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CASE STUDY FROM RECENT RESEARCH

Condensing Wall Furnaces

OVERVIEW

- Field monitoring measured furnace operation, IAQ
- Laboratory testing measured performance, flue emissions
- Project also characterized costs, operability & reliability
- Two existing standard wall furnaces in Hayward
- Two condensing wall furnaces installed as retrofits:

Williams Comfort Products
Model 1753012
condensing, direct vent

RESULTS

- **Natural Gas Savings:** 68%
- **Utility Cost Savings:** 77%
- **Emissions Reductions:** 96% CO, 76% NOx, 99% THC
- **IAQ Effects:** Mixed
- **Payback:** 13+ years

Figure 1: Williams 1753012 Condensing, Direct Vent Wall Furnace

Funded by the California Energy Commission and Southern California Gas, a team of researchers from GTI Energy and Frontier Energy recently evaluated condensing wall furnaces as replacements for existing inefficient wall furnaces. Condensing furnaces recover heat from flue gases to improve their operating efficiency.

Wall furnaces are small, natural gas-fueled furnaces that heat one or two rooms. Wall furnaces are usually sized and shaped to fit into the wall cavity of an interior wall. The condensing, direct vent furnaces studied in this project were almost square in shape and designed to sit on an exterior wall, but they were installed here as interior wall furnace replacements. Standard wall furnaces are simple devices with no frills. The advanced condensing wall furnace has the features listed below, which improve its heat delivery, energy efficiency, and emissions.

Wall Furnace Features	STANDARD	ADVANCED
Heat Distribution:	Gravity	Fan-type
Combustion Air:	Top vent	Direct vent
Burner Ignition:	Standing pilot	Intermittent pilot
Heat recovery:	Non-condensing	Condensing
AC Power:	Self-powered	AC-powered
Rated Thermal Efficiency (TE):	ANSI Z21.86-2016 70% minimum; as low as 50% on existing furnaces	ANSI Z21.86-2016 75% minimum; 94% 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.

Both existing wall furnaces were standard gravity wall furnaces rated at 25,000 Btu/hr and 70% thermal efficiency. The retrofit condensing furnaces were new offerings from the largest manufacturer of wall furnaces, Williams Comfort Products, rated at 17,500 Btu/hr and 94% TE.

STATISTICAL AVERAGES from Furnaces at 2 Sites

Furnace Age:
Std Existing: 35 years
Avg Retrofit: new

Tested Thermal Efficiency:
Std Existing: 74%
Adv Retrofit: 90% +14%

Tested Input Capacity:
Std Existing: 20,250 Btu/hr
Adv Retrofit: 19,790 Btu/hr -2%

Pilot or Power Use:
Std Existing: 520 Btu/hr inactive
Adv Retrofit: 100 W active

Tested Output Capacity:
Std Existing: 15,000 Btu/hr
Adv Retrofit: 17,700 Btu/hr +18%

Annual Operation:
Std Existing: 160 hours
Adv Retrofit: 95 hours +40%

Annual Furnace Cycles:
Std Existing: 330
Adv Retrofit: 165 -50%

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Laboratory Testing & Field Monitoring Findings

Advanced drop-in 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 24% higher output capacity than standard furnaces.

Field monitoring showed that wall furnaces tend to be turned on and off manually by occupants. Due to higher capacity and better heat distribution, condensing wall furnace annual operating hours were 40% lower and cycled half as much as with standard furnaces.

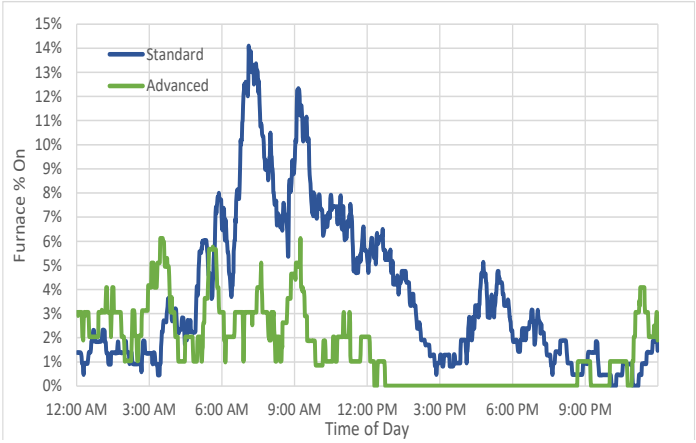

Figure 2: Monitored Daily Standard & Condensing Furnace Operation

Overall, advanced drop-in furnaces reduced natural gas use by 68%. This condensing furnaces eliminated standby pilot energy use but drew 100 W of AC power while active. Net utility bills were decreased by 77%. Condensing furnaces decreased emissions of carbon monoxide and total hydrocarbons by over 96%, and emissions of nitrogen oxides by 76%, compared to the standard existing furnaces, but NOx emissions were still about twice the 0.033 lbm MMBtu NOx limit for central furnaces.

Despite greatly reduced emissions, indoor air quality only improved slightly after the condensing wall furnaces were installed. Wall furnace operation – even just operation of a standing pilot – was found to draw enough air from the space to remove indoor pollutants produced by other sources.

Challenges and Next Steps

To realize their potential, condensing wall furnaces could benefit from operational improvements. First, they 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.

Incremental costs for condensing furnaces are also currently quite high, with simple paybacks ranging from 13 to 38 years in this study. Utility incentives are recommended to encourage adoption until costs can be reduced.

Manufacturer	Model	Condition	CO lbm/year	NOx lbm/year	THC lbm/year
Perfection Products	PW8G25SEN	Standard	2.04	0.91	0.58
Perfection Products	PW8G25SEN	Standard	0.36	0.39	2.19
		Standard Average	**1.20**	**0.65**	**1.39**
Williams	1753012	Retrofit	0.01	0.05	0.00
Williams	1753012	Retrofit	0.06	0.24	0.00
		Retrofit Average	**0.04**	**0.14**	**0.00**
		% Reduction	**97%**	**78%**	**99%**

Figure 3: Annual Emissions from Standard and Condensing Wall Furnaces