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SUMMARY OF RECENT RESEARCH

Wall Furnace Research Project

OVERVIEW

- Field monitoring measured furnace operation, IAQ
- Laboratory testing measured performance, flue emissions
- Ten existing standard wall furnaces in Los Angeles, Hayward, Oakland & Sacramento homes
- Four types of advanced wall furnaces installed as retrofits
- Project also characterized costs, operability & reliability

RESULTS

- **Energy Savings:** 68%
- **Utility Cost Savings:** 68%
- **Emissions Reductions:** 87% CO, 86% NOx, 93% THC
- **IAQ Effects:** Mixed
- **Payback:** 8+ years

Figure 1: Advanced Single-Sided, Condensing, and Double-Sided Wall Furnaces (L to R)

Funded by the California Energy Commission and Southern California Gas, a team of researchers from GTI Energy and Frontier Energy recently tested and monitored a variety of wall furnaces to evaluate advancements in wall furnace technology.

Wall furnaces are small, natural gas-fueled furnaces that heat only one or two rooms, depending on whether they are single- or double-sided. Most are sized and shaped to fit into the wall cavity between studs, usually on an interior wall, although some may be installed on exterior walls. Standard wall furnaces are simple devices with no frills, while advanced wall furnaces have features to improve heat delivery, energy efficiency, and emissions.

Wall Furnace Options	STANDARD	ADVANCED
Heat Distribution:	Gravity	Fan-type
Combustion Air:	Top vent	Direct vent
Burner Ignition:	Standing pilot	Intermittent pilot or Hot surface igniter
Heat Recovery:	Non-condensing	Condensing
Emissions:	No controls	Low NOx controls
AC Power:	Self-powered	AC- or self-powered
Rated Thermal Efficiency (TE):	ANSI Z21.86-2016 70% minimum; as low as 50% on existing furnaces	ANSI Z21.86-2016 75% minimum; up to 94% condensing, 85% non-condensing

No emissions regulations currently apply to wall furnaces, although central furnace NOx emissions are limited to 0.033 lbm/MMBtu (14 ng/J) by rules in two California air quality management districts, SCAQMD Rule 1111 & SJVAPCD Rule 4905.

The existing wall furnaces evaluated were all standard gravity wall furnaces with average input rating of 33,500 Btu/hr and TE of 67%. The four types of advanced wall furnaces were installed as follows:

Two 17,500 Btu/hr, 94% TE direct vent, condensing furnaces in Hayward
Four 30,000 Btu/hr, 85% TE top vent, fan-type furnaces in Los Angeles
One 40,000 Btu/hr, 83% TE top vent, fan-type, double-sided in Oakland
Three 30,000 Btu/hr 82% TE top-vent, fan-type, self-powered in Sacramento

STATISTICAL AVERAGES from Furnaces at 10 Sites

Furnace Age:
Std Existing: 32 years
Avg Retrofit: new

Tested Thermal Efficiency:
Std Existing: 65%
Adv Retrofit: 82% +17%

Tested Input Capacity:
Std Existing: 29,990 Btu/hr
Adv Retrofit: 30,830 Btu/hr +3%

Pilot or Power Use:
Std Existing: 690 Btu/hr inactive
Adv Retrofit: 0-12.5-100 W active

Tested Output Capacity:
Std Existing: 19,190 Btu/hr
Adv Retrofit: 25,050 Btu/hr +31%

Annual Operation:
Std Existing: 188 hours
Adv Retrofit: 119 hours -37%

Annual Furnace Cycles:
Std Existing: 417
Adv Retrofit: 208 -54%

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Laboratory Testing & Field Monitoring Findings

Advanced retrofit wall furnaces were significantly more energy efficient than standard existing wall furnaces due to enhanced combustion controls and elimination of the standing pilot. Laboratory tests showed that advanced furnaces also had 31% higher output capacity than standard furnaces.

Field monitoring showed that wall furnaces tend to be turned on and off manually by occupants. Annual operating hours decreased by one-third and the number of on-off cycles dropped more than half for advanced furnaces compared to standard furnaces.

Overall, advanced retrofit furnaces reduced energy use by 68%, reduced utility bills by 68%, and decreased emissions of carbon monoxide, nitrogen oxides, and total hydrocarbons by 86% or more compared to standard existing furnaces. Only the condensing furnace did not meet the 0.033 lbm/MMBtu limit on NOx for central furnaces.

However, indoor air quality only improved slightly after retrofit wall furnaces were installed despite their greatly reduced emissions. Wall furnace operation, even operating the pilot on standard furnaces, draws air from inside for combustion, removing pollutants produced by other sources.

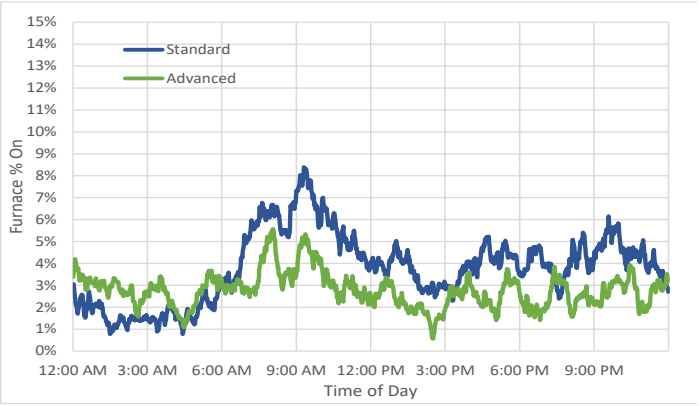

Figure 2: Monitored Daily Standard & Advanced Wall Furnace

Challenges and Next Steps

To realize their potential, advanced furnaces could benefit from three operational improvements. First, fan-type furnaces should aim to adhere to ASHRAE 6.2 noise limits for intermittent indoor fans. Second, thermostatic controls can be improved to make them more responsive to occupants. Third, units powered by self-charging batteries need further testing as manufacturers work to improve reliability.

Incremental costs for advanced wall furnaces are also currently quite high. Simple paybacks for the furnaces in this study ranged from 6.5 to 40+ years. Based on energy savings alone, the extra expense of advanced wall furnaces is most cost effective in colder climates with higher heating needs. Utility incentives can be used to encourage advanced wall furnace adoption until costs of these new technologies can be reduced.

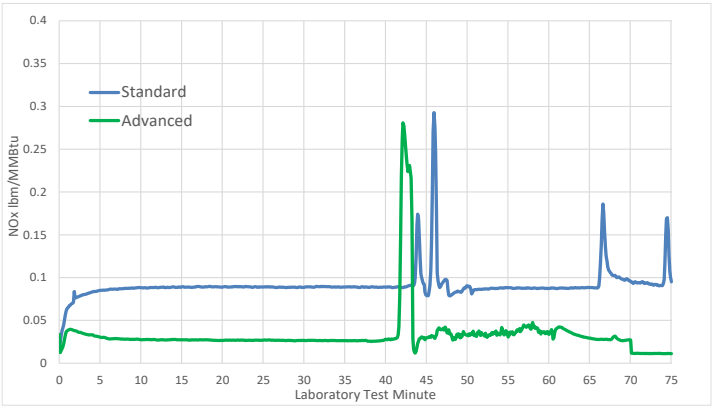

Figure 3: Tested Standard & Advanced Wall Furnace NOx Emissions