Codes to Cleaner Buildings: Effectiveness of U.S. Building Energy Codes

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Research Questions

What impacts have U.S. residential building energy codes had on:

- total household energy use?
- fuel mix used?
- household greenhouse gas emissions?

Motivation

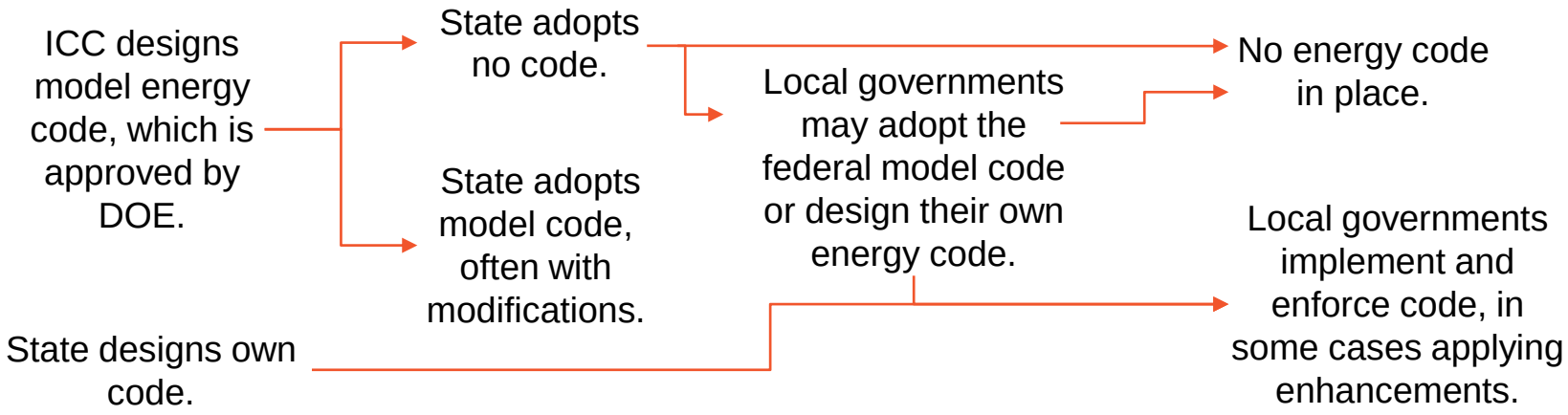
Most existing estimates of energy code impact are *ex ante*, made using building energy simulation models

For several reasons, these projections might not match reality:

- Noncompliance
- Codes might not “bind”
- Behavior (e.g., rebound)

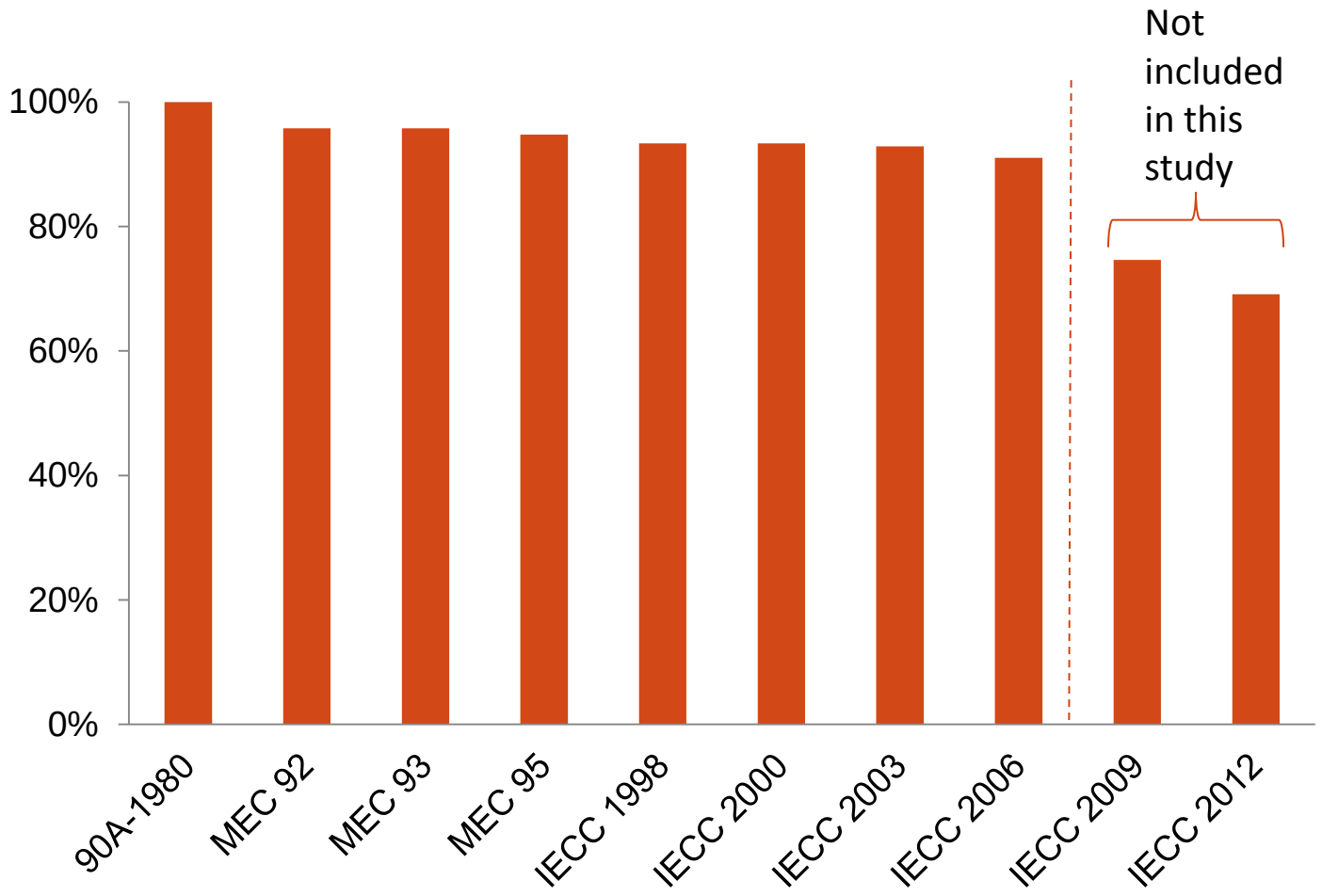
Our method uses state-level observed energy use, which embeds these factors

The U.S. Building Code Adoption Process

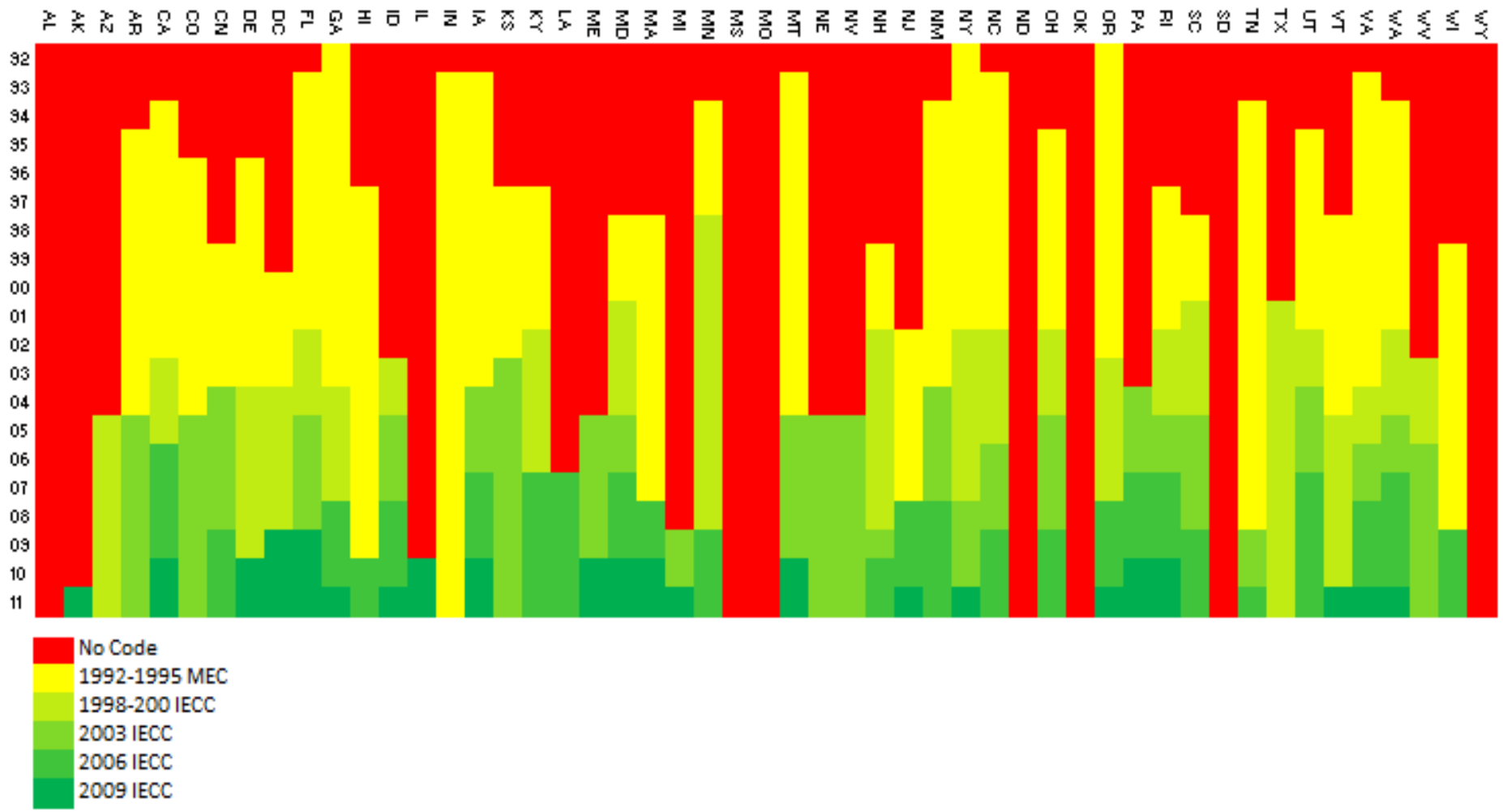


Each state decides whether to adopt a code, as well as which code to adopt.

Projected impacts of building codes relative to baseline



Adoption by state and year



Approach

U.S. states have adopted building energy codes at varying times

This allows use of a panel regression model to estimate code impacts in the years 1992-2008

We estimate the impact of code adoption on the average household's energy use using data on housing unit construction, controlling for weather, energy prices, and income

Statistical Model

We model building energy use

$$E_{st} = P_{st}^{\beta_1} Y_{st}^{\beta_2} W_{st}^{\beta_3} \exp\left(g\left(\sum_{c=1}^{C} \beta_4 F_{c,st} \sum_{c=1}^{C} \beta_5 N_{c,st} \right) \right)$$

Yielding for estimation

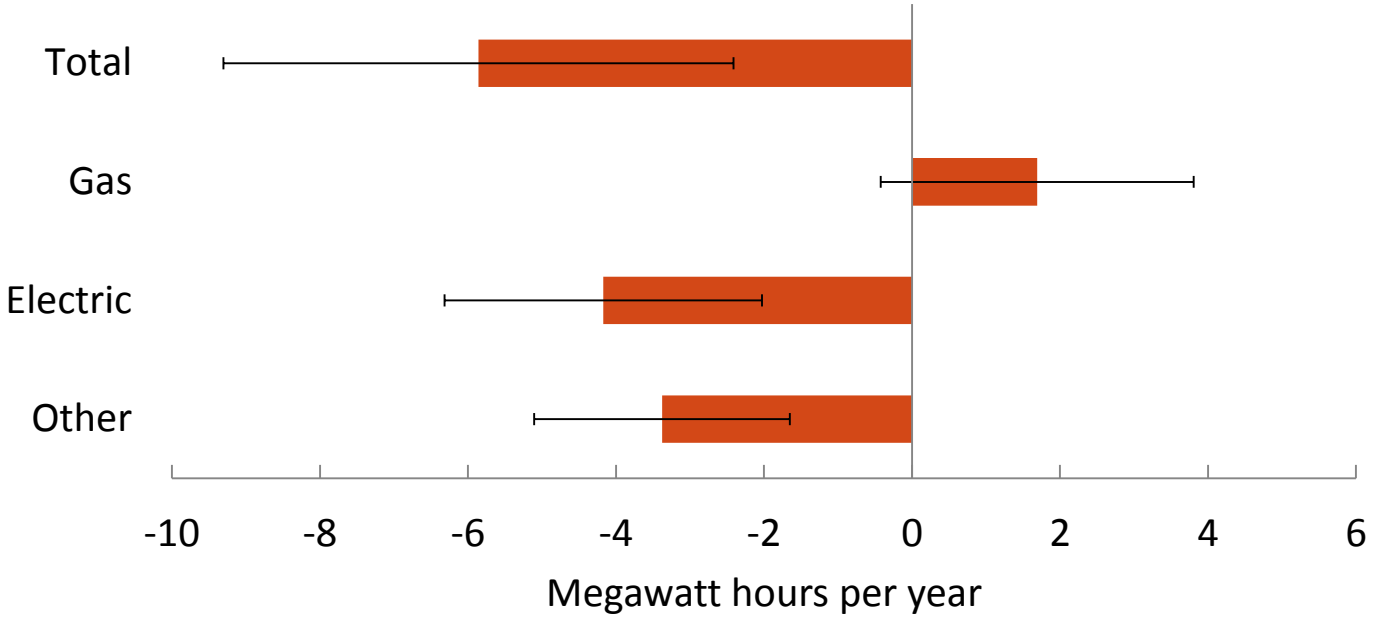
$$\ln E_{st} = \beta_0 + \beta_1 \ln P_{st} + \beta_2 \ln Y_{st} + \beta_3 \ln W_{st} + \beta_4 F_{st} + \beta_5 N_{st} + v_s + u_t + \varepsilon_{st}$$

We control for fuel prices *P*, average household income *Y*, and weather *W*.

F is the fraction of all homes that exist in a year built under a code; *N* is the fraction built since 1992.

Key Findings (1)

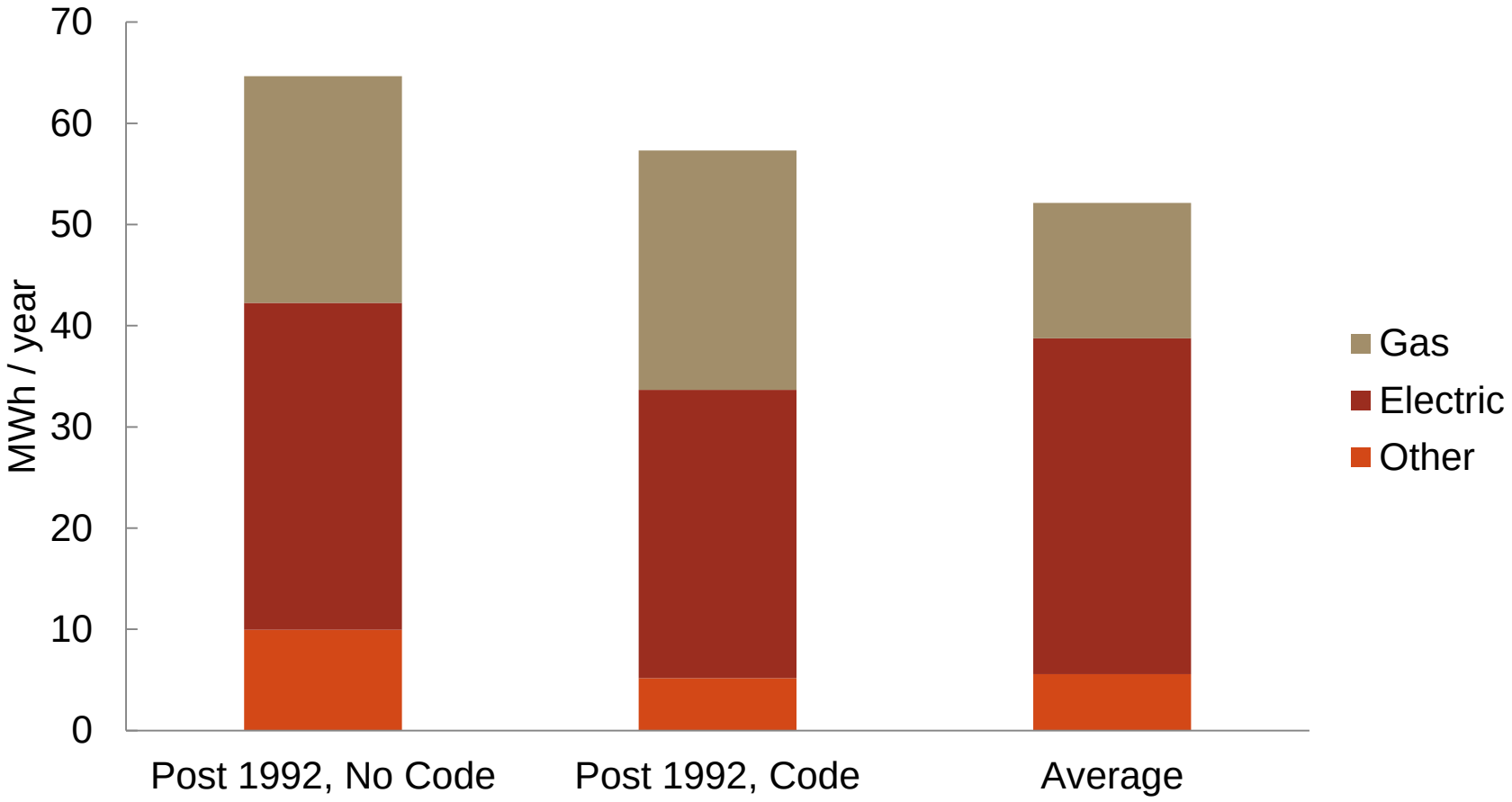
Average estimated annual impacts of building energy codes on household primary energy consumption



Building codes were associated with an estimated 16% reduction in greenhouse gas emissions for affected homes.

Key Findings (2)

Annual primary energy use per household



Conclusions

Codes work! Delivered clear savings despite known compliance problems, potential rebound effects, and other issues.

Codes studied reduced household energy consumption by 11%, *perhaps* even more than engineering models predict.

Fuel usage shifted towards natural gas, perhaps due to provisions in some codes that encourage natural gas heating (or discourage electric resistance heating).

The net effect of energy reductions and fuel switching was a 16% reduction in household greenhouse gas emissions—11% from energy savings, 5% from fuel switching.

Questions?

For more details, download the paper and technical appendices from URL:
http://clmtp.lc/cleanerbuildings

or visit our website at:
www.climatepolicyinitiative.org

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Energy consumption varies regionally