Combining Space and Water Heating with Highly Efficient Results

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Overview

A. Background: Project and Equipment
B. System Design
C. Field Results: Efficiency, Savings, Comfort
D. Cost
E. What’s next
How this project came about

- Weatherization is able to seal homes tighter and tighter
- Leads to combustion safety issues
- Requires sealed combustion
- Requirements on Savings vs installed cost rule out high efficiency water heaters
- Forced to use safety budget to install 60% direct vent tanks with very little energy savings
- SRC got a SERC grant to look at using a DIA
What is a Dual Integrated Appliance?

A. A mechanical system that uses one heating plant (natural gas burner) to provide both space heating and hot water
B. Space heating side can be either hydronic or forced air
C. Systems can use a closed or open heating loop

This project will look at natural gas forced air DIA systems. Boiler based systems will be closed loop and water heater systems have an open loop.
CONVENTIONAL SYSTEM
WATER AND SPACE HEATING
COMBINED WATER AND SPACE HEATER
USING STORAGE WATER HEATER
COMBINED WATER AND SPACE HEATER
USING TANKLESS WATER HEATER
COMBINED WATER AND SPACE HEATER
USING COMBI BOILER
Why Dual-Integrated Appliances?

+ Two high efficiency heaters (Space and Water) in one package
  - potentially cheaper
  - Simpler, less maintenance
+ Sealed combustion
  - Eliminates combustion safety issues
+ Further reduction in air infiltration
  - Removal of make up air inlets
  - Sealing chimneys
Installation and Sizing

PROBLEM

+ Some contractor’s had little experience
+ System schematics often developed on site
+ Little or no sizing information provided
+ System components came from several manufacturers
+ Manufacturer’s settings typically do not lead to best performance

+ Decided to design and optimize systems in a laboratory
+ Could then provide contractors with more detail installation guidelines
Full report at:
Steady-state heating plant efficiency
Air handler performance

+ Hydronic coil transfers heat from water to air
+ Goals:
  + Return water <105 °F
  + Delivered air >110 °F
+ Goals must be balanced with capacity needs
+ Installation parameter charts were developed for each air handler
Poor install
(for a 40,000 Btu/hr design load)

Tset = 140°F

GPM = 5

CFM = 1500

120°F

100°F

60,000 Btu/hr
Better install
(for a 40,000 Btu/hr design load)

Tset = 140°F
GPM = 2.5
CFM = 900
112°F
45,000 Btu/hr
105°F
Best install
(for a 40,000 Btu/hr design load)

\[ T_{\text{set}} = 125 \, ^\circ\text{F} \]

\[ \text{CFM} = 900 \]

\[ \text{GPM} = 2.5 \]

\[ 106^\circ\text{F} \]

\[ 43,000 \text{ Btu/hr} \]
Ideal future install
(for a 40,000 Btu/hr design load)

\[ T_{\text{set}} = 120 - 140 \, ^\circ\text{F} \]

\[ \text{CFM} = 800 - 1000 \]

\[ \text{GPM} = 2 - 3 \]

\[ 100 - 115 \, ^\circ\text{F} \]

\[ 20 - 50 \, \text{kBtu/hr} \]
Equipment and Site Selection: Trouble Areas

+ Very large DHW loads
  + High flow rate showers
  + Several simultaneous or back to back showers

+ Water quality

+ Integration with existing duct work and mechanical room

+ Heating load estimates
Field Implementation and Monitoring

+ 250 installs in Minnesota
  + Utility bill analysis on all 250 sites (to come in 2013)
  + Detailed pre/post monitoring on 20 sites (NEXT!)
House Characteristics

Minneapolis
+ Heating Degree Days: 7565
+ Heating Design Temp: -13.4 F

Project Averages
+ Space Heating Design Condition: 25,000 btu/hr
+ DHW Daily Usage: 41 gallons/day (830 Btu/hr)
+ Combined Gas Consumption (AFUE~80 and EF~58):
  900 therms/year

Typical Installation
+ Unfinished basements or mechanical rooms in finished basements
Existing Equipment

- Cold In from Mains
- DHW Loads
- Ambient T
- ND Tank Water Heater
- Gas
- Conditioned Space
- Hot Space Heating Air
- Single Stage Furnace
- Electric
- Gas
- Runtime
- Air Temp
DIA Installation

- Cold In from Mains
- DHW Loads
- Supply to AH
- Return from AH
- Water Temp
- Water Flow
- Air Temp
- Air Flow
- Consumption

Water Heater

Hydronic Air Handler
Efficiency
System Efficiencies under Actual Loads
Why the low efficiencies in the summer?

Setpoint = 140°F
$1/\text{therm}$
$0.12/\text{kWhr}$
TWH 2 – Storage Tankless Hybrid