Savings through the Proper Installation of Combined Heat and Hot Water Systems

2014 Industry Partner Meeting

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What we do

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  • Research
  • Education and Outreach
• Sound Insulation Program
• Public Policy
• Lending Center
• Energy Program Design and Delivery
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- NorthernSTAR - A DOE Building America Research Team
- Sustainable Energy Resources for Consumers Grants

- Center for Energy and Environment
- Sustainable Resources Center
- University of Minnesota
- The Energy Conservatory
Agenda

• Introduction to Combination Systems
• Savings Potential
• Best Installation Practices
  • Home Assessment
  • Combi Equipment
  • Installation
  • Optimization
  • Verification
• Performance
• Conclusions
Energy Savings Potential

- LIWX agency installed 200+ in Twin Cities metro
- Typically replaced a 80% AFUE furnace and a 0.59 EF water heater
- Utility bills showed a median savings of 13%

- 11 home detailed pre/post analysis
- Savings of 16%
### Savings

<table>
<thead>
<tr>
<th>Heating Plant</th>
<th>Installed Efficiency</th>
<th>Rated Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual</td>
<td>Winter Space Heat</td>
</tr>
<tr>
<td>StWH</td>
<td>86%</td>
<td>87%</td>
</tr>
<tr>
<td>TWH</td>
<td>86%</td>
<td>85%</td>
</tr>
<tr>
<td>HWH</td>
<td>90%</td>
<td>92%</td>
</tr>
<tr>
<td>Existing₁</td>
<td>71%</td>
<td>72%</td>
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Home Assessment

- Space Heating Load
  - Manual J

- DHW Load
  - Number of bathrooms/Number of people
  - Inlet water temperature
Installation

• Codes
  • Open loop requires hydronic air handlers and pumps rated for potable water
    • Stagnation prevention mode
  
  • Lack of familiarity of codes officials
    • Can water heaters be used for space heat?
    • Closed loop system required?
    • Other concerns???
Installation

- Special equipment
  - Venting
  - Mixing valve
  - Condensate pump
  - Air Handler flow rate control valve

![Diagram of installation with labels: Storage Water Heater, Hydronic Air Handler, DHW Mixing Valve, AHU Control Valve, Condensate management]
Installation: Venting

Venting

B-Vent

Direct
Installation: Mixing Valve
Installation: Condensate Management
Installation: Air Handler Control Valve
Installation

• Other considerations
  • May need to install an electric outlet for the water heater

• May need to increase the size of the gas line or even the gas meter/supply line

• Hybrid and tankless water heaters typically can be wall mounted which will reduce system footprint – can also mean changing the location of the plumbing
No Optimization

(for a 40,000 Btu/hr design load)

T_set = 140 °F
GPM = 5
120°F

CFM = 1500

100°F
60,000 Btu/hr

Graph: Heating Plant Efficiency vs. Return Water Temperature (°F)
Improved Installation

(for a 40,000 Btu/hr design load)

112°F
45,000 Btu/hr

Tset = 140 °F
GPM = 2.5

CFM = 900

105°F
Fully Optimized

(for a 40,000 Btu/hr design load)

Tset = 125 °F
GPM = 2.5
90°F

106°F
43,000 Btu/hr

CFM = 900

Return Water Temperature (°F)

Heating Plant Efficiency

95%
93%
91%
89%
87%
85%
83%
81%
79%
77%
75%
80 85 90 95 100 105 110 115 120 125
Verification

- 3 Tiers of Verification

<table>
<thead>
<tr>
<th>Verification Measures</th>
<th>Expected Performance</th>
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<tbody>
<tr>
<td>Approved Equipment</td>
<td></td>
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<tr>
<td>Trained Contractor</td>
<td></td>
</tr>
<tr>
<td>Verified Performance</td>
<td></td>
</tr>
<tr>
<td>Space Heat</td>
<td>80% of Optimal</td>
</tr>
<tr>
<td></td>
<td>Optimal</td>
</tr>
<tr>
<td></td>
<td>90% of Optimal</td>
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<td>Optimal</td>
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</tbody>
</table>

| ✓     | ✓     | ✓     | 80% of Optimal | Optimal |
| ✓     | ✓     |       | 90% of Optimal | Optimal |
| ✓     | ✓     | ✓     | Optimal       | Optimal |
Performance: Field Monitoring

DHW Loads
Cold In from Mains
Supply to AH
Return from AH
Ambient T

Water Temp
Electric
Gas

Conditioned Space
Hot Space Heating Air

Electric
Water Flow
Air Temp
Air Flow
Consumption

Center for Energy and Environment
Performance

- Delivered air temperature may be slightly cooler than a furnace

- Hot water may change slightly depending on water heater type

- Maintenance and durability
Water Temperature Delivery

- Hybrid (Cond)
- Storage (Cond)
- Tankless (Cond)
- Storage (non-Cond)
Performance
Performance: Stand-by Loss
Performance
Installed Performance

![Chart showing installed annual efficiency for various field test sites](chart.png)
Cost

![Cost Graph]

- **Combi Storage**: Therm Eff. 95%
- **Combi TWH**: EF 92%
- **Combi Hybrid**: EF 95%
- **Combi Boiler**: AFUE 90%
- **ND furn, ND WH**: AFUE 80%, EF 60%
- **Cond furn, PV WH**: AFUE 95%, EF 60%
- **Cond furn, Cond stor WH**: AFUE 95%, Therm Eff 95%
- **Cond furn, Cond TWH**: AFUE 95%, EF 92%

This graph compares average installed costs for different heating and cooling systems, showing mature costs and limited installations.
Conclusions

• Condensing combi systems can achieve efficiencies equal to or slightly greater than a condensing furnace and PV water heater
• Oversize the hydronic air handlers
• Carefully adjust water flow, air flow, and heater setpoint to achieve return water temperature < 105°F
• Work with code officials to address their concerns prior to installations
• New water heaters and air handlers should improve performance (and lower cost?)
Future

- Water Heaters

- Air Handlers

- ASHRAE 124 method of test is being updated and would include integrated water heaters and air handlers – provide method for higher efficiency systems for utility incentives
THANK you!

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