# Residential Energy Code Evaluations

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# Building Codes Assistance Project

- Mission
  - Reducing the Nation's energy consumption through the adoption, implementation, and utilization of building energy codes and standards
- Joint effort of
  - Alliance to Save Energy
  - National Resources Defense Council
  - American Council for an Energy-Efficient Economy
- 11 years experience helping states and municipalities adopt and implement up-to-date building energy codes

# Energy Code Evaluations

- Introduction
- Overview of Evaluation Techniques
- Major Findings and Recommendations from Current Literature
- Further BCAP Recommendations and Conclusion

# Introduction

- Why look at evaluations?
  - Attempt to quantify the savings gap, which we define as the energy savings foregone from non-compliance with the energy code adopted in a state or local jurisdiction.
  - The magnitude of realized energy savings from the adoption of energy codes is an essential indicator of the impact of those codes and the programs that support them.

# Introduction

- Current Literature
  - Residential energy code evaluations for 16 states (including 2 that look at local jurisdictions).
  - Evaluations generally attempt to typify the average residential structure, usually owner-occupied and single-family.
  - They are also carried out independently of each other, with differing goals and methodologies.

# Overview of Evaluation Techniques

**Sampling**

- Size and methodologies are across the board and largely dependent on local conditions.
- Most common method is to draw samples from a distribution proportional to housing starts in jurisdictions or from largest population areas.

# Overview of Evaluation Techniques

**Sampling**

- Small samples can still be representative of populations, however bias is recognized as a problem in many evaluations.
- Cost and builder resistance are frequently cited as the largest barriers to obtaining good samples.
- Types of bias: Self-selection, convenience sample.

# Overview of Evaluation Techniques

## Sampling

- Examples:
  - Nevada – Field inspection conducted on only 13 homes from the original sample of 140 homes.
  - Arkansas – Builders “expressed trepidation”, concerns about cost, negative consequences, disruption of construction process.

# Overview of Evaluation Techniques

## Data Collection and Analysis

- Similar to sampling, there is no standard data set or analysis tool used.
  - Quantitative VS qualitative data: Is it there vs. how is it installed?
  - Analysis tools: code compliance, energy simulation, utility analysis software. These are developed by private industry, educational institutions, and the federal government.

# Overview of Evaluation Techniques

## Data Collection and Analysis

- Building Components
  - Report average values *as well as* median and distribution of data. Why?
    - Market penetration
    - Identify where tradeoffs are useful to the building community.
  - Issues
    - Component data is of limited value, especially as a metric for identifying code compliance.

# Overview of Evaluation Techniques

## Data Collection and Analysis

- Analysis Tools
  - Code compliance and energy simulation software is preferable to a component based method of assessing compliance.
  - However, the use of these tools raises an even more fundamental question: How do compliance rates translate into real energy savings?
    - Example: Commonly used software packages, such as REM/rate, generate a rating score independent of house size. This is important

# Overview of Evaluation Techniques

## Data Collection and Analysis

- Analysis Tools
  - How about using energy simulation software to assess home performance and thus energy savings?
    - Wisconsin study finds systematic errors in heating energy estimates from REM/rate (version 8.46).
    - We can expect future iterations to become more accurate.
    - However, energy simulation software usage remains problematic because of a fundamental problem, its inability to capture human behavior.

# Overview of Evaluation Techniques

## Data Collection and Analysis

- Standardized Protocols
  - Need for national leadership by DOE in developing a set of standard data collection protocols.
  - Why? Cross comparison of data across states and development of a reliable baseline for comparison across time series.

# Overview of Evaluation Techniques

## Compliance Rates

- Definition of compliance rates differs across studies.
  - Compliance as average percentage by which sampled houses are above or below code requirements.

  VS

  - Percentage of homes in the sample that meet or exceed minimum code requirements.

# Overview of Evaluation Techniques

## Compliance Rates

- Compliance as average percentage by which sampled houses are above or below code requirements.

  For example: houses are on average 5% more efficient than code.

  - Pros: understand how efficiency looks on average.
  - Cons: We do not know what proportion of homes are in compliance. In particular, it does not give us much information about noncompliance.

# Overview of Evaluation Techniques

## Compliance Rates

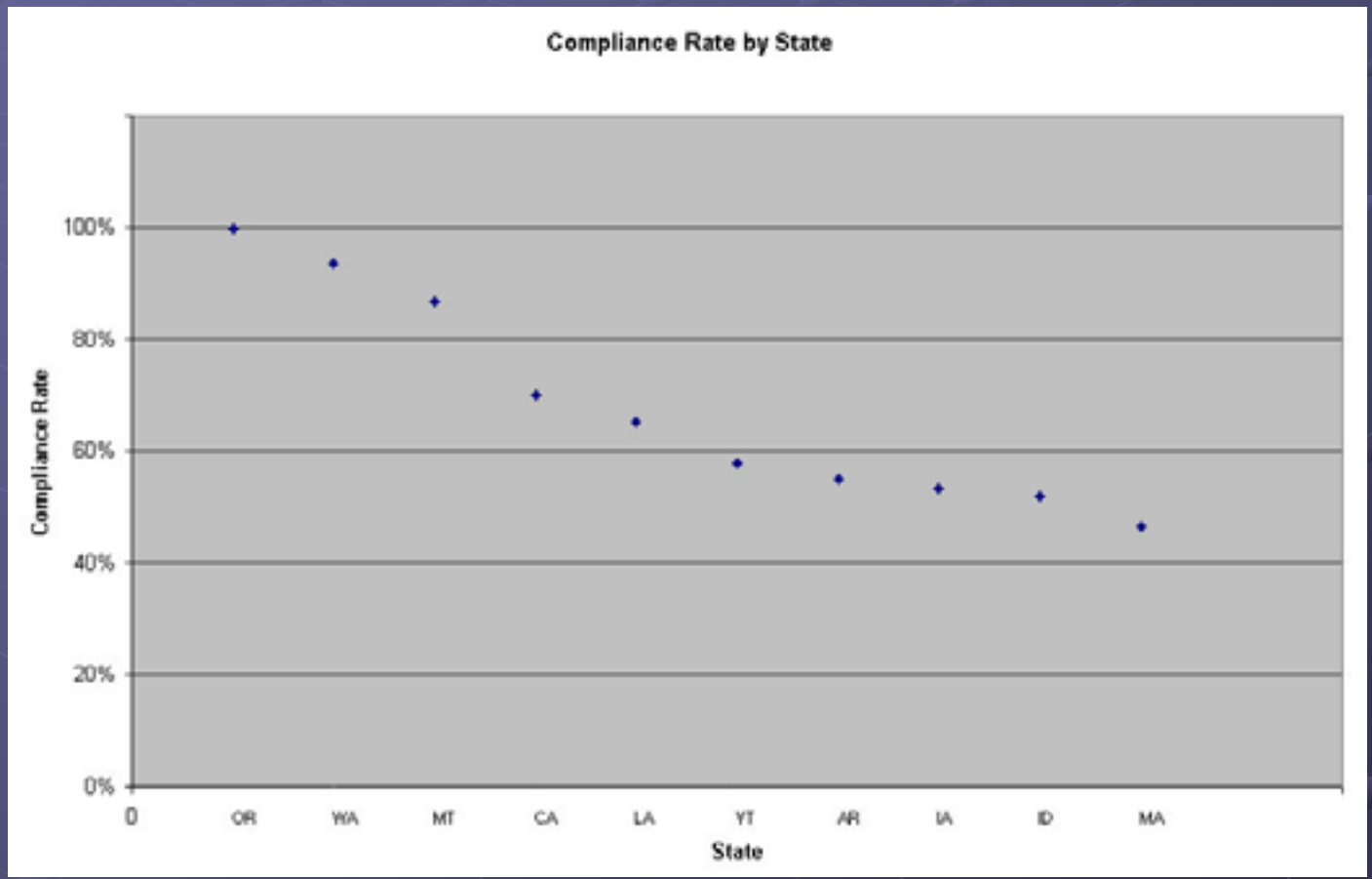
- Percentage of homes in the sample that meet or exceed minimum code requirements.

  For example: 60% of homes complied with code.

  - We are partial to this definition of compliance, but distribution of compliance should be reported as well, so that we understand how non-compliance affects the savings gap.

# Major Findings and Recommendations from Current Literature

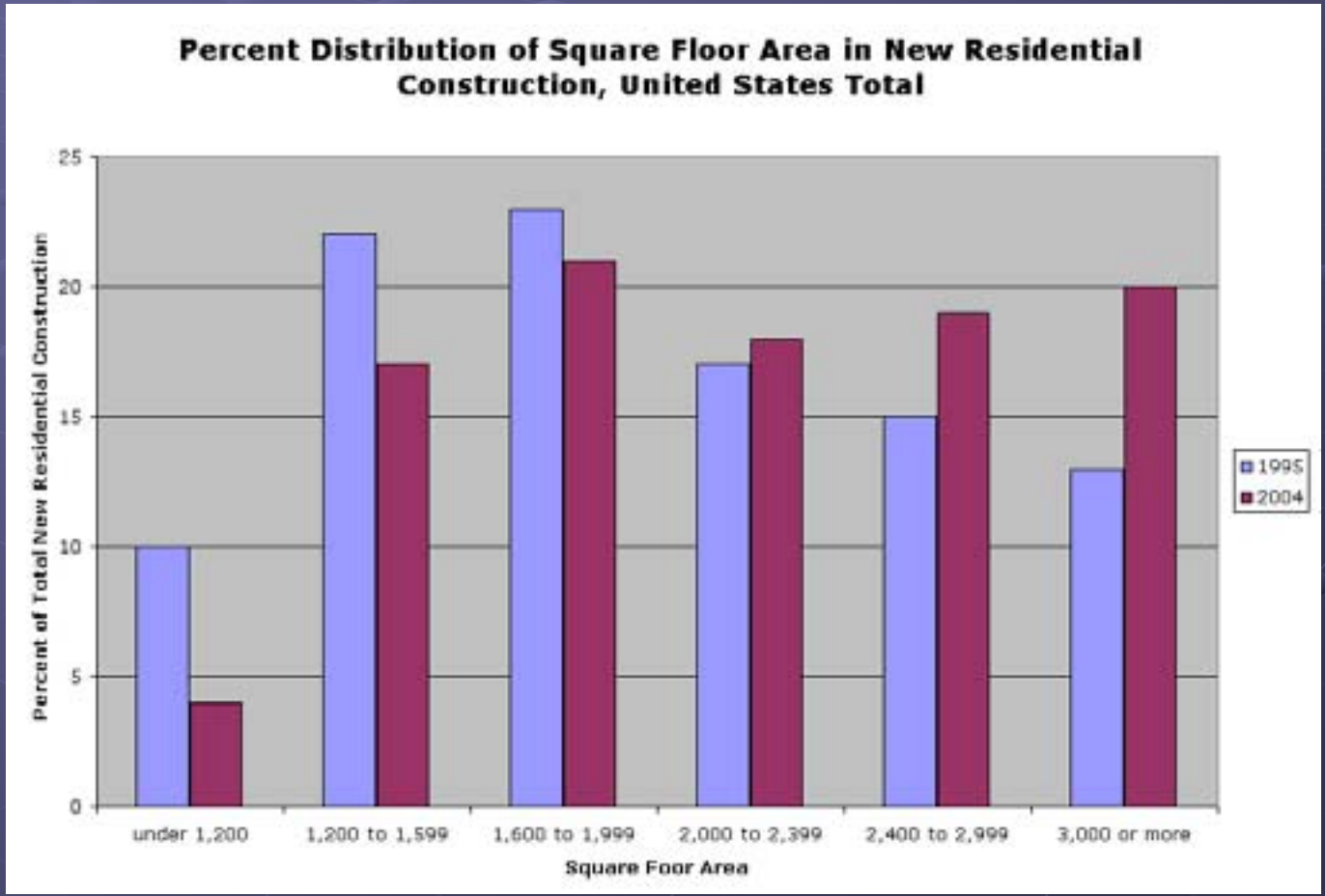
So what do compliance rates look like?



# Major Findings and Recommendations from Current Literature

**Larger Homes**

While newer homes are relatively more efficient, increasing home sizes continues to provide upward pressure on total energy use.



# Major Findings and Recommendations from Current Literature

## Larger Homes

- Wisconsin: New homes use 23 percent less energy per square foot than older homes, but are 22 percent larger.
- Pacific Northwest: Had home sizes remained constant, energy use would have dropped by 50%
- Minnesota: Average home built in 2000 uses 25% less energy to heat than the average 1994 home.
  - But a quick calculation reveals that once home size is taken into account, the average 2000 home requires 13,244 Btu/HDD compared to 12,581 Btu/HDD for the 1994 home.

# Major Findings and Recommendations from Current Literature

## Excessive oversizing of HVAC equipment.

- This is endemic and both homeowners and builders are generally not aware of its negative consequences.

| State | Equipment Sizing | |
|---|---|---|
| | Heating | Cooling |
| Arkansas | ≈ 200% | Not Reported |
| Colorado | 158% | 208% |
| Idaho | 192% | Not Reported |
| Montana | 160% | Not Reported |
| New York | 190% | 170% |
| Oregon | 278% | Not Reported |
| Vermont | 181% | Not Reported |
| Washington | 216% | Not Reported |

# Major Findings and Recommendations from Current Literature

**Compact Fluorescent Lighting Penetration**

- CFL Penetration is generally less than expected.
- CFLs represent 3% of all fixtures in Long Island, NY, and 5% of all fixtures in Wisconsin
- In Vermont, CFLs represented 8% of all fixtures, but the penetration rate doubled in houses participating in Vermont Star Homes and utility efficiency programs.
- Overall, CFLs have not had general market acceptance.

# Major Findings and Recommendations from Current Literature

## Need for Consumer/Builder Education

| Rater \ Rated | Designer | Developer | **Builder** | Supplier | Local Code Officials |
|---|---|---|---|---|---|
| Designer | Good to Excellent | Fair | **Poor to Fair** | Fair to Good | Fair to Good |
| Developer | Good to Excellent | Good | **Poor to Fair** | Good | Good to Excellent |
| Builder | Good | Good | **Good to Very Good** | Good to Excellent | Fair to Good |
| Supplier | Excellent | Good | **Poor to Fair** | Very Good | Good to Very Good |
| Local Code Officials | Good to Very Good | Fair to Good | **Poor to Fair** | Good | Good to Very Good |

Table 1. Assessment of Market Player's Energy Efficiency Knowledge in Massachusetts, reproduced p. 6-3.

# Major Findings and Recommendations from Current Literature

**Need for Consumer/Builder Education**

- 25% of builders in Ft Collins, CO felt that the energy code had no value at all.
- 64% of builders in the Pacific Northwest indicated they had never participated in any training on energy efficiency practices.
- End result?
  - Oversizing of HVAC equipment.
  - Subcontractors sometimes have negative impacts on energy efficiency.
  - Lack of interest in energy efficiency as a marketing tool.

# Major Findings and Recommendations from Current Literature

## Need for Consumer/Builder Education

- The lack in consumer interest or knowledge in energy efficiency drives the market.
  - Less than ½ the builders in Massachusetts say there is any homebuyer interest in energy efficiency. As a result, less than 1/3 of builders use energy efficiency to market their homes.
  - Capital costs vs. lifetime savings. Homebuyers usually choose up front savings.
- Need for education in the building as a system.
  - Builders and homebuyers need to understand the house as a system and how it affects energy efficiency.

# Major Findings and Recommendations from Current Literature

## Low-Income Housing

- Typically older and smaller than the average house.
- Surprisingly, evaluations indicate that smaller houses in particular are not only relatively more inefficient, but in terms of absolute energy use as well.

# Major Findings and Recommendations from Current Literature

## Low-Income Housing

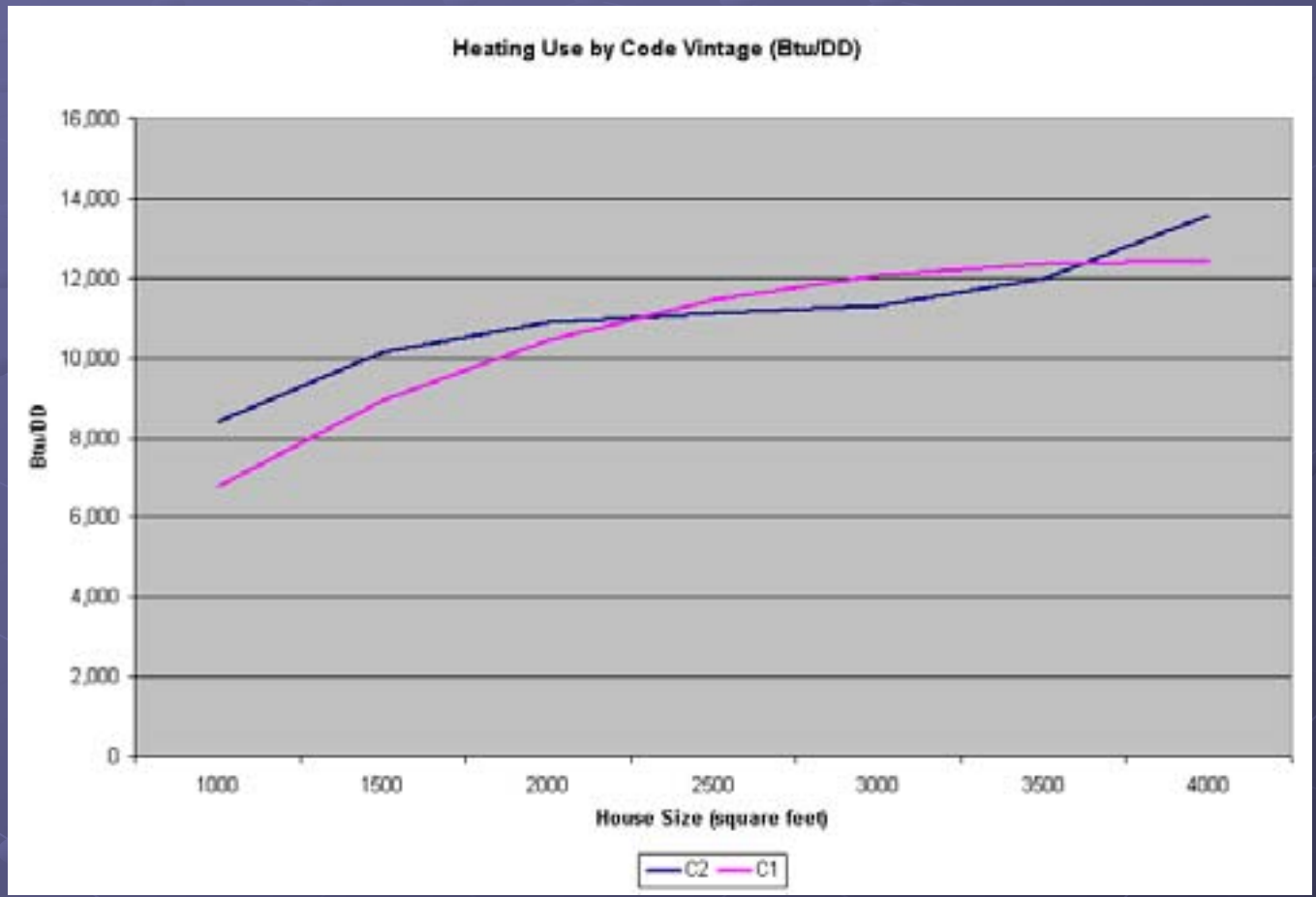
- Louisiana study found the following yearly costs for heating, cooling, and hot water:
  - 1,000 – 1,400 square foot home → $814
  - 1,400 – 2,700 square foot home → $614-$709
- Wisconsin study found that owner occupied low-income homes are 16% smaller on average, but overall energy bills are about the same as for the rest of the population.

# Major Findings and Recommendations from Current Literature

## Low-Income Housing

- We decided to test this assertion by running a regression on PRISM data from the Minnesota study.
- First regression run on all data.
  - There is a correlation between house size and code vintage. Newer, larger houses tend to be more efficient.
- Second set of regressions run on houses stratified by code C1 and C2.
  - Larger houses are more efficient, but smaller houses built to the more stringent code, C1, gain in relative efficiency.

# Major Findings and Recommendations from Current Literature




Regression data indicates that smaller houses are indeed less efficient, and that the rate of inefficiency increases as size decreases. However, smaller houses built to the more stringent code C1 appear to be more efficient than those built to C2.

# Further BCAP Recommendations and Conclusion

## Further Research

- Look at real energy consumption as a metric for the success of code implementation programs.
- Why actual energy use?
  - Capture human behavior
  - Possibility of being cheaper and a larger sample yield.
  - Possibility of simultaneously tracking electricity leakages from standby electronic devices?
  - RAND: “The purpose of a residential energy code is to … cost-effectively reduce energy consumption. Therefore, it is important to consider the performance of the codes as measured by the decline in per capita energy consumption and percent change in per capita energy consumption.”

# Further BCAP Recommendations and Conclusion

## Further Research

2002 Ft Collins, CO study:

*Is it there?*

*Does it work?*

Should we instead be asking:

*Does it work?*

*Is it there?*

- Baseline characteristics are important. However, we need to start thinking about the real savings that we are or are not obtaining through code programs.
- We can then target policy and code development programs to maximize energy savings.

# Further BCAP Recommendations and Conclusion

**Conclusion**

- Evaluation Techniques
  - Sampling
  - Data Collection
  - Compliance Rates
- Findings and Recommendations from Current Literature
  - Larger Homes
  - HVAC Sizing
  - CFLs
  - Education
  - Low Income
- Further BCAP Recommendation
- Research into real energy usage