



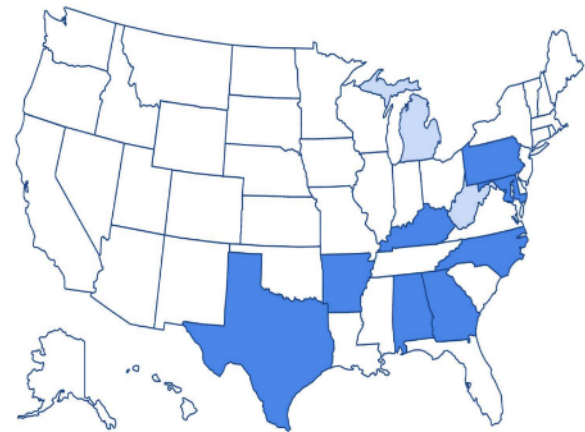
# Making an Impact with Energy Code Training

(and Measuring it!)

# Residential Energy Code Field Study

- Phase 1: Baseline field study
- Phase 2: Education and training using info from initial study
- Phase 3: Follow-up field study

Can the case be made  
for utility investment?



# Residential Energy Code Field Study

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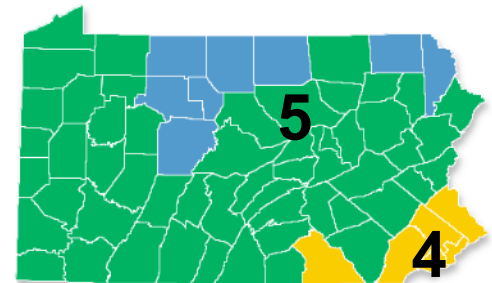
## 8 Key Items:

- Above-grade wall insulation
- Ceiling insulation
- Foundation insulation
- Window U-factor
- Window SHGC
- Envelope tightness (ACH50)
- Duct tightness (total leakage test)
- High-efficacy lighting

63 observations of each key  
item minimum

# Residential Energy Code Field Study

- Phase I: Baseline field study
  - Random sample of municipalities, collect permits
  - Random sample of homes
  - Site visits – No site visited twice (site visits = 2-4 times 63)
  - Modeling to determine savings potential from items with  $\geq 15\%$  non-compliance
- Phase II: Training, education, outreach
  - Training focused on items identified in Phase I
- Phase III: Follow-up field study
  - Same as Phase I, new random sample





# Measuring Training Effectiveness – Other Methods

---

- Immediate post-training surveys
- Follow-up interviews
  - What have you done differently?
- Evaluator review of training programs
- Building department documentation reviews
- Compliance field studies
- Delphi panels (industry experts) for savings attribution
  - Provide packet of info
  - Counterfactual (What would construction be like without the program?)
  - Model counterfactual vs. field study findings





State nickname:



The Keystone State

State bird:



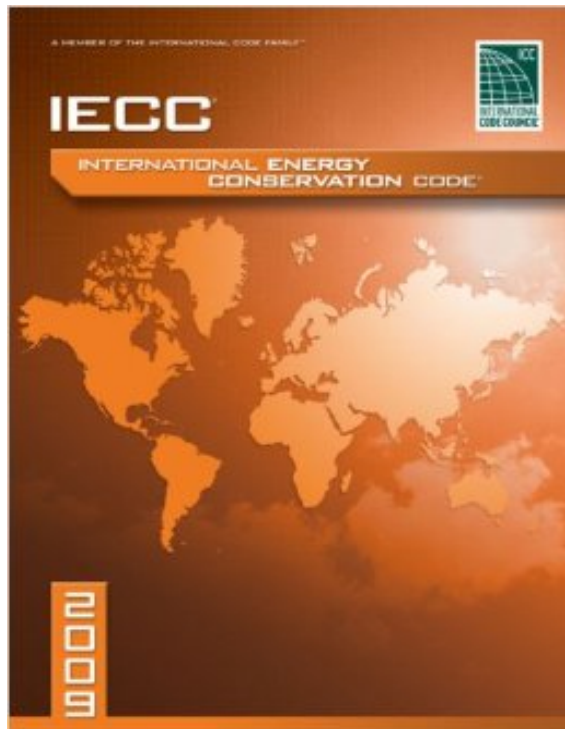
Ruffed Grouse

State insect:



Lightning Bug

## State energy code:

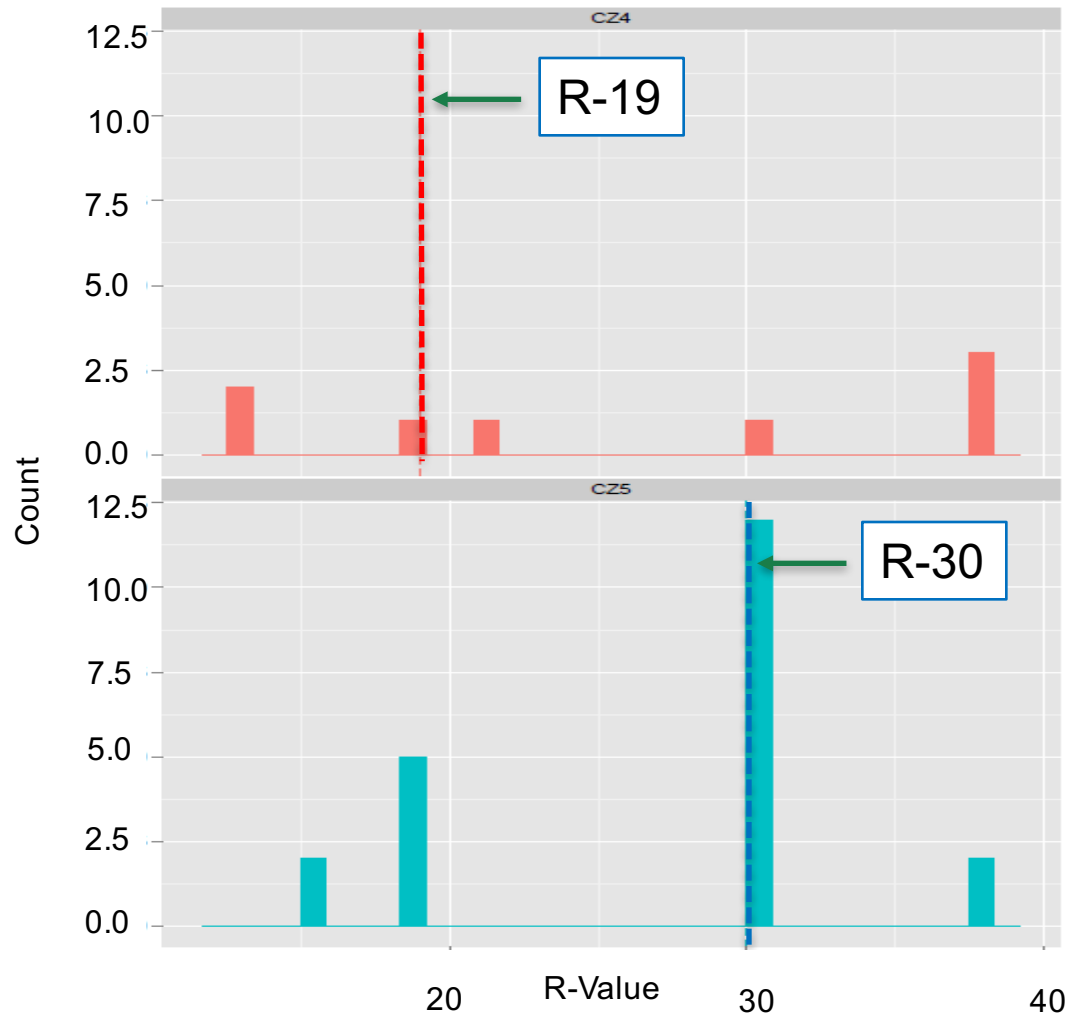


- Duct blaster test required
- Building cavities as returns OK
- No mandatory blower door test
- No DET verifier qualification requirements

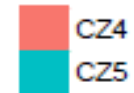


# Foundations





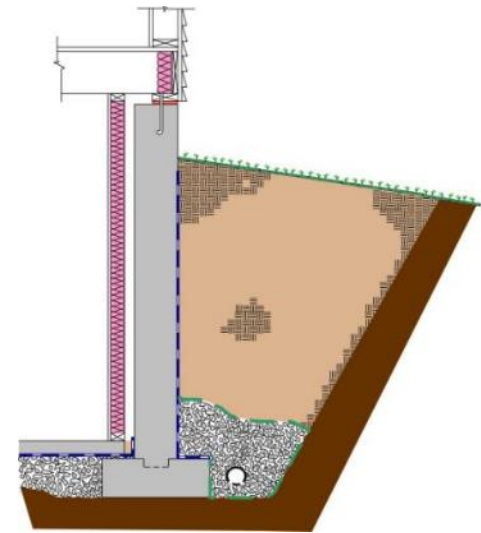
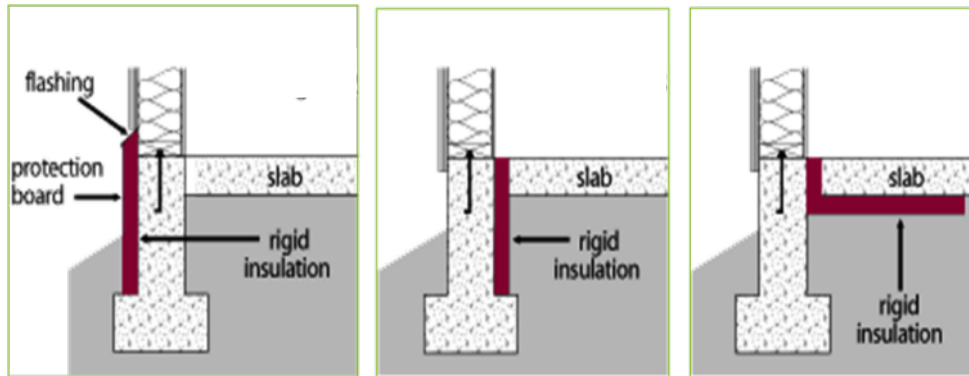
## Climate Zone



90% Compliant



- Slab and basement walls

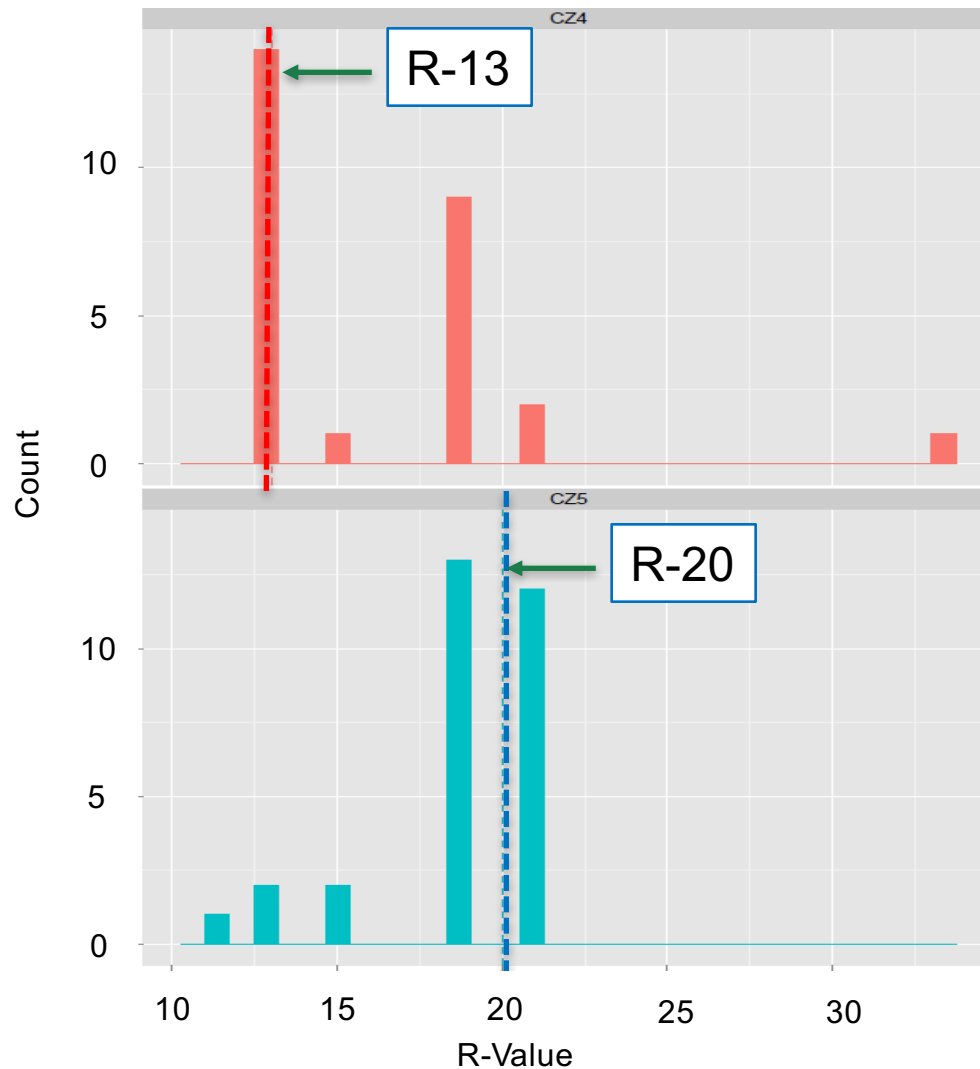


Overall 89% Compliant

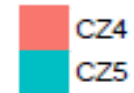


# Above Grade Walls

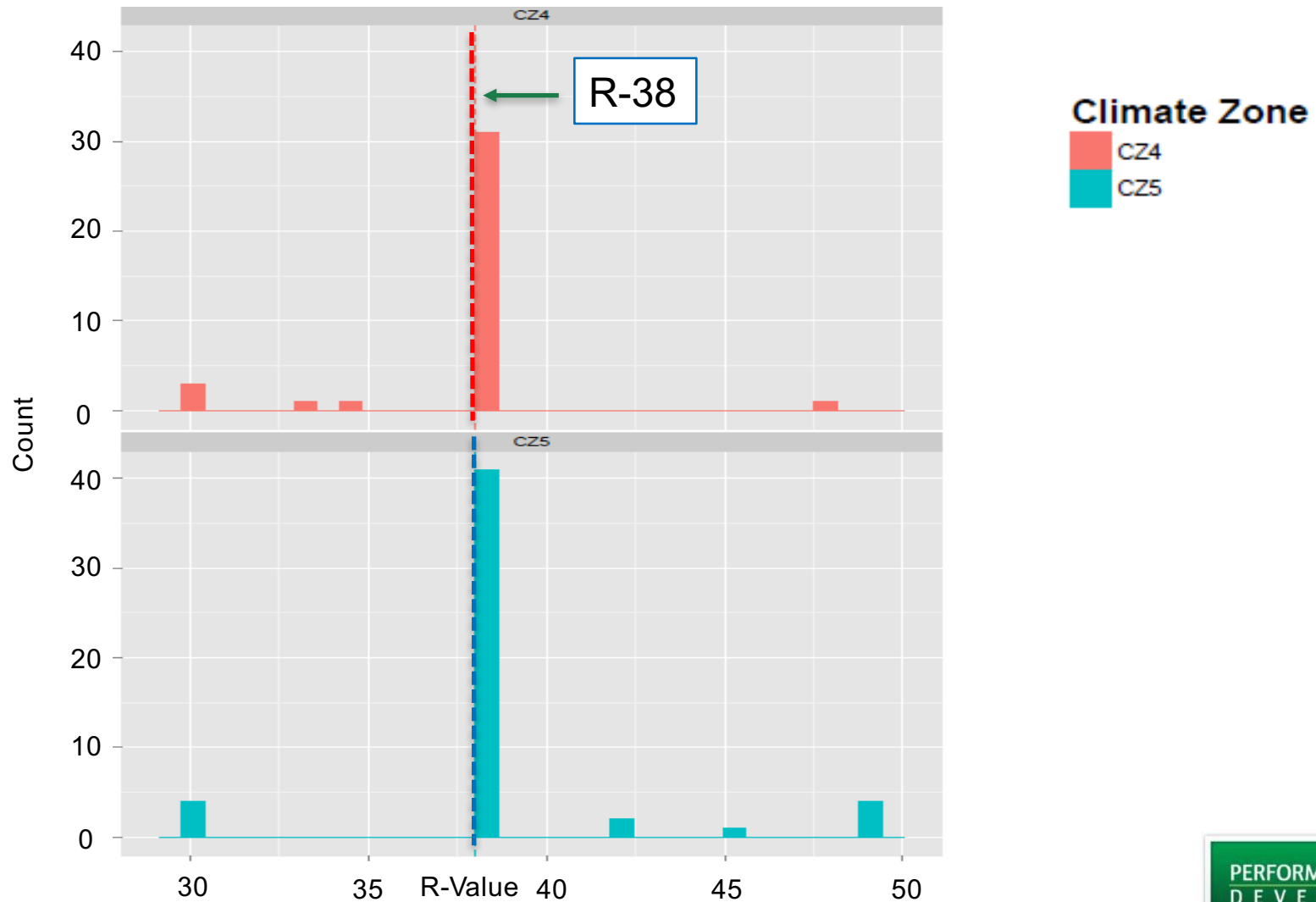
# Frame Wall R (Cavity Only)



## Climate Zone

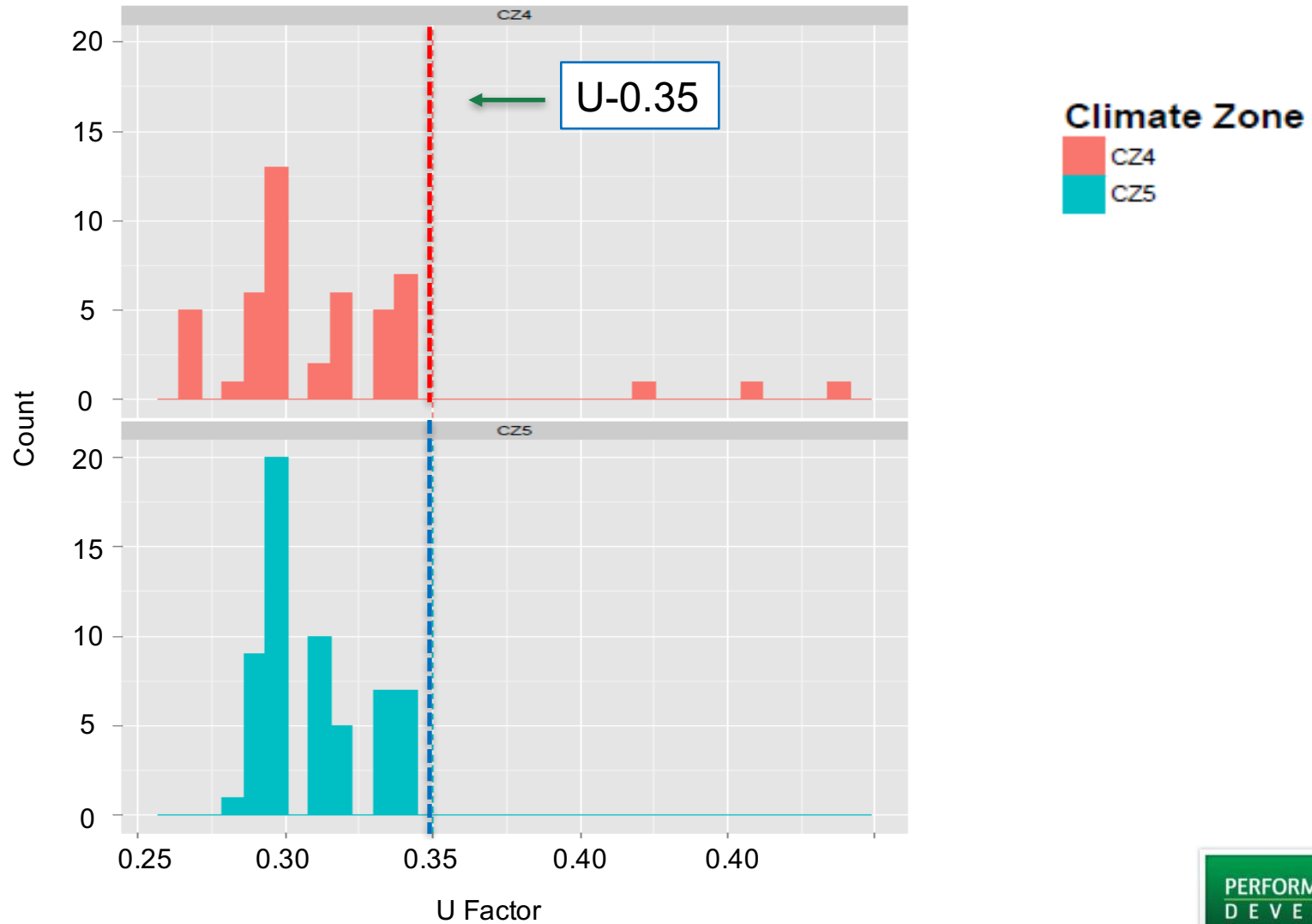


In Climate Zone 5:  
15 of 26 (58%) were  
below R-20





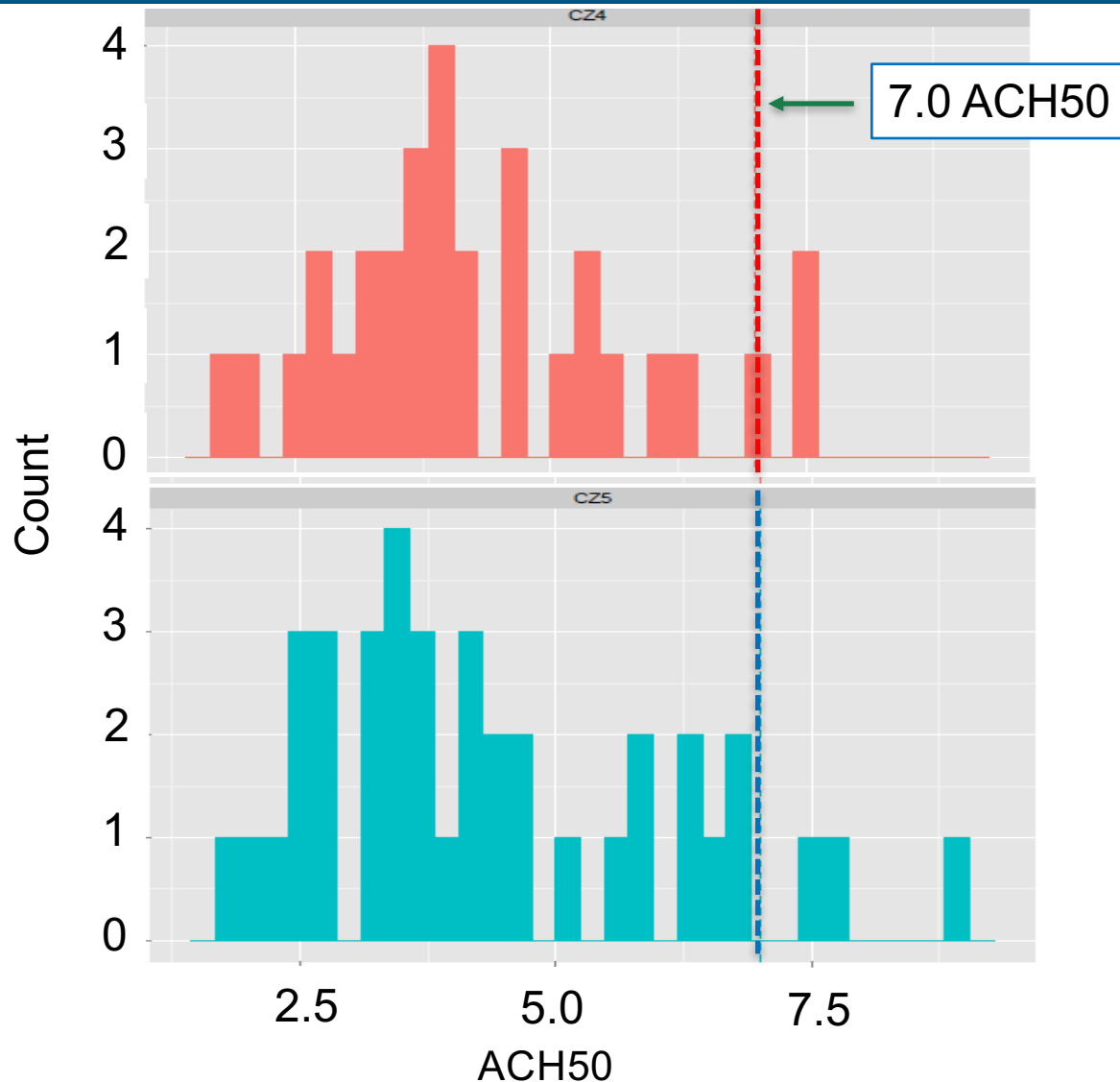
# Windows



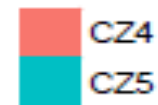


# Envelope Tightness

# Envelope Tightness (ACH50)



## Climate Zone



All Climates		
ACH50	Count	70
	Number > 7.0	5
	Percent > 7.0	7%
	Average	4.3
	Max	8.9
	Min	1.7

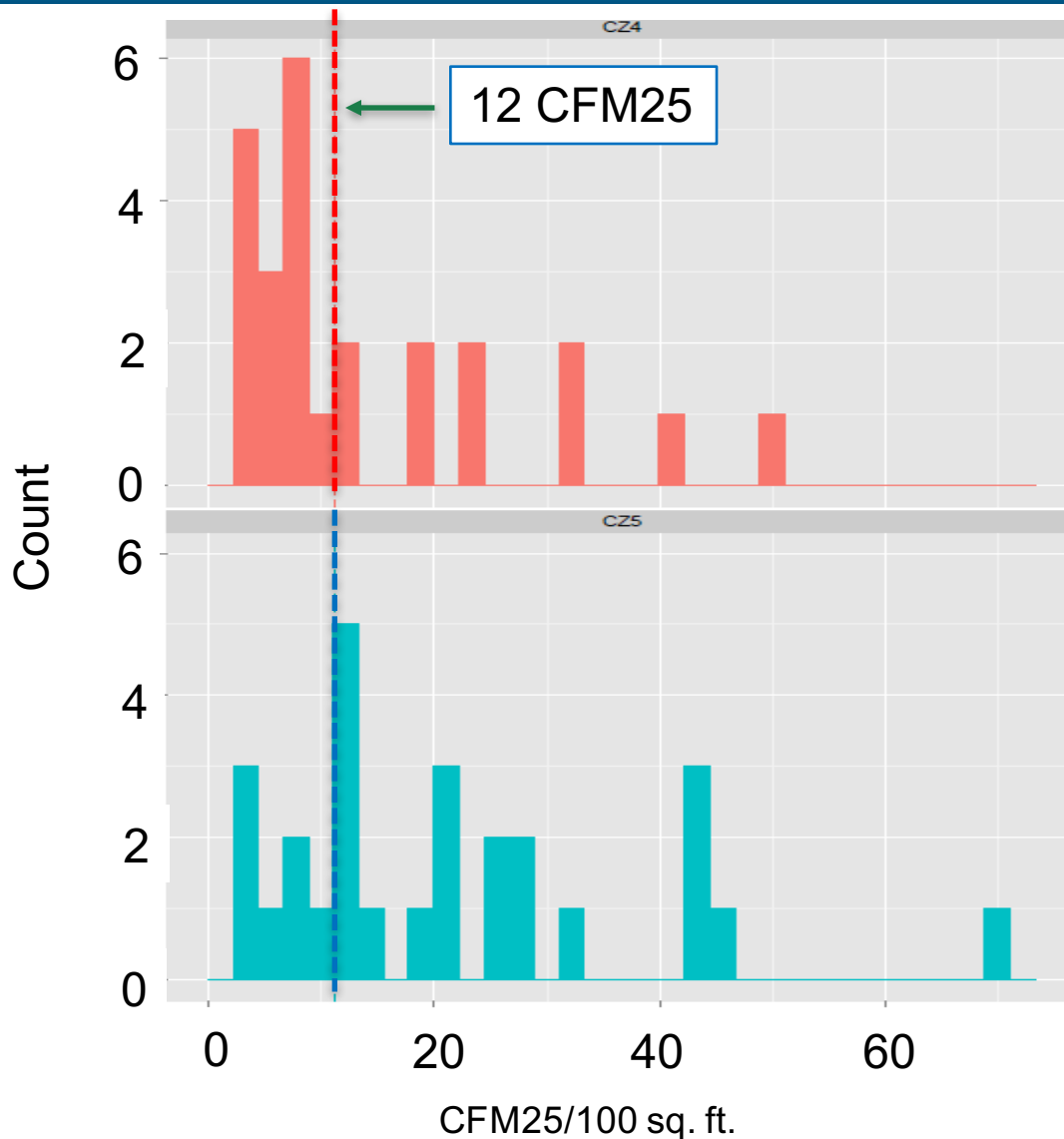




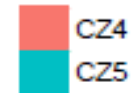
# Duct Leakage

# Field Study Results

## Total Leakage (CFM25/100 sq. ft.)

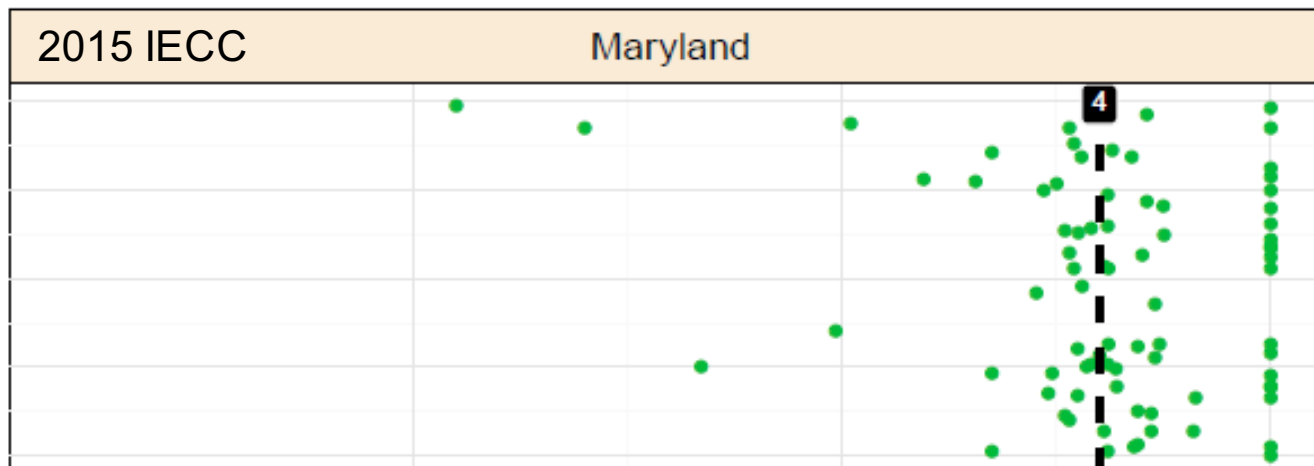
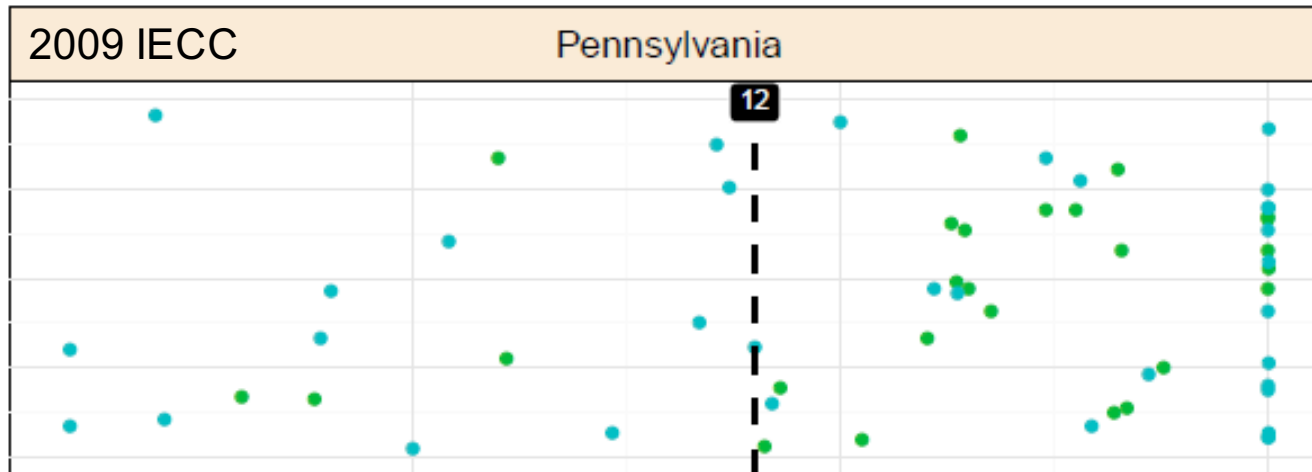


### Climate Zone



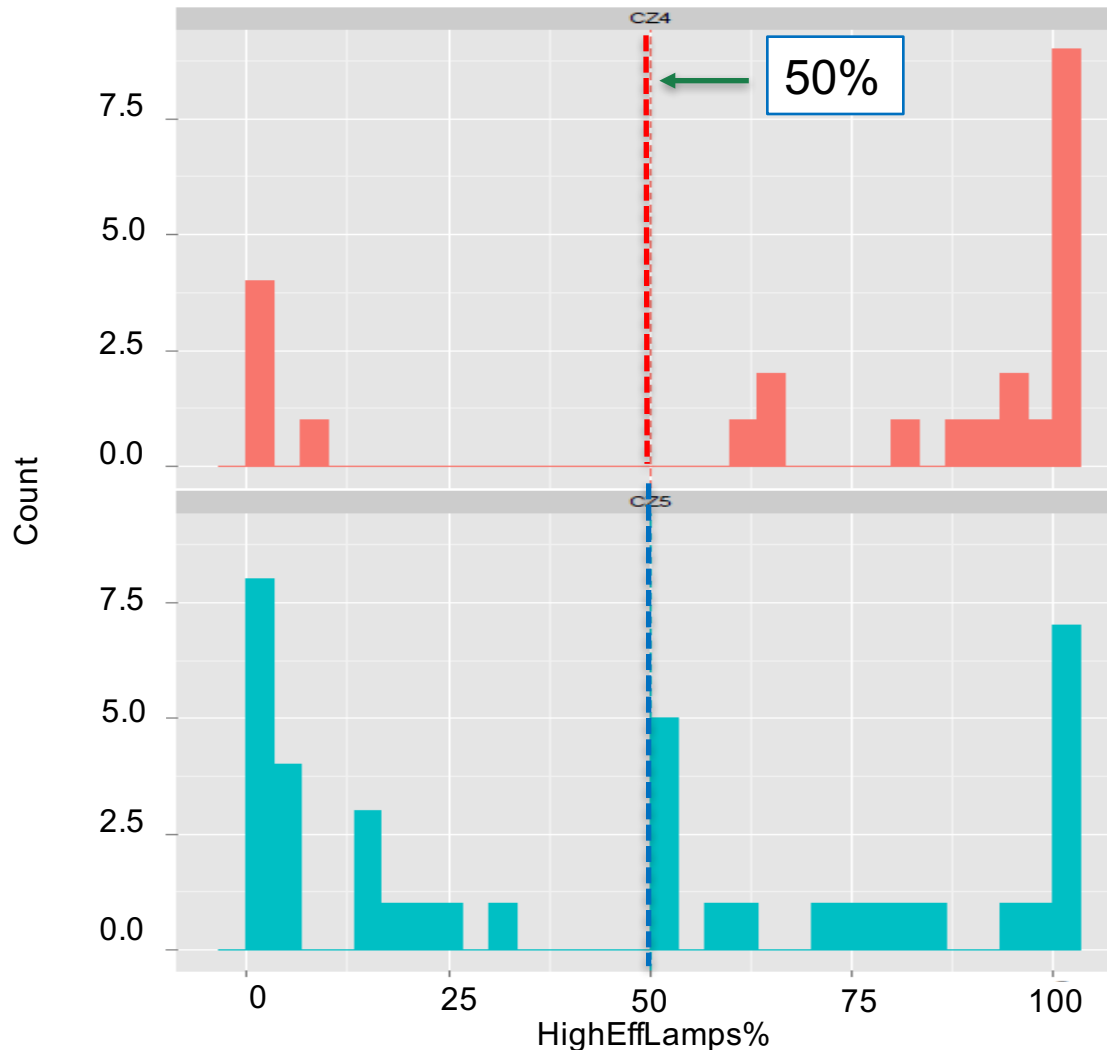
### All Climates

CFM25	Count	52
	No. > 12	26
	Percent > 12	50%
	Average	18
	Median	12
	Max	69
	Min	2.4

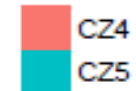




# High-Efficacy Lighting



## Climate Zone



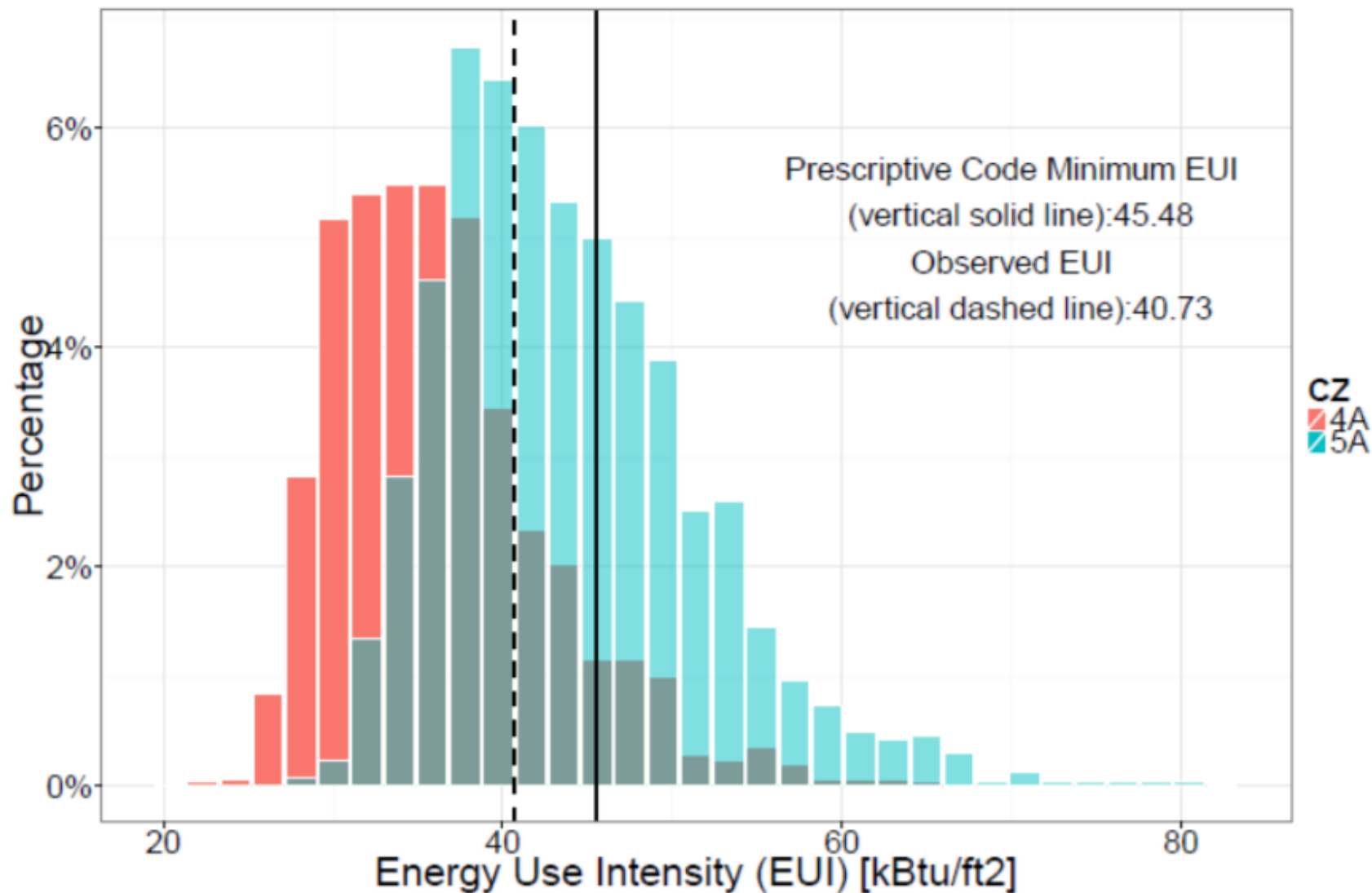
## All Homes

	No.	%
≥50% HE	39	62%
<50% HE	24	38%



# Savings Potential

# Whole-house Savings Method



**Figure ES.2.** Modeled distribution of regulated EUI (kBtu/ft<sup>2</sup>/year) in Pennsylvania



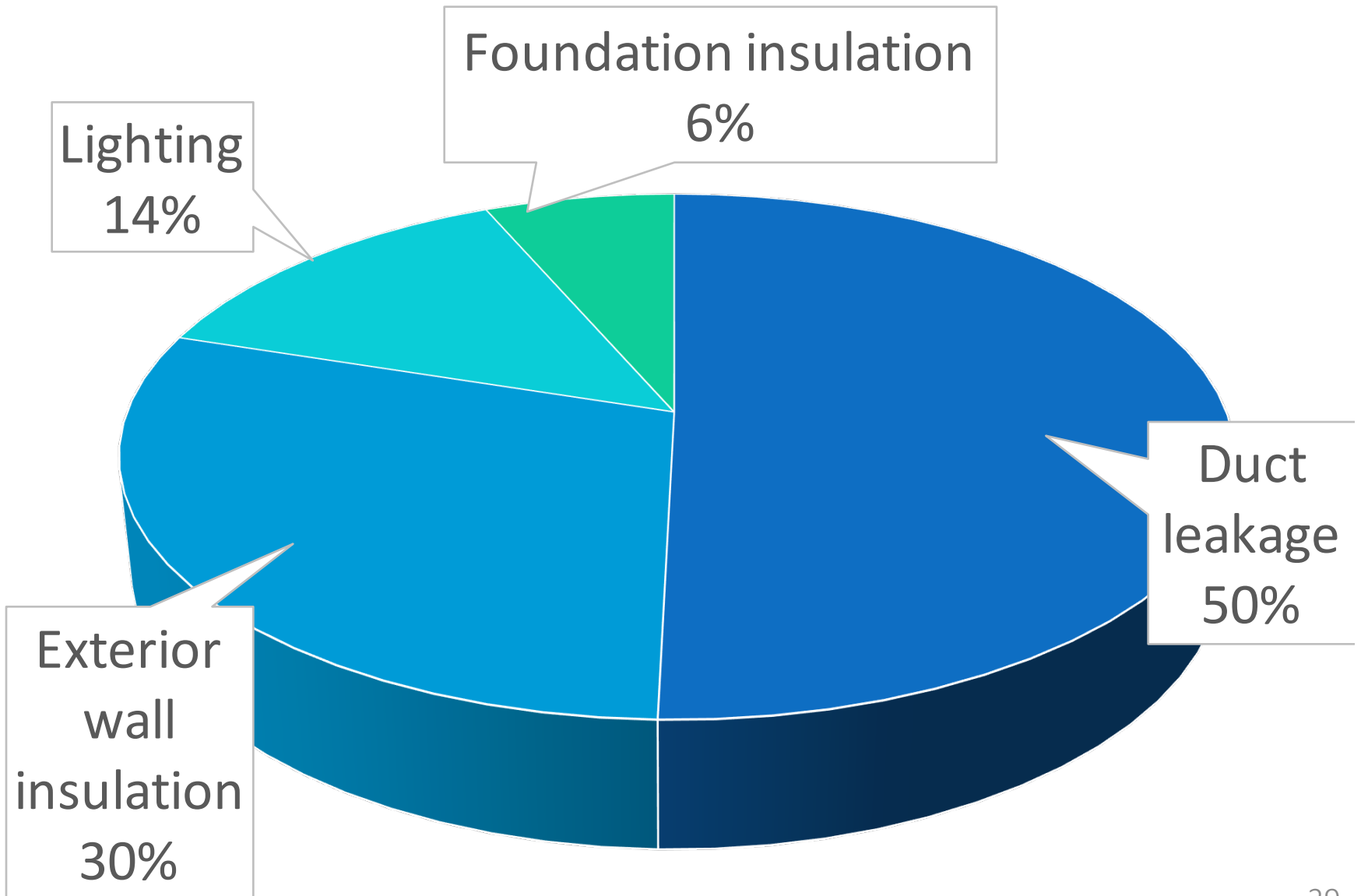
**Table 3.11.** Statewide Annual Measure-Level Savings for Pennsylvania

Measure	Climate Zone	Electricity Savings (kWh/home)	Natural Gas Savings (therms/home)	Total Savings (kBtu/home)	Number of homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings (\$)	Total State Emissions Reduction (MT CO <sub>2</sub> e)
<b>Duct Leakage</b>	4A	215	46	5,359	7,040	37,728	594,504	2,761
	5A	206	45	5,233	9,331	48,828	766,056	3,552
	<b>State Total</b>	<b>210</b>	<b>46</b>	<b>5,287</b>	<b>16,371</b>	<b>86,553</b>	<b>1,360,493</b>	<b>6,363</b>
<b>Exterior Wall Insulation</b>	4A	16	5	532	7,040	3,745	55,233	264
	5A	159	49	5,449	9,331	50,849	742,797	3,447
	<b>State Total</b>	<b>98</b>	<b>30</b>	<b>3,335</b>	<b>16,371</b>	<b>54,594</b>	<b>798,031</b>	<b>3,710</b>
<b>Foundation Insulation*</b>	4A	-31	16	1,482	6,312	6,573	66,149	302
	5A	-61	22	2,016	8,366	11,138	109,462	499
	<b>State Total</b>	<b>-48</b>	<b>20</b>	<b>1,788</b>	<b>14,677</b>	<b>17,711</b>	<b>175,610</b>	<b>802</b>
<b>Lighting*</b>	4A	179	-3	312	7,040	2,193	158,333	757
	5A	179	-3	287	9,331	2,676	206,930	1,003
	<b>State Total</b>	<b>179</b>	<b>-3</b>	<b>297</b>	<b>16,371</b>	<b>4,868</b>	<b>365,254</b>	<b>1,760</b>
<b>TOTAL</b>		<b>439</b>	<b>93</b>	<b>10,707</b>		<b>163,726</b>	<b>2,699,388</b>	<b>12,635</b>

\* Negative values mean that savings or reductions decrease if the measure is brought up to code. For example, for lighting, increasing the amount of high-efficacy lighting reduces electrical usage, but increases natural gas usage for heating, as the heat from less efficient bulbs must be replaced.

\*\*See Table 3.12 for annual measure-level savings results by foundation type.

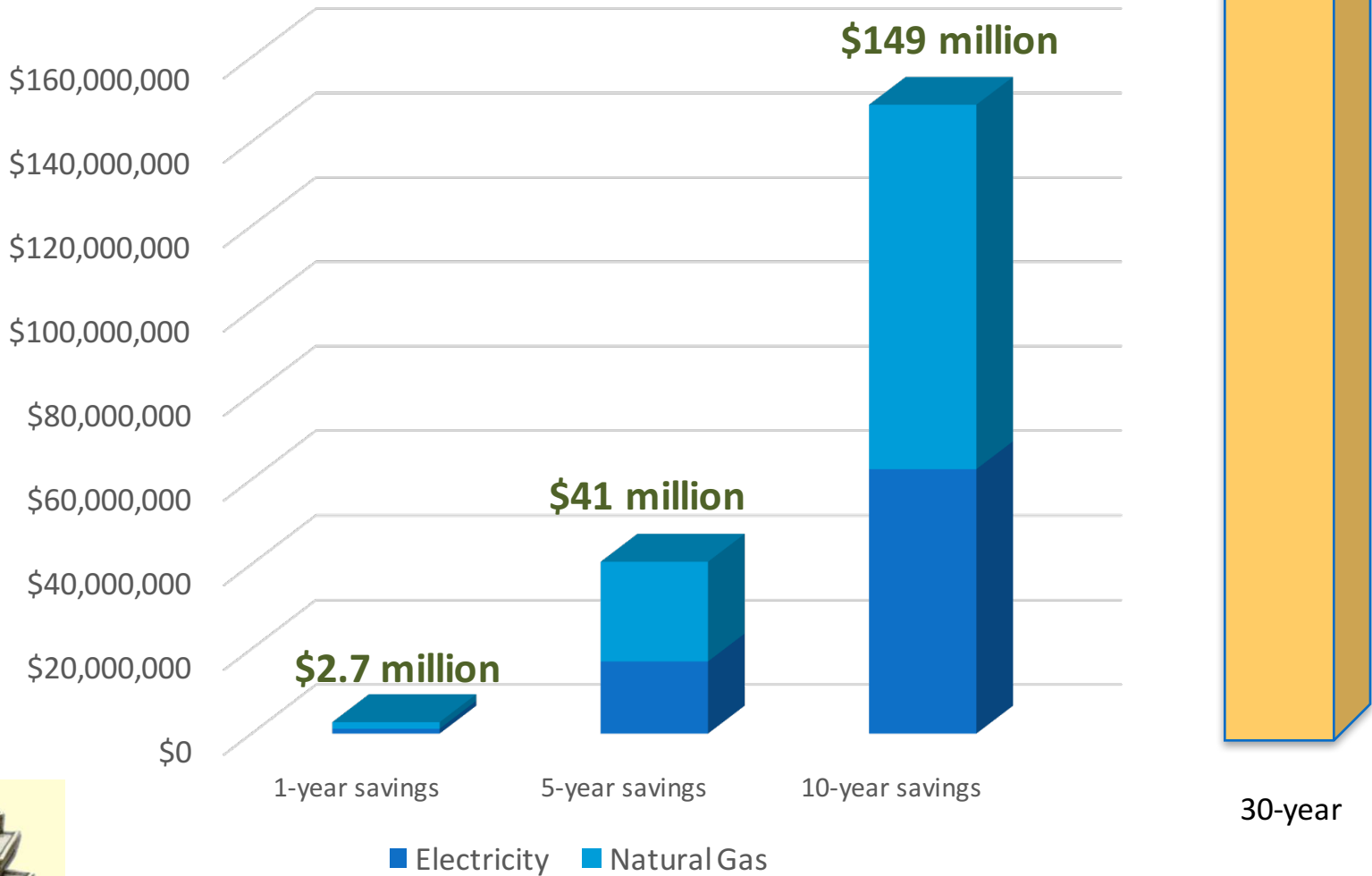




# Statewide Savings Potential

**\$1.3 billion**

## Energy cost savings from full compliance



\*Assumes 16,400 homes/yr



# Energy Savings Opportunities

## The Big Three...

- 1) Duct Leakage
- 2) Insulation Quality
- 3) Lighting











Return air cavity



Connected to attic











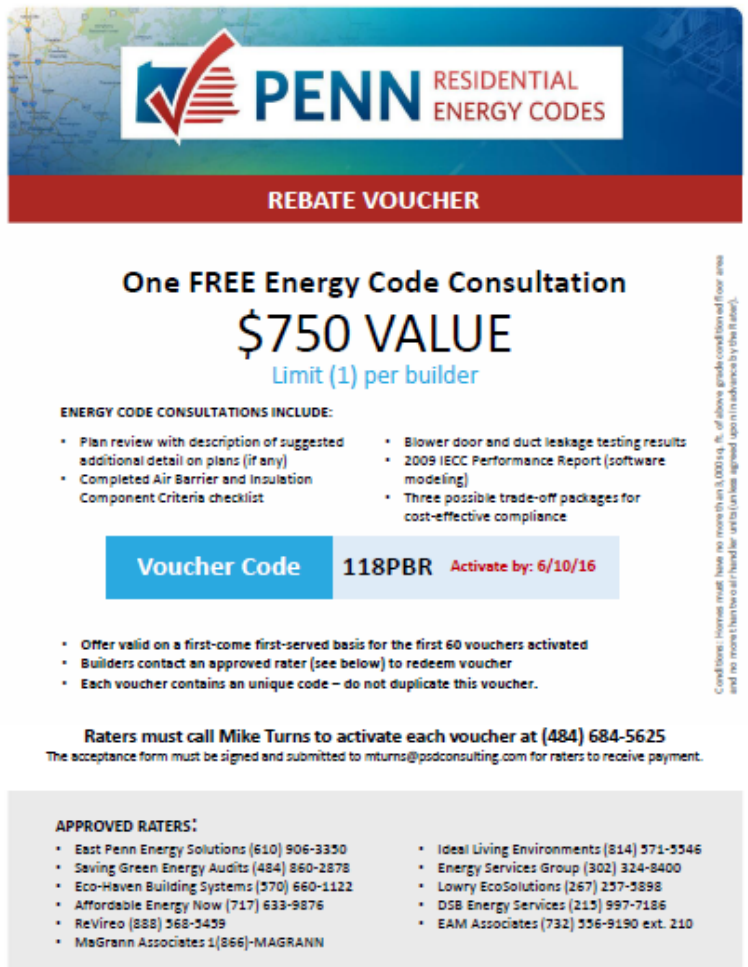
Vibration-resistant



130V 60W  
485 Lumens  
CHINA



# Training, Education, & Outreach



**REBATE VOUCHER**

**One FREE Energy Code Consultation**  
**\$750 VALUE**  
 Limit (1) per builder

**ENERGY CODE CONSULTATIONS INCLUDE:**

- Plan review with description of suggested additional detail on plans (if any)
- Completed Air Barrier and Insulation Component Criteria checklist
- Blower door and duct leakage testing results
- 2009 IECC Performance Report (software modeling)
- Three possible trade-off packages for cost-effective compliance

**Voucher Code** **118PBR** **Activate by: 6/10/16**

• Offer valid on a first-come first-served basis for the first 60 vouchers activated  
 • Builders contact an approved rater (see below) to redeem voucher  
 • Each voucher contains an unique code – do not duplicate this voucher.

**Raters must call Mike Turns to activate each voucher at (484) 684-5625**  
 The acceptance form must be signed and submitted to [mturns@psdconsulting.com](mailto:mturns@psdconsulting.com) for raters to receive payment.

**APPROVED RATERS:**

- East Penn Energy Solutions (610) 906-3330
- Saving Green Energy Audits (484) 860-2878
- Eco-Haven Building Systems (570) 660-1122
- Affordable Energy Now (717) 633-9876
- ReVireo (888) 368-3459
- McGrann Associates 1(866)-MAGRANN
- Ideal Living Environments (814) 371-3346
- Energy Services Group (302) 324-8400
- Lowry EcoSolutions (267) 257-3898
- DSB Energy Services (215) 997-7186
- EAM Associates (732) 356-9190 ext. 210

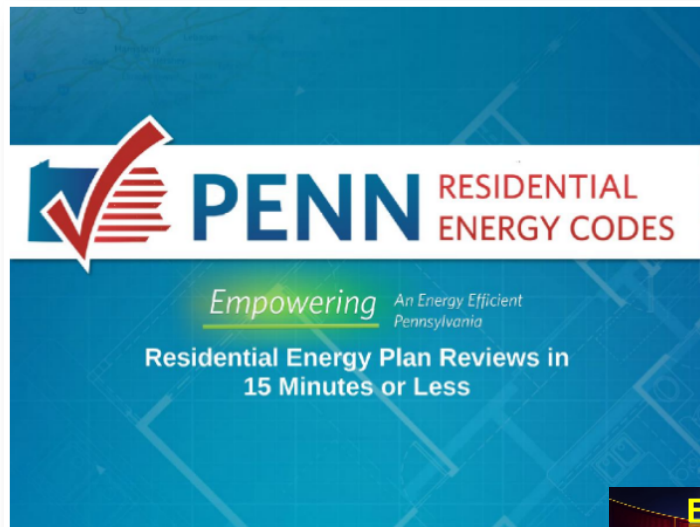
Conditions: Homes must have no more than 1,000 sq. ft. of above grade conditioned floor area and no more than two air-handling units (AHUs) installed upon issuance by the Rater.

## Rater Voucher Program:

- Plan review/software analysis
- Air barrier and insulation inspection
- Blower door test
- Duct leakage test
- Recommendations

- Limited Rater participation, seem to only focus on big fish
- Difficulty generating builder interest

- Plan Reviews in 15 Minutes or Less
- Keys to Effective Energy Code Implementation

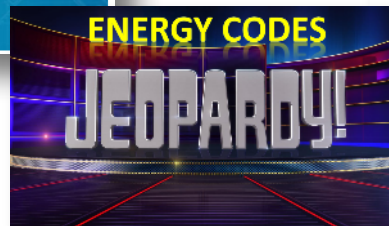


#### Keys to Effective Energy Code Implementation

Presented by Performance Systems Development and the Penn Energy Codes Program



44 Events  
887 attendees



## **1. Plan review:**

Identify duct location

## **2. Notify the applicant:**

Issue duct sealing verification form with approved plans

## **3. Final inspection checklist:**

Add check box, “Duct Sealing Verification Form received”



- Monthly webinar series

## WEBINARS

**Recent webinar:** New Tools for Quick Residential Energy Code Enforcement

**Email Brandon at [bcornell@psdconsulting.com](mailto:bcornell@psdconsulting.com) to request an archived webinar recording or slide deck.**

- Pennsylvania Residential Energy Code Field Study: How Are We Doing?
- Using the E-CODE Assistant: An iPad-Based Energy Code Checklist and Educational Tool
- Builders, Code Officials, and Home Energy Raters Working Together
- Understanding Blower Door Testing and Documenting Results
- Understanding Duct Leakage Testing and Documenting Results
- Flaws and Fudging HVAC Equipment Sizing Calculations
- Insulation Installation – A Tongue Twister and Construction Kicker
- Understanding REScheck and the Simulated Performance Alternative
- Energy Code Plan Reviews and Bullet Proof Submittals
- Important (But Commonly Missed) Air Barrier Details
- Going Beyond Code – Above Code Programs and The Future of Energy Efficient Housing



## PERFORMANCE SYSTEMS DEVELOPMENT



## Fact sheets

### Duct Leakage Fact Sheet

**Pennsylvania Energy Code Field Study**  
PSD recently completed a study of 171 randomly selected homes in an effort to assess implementation of the 2009 energy code in eastern Pennsylvania. This study revealed three main areas for improvement: duct leakage, insulation quality, and high-efficiency lighting. We estimate that correcting these items statewide could result in a savings of nearly \$39 million over five years. This fact sheet contains information and resources aimed at improving the efficiency of new residential construction by focusing on duct leakage.

**The Code on Duct Leakage:**

- The 2009 IECC and other PA compliance paths require that all ducts, air handlers, filter boxes, and building cavities used as duct are sealed.
- Further, the code requires duct leakage testing for all systems, unless the air handler and all portions of the ducts are completely within the conditioned space.
- Duct leakage testing may be performed at rough-in or final construction phases with leakage limits depending on the type of test performed.



Unsealed Duct Runout

**Study Findings:**

- The PSD study found that, of the HVAC systems requiring testing, 90% did not meet the code leakage limits for a Total Leakage test.
- Many of these systems were far in excess of the leakage limit, indicating serious leakage problems.

**How We Can Improve:**

- Test the ducts. The only way to really know if the ducts have been well-sealed is through performance testing. Not only is testing required by code, but it can be an effective quality assurance tool.
- Limit the use of building cavities as return ducts. With typical installation practices, this approach results in high-duct leakage rates.
- Use duct mastic. Mastic is the most effective and durable way to seal duct joints, seams, and connections.



Ducts Sealed with Mastic

Go to [pennenergycodes.com/resources/pa-energy-code-toolkit/](http://pennenergycodes.com/resources/pa-energy-code-toolkit/) to access the following resources:

- Duct Leakage verification form
- Air Diffusion Council Flex Duct Installation Standards
- Webinar: Understanding Duct Leakage Testing and Documentation Results

Find a duct and envelope testing professional:

- [PennEnergyCodes.com/envelopeprofs](http://PennEnergyCodes.com/envelopeprofs)
- [NHERP's.org/find-hvac-pro](http://NHERP's.org/find-hvac-pro)
- [BPDhomeowner.org/find-a-contractor](http://BPDhomeowner.org/find-a-contractor)

The Penn Energy Codes Program offers a variety of free and low-cost energy code support services, including seminars, custom training, on-site demonstrations, the E-CODE Assistant App, and more.

View upcoming events at [pennenergycodes.com/events](http://pennenergycodes.com/events) or contact Mike Turns at 484-684-5625 or [mturns@psdconsulting.com](mailto:mturns@psdconsulting.com) to schedule an event for your organization.

**PennEnergyCodes.com**




### High-Efficiency Lighting Requirements for New Homes

#### Pennsylvania Energy Code Field Study

PSD recently completed a study of 171 randomly selected homes in an effort to assess implementation of the 2009 energy code in eastern Pennsylvania. This study revealed three main areas for improvement: duct leakage, insulation quality, and high-efficiency lighting. We estimate that correcting these items statewide could result in a savings of nearly \$39 million over five years.

#### The Code on Lighting

The 2009 International Energy Conservation Code states that a minimum of 50% of lamps in permanently installed fixtures shall be high efficacy.

#### High efficacy lamp definition:

Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

- 60 lumens per watt for lamps over 40 watts
- 50 lumens per watt for lamps over 15 watts and up to 40 watts
- 40 lumens per watt for lamps 15 watts or less



#### Study Findings

Nearly 40 percent of homes visited did not have at least 50 percent high efficacy bulbs, as required by code. We estimate that owners of new homes in Pennsylvania could save over \$365,000 in the first year if all new homes met this requirement.

Technology	Efficacy (lumens/W)	High-Efficacy	Lifetime (hrs)	Color Temperature (K)
Incandescent	12-18	X	750-1,500	2400-2900
Halogen	14-29	X	2,000-4,000	2850-3200
CFL	60-70	✓	6,000-10,000	2700-6500
Linear Fluorescent	80-100+	✓	20,000	2700-6500
White LED	20-50	✓	Up to 100,000	2700-6500

Source: [www.enr.com](http://www.enr.com)

#### Considerations for Lighting Selection

- Brightness, measured in lumens
- Estimated yearly energy cost
- Lifespan
- Light appearance, measured by correlated color temperature (CCT) on the Kelvin (K) scale, from warm to cool.



- Direct mail with cover letter



iPad 12:35 PM 93%

Back to List View **E-CODE Assistant** ? 0% COMPLETE

**INSULATION INSPECTION**

BUILDRITE — 123 MAIN STREET — 1/8/2016

Inspection Details	Codes Checklist	Notes	Report
Foundation	Floors	Walls	Air Sealing
Other			

Is there an unvented crawl space?

Select... Enter notes as applicable...

Unvented crawl spaces: continuous vapor retarder installed with joints overlapped by 6 inches and sealed, and extending at least 6" up the stem wall.

Select... Enter notes as applicable...

Unvented crawl spaces: is the wall insulation on the interior, exterior, or both?

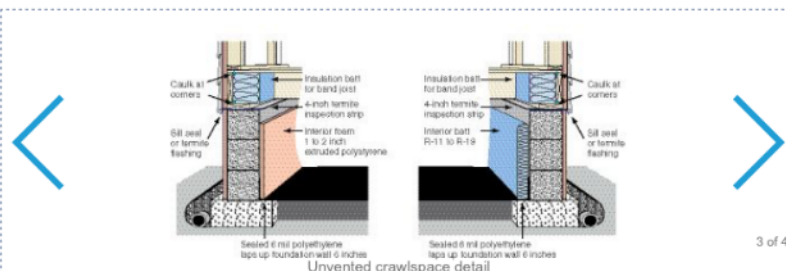
Select... Enter notes as applicable...

Unvented crawl spaces: interior wall insulation R-value

Enter R-Value Enter notes as applicable...

Unvented crawl spaces: interior wall insulation extends downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches.

Select... Enter notes as applicable...



## The E-CODE Assistant:

### An iPad-Based Energy Code Checklist and Educational Tool

28 office/field visits covering >150 jurisdictions





## In-field demonstrations and training for Builders and HVAC contractors





## ENERGY CODE TOOLKIT

Below you will find energy code checklists, forms, and guidebooks to improve your knowledge and ensure compliance within the state of Pennsylvania.

[Forms](#)[Webinars](#)[Videos](#)[iPad App](#)[Energy Code Guides](#)[Related Resources](#)[Related Websites](#)[Newsletter Archive](#)

### FORMS

- Plan Review and Inspection Form CZ 4
- Plan Review and Inspection Form – Climate Zone 5
- Custom/Editable Plan Review and Inspection Form
- Air Barrier and Insulation Inspection Checklist (Table 402.4.2)

### WEBINARS

- Pennsylvania Residential Energy Code Field Study: How Are We Doing?
- Using the E-CODE Assistant: An iPad-Based Energy Code Checklist and Educational Tool

### NEWSLETTER ARCHIVE

- Newsletter #1 – Penn Energy Codes Launch 9-3-15
- Newsletter #2 – Webinar – Energy Code Field Study 11-30-15
- Newsletter #3 – Webinar Series 12-21-15
- Newsletter #4 – Training & CEUs 1-7-16
- Newsletter #5 – Energy Code Challenge Update 1-21-16

### IPAD APP

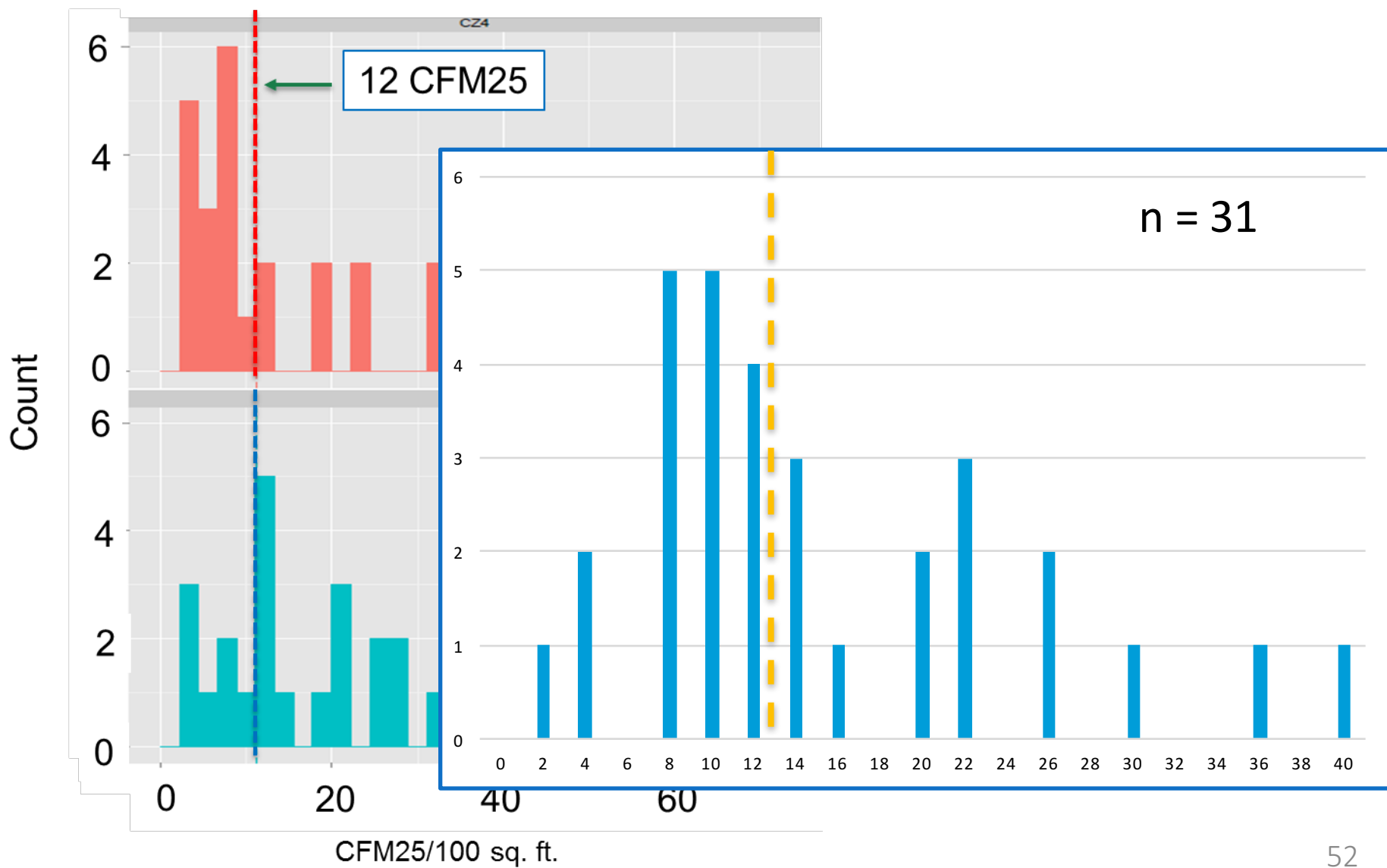




# Results

(Preliminary and Not  
Statistically Significant)

# Total Duct Leakage







## Average total duct leakage

- Phase I:
  - 70 observations
  - 18 cfm/100 sqft
- Phase III:
  - 31 observations
  - 14 cfm/100 sqft

	Homes	Percent
Pass	17	55%
Fail	14	45%

20% reduction



## 2014-2015

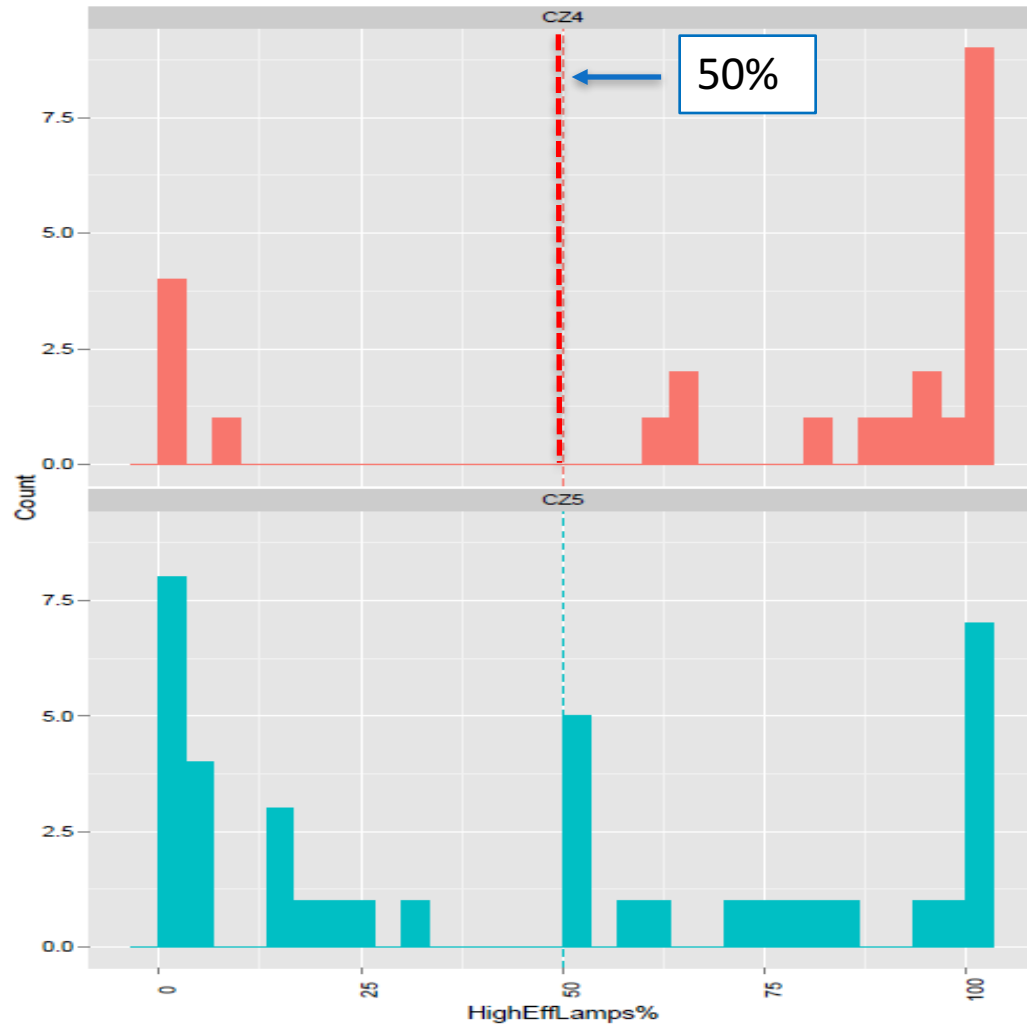
Grade	Homes	Percent
I	20	32%
II	40	65%
III	2	3%

## 2017-2018

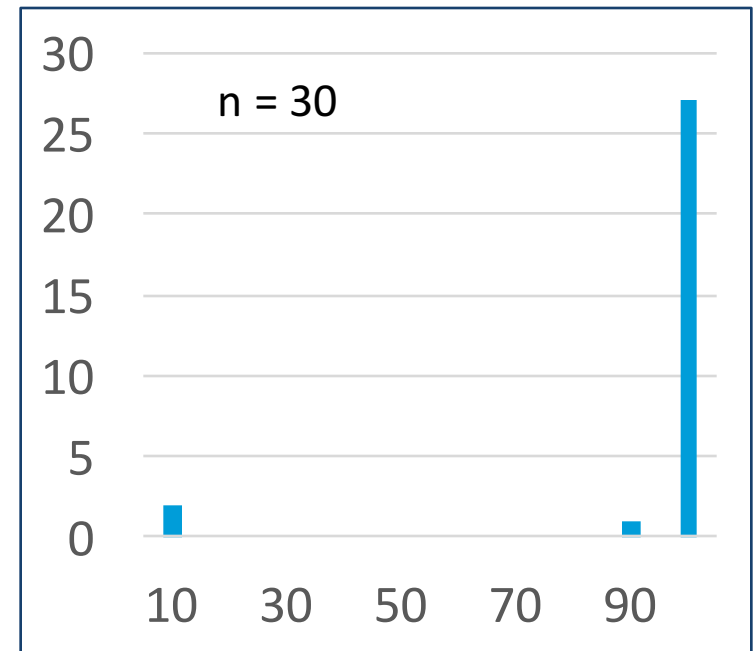
Grade	Homes	Percent
I	2	7%
II	23	77%
III	0	0%



2014-2015



2017-2018





# Thank You

Mike Turns  
PSD

[mturns@psdconsulting.com](mailto:mturns@psdconsulting.com)

484-684-5625