Energy Code Implementation: Insights from the Field to the Classroom

National Energy Codes Conference Seminar Series
Building Technologies Office
Summer 2022
NECC Seminar Series Lineup

Catch the entire lineup of sessions bi-weekly—Thursdays @ 1p ET:

- 8/18: Taking Charge of Climate Change through Stretch Codes
- 9/22: Energy Code Implementation: Insights from the Field to the Classroom
- 10/6: Less is more: Building to Zero Energy, Water and Carbon
- 10/20: Cracking the Code: Unlocking the Benefits of Off-site Construction
- 11/17: Outside-the-Box Options to Advance Multifamily Building Efficiency

> Learn more: https://www.energycodes.gov/2022-summer-seminar-series
History of the Program

• As part of ARRA, code compliance was a critical metric to assess energy code impacts, resulting in several states conducting studies.
• In 2014, DOE funded 8 states to utilize a new methodology to assess the impacts of energy code compliance in residential single-family homes.
• To date, over 25 states have conducted field studies using a DOE methodology.
Why conduct a field study?

1. Understand typical construction practices across states (e.g., foundation type, air leakage rates, insulation levels, etc.)
2. Calculate rates of non-compliance and identify specific measures to target education and training programs
3. Help validate expected savings from energy code adoption (e.g., $, CO2)
4. Support a business case for additional investments (e.g., utility programs)
Key Measures

1. Foundation R-value and insulation installation quality (IIQ)
2. Wall R-value and IIQ
3. Ceiling/Attic R-value and IIQ
4. Window U-factor
5. Window SHGC
6. Envelope air tightness (ACH50)
7. Duct tightness (CFM25/100 ft²)
8. Percentage of high-efficacy lighting
<table>
<thead>
<tr>
<th>State</th>
<th>Annual Potential Savings</th>
<th>Statewide Savings Achieved from Phase II (Phase I – Phase III)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase I</td>
<td>Phase III</td>
</tr>
<tr>
<td>Texas</td>
<td>$4,847,797</td>
<td>$1,243,958</td>
</tr>
<tr>
<td>Georgia</td>
<td>$4,516,678</td>
<td>$1,751,143</td>
</tr>
<tr>
<td>Maryland</td>
<td>$1,542,788</td>
<td>$311,414</td>
</tr>
<tr>
<td>Alabama</td>
<td>$1,299,382</td>
<td>$978,585</td>
</tr>
<tr>
<td>Kentucky</td>
<td>$1,219,856</td>
<td>$928,586</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>$3,198,846</td>
<td>$3,013,497</td>
</tr>
<tr>
<td>North Carolina</td>
<td>$2,025,958</td>
<td>$2,368,044</td>
</tr>
<tr>
<td>Total</td>
<td>$18,651,305</td>
<td>$10,595,227</td>
</tr>
</tbody>
</table>
So, where are we now?

Residential Energy Code Field Study Dashboard
Thank you
Market Driven Residential Energy Codes: Comparing Performance in a Changing Technological Environment

Rob Vieira, Director, Buildings Research Division
Robin@fsec.ucf.edu
Acknowledgements

- Christina Volpi, Jeremy Williams, Chris Perry, and Basu Kalpita
  - U.S. Department of Energy, Building Technologies Office

- Ian Blanding
  - Pacific Northwest National Laboratory

- A number of cooperating Utilities
- Southwest Energy Efficiency Project
Introduction

• Evaluate relative energy impacts for International Energy Conservation Code® (IECC®) compliant homes
  – Differentiating between prescriptive- and performance-based residential compliance methods

• Two research investigations in this presentation:
  – Survey of Building Officials’ perception of performance differences, conducted February 18 to March 20, 2020
  – Utility data comparison in 2 locations where prescriptive and performance methods are used for comparable codes
Building Official Energy Code Officials Survey

- 15% of respondents were from jurisdictions that do not enforce the Residential Energy Code (of 907 responses)
- 2015 International Energy Conservation Code (IECC) was most common (36%), 2018 IECC was second-most (26%) (of 640 responses)
Number of projects by compliance path:

Number of Responses by Compliance Path

<table>
<thead>
<tr>
<th>Compliance Path</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Prescriptive</td>
<td>49%, 72</td>
</tr>
<tr>
<td>60-99% Prescriptive</td>
<td>20%, 29</td>
</tr>
<tr>
<td>Mixed</td>
<td>4%, 6</td>
</tr>
<tr>
<td>60-99% Performance</td>
<td>17%, 25</td>
</tr>
<tr>
<td>100% Performance</td>
<td>11%, 16</td>
</tr>
</tbody>
</table>
Jurisdictions Following Older Code Followed the Prescriptive Path Most or All of the Time.
Code Official Opinions

• Why do builders choose the prescriptive path?
  *Prescriptive is easier*

• How much time spent at design, on-site, and follow-up?
  *Prescriptive total about 2 hours*
  *Performance total about 3 hours*

• Which compliance method takes longer to verify?
  *Mixed, but the most popular answer was that performance takes longer (44%)*
Officials Opinions of Builder Consistency

How would you rate the consistency of local builders with respect to Energy Code compliance?

- Performance (60%+), n=36:
  - Good: 44%
  - Variable: 60%
  - Poor: 8%

- Mixed, n=5:
  - Good: 40%
  - Variable: 60%

- Prescriptive (60%+), n=101:
  - Good: 54%
  - Variable: 37%
  - Poor: 9%
Utility Bill Comparison

- Utility bill evaluation of two locations in climate zone 5 with both performance and prescriptive compliance methods: Fort Collins, Colorado and Iowa
- Data collection limitations due to restrictions to protect homeowner identification
  - Colorado
    - State-level data release restrictions required ‘binning’ of homes into 15+
  - Iowa
    - Utility required binning homes into 5+
3 Cohorts of Compliance in Fort Collins

- **Prescriptive, R-Value** – meeting or exceeding specific energy code minimums, such as R-values and U values in Sections R401 through R404 of the IECC.

- **Prescriptive, REScheck** – demonstrating compliance per the Total UA Alternative (Section R402.1.5) methods using REScheck™ software.

- **Performance** – using a computer simulation tool to model the annual energy cost of the proposed design for comparison to a code-compliant reference building's energy cost by Section R405 Simulated Performance Alternative (Performance) or Section R406 Energy Rating Index (ERI) Compliance Alternative.
Fort Collins Data Groups

- Bins differentiated by compliance method, code year, and residence type
  - 2015 IECC Code year, attached
  - 2015 IECC Code year, detached
  - 2018 IECC Code year, attached
  - 2018 IECC Code year, detached
Fort Collins Bins

- Ultimately, monthly energy use data for 39 bins were received, each bin comprises similarly sized homes, representing 731 homes

Breakdown of Bins

<table>
<thead>
<tr>
<th>Type of Home</th>
<th>Performance</th>
<th>Prescriptive, R-Value</th>
<th>Prescriptive, REScheck</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Code Year 2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attached</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Detached</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Code Year 2018</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attached</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Detached</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>4</td>
<td>19</td>
<td>39</td>
</tr>
</tbody>
</table>
Monthly Data

- Utilities normalized data by calendar month
- Provided number of homes in bin for each month
- Provided standard deviation, minimum and maximum usage for each bin each month
- Provided monthly average usage for each bin
2015 IECC Attached Bins by House Size
2015 IECC Detached Bins by House Size

Home Sizes for Detached Dwellings, Code Year 2015 by Bin Number

- R-Value
- REScheck
- Performance

Living Area (ft²)

1,510 1,521 1,522 1,523 1,524 1,525 1,526 1,527 1,528 1,529 1,530 1,531 1,532 1,533 1,534 1,535 1,536 1,537 1,538 1,539 1,540 1,541 1,542 1,543 1,544 1,545 1,546 1,547

Avg SF, Min SF, Max SF
2018 IECC Attached Bins by House Size

Home Sizes for Attached Dwellings, Code Year 2018 by Bin Number

- REScheck
- Performance

Living Area (ft²)

<table>
<thead>
<tr>
<th>Bin Number</th>
<th>Avg SF</th>
<th>Min SF</th>
<th>Max SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1805</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1806</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1810</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1811</td>
<td>2200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2018 IECC Detached Bins by House Size
Attached Bin Comparison

- Bins carefully selected to include homes of same type and similar size.
- Smaller attached homes example with Performance using more gas, but less electricity. However, Bin 1506 is known to comprise homes with electric water heating.
Comparing Detached Bins of ~ 3500 ft²
Comparing Detached Bins of ~4000 ft\(^2\)
Comparing Detached Bins of ~5000 ft$^2$
### GAS

<table>
<thead>
<tr>
<th></th>
<th>2015 IECC, Attached</th>
<th>2015 IECC, Detached</th>
<th>2018 IECC, Attached</th>
<th>2018 IECC, Detached</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Performance</td>
<td>RES check</td>
<td>R-Value</td>
<td>Performance</td>
</tr>
<tr>
<td>Relative to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REScheck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Gas DHW</td>
<td>1.00</td>
<td>0.75</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Electrical Tape</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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</tbody>
</table>

### ELECTRIC

<table>
<thead>
<tr>
<th></th>
<th>2015 IECC, Attached</th>
<th>2015 IECC, Detached</th>
<th>2018 IECC, Attached</th>
<th>2018 IECC, Detached</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Performance</td>
<td>RES check</td>
<td>R-Value</td>
<td>Performance</td>
</tr>
<tr>
<td>Relative to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REScheck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Electric DHW</td>
<td>-</td>
<td>0.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Electrical Tape</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Possible Electrical Tape on Condensate Line:** ~5% of R-Value cohort

About 65% of the REScheck cohort
Home Size is Significant

- For both code years, larger detached homes used significantly more gas and electricity than smaller homes, with home size being more significantly related to gas use than electricity use. Home size was not statistically significant for the attached houses where the size range was small.
## Model Projected 6 month Gas Use

**Therms for Mean Home Size, Assuming 100% Gas DHW**

<table>
<thead>
<tr>
<th>Group</th>
<th>RValue to Perf.</th>
<th>Perf to RValue</th>
<th>RESChk to Perf.</th>
<th>Perf to RESChk</th>
<th>RValue toRESChk</th>
<th>ResChk to RValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 Attached</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>264</td>
<td>384</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
<tr>
<td>2015 Detached</td>
<td>709</td>
<td>631</td>
<td>710</td>
<td>616</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
</tbody>
</table>
# Model Projected Annual Electricity Use

kWh for Mean Home Size, Assuming 100% Gas DHW

<table>
<thead>
<tr>
<th>Group</th>
<th>RValue to Perf.</th>
<th>Perf to RValue</th>
<th>RESChk to Perf.</th>
<th>Perf to RESChk</th>
<th>RValue to RESChk</th>
<th>ResChk to RValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 Attached</td>
<td>6003</td>
<td>6846</td>
<td>9403</td>
<td>5955</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
<tr>
<td>2015 Detached</td>
<td>10414</td>
<td>8875</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
<tr>
<td>2018 Attached</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
<tr>
<td>2018 Detached</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
<td>9353</td>
<td>8733</td>
<td>No Sig. Difference</td>
<td>No Sig. Difference</td>
</tr>
</tbody>
</table>
Conclusions from Ft. Collins Utility Data

• **Bottom line:** There is unlikely a huge prevalent difference in energy use based on compliance method. However, we cannot conclude that the methodologies are equal.
Iowa Utility Bill Compliance Cohorts

- Homes achieved energy code compliance via:
  - **Prescriptive** – meeting or exceeding specific Energy Code minimums using the R-value, U-factor Alternative or Total UA Alternative methods as required in Sections R401 through R404 of the 2012 IECC.
  - **HERS+ Prescriptive** – meeting compliance per the U-factor Alternative or the UA Tradeoff methods, and also including a Home Energy Rating System (HERS) index rating.
  - **Performance** – using a computer simulation tool to model the annual energy cost of the proposed design for comparison to a Code-compliant reference building's energy cost as required in Section R405 Simulated Performance Alternative (Performance).
Iowa Data

- Ultimately, monthly energy use data for 130 bins representing 754 homes were received.

<table>
<thead>
<tr>
<th>Breakdown of Bins</th>
<th>Performance</th>
<th>HERS+ Prescriptive</th>
<th>Prescriptive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bins with Electric Data</td>
<td>9</td>
<td>41</td>
<td>44</td>
<td>94</td>
</tr>
<tr>
<td>Bins with Gas Data</td>
<td>45</td>
<td>41</td>
<td>44</td>
<td>130</td>
</tr>
<tr>
<td>Bins having both Gas &amp; Electric Data</td>
<td>9</td>
<td>41</td>
<td>44</td>
<td>94</td>
</tr>
</tbody>
</table>
## Iowa Home Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HERS +</th>
<th>Performance</th>
<th>Prescriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average CFA (Ft²)</td>
<td>3,288</td>
<td>2,846</td>
<td>2,898</td>
</tr>
<tr>
<td>Min CF (Ft²)</td>
<td>2,160</td>
<td>891</td>
<td>1,057</td>
</tr>
<tr>
<td>Max CFA (Ft²)</td>
<td>5,247</td>
<td>4,674</td>
<td>4,848</td>
</tr>
<tr>
<td>Average Number of Stories</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Average Number of Bedrooms</td>
<td>3.6</td>
<td>3.4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Home Count with Foundation Type:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditioned Basement</td>
<td>261</td>
<td>221</td>
<td>222</td>
</tr>
<tr>
<td>Slab on Grade</td>
<td></td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td><strong>Home Count with Housing Type:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Family</td>
<td>219</td>
<td>193</td>
<td>254</td>
</tr>
<tr>
<td>Townhouse Interior</td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Townhouse Exterior</td>
<td>42</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Duplex</td>
<td></td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
Iowa Results by Fuel

• The available characteristics were very poor at predicting electricity use.
• The model for predicting natural gas usage was moderately strong.
• And when electricity and gas energy use were translated into kBtu and combined per bin, prediction strength was much weaker than predicting gas use alone.
• Iowa analysis focuses on winter gas usage.
All Iowa Homes Gas by Path

Iowa Homes Residential Cohort Comparison Model Results for Average Annual Gas Use

- HERS+ Prescriptive
- Performance
- Prescriptive

y = 0.3343x - 435.82
R² = 0.6971

y = 0.1976x + 54.247
R² = 0.6073

y = 0.1752x + 91.516
R² = 0.6566

Annual Gas Use (Therms)

Average Conditioned Floor Area

Range: 1,200 to 4,700
Iowa Results of Homes < 3000 ft²

- Smaller home segment of bins had limited findings...
Iowa Smaller Home Results

- Cohorts of smaller homes (<3,000 Ft2) complying by the 2012 IECC
  - HERS+ path used statistically significantly less gas and electricity than Performance cohort. **Caveat: Regression strength is weak**
  - HERS+ path used marginally statistically significantly less gas than Prescriptive cohort.
Summary Page 1

• Compliance path in many jurisdictions is dominated by one method.
• In locations where there are multiple types, building jurisdiction personnel on average believe it takes more personnel time for performance relative to prescriptive.
In two climate-zone-five regions studied, compliance path was not *consistently* significant in determining energy use of occupants.

However, in some cases there were statistical significances.
• HERS+ path homes in Iowa used less gas than performance or prescriptive for homes under 3,000 square feet

• In Ft. Collins, detached homes complying by the Performance method used both less gas and electricity than the homes complying with REScheck or the R-value method when there was a statistical difference. Attached homes did not follow these results.
Future Study

• Different Climate Zones
• **Very large samples required due to binning**
• Utility cooperation required
• How to account for fact that each builder in an area typically complies using one method?
• Does exceeding code matter (lower UA total than required, lower ERI or Performance ratio)?
# Reports

## Available Project Reports

<table>
<thead>
<tr>
<th>Report</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Driven Residential Energy Codes - Compliance Path Enforcement Costs</td>
<td>based on survey results</td>
</tr>
</tbody>
</table>
# Research Team

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- Jeff Sonne
- Rob Vieira
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## International Code Council
- Jerica Stacey
- Dave Walls
- Kris Stenger
NECC Seminar Series Lineup

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- **8/18**: Taking Charge of Climate Change through Stretch Codes
- **9/8**: Energy Codes and Utility Programs: The Peanut Butter & Jelly of Energy Efficiency
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