To Condense, or not to Condense?

Installation Practices Leave Boiler Savings on the Table

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Condensing boilers are like racehorses
If they’re not handled properly, things can go wrong...
Methodology

Long-term metering

Gas consumption spot measurements

Efficiency spot measurements

Billing data disaggregation

Calibrated simulation for weather normalization

On-site Data Collection

Analysis
Average rated efficiency for the sample was 94 percent AFUE...
Overall, verified boiler savings exceeded TRM estimates

Increased savings due to…
- Larger heating load
- Heating and hot water loads included
- Measured baseline efficiency below rated

Decreased savings due to…
- High-efficiency units operating well below rated efficiency

Final results were 106% - 113% of TRM values for standard boilers (replace-on-failure measures)
Actual estimated efficiency was only 88 percent
Boiler Savings: Below Expectations

30-40 percent of potential savings NOT REALIZED!

Energy Savings, Therms

- 90% AFUE Boiler
- 95% AFUE Boiler
- 96% AFUE Boiler

Rated Potential
Actual
Condensing boiler efficiency is primarily a function of return water temperature.
Distribution of hours by return water temperature (RWT)

- **High RWT**
  - Low Efficiency
  - 81% of sites

- **Varying RWT**
  - Medium Efficiency
  - 11% of sites

- **Low RWT**
  - High Efficiency
  - 8% of sites

Return Water Temperature [°F] vs. Time [hrs]
What kind of TLC do boilers need?
Strong outdoor reset

Condensing Range

~35°F OAT

12% of sites
No outdoor reset: 51% of sites
Strategy 1: Improve Outdoor Reset Controls

Preliminary Estimate of Improved OAT Reset Potential

- 90% AFUE Boiler
- 95% AFUE Boiler
- 96% AFUE Boiler

Energy Savings, Therms

- Rated Potential
- Est. OAT Achievable
- Actual
Strategy 2: Right-size distribution to heating loads

Add Distribution

Reduce Loads
Strategy 3: Manage Homeowner Expectations

Smaller or no setbacks

Smarter thermostats?
Future Research

Which strategies are most cost effective?

Which can we realistically implement?

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Link to Evaluation Report:
Nested Sampling Approach for Boilers

Program population

Billing Data Disaggregation
\( n = 1688 \)

On-site Metering
\( n = 70 \)
Methodology: Calculating Final Annual Gas Consumption

Calculated ratio of metered therms to estimated heating therms billed for metered sites during the metering period

Building model based on site characteristics calibrated to billing data for entire disaggregation sample
# Boiler Sample Dispositions

<table>
<thead>
<tr>
<th>Group</th>
<th>Target</th>
<th>Achieved</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Term Metering: Gas Consumption</td>
<td>70</td>
<td>42</td>
<td>Unusable metered data (16) Unusable spot measurements (12)</td>
</tr>
<tr>
<td>Long Term Metering: Efficiency</td>
<td>70</td>
<td>54</td>
<td>Unusable metered data (16)</td>
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<tr>
<td>Billing Data Disaggregation</td>
<td>1,000</td>
<td>1,688</td>
<td>n/a</td>
</tr>
<tr>
<td>Standard New Efficiency Spot Measurements</td>
<td>30 (36 visited)</td>
<td>28</td>
<td>Efficiency &gt;=90% AFUE (6)* Unable to take measurements (3)* Unable to verify nameplate (1)</td>
</tr>
</tbody>
</table>

*Two of the units without spot measurements were also high efficiency. 36 total sites visited.*
## Boiler Savings: Standard Boilers, Heating & Hot Water

<table>
<thead>
<tr>
<th>Measure</th>
<th>AFUE Type</th>
<th>Efficient AFUE</th>
<th>Baseline AFUE</th>
<th>Verified ROF Therm Savings</th>
<th>2013 Report TRM ROF Therm Savings</th>
<th>Rel. Precision at 90% Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% AFUE Boiler ROF Baseline</td>
<td>Rated</td>
<td>92.7%</td>
<td></td>
<td></td>
<td>96</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>Verified</td>
<td>86.2%</td>
<td></td>
<td></td>
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<tr>
<td>95% AFUE Boiler ROF Baseline</td>
<td>Rated</td>
<td>95.0%</td>
<td>Rated: 82.0%</td>
<td>123</td>
<td>123</td>
<td>9.9%</td>
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<tr>
<td></td>
<td>Verified</td>
<td>88.4%</td>
<td>Verified: 79.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>96% AFUE Boiler ROF Baseline</td>
<td>Rated</td>
<td>96.0%</td>
<td></td>
<td></td>
<td>135</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>Verified</td>
<td>89.3%</td>
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</tbody>
</table>
Comparison of Metered and Billing Data: With and Without Outliers

Includes both heating and hot water loads: 83% of final metered boilers served hot water and heating.