Modeling how large-scale, residential energy efficiency investments impact power sector dispatch and emissions

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Motivation – can residential energy efficiency substitute for generation capacity?

- Increased electricity demand
- Power plant retirements
  - reduced firm capacity
- Renewables growth
  - unreliable capacity
  - reduced profits for traditional generators / firm capacity

Can energy efficiency economically reduce peak demand?
Motivation – the residential sector is a significant part of demand with energy efficiency co-benefits

Residential sector comprises 50% of peak demand in some grids

Many cost effective EE investments do not happen

Grid operators’ support might help investment?
Overview

Validating large-scale residential demand models

Energy efficiency impacts on demand profile

Energy efficiency as a substitute for grid capacity
Modeling electricity demand is difficult for individual residential buildings.
Aggregated demand modeling using NREL’s ResStock program and Parametric Analysis Tool

Nationwide distributions for building characteristics

Super-computer stochastic simulations of building stock

https://www.nrel.gov/buildings/resstock.html
2 subsets of data: similar average characteristics but different attic insulation and air infiltration
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We simulate the 2 subsets, using ResStock to populate characteristics excluded from the audits

Simulate 150 houses in Energy Plus

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>construction year</td>
<td>2005</td>
</tr>
<tr>
<td>floors</td>
<td>70% 2 story houses</td>
</tr>
<tr>
<td>gas heat</td>
<td>87% of houses</td>
</tr>
<tr>
<td>square footage</td>
<td>2370</td>
</tr>
<tr>
<td>condenser EER</td>
<td>11.05</td>
</tr>
<tr>
<td>window ratio</td>
<td>13.3%</td>
</tr>
<tr>
<td>attic insulation R-28</td>
<td>Low Effic.</td>
</tr>
<tr>
<td>attic insulation R-41</td>
<td>High Effic.</td>
</tr>
<tr>
<td>infiltration</td>
<td>6.5 ACH</td>
</tr>
<tr>
<td></td>
<td>4.2 ACH</td>
</tr>
</tbody>
</table>
Mean hourly consumption during the hottest week of 2015 shows good agreement.
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- Difference: 0.36 kW/house
- Difference: 0.40 kW/house
Model 150 average Austin houses with incremental additions of attic insulation
Investing in the least efficient buildings has the largest impact on peak demand
The cost of reducing demand via attic insulation compares to the cost of adding generation capacity.
The cost of reducing demand via attic insulation compares to the cost of adding generation capacity.
Deferred capacity contributes significantly to the overall value of attic insulation projects.
Conclusions

Aggregate building demand can be accurately simulated

Attic insulation can be an economical substitute for power plant capacity for meeting peak demand
  + reduces emissions
  + reduces consumer cost

Grid operators could consider encouraging energy efficiency measures as part of their resource adequacy planning
Future Work

More robust validation
simulated vs. historical over the whole year
need more data from more regions of the country

Simulate other cities and energy efficiency measures

Connect with grid models to simulate non-marginal impacts
significant energy efficiency investments will impact the
dispatch and marginal emissions / prices
Acknowledgements

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