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Presentation Highlights

♦ Purpose of evaluation
♦ Challenges of evaluation
♦ Prerequisites for effective impact evaluation
♦ General approach to evaluation
♦ Impact evaluation methodologies used, advantages and challenges (billing, metering, modeling)
♦ Select findings
♦ Conclusions
Market actors include builders, homeowners, utility staff, Home Energy Rater registry staff, and plan check consultants.
Background

♦ Statewide program PG&E, SCE, SDG&E, SCG
♦ 2004-05 evaluation performed by RLW Analytics, Inc.
♦ Energy Star Homes in CA means > 15% Title 24
♦ Evaluation background
  – CA Evaluation Framework (document)
  – CPUC defined and approved SOW, utilities managed evaluation
  – 04-05 Evaluation begun after program close in 2006
♦ Number homes/dwelling units

<table>
<thead>
<tr>
<th>Utility</th>
<th>Single Family</th>
<th>Multi-Family</th>
<th>High Rise</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGE</td>
<td>12,309</td>
<td>2,758</td>
<td>269</td>
<td>15,336</td>
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<td>SCE</td>
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<td>16,592</td>
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<td>SCG</td>
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<td>6,322</td>
<td>602</td>
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<td>SDGE</td>
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<td>12,306</td>
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<tr>
<td>Total</td>
<td>31,113</td>
<td>19,128</td>
<td>2,108</td>
<td>52,349</td>
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</tbody>
</table>
California Energy Star Homes
Title 24 and 16 Climate Zones (CZ)

- Widely varying energy usage in each CZ
- Title 24 requirements vary by CZ
- Energy Star program requires HERS inspections
- Coastal = CZ 1-7
- Inland = CZ 8-16
- Single family units 86% inland
- Multi-family units 59% inland
Purpose & Goals of Evaluation

♦ To help ensure good decision making for energy program resources ($)

♦ Estimate specific program effects, for example:
  – Program cost effectiveness?
  – Are savings “real”?
  – What are gross and net savings (impact evaluation)? *(Focus of this presentation)*
  – And many others

♦ Attempt to understand how program effects occurred to make recommendations for increased program effectiveness

To fulfill requirements
Fundamental Challenge of Impact Evaluation

♦ Measuring energy use that didn’t happen

♦ For Energy Star New Homes:
  – Estimating program effects of new Energy Star homes compared to non-participant homes
  – Determining appropriate participant classes for evaluation (e.g. by utility, climate zone, SF vs. MF, single story/multi-story, end-uses, energy types, others)
  – Estimating energy savings of even a single home is challenging!

♦ Evaluation is part science and part art
Program Timing

♦ Time to build-out projects typically (1-3 years)

♦ Participant accounting is critical
  – California program impacts are accrued when they are realized (built/installed, inspected, approved)
  – This can be years after the program application is completed for new construction
  – Building code changes can occur every few years

♦ Net result: ES homes evaluated in 2006 may be from program years ‘03, ‘04, ‘05, ‘06 and span more than one building code
Approach to Evaluation

♦ Sequential vs. Integrated Evaluation

♦ Evaluation results 2+ years after program cycle do not support timely decision making
Prerequisites for Effective Evaluation

♦ A well-conceived program theory and logic model
♦ Complete and accurate program tracking data
California Energy Star Homes ’04-’05 Evaluation Activities

♦ Billing Analysis
♦ Metering Analysis
♦ Modeling Analysis
Billing Analysis

♦ Approach and advantages
  – Examine the billed energy use of the participants and non-participants
  – Uses existing metered consumption data
  – Possible to have very large sample sizes (both P and NP)

♦ Challenges
  – Data acquisition - Multiple fuel types provided by multiple sources
  – Data management
  – De-aggregating billing data (example: cooling)
  – Large variability of household usage (variance can swamp differences)
  – Controlling for differences in participants vs. non-participants (e.g. floor area, occupancy, income, stories)
  – Behavior – how do participant intentions and behavior affect energy savings? E.g., snap-back, energy efficiency attitudes, etc.

♦ Responses
  – Use regression analysis to statistically control for other factors affecting energy consumption
  – Carefully select large samples of participants and non-participants
  – Careful data QA/QC
End-use Metering Analysis

♦ Approach and advantages
  – Directly meter energy usage on specific end-uses of interest (space heating, cooling, and water heating)
  – Focuses on the affected measures and end-uses to reduce variation and bias from other factors
  – Examine the installed measures in a sample of the participants and use the engineering model and site-specific data to the savings at each site.

♦ Challenges
  – Data acquisition – Cost, time, losses, access to homes
  – Variance of usage still very large
  – Sample size(s) – how many participants (and NP’s) for meaningful results?
  – Sample bias – are the samples representative?
  – Measurement plan – what are the key factors affecting use or savings? Behavior – how do participant intentions and behavior affect energy savings? E.g., snap-back, energy efficiency attitudes, etc.
Modeling Analysis

♦ Approach and Advantages
  – Use energy modeling to simulate usage and savings
  – Takes advantage of models created for code compliance
  – Can be performed on entire population of participants
  – Can compare

♦ Challenges
  – Compliance software (models) not intended to estimate energy consumption
  – Data acquisition -- Requires obtaining/modeling representative non-participant homes (Requires a baseline study)
  – Trickier for multifamily housing
  – Homes often not built exactly as modeled
  – Program compliance is also through modeling, so not an independent verification
Select Results (1)

♦ Billing, metering, and modeling methodologies showed some conflicting results

♦ Metering analysis showed less overall energy usage than models predicted

♦ Billing analysis sometimes showed greater energy usage in Energy Star homes

♦ Metering and billing analyses showed large variance in usage (as expected)
Select Results (2)

♦ Orientation of homes can have a significant impact on modeled energy savings

♦ Production homes usually modeled N, E, S, W

<table>
<thead>
<tr>
<th>Climate Region</th>
<th>End Use</th>
<th>Single Family</th>
<th>MultiFamily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B-Ratios for Orientation Adjustments</td>
<td>B-Ratios for Orientation Adjustments</td>
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<tr>
<td>Coastal</td>
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<tr>
<td>Cooling</td>
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<tr>
<td>Heating</td>
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<tr>
<td>Water Heating</td>
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<tr>
<td>Inland</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
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<td>1.27</td>
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</tr>
<tr>
<td>Heating</td>
<td>1.17</td>
<td>1.07</td>
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<tr>
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<td>1.00</td>
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<td></td>
</tr>
</tbody>
</table>

Ratios of energy savings from average orientation to worst orientation

♦ Example: Inland cooling modeled energy savings averaged over N, E, S, W is 25% greater than the worst orientation’s energy savings
Select Results (3): Single Family
Free Ridership Varies by End Use

Statewide Single Family Energy Savings of Participants and Energy
Savings of Non-Participants Above Title-24

- Energy Savings of Participants above non-Participants
- Energy Savings of Non-Participants above Title-24
- Proposed Energy Consumption of Participants

Total height of bar represents Title 24 Standard design energy use
Conclusions

- Integrated approach to evaluation preferred over sequential
- Single family impact analysis is complex, multifamily even harder
- Critical for program (and evaluation) to define “savings” as inclusive or exclusive of occupant behavior (take-back)
- Large variance in individual energy usage challenging particularly for metering methodologies
- Evaluators must carefully consider participant classes for evaluation (results may vary by end-use, fuel type, other classes)
- Modeling software appears to be a poor predictor of consumption, but may be good at estimating average savings
- Home orientation can have a significant impact on energy savings – large opportunity for savings in simple passive solar design
- The cost of engineering approaches depends on the accuracy of the tracking estimates of savings

Final report available at [www.calmac.org](http://www.calmac.org) in May