

# Making an Impact with Energy Code Training

(and Measuring it!)

Mike Turns Performance Systems Development <u>www.psdconsulting.com</u>

### 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

### 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 ≥15% noncompliance
- 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:

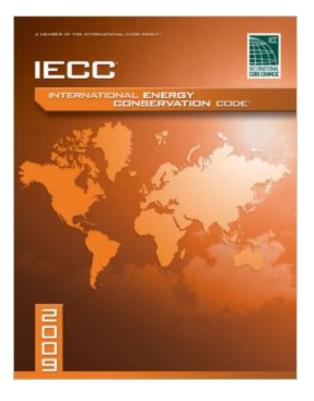


Lightning Bug





### State energy code:



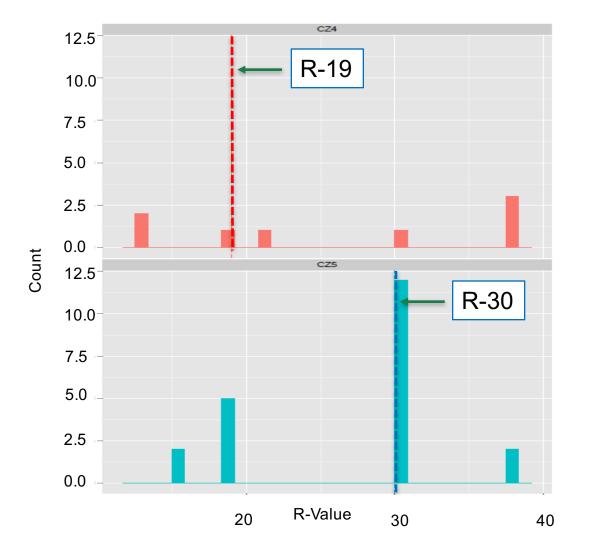
- Duct blaster test required
- Building cavities as returns OK
- No mandatory blower door test
- No DET verifier qualification requirements



### Foundations



### Floor R-Value (Cavity)





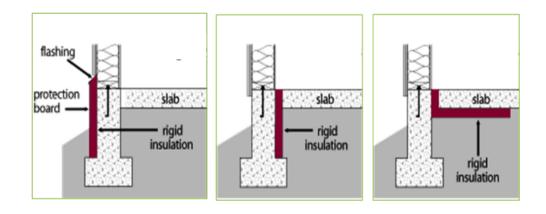
#### 90% Compliant

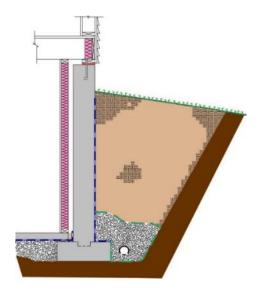




#### Foundations

### Slab and basement walls





### **Overall 89% Compliant**

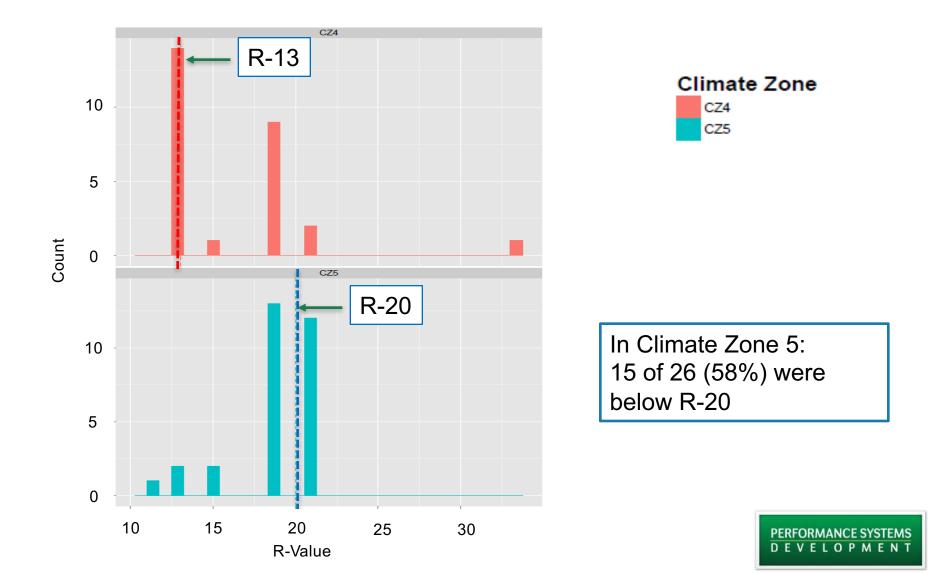




### Above Grade Walls

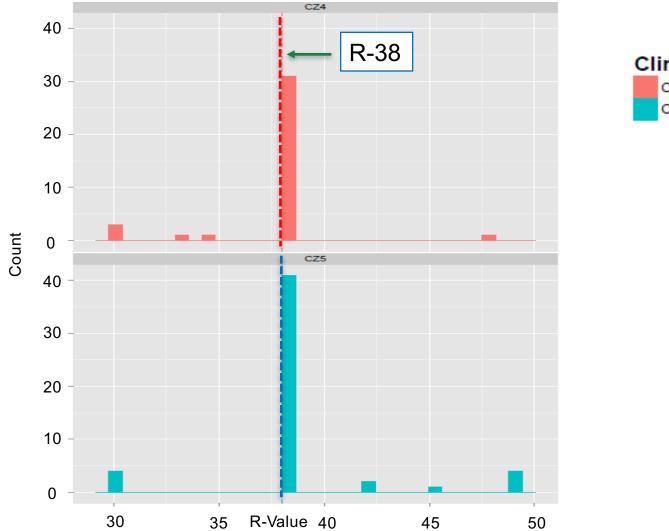


### Frame Wall R (Cavity Only)





### **Ceiling R-Value**





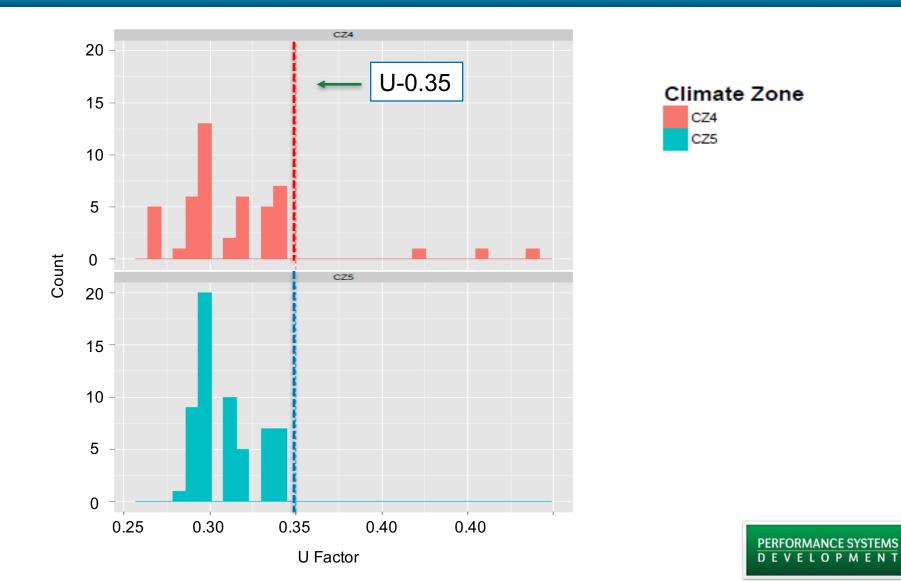




# Windows



### Window U-Factor

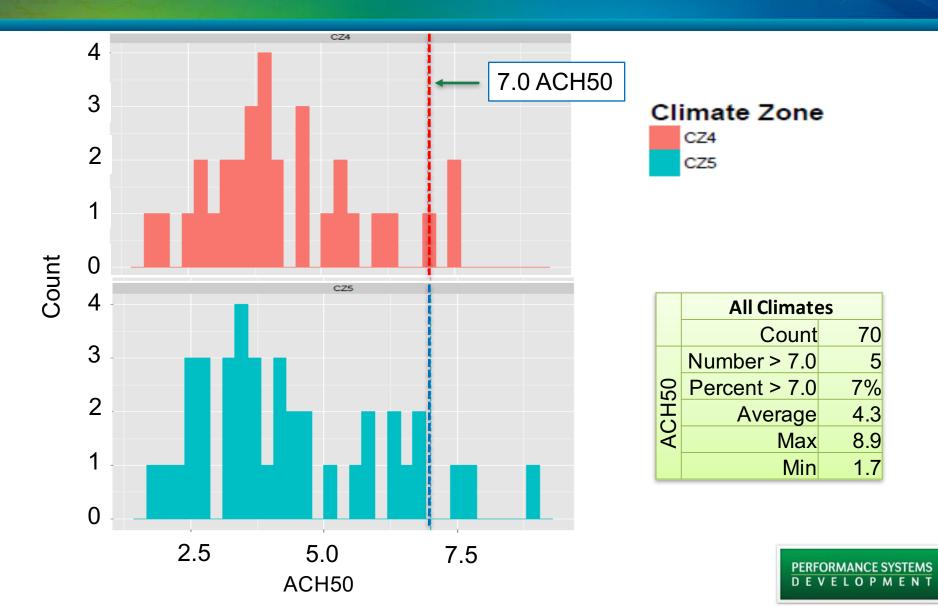




# **Envelope Tightness**



### Envelope Tightness (ACH50)

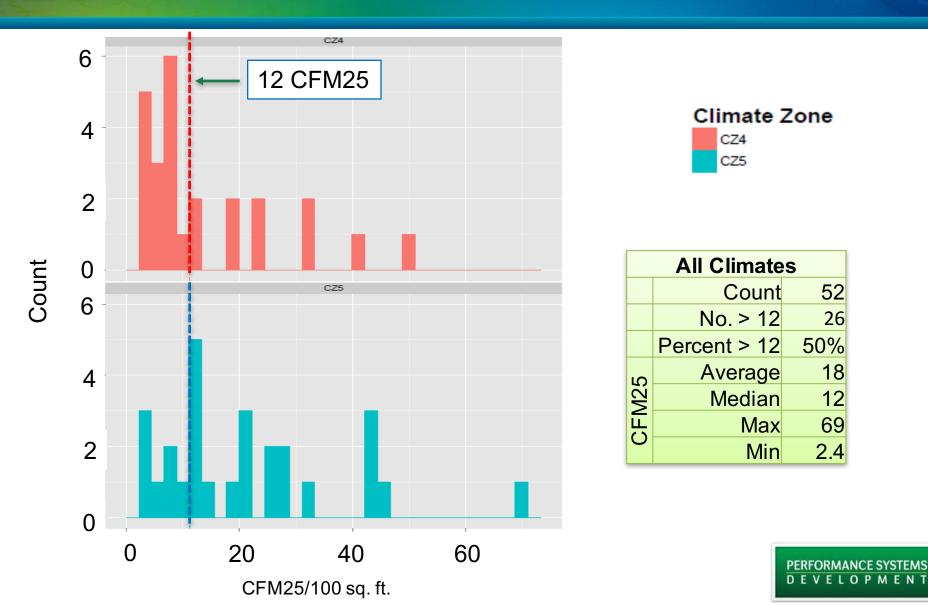




# Duct Leakage

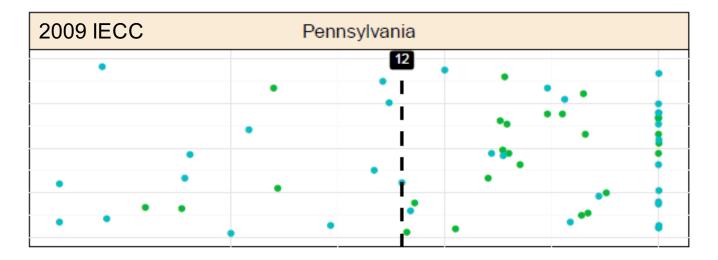


### Field Study Results Total Leakage (CFM25/100 sq. ft.)





### Impact of Code Versions



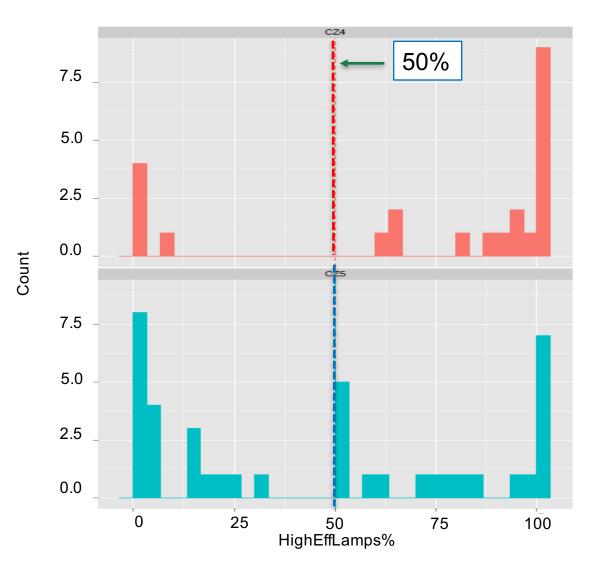
2015 IECC	Maryland					
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	•					

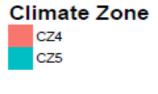


# **High-Efficacy Lighting**



### High-Efficacy Lamps (%)





All Homes						
	No.	%				
≥50% HE	39	62%				
<50% HE	24	38%				





# **Savings Potential**

#### Whole-house Savings Method



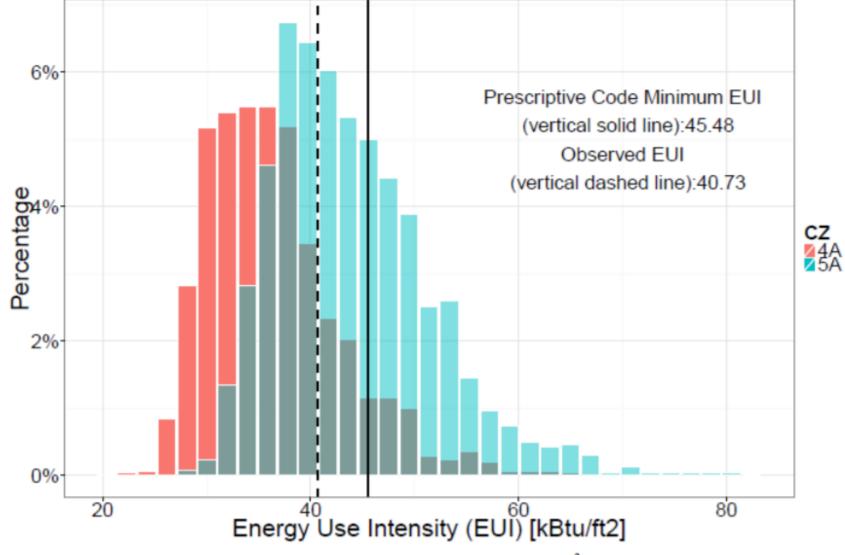


Figure ES.2. Modeled distribution of regulated EUI (kBtu/ft²/year) in Pennsylvania



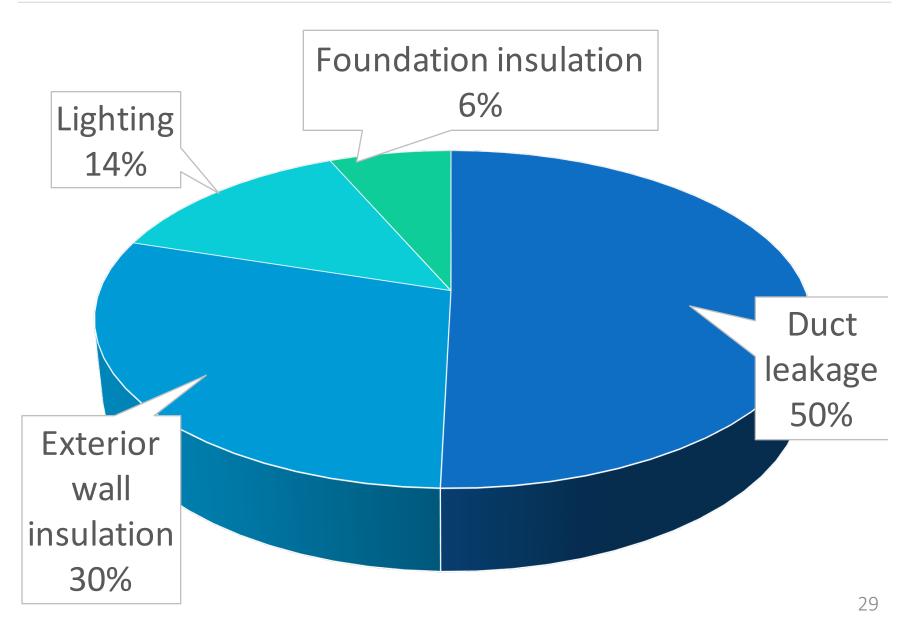
Measure	Climate Zone	Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ home)	Total Savings (kBtu/ home)	Number of homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings (\$)	Total State Emissions Reduction (MT CO2e)
Duct Leakage	4A	215	46	5,359	7,040	37,728	594,504	2,761
	5A State	206	45	5,233	9,331	48,828	766,056	3,552
	Total	210	46	5,287	16,371	86,553	1,360,493	6,363
Exterior Wall Insulation	4A	16	5	532	7,040	3,745	55,233	264
	5A State	159	49	5,449	9,331	50,849	742,797	3,447
	Total	98	30	3,335	16,371	54,594	798,031	3,710
Foundation Insulation*	4A	-31	16	1,482	6,312	6,573	66,149	302
	5A State	-61	22	2,016	8,366	11,138	109,462	499
	Total	-48	20	1,788	14,677	17,711	175,610	802
Lighting*	4A	179	-3	312	7,040	2,193	158,333	757
	5A State	179	-3	287	9,331	2,676	206,930	1,003
	Total	179	-3	297	16,371	4,868	365,254	1,760
TOTAL		439	93	10,707		163,726	2,699,388	12,635

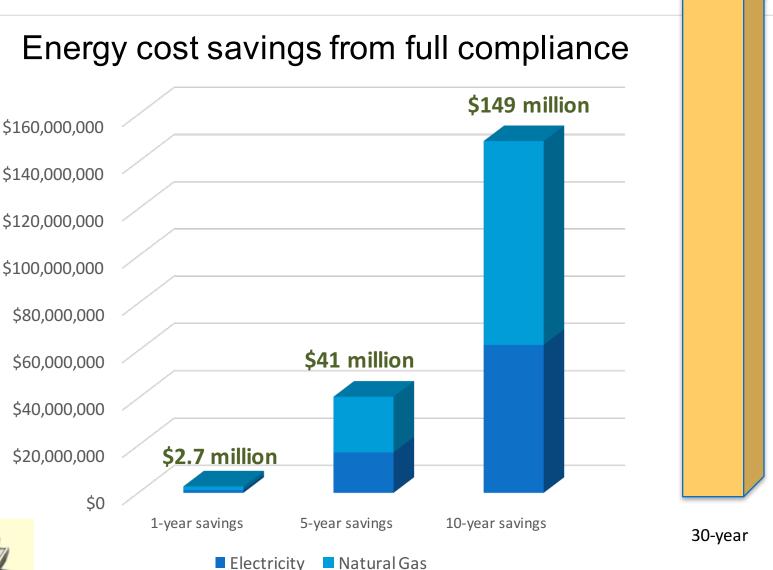
#### Table 3.11. Statewide Annual Measure-Level Savings for Pennsylvania

\* 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.







\*Assumes 16,400 homes/yr

\$1.3 billion



### **Energy Savings Opportunities**

### The Big Three...

Duct Leakage
 Insulation Quality
 Lighting









Return air cavity

Connected to attic



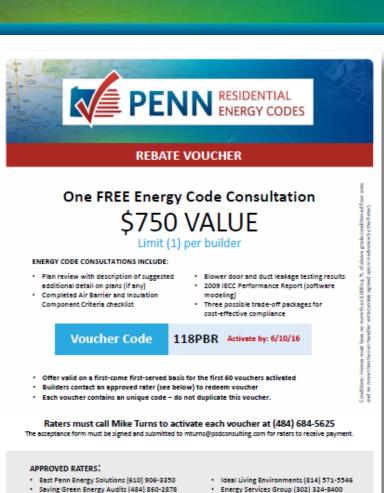






# Training, Education, & Outreach

### **Voucher Program**



PENN RESIDENTIAL ENERGY CODES

- Eco-Haven Building Systems (570) 660-1122
- Affordable Energy Now (717) 633-9876
- ReVireo (888) 568-5459
- MaGrann Associates 1(866)-MAGRANN
- Lowry EcoSolutions (267) 257-5898
- DSB Energy Services (215) 997-7186
- EAM Associates (732) 556-9190 ext. 210

#### **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



# **Classroom Training**

- 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

ERFORMANCE SYSTEMS

PENN RESIDENTIAL ENERGY CODES





Focus on the Core Message

# **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"



### Webinars

 Monthly webinar series

#### WEBINARS

Recent webinar: New Tools for Quick Residential Energy Code Enforcement

# Email Brandon at 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





#### Customizable forms/checklists

#### Energy Code Checklist

#### Air Sealing Verification Form

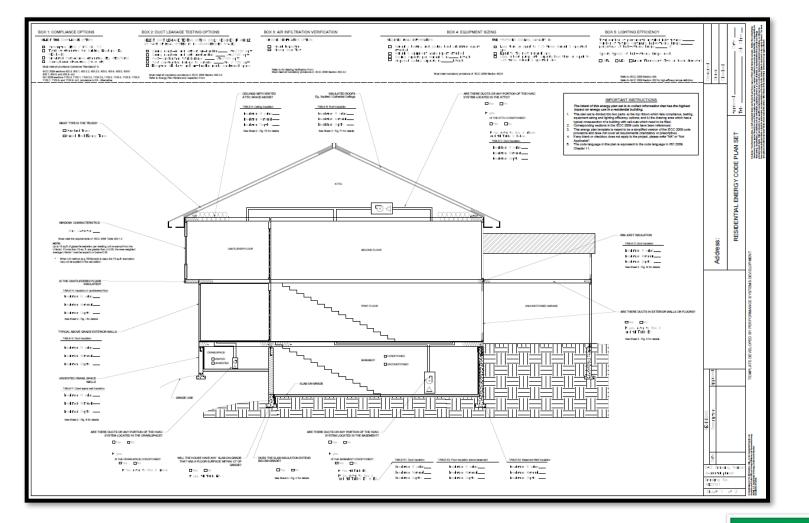
		Duct Sealing Verification Form	Your Municipality or	Company Letterhead Here			
Energy Plan Review and Inspection Form		0					
Building ID: Date: Name of Plans Examiner;				Residential Envelope A	r Leakage Verification Form		
Building Contact: New							
-			Project Address		Permit #	_	
Building Name & At			Builder/Owner:		Buildes/Dwner Phone Number:		
Subdivision:							
State:	Ducts:		Choose a buil	Your Municipality or Com	pany Letterhead Here		
Choose a comptian	Yez [No Is the sir handler or any portion of the duct system located outside of conditioned space? If yez, complete the rest of this section:	The Manufacture of Decision (Here					
c IECC/IRC ON 11	or this section: Supply ducts in ventilated attics have an R-value of at least R-8, as indicated on the plans		D Testin D Visco	Air Barrie	r and Insulation Inspection Checklist (Tabl	e 402.4.2)	
D IECC-UA Alter	Ducts outside of conditioned space have an R-value of at least R-6, as indicated on the plans	Residential Energy Code Doxt Lawlage Verification Form	<ul> <li>Visual</li> </ul>	Component	Criteria	Complies	Does not
Yes No Will the	Duct leakage rate in cfm per 100 ft <sup>2</sup> conditioned floor area		insula	-	Exterior Thermal envelope inculation for framed walls is		Comply
	Choose the proposed type of duct leakage text: Required Rate Proposed Rate Field verified Rate (trom report				installed in substantial contact and continuous alignment		
Component	Precipite Petermona path only provided by permit holder	Project Address: Farmic #		Air barrier and thermal	with building envelope air barrier. Breaks or joints in the air barrier are filled or repaired.	-	0
	Rough-in test without air handler     4 dm/ssofti	Buildey/Dancer Buildey/Dance Floure Floure Floure	Conditioned f	barrier	Air-permeable insulation is not used as a sealing materia		
Ceiling with attics	Post-construction test – leakage to outdoors II driv/30 tr'     Post-construction test – total leakage 12 driv/30 tr'		Average callin		Air-permeable insulation is inside of an air barrier.		
Ceiling w/o attic s		Unied all ducts are located within conditioned space, one of the following must be verified indicate one;:	Average calls		Air barrier in any dropped celling/coffit is substantially		0
Typical above grad	Equipment sizing:	D The air handler and all decars are loaged consistently within conditioned space. Testing is not regulated.	Valume of co	Celling/attic	aligned with insulation and any gaps are sealed.	-	
Attic knee wells	Manual J heating and cooling load calculation report is attached     Manual S equipment signe report is attached	<ul> <li>The initial state in the initial initial and an an approximate an additional state approximation appr</li></ul>		-	Attic access (except unvented attic), knee wall door, or drop down stair is sealed.		
Rim/band joists	Cooling capacity per Manual S Proposed cooling capacity	<ul> <li>Rough-In social duct leakage with air hendler installed is all offer per 100 fm #25 Fe</li> </ul>	Diswer door t	Walls	Corners and headers are insulated.		
Welkout portion of	<ul> <li>Proposed cooling capacity is less than or equal to 1.15 times<sup>1</sup> the size specified by Manual S report, or next nominal size</li> </ul>	<ul> <li>Rough to start duct loading without with market load of the part (2015 Mr / 425 Te         <ul> <li>Provide the start of the part of the</li></ul></li></ul>		Wald	Junction of foundation and all plate is sealed.		
1" through 3" not	Linksing	<ul> <li>Executive and a state of the st</li></ul>		Windows and doors	Space between window/door jams and framing is sealed		
Enclosing a conditi	a Building plans indicate that at least 50 percent of the bulls in permanently installed firstures will be high-efficacy			Rim jeists	Rim joists are insulated and include an air barrier.		
Over outside air le	Details and notes	Duct leakage testing exception:		Floors (including above-	Insulation is installed to maintain permanent contact with	• o	
Over vented crew!	Detads and notes: © Required details or notes, when applicable (attached are examples of details that may be used)	Contraction the accounter and adjustments and adjustments within a second provided the second provided and adjustment of the second provided an		garage and cantilevered floors)	underside of subfloor decking. Air barrier is installed at any exposed edge of insulation.		
Over unconditions	<ul> <li>Slab on grade with insulation extending downward from the top of the slab</li> </ul>	continued (park		[Unvertex]	Insulation is permanently attached to walls.	1 6	
Basement wells	o Insulated corners: Framing allows space for insulation	Sgrature Cate		Crawl space walls	Exposed earth in unvented crawl spaces is covered with		
Unvented crewl sp Slabs on grade <sup>vil</sup>	Insulated headers: Insulation installed in headers as space allows     Finglaces on exterior walls: Air barrier between insulation and finglace insert				Class I vapor retarder with overlapping joints taped. Duct shafts, utility genetrations, knee walls, and five	-	<u> </u>
sites on grade.	Prepises on exterior value: writemer between insulation and trepises intert     Dropped celline/coffit: Air barrier allened with insulation			Shafts/penetrations	shafts opening to exterior or unconditioned space are		
D The highest wir	<ul> <li>Porch roofs: Exterior wall sheathing extends behind intersection with porch roof</li> </ul>	Duct lexicoge text result:			sealed Batts in narrow cavities are cut to fit, or narrow cavities		
or performance	<ul> <li>Skylight shafts: Shaft walls are insulated and include attic-olde air barriers</li> </ul>	Square fundage of conditioned three areas served by MOR system: 10 <sup>2</sup>	_	Narrow cavities	are filled by sprayed/blown insulation.		
Choose and air seal	<ul> <li>Showers/tubs on exterior walls: Air barrier located between wall insulation and the shower/tub</li> <li>Ence walls: Air barrier on attic side of knee wall, top plate installed, blocking between floor joists under knee wall</li> </ul>	Techni levikov rozed'im	Testing compa	Garage separation	Air sealing is provided between the garage and conditioned spaces.		
<ul> <li>Visual inspectic</li> </ul>	<ul> <li>Cartilevered floors: Insulated with solid air barriers underneath insulation and blockine between joints</li> </ul>	Formating characterized 2007 (Ford somethioned) flows area served + Days (solvage Flow).			Recessed light fixtures are air tight, IC rated, and sealed	• •	
<ul> <li>Blower door te</li> </ul>	<ul> <li>Attic access hatches: Weatherstripped and insulated to the same R-value as the surrounding surface</li> </ul>		A blower door leakage was m	Received lighting	drywall. Exception-fixtures in conditioned space. Insulation is placed between outside and pipes.	_	
		deg x 300 / 11 <sup>2</sup> of confidence like care care despection 2011 <sup>2</sup> 425 M	Conservation C		Batt insulation is cut to fit around wiring and plumbing.		
	<ul> <li>Applicant must provide the compliance certificate and inspection checking generated by Historica (or other approved UL asiculation tool)</li> <li>Applicant must provide compliance certificate and inspection checkin, including proposal information and out stateger retex. To receive a certificate of occupancy, blower down and duct stateger text results must be provided to only their to inspection.</li> </ul>	a filos a fill	Energy Provisio	Plumbing and wiring	sprayed/blown inculation extends behind piping and wiring.	<u>۔</u>	
	"If the basement will be conditioned, a basement wall involve multiple lated at the basement will be conditioned.	Tolina umany wine Tablida		Shower/tub on exterior wal	Showers and tubs on exterior walls have insulation and a air barrier separating them from the exterior wall.	° 🗆	
	* For homes under the UK or Tenformence approach, Rivelues must also metch NECoheci, REM/Rate, or other documentation.	A dust beings to 3 has been performed for the server performed on the MMD system for the biochim states, and the	Spatate	Electrics//phone box on	Air barrier extends behind baxes or air-sealed-type baxe		
	<sup>4</sup> A minimum of R12 may be installed when using the Ferrey/varia Alternative <sup>45</sup> Sab insulation is required anywhere the space above the sab is conditioned and the floor is location 12° or less below grade. This may include portions of welkout	duct system means the minimum lookage requirements out inted in the 2009 international Charge Conservation		exterior wall	are installed. Air barrier is installed in common wall between dwelling	-	
	bacements: A hath-lock thermal break inclead of a full #-00 b allowed under the Pennoykania Alternative If the code official may require an approved party independent from the inclusion to impact the air barrier and inclusion. A list of HERS Raters	Conc. (Chapter 11 of the 2005 International Realidential Conc., Plantay Henrich & Asternative Residential Energy Without		Common wall	units.	-	
	participating in the Ferin Directly Codes Program can be found at pervice engycodes.com. The cooling capaday of a heat pump may be 1.23 times the size specified by Manual Sreport.			HVAC register boots	HVAC register boots that penetrate building envelope an sealed to subfloor or drywall.		
				Fireplace	Fireplace walls include an air barrier.		
	PDN Resterior Deep Cales   Schenkur/Iven   prevenzygnatio.com	Square Dra India wetfel peleseet "Introduces and compared to an observationed Intel Annual Annual Annual Annual Annual Annual Annual Annual Intel Annual Annu		Find a certified professio	Altp://pannenerspcodes.com/enerspeapers/ http://www.nehers.org/find-herscrateg http://www.hphpmeowner.org/find-a-contracto		

Hard-copy checklist and forms distributed to over 750 people

PERFORMANCE SYSTEMS D E V E L O P M E N T



### Tools

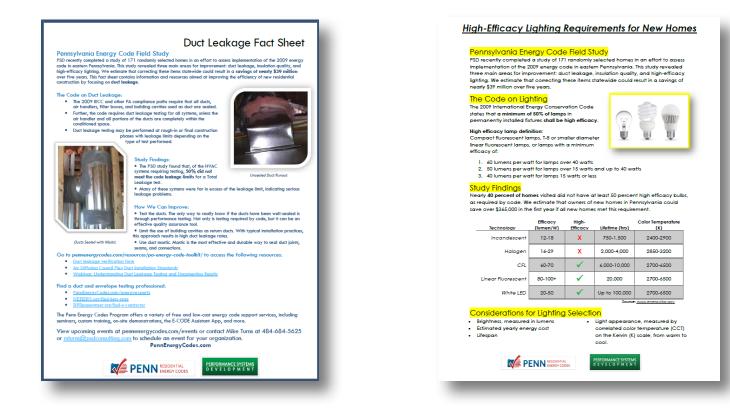


#### PERFORMANCE SYSTEMS D E V E L O P M E N T



### Tools

### Fact sheets





**Field Guides** 

# • Direct mail with cover letter



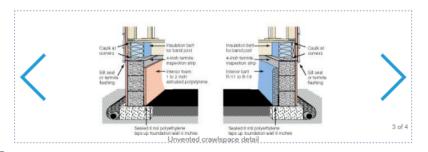






### **Tablet App**

iPad ♀ 12:35 PM 93% 🗩					
Back to List View	<b>G</b> E-0	CODE Ass	sistant	COMPLETE	
INSULATION INSPECTION					
BUILDRITE — 123 MAIN STREET — 1/8/2016					
Inspection Details	Code	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 stern wall.					
Select •	Enter notes as	applicable		Ö	
Unvented crawl spaces: is Select •	the wall insulation		xterior, or both?	Ö	
Unvented crawl spaces: interior wall insulation R-value					
Enter R-Value	Enter notes as	applicable		0	
Unvented crawl spaces: ir finished grade level and th Select		or horizontally for			



# The E-CODE Assistant:

An iPad-Based Energy Code Checklist and Educational Tool





Custom Training and Technical Assistance

# 28 office/field visits covering >150 jurisdictions



PERFORMANCE SYSTEMS D E V E L O P M E N T



## **On-site Training**

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



PERFORMANCE SYSTEMS DEVELOPMENT





#### **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 Resourc	es
Related We	bsites	Newsletter Archiv	e

#### FORMS

PENN RESIDENTIAL ENERGY CODES

- 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



#### www.pennenergycodes.com

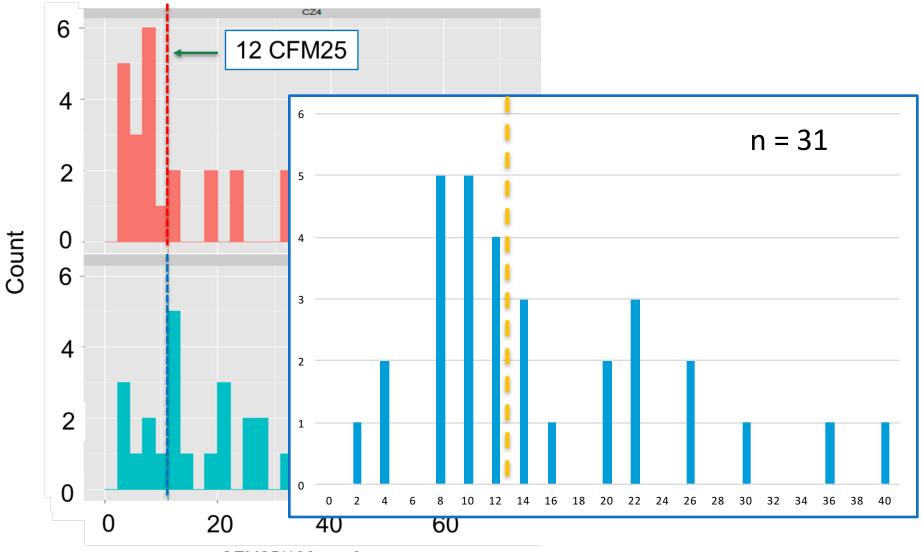
PERFORMANCE SYSTEMS DEVELOPMENT



# Results

# (Preliminary and Not Statistically Significant)





CFM25/100 sq. ft.

52

# Average total duct leakage

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

20% reduction

	Homes	Percent
Pass	17	55%
Fail	14	45%



## 2014-2015

Grade	Homes	Percent
Ι	20	32%
II	40	65%
	2	3%

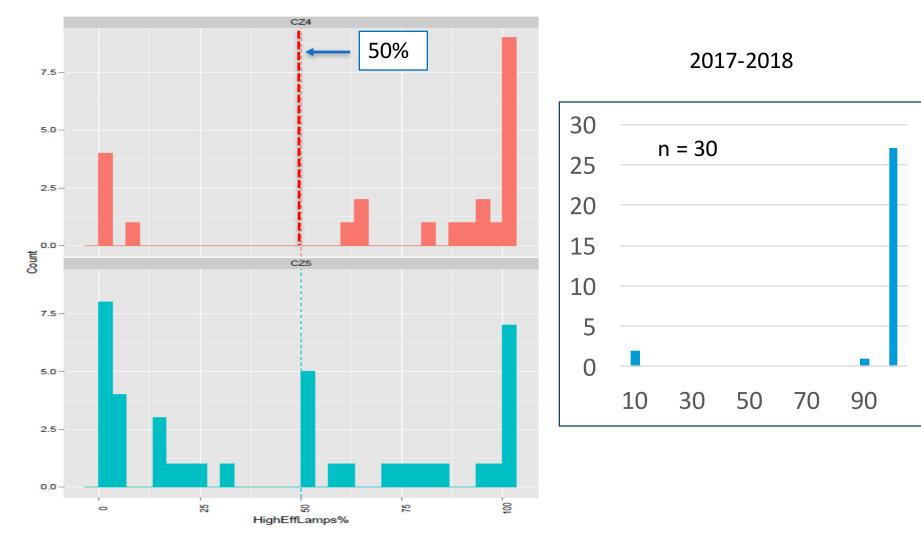
## 2017-2018

Grade	Homes	Percent
	2	7%
	23	77%
	0	<b>0%</b> 54

Lighting



2014-2015





# Thank You

Mike Turns PSD <u>mturns@psdconsulting.com</u> 484-684-5625