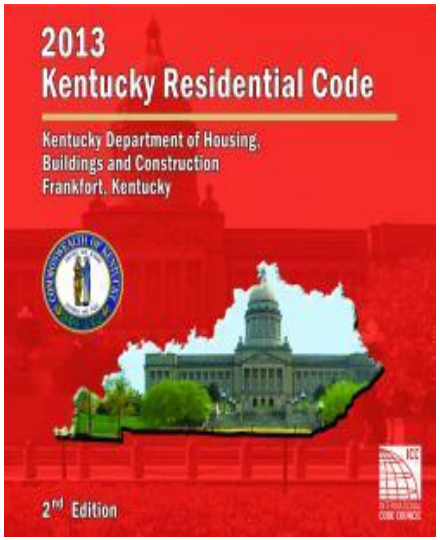
Kentucky Energy Code Compliance Study



Program Update

George Mann, Program Manager

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

COMMONWEALTH OF KENTUCKY
HOUSING★BUILDINGS
CONSTRUCTION

DEDI

Project Team

- George Mann (Project Manager)
- Larry Mahaffey (Circuit Rider)
- Isaac Elnecave/Chris Burgess/Adam Castillo (MEEA)
- Roger Banks/Ric McNees (DHBC)
- Lee Colten /Michael Kennedy (DEDI)

Overview of Project

Purpose: Determine if energy code compliance can be improved and how.

Phase1: Establish statewide level of code compliance.

Phase 2: Circuit Rider program/Training & Education program.

Phase 3: May 2017 Rerun code compliance study to determine level of improvement.

Phase 2

Southface Building know-how for a sustainable future

- **Southface**, a nationally-recognized Atlanta based training provider, has been providing our onsite training
- **22 full day** training sessions offered in 2016
- **Up to 6** additional classes in 2017

Phase 2

- Offer online registration and paper registration
- Nominal registration fee: $25 (+$200 value)
  - Attendees receive a binder containing valuable how-to Technical Guidelines relative to material presented in class
  - **Lunch is being provided** by Panera Café, Hawg Heaven and Mona's Creative Catering
- Classes are approved for CEU credits by:
  - Division of HVAC
  - Division of Building Codes Enforcement
  - International Code Council (ICC)
  - Building Performance Institute (BPI)

Phase 2

Training Topics

1. HVAC
2. **Air Sealing**
3. **Common Compliance Challenges**

HVAC Training Content

Learning Objectives:

- Identify code requirements regarding **sizing, design, and selection** of HVAC equipment and ducts
- Explain how the ACCA **Manual J, S and D** load calculation standards are used to determine appropriate sizing and design of ducts and HVAC equipment
- Describe the role the **HVAC system plays in moisture control** and the effect excessive moisture has on building durability and occupant comfort and health

HVAC Training Content

- Define **sensible and latent heat**
- **Review a completed load calculation printout** for common errors and intentional inputs of incorrect data and identify examples of such errors
- **Compare installed HVAC and duct systems** to outputs of Manual J, S, and D to verify proper sizing and design
- Describe the consequences of **improperly sized HVAC systems**

Phase 2 - HVAC

Madisonville -- March 28

14 — Brothers Bar-B-Q
1055 North Main Street

Lexington -- March 30

38 — Brock McVey
1100 Brock McVey Drive

Corbin -- March 31

29 — Brock McVey
71 Peachtree St.

Morehead -- May 17

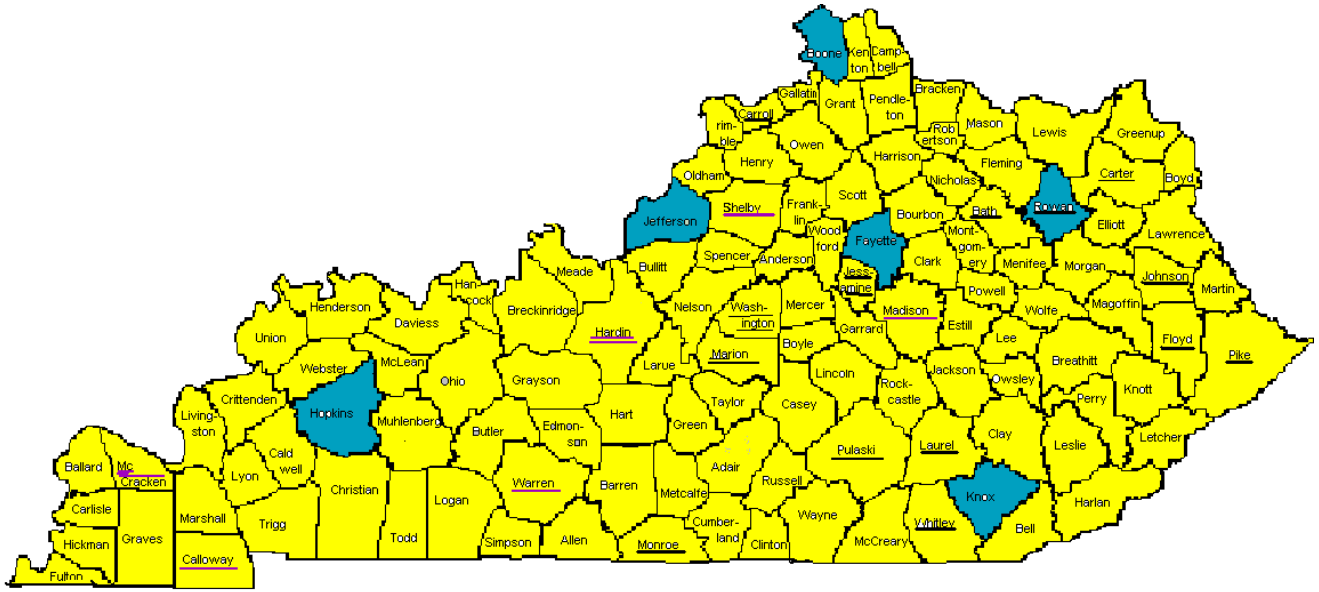
8 — KCTCS
609 Viking Dr.

Louisville -- May 19

4 — Corken Steel
1226 W. Market St.

Florence – May 20

13 — Corken Steel
7920 Kentucky Dr



Thermal Envelope Content

- **Define the building envelope** and identify the qualities of effective and ineffective envelopes
- Summarize fundamental **properties of air movement** and describe **importance of air sealing**
- **Compare infiltration and controlled ventilation** and identify benefits of controlled ventilation
- Identify **code requirements for air sealing** and **identify accepted methods to verify compliance**

Thermal Envelope Content

- Discuss **methods commonly used** to perform air sealing in homes
- Explain **relationship between air sealing and insulation**
- **Define methods of heat transfer**
- Identify **code requirements for insulation** and describe importance of insulation for home performance
- Summarize **common methods used to insulate homes**
- Employ industry-established **inspection methods for determining effectiveness of insulation installation**

Common Compliance Challenges

- **Methods of air sealing and insulating conditioned crawl spaces**
- **Calculate appropriate sizing for attic ventilation**
- **Define building envelope** and **identify qualities of effective and ineffective building envelopes** in homes
- Define **high-efficiency lighting and explore lighting options**

Common Compliance Challenges

- Identify **common missed air sealing opportunities** and describe how to air seal in these locations
- Explain **importance of sealing ducts** within conditioned space and summarize common methods used to seal ducts
- Summarize **common methods, materials and practices used to install insulation effectively**
- Identify **methods to air seal and insulate attic doors and hatches**

Thermal Envelope & Common Compliance Challenges

Louisville -- August 30 & 31

45 / 30

Memorial Auditorium
970 South 4th Street

Paducah -- October 5 & 6

Emergency Management Complex
3700 Coleman Road

Bowling Green -- October 17 & 18

Neighborhood Community Ctr
707 East Main Street

Burlington – October 20

Boone Co Extension Office
6028 Camp Ernst Road

Ashland – November 7

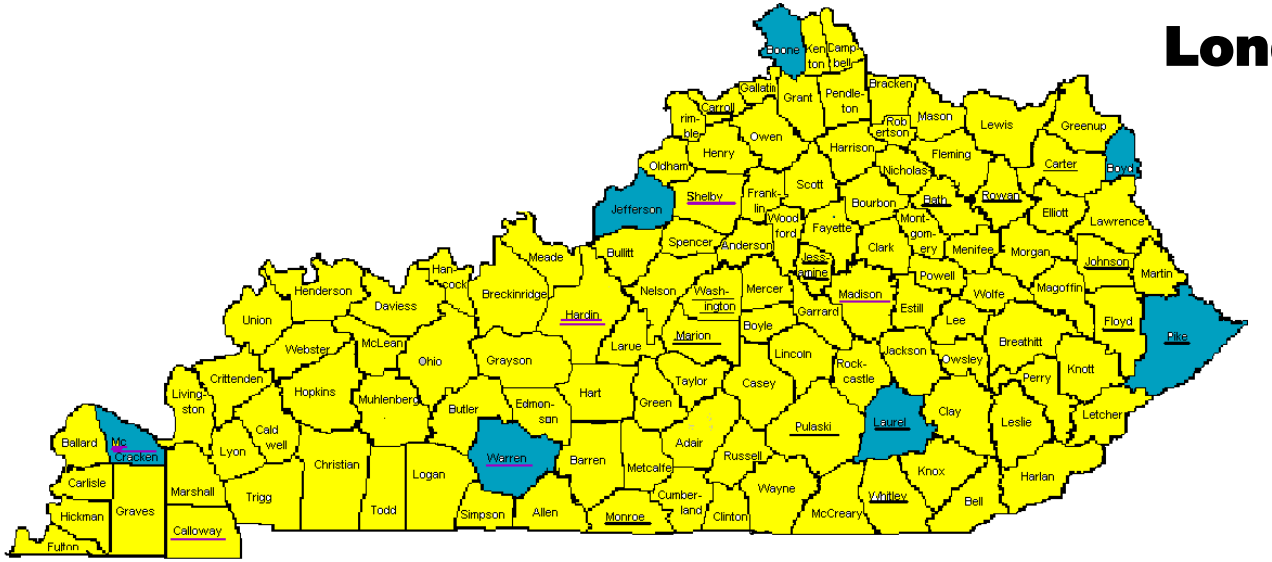
Transportation Ctr
99 15th Street

Pikeville – November 8

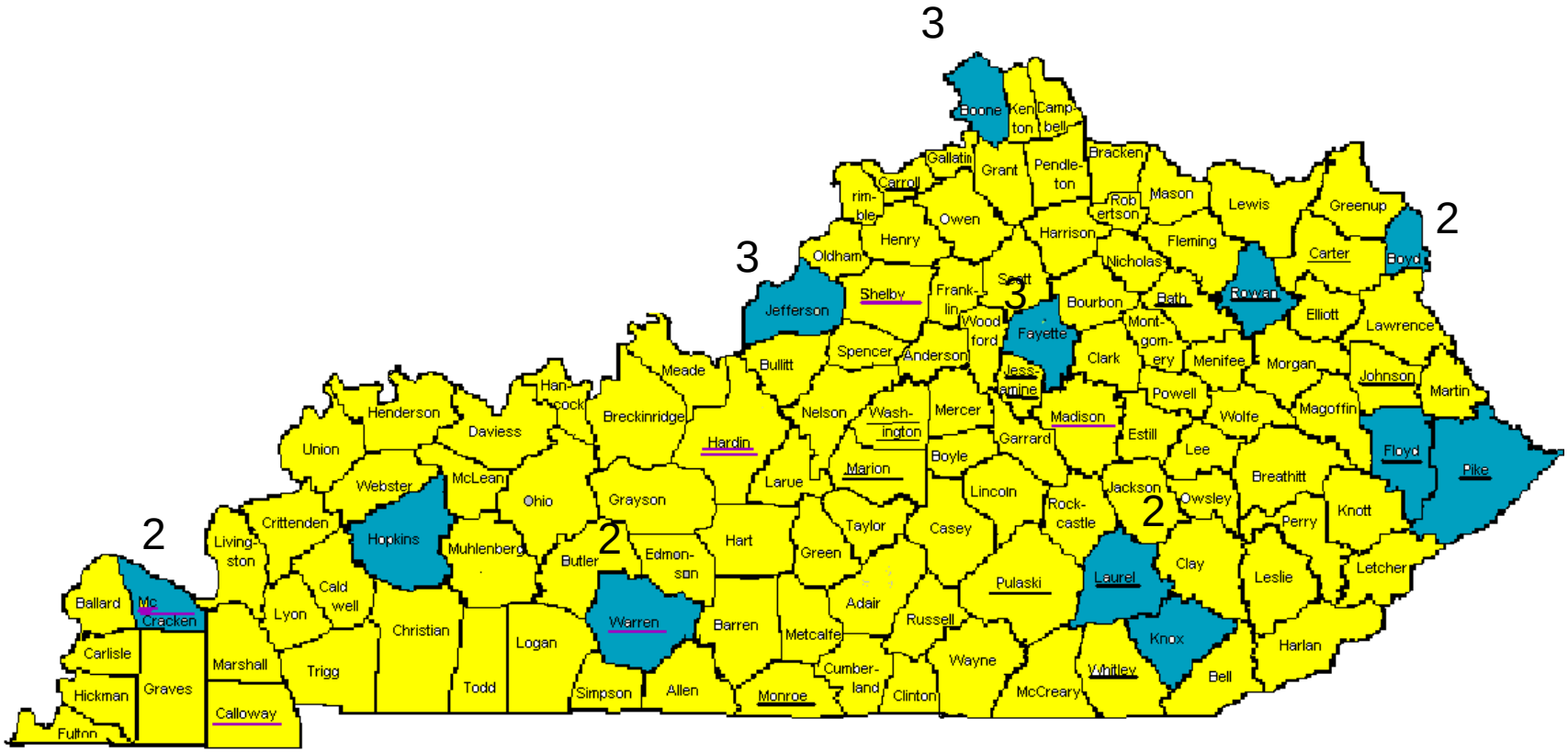
Fire Station #1
104 Chloe Rd

London – November 9

Community Ctr.
529 S. Main St



Coverage Across the Commonwealth



Class Attendance

- Total attendance to date per class
  - HVAC ……..113
  - Thermal Envelope ……100
  - Common Compliance Challenges ……43
- Attendee breakdown
  - HVAC industry ……71 **(28%)**
  - Builder / Contractor ……54 **(21%)**
  - Building Inspector ……115 **(45%)**
  - Designer ……8 (3%)
  - Utilities ……5 (2%)
  - Energy Auditor ……1 (0.4%)
  - Fire Officials ……2 (0.8%)

- **TOTAL = 256 AVG. = 18.28 / class**

Future Classes in 2017

Common Compliance Challenges
Thermal Envelope
HVAC

Locations

HVAC - Paducah / Bowling Green / Owensboro

Thermal Envelope - ?

Common Compliance Challenges - ?

Class Advertising and Outreach

- **Kentucky Association of Master Contractors**
- **Home Builders Association of Kentucky**
- **Code Administrators Association of Kentucky**
- **Home Builders Association of Lexington**
- **Regional offices of the Home Builders Assoc.**
- **Lowes**
- **Home Depot**
- **Local building departments**
- **Internet**

Hotline Use

- 3 Hotline inquiries to date
  - September 18, 2015 – residential (multi-family) kitchen hood requirements
  - April 15, 2016 – comparison between IECC and KY energy code, information on future updates
  - April 28, 2016 – what compliance method to use

Contact Information

- George Mann, Project Manager - gmann@kyenergystudy.org
- Larry Mahaffey, Circuit Rider – lmahaffey@kyenergystudy.org
- Isaac Elnecave, MEEA – ielnecave@mwalliance.org
- Chris Burgess, MEEA – cburgess@mwalliance.org
- Roger Banks, DHBC – roger.banks@ky.gov
- Ric McNees, DHBC – ric.mcnees@ky.gov
- Lee Colten, DEDI – lee.colten@ky.gov
- Michael Kennedy – michael.kennedy@ky.gov

Questions?

Kentucky Energy Code Compliance Study

Circuit Rider Program Update

Larry Mahaffey
Circuit Rider
September 29, 2016

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

COMMONWEALTH OF KENTUCKY
HOUSING ★ BUILDINGS CONSTRUCTION

DEDI

Circuit Rider Position

- Started work on August 1, 2015
- 14th month of 26 month program
- Provide individual assistance to code officials, builders and other energy code stakeholders
- Pro-actively reach out to stakeholders on a regular basis
  - Typically discuss non-compliant measures found in baseline study
  - Ask what issues the code official / builder might have
- Establish and maintain a trusted energy code advisor relationship

Meetings/Contacts Conducted

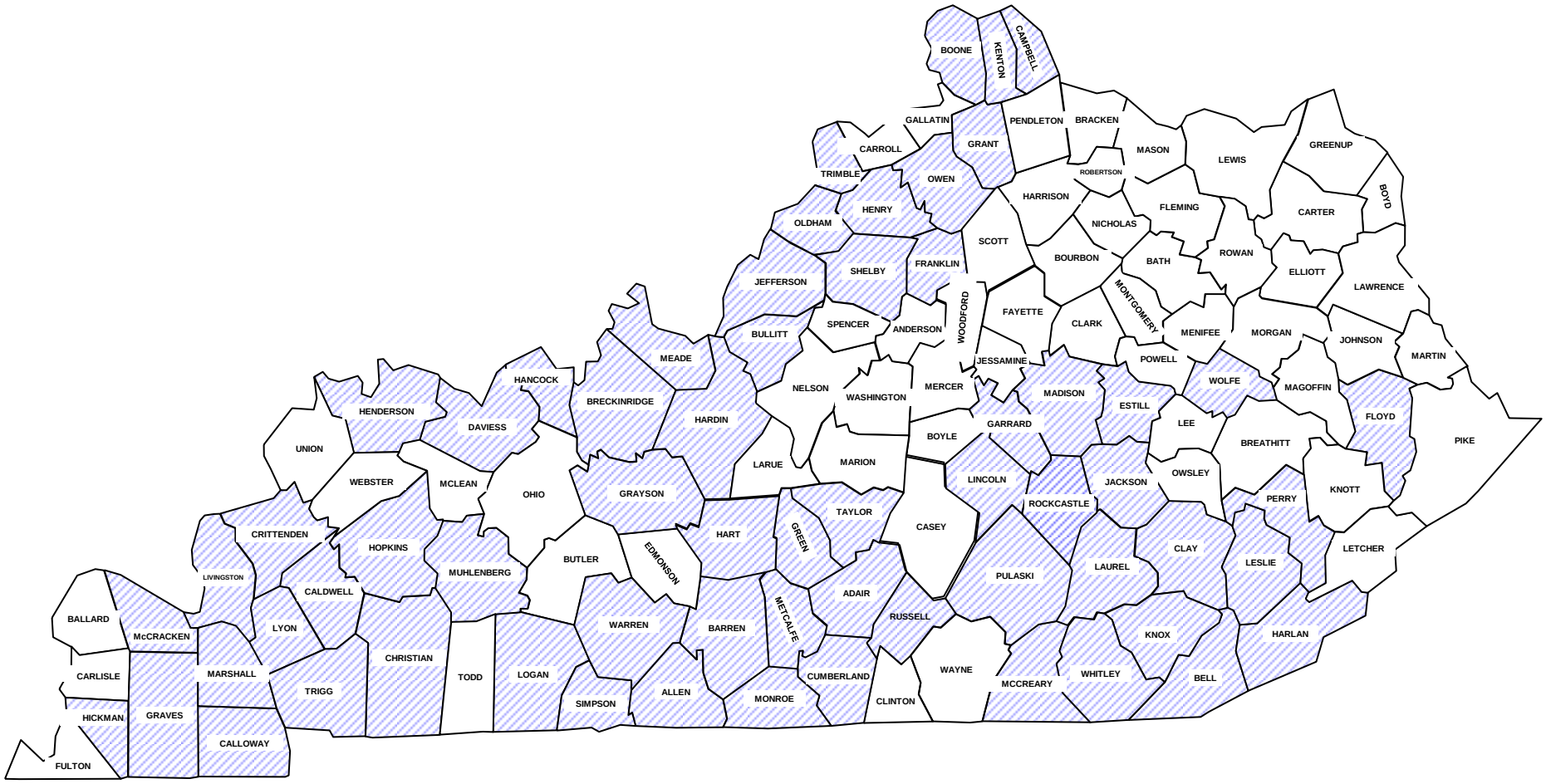
- 110 Meetings to date
  - 40 with homebuilders
  - 47 with inspection departments
  - 7 with HVAC contractors
  - 4 with Insulation contractors
  - 5 with a local officials
  - 5 with building supply businesses
  - 2 with local co-ops.
- Meeting typically last from 30 – 120 minutes with 1 to 4 attendees. **174 total attendees** as of September 1, 2016
- Also made 103 “in-field” contacts where information or assistance was given when on a building site.

Meetings/Contacts Conducted

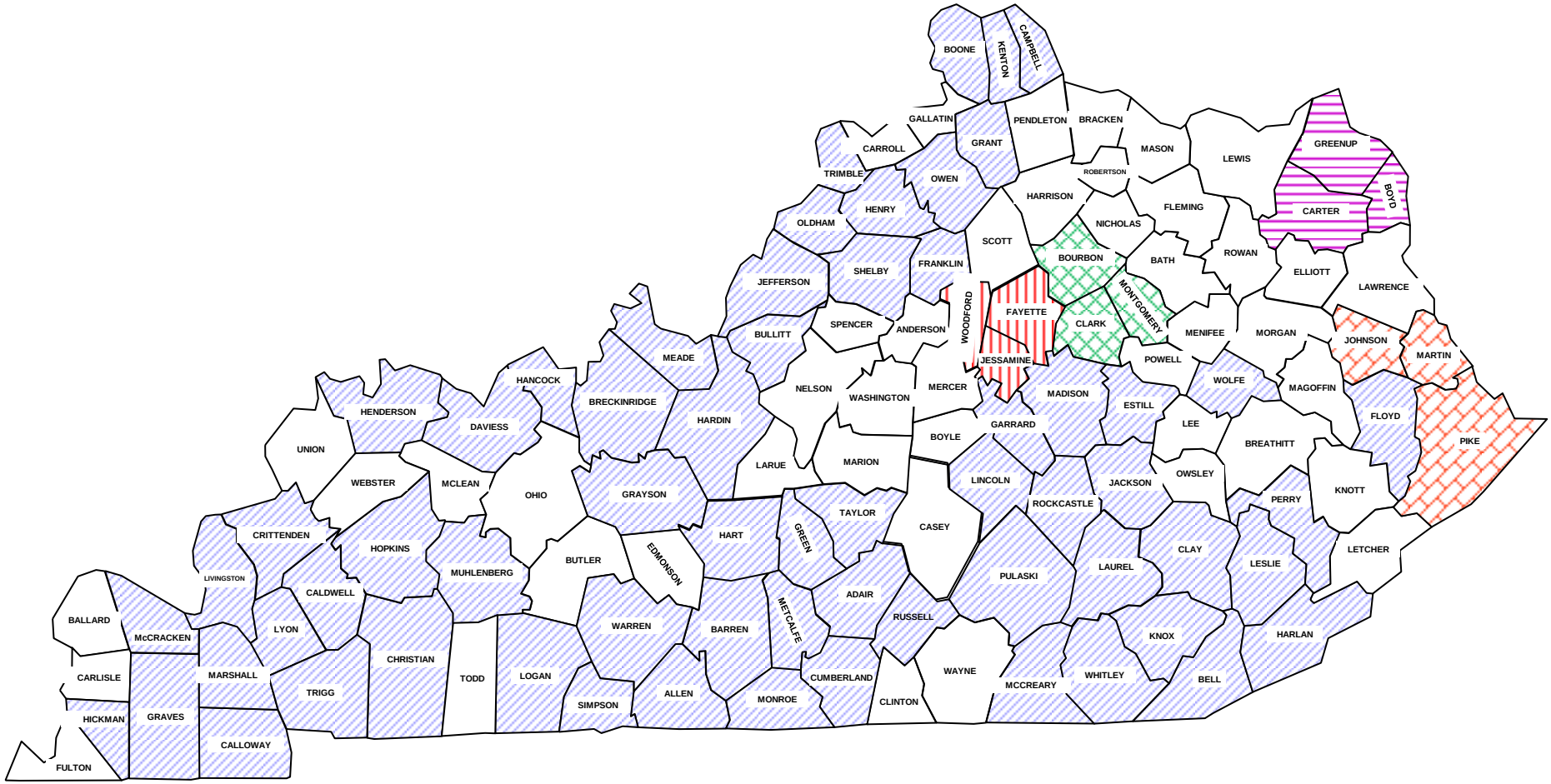
- Builders, contractors and code officials have generally been open to meetings and often **willingly provide referrals**
- Continuing follow-up visits with previous contacts
- Energy code “hotline” remains a stubbornly underutilized resource – only three calls / emails to date.
- Have also been promoting the online training videos. These are a good resource and there have been **271 views** to date.

Kentucky Circuit Rider Visits

Through 9/1/2016



Kentucky Circuit Rider Upcoming Visits



Preliminary Guidelines for Re-Visits

- **All regions** of the state will have been visited within the next couple of months.

- Re-visits will be focus more on code officials and will prioritize

  - Areas shown to need **additional education** and support

  - Areas where **meaningful numbers** of homes are being built

Topics Discussed with Homebuilders

- Provide information on the Kentucky Energy Code Improvement Study, contact / hotline information, classroom training opportunities and online videos.
- The prescriptive requirements of the 2009 IECC
  - Maintaining **continuous alignment** of the insulation with the building envelope air barrier
  - Equipment sizing, duct sealing and programmable thermostats
  - Insulation installation quality, **air sealing** behind tub/shower units, garage separation, wall corners, headers & around windows / doors
  - **High efficacy lighting** requirements
  - Foundation types; slabs, crawlspaces and basements
  - The posting of the required permanent certificate

Frequent Questions from Homebuilders

- **Moisture problems** in vented crawlspaces
- When do you add **whole house ventilation**
- Non-vented, conditioned crawlspace construction
- **Energy framing** techniques
- Energy code requirements for knee wall construction
- Methods for installing **slab edge insulation** that meets code

Topics Discussed With Building Officials

- **Application** and compliance issues with the 2009 IECC during plan review and inspection
- Energy code **field inspection** requirements
- Insulation installation quality, air sealing , thermal envelope requirements
- High efficacy lighting requirements

Topics Discussed With Building Officials

- Foundation types and **foundation insulation** requirements
- Checking **energy certificate** for correct information
- Kentucky Energy Code Compliance Study; support and training opportunities; hotline use and online videos

Building Departments Visited to Date

City Departments

Murray
Scottsville
Paducah
Shelbyville
Mayfield
Glasgow
Madisonville
Louisville
Henderson
Mt. Washington
Hopkinsville
Tomkinsville
Kuttawa
Greensburg
Owensboro
Campbellsville
Central City
Columbia
Russellville
Burkesville
Leitchfield
Jamestown
Elizabethtown
Richmond
Bowling Green
Berea
Corbin
London
Burnside

County Departments

Barren
McCracken
Marshall
Franklin
Hopkins
Shelby
Henderson
Oldham
Daviess
Owen
Simpson
Jefferson
Hart
Bullitt
Hardin
Madison
Warren
Garrard
Lincoln
Kenton
Grant
Campbell
Meade
Boone

Common Challenges Noted During Field Observations

- **Lack of air sealing** around windows and doors
- No insulation or air barrier behind tub/shower units
- No insulation in the corners/tees of exterior wall framing
- **Poor quality** insulation installation
- Floor slab edge insulation omitted
- Maintaining **continuous air barrier** and thermal barrier

Statewide Observations

- Foundation types range from mostly crawlspaces in the east and west, to a blend of slab, basement and crawlspaces in the central areas of the state.

- The **building inspectors help** the homebuilders and contractors understand the energy code in their county and surrounding counties.

- **Housing co-ops** require above code standards (Energy Star®) in several areas across the state.

Statewide Observations

- Approximately 25 % of the homes being built by private homebuilders have **2 x 6 exterior wall** framing.

- Building departments, homebuilders and contractors are in **need of training** on HVAC sizing and ventilation requirements

- Site visits revealed significant opportunities for **focused training**

Contact Information

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energycodehotline@kyenergystudy.org

Website: www.kyenergystudy.org

Questions?

More Bang for the Buck – Can Code Compliance Save kWh *and* kW?

Chris Burgess
Midwest Energy Efficiency Alliance

Vrushali Mendon
Pacific Northwest National Laboratory

KENTUCKY ENERGY CODE STUDY STAKEHOLDER MEETING

SEPTEMBER 29,2016

Background

Benefits of code compliance have been generally viewed in terms of energy use – kWh and therms

Electric demand savings (kW) from code compliance is a largely unexplored area

There are substantial benefits to both consumers and utilities in identifying and capturing the kW savings associated with improved code compliance.

Being able to include kW savings in the analysis may improve the cost-effectiveness of compliance programs, as well as offer a new path for developing programs

Three areas will be explored here – measure level savings, HVAC system sizing savings, and in a separate analysis, HVAC equipment cost savings.

Introduction

In Fall 2014, the US Department of Energy (DOE) funded eight states, including Kentucky, to conduct a three-year code compliance and energy use study on **newly constructed single-family homes**

The baseline data collection effort for Kentucky was completed in August 2015 and was led by MEEA, DHBC, and DEDI – this was Phase 1 of the KY Energy Code Study

The data analysis was conducted by the Pacific Northwest National Laboratory (PNNL), on behalf of DOE

Data Collection

Key Items were identified by PNNL as code-related elements having the greatest impact on a home's **energy use**

- Envelope Air Tightness (ACH50)
- Ceiling Insulation
- High Efficacy Lighting
- Window SHGC
- Duct Air Sealing (CFM25)
- Above-Grade Wall Insulation
- Window U-Factor
- Foundation Insulation

However, all key items also clearly impact **peak demand**

- One of the goals of this study was to quantify the kW savings associated with measure level code compliance

Data Collection: Methodology

PNNL determined the **statistically significant** sample size to be 63 observations for each key item or, in other words, 63 data sets

- Statistical significance applies only to kWh and therm savings results
- A data set is all eight key items being observed at least once

Each home could only be **visited once** and each item had to be directly observed

- No assumed conditions or default values could be used

Thus, **multiple homes** had to be visited in order to complete a full data set

A statewide, county-based sampling plan was developed to assure a random mix of data sets were sampled

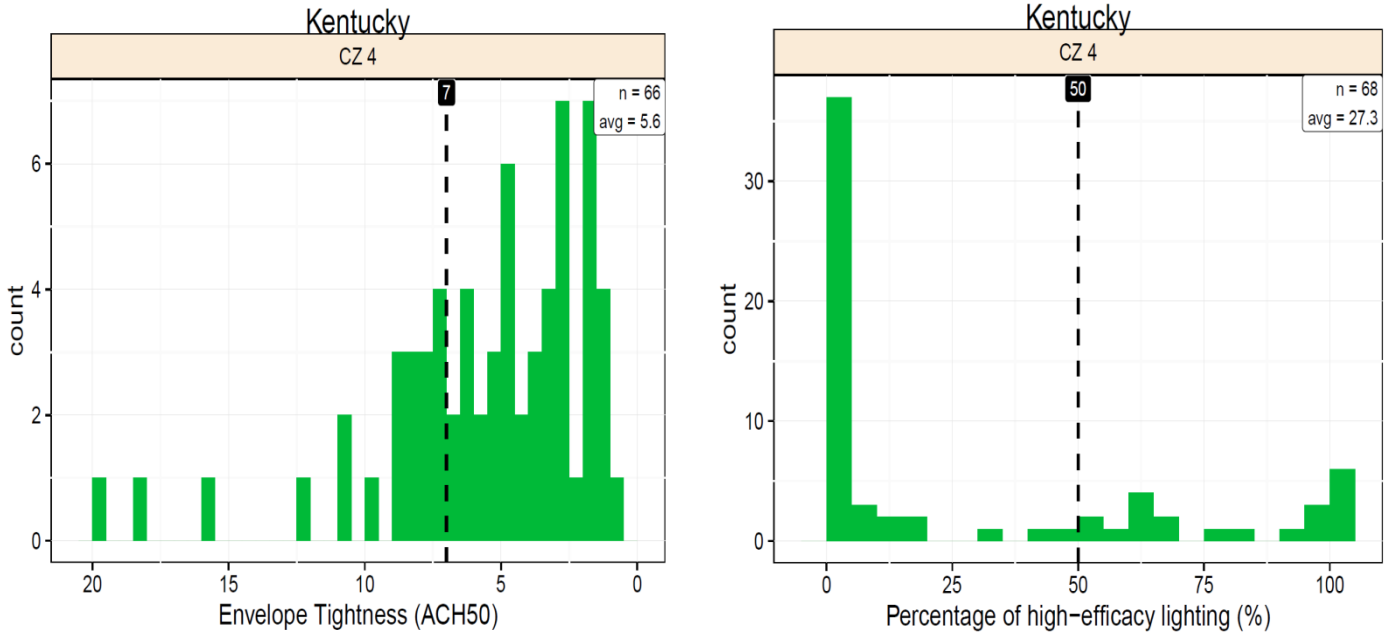
In Kentucky, **140 homes** were visited to collect the required 63 complete data sets of key items

- In addition to the key items, HVAC Sizing (Manual J) data was collected for 54 of the sampled homes

Kentucky Key Item Observations

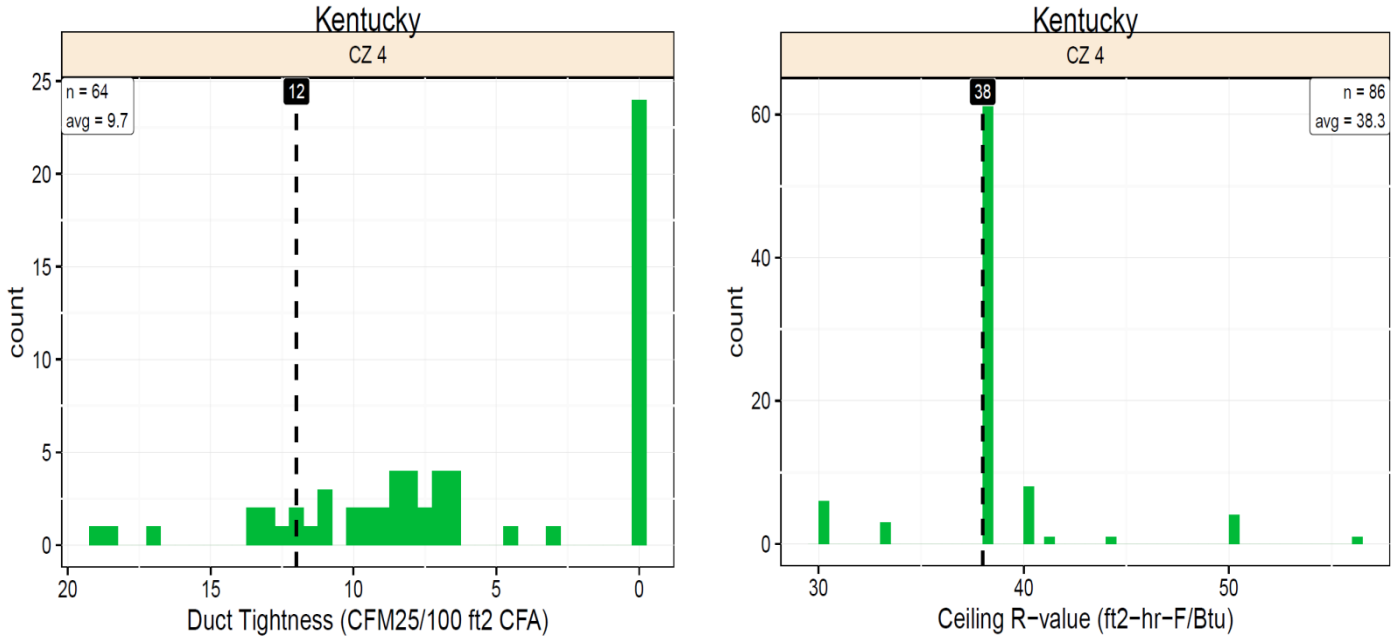
No.	Key Item	Number of Observations
1.	Envelope Air Tightness (ACH50)	66
2.	Ceiling Insulation (R-value)	86
3.	Duct Air Sealing (CFM25/100 ft^2 Conditioned Floor Area)	64
4.	Above-Grade Frame Wall Insulation (R-value)	74
5.	High-Efficacy Lighting (percentage)	68
6.	Window U-factor (Btu/hr-ft^2-F)	91
7.	Window SHGC	91

Kentucky Key Item Data Overview



- *Code requirement is indicated by the vertical dashed line and the code value is indicated inside the black box. Values to the right of the vertical line are better than the code; those to the left are weaker than code.*

Kentucky Key Item Data Overview (Cont'd)



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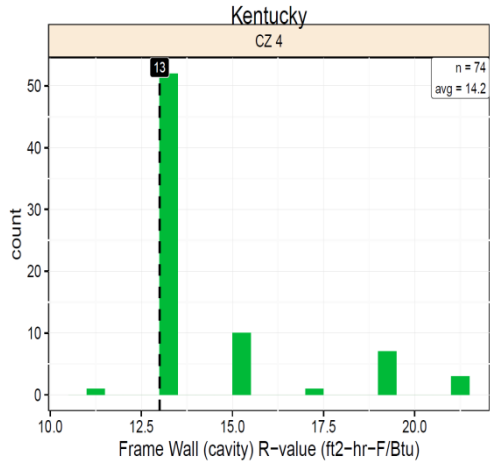

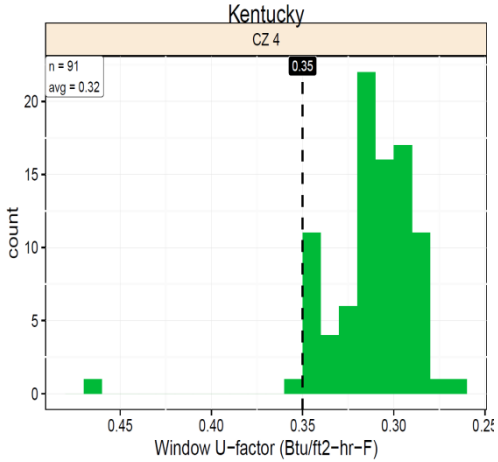

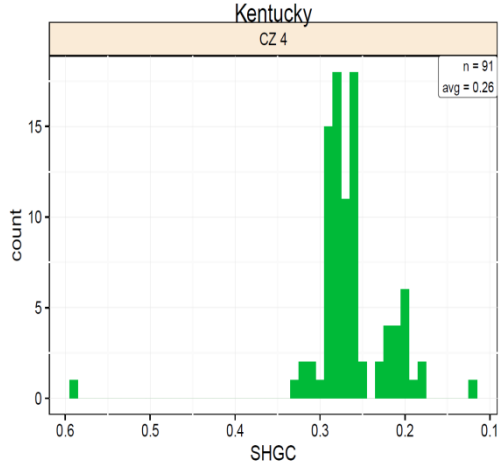

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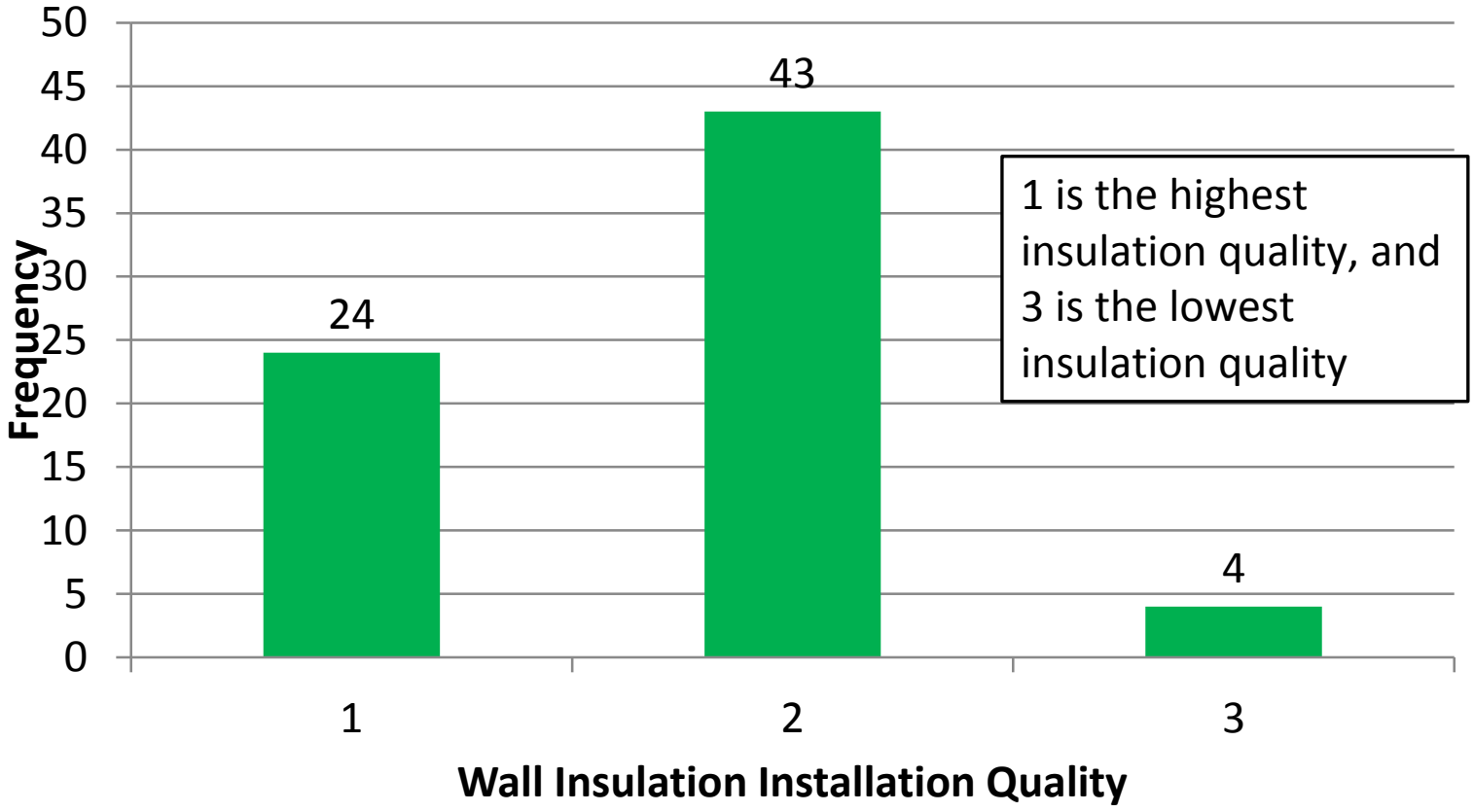


Methodology for Estimating "Lost" Energy Savings

Key items for which more than 15% of the observations were worse than code were selected for evaluation

- High Efficacy Lighting
- Above-Grade Wall Insulation, including insulation installation quality
- Envelope Air Tightness
- Duct Air Sealing

Each item was evaluated in isolation to determine potential savings

- A separate analysis indicated little impact of interactive effects on the energy savings potential

Energy Simulation was conducted using DOE's single-family residential building prototype and *EnergyPlus*

Energy and kW savings were calculated based on the delta from a minimally code-compliant building model and aggregated to the state level

Estimated "Lost" Energy Savings for the State of Kentucky

Measure	Potential Electricity Savings (kWh/year)	Potential Natural Gas Savings (therms/year)	Potential Energy Cost Savings ($/year)
High-efficacy Lighting	2,206,514	-17,865	$197,544
Above-grade Wall Insulation	1,199,555	51,841	$171,044
Envelope Air Tightness	3,245,622	161,079	$484,314
Duct Air Tightness	444,934	13,060	$57,064
Total	**7,096,625**	**208,115**	**$909,967**

** The above estimates are based on an annual projected construction volume of 7345 homes for the entire state of Kentucky*

Same Methodology Applied for Estimating kW Reduction

Measure	Electric Demand Reduction for the state of Kentucky (kW in a typical year)
High-Efficacy Lighting	558
Above-Grade Wall Insulation	971
Envelope Air Tightness	2,987
Duct Air Tightness	40

** The above estimates are based on an annual projected construction volume of 7345 homes for the entire state of Kentucky*

*** Further work is needed to determine if and how these measure-level savings can be combined to yield an aggregate estimate*

Consideration of Oversizing

Numerous studies suggest that HVAC oversizing is a common occurrence. However, few quantify the incidence, extent, and impact of oversizing

This study determines how often oversizing occurs in air-conditioners and heat pumps, the amount by which the installed units are oversized, and what kW savings could be gained if all units were right-sized

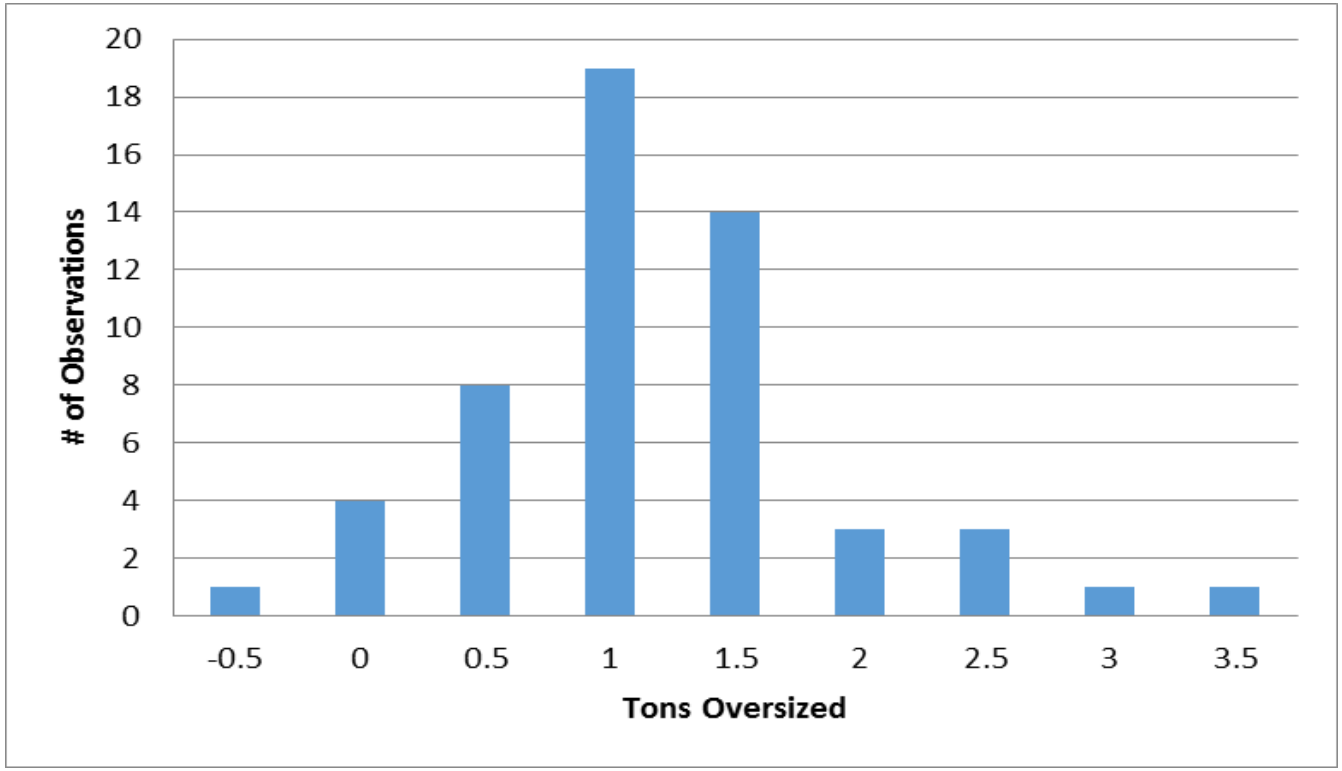
In addition to the key item data that was collected, building orientation, window/wall ratio, building volume, equipment capacity and type, and other data were collected to allow Manual J load calculations to be performed for 54 homes

Estimating the Oversizing Factor for Air-Conditioners and Heat Pumps

The load calculation for each home was conducted using *Wrightsoft* software

- As-built home data were used
- Where orientation was not given in the field data, the maximum load orientation was used
- Based on the calculated load, the next largest standard unit size was selected as the “right-sized” unit for that home
- The “right-sized” unit was then compared to the unit actually installed in the home to calculate the oversizing factors

Resulting Oversizing Factors for Air-Conditioners and Heat Pumps



Over 75% of the units were oversized by 1 ton or more

Estimating the Potential kW Reduction from Right-sizing

A simplified analysis was used to determine the potential kW reduction from right-sized air-conditioners and heat pumps

- The oversizing factors calculated from the *Wrightsoft* analysis were used to calculate an average oversizing factor
- The average factor was then used as an input to the *EnergyPlus* sizing factor field and an annual simulation was conducted to estimate the impact on peak demand

The overall potential kW reduction from right-sized HVAC equipment was found to be **2,373 kW in a typical year** for the state of Kentucky

More Bang for the Buck - http://www.mwalliance.org/resources/meea-publications/archive/policy

Consumer Cost of AC Oversizing

Consumer Cost of AC Oversizing

There are three main AC oversizing costs that impact the consumer

- Capital Cost – **Increased cost** of oversized unit
- Unit Life – Oversized units tend to **short-cycle**, reducing useful life of unit
- Performance/Efficiency – Oversized fixed-capacity units tend to **operate less efficiently** than right-sized units. They can also lead to dehumidification (moisture) problems and other indoor comfort issues.

Consumer Cost of AC Oversizing

		Ballpark Base Case
Annual # of New Homes	7,345	
90% Oversized		6,611
# of Existing Single Family Homes	1,156,003	
90% Have Central AC	1,040,403	
90% of Those Are Oversized	936,362	
Annual Replacement (25 yr life)	4.0%	37,454
Total Annual New or Replaced AC Units		**44,065**
AC	74%	32,497
Heat Pump	26%	11,568
Incremental AC Cost (1 ton)	$418	
Incremental Heat Pump Cost (1 ton)	$546	
Potential Savings - AC		$13,583,902
Potential Savings - Heat Pump		$6,315,923
TOTAL POTENTIAL ANNUAL CONSUMER SAVINGS		**$19,899,825**

Consumer Cost of AC Oversizing

Total Impact?

- **Higher** Equipment Cost: ~ $20,000,000
- **Increase** from Short-Cycling/Reduced Useful Life (15 yrs): +$12,000,000
- Increased **Energy Use**
  - Lower Bound ($8/yr/home): $350,000 to $550,000
  - Upper Bound ($72/yr/home): $3,170,000 to $5,000,000
- Single-family attached, 2-4 unit, and multi-family unit buildings (over 11,000 annual units) were not included in these calculations.

Summary

Despite an increasing focus on energy efficiency in buildings today, significant energy savings can be potentially achieved by **improving a few non-compliant building components** across the board

While most code compliance efforts have focused on energy consumption, peak demand reduction is shown to be a **significant result** of improving energy efficiency

Determining the peak demand reduction potential is a **more complex problem** due to the interactions between different building components and the mix of buildings within a given utility territory

Even so, isolated analyses conducted by the authors indicate significant peak demand reduction potential from improving code compliance in single-family residential buildings

In a separate analysis, MEEA and DEDI determined that there are **substantial consumer equipment cost savings** associated with right-sizing HVAC equipment

Analysis Limitations and Future Work

The present analysis uses many **simplifying assumptions** to reduce the complexity of the problem

- No consideration of **co-incident peak demand**
- No consideration of impact of interactions between different building components on the peak demand
- **Weather data** used in simulation (TMY3 data) represents a “typical” weather year and does not include extreme points more suitable for peak load calculations

Future iterations will aim to address these limitations and their impact on peak demand reduction

Contact Information

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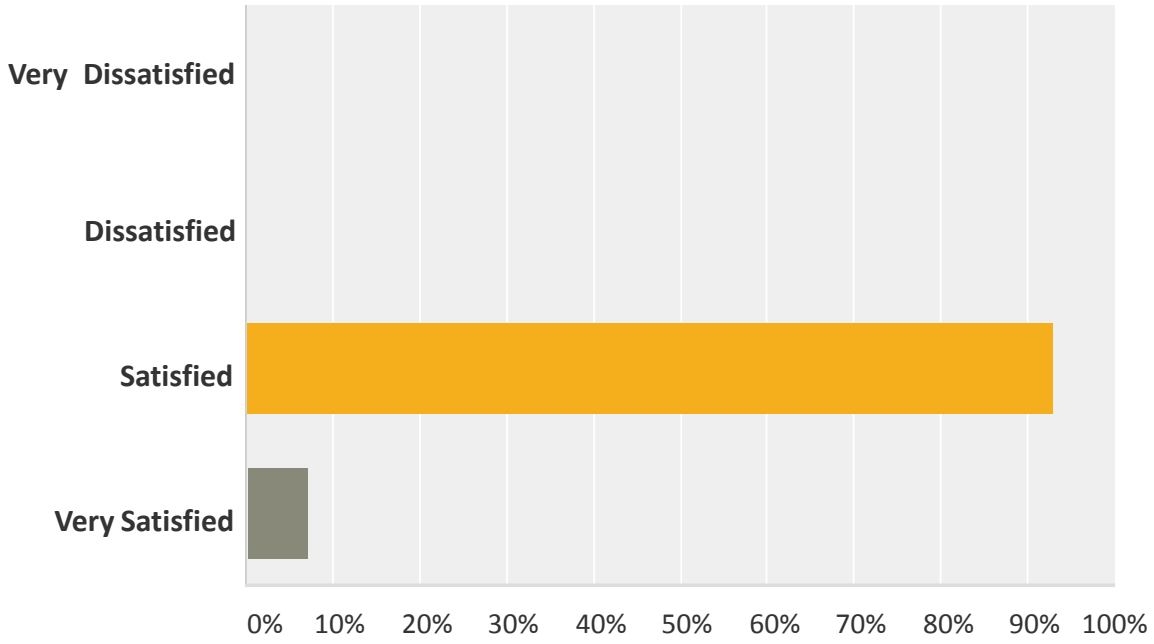
TIME FOR QUESTIONS

Stakeholder Survey

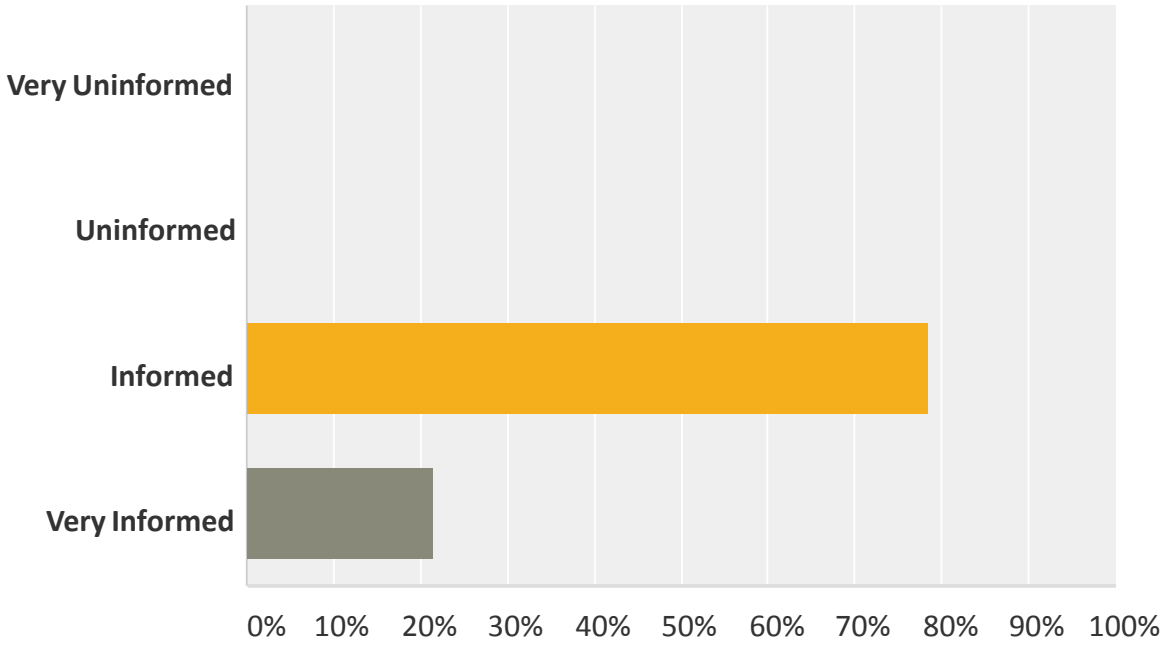
Q1 Overall, how satisfied are you with the progress of the Energy Code Compliance Study?

Answered: 14 Skipped: 0



Q2 Do the Energy Code Compliance Study Stakeholder Meetings keep you informed of the project status?

Answered: 14 Skipped: 0



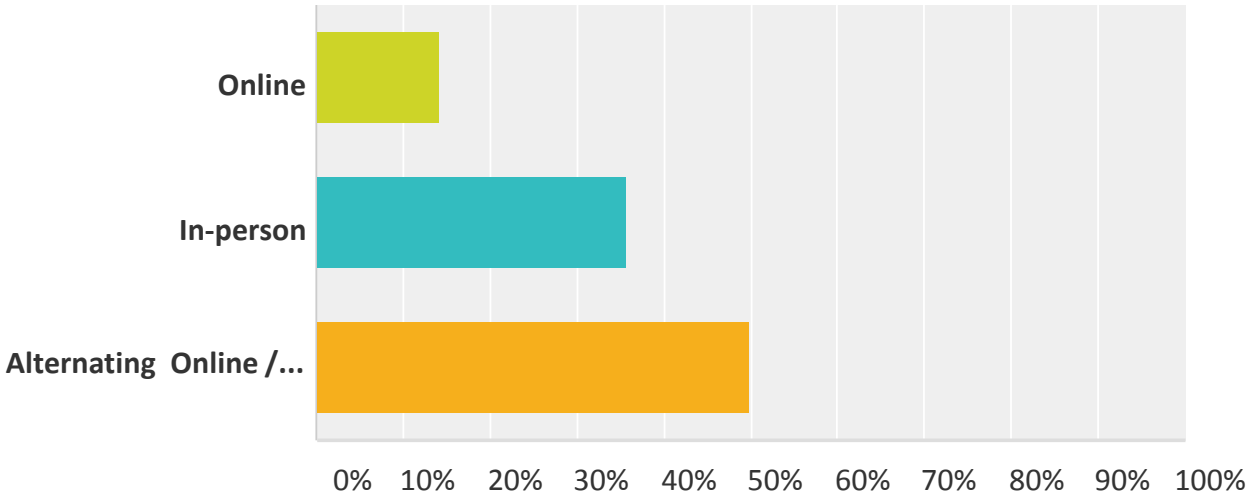
Q3 What actions could the Study's Project Team take to keep you better informed? Please explain:

Answered: 5 Skipped: 9

#	Responses
1	put information in a central depository for those who can not attend every meeting.
2	I would like to see the data published.extend public awareness
3	Do not know any better actions at this time
4	I think the Study's Project Team is doing a good job, especially George Mann!
5	Brief 1 page monthly updates

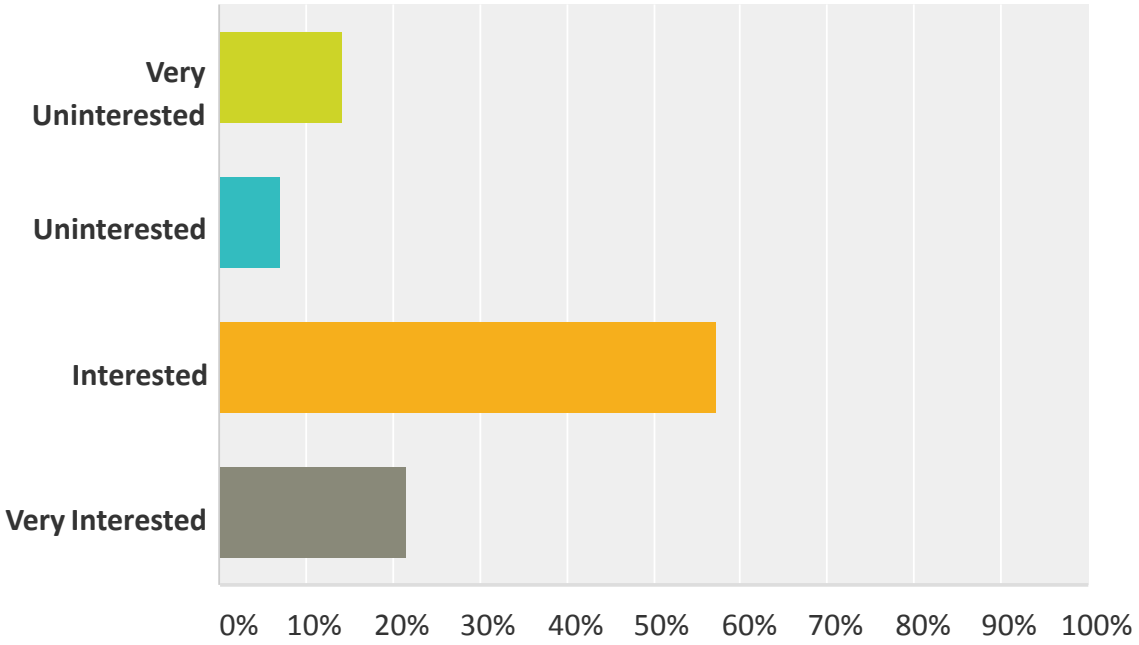
Q4 What format would you prefer the Quarterly Stakeholder Meetings take -- online, in person, or alternating online/in person?

Answered: 14 Skipped: 0



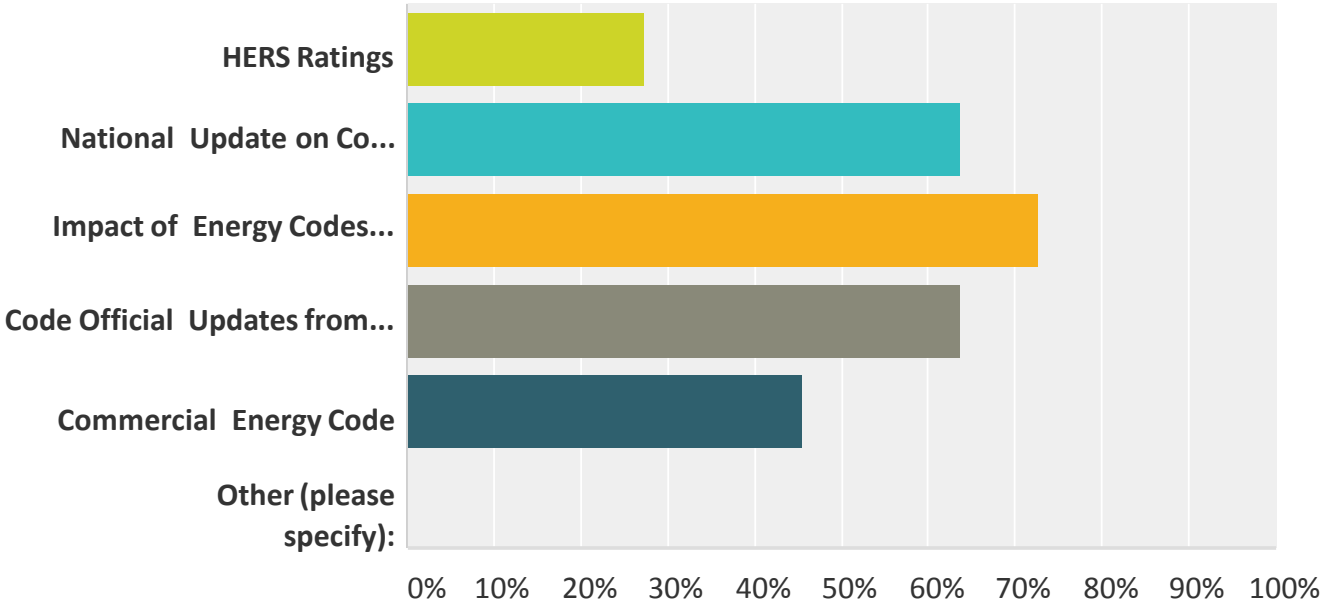
Q5 Are you interested in learning about other codes-related topics beyond the scope of the ComplianceStudy at the Quarterly Stakeholder Meetings?

Answered: 14 Skipped: 0



Q6 Please select all topics that would interest you for further discussion at a Quarterly Stakeholder Meeting:

Answered: 11 Skipped: 3




ASK
QUESTIONS

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

7th Annual

Midwest Building Energy Codes Conference

November 15 & 16, 2016
Westin, Cleveland, OH

Travel stipends must be applied for by October 7th

http://www.mwalliance.org/node/3845#7th
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