events	Day	Time
Seattle City Light Trade Ally Office Hours	Fri Jan 23	8:30 – 9:30 a.m.

Stay up-to-date at LightingDesignLab.com and by subscribing to our newsletter.

Small Commercial Buildings – HVAC Incentives by City Light

HVAC Performance & Midstream Incentives

Seattle City Light

HVAC Incentives – Controls Upgrades

CONNECTED THERMOSTATS: *Rebates up to 70% (capped at $200/thermostat)*

- Typical Payback: 2-3 years (including rebate)
- Must replace an existing standard thermostat
- One new thermostat per supply fan serving a single zone
- Gas or electric heating are eligible

EXAMPLE PROJECT COST SAVINGS PER YEAR (ELECTRIC HEAT) *Average savings:$90/year per thermostat*

BUILDING TYPE	SQUARE FOOTAGE	BEFORE CONNECTED THERMOSTAT	AFTER CONNECTED THERMOSTAT	COST SAVINGS	% SAVINGS
Class C Office	5,503 sq. ft.	$13,758	$12,470	$1,288	9%
Retail Store	24,695 sq. ft.	$91,372	$83,815	$7,557	8%
Grocery Store	45,006 sq. ft.	$457,225	$412,399	$44,826	10%

Savings estimated from Regional Technical Forum study and an average rate of 8¢ per kWh.

ADVANCED ROOFTOP CONTROLS: *Rebates from $120-$500/Ton (Gas or Electric)*

- The rebates are based on levels of BPA qualifies retrofits:
  - Advanced rooftop control-single phase: $500/Ton
  - Advanced rooftop control – full: $250/Ton
  - Advanced rooftop control – lite: $120/Ton

Controls upgrades
$0.36/kWh saved!

- Occ Sensors
- Pneumatic to digital (DDC)
- Adding VFDs to CV fans

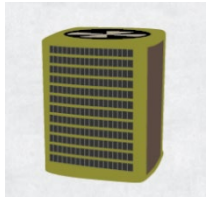
Building Automation Programming
$0.06/kWh saved!

- Scheduling
- Optimizing Sequence of Operations
- Setpoints

https://www.seattle.gov/documents/Departments/CityLight/ConnectedThermostatFacts.pdf

https://www.seattle.gov/documents/Departments/CityLight/CommercialRebates.pdf

HVAC Incentives – Distributor Discounts

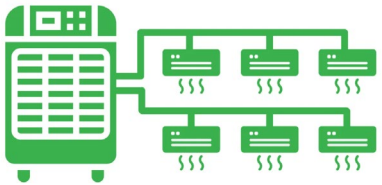


HEAT PUMPS

CHILLERS/AIR CONDITIONING

PUMPS, FANS, CIRCULATORS

HEAT PUMP WATER HEATERS

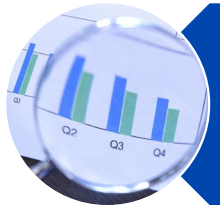


VRF SYSTEMS

Get instant rebates when buying High Performance/High Efficiency equipment

Enhance Occupant Comfort

No Pre-Approval required!



Lower equipment costs & Lower energy costs over equipment lifetime

https://www.seattle.gov/documents/Departments/CityLight/HVACProgramFS.pdf
https://www.seattle.gov/documents/Departments/CityLight/HVACDistributorList.pdf

Small Buildings, Big Impact: Leveraging Controls for Energy Efficiency, Thermal Comfort and Demand Response

Presenter: Nora Hart, Berkeley Lab
norahart@lbl.gov

ENERGY TECHNOLOGIES AREA
BERKELEY LAB

Agenda

1. Why Improve Rooftop Unit (RTU) Controls?
2. Types of Controls for Small & Medium-Sized Buildings
3. Demand Response in Small to Medium-Sized Buildings
4. Case Studies
5. Resources for Common Barriers to Control Implementation
6. Q+A

Why improve RTU controls?

Rooftop Units (RTUs)

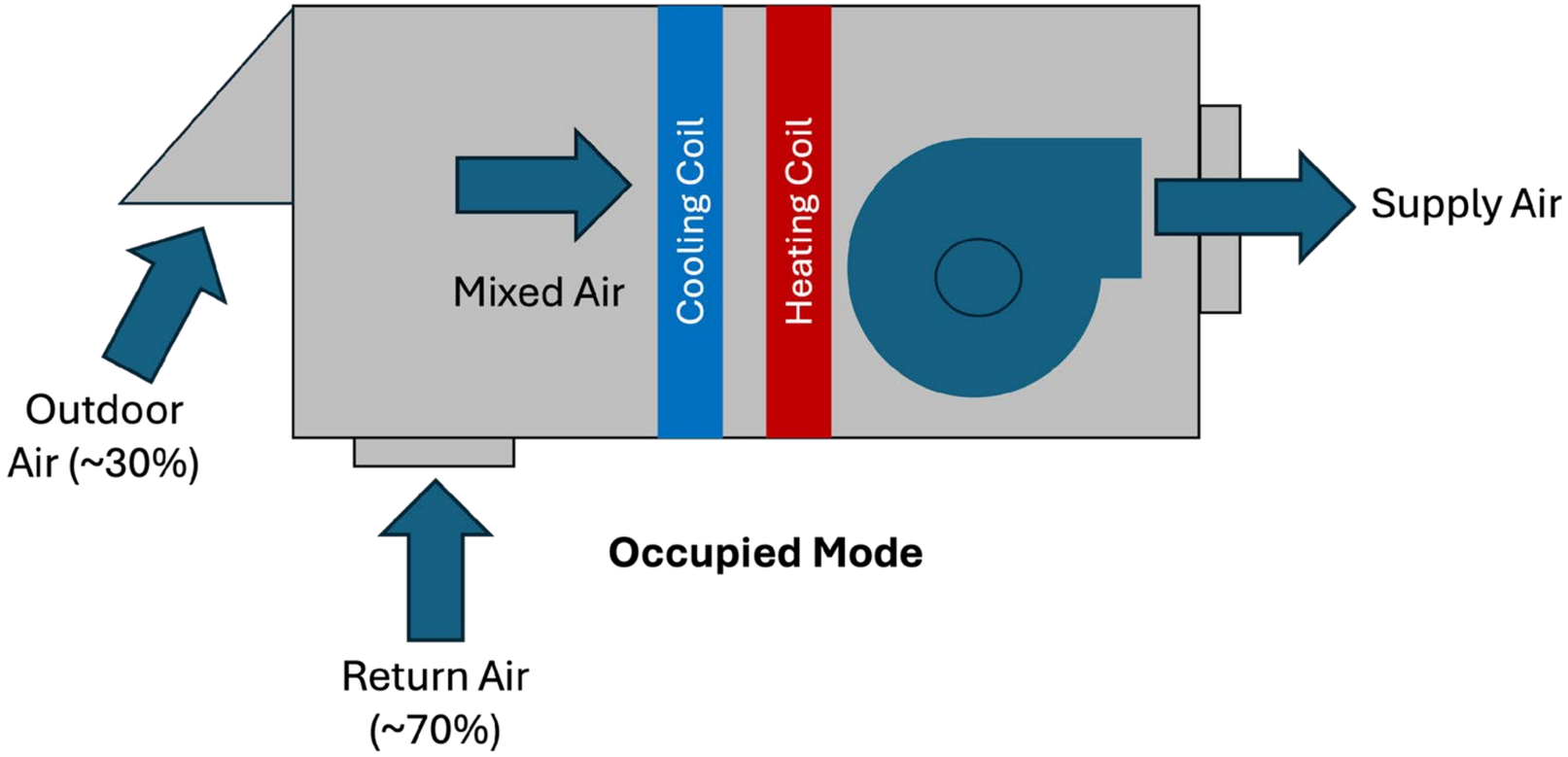


Image Source: DOE (Link)

Inefficient HVAC controls, a $16B opportunity

94% of commercial buildings are less than 50,000 sq. ft.

Only **15%** have controls

$16B of energy wasted annually

Savings from Implementing Controls in Small Buildings

144
Buildings

600,000
Sq. Ft.

10%
Average Whole Building Energy Savings

12%
Median Whole Building Energy Savings

Control Strategies Reported Include:

- Centralized configuration of setpoints and schedules, data collection & review, and data visualization & analysis
- Automatic of zone setpoint and schedule overrides
- Optimal start/stop
- Economizer control
- Variable speed fan control
- Automated grid-responsive strategies (e.g., demand response, load shedding and shifting)
- Coordination of RTUs to limit peak demand
- Exhaust fan schedules centrally controlled

Benefits

Cost savings

Streamlined maintenance

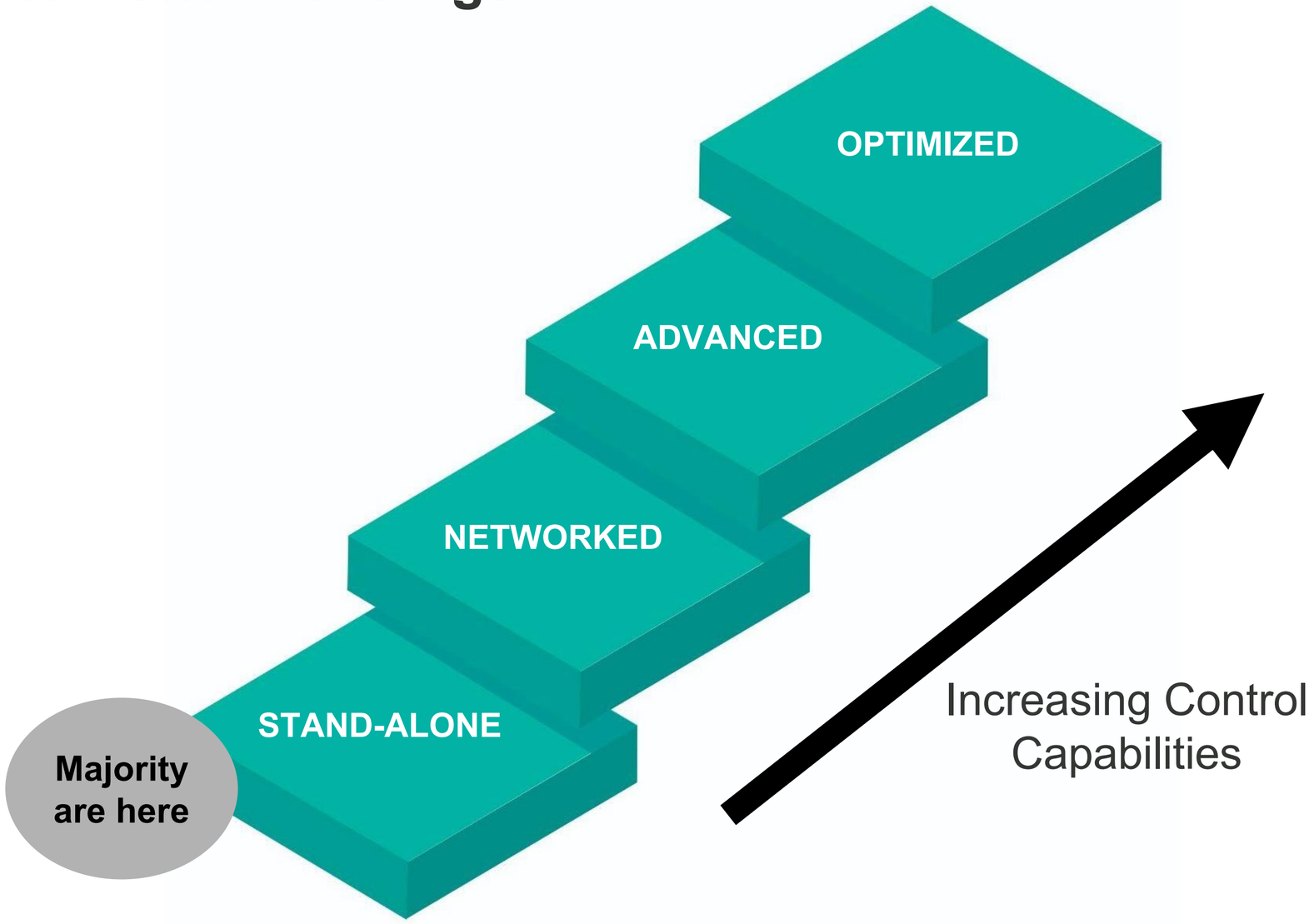
Energy savings

Improved occupant comfort

Improved indoor air quality

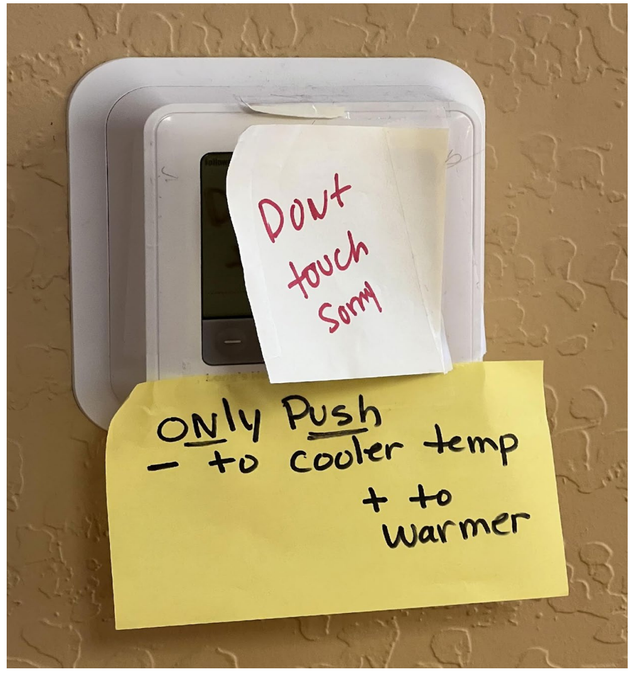
Types of Controls for Small & Medium-Sized Buildings

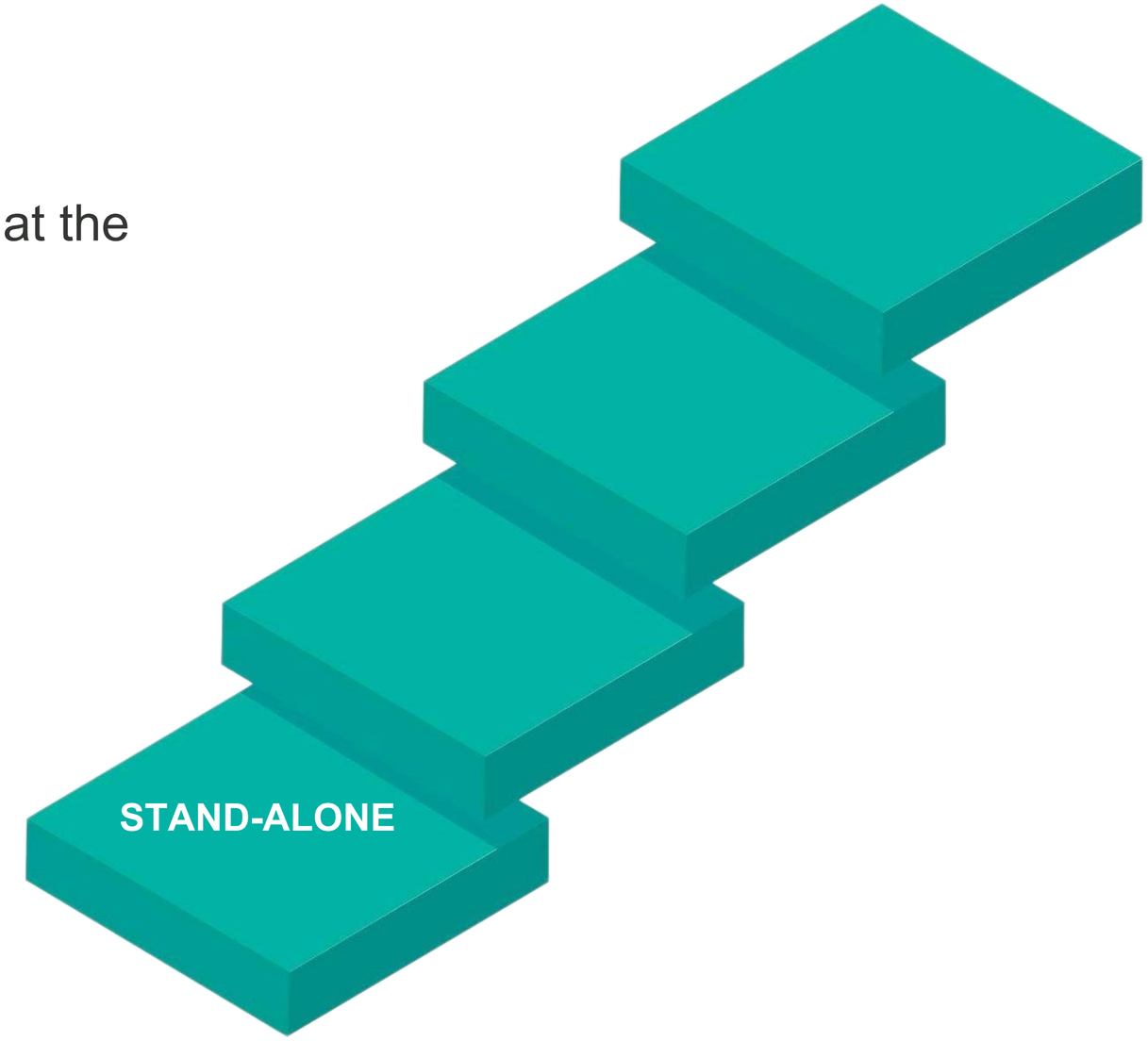
Stairway to Better Buildings



Stand-Alone Controls

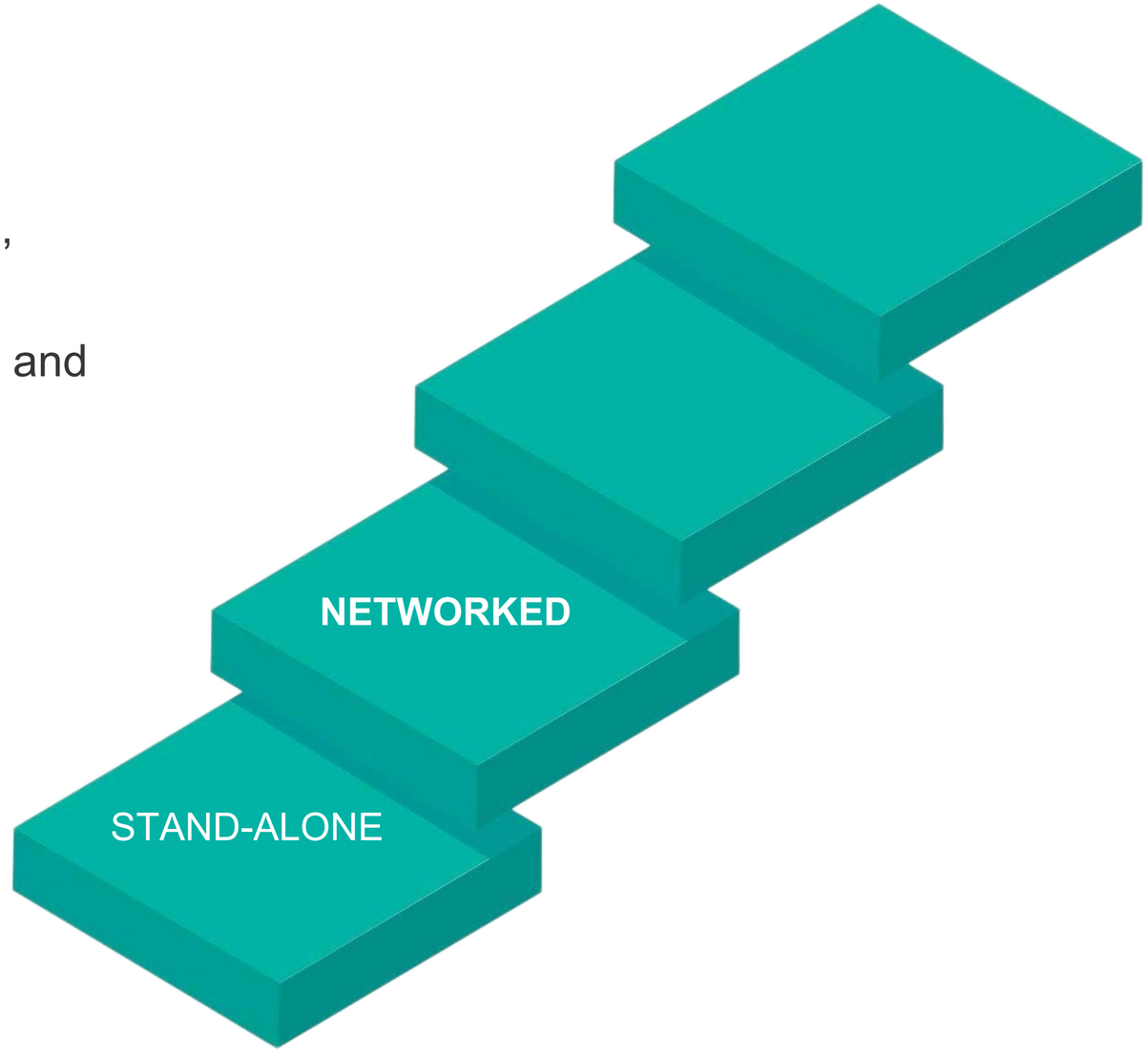
- **Status Quo**
- Programmable
- Allows for scheduling and setpoint adjustment at the thermostat
- Non-Communicating





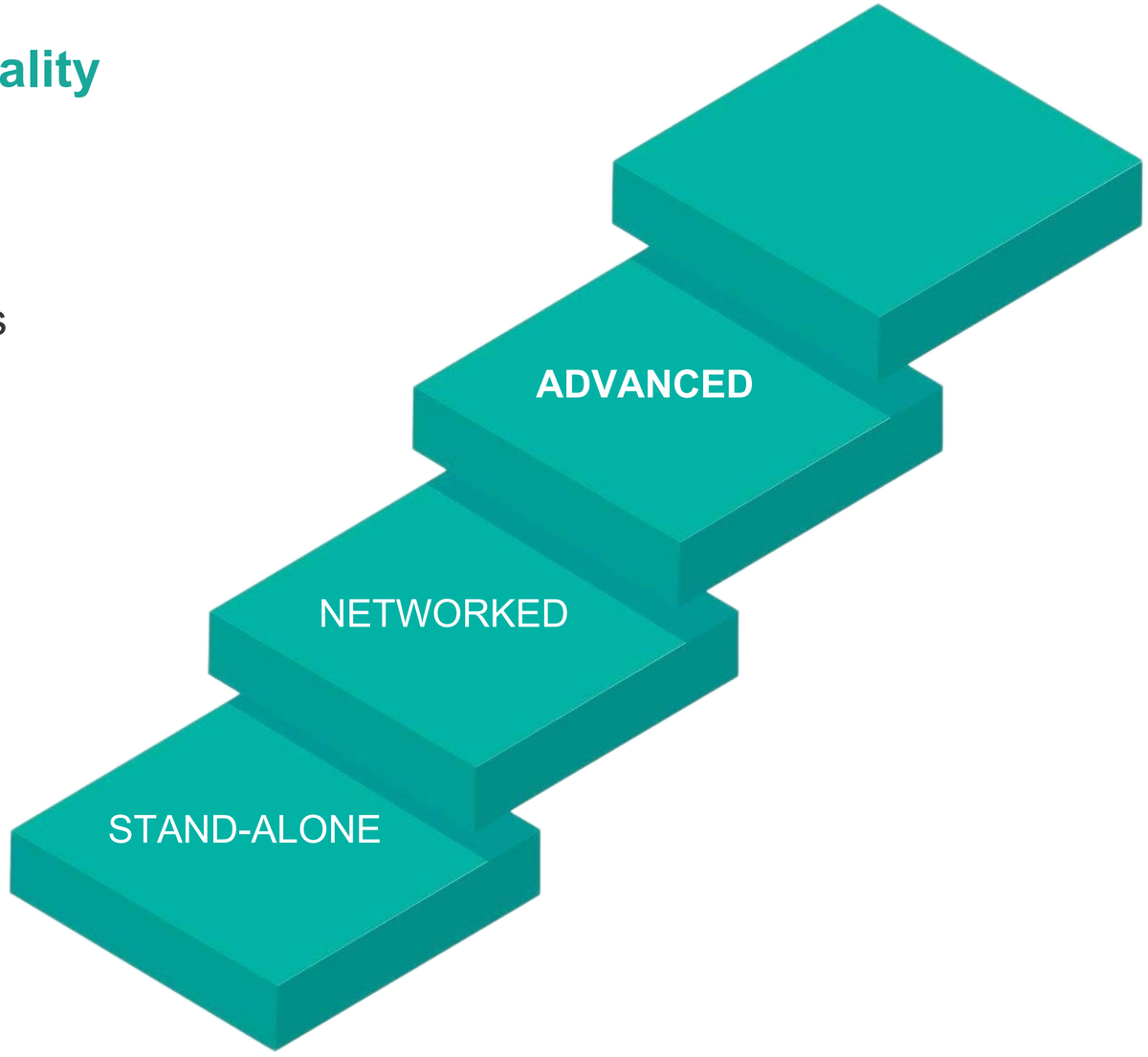
Networked Controls

- **Reduce Energy Waste**
- Allows for:
  - Remote monitoring of zone temperatures, setpoints, schedules, equipment status, and critical alarms
  - Adjustment of control parameters such as setpoints and schedules
- Great for multiple RTUs and buildings
- **10-20%** whole building energy savings
- Requires communicating thermostats



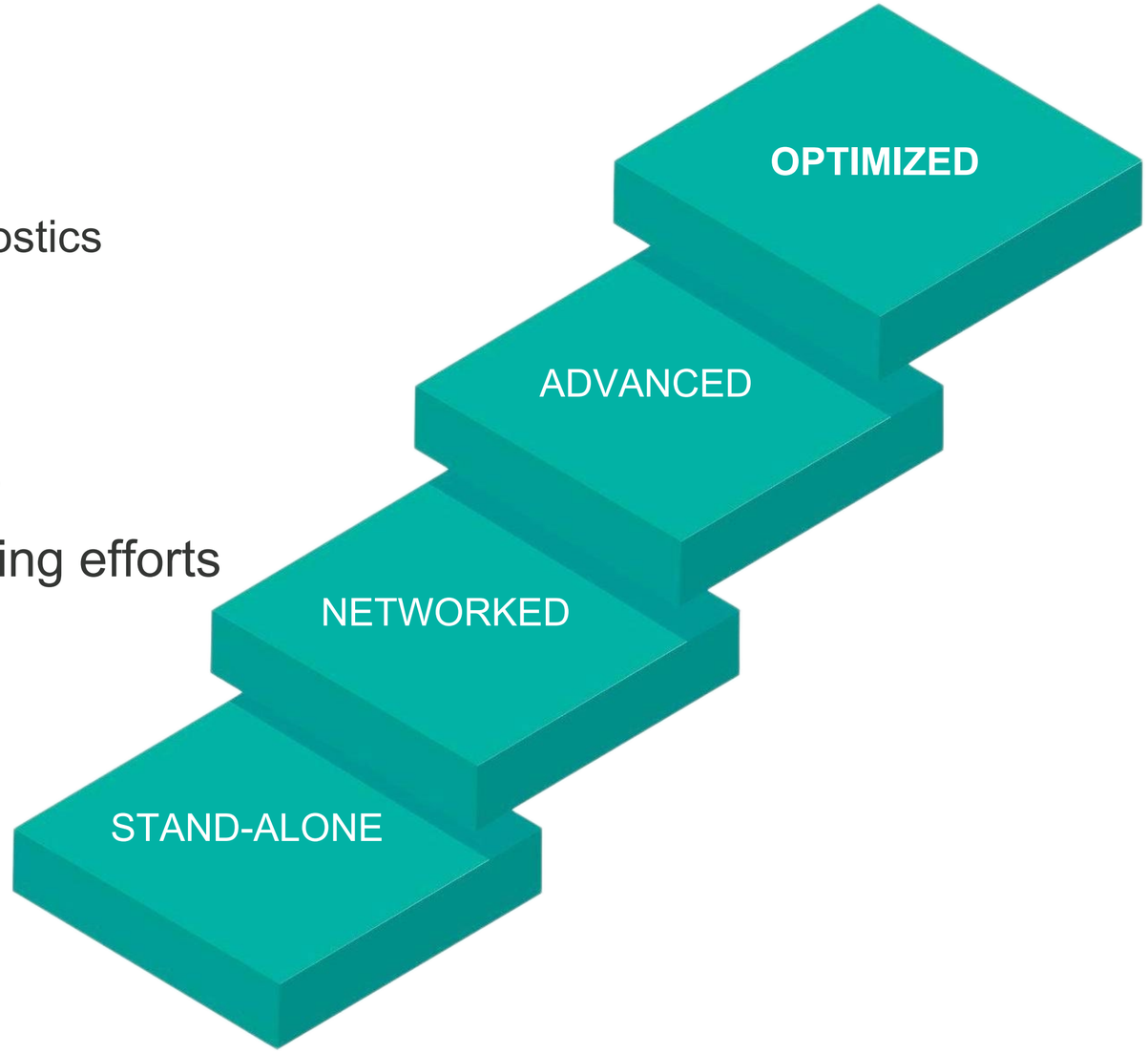
Advanced Controls

- **Improve energy efficiency and indoor air quality**
- Allows for some of the following capabilities:
  - Variable Speed or Multi-Speed Supply Fan Control
  - Economizer Controls, Fault Detection & Diagnostics
  - Occupancy-Based Controls
  - Optimal Start/Stop
  - Demand Control Ventilation
- Average Whole Building Energy Savings of **35%** across 16 locations in 15 climate zones based on a combination of Advanced Control Measures [1]
- Requires additional sensors and control hardware



Optimized Controls

- **Grid-interactive, efficient building control**
- Allows for some of the following capabilities:
  - Vapor Compression Cycle Fault Detection & Diagnostics
  - Coordination of Multiple Units
  - Dynamic Multi-Unit Coordination
  - Facilitation of Automated Grid Response Strategies
- Requires additional commissioning and monitoring efforts



Stairway to Better Buildings

Grid-interactive, efficient building control

- Requires additional commissioning (Cx) and monitoring effort
- Dynamic optimization, automated demand flexibility

Improved energy efficiency and air quality

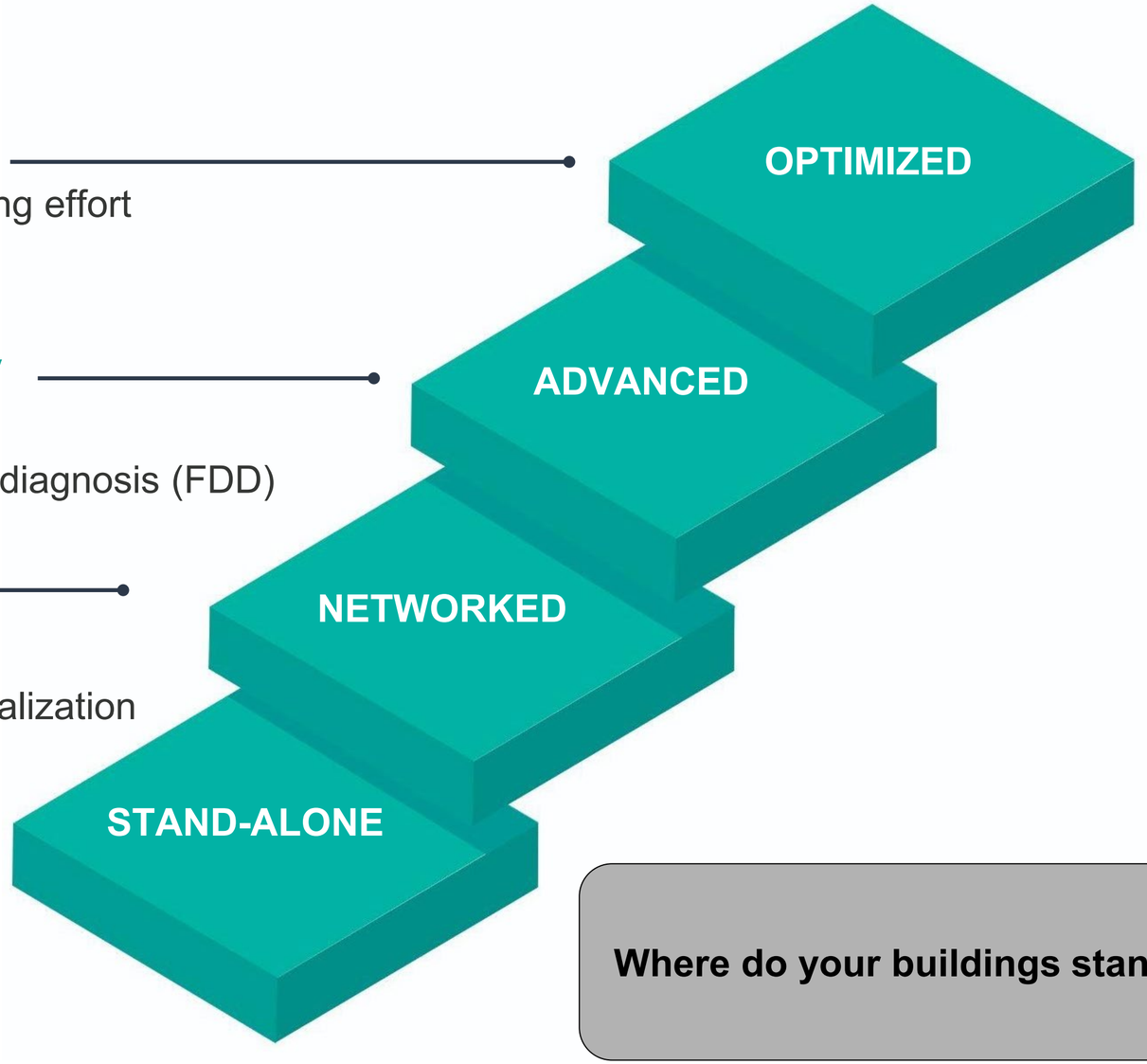
- Requires additional sensors and control hardware
- Advanced component control and fault-detection and diagnosis (FDD) capabilities

Reduced energy waste

- Requires communicating thermostats
- Remotely accessible, centralized data collection, visualization and monitoring

Status quo

- Programmable thermostats
- Scheduling, setpoint adjustment



Where do your buildings stand?

Categorized Listing of Packaged RTU Controls

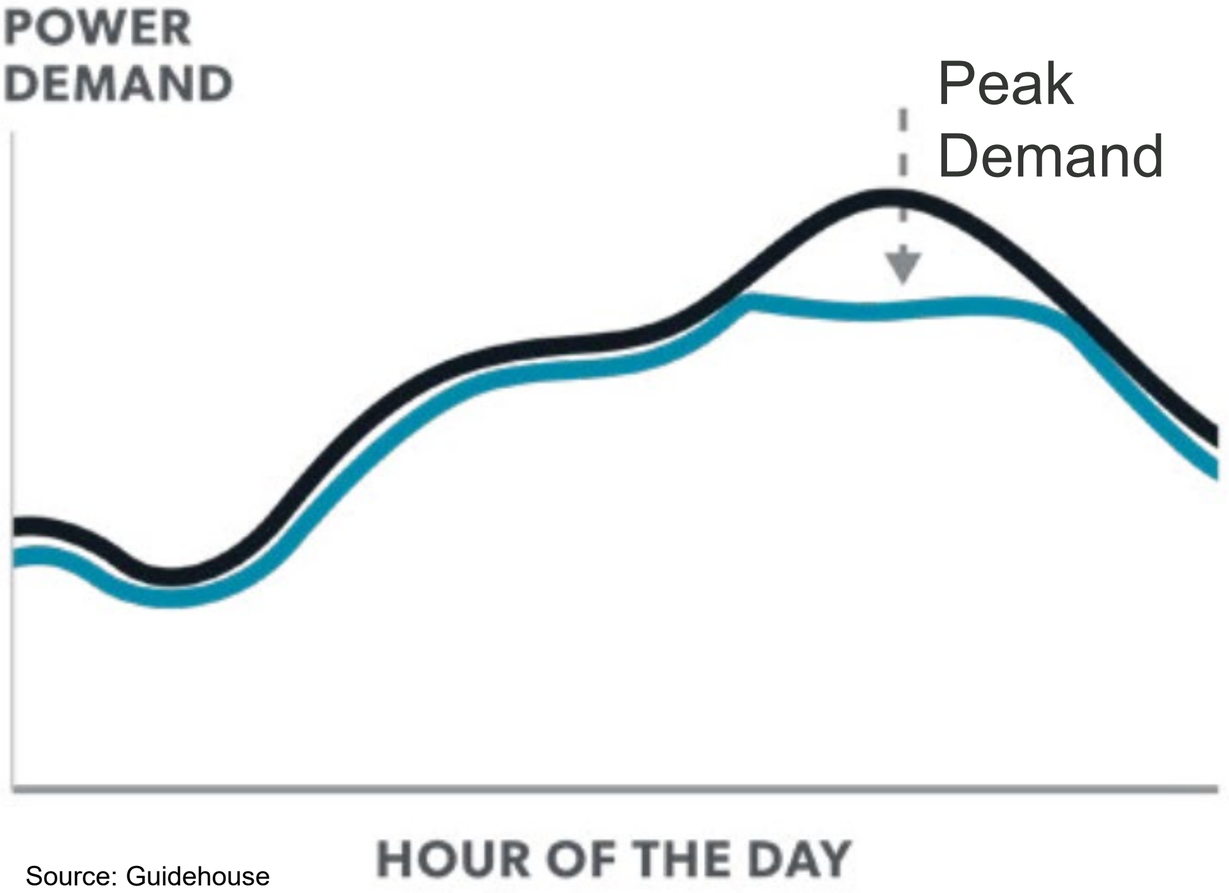
Manufacturer	Solution	Networked Thermostatic Control	Advanced RTU Control	Optimized RTU Control	Light Commercial BAS		Demand Flexibility	Components
					Integrates with Multiple-Zone HVAC Systems	Integrates with Other Energy End Uses		
Acuity Brands	Atrius and Distech Controls	✓	✓	✓	✓	✓	✓	Atrius cloud applications and data platform along with Distech Controls occupant interfaces, sensors, controllers, and displays.
Bes-Tech	Digi-RTU®		✓	✓			✓	Digi-RTU® controller, Digi-SBM® supervisory controller and gateway, one or more VFDs, temperature and CO_2 sensors, and Digi-SFT® desktop app
BrainBox AI	BrainBox AI	✓	✓	✓			✓	WiFi-enabled thermostats and BrainBox AI cloud
Carrier	ComfortVu and ComfortVu+ BACnet Thermostats	✓					✓	Requires wired BACnet MSTP network for integration into Carrier i-Vu or third-party BAS (local or cloud based) for remote access.
	Connect43 and Connect43FX BACnet and WiFi Thermostats + Connect Cloud	✓	✓	✓			✓	Connect Cloud requires connectivity to customer WiFi network. Optional wired BACnet MSTP for connectivity to Carrier i-Vu or third-party BAS for alternative remote access.
	RTU Open Advanced BACnet RTU controller + Communicating Sensors	✓	✓	✓	✓	✓	✓	Requires BACnet network for Carrier i-Vu or third-party BAS integration. Requires additional communicating controllers for control of ancillary equipment and/or zoning systems.
Cognition Controls	Smart HVAC Control Solution	✓	✓	✓				Cellular connected smart thermostat, wireless sensors, Cognition Controls web platform, and dedicated Cognition Controls support
Contemporary Controls	BASstat Thermostats + BASview3	✓						BASstat BACnet thermostat and BASview3 supervisory graphical interface
	BAScontrol Unitary Controller + BASview3	✓	✓			✓		BAScontrol unitary controller, BASview3 supervisory graphical interface, and third party wall setters (provides zone conditions and setpoint adjustment)

Please note, inclusion in this table does not indicate endorsement, nor does absence from the table indicate a product is not suited to this application or market. This table is not exhaustive and will be updated on an ongoing basis in collaboration with representatives from product manufacturers. The performance of these products has not been validated by Berkeley Lab.

Demand Response and How to Reduce Peak Demand in Small to Medium-Sized Buildings

Demand Response (DR)

- Encourages customers to reduce or shift electricity consumption in response to an event signal
- The Utility/ Aggregator will send an event signal to the energy management system



Source: Guidehouse

Reducing Building Peak Demand in Small to Medium Sized Buildings

- Common Strategies
  - Temporarily adjust setpoints
  - Cycle the operation of multiple RTUs to avoid simultaneous spikes
  - Pre-condition zones
  - Fan speed reduction
  - Lighting Strategies (Zoning and Dimming)
- Possible to configure multiple levels of logic, allowing for different depths of load shedding

Case Studies

Case Study

UC DAVIS

- Replaced stand-alone thermostats with networked thermostats
- Operational Benefits:
  - Allow users to modify setpoints, and the facilities team can remotely reset temporary changes
  - Reduces equipment wear by minimizing run times through efficient scheduling
  - Enabled participation in demand response programs
  - Transformed maintenance workflow

Building Type	Office, Child Care Center, Lab
Average Building Size	5,000 sq ft
Number of Buildings with Controls	101
Whole Building Energy Savings	28%
Simple Payback	< 3 years

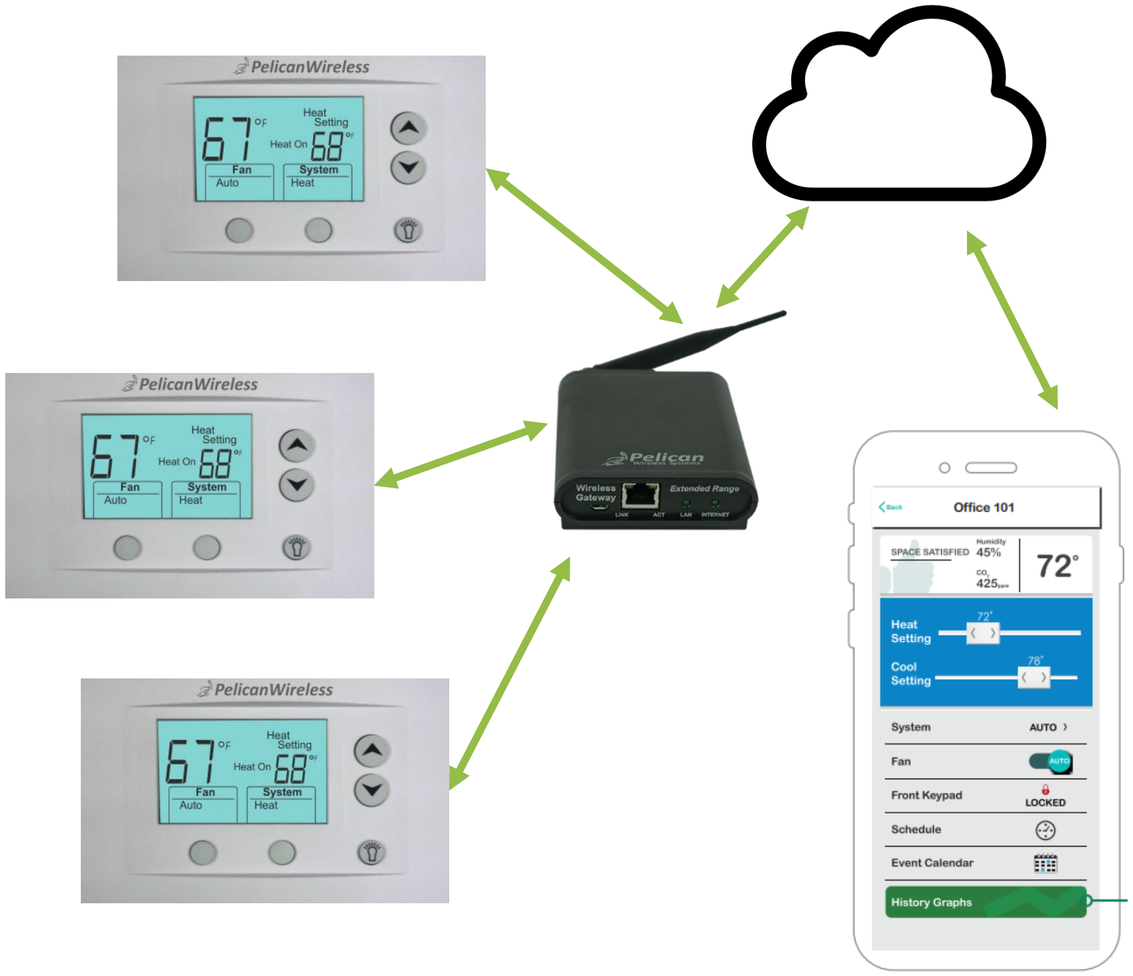
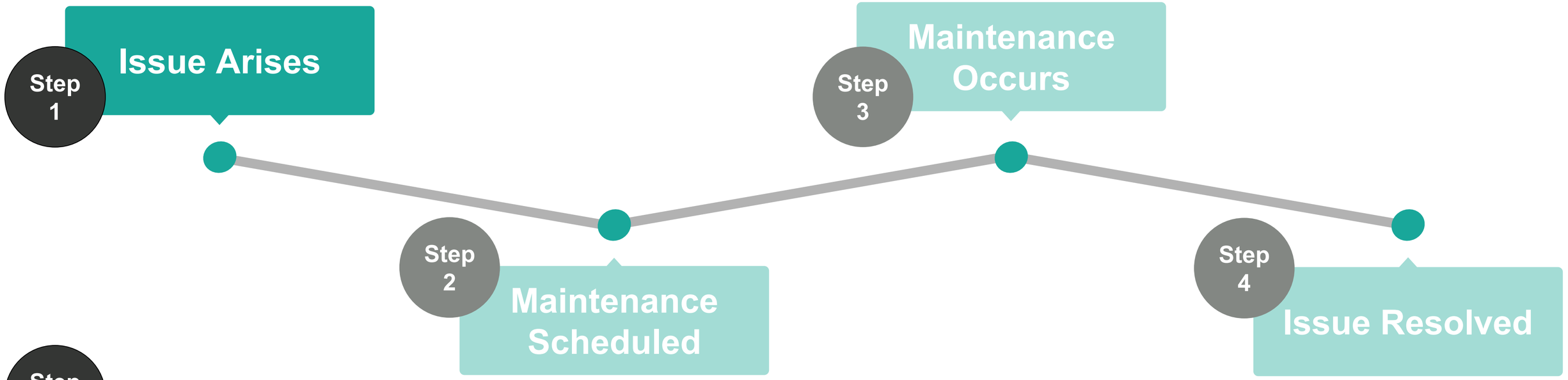


Image Source: UC Davis (Webinar Link)
Note: Other technology providers are available

Source: SSBC UC Davis Case Studies (Link 1 & Link 2)

Improved Maintenance Workflow

Source: SSBC UC Davis Case Study (Link)



Step 1

Stand-Alone Thermostats

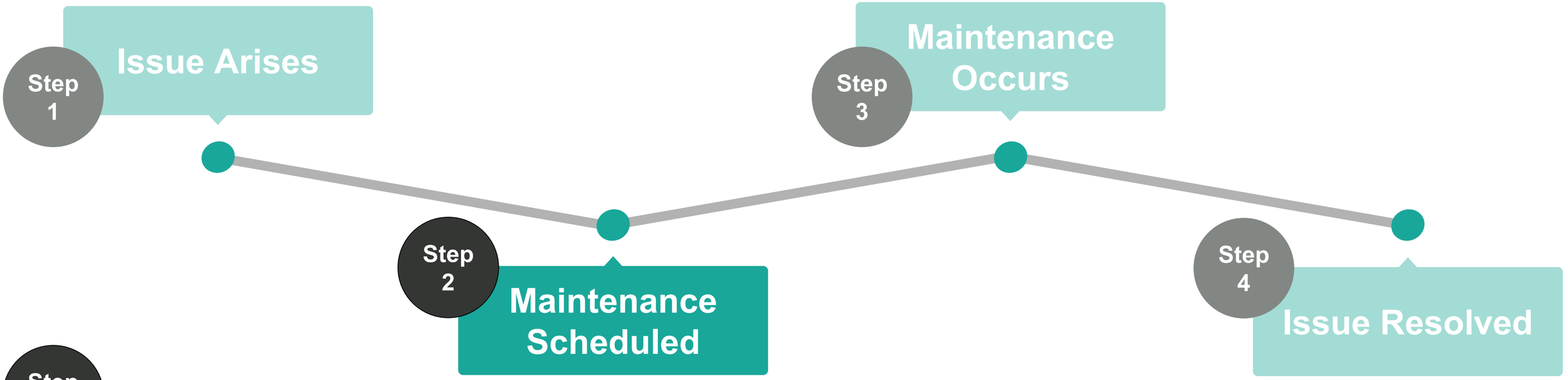
- The occupant submits a complaint to the facilities team

Networked Thermostats

- Deviations from space setpoints trigger an alarm

Improved Maintenance Workflow

Source: SSBC UC Davis Case Study (Link)



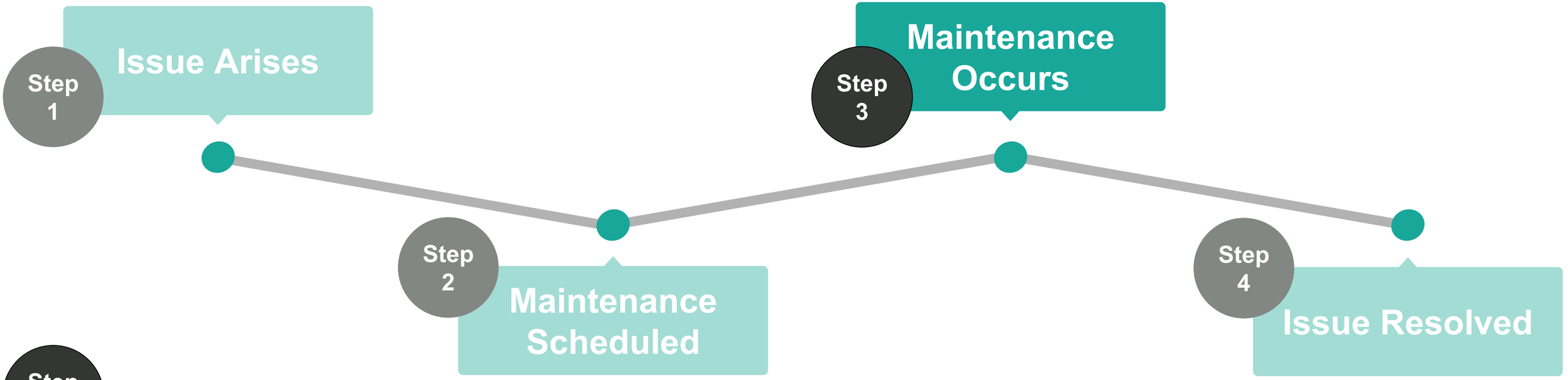
Step 2

Stand-Alone Thermostats
- Site visit scheduled

Networked Thermostats
- Fault and corresponding data reviewed remotely

Improved Maintenance Workflow

Source: SSBC UC Davis Case Study (Link)



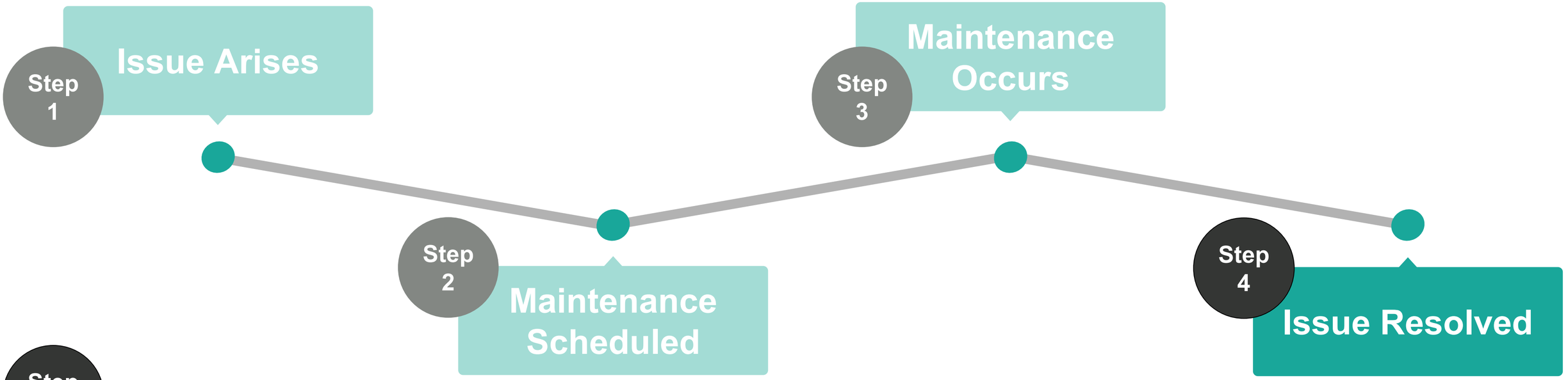
Step 3

Stand-Alone Thermostats
- Fault resolved on-site

Networked Thermostats
- Fault resolved either remotely or on-site

Improved Maintenance Workflow

Source: SSBC UC Davis Case Study (Link)



Step 4

Stand-Alone Thermostats

- Occupants need to verify that the issue has been resolved

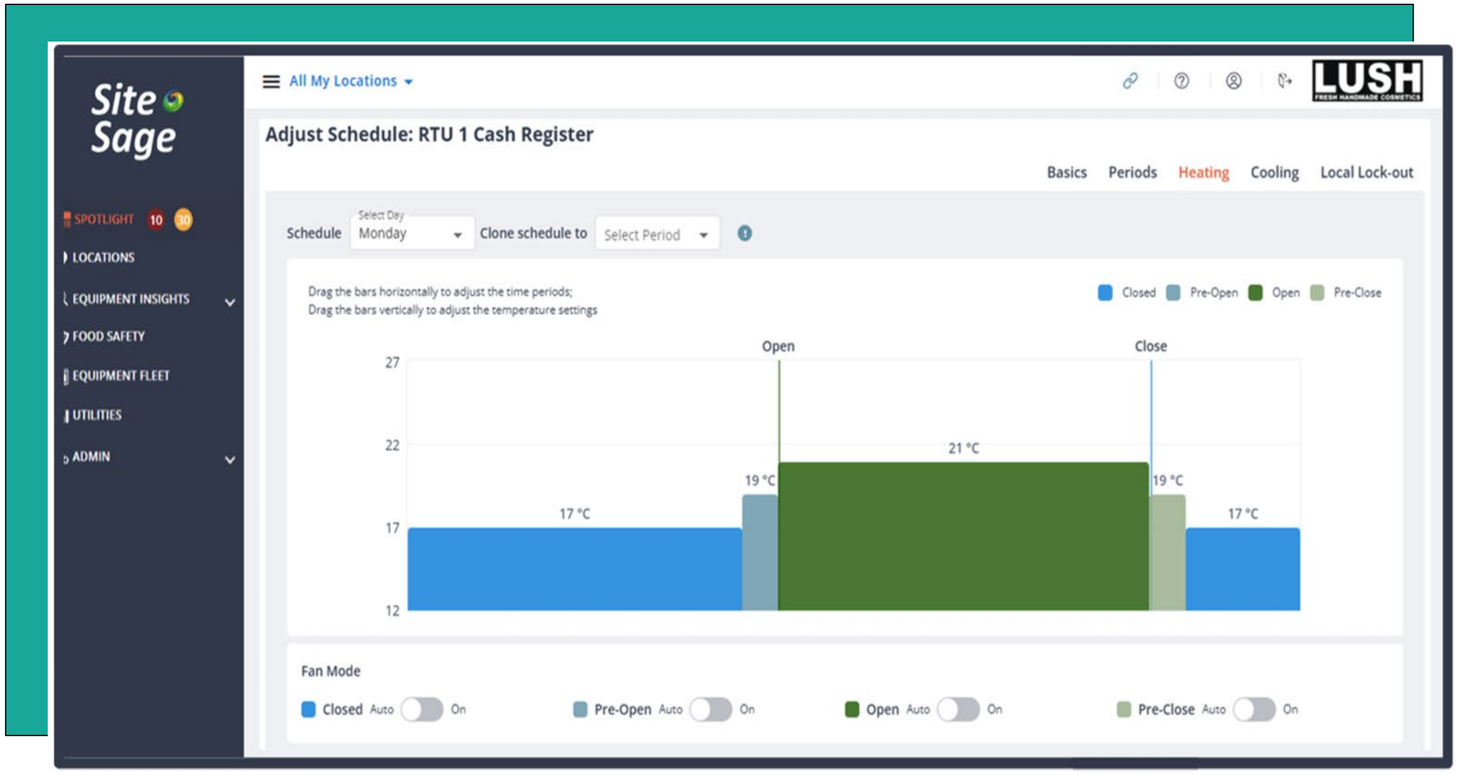
Networked Thermostats

- Fault can be verified remotely through trend data

Case Study

- Installed networked controls across 183 stores
- Were able to
  - Schedule exhaust fans
  - Have better temperature control
  - Improve maintenance workflow
  - Automatically generate a monthly ‘HVAC Fix List’

Building Type	Retail
Average Building Size	1,687 sq ft
Number of Buildings with Controls	183
Whole Building Energy Savings	17%



Source: SSBC Lush Case Study (link)
Note: Other technology providers available

Case Study

- Installed building management systems (BMS)
  - Across 700 stores
- Able to control:
  - HVAC
  - Exterior Lighting
- Able to monitor:
  - Refrigeration
  - Energy Consumption
  - HVAC operating parameters
- Advanced controls have helped
  - Streamline maintenance and reduce truck rolls
  - Provide more insight into the equipment
  - Reduce equipment failures
  - Improve occupant comfort

Building Type	Convenience Store
Average Building Size	6,000 sq ft
Number of Buildings with Controls	700
Whole Building Energy Savings	11%

Source: SSBC Sheetz Case Study (link)

Resources

Smarter Small Buildings Campaign

What is the Campaign?

- DOE-sponsored program managed by Berkeley Lab to promote improved HVAC controls for small/medium buildings
- Applicable to all buildings with packaged rooftop units

Benefits

- 1:1 Technical Support
- Peer-to-Peer Support
- Resources, Webinars, etc.
- Case Study Opportunities

Who can Join?

- Building Owners/Operators
- Product vendors, contractors, industry organizations, utilities

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https://smartersmallbuildings.lbl.gov/

Top 5 Most Common Support Topics

"Can you share information on the capabilities of products offered for small building controls?"

"Can you provide some details on the expected energy savings from controls so I can make the business case to leadership?"

"How can I measure the indoor air quality of my buildings?"

Smarter Small Buildings Campaign

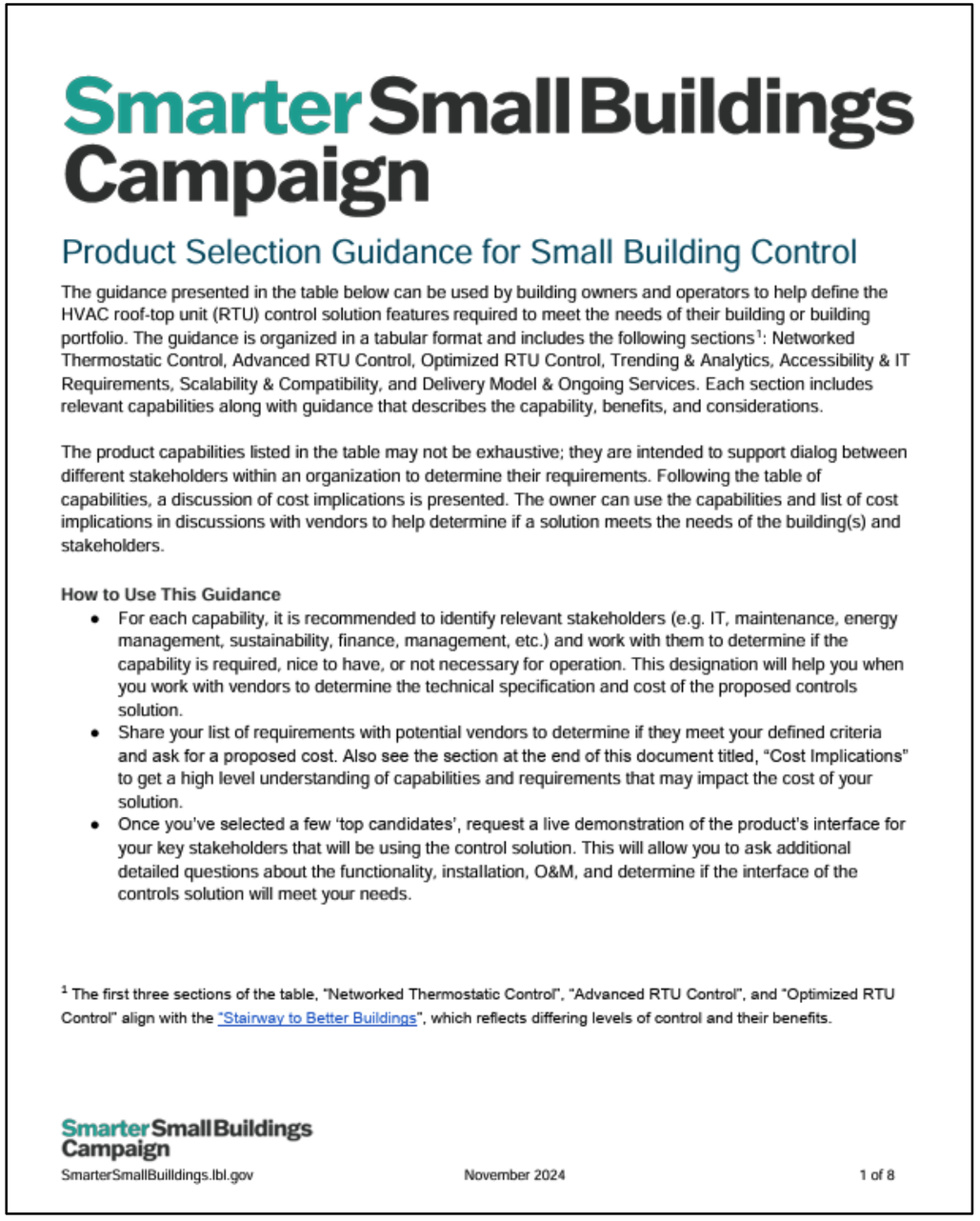
Resources

- Product Selection Guidance
- Control Guidelines for Single-Zone RTUs
- Categorized Listing of Packaged RTU Controls
- Setpoints & Scheduling for Packaged RTU Controls
- Cybersecurity Best Practices
- Cost Analysis of Rooftop Unit Controls

Available at: smartersmallbuildings.lbl.gov

Product Selection Guidance

- Helps define HVAC RTU control capabilities to meet your needs



Smarter Small Buildings Campaign

Product Selection Guidance for Small Building Control

The guidance presented in the table below can be used by building owners and operators to help define the HVAC roof-top unit (RTU) control solution features required to meet the needs of their building or building portfolio. The guidance is organized in a tabular format and includes the following sections[1]: Networked Thermostatic Control, Advanced RTU Control, Optimized RTU Control, Trending & Analytics, Accessibility & IT Requirements, Scalability & Compatibility, and Delivery Model & Ongoing Services. Each section includes relevant capabilities along with guidance that describes the capability, benefits, and considerations.

The product capabilities listed in the table may not be exhaustive; they are intended to support dialog between different stakeholders within an organization to determine their requirements. Following the table of capabilities, a discussion of cost implications is presented. The owner can use the capabilities and list of cost implications in discussions with vendors to help determine if a solution meets the needs of the building(s) and stakeholders.

How to Use This Guidance

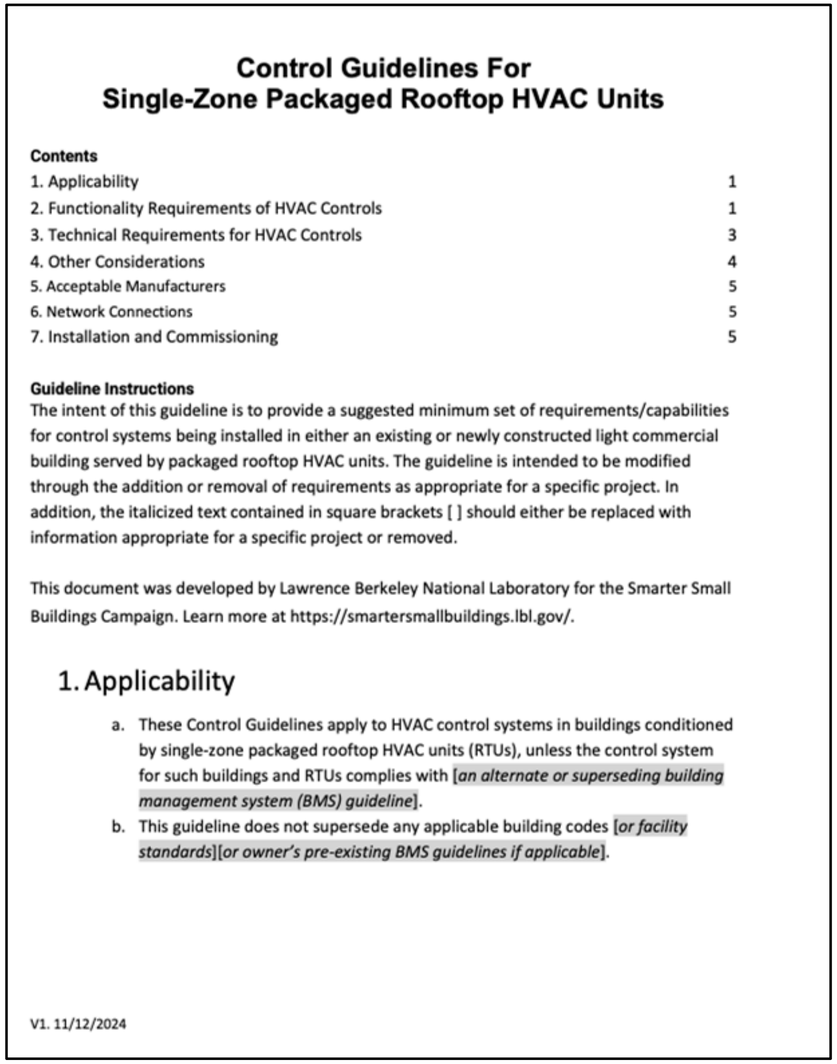
- For each capability, it is recommended to identify relevant stakeholders (e.g. IT, maintenance, energy management, sustainability, finance, management, etc.) and work with them to determine if the capability is required, nice to have, or not necessary for operation. This designation will help you when you work with vendors to determine the technical specification and cost of the proposed controls solution.
- Share your list of requirements with potential vendors to determine if they meet your defined criteria and ask for a proposed cost. Also see the section at the end of this document titled, "Cost Implications" to get a high level understanding of capabilities and requirements that may impact the cost of your solution.
- Once you've selected a few 'top candidates', request a live demonstration of the product's interface for your key stakeholders that will be using the control solution. This will allow you to ask additional detailed questions about the functionality, installation, O&M, and determine if the interface of the controls solution will meet your needs.

[1] The first three sections of the table, "Networked Thermostatic Control", "Advanced RTU Control", and "Optimized RTU Control" align with the "Stairway to Better Buildings", which reflects differing levels of control and their benefits.

Smarter Small Buildings Campaign
SmarterSmallBuildings.lbl.gov November 2024 1 of 8

Control Guidelines for Single-Zone RTUs

- Provides a minimum set of requirements and capabilities for RTU control systems
- It's editable and is intended to be adjusted to meet the needs of your project



Control Guidelines For
Single-Zone Packaged Rooftop HVAC Units

Contents

Guideline Instructions

The intent of this guideline is to provide a suggested minimum set of requirements/capabilities for control systems being installed in either an existing or newly constructed light commercial building served by packaged rooftop HVAC units. The guideline is intended to be modified through the addition or removal of requirements as appropriate for a specific project. In addition, the italicized text contained in square brackets [ ] should either be replaced with information appropriate for a specific project or removed.

This document was developed by Lawrence Berkeley National Laboratory for the Smarter Small Buildings Campaign. Learn more at https://smartersmallbuildings.lbl.gov/.

1. Applicability

a. These Control Guidelines apply to HVAC control systems in buildings conditioned by single-zone packaged rooftop HVAC units (RTUs), unless the control system for such buildings and RTUs complies with [*an alternate or superseding building management system (BMS) guideline*].

b. This guideline does not supersede any applicable building codes [*or facility standards*][*or owner's pre-existing BMS guidelines if applicable*].

V1. 11/12/2024

Categorized Listing of Packaged RTU Controls

- Categorizes control manufacturers and their respective products
- Catered to small to medium-sized commercial buildings
- Categorized by:
  - Networked Thermostatic Control
  - Advanced RTU Control
  - Light Commercial BAS
  - Demand Flex Capable

Manufacturer	Solution	Networked Thermostatic Control	Advanced RTU Control	Optimized RTU Control	Light Commercial BAS		Demand Flexibility	Components
					Integrates with Multiple-Zone HVAC Systems	Integrates with Other Energy End Uses		
Acuity Brands	Atrius and Distech Controls	✓	✓	✓	✓	✓	✓	Atrius cloud applications and data platform along with Distech Controls occupant interfaces, sensors, controllers, and displays.
Bes-Tech	Digi-RTU®		✓	✓			✓	Digi-RTU® controller, Digi-SBM® supervisory controller and gateway, one or more VFDs, temperature and CO_2 sensors, and Digi-SFT® desktop app
BrainBox AI	BrainBox AI	✓	✓	✓			✓	WiFi-enabled thermostats and BrainBox AI cloud
Carrier	ComfortVu and ComfortVu+ BACnet Thermostats	✓					✓	Requires wired BACnet MSTP network for integration into Carrier i-Vu or third-party BAS (local or cloud based) for remote access.
	Connect43 and Connect43FX BACnet and WiFi Thermostats + Connect Cloud	✓	✓	✓			✓	Connect Cloud requires connectivity to customer WiFi network. Optional wired BACnet MSTP for connectivity to Carrier i-Vu or third-party BAS for alternative remote access.
	RTU Open Advanced BACnet RTU controller + Communicating Sensors	✓	✓	✓	✓	✓	✓	Requires BACnet network for Carrier i-Vu or third-party BAS integration. Requires additional communicating controllers for control of ancillary equipment and/or zoning systems.
Cognition Controls	Smart HVAC Control Solution	✓	✓	✓				Cellular connected smart thermostat, wireless sensors, Cognition Controls web platform, and dedicated Cognition Controls support
Contemporary Controls	BASstat Thermostats + BASview3	✓						BASstat BACnet thermostat and BASview3 supervisory graphical interface
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Setpoints & Scheduling for Packaged RTU Controls

- Guidance on creating more energy-efficient setpoint schedules and operational policies

Cost Analysis of Controls for Small/Medium Buildings

- Provides an analysis of the cost of networked and advanced rooftop unit controls, as well as an overview of the utility rebates available for these types of controls projects.

Smarter Small Buildings Campaign

Cost Analysis of Networked Thermostats & Advanced Rooftop Controls for Small/Medium Buildings

Common Controls Incentives

- Smart Thermostats
- VFDs for Fans and Pumps
- Economizers
- Demand control ventilation
- Lighting and Lighting Controls
- Demand Response & Automated Demand Response

For example, Seattle City Light offers rebates for advanced rooftop control, connected thermostats, and networked lighting controls.

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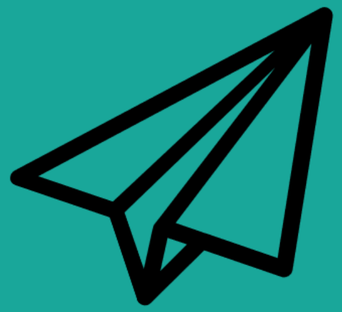
Savings Potential

While there has been no large-scale study on the potential energy savings of improved HVAC controls in small commercial buildings, there is a growing collection of case studies and limited scale reporting that indicates **savings of 10% - 20%** could be reasonably expected if improved controls were deployed at scale.

Title/Date	
Improving Operating Efficiency of Packaged Air Conditioners and Heat Pumps (PNNL 2014)	EnergyPlus simulation study of advanced control strategies for packaged rooftop HVAC units (RTUs) found that multispeed supply fan control combined with DCV resulted in HVAC energy savings (fan electricity energy consumption, cooling electricity energy consumption, and heating gas energy consumption) of 24% to 35% across four building types and 16 locations.
A Low-cost Centralized HVAC Control System Solution for Energy Savings, Load Shedding, and Improved Maintenance (UC Davis 2022)	Implementation of SWARM at UC Davis has resulted in whole building energy savings ranging from -2% to 52%, with a median savings of 28%.
Small- and Medium-Sized Commercial Building Monitoring and Controls Needs: A Scoping Study (PNNL 2012)	Case study of a controls upgrade for a 20,000 sq.ft. building. Whole building energy savings of approximately 22% were estimated using empirical models of pre- and post-upgrade building energy use.
Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction (PNNL 2017)	A simulation study was performed using Energy Plus to evaluate the energy savings that could be achieved through various energy efficiency measures (EEMs) implemented in the control system. National savings of 11% ("efficient") to 48% ("inefficient") were found for stand-alone retail buildings, and 4% ("efficient") to 31% ("inefficient") for strip mall retail buildings.
Deep Savings for Small Commercial Direct Install: A Replicable Model for High Volume, Cost Effective Energy Savings (NBI 2016)	By installing highly efficient equipment, addressing multiple measure types, and identifying as many energy savings opportunities as possible, SMUD's Complete Energy Solutions (CES) program was able to reduce customers' total electrical kWh consumption by 19% over baseline.
Scaled Deployment of Advanced Rooftop Unit (RTU) Controls in New York State (Final Report)(Energy Solutions 2019)	Report describes the energy savings achieved through the field deployment of the CATALYST advanced rooftop controller. Average RTU electricity savings of 35% were achieved across 186 units at 24 sites, and 75% of all units achieved at least 30% electricity savings per RTU.

THANK YOU!

Q+A



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References

[1] Wang, W., Katipamula, S., Huang, Y., & Brambley, M. R. (2011). *Energy savings and economics of advanced control strategies for packaged air-conditioning units with gas heat* (Report No. PNNL-20955). Pacific Northwest National Laboratory. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20955.pdf

Q & A and closing

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