Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Roadmap Towards A Predictive Performance-based Commercial Code

BING LIU, P.E.
PROGRAM MANAGER, BUILDING ENERGY CODES

Pacific Northwest National Laboratory

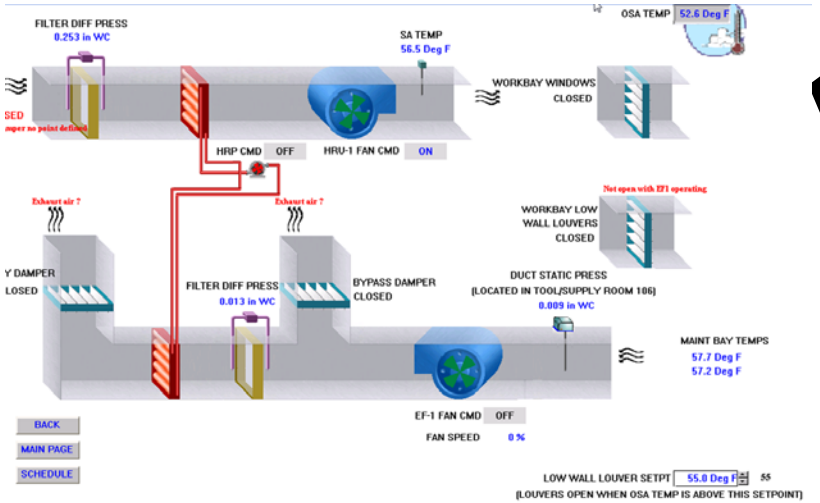
DOE National Energy Codes Conference 2015

U.S. DEPARTMENT OF
ENERGY

Big Picture:
Purpose of Energy Codes?

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

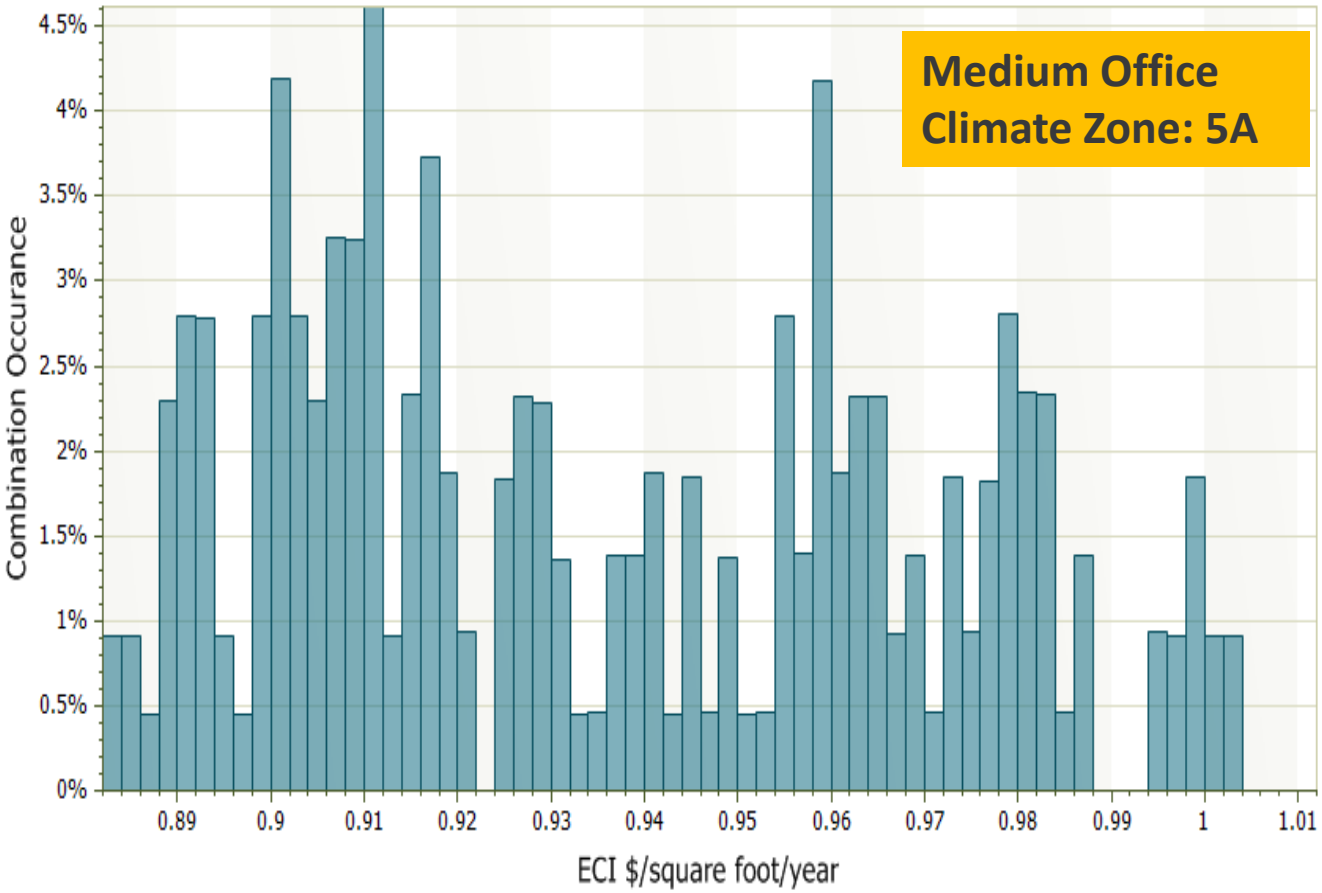
- **Design and construct for energy efficiency**
- Configure to operate as designed for energy efficiency
- Maintain long term energy performance verified by actual energy use



Where is the Commercial Code Now?

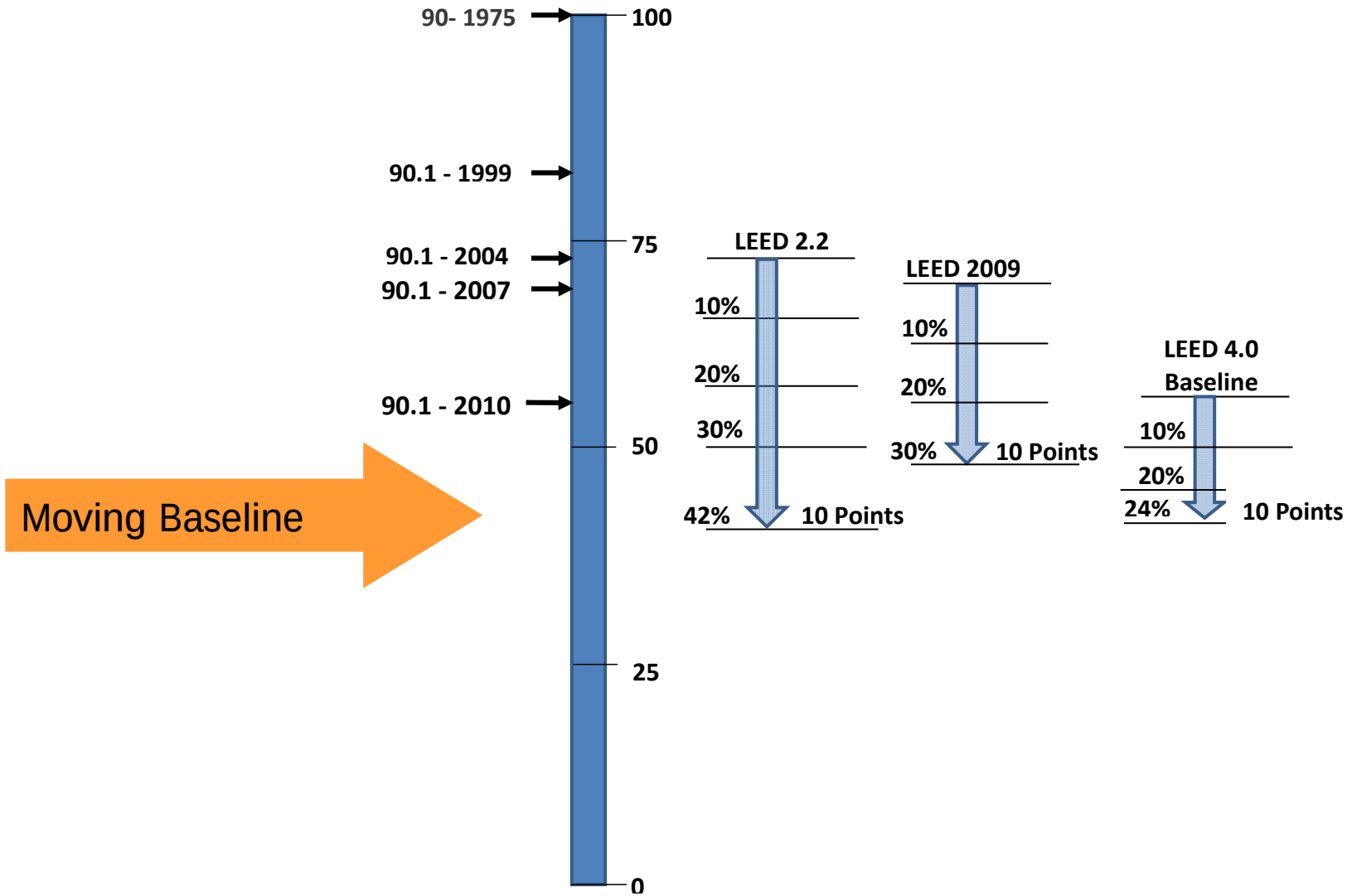
- A code led by prescriptive requirements with an under used performance path
- Prescriptive requirements are set individually at the limit of cost-effectiveness
- A performance path that follows prescriptive requirements
- Compliance verified only to the certificate of occupancy

Problem 1:
Energy Use Varies with Designs



- WWR: 25% vs. 40%
- Roof insulation: above deck vs. below deck
- Wall type: steel frame vs. mass
- Window: metal vs. non-metal
- Heat source: electric vs. natural gas
- HVAC size: small vs. large

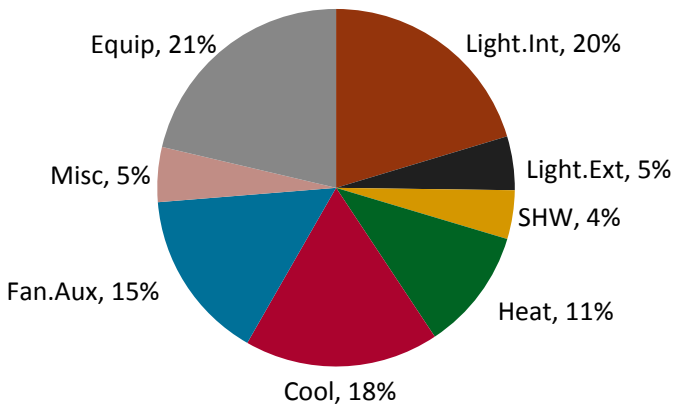
Problem 2:
Baseline is a Moving Target



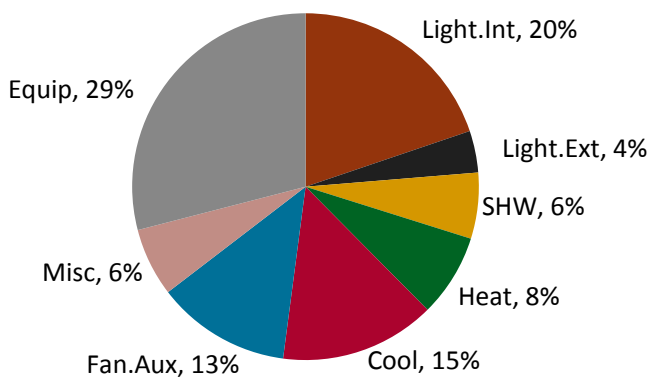
Normalized Building Energy Use for Versions of Standard 90.1

Problem 3:
Increased Unregulated Loads

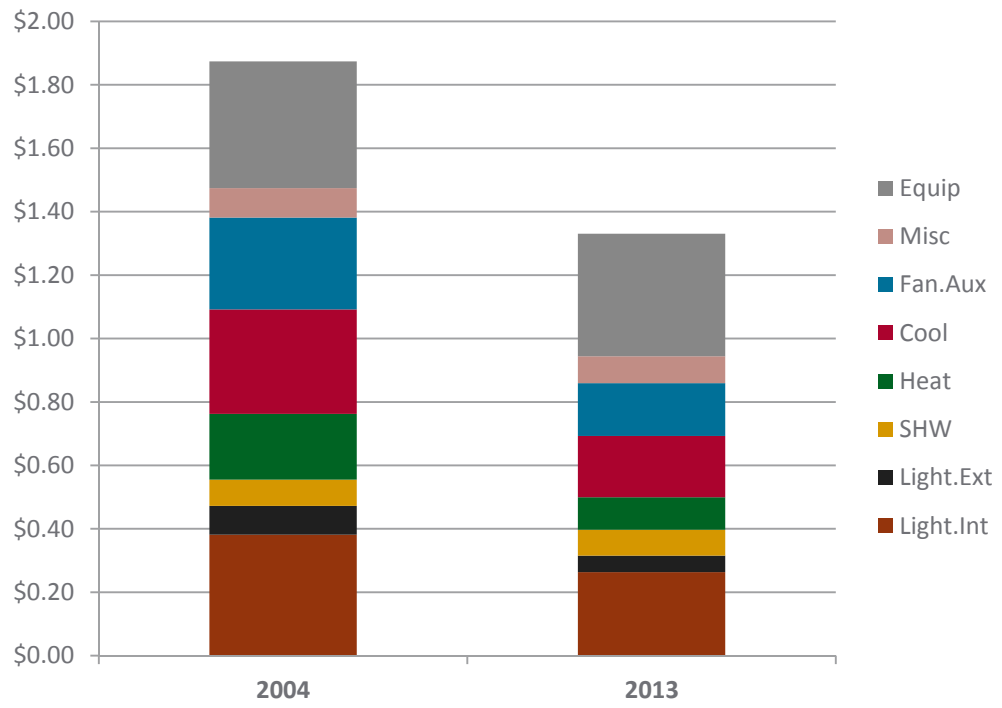
90.1-2004



90.1-2013

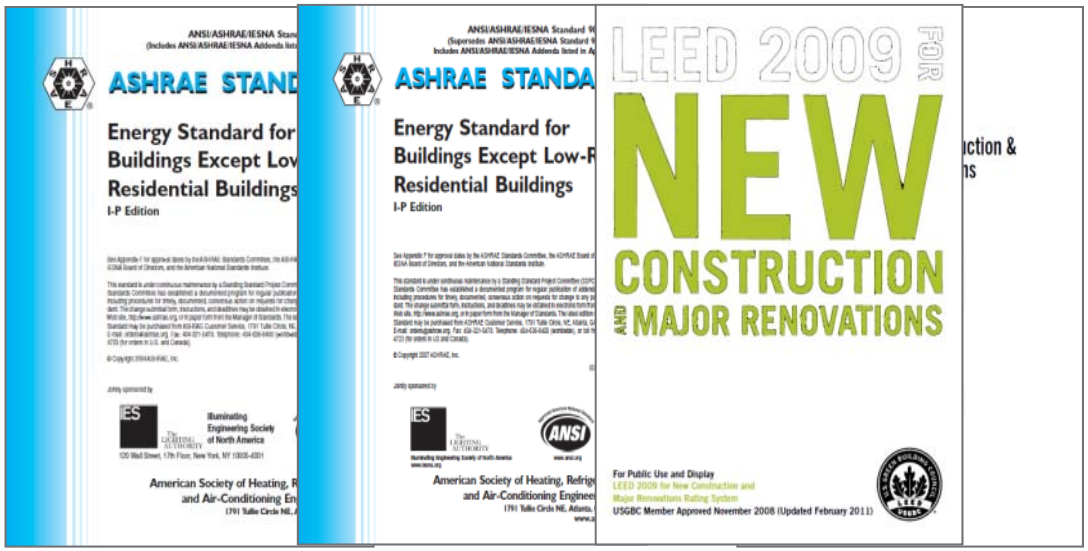


Energy Cost Index



Problem 4:
Too Many Performance Methods

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



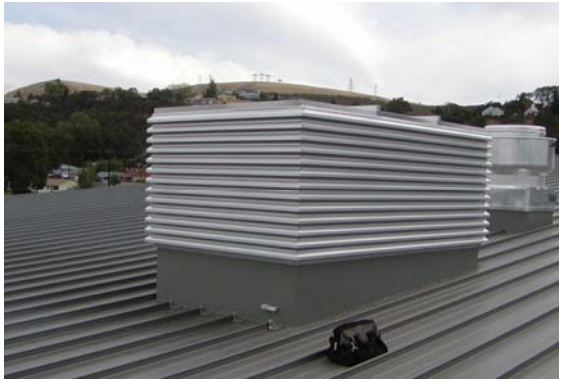
Use	Performance Method
Energy Code Compliance for 3 States	2001 Energy Cost Budget
Energy Code Compliance for 4 States	2004 Energy Cost Budget
Energy Code Compliance for 26 States	2007 Energy Cost Budget
Maryland Energy Code , Washington State Energy Code	2010 Energy Cost Budget
Florida Energy Code	2007 Energy Cost Budget (modified)
LEED Version 2.2	2004 Performance Rating Method
LEED 2009	2007 Performance Rating Method
LEED Version 4	2010 Performance Rating Method
2012 International Green Construction Code	2010 Performance Rating Method (modified)
FEMP (Projects beginning before August 10, 2012)	2004 Performance Rating Method (modified)
FEMP (Projects beginning on or after August 10, 2012)	2007 Performance Rating Method (modified)
ASHRAE Standard 189.1-2009	2007 Performance Rating Method (modified)
ASHRAE Standard 189.1-2011	2010 Performance Rating Method (modified)
Commercial Building Federal Tax Incentives	2004 Performance Rating Method (modified)

Problem 5:
Buildings Don't Perform as Designed

Building controls in energy codes are responsible for an increasing amount of savings

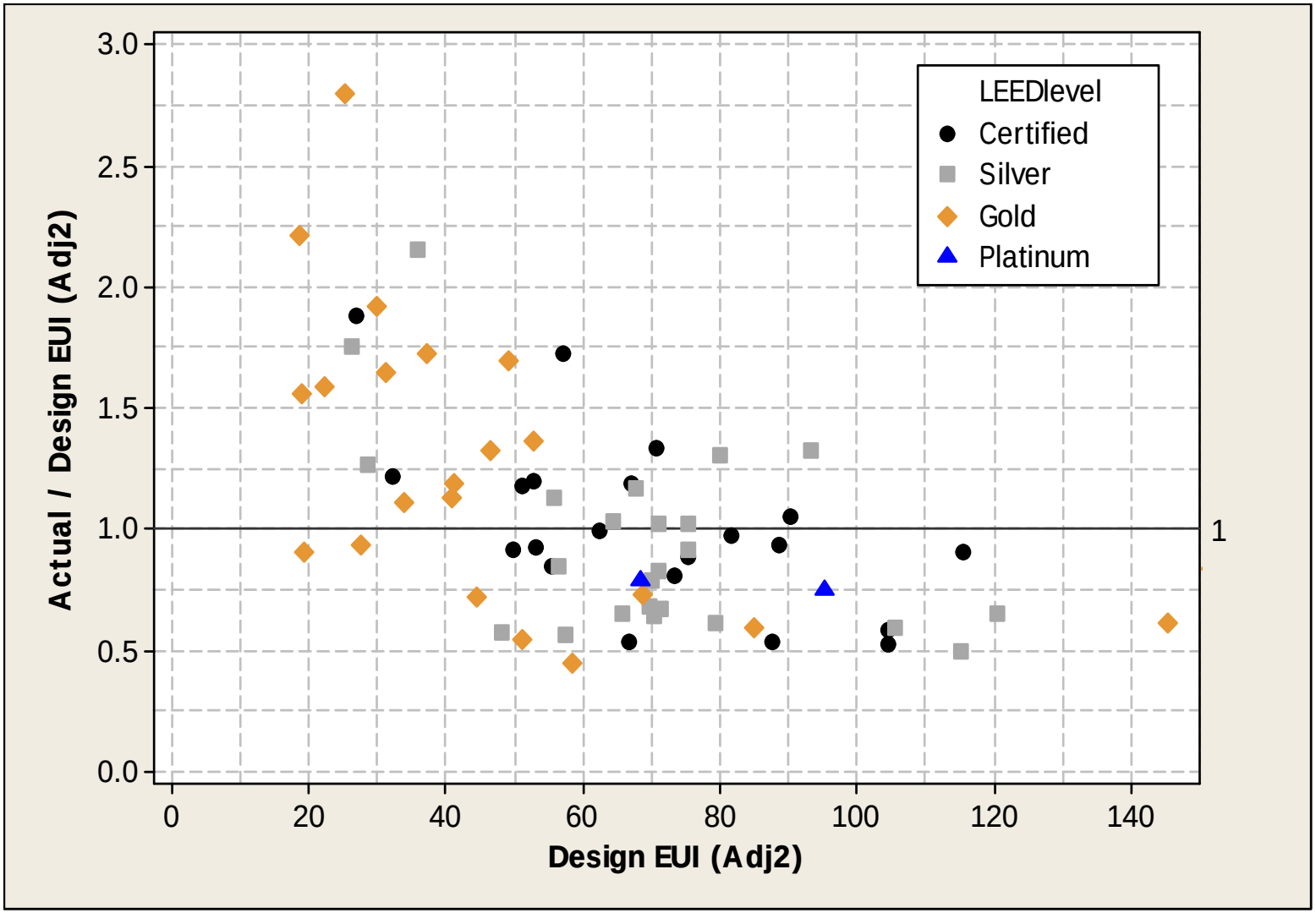
Supply air blowing on mobile triggering occupancy sensor

Non functioning daylighting controls



Outdoor air temperature sensor placed in direct sunlight

Problem 6:
Actual Performance is not Verified



Source: Turner and Frankel NBI, 2008

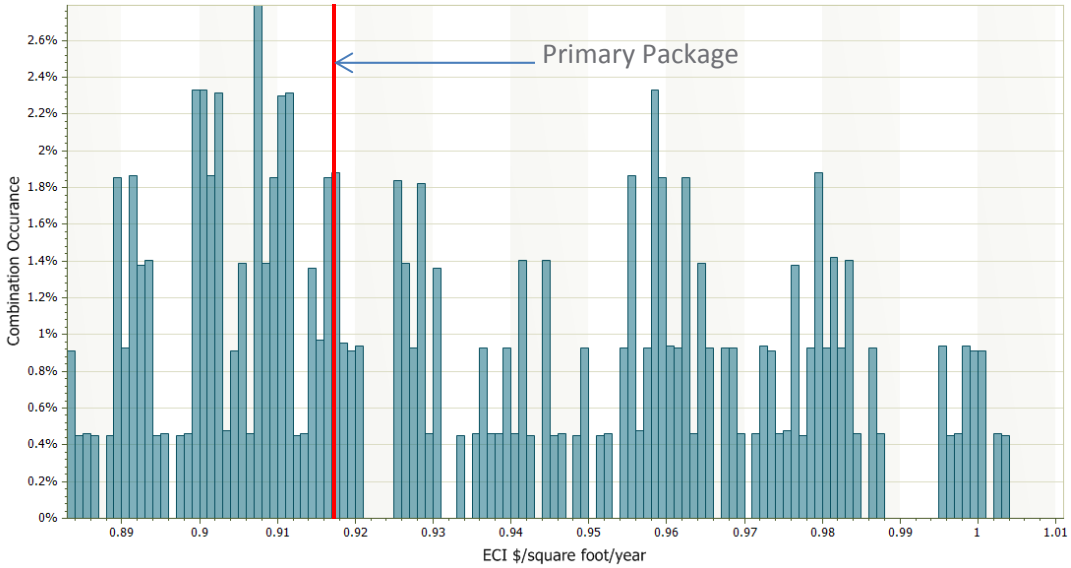
Proposed Solutions

Solution 1:
Performance Path to Lead

Performance Path to Lead: required performance level determined by a "standard design package"

Prescriptive Path to Follow: create prescriptive packages for each building type and climate zone

- Match standard selection energy level
- Provide preset popular tradeoffs
- Eliminate variability in energy performance from prescriptive path

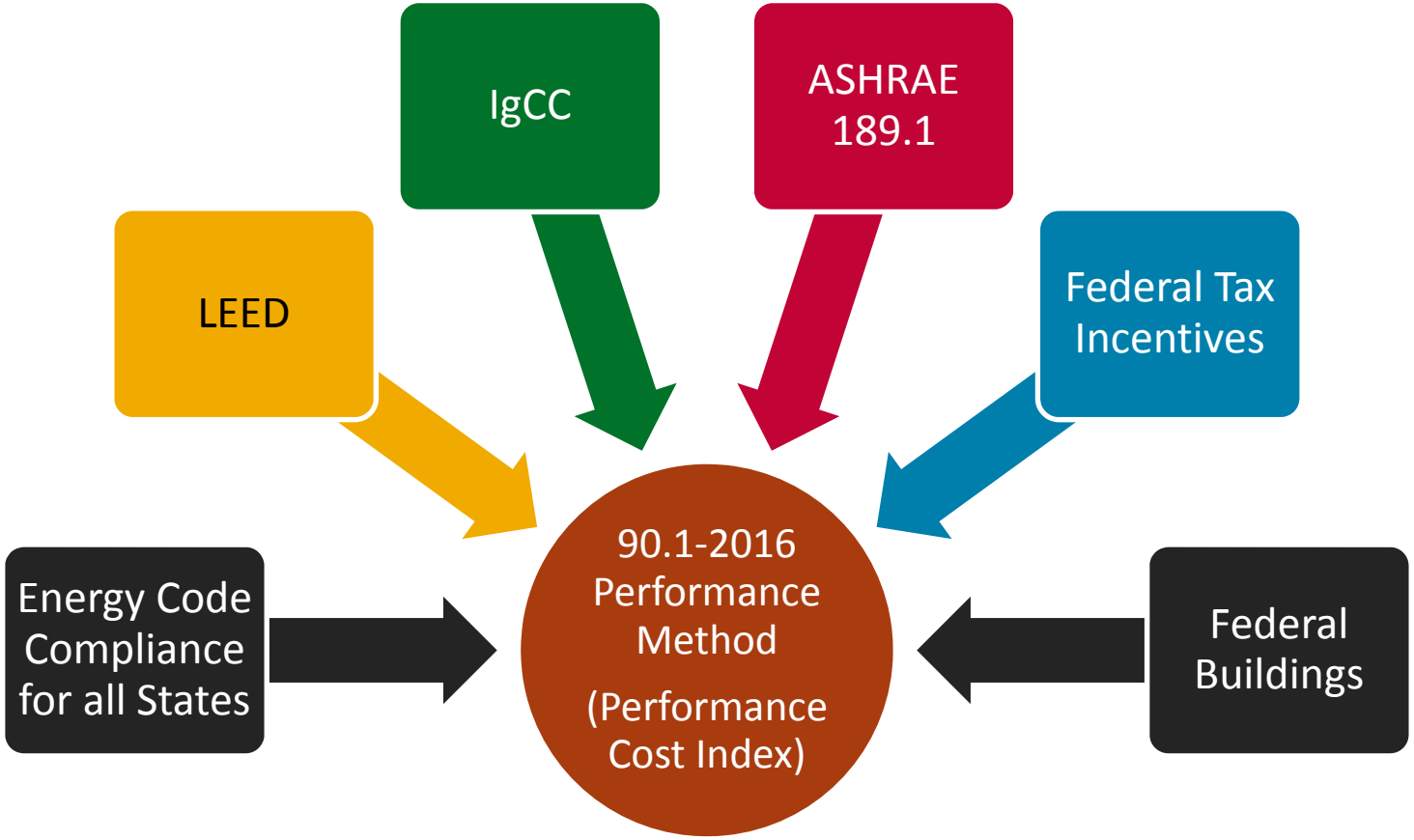


Prescriptive Package Path Method for Office buildings in Climate Zone 5A (5,000 to 50,000 ft²)

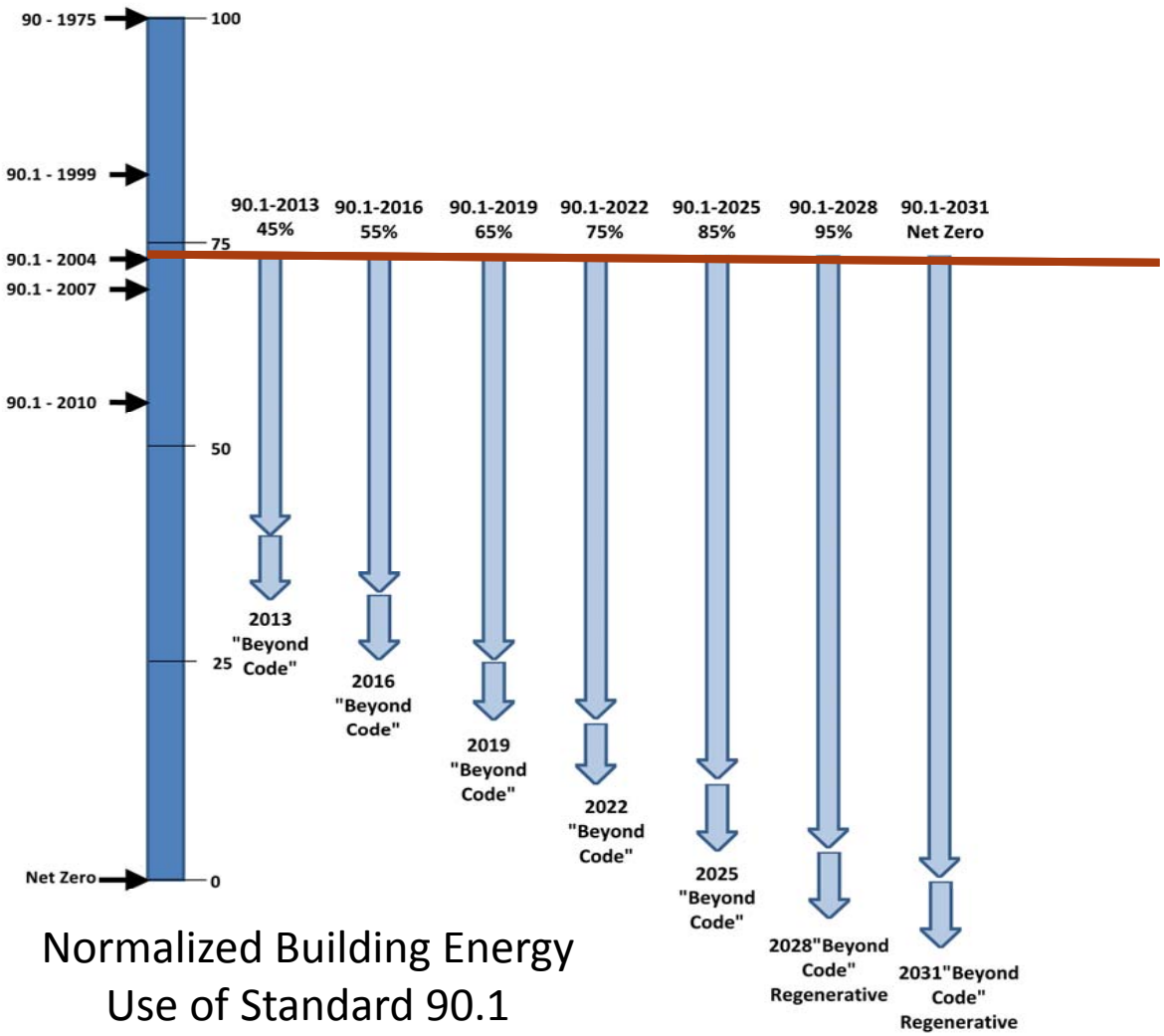
Package	HVAC System	Heating Source	% of Heating Efficiency[1]	% of Cooling Efficiency[2]	Roof/Wall U-Value[3]	Max WWR	Window U-Value[3]	Window SHGC[3]	Max Fan Brake HP[4]	Max LPD (W/ft²)	Min Daylight Area[5]	Min Occupancy Sensor Coverage Area
Package 1 (Primary)	MZ VAV hydronic Reheat	Boiler	100%	100%	100%	33%	100%	100%	100%	0.82	21%	53%
Package 2	MZ VAV hydronic Reheat	Boiler	100%	100%	100%	50%	100%	100%	100%	0.82	41%	53%
Package 3	MZ VAV hydronic Reheat	Boiler	120%	115%	125%	50%	125%	100%	100%	0.82	21%	53%
Package 4	MZ VAV hydronic Reheat	Boiler	100%	100%	108%	40%	108%	100%	100%	1.00	21%	91%
Package 5	MZ VAV hydronic Reheat	Boiler	110%	110%	100%	33%	100%	100%	135%	0.82	21%	53%
Package 6	MZ VAV hydronic Reheat	Boiler	100%	100%	150%	40%	150%	100%	100%	0.82	21%	91%
Package 7	MZ VAV Electric Reheat	Gas Furnace	100%	120%	108%	40%	108%	100%	100%	0.66	21%	91%
Package 8	MZ VAV Electric Reheat	Gas Furnace	100%	100%	83%	40%	83%	100%	100%	0.82	41%	91%
Package 9	MZ VAV Electric Reheat	Gas Furnace	100%	115%	67%	25%	67%	100%	80%	1.00	21%	91%
Package 10	MZ VAV Electric Reheat	Gas Furnace	100%	115%	100%	33%	100%	100%	135%	0.82	41%	91%
Package 11	MZ VAV Electric Reheat	Gas Furnace	100%	100%	108%	25%	108%	100%	100%	0.82	41%	91%

1. % of req'd heating efficiency in Table 6.8.1-6 of Std 90.1
2. % of EER required efficiency in Table 6.8.1-1 of Std 90.1
3. % of U-value required in Table 5.5-5 of Std 90.1
4. % of fan BHP calculated according to 6.5.3.11 Option 2 of Standard 90.1
5. Daylight areas must include controls per Section 9.4.1.1.e and f of Std 90.1
6. Values in bold differ from the primary package.

Solution 2:
Single Performance Method



Solution 3:
Stable Baseline



Normalized Building Energy Use of Standard 90.1

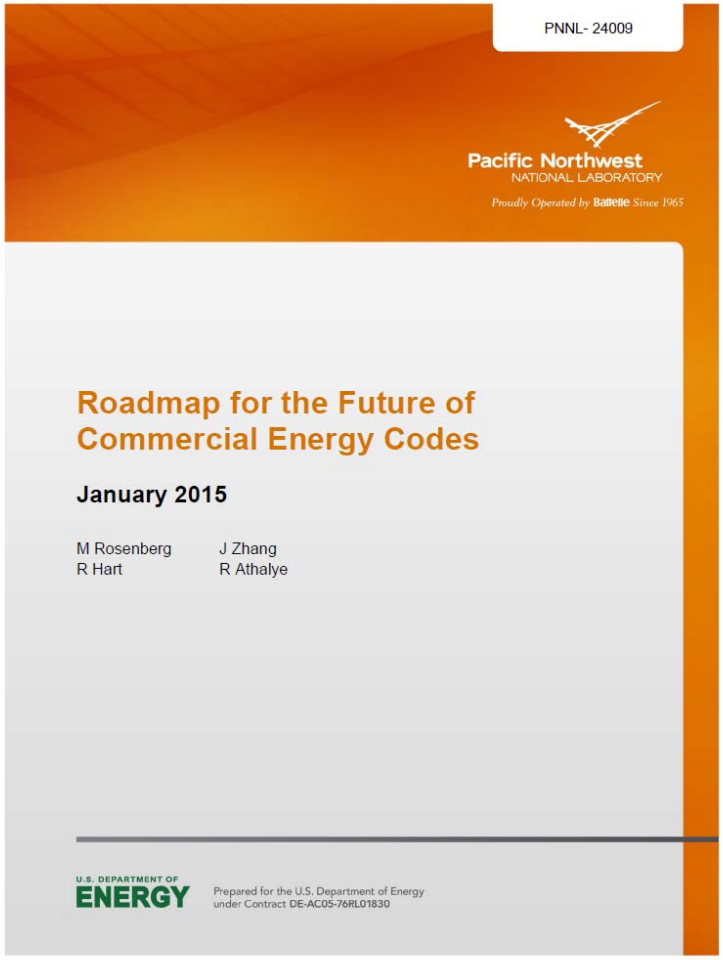
Fixed baseline: 90.1-2004

Only change the **Performance Cost Index** for each subsequent standard

Other Solutions

4. Regulate currently unregulated loads where practical
   - Recent progress made in refrigeration, elevators, and computer room air-conditoners
5. Include all loads in the performance target
   - Allow path toward net zero energy buildings
   - Encourage renewables
     - If code doesn't directly regulate a load, it can require that it be offset by renewables
6. Require acceptance testing or commissioning
   - Required in IECC, 189.1, and California T-24
7. Couple an outcome based code with a design and construction code

Resource



PNNL- 24009

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Roadmap for the Future of Commercial Energy Codes

January 2015

M Rosenberg, J Zhang
R Hart, R Athalye

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

TECHNICAL FEATURE

This article was published in ASHRAE Journal, May 2013. Copyright 2013 ASHRAE. Posted at www.ashrae.org. This article may not be copied and/or distributed electronically or in paper form without permission of ASHRAE. For more information about ASHRAE Journal, visit www.ashrae.org.

A Stable Whole Building Performance Method For Standard 90.1

By **Michael Rosenberg**, Member ASHRAE, and **Charles Eley, P.E., FAIA**, Member ASHRAE

Wouldn't it be great if a single energy model could be used to demonstrate minimum code compliance, green code compliance, establish a LEED rating, and determine eligibility for federal tax and utility incentives? Even better, what if the basic rules for creating those models did not change every few years?

A recently proposed addendum to ANSI/ASHRAE/IES Standard 90.1-2010 aims to meet those goals. Addendum *bm* establishes the Performance Rating Method found in Appendix G of Standard 90.1 as a new method of compliance while maintaining its traditional use in gauging the efficiency of "beyond code" buildings. Furthermore, the addendum sets a common baseline building that would stay the same for 2013 and future versions of Standard 90.1, while only the improvement target will change with each new edition.

Background

Standard 90.1-2010 has two whole building performance approaches: the Energy Cost Budget (ECB) method used for code compliance and the Performance Rating Method (PRM) used for LEED calculations and other beyond-code programs. The performance methods are similar in that the design or proposed building is compared to a baseline building that is in compliance with the prescriptive standards. The differences are in the details of how the baseline is defined and the scope of design elements that can be credited.

The ECB method is intended to be used for code compliance, and as result, the baseline building tracks the proposed design in many respects. For example, if the proposed building design has wood-framed walls, a 20% window-to-wall ratio, all windows facing south, and is served by a water-source heat pump system, the comparison is to a baseline building with wood-framed walls, a 20% window-to-wall ratio, all windows facing south, served by a water-source heat pump system, with all components just meeting prescriptive requirements. If the same building had mass walls, a 40% window-to-wall ratio, all windows facing west, and an air-source heat pump system, the comparison would be to a baseline building with mass walls, a 40% window-to-wall ratio, all windows facing west, and an air source heat pump system, with all components just meeting prescriptive requirements.

About the Authors

Michael Rosenberg is a senior research scientist at Pacific Northwest National Laboratory, Eugene, Ore. He is a member of the SSPC 90.1 Energy Cost Budget Subcommittee and the LEED Energy and Atmosphere Technical Advisory Group. **Charles Eley, P.E., FAIA,** is a consulting architect and mechanical engineer in San Francisco. He is a past member of SSPC 90.1 and is currently a member of SSPC 189.1. He is an ASHRAE certified building energy modeling professional.

May 2013 ASHRAE Journal 33

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24009.pdf

Future So Bright Gotta Wear Shades