Kentucky Residential Energy Code Study – Data Driven Results

National Energy Codes Conference

Austin, Texas

July 17, 2018

MEEA

MIDWEST ENERGY EFFICIENCY ALLIANCE

Outline

- Overview of Project
- Phase I
- Phase II
- Phase III
- Results
- Conclusions / Observations
- Resources

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Acknowledgements

Project Team

- **MEEA** - Chris Burgess/Ian Blanding/Alison Lindburg/Adam Castillo/Isaac Elnecave/Kelsey Horton
- **KY Department of Housing Buildings and Construction** (DHBC) - Roger Banks/Ric McNees
- **KY Department for Energy Development and Independence** (DEDI) Lee Colten /Michael Kennedy
- **The Cadmus Group** - Nigel Makela/Jolyn Green/Eric Makela
- **Pacific Northwest National Laboratory** (PNNL) – Vrushali Mendon
- **Project Manager** - George Mann
- **Circuit Rider** - Larry Mahaffey

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Project Overview

- In 2014 the US Department of Energy funded residential energy code compliance studies in eight states, including KY
- Establish residential energy code **compliance baseline**, and determine if focused training & support can improve compliance.
- 3-year, three phase, statewide program targeting new, **single-family homes**
  - Baseline Study and Analysis
  - Intervention
  - Post Intervention Baseline Study and Analysis
- MEEA was the lead agency for KY, with DHBC and DEDI as project partners

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

PHASE *ONE*

Data Collection & Analysis

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Identifying Key Items

- Prior to starting the study, the Pacific Northwest National Laboratory (PNNL) conducted **sensitivity analysis**
  - Based on prescriptive and mandatory provision of the 2009 IECC
  - Determined which code requirements drive the majority of energy savings (*Key Items*)
  - Same key items for all climate zones
- Eight states participated in the studies, including Kentucky, Alabama, Arkansas, Georgia, Maryland, North Carolina, Pennsylvania, and Texas

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Key Items

- Envelope Tightness (ACH50)
- Window Solar Heat Gain Coefficient
- Wall Insulation (R-value and Quality)
- Ceiling Insulation (R-value and Quality)

- Foundation Insulation (R-value and Quality)
- High Efficacy Lighting
- Duct Leakage (CFM25)
- Window U-factor

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Data Collection Process

- Followed DOE data collection **protocol**
  - Randomized Sampling Plan
  - Key Items Must be Observed
  - Minimum of 63 Observations of Each Key Item
  - Single Visit to a Given Home
  - Statistically Significant Results at State Level
- Survey team spent about **5 months** collecting field data
- A **stakeholder group** was established to provide feedback and guide the project
- **140 homes** were visited in Phase I

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

PNNL Analysis

PNNL conducted three separate analyses of the collected data

- ***Statistical Analysis***
  - Examination of the field data, and data distribution relative to compliance requirements
- ***Energy Analysis***
  - Modeling of energy consumption representative of observed homes
- ***Measure-Level Savings Analysis***
  - Projection of potential savings associated with improved compliance
  - *Compliance happens at the measure level*

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Measure-Level Analysis

- Key items were **individually examined** to determine the number of worse-than-code observations
- All key items having 15% or more **non-compliant observations** were included in the measure-level analysis
- An individual "as-built" model was created for **each non-compliant value**, with all other values remaining at code compliant levels

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Measure-Level Analysis

- This allowed the savings potential from each key item to be **evaluated in isolation**
- Differences in energy use were **weighted** according to the frequency of each observation to arrive at an average energy savings potential for each key item
- State-specific construction volumes and fuel prices were then used to calculate the energy **savings potential of full compliance** for that key item
- About **25,000 data points** related to new single-family homes were collected in Phase I

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Annual Potential Compliance Savings (2009 IECC)

Key Measure		Annual Savings	
		Energy (MMBtu)	Cost ($)
1	Envelope Air Leakage	27,182	$484,314
2	Ceiling Insulation	11,372	$215,656
3	Exterior Wall Insulation	9,277	$171,044
4	Foundation Insulation	6,800	$108,156
5	Lighting	5,742	$197,544
6	Duct Leakage	2,135	$43,142
Total		**62,508 MMBtu**	**$1,219,856**

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase I

Cumulative Potential Compliance Savings (2009 IECC)

Measure	Total Energy Savings (MMBtu)			Total Energy Cost Savings ($)		
	5yr	10yr	30yr	5yr	10yr	30yr
Envelope Air Leakage	407,730	1,495,010	12,639,630	$7,264,710	$26,637,270	$225,206,010
Ceiling Insulation	170,580	625,459	5,287,971	$3,234,844	$11,861,095	$100,280,170
Exterior Wall Insulation	139,155	510,235	4,313,805	$2,565,660	$9,407,420	$79,535,460
Foundation Insulation	101,997	373,989	3,161,903	$1,622,345	$5,948,598	$50,292,689
Lighting	86,130	315,810	2,670,030	$2,963,160	$10,864,920	$91,857,960
Duct Leakage	32,025	117,425	992,775	$647,130	$2,372,810	$20,061,030
TOTAL	937,620	3,437,939	29,066,211	$18,297,844	$67,092,095	$567,233,170

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

PHASE *TWO*

Training and Education

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase II
Overview

- Phase Two programs were **developed and implemented** based on findings of Phase I
- Phase Two programs focused on code officials and builders, and were implemented **in all parts of the state**
  - Go to where the builders and code officials work
- Programs included a **pro-active** circuit rider providing **individual assistance**, statewide in-person training, and online training available 24/7
- Phase II was a **relatively inexpensive intervention** – core program ~$200,000 per year

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase II

Circuit Rider Program

- Hired **retired code official** as circuit rider (half-time)
- **Pro-actively** reach out to code officials, homebuilders, and other stakeholders on a regular basis
- Provide **individual assistance** at stakeholder's office or jobsite
- Establish and maintain **trusted** advisor relationship
- Traveled over **32,450 miles**

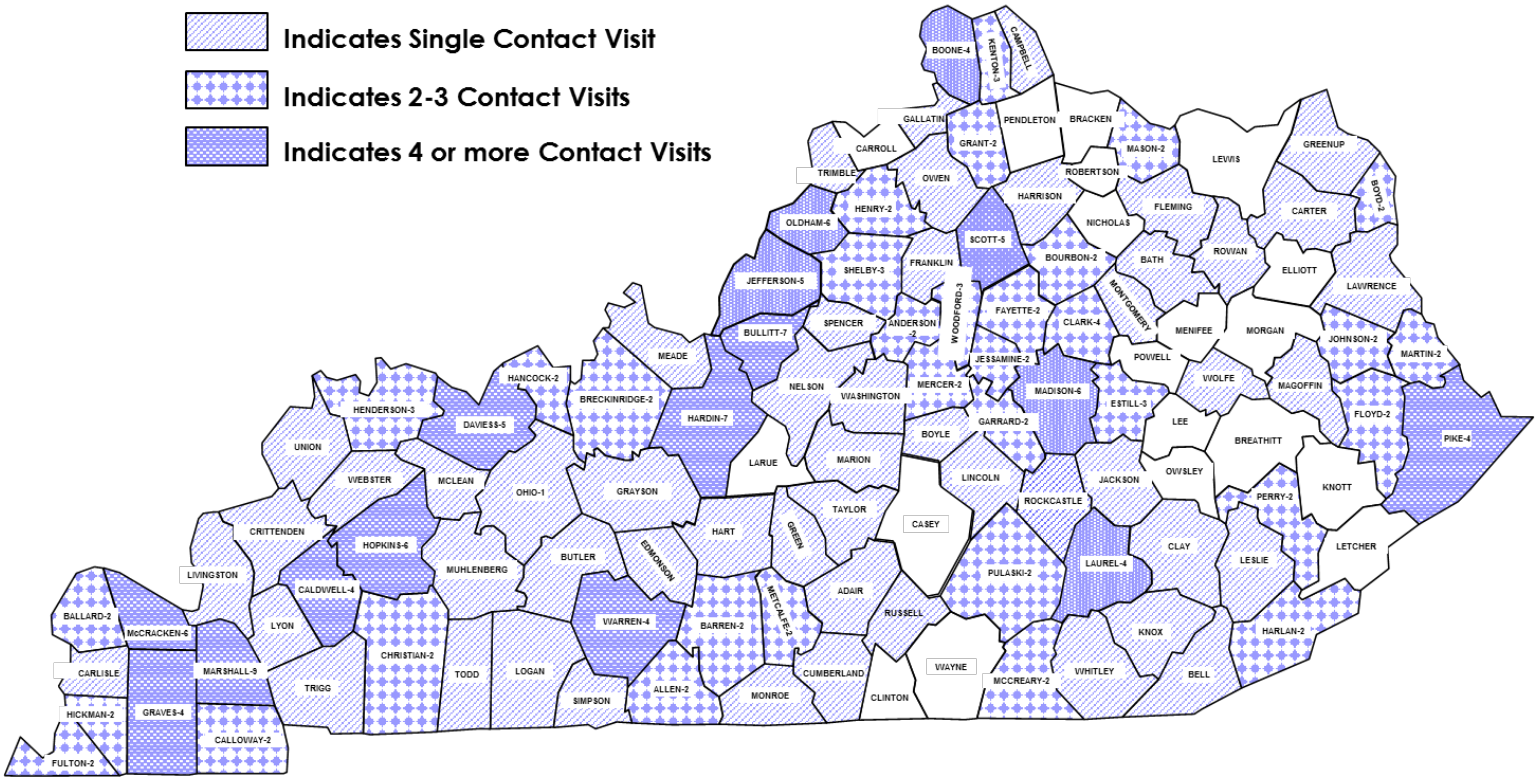
MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase II

Circuit Rider Program

Kentucky Circuit Rider Visits

Through 09/27/2017



MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase II

In Person Training Program

- **25 full-day,** in-depth training sessions offered in 14 different counties across the state
  - 1 half-day class for stakeholder group
- Classes approved for **CEU credits**
- ~400 students and over **3,000 contact hours**
- Training Topics
  - HVAC Design and Sizing Principals
  - Air Sealing and Insulation Principals
  - Common Compliance Challenges

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase II

Outreach and Resources

- Created 14 short (4-14 minute) code overview videos and posted on YouTube, with >**735 views** to date
  - Views dropped off after program ended
- Made 37 presentations (yup, just like this one!) with a total attendance of **1,128 people**
- Distributed about **1,500 pieces** of compliance literature
  - 734 compliance guides
  - 380 compliance certificates (blank)
  - 254 code books
  - 49 insulation guides
  - 49 resource cards

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

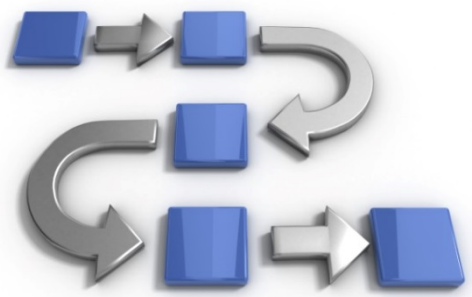
PHASE *THREE*

Déjà Vu All Over Again

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Phase III
Methodology

- Created **new** randomized sampling plan
- Conducted a second data collection effort following the **same protocol**
- **129 homes** were visited in Phase III
- Phase III data was analyzed and **compared** to Phase I data to determine impact of Phase II
- Study was designed to give **statistically significant results** only at the state level



MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Final Results!

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Measure Comparison

KY - Non-compliance comparison: Phase I to Phase III			
Measure	Phase I Non-Compliance	Phase III Non-Compliance	Percentage Point Improvement
Envelope Air Leakage	32%	2%	30
Ceiling Insulation (R-value)	13%	11%	2
Ceiling Insulation (quality)	58%	40%	18
Exterior Wall Insulation (R-value)	1%	0%	1
Exterior Wall Insulation (quality)	66%	58%	8
Foundation Insulation (R-value)	19%	30%	-11
Foundation Insulation (quality)	86%	76%	10
Lighting	67%	60%	7
Duct Leakage (conditioned space)	80%	65%	15
Duct Leakage (unconditioned space)	32%	39%	-7
Window U-Factor	2%	9%	-7

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Final Analysis

Measure	Phase I Total Energy Savings (MMBtu)	Phase I Total Energy Cost Savings ($)	Phase I Total State Emissions Reduction (MT CO2e)		Phase III Total Energy Savings (MMBtu)	Phase III Total Energy Cost Savings ($)	Phase III Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	27,182	484,314	3,092		581	10,321	65
Ceiling Insulation	11,372	215,656	1,080		4,835	91,786	595
Exterior Wall Insulation	9,277	171,044	1,102		8243	151,974	976
Foundation Insulation	6,800	108,156	668		11,676	178,905	1,075
Lighting	5,742	197,544	1,427		4,454	153,383	1,130
Duct Leakage	2,135	43,142	284		17,151	342,217	2,251
TOTAL	62,508	$1,219,856	7,653		46,941	$928,585	6,093
Savings					**25%**	**24%**	**20%**

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Conclusions

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Conclusions

Really Just Some Observations

- There is an **opportunity for improving** the quality and energy efficiency of new single-family homes through improved compliance
- DOE established a **replicable and robust** quantitative data collection and analysis protocol
- Substantial improvement can be achieved in **cost-effective ways**, but reliable, quantitative, actionable data is key
- Methodology provides an opportunity for **ongoing stakeholder engagement**
- **Others have learned** from the KY study
  - Ameren MO
  - IL Investor-Owned Utilities

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

RESOURCES

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Resources

- **2009 IECC Energy Code** - https://codes.iccsafe.org/public/document/details/toc/747
- **Kentucky Amendments** (page 46) - http://dhbc.ky.gov/Documents/2013%20KRC%203rd%20Ed%20(December%202015)%20-%206-22-2016.pdf
- **KY Study Website** - http://www.mwalliance.org/initiatives/policy/kentucky/residential-energy-code-improvement-study
- **DOE Study Website** - https://www.energycodes.gov/compliance/energy-code-field-studies
- **Online Videos** - https://www.youtube.com/playlist?list=PLkWlq0Kgprm7oXX5zm6_Jh6l6mlnU6TTv
- **Insulation Installation Guide** - http://www.mwalliance.org/sites/default/files/media/Insulation-Installation-Grading.pdf
- **Equipment Right-Sizing -** http://www.mwalliance.org/sites/default/files/media/More-Bang-for-the-Buck-Final.pdf

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Questions

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

(Two More Speakers to Go)

Thank you!

Chris Burgess
Midwest Energy Efficiency Alliance
cburgess@mwalliance.org

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE