Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Are We Saving Energy from Code Controls Requirements in Real Buildings?

DAVID COHAN

U.S. DEPARTMENT OF ENERGY

MICHAEL ROSENBERG

PACIFIC NORTHWEST NATIONAL LABORATORY

U.S. Department of Energy Building Energy Codes Program
Energy Codes Commentator Webinar Series
AIA Provider #: I014 AIA Course #: BECPWS417
ICC Provider Course # 11868
April 13, 2017

U.S. DEPARTMENT OF ENERGY

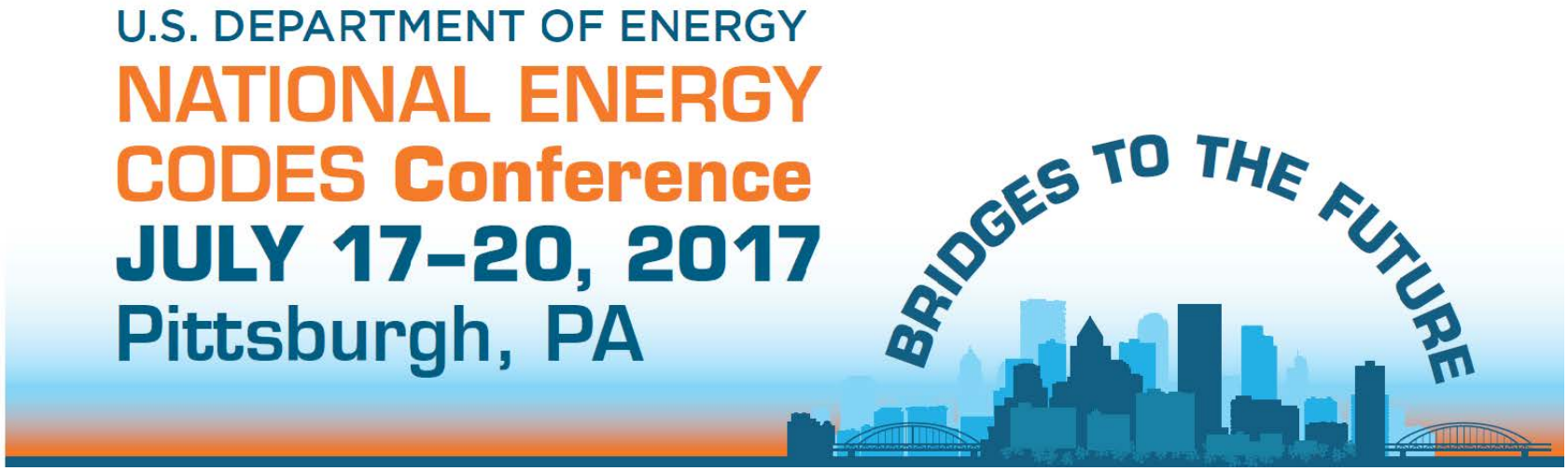
PNNL-SA-125220

CONTINUING EDUCATION AIA

ICC PREFERRED EDUCATION PROVIDER

2017 National Energy Codes Conference

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*



Registration and Information

www.energycodes.gov

Course Description

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

This webinar will examine the findings of a study that reviewed energy savings resulting from the implementation of code controls requirements in real buildings, as part of DOE's Building Energy Codes Program Energy Codes Commentator webinar series.

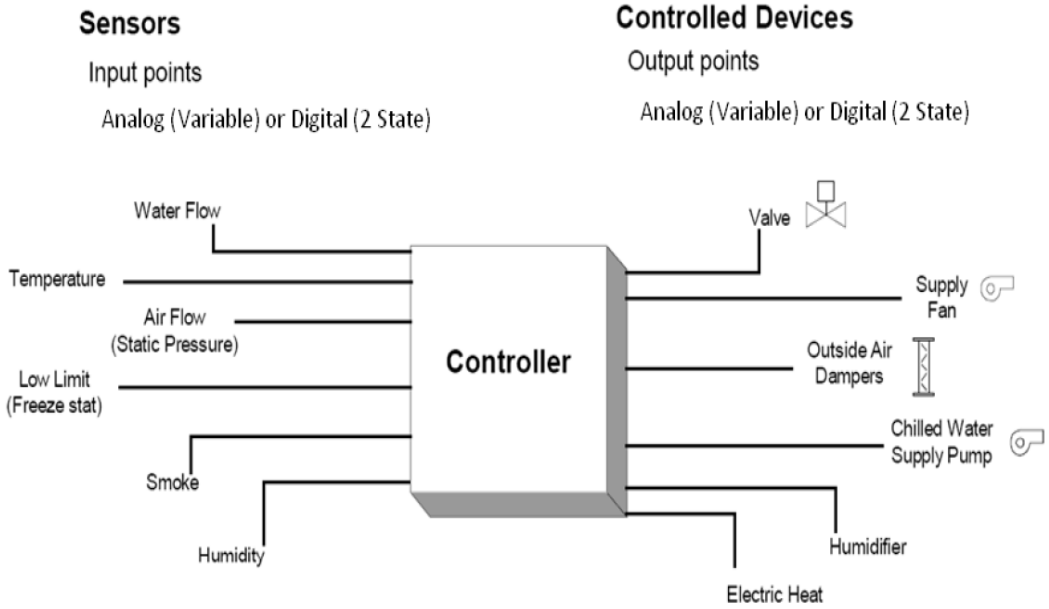
In the last four cycles of commercial energy codes, about 30% of all new requirements have been related to building controls. Estimates of energy savings from these requirements assume they are designed, installed and operating correctly despite widely-known difficulties in all of these areas. To investigate the real-life energy impact of these controls, PNNL conducted an exploratory study which included (1) interviewing commissioning agents to get a better understanding of their activities as they relate to code-required controls measures and (2) a field study of a sample of commercial buildings to determine whether the code-required control measures are being designed, commissioned, and correctly implemented and functioning in new buildings. The findings of the study will be valuable to building owners and tenants, business owners, code developers, energy planners, designers, and building officials.

Learning Objectives

- Learn about the importance of building controls in commercial energy codes.
- Identify the 14 most impactful building control measures in commercial energy codes.
- Understand the relationship of commissioning activities to commercial code control requirements.
- Understand the degree to which building controls are being designed, installed and configured according to code requirements.

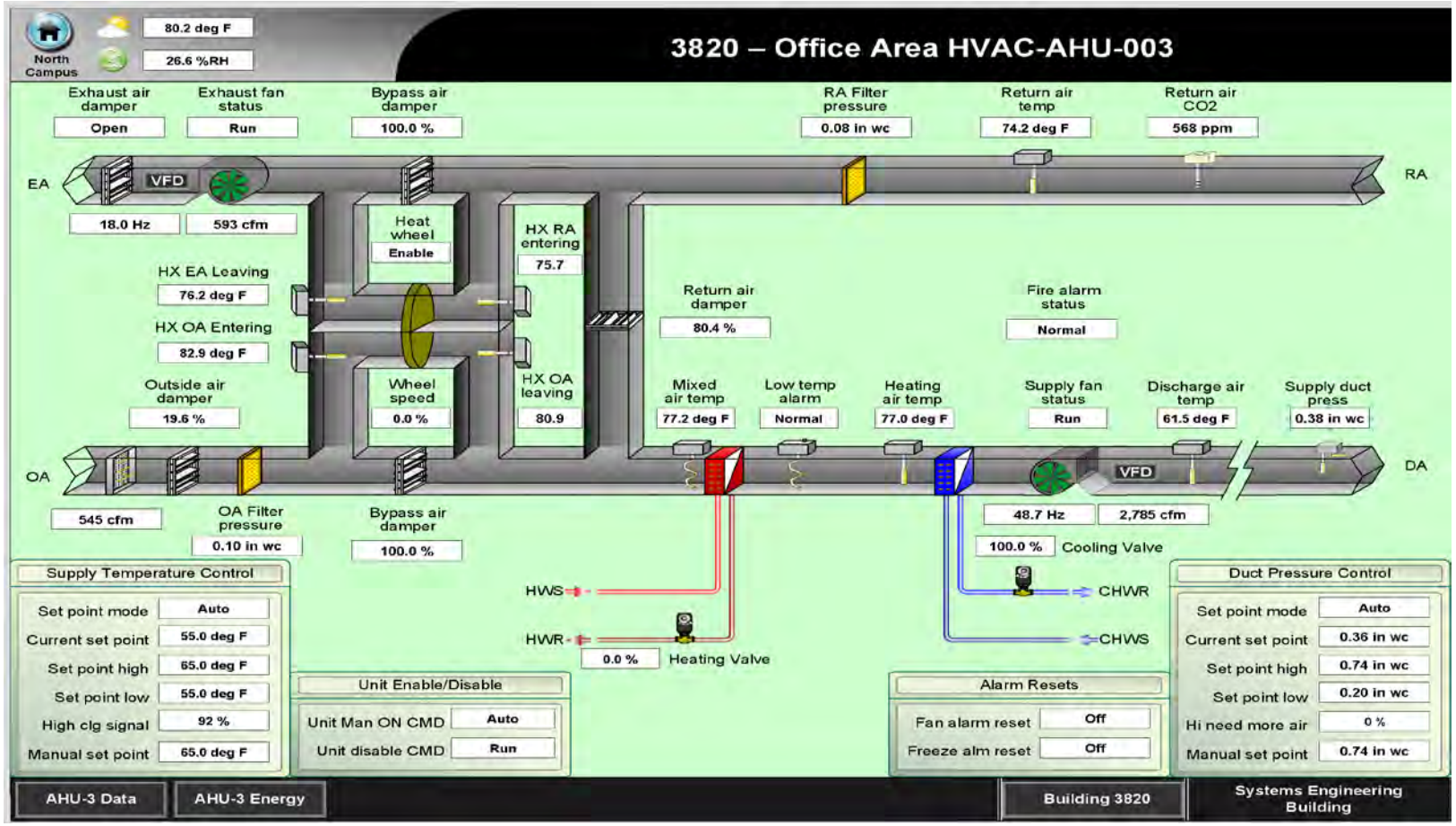
Background

- Building controls automatically adjust a building's lighting, SWH, HVAC, and sometimes even envelope systems
  - Typically in response to:
    - Environmental parameters, time schedules, or occupancy
  - Include sensors, controllers, and controlled devices



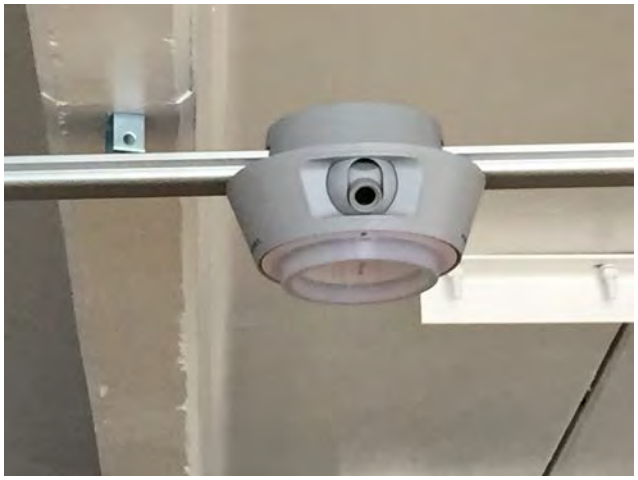
Background

- Often under the management of a building automation system



Building Controls

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle *Since 1965*



Building Controls

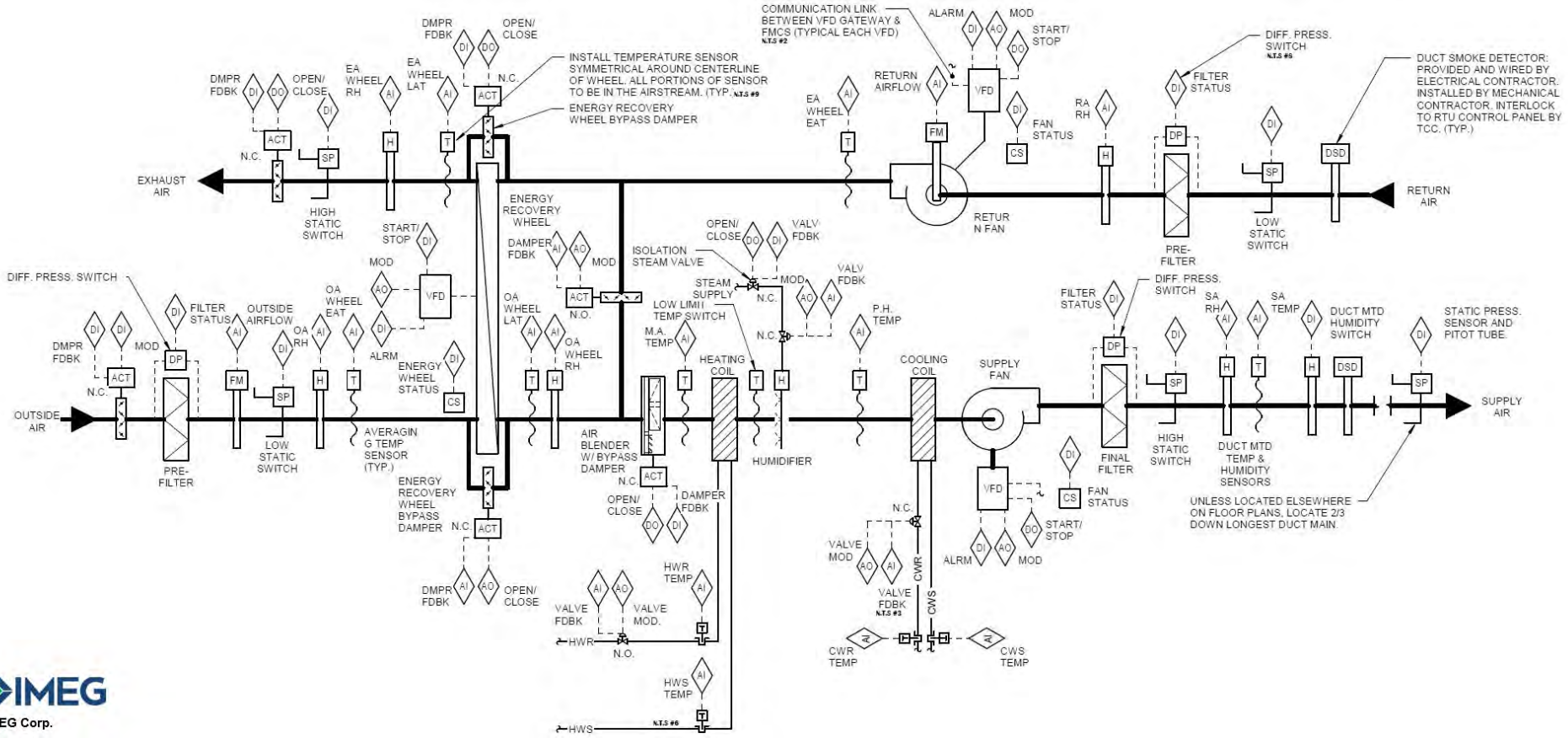
Project Introduction

- Background
  - Since 2004, about 30% of all new commercial energy code requirements have been related to building controls
  - Control requirements can be difficult to implement
  - Verification is beyond the expertise of most code officials

Controls are Complicated

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965



IMEG Corp.

Technical Approach

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- Goal: Evaluate the degree to which high-impact code controls requirements are:
  - Properly designed and
  - Implemented in new buildings

Identify Requirements

- 14 most impactful code controls requirements

Survey Cx Agents

- Understand the relationship of Cx to code controls requirements

Field Study

- Assess the design and implementation of control requirements in 24 new buildings

Control Measures Evaluated

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- A survey of ASHRAE Standard 90.1-2013 and the 2015 IECC identified 90 requirements related to controlling building systems or equipment
- Related requirements were grouped into measures
  - Example: Thermostat setback controls
    - Thermostats must have temperature setback when spaces are unoccupied (ex. 55° F heating, 85° F cooling)
    - Programmable controls that start/stop HVAC fan systems with at least 7 schedules
    - Manual unoccupied override for maximum of 2 hours
- Resulted in 51 measures
- Ranked independently by 6 experts for:
  - Applicability in buildings
  - Energy impact of non-compliance
  - Likelihood of non-compliance

14 Highest Ranked Control Measures Selected

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

	Abbreviation	Control Measure Description
HVAC	TstatDdBnd	Five degree thermostat deadband and setpoint overlap prevention
	EconoInt	Economizer integration and/or high limit controls
	TstatSetbk	Off-hour automatic temperature setback and system shutoff (fan cycling) with manual override
	DCV	Demand controlled ventilation
	AutoDamp	Automatic outdoor air damper controls
	OptStart	Optimum start controls
	ZoneIso	Zone isolation controls
	SimultHtCl	Limits on simultaneous heating and cooling - airside
	SP-Reset	Fan static pressure reset controls
	SAT-Reset	Supply air temperature reset - reheat systems
Lighting	OccSenLtg	Occupant-based interior lighting controls
	DayLtgCtl	Daylighting controls implemented correctly when required
	ExtLtgCtl	Exterior lighting controls
	IntLtgCtl	Occupant-based interior lighting controls

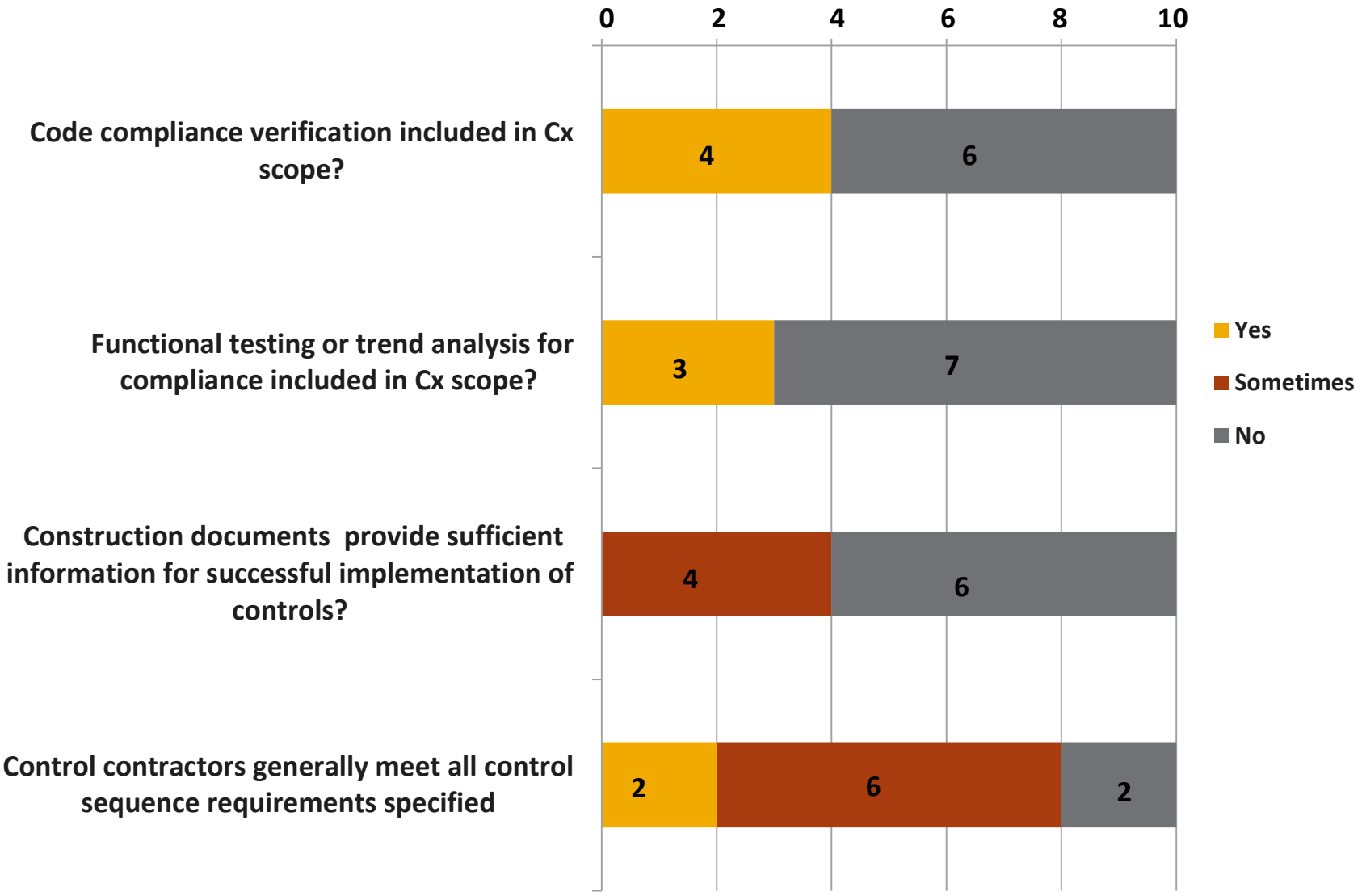
Commissioning Agent Survey

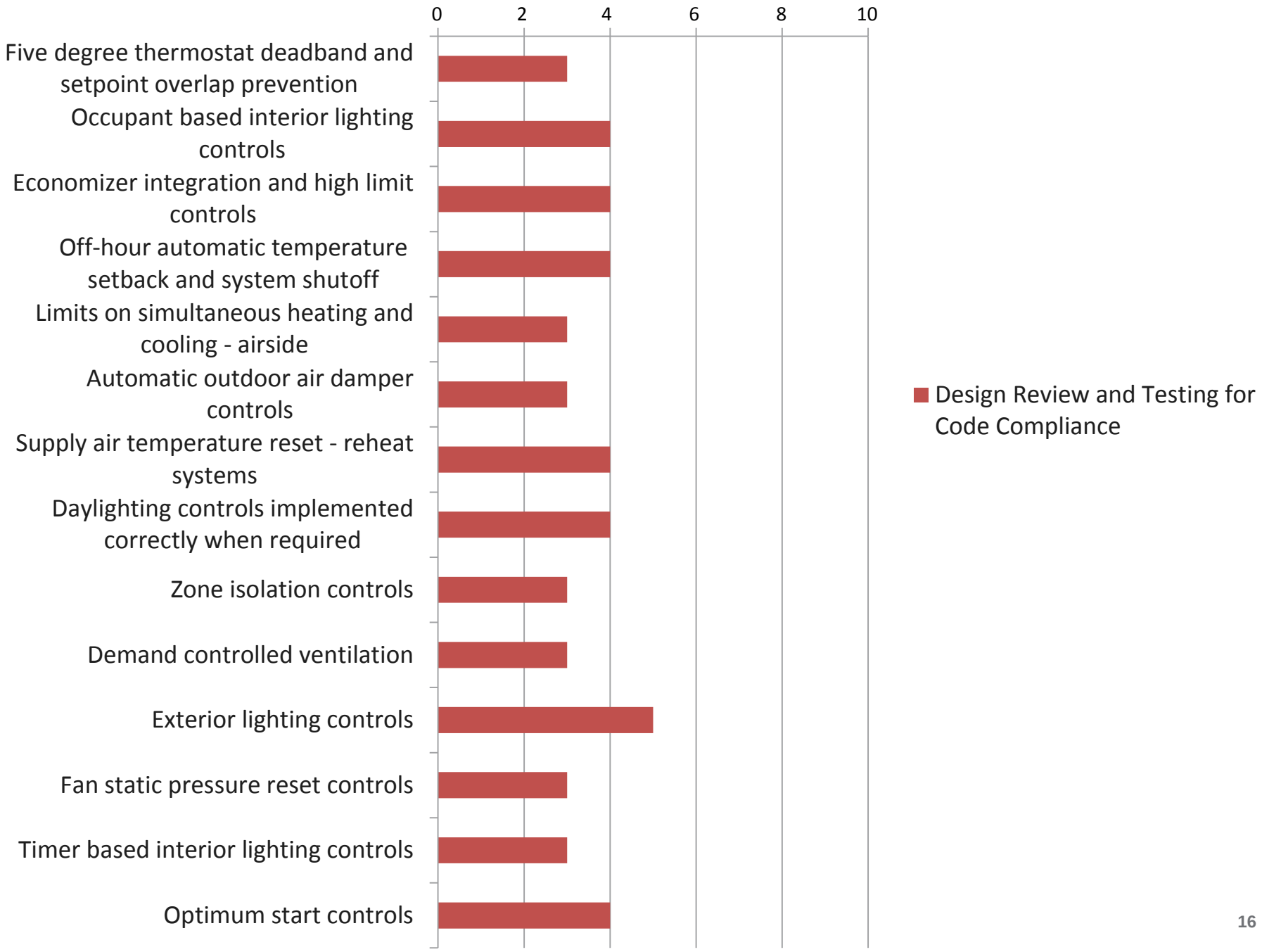
Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

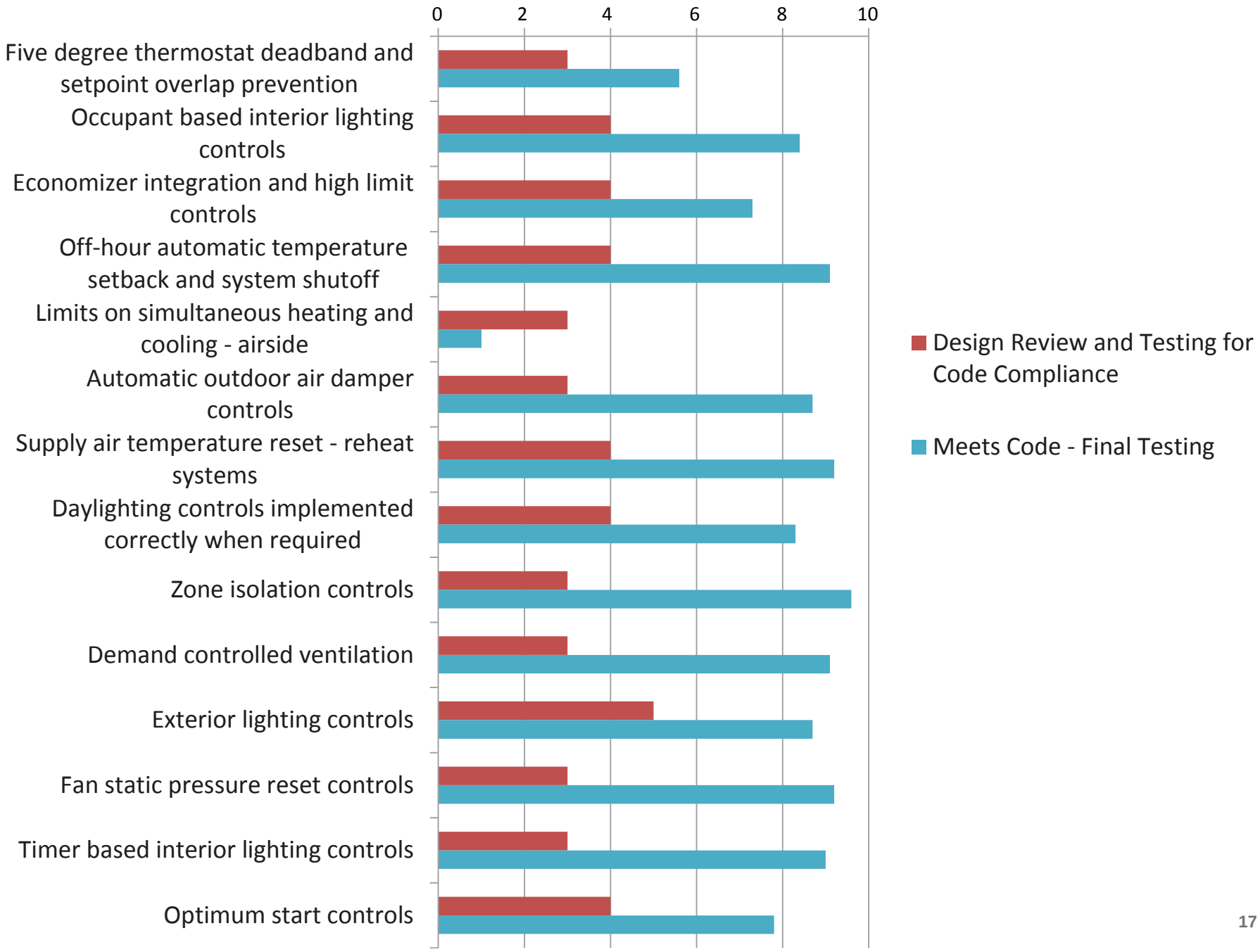
- 10 Experienced commissioning agents (CxA) surveyed
  - Representing 7 States and one Canadian province
  - Average of 215 buildings commissioned each
- Surveyed on:
  - The extent of their services regarding code required controls
  - Their knowledge of code required controls
  - Their findings regarding code required controls in design documents and final construction
  - Their thoughts on the greatest impediments to successful inclusion of code required controls

Commissioning Survey – Commissioning Scope

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

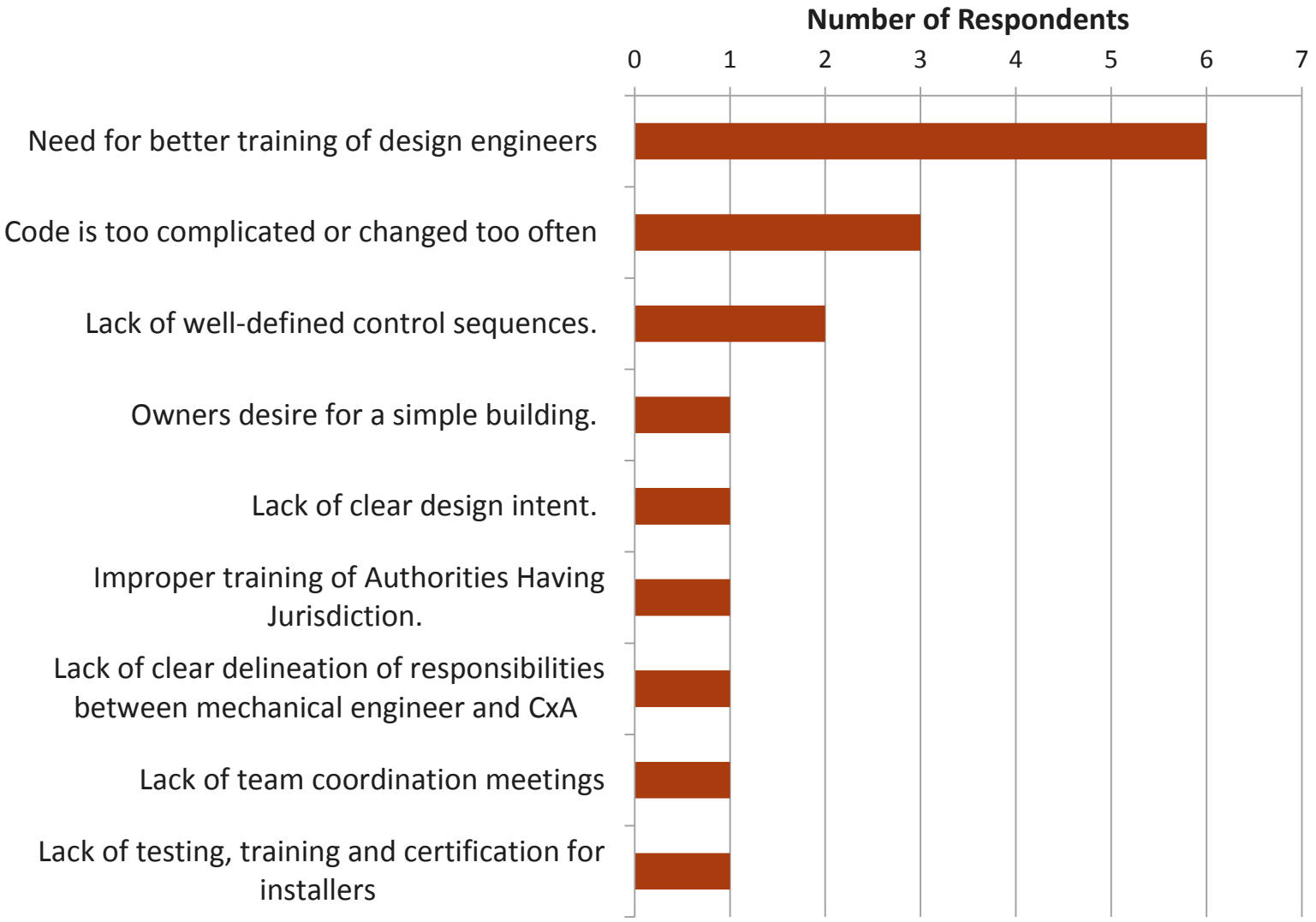



0
2
4
6
8
10
Five degree thermostat deadband and setpoint overlap prevention
Occupant based interior lighting controls
Economizer integration and high limit controls
Off-hour automatic temperature setback and system shutoff
Limits on simultaneous heating and cooling - airside
Automatic outdoor air damper controls
Supply air temperature reset - reheat systems
Daylighting controls implemented correctly when required
Zone isolation controls
Demand controlled ventilation
Exterior lighting controls
Fan static pressure reset controls
Timer based interior lighting controls
Optimum start controls
Design Review and Testing for Code Compliance


0
2
4
6
8
10
Five degree thermostat deadband and setpoint overlap prevention
Occupant based interior lighting controls
Economizer integration and high limit controls
Off-hour automatic temperature setback and system shutoff
Limits on simultaneous heating and cooling - airside
Automatic outdoor air damper controls
Supply air temperature reset - reheat systems
Daylighting controls implemented correctly when required
Zone isolation controls
Demand controlled ventilation
Exterior lighting controls
Fan static pressure reset controls
Timer based interior lighting controls
Optimum start controls
Design Review and Testing for Code Compliance
Meets Code - Final Testing

Commissioning Survey - Impediments to Successful Implementation

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



Field Study

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- 24 buildings:
  - 4 Office
  - 1 Fitness Center
  - 2 Dormitory
  - 2 Retail
  - 3 Medical Office
  - 2 Hospital
  - 9 Education: Higher Ed & K-12
  - 1 Multipurpose (studio, cafe, office, hot yoga)
- Size range
  - from 10,000 to 240,000 square feet
  - Median size of 70,000 square feet
- Six states, 3 climate zones

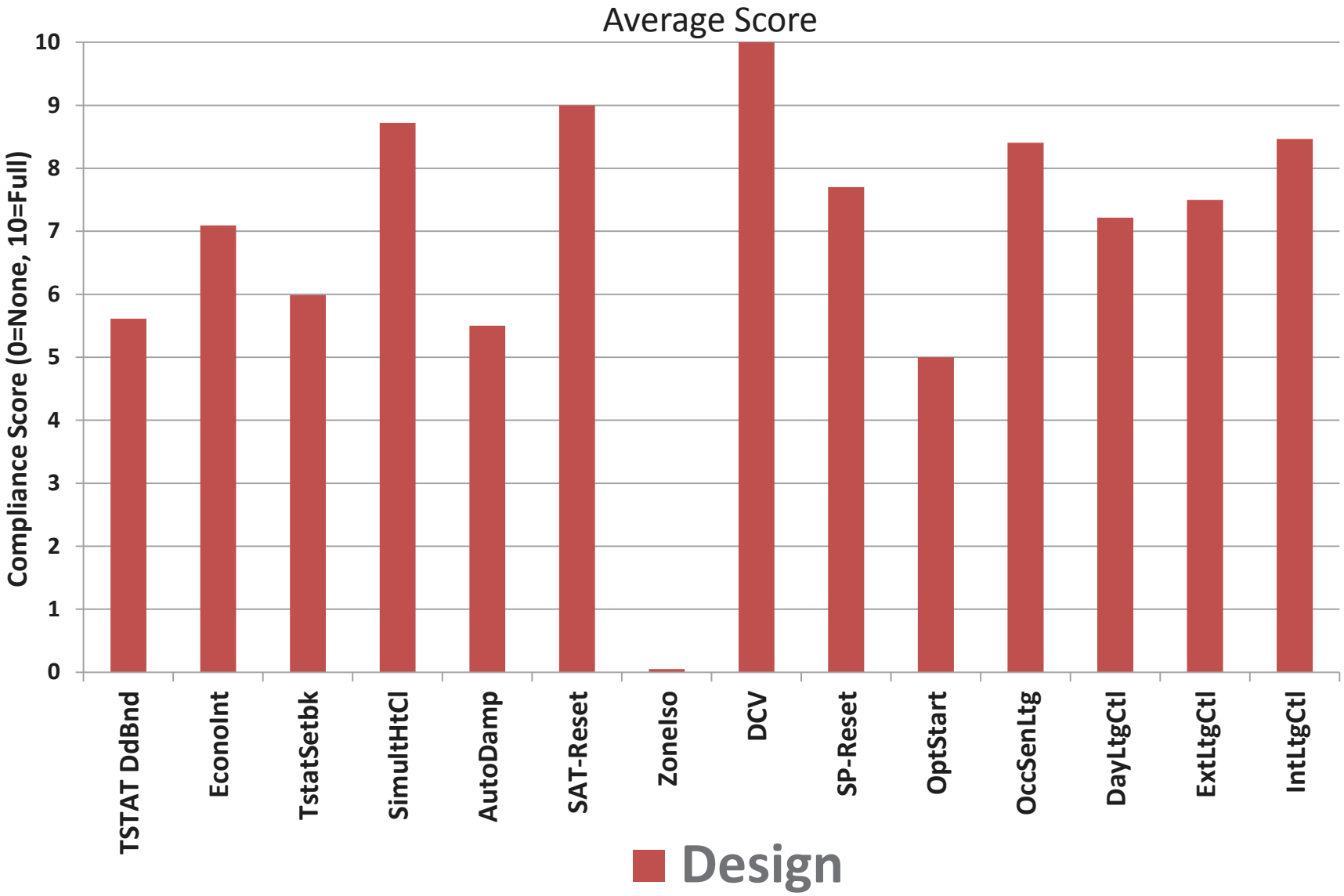
Location (State)	Climate Zone	No. of Buildings
Colorado	5B	1
Idaho	5B	3
Oregon	4C	4
Utah	5B	6
Washington	4C	2
Washington	5B	4
Wyoming	6B	4

Field Study

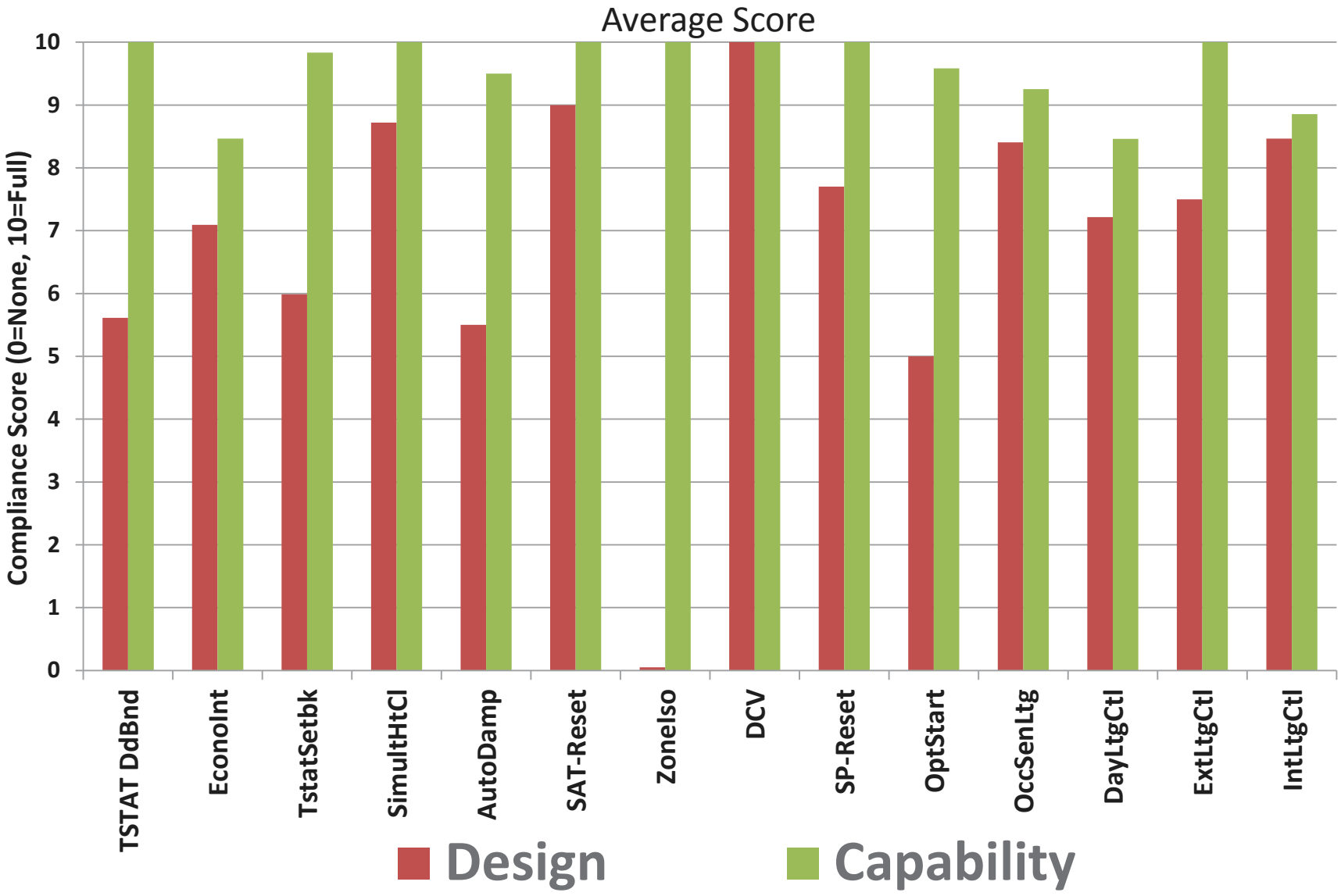
- 14 Measures evaluated from three perspectives
  - How well the requirement is included in design documents (**design**)
  - The capability of the installed components to achieve the code described controls sequence (**capability**)
  - How the building controls are implemented (**configuration**)
- Each measure scored for each perspective from zero to ten
  - Zero indicates complete non-compliance
  - Ten indicates fully compliant or exceeding compliance
  - Scores between zero and ten based on field observation and scoring system
- Scoring example –thermostat setback controls
  - Heating setpoint 55° F, cooling 85° F – Full range (30° offset) = 8 points, 15° offset = 4 points, no offset = 0 points
  - Manual override required –1 point if override included
  - 7-day programming required –1 point if included

Field Study Measure Results

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

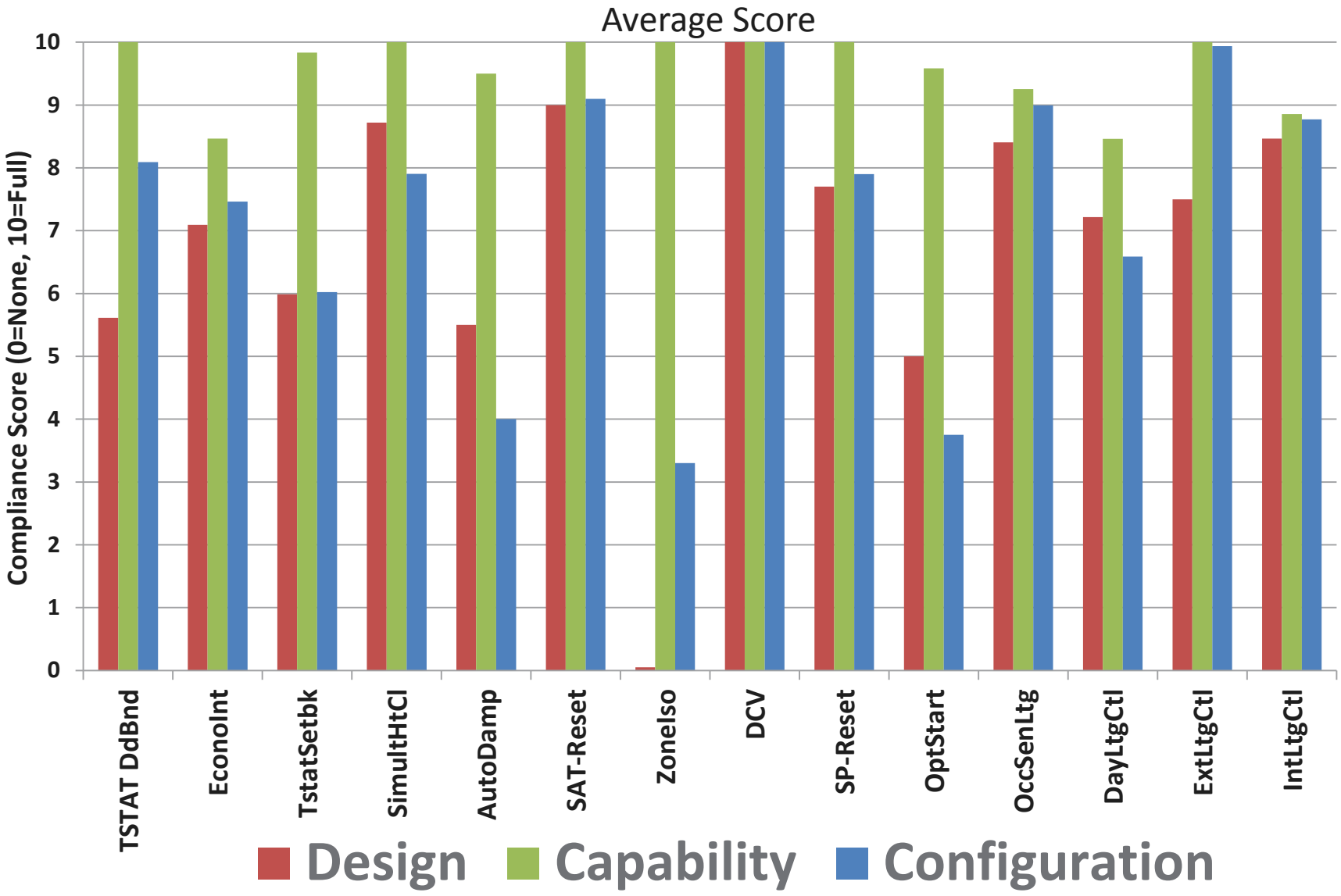


Field Study Measure Results



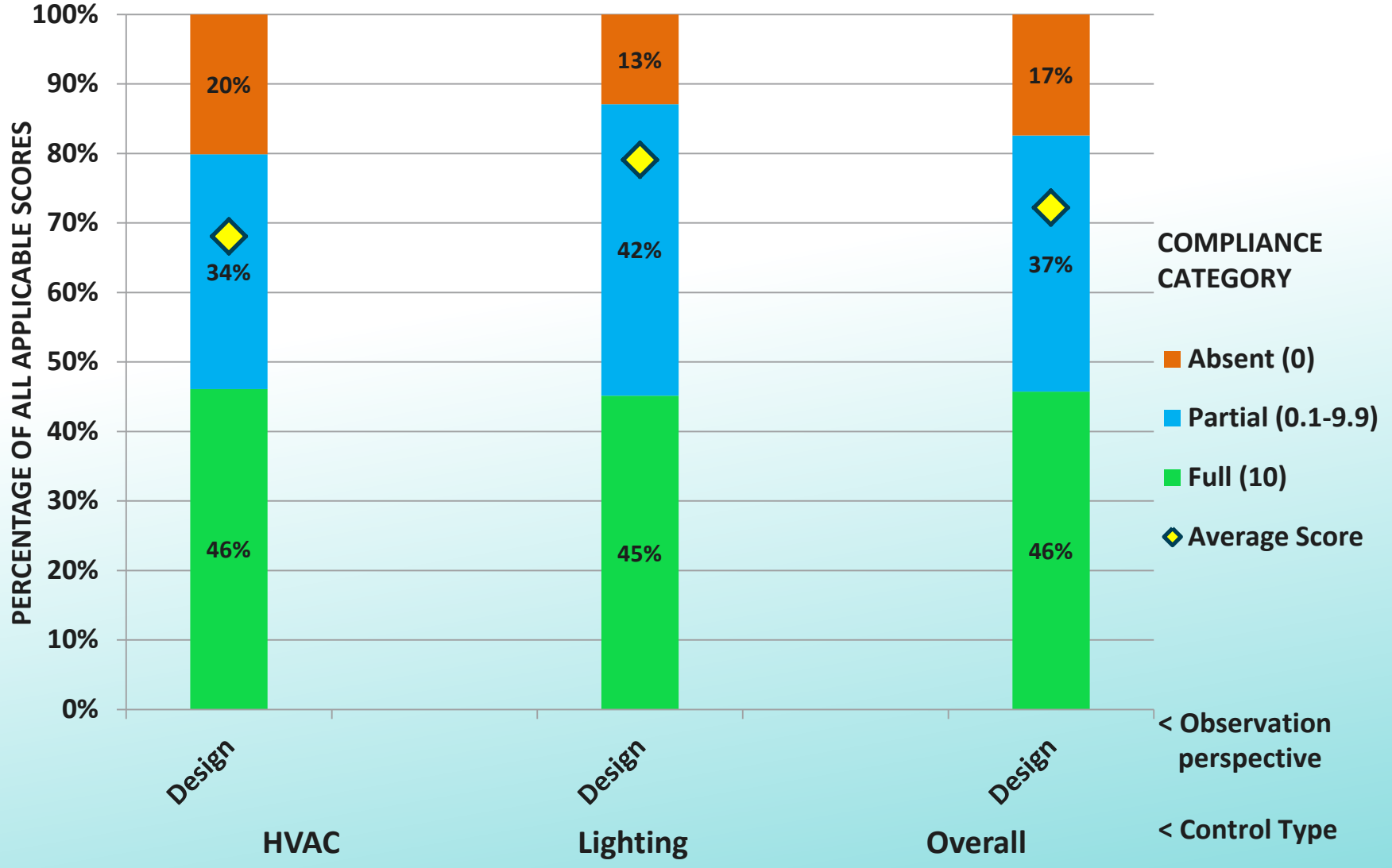
Field Study Measure Results

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



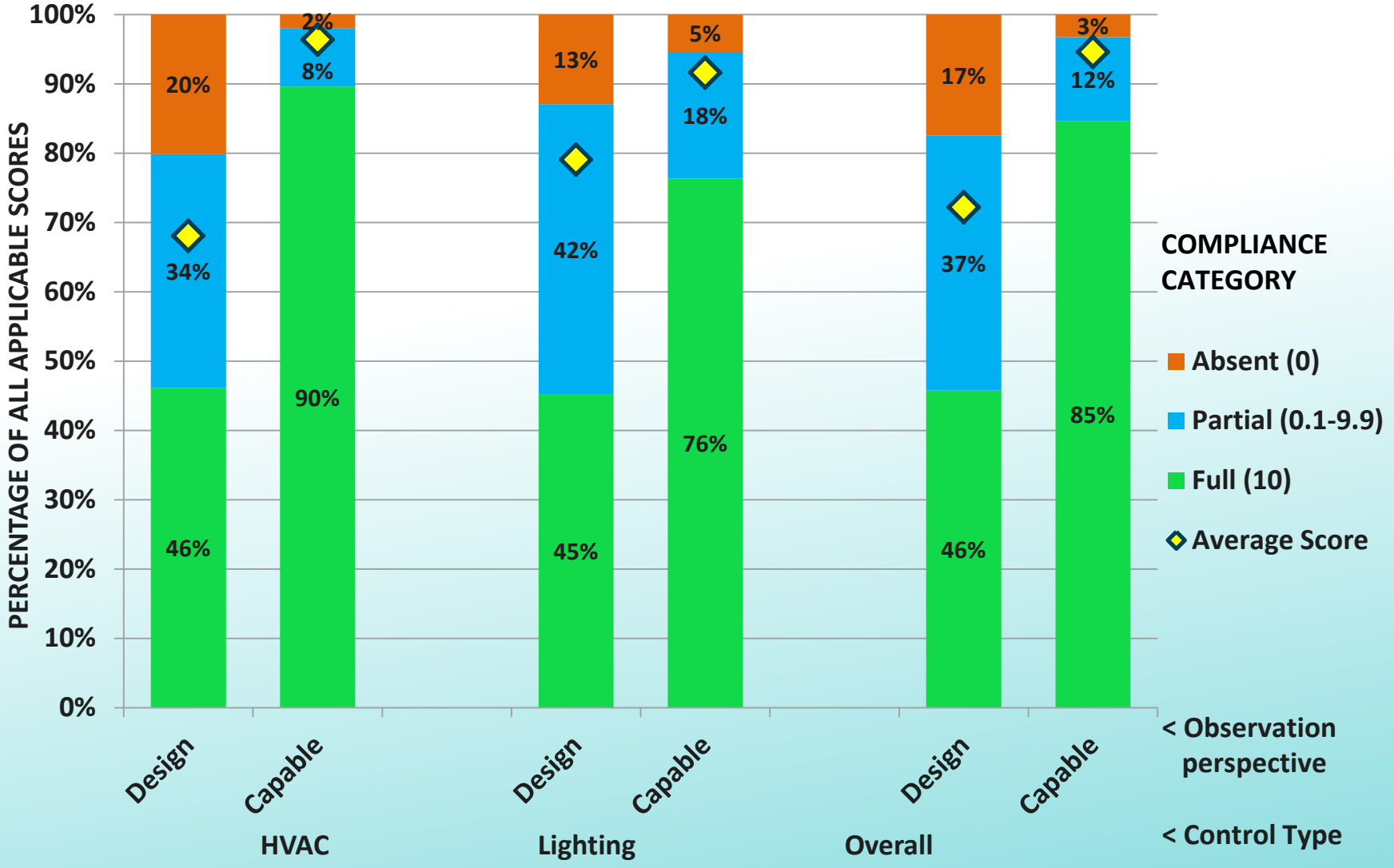
Field Study Group Results

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



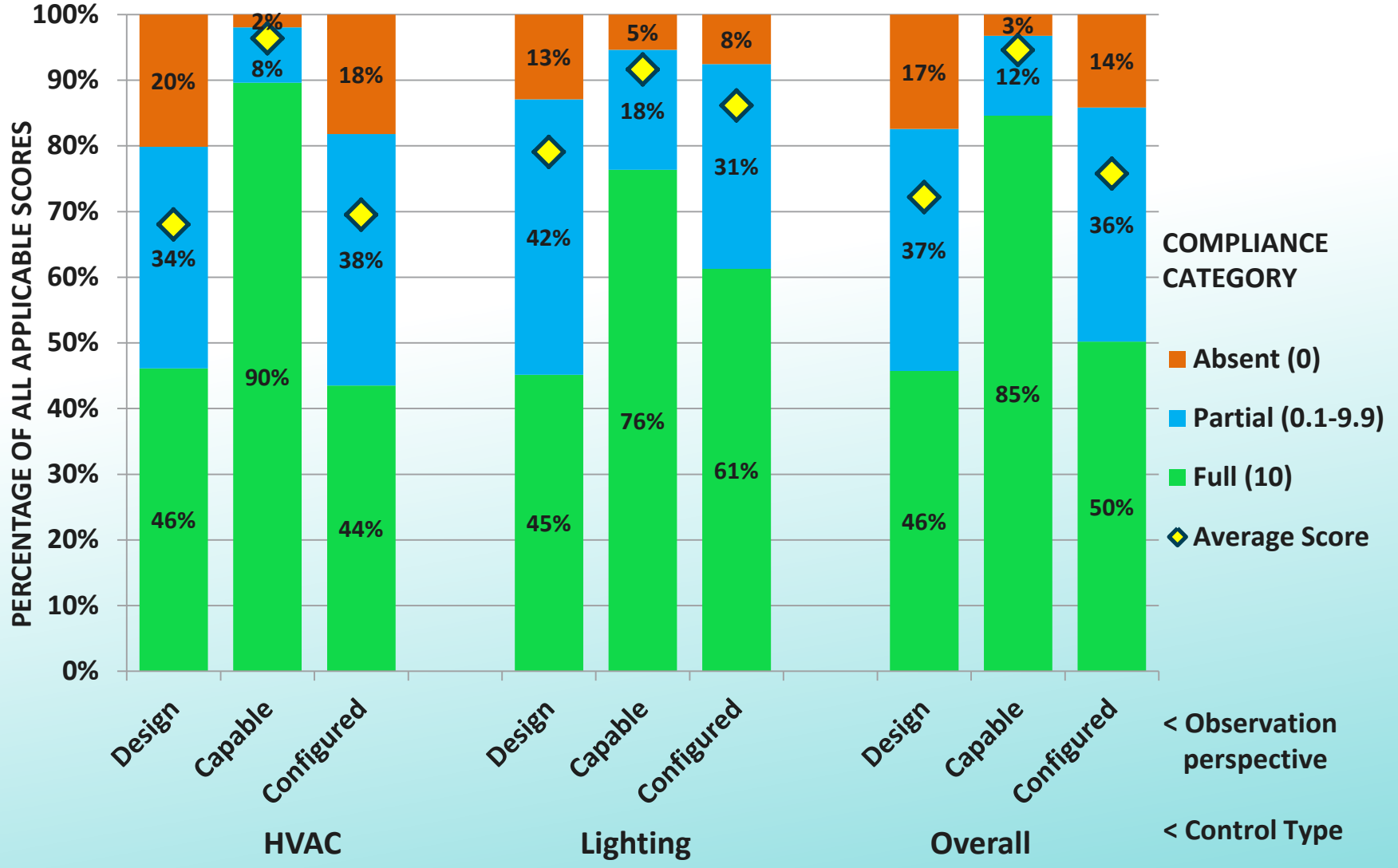
Field Study Group Results

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



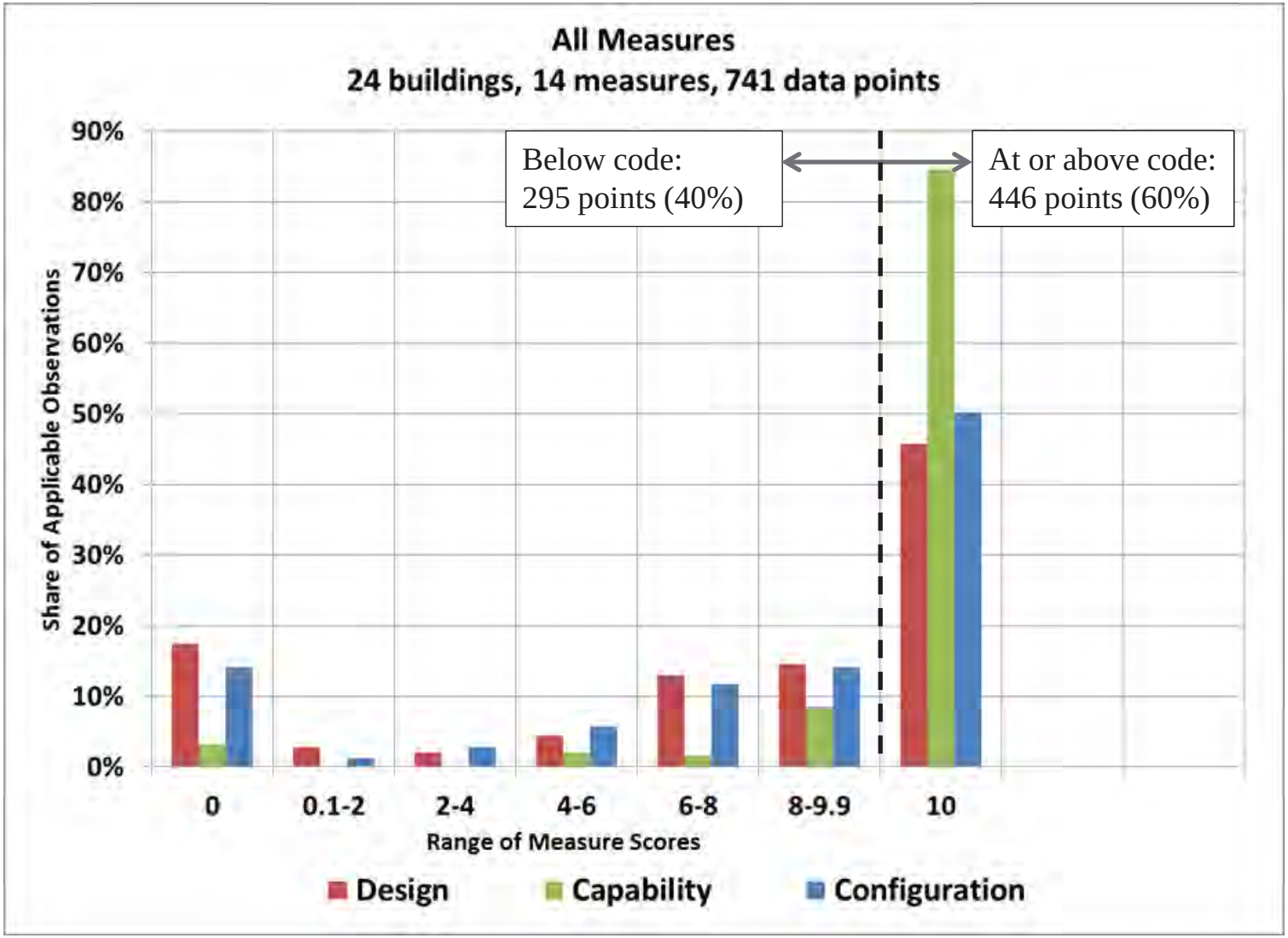
Field Study Group Results

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



Field Study
Compliance Score Distribution

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



Energy Cost Impact of Non-Compliance

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- *What is the energy or energy cost impact of the variation between how these buildings are being operated and the code?*
  - Approximation based on several previous PNNL studies using prototype building simulations (1,2)
    - Did not always match the climate zone (some national averages)
    - Did not always match building type (some savings based on office occupancy were assigned to other building types)

1. Rosenberg, M., R. Hart, R. Athalye, J.Zhang, W. Wang, B. Liu, 2016. *An Approach to Assessing Potential Energy Cost Savings from Increased Energy Code Compliance in Commercial Buildings*. PNNL-24979. Richland, Washington: Pacific Northwest National Laboratory.
2. Fernandez, N., S. Katipamula, W. Wang, Y. Huang, G. Liu. *Energy Savings Modeling of Standard Commercial Building Retuning Measures: Large Office Buildings*. PNNL-21569. Richland, Washington: Pacific Northwest National Laboratory

Energy Cost Impact of Non-Compliance

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Approximate Lost Savings from Non-Compliance for 24 Buildings

Measure Category	Lost Savings Total Sample	Lost Savings per Building	Lost Savings ($/thousand ft^2-yr)
HVAC	$288,000	$12,000	$160
Lighting	$14,000	$570	$8
Overall	$302,000	$12,570	$168

*If the code required controls were correctly configured in the sample, a total of ~$302,000 in energy cost could have been saved. Or ~12% of total building energy cost.

Conclusions

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Are We Saving Energy from Code Controls Requirements in Real Buildings?

YES!

Conclusions

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

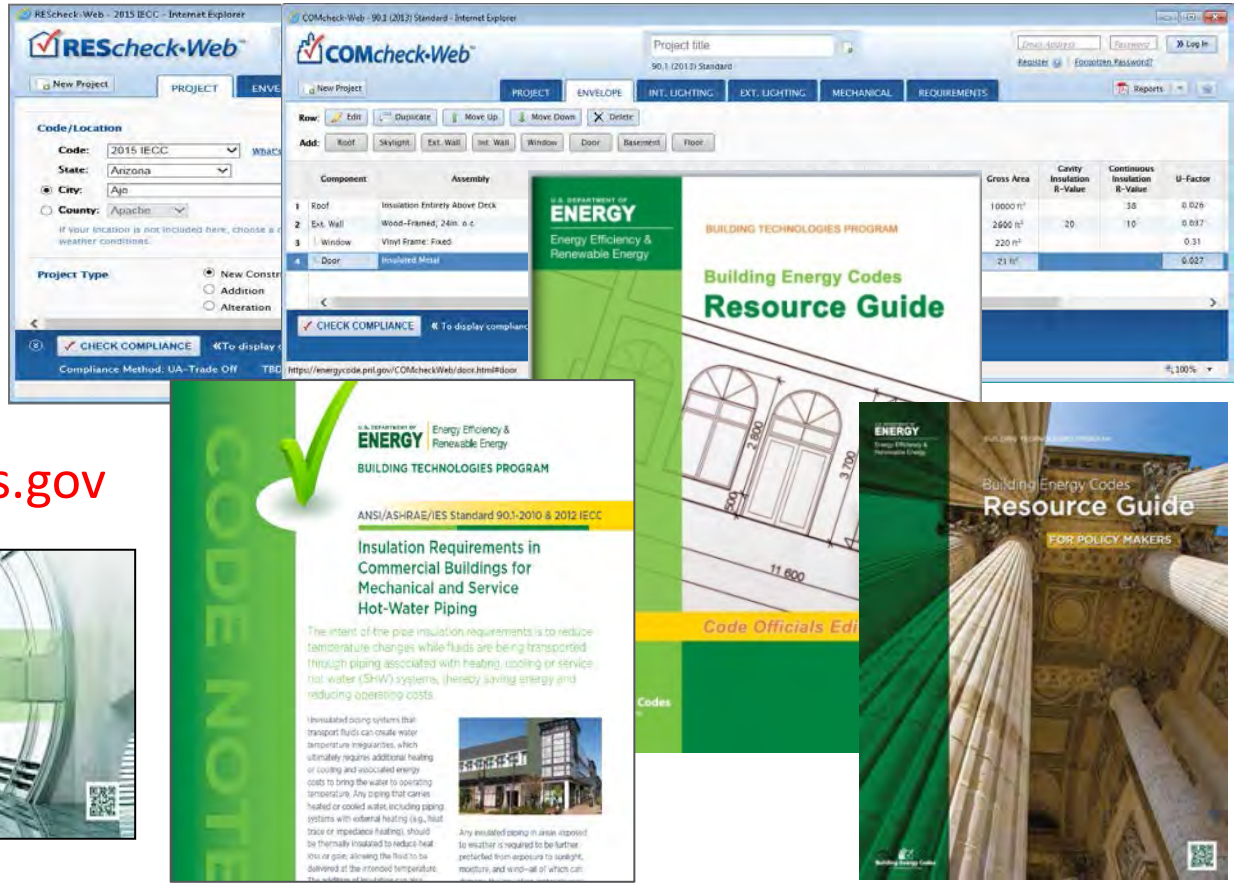
- Commissioning Agent Surveys
  - Verifying code compliance is not in Cx agent's scope
  - Poor documentation of control requirements from designers
  - CxA believe code controls are successfully implemented in most cases (**60%**)
- Field Study Results
  - Requirements adequately specified in design documents are more likely to be implemented successfully
  - Control requirements were **capable** of compliance in **85%** of observations, but successfully **configured** in only **50%** of observations
  - Substantial energy cost could be recovered if implementation (configured) is improved ~$168/1000ft^2/yr or 12% of energy cost

U.S. DOE: Building Energy Codes Program Resources

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- Compliance software
- Technical support
- Code notes
- Publications
- Resource guides
- Training materials

www.energycodes.gov



Thank you

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Implementation of Energy Code Controls Requirements in New Commercial Buildings

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26348.pdf

Building Energy Codes Program

www.energycodes.gov/training

BECP help desk

https://www.energycodes.gov/HelpDesk

CONTINUING EDUCATION AIA

ICC PREFERRED EDUCATION PROVIDER

Questions

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

U.S. DEPARTMENT OF
ENERGY