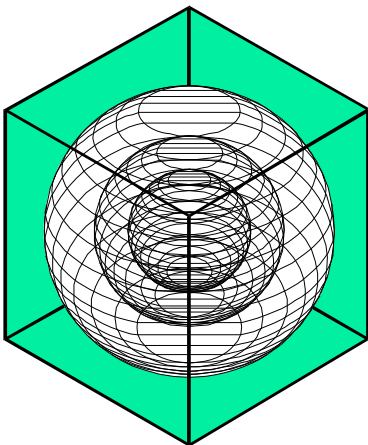


**RECOMMENDATIONS FOR 15% ABOVE-CODE ENERGY
EFFICIENCY MEASURES FOR RESIDENTIAL BUILDINGS**

**A Project for
Texas' Senate Bill 5 Legislation
For Reducing Pollution in
Nonattainment and Affected Areas**

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Executive Summary

This report presents detailed information about the recommendations for achieving 15% above-code energy performance for single-family residences. The analysis was performed using a simulation model¹ of an International Energy Conservation Code (IECC)-compliant, single family residence in Houston, Texas. To accomplish the 15% annual energy use reductions, twelve measures were considered including: tankless water heater, solar domestic water heating system, natural gas water heater without the standing pilot light, HVAC system including ducts in the conditioned space, improved duct sealing, increased air tightness, window shading and redistribution, improved window performance, and improved heating and cooling system efficiency. After the total annual energy use was determined for each measure, they were then grouped to accomplish a 15% total annual energy use reduction.

¹ The analysis was conducted using sngfam2st.inp version M1.2.

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1. Base Case Building Description

The base-case building simulation model in this analysis is based on the *standard* design as defined in Chapter 4 of the 2001 IECC² and certain assumptions, which are described throughout this document. The base-case building is a 2,325 sq. ft., square-shape, one story, single-family, detached house oriented N, S, E, W, with a floor-to-ceiling height of 8 feet. The house has an attic with a roof pitched at 23 degrees, which contains the HVAC systems and ductwork. Two options for the heating fuel type were considered: a) natural gas (gas-fired furnace for space heating, and gas water heater for domestic water heating), and b) electricity (heat pump for space heating, and electric water heater for domestic water heating). For the rest of this report, these houses will be referred to as (a) electric/gas house and (b) all-electric house, respectively. The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2001 IECC.

Table 1 summarizes the base-case building characteristics used in the DOE-2 simulation model. The simulation results are based on the TMY2 hourly weather data for Houston. The cost analysis is based on utility costs of \$0.15/kWh for electricity and \$1.00/therm for natural gas.

The house was simulated as a single-zone building with a delayed construction mode to take into account the thermal mass of the construction materials³. The fenestration characteristics were simulated by creating custom windows with double pane, low-e glazing and aluminum frames with a thermal break, using the WINDOW5 program⁴.

² The 2001 IECC notation is used to represent the 2000 IECC including the 2001 Supplement.

³ This is accomplished using DOE-2 Custom Weighting Factors.

⁴ More information on the Window 5 program can be found at <http://windows.lbl.gov/software/window/window.html>.

Table 1. Base Case Building Description.

CHARACTERISTIC	BASECASE ASSUMPTIONS		COMMENTS	SOURCES
Building				
Building type	Single family, detached house			
Gross area	2,325 sq. ft. (48.22 ft. x 48.22 ft.)			NAHB (2003)
Number of floors	1			NAHB (2003)
Floor to floor height (ft.)	8			NAHB (2003)
Orientation	South facing			
Construction				
Construction	Light-weight wood frame with 2x4 studs spaced at 16" on center			NAHB (2003)
Floor	Slab-on-grade floor			NAHB (2003)
Roof configuration	Unconditioned, vented attic			NAHB (2003)
Roof absorptance	0.75		Assuming asphalt shingle roofing	
Ceiling insulation (hr-sq.ft.-°F/Btu)	Varies		Based on HDD65 and 27% window-to-wall area ratio	2001 IECC, Table 502.2.4(6), (p.83)
Wall absorptance	0.75		Assuming brick facia exterior	
Wall insulation (hr-sq.ft.-°F/Btu)	Varies		Based on HDD65	2001 IECC, Table 402.1.1(1), (p.63)
Slab Perimeter Insulation	None		Based on HDD65 and 27% window-to-wall area ratio	2001 IECC, Table 502.2.4(6), (p.83)
Ground reflectance	0.24		Assuming grass	DOE2.1e User Manual (LBL 1993)
U-Factor of glazing (Btu/hr-sq.ft.°F)	Varies (0.42 for El Paso, 0.47 for other counties analyzed)		Based on HDD65	2001 IECC, Table 402.1.1(2), (p.63)
Solar Heat Gain Coefficient (SHGC)	Varies		0.4 for HDD < 3500, and 0.68 for HDD ≥ 3500	2001 IECC, Section 402.1.3.1.4, (p.64)
Window area	18% of conditioned floor area		This amounts to 418.5 sq. ft. window area and 27% window-to-wall area ratio for the assumed base case building configuration	2001 IECC, Section 402.1.1, (p.63)
Exterior shading	None			2001 IECC, Section 402.1.3.1.3, (p.64)
Space Conditions				
Space temperature setpoint	68°F Heating, 78°F Cooling, 5°F set-back/set-up for winter and summer, respectively, for 6 hours per day			2001 IECC, Table 402.1.3.5, (p.64)
Internal heat gains	0.88 W (modeled as 0.44 W for lighting and 0.44 W for equipment)		This assumes heat gains from lighting, equipment and occupants.	2001 IECC, Section 402.1.3.6, (p.65)
Number of occupants	None		Assuming internal gains include heat gain from occupants	2001 IECC, Section 402.1.3.6, (p.65)
Mechanical Systems				
HVAC system type	Electric cooling (air conditioner) and natural gas heating (gas fired furnace)	Electric cooling and heating (air conditioner with heat pump)		
HVAC system efficiency	SEER 13 AC 0.78 AFUE furnace	SEER 13 AC, 7.7 HSPF heat pump		NAECA (2006)
Cooling capacity (Btu/hr)	55,800		500 sq. ft./ton	
Heating capacity (Btu/hr)	72,540		1.3 x cooling capacity	
DHW system type	40-gallon tanktype gas water heater with a standing pilot light	50-gallon tanktype electric water heater (without a pilot light)		Tank size from ASHRAE HVAC Systems and Equipment Handbook
DHW heater energy factor	0.54	0.86	(a) 0.62-0.0019V, (b) 0.93-0.00132V, Where V=storage volume (gal.)	2001 IECC, Table 504.2, (p.91)
Duct location	Unconditioned, vented attic			NAHB (2003)
Duct leakage (%)	10%			Parker et al. (1993)
Duct insulation (hr-sq.ft.-°F/Btu)	R-8 (supply) and R-4 (return)			2001 IECC

2. Energy Efficiency Measures (EEMs)

For achieving 15% above-code energy performance in single-family residential buildings, twelve measures were considered as shown in Table 2. These include measures for the domestic hot water (DHW) system, air distribution system, building envelope and fenestration, and HVAC system. These measures were simulated by modifying the selected parameters used for the DOE-2 simulation model. One or more of these measures were applied to the base-case house in different combinations for achieving a goal of 15% above-code energy performance.

Table 2. Energy Efficiency Measures.

NATURAL GAS HEATING/ NATURAL GAS DHW SYSTEM	HEAT PUMP/ELECTRIC DHW SYSTEM
A. Domestic Hot Water System Measures	
1. Tankless Gas Water Heater	1. Tankless Electric Water Heater
2. Solar DHW System	2. Solar DHW System
3. Removal of Pilot Light	
B. Air Distribution System Measures	
4. HVAC Unit and Ducts in Cond. Space	4. HVAC Unit and Ducts in Cond. Space
5. Improved Duct Sealing	5. Improved Duct Sealing
C. Envelope and Fenestration Measures	
6. Increased Air-tightness	6. Increased Air-tightness
7. Window Shading (4' Overhang)	7. Window Shading (4' Overhang)
8. Window Shading & Redistribution	8. Window Shading & Redistribution
9. Improved Window Performance	9. Improved Window Performance
D. HVAC System Measures	
10. AC Eff.: SEER 13 to SEER 15	12. SEER 15 AC/8.5 HSPF Heat Pump
11. Furnace Eff.: 0.78 AFUE to 0.93 AFUE	

3. Simulation Input

Table 3 and Table 4 list the parameter values for simulating these measures in: (a) an electric/gas house, and (b) an all-electric house, respectively, located in Houston (Harris County), Texas. The first row of values in both tables presents information used in the base case runs. The remaining rows present information used in the simulation of the individual energy efficiency measures. The shaded cell in each row indicates the change in the value used to simulate the measure. A detailed description of these measures is included in Section 5.

4. Simulation Results

Figure 1 and

Figure 2 show the impact of EEMs on different energy end-uses for: (a) an electric/gas house and (b) an all-electric house, respectively. The energy use is obtained from the BEPS report of the DOE-2 output. Table 5 and Table 6 summarize the results of simulation and cost analysis for (a) an electric/gas house and (b) an all-electric house, respectively, and include: the annual energy use (obtained from the BEPS and BEPU report of the DOE-2 output), calculated energy savings, increased cost of implementation (obtained from various resources listed in Appendix B⁵) and the calculated payback period for each measure. The results of the cost analysis are graphically represented in Figure 3 through Figure 6. Figure 3 and Figure 4 show the first costs and energy cost savings for different measures; Figure 5 and Figure 6 show the corresponding payback period in years, for (a) an electric/gas house and (b) an all-electric house, respectively.

⁵ The ranges of total implementation cost for some measures were modified according to the recommendations of stakeholders.

Table 3. Simulation Inputs for an Electric/Gas House.

EEM #	Energy Efficiency Measure	DHW System Energy Factor	DHW System Type		DHW Pilot Light	Duct Location (Uncond. Vented Attic/Cond. Room)	Duct Leakage (%)	Infiltration Rate (ACH/hr)	Exterior Shading (ft.)	Window Distribution (S:N:E:W)	Window U-Factor (Btu/hr-ft ² -F)	Glazing SHGC	AC Eff. (SEER)	Furnace Eff. (AFUE)
	Basecase	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	0.78
Domestic Hot Water System Measures														
1	Tankless Gas Water Heater	0.85	Tankless	Gas	No	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	0.78
2	Solar DHW System	0.54 (Aux.)	Tanktype (Aux.)	Solar	Yes (Aux.)	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	0.78
3	Removal of Pilot Light	0.54	Tanktype	Gas	No	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	0.78
Air Distribution System Measures														
4	HVAC Unit and Ducts in Cond. Space	0.54	Tanktype	Gas	Yes	Room	None	0.462	None	Equal	0.47	0.4	13	0.78
5	Improved Duct Sealing	0.54	Tanktype	Gas	Yes	Vented Attic	5%	0.462	None	Equal	0.47	0.4	13	0.78
Envelope and Fenestration Measures														
6	Increased Air-tightness	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.35	None	Equal	0.47	0.4	13	0.78
7	Window Shading (4' Overhang)	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	4' Eaves	Equal	0.47	0.4	13	0.78
8	Window Shading & Redistribution	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	4' Eaves	45:25:15:15	0.47	0.4	13	0.78
9	Improved Window Performance	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	None	Equal	0.42	0.33	13	0.78
HVAC System Measures														
10	AC Eff.: SEER 13 to SEER 15	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	None	Equal	0.47	0.4	15	0.78
11	Furnace Eff.: 0.78 AFUE to 0.93 AFUE	0.54	Tanktype	Gas	Yes	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	0.93

Table 4. Simulation Inputs for an All-electric House.

EEM #	Energy Efficiency Measure	DHW System Energy Factor	DHW System Type		DHW Pilot Light	Duct Location (Uncond. Vented Attic/Cond. Room)	Duct Leakage (%)	Infiltration Rate (ACH/hr)	Exterior Shading (ft.)	Window Distribution (S:N:E:W)	Window U-Factor (Btu/hr-ft ² -F)	Glazing SHGC	AC Eff. (SEER)	Heat Pump Eff. (HSPF)
	Basecase	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	7.7
Domestic Hot Water System Measures														
1	Tankless Electric Water Heater	0.95	Tankless	Elec.	No	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	7.7
2	Solar DHW System	0.86 (Aux.)	Tanktype (Aux.)	Solar	No (Aux.)	Vented Attic	10%	0.462	None	Equal	0.47	0.4	13	7.7
Air Distribution System Measures														
4	HVAC Unit and Ducts in Cond. Space	0.86	Tanktype	Elec.	No	Room	None	0.462	None	Equal	0.47	0.4	13	7.7
5	Improved Duct Sealing	0.86	Tanktype	Elec.	No	Vented Attic	5%	0.462	None	Equal	0.47	0.4	13	7.7
Envelope and Fenestration Measures														
6	Increased Air-tightness	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.35	None	Equal	0.47	0.4	13	7.7
7	Window Shading (4' Overhang)	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.462	4' Eaves	Equal	0.47	0.4	13	7.7
8	Window Shading & Redistribution	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.462	4' Eaves	45:25:15:15	0.47	0.4	13	7.7
9	Improved Window Performance	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.462	None	Equal	0.42	0.33	13	7.7
HVAC System Measures														
12	SEER 15 AC/8.5 HSPF Heat Pump	0.86	Tanktype	Elec.	No	Vented Attic	10%	0.462	None	Equal	0.47	0.4	15	8.5

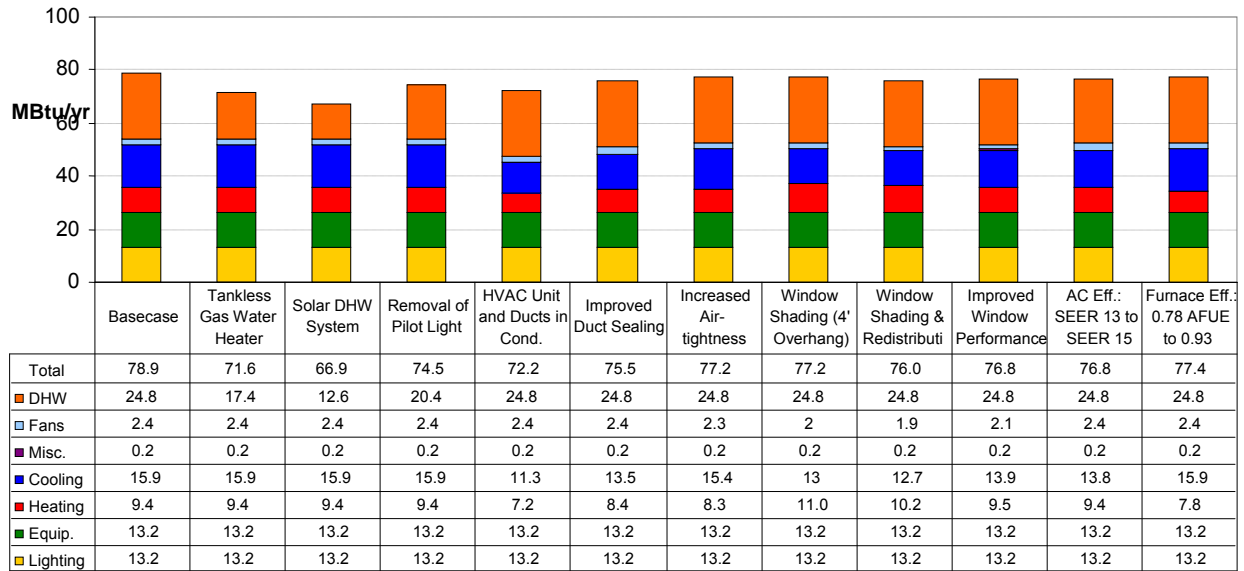


Figure 1. Energy Use for Various EEMs for an Electric/Gas House.

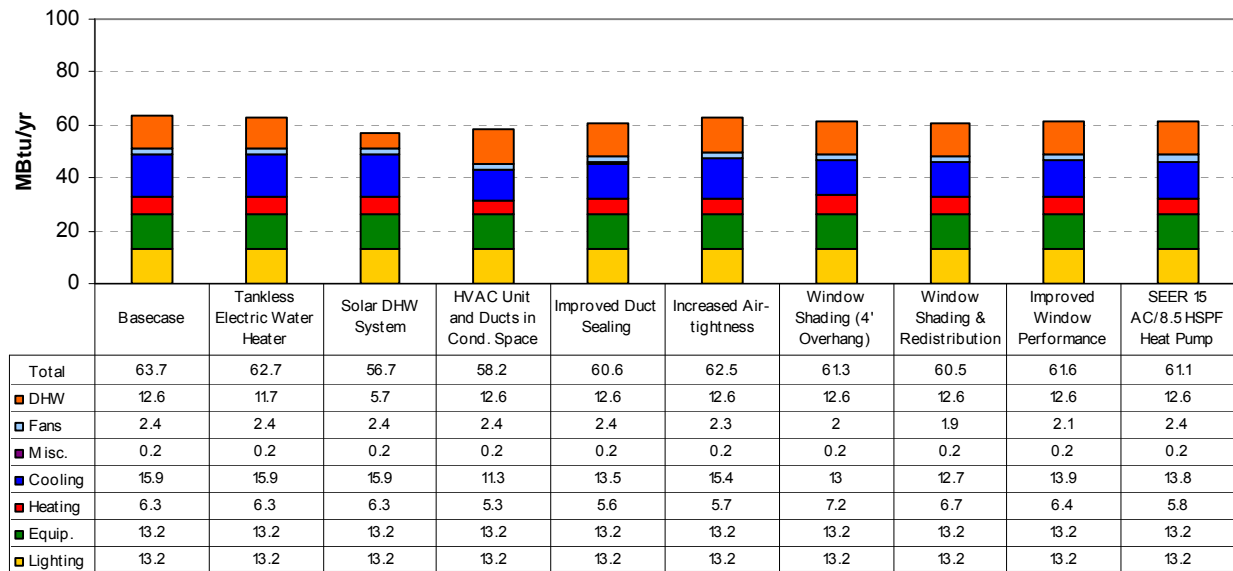


Figure 2. Energy Use for Various EEMs for an All-electric House.

Table 5. Energy Use and Cost Savings for an Electric/Gas House.

EEM #	Energy Efficient Measures	Energy Use (MMBtu/yr)					Energy Use (Utility Units)			Energy Savings				Increased Marginal Cost (\$)	Increased New System Cost (\$)	Payback (yrs)	
		Cooling	Heating	DHW	Other	Total	kWh/yr	therms/yr	\$/yr	MMBtu/yr	%	kWh/yr	therms/yr				\$/yr
	Basecase	15.9	9.4	24.8	29.0	78.9	13,115	341	\$2,308								
	(% of Total)	20.2%	11.9%	31.4%	36.8%												
DHW System Measures																	
1	Tankless Gas Water Heater	15.9	9.4	17.4	29.0	71.6	13,115	268	\$2,235	7.3	9.3%	0	73	\$73	\$1,000 - \$3,500		13.7 - 47.9
2	Solar DHW System	15.9	9.4	12.6	29.0	66.9	13,523	206	\$2,235	12.0	15.2%	-408	135	\$74	\$2,900 - \$5,200		39.3 - 70.5
3	Removal of Pilot Light	15.9	9.4	20.4	29.0	74.5	13,115	298	\$2,265	4.3	5.5%	0	43	\$43	\$200 - \$600		4.7 - 14.0
Air Distribution System Measures																	
4	HVAC Unit and Ducts in Cond. Space	11.3	7.2	24.8	29.0	72.2	11,785	320	\$2,088	6.7	8.5%	1,330	21	\$221	\$1,000 - \$7,000		4.5 - 31.7
5	Improved Duct Sealing	13.5	8.4	24.8	29.0	75.5	12,403	331	\$2,191	3.4	4.3%	712	10	\$117		\$450 - \$650	3.9 - 5.6
Envelope and Fenestration Measures																	
6	Increased Air-tightness	15.4	8.3	24.8	28.9	77.2	12,956	330	\$2,273	1.7	2.1%	159	11	\$35		\$350 - \$1,500	10.0 - 43.0
7	Window Shading (4' Overhang)	13.0	11.0	24.8	28.6	77.2	12,150	358	\$2,181	1.7	2.1%	965	-17	\$128		\$3,100 - \$3,500	24.3 - 27.4
8	Window Shading & Redistribution	12.7	10.2	24.8	28.5	76.0	12,047	349	\$2,156	2.8	3.6%	1,068	-8	\$152		\$3,100 - \$3,500	20.4 - 23.0
9	Improved Window Performance	13.9	9.5	24.8	28.7	76.8	12,458	343	\$2,212	2.1	2.6%	657	-2	\$97	\$800 - \$1,100		8.3 - 11.4
HVAC System Measures																	
10	AC Eff.: SEER 13 to SEER 15	13.8	9.4	24.8	29.0	76.8	12,495	341	\$2,215	2.1	2.7%	620	0	\$93	\$900 - \$2,500		9.7 - 26.9
11	Furnace Eff.: 0.78 AFUE to 0.93 AFUE	15.9	7.8	24.8	29.0	77.4	13,115	326	\$2,293	1.5	1.9%	0	15	\$15	\$600 - \$1,500		40.0 - 100.0

Table 6. Energy Use and Cost Savings for an All-electric House.

EEM #	Energy Efficient Measures	Energy Use (MMBtu/yr)					Energy Use (Utility Units)			Energy Savings				Increased Marginal Cost (\$)	Increased New System Cost (\$)	Payback (yrs)	
		Cooling	Heating	DHW	Other	Total	kWh/yr	therms/yr	\$/yr	MMBtu/yr	%	kWh/yr	therms/yr				\$/yr
	Basecase	15.9	6.3	12.6	29.0	63.7	18,653	0	\$2,798								
	(% of Total)	25.0%	9.9%	19.8%	45.6%												
DHW System Measures																	
1	Tankless Electric Water Heater	15.9	6.3	11.7	29.0	62.7	18,370	0	\$2,756	1.0	1.5%	283	0	\$42	\$700 - \$1,400		16.5 - 33.0
2	Solar DHW System	15.9	6.3	5.7	29.0	56.7	16,624	0	\$2,494	6.9	10.9%	2,029	0	\$304	\$2,900 - \$5,200		9.5 - 17.1
Air Distribution System Measures																	
4	HVAC Unit and Ducts in Cond. Space	11.3	5.3	12.6	29.0	58.2	17,038	0	\$2,556	5.5	8.7%	1,615	0	\$242	\$1,000 - \$7,000		4.1 - 28.9
5	Improved Duct Sealing	13.5	5.6	12.6	29.0	60.6	17,762	0	\$2,664	3.0	4.8%	891	0	\$134		\$450 - \$650	3.4 - 4.9
Envelope and Fenestration Measures																	
6	Increased Air-tightness	15.4	5.7	12.6	28.9	62.5	18,321	0	\$2,748	1.1	1.8%	332	0	\$50		\$350 - \$1,500	7.0 - 30.1
7	Window Shading (4' Overhang)	13.0	7.2	12.6	28.6	61.3	17,965	0	\$2,695	2.3	3.7%	688	0	\$103		\$3,100 - \$3,500	30.0 - 33.9
8	Window Shading & Redistribution	12.7	6.7	12.6	28.5	60.5	17,714	0	\$2,657	3.2	5.0%	939	0	\$141		\$3,100 - \$3,500	22.0 - 24.8
9	Improved Window Performance	13.9	6.4	12.6	28.7	61.6	18,042	0	\$2,706	2.1	3.3%	611	0	\$92	\$800 - \$1,100		8.7 - 12.0
HVAC System Measures																	
12	SEER 15 AC/8.5 HSPF Heat Pump	13.8	5.8	12.6	29.0	61.1	17,895	0	\$2,684	2.6	4.1%	758	0	\$114	\$1,500 - \$2,400		13.2 - 21.1

4.1. Base Case Energy Use

Table 5 shows that the base case total annual energy consumption was 78.9 MMBtu for an electric/gas house. This includes: 20.2% for cooling, 11.9% for heating, 31.4% for domestic water heating and 36.8% for other end-uses (that includes 33.5% for lighting and equipment, and 3.3% for heating and cooling fans, pump and miscellaneous).

Table 6 shows that for an all-electric house, the base case total energy consumption was 63.7 MMBtu that includes: 25.0% for cooling, 9.9% for heating, 19.8% for domestic water heating and 45.6% for other end-uses (that includes 41.5% for lighting and equipment, and 4.1% for heating and cooling fans, pump and miscellaneous).

It is noted that due to the lower fuel efficiency of gas, space heating and domestic water heating energy use were a larger fraction of the total, and cooling energy use was a smaller fraction of the total in an electric/gas house compared to an all-electric house. This suggests that measures that reduce space heating and domestic water heating use would have a large impact on the total energy use in an electric/gas house, and the measures that reduce the cooling energy use would have a higher impact on the total energy use in an all-electric house.

4.2. Energy Savings from Various EEMs

Table 5 and Table 6 show that for both types of houses, the solar domestic hot water (DHW) system had the largest annual total energy savings of 15.2% in an electric/gas house, and 10.9% in an all-electric house. The tankless water heater resulted in a total energy savings of 9.3% in the electric/gas house. This includes a 5.5% savings due to elimination of the standing pilot light and the remainder is due to a significant increase in the EF from the base case, i.e., from 0.54 to 0.85.

Locating the HVAC unit and ducts in the conditioned space also resulted in a savings of 8.5% in an electric/gas house and 8.7% in an all-electric house. Improved duct sealing resulted in a 4.3% savings in an electric/gas house and 4.8% in an all-electric house.

Among the envelope measures, increased air-tightness resulted in a small total energy savings of 2.1% in an electric/gas house and 1.8% in an all-electric house. Fenestration measures were found more effective in an all-electric house than in an electric/gas house because the cooling energy savings from these measures were offset by the heating energy penalty, and the heating energy penalty was more pronounced in the electric/gas house due to lower heating fuel efficiency.

The addition of overhangs was more effective with a greater percentage of windows on the south and a lesser percentage of windows on the east and west. With the window redistribution, the total energy savings were 3.6% in an electric/gas house, and 5.0% in an all-electric house. Improved windows resulted in a total energy savings of 2.6% in an electric/gas house and 3.3% in an all-electric house.

The cooling energy use reduction due to SEER 13 air conditioner was more pronounced in an all-electric house (2.7% in an electric/gas house, and 3.3% in an all-electric house). The savings from a 0.93 AFUE furnace was 1.9% in an electric/gas house and less than 1% in an all-electric house using a 7.7 HSPF heat pump. However, the combined effect of heating and cooling system improvements was comparable (approx. 4 to 4.5%) in both types of houses.

4.3. Cost Effectiveness of Various EEMs

It should be noted that, due to the difference in the unit cost of electricity and gas, the energy cost savings for a measure are not always of the same order as the energy savings, and depends upon the fuel type associated with the end use affected from that measure. Measures that reduced electricity use for space cooling in both types of houses and heating in the all-electric house resulted in significant energy cost savings compared to the measures that reduced only gas use.

For example, Figure 3 and Figure 4 show that DHW system measures resulted in considerable energy savings in the electric/gas house but had small energy cost savings. Even the solar DHW system that resulted in the highest energy use reduction was not very effective in reducing the energy cost. This is because the cost savings from the significant reduction in gas use was offset by the increased cost of electricity use for operating the pump.

For an electric/gas house, moving the HVAC unit and ductwork to the conditioned space, window shading and redistribution showed a significant reduction in cooling electricity use, and, therefore, were very effective in reducing the overall energy cost.

For the all-electric house, moving the HVAC unit and ductwork to the conditioned space, the solar DHW system, and window shading and redistribution had high first costs (ranging from \$2,900 to \$5,200, \$1,000 to \$7,000, and \$3,100 to \$3,500, respectively), however, they resulted in the largest electricity savings, and, therefore, were the most effective in reducing the overall energy cost.

Furthermore, the cost-effectiveness of a measure depends upon the energy cost savings versus the cost of implementation. Simple payback for each measure was calculated for both types of houses. Figure 5 and Figure 6 show that most of the common measures had nearly equal payback periods for both type of houses, except for the solar DHW system, and increased air tightness that showed a longer payback period for an electric/gas house. The shortest payback periods were for the improved duct sealing (3 to 6 years) and improved window performance (8 to 12 years). Using a gas water heater without a standing pilot light was a cost-effective measure for an electric/gas house with a payback period of 4.7 to 14 years. On the other hand, the solar DHW system with a payback period of 9.5 to 17 years was a cost-effective measure for an all-electric house.

In summary, the most cost-effective measures were moving the HVAC unit and the ductwork to a conditioned space, which resulted in 8-9% energy savings, 9-11% energy cost savings, and a payback period ranged from 4-32 years for both type of houses, and improving duct sealing, which resulted in 4-5% energy savings and was the most cost-effective with a 3-6 year payback period.

4.4. 15% Above-Code Energy Savings

The results from individual measures were used to guide the selection of measures that would result in 15% above-code combined total energy savings. Another set of simulations was performed with the selected measures applied in combination, and the energy cost savings were calculated. Using the estimated first cost for the selected measures, the payback period for the combined application of measures was calculated. These steps were followed for different groups of measures that could result in 15% or more total energy savings above the 2001 IECC compliant base-case house with electric/gas systems and all-electric systems.

Figures 7 and 8 present the 15% above-code savings charts for an electric/gas house and an all-electric house, respectively, in Houston, Texas. Appendix A includes charts for other non-attainment and affected counties in Texas. In each figure, the first table summarizes the results obtained from individual measures in terms of annual energy savings and the estimated costs for each measure implemented individually. The second table summarizes the results obtained by implementing three combinations of measures to achieve 15% or more total energy savings, and includes: energy savings, energy cost savings, estimated cost, and payback period for each combination. Information regarding the ozone emissions for each of the combinations is also presented in terms of combined annual NO_x emission savings and combined ozone season period NO_x emission savings.

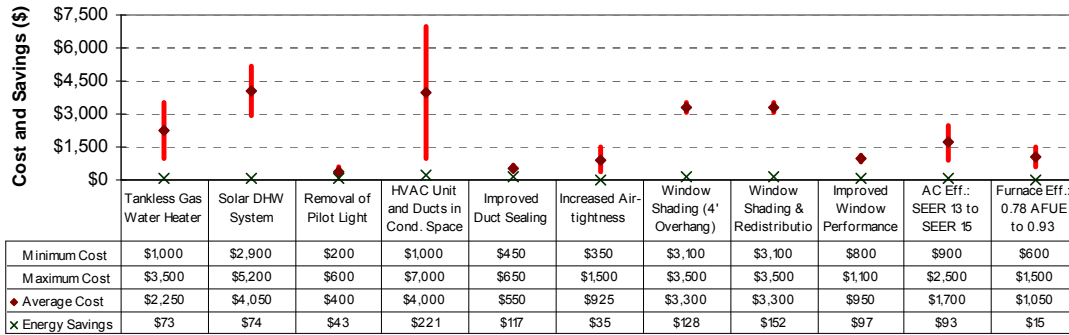


Figure 3. First Costs and Energy Cost Savings for Various EEMs for an Electric/Gas House.

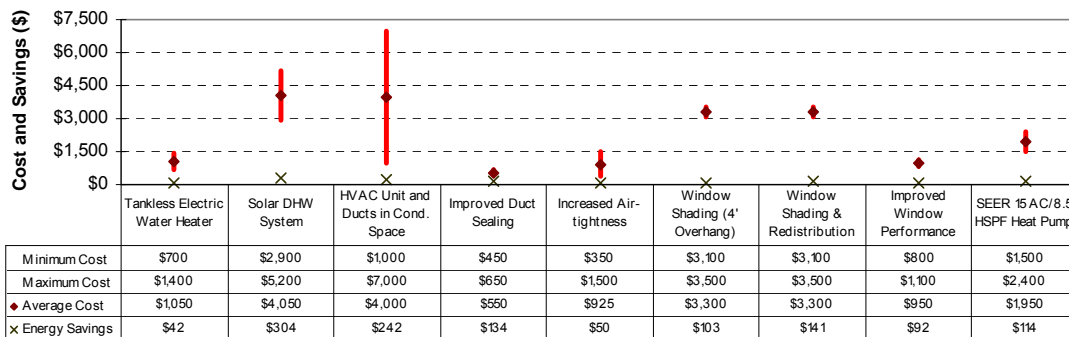


Figure 4. First Costs and Energy Cost Savings for Various EEMs for an All-electric House.

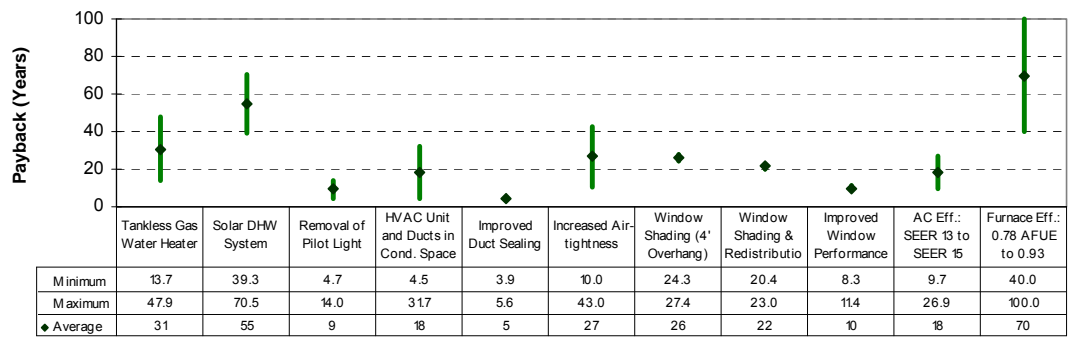


Figure 5. Payback Period for Various EEMs in an Electric/Gas House.

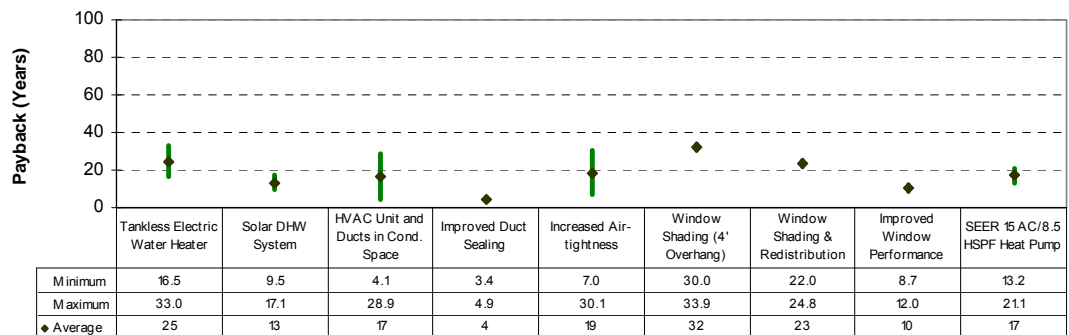


Figure 6. Payback Period for Various EEMs for an All-electric House.

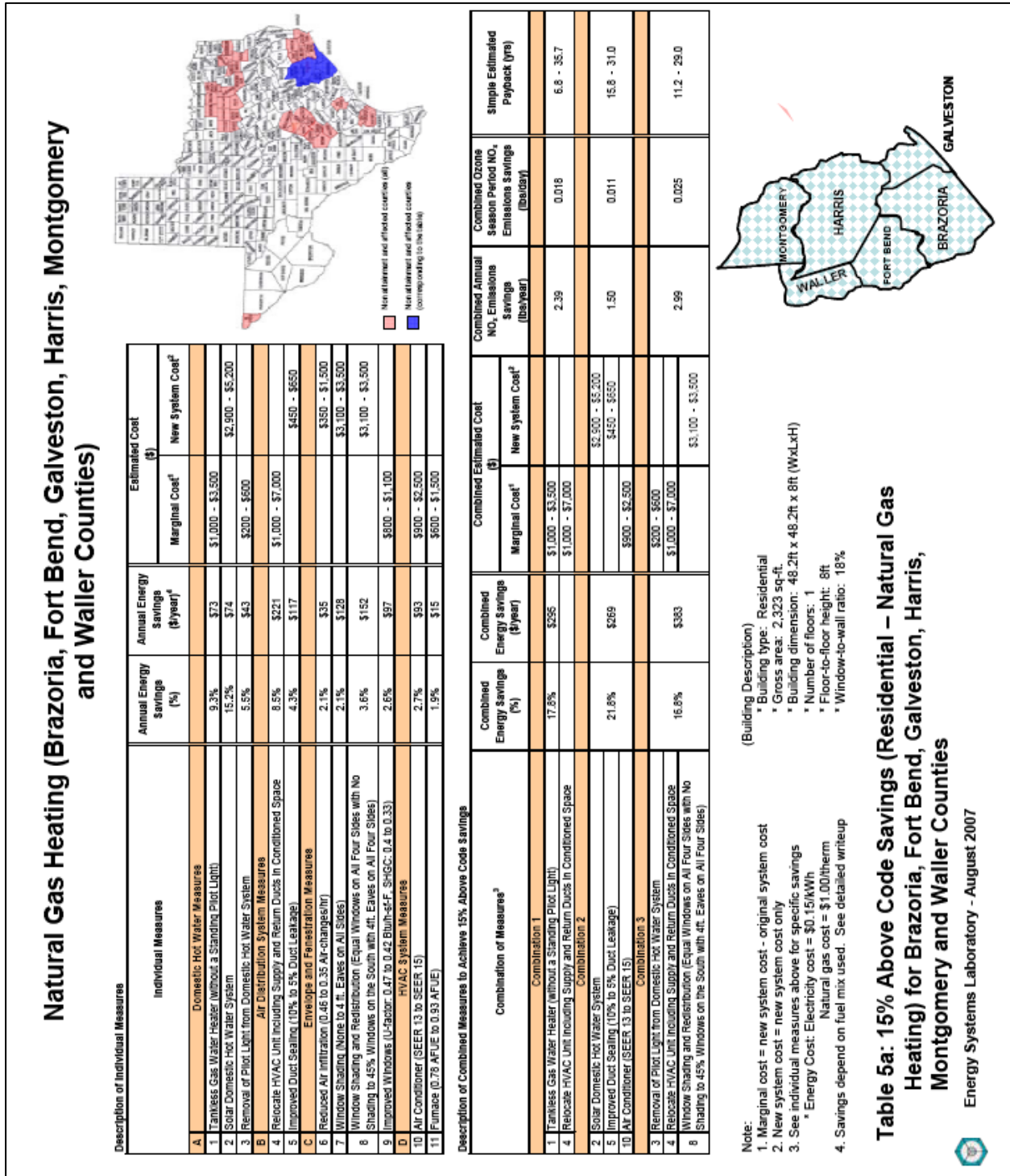


Figure 7. 15% Above-code Savings Chart for an Electric/Gas House in Houston, Texas.

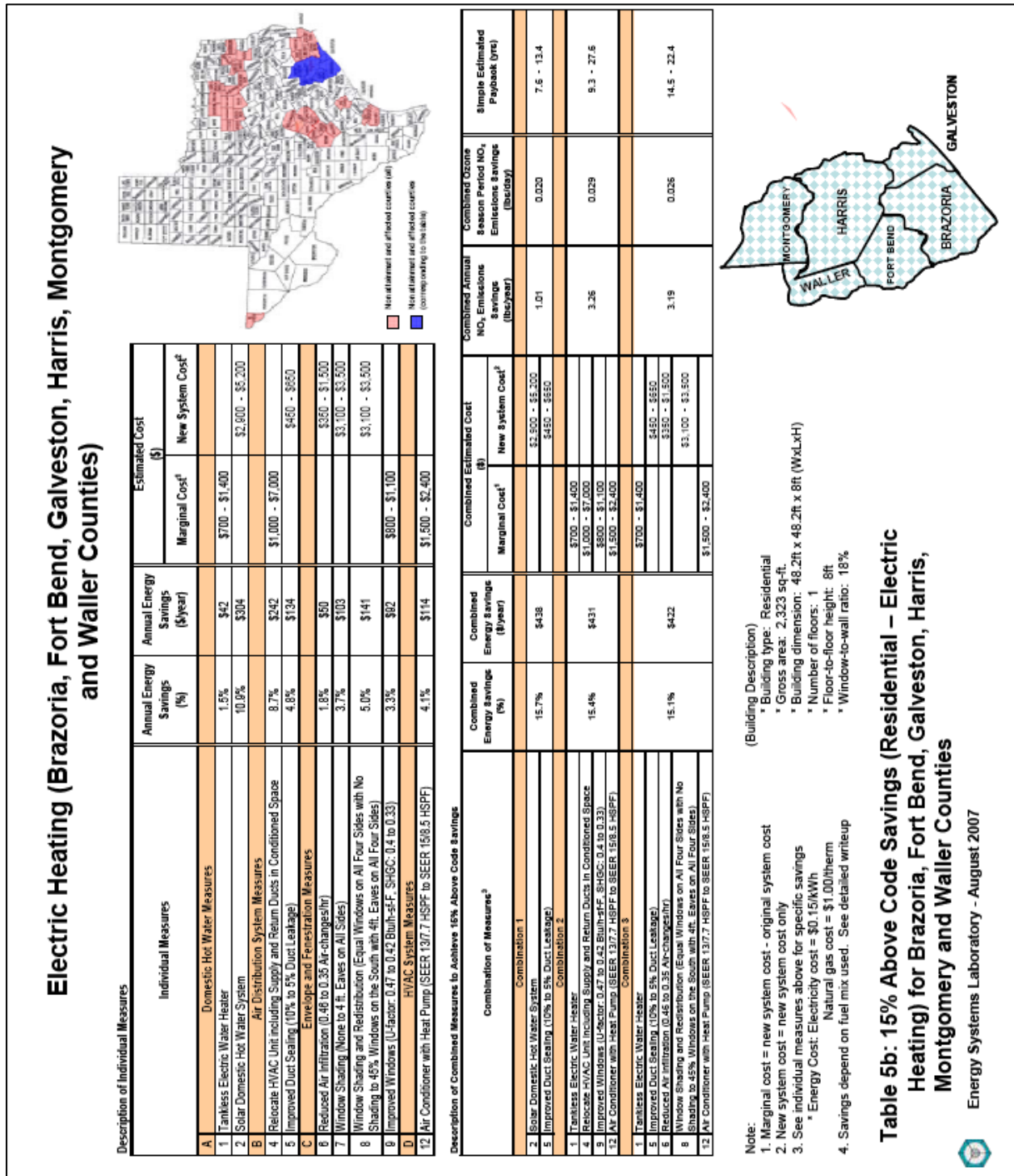


Figure 8. 15% Above-code Savings Chart for an All-electric House in Houston, Texas.

5. Description of Energy Efficiency Measures (EEMs)

This section includes a description of EEMs, their impact on the energy use, increased cost of implementation⁶, and calculations for simple payback. The energy use of the house with base-case characteristics and with the EEM is also plotted. This includes: (i) annual end-use energy use (MMBtu) obtained from the BEPS report, and (ii) monthly electricity use (kWh) and gas use (therm) obtained from PS-B report of the DOE-2 output.

5.1. Tankless Water Heater

Base Case: For an electric/gas house, the base-case, domestic hot water (DHW) system is a 40-gallon⁷, storage type, natural gas water heater with a standing pilot light that consumes 500 Btu/hr⁸, with a calculated energy factor (EF) of the system of 0.54⁹. For an all-electric house, the base-case DHW system is a 50-gallon⁷, storage type, electric water heater. The energy factor (EF) of the system is 0.869. The daily hot water use was calculated as 70 gallons/day¹⁰, which assumes that the house has four bedrooms. The hot water supply temperature is 120°F¹⁰.

The method to simulate DHW in DOE-2.1e using the energy factor is based on Building America House Performance Analysis Procedures (NREL 2001) that assumes a constant hourly DHW use and eliminates the efficiency dependence on part-loads.

EEM 1: For an electric/gas house, this measure was simulated by eliminating the standing pilot light, with a resultant change in the DHW Energy Factor (EF) from 0.54 to 0.85¹¹. For an all-electric house, this measure was simulated by increasing the DHW energy factor from 0.86 to 0.95¹¹.

Energy Savings: Figure 9 and Figure 10 compare the energy use of a house in Houston with base-case characteristics and with this measure.

Figure 9 shows that this measure applied to an electric/gas base-case house:

- Reduced the DHW energy use from 24.8 MMBtu/year to 17.4 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 71.6 MMBtu/year, i.e., 7.3 MMBtu/year or 9.3% total energy savings, and
- Reduced the gas use from 341 therm/year to 268 therm/year, i.e., 73 therm/year gas savings.

Figure 10 shows that this measure applied to an all-electric base-case house:

- Reduced the DHW energy use from 12.6 MMBtu/year to 11.7 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 62.7 MMBtu/year, i.e., 1.0 MMBtu/year or 1.5% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 18,370 kWh/year, i.e., 283 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-1 and is summarized in the following table. It shows that in an electric/gas house, installing a

⁶ The ranges of total implementation cost for some measures were modified according to the recommendations of stakeholders.

⁷ The size of the DHW tank are adopted from HUD-FHA minimum water heater capacities for a four bedroom 2.5 bath single family living unit (Table 4, p. 49.9, ASHRAE 2003).

⁸ This value is consistent with information provided by DHW manufacturers.

⁹ The EF of the DHW system was calculated from the minimum performance requirement using Table 504.2, p. 91 of the 2001 IECC.

¹⁰ This is specified in Section 402.1.3.7, p. 65 of the 2001 IECC.

¹¹ The EF for the tankless water heater is based on a survey of manufacturers.

tankless gas water heater would increase the cost by \$1,000 - \$3,500. Installing a tankless electric water heater in an all-electric house would increase the cost only by \$700 to \$1,400.

Table 7. Cost Information for Tankless Water Heating Systems.

DHW System Measures		Capacity	Equipment Cost (\$)	Installation Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-1)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	\$310-\$410 (Avg: \$360)	\$240		Table Water Heater-1 - No. 7, 8, 9, 10. Water Heater-2 - No. 3, 5.
EEM1	Tankless Gas Water Heater w/o pilot light	7.4 GPM	\$930-\$1,460	\$720-\$1,200	\$1,000-\$3,500*	Table Water Heater-1 - No. 1, 2, 3, 4, 5, 6.
HEAT PUMP/ELECTRIC DHW SYSTEM						
Base Case	Tanktype Elec. Water Heater	40/50 Gallon	\$270-\$385 (Avg: \$330)	\$240		Table Water Heater-1 - No. 17, 18. Water Heater-2 - No. 2.
EEM1	Tankless Elec. Water Heater	3.5-4.5 GPM	\$585-\$750	\$720-\$1,200	\$700-\$1,400	Table Water Heater-1 - No. 19, 20, 21, 22.

Payback Calculation:

(a) Electric/gas house:

$$\begin{aligned} \text{Gas cost savings} &= 73 \text{ therm} \times \$1/\text{therm} = \$73 \\ \text{Implementation cost} &= \$1,000 - \$3,500 \\ \text{Simple Payback} &= \underline{\mathbf{13.7 \text{ to } 47.9 \text{ years}}} \end{aligned}$$

(b) All-electric house:

$$\begin{aligned} \text{Electricity cost savings} &= 283 \text{ kWh} \times \$0.15/\text{kWh} = \$42 \\ \text{Implementation cost} &= \$700 - \$1,400 \\ \text{Simple Payback} &= \underline{\mathbf{16.5 \text{ to } 33.0 \text{ years}}} \end{aligned}$$

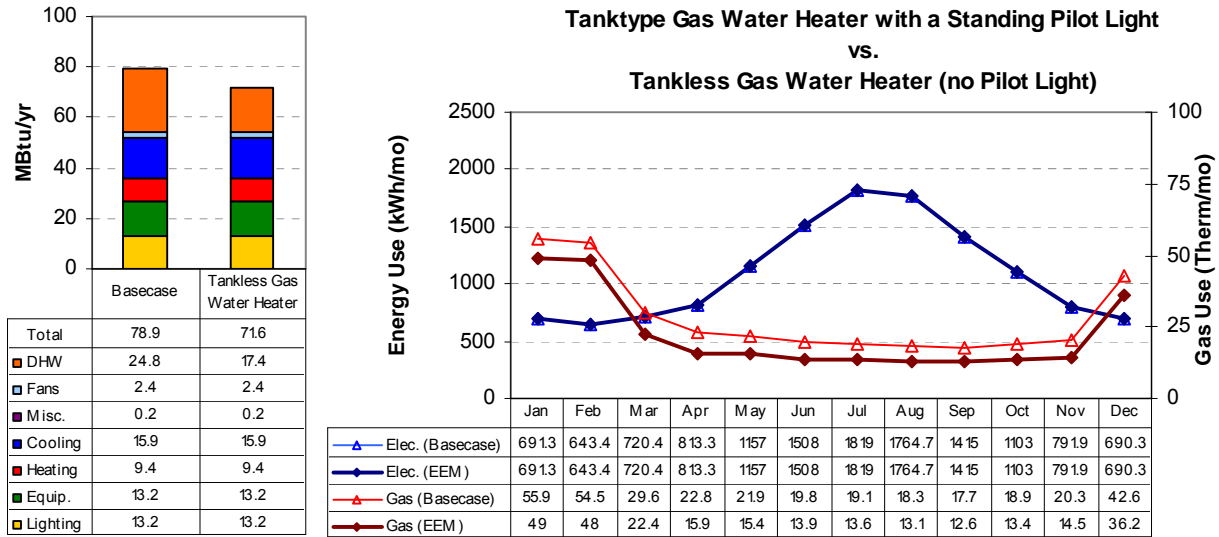


Figure 9. Energy Use Comparison for Base Case (tanktype gas water heater with a standing pilot light, EF = 0.544) and EEM (tankless gas water heater (no pilot light), EF = 0.85).

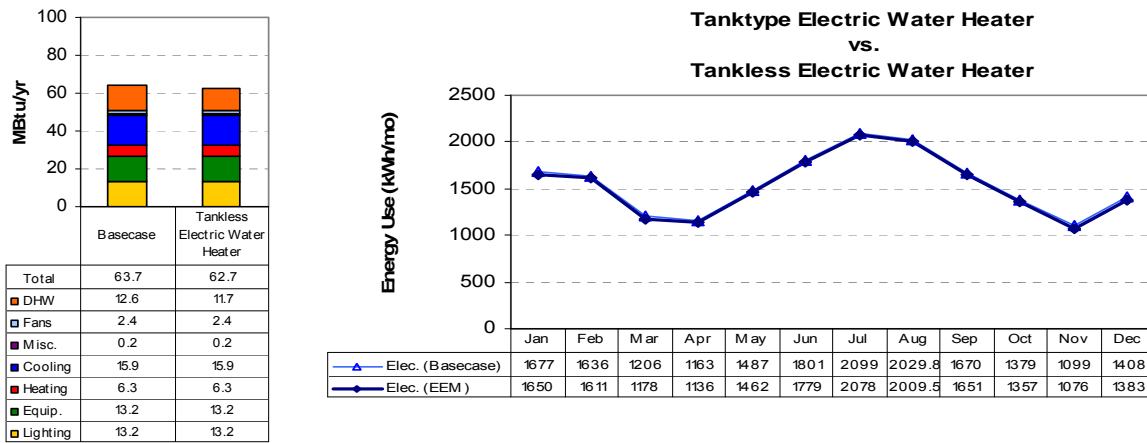


Figure 10. Energy Use Comparison for Base Case (tanktype electric water heater, EF = 0.864) and EEM (tankless electric water heater, EF = 0.95).

5.2. Solar Domestic Water Heating System

Base Case: For an electric/gas house, the base-case, domestic hot water (DHW) system is a 40-gallon, storage type, natural gas water heater with a standing pilot light that consumes 500 Btu/hr, with a calculated energy factor (EF) of the system of 0.54. For an all-electric house, the base-case DHW system is a 50-gallon, storage type, electric water heater. The energy factor (EF) of the system is 0.869. The daily hot water use was calculated as 70 gallons/day, which assumes that the house has four bedrooms. The hot water supply temperature is 120°F.

The method to simulate DHW in DOE-2.1e using the energy factor is based on Building America House Performance Analysis Procedures (NREL 2001) that assumes a constant hourly DHW use and eliminates the efficiency dependence on part-loads.

EEM 2: For this measure, a solar thermal DHW system, comprising of two 32 sq. ft. of flat plate solar collectors, was simulated using the F-Chart program (Klein and Beckman 1983). In this analysis, the collector tilt was assumed to be the same as the latitude for that location, considering a hot water use of 70 gallons/day, year around. Table 8 lists the characteristics of the solar thermal system for Houston. In this analysis, any supplementary hot water heating was provided by the base-case water heating system. Also, additional electricity use was taken into account for operating the pump.

Table 8. Solar DHW System Characteristics.

Number of collector panels	2
Collector panel area	32 sq. ft.
Collector slope	30 deg.
Collector azimuth (South=0)	0 deg.
Number of glazings	1
Collector flow rate/area	11 lb/hr-sq. ft.
Water set temperature	120°F
Daily hot water usage	70 gal.

Energy Savings: Figure 11 and Figure 12 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 11 shows that this measure applied to an electric/gas base-case house:

- Reduced the DHW energy use from 24.8 MMBtu/year to 12.6 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 66.9 MMBtu/year, i.e., 12.0 MMBtu/year or 15.2% total energy savings, and
- Reduced the gas use from 341 therm/year to 206 therm/year, i.e., 135 therm/year gas savings, and increased the electricity use from 13,115 kWh/year to 13,523 kWh/year for operating a solar pump, i.e., 408 kWh/year increase in electricity use.

Figure 12 shows that this measure applied to an all-electric base-case house:

- Reduced the DHW energy use from 12.6 MMBtu/year to 5.7 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 56.7 MMBtu/year, i.e., 6.9 MMBtu/year or 10.9% total energy savings, and

- Reduced the electricity use from 18,653 kWh/year to 16,624 kWh/year, i.e., 2,029 kWh/year electricity savings, which includes 408 kWh/year increased electricity use due to operating a solar pump.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-1, and is summarized in the following table. It shows that installing a solar DHW system would increase the cost by \$2,900 to \$5,200.

Table 9. Cost Information for Solar Domestic Hot Water Systems.

DHW System Measures		Capacity	Equipment Cost (\$)	Installation Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-1)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	\$310-\$410 (Avg: \$360)	\$240		Table Water Heater-1 - No. 7,8,9,10. Water Heater-2 - No. 3,5.
EEM2	Solar Water Heater	80 Gallon	\$3,300	\$2,500	\$2,900-\$5,200*	Table Solar Water Heater - No. 1, 2, 3
HEAT PUMP/ELECTRIC DHW SYSTEM						
Base Case	Tanktype Elec. Water Heater	40/50 Gallon	\$270-\$385 (Avg: \$330)	\$240		Table Water Heater-1 - No. 17,18. Water Heater-2 - No. 2.
EEM2	Solar Water Heater	80 Gallon	\$3,300	\$2,500	\$2,900-\$5,200*	Table Solar Water Heater - No. 1, 2, 3

Payback Calculation:

(a) Electric/gas house:

Gas cost savings	= 135 therm x \$1/therm = \$135
Electricity cost increase	= -408 kWh x \$0.15/kWh = -\$61
Net energy cost savings	= \$74
Implementation cost	= \$2,900 - \$5,200
Simple Payback	= <u>39.3 to 70.5 years</u>

(b) All-electric house:

Electricity cost savings	= 2,029 kWh x \$0.15/kWh = \$304
Implementation cost	= \$2,900 - \$5,200
Simple Payback	= <u>9.5 to 17.1 years</u>

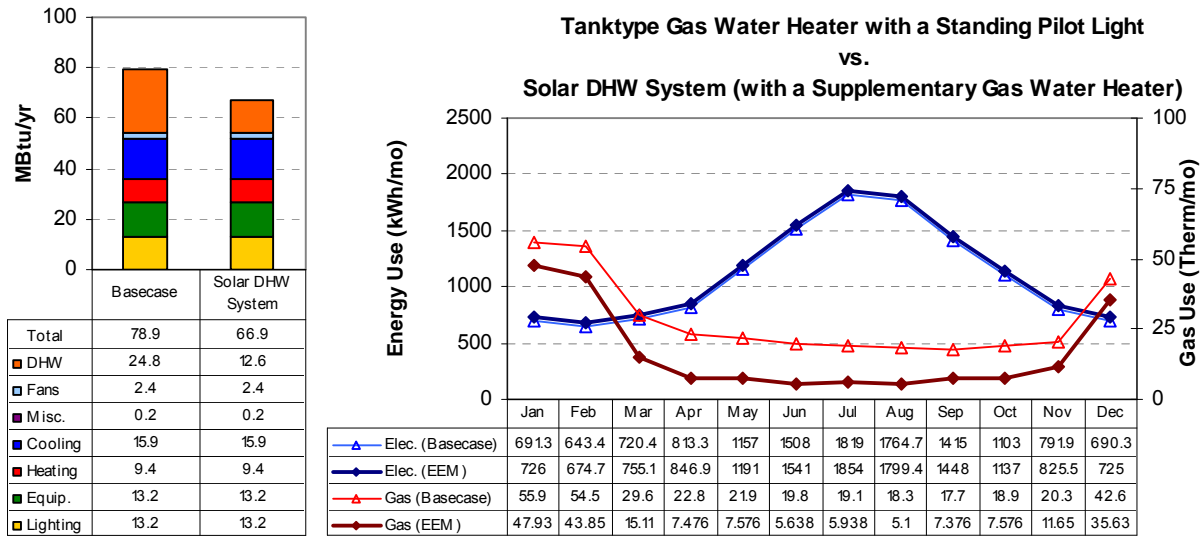


Figure 11. Energy Use Comparison for Base Case (tanktype gas water heater with a standing pilot light) and EEM (solar DHW system with a supplementary gas water heater).

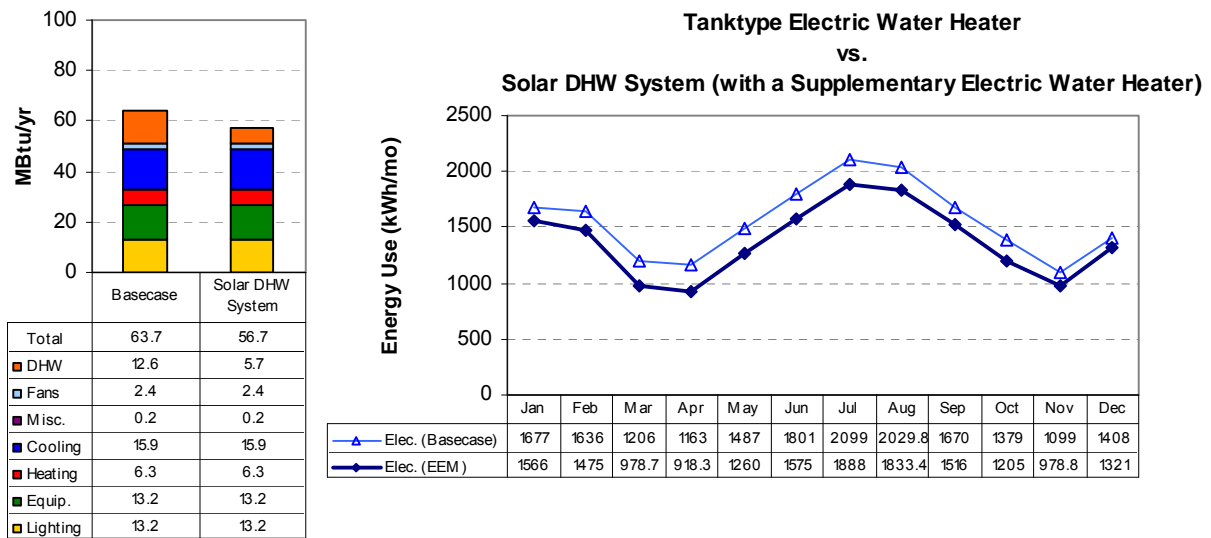


Figure 12. Energy Use Comparison for Base Case (tanktype electric water heater) and EEM (solar DHW system with a supplementary electric water heater).

5.3. Removal of Standing Pilot Light from Gas DHW System

Base Case: For an electric/gas house, the base-case, domestic hot water (DHW) system is a 40-gallon, storage type, natural gas water heater with a standing pilot light that consumes 500 Btu/hr, with a calculated energy factor (EF) of the system of 0.54. For an all-electric house, the base-case DHW system is a 50-gallon, storage type, electric water heater. The energy factor (EF) of the system is 0.869. The daily hot water use was calculated as 70 gallons/day, which assumes that the house has four bedrooms. The hot water supply temperature is 120°F.

The method to simulate DHW in DOE-2.1e using the energy factor is based on Building America House Performance Analysis Procedures (NREL 2001) that assumes a constant hourly DHW use and eliminates the efficiency dependence on part-loads.

EEM 3: This measure is applicable only for the electric/gas house that has a gas DHW heater with a standing pilot light. This analysis assumed the same DHW Energy Factor as the base-case house, with the removal of calculated hourly energy use equivalent to an average pilot light, i.e., 500 Btu/h.

Energy savings: Figure 13 compares the energy use of a house in Houston with base-case characteristics and with this measure. It shows that this measure applied to an electric/gas base-case house reduced:

- Reduced the DHW energy use from 24.8 MMBtu/year to 20.4 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 74.5 MMBtu/year, i.e., 4.3 MMBtu/year or 5.5% total energy savings, and
- Reduced the gas use from 341 therm/year to 298 therm/year, i.e., 43 therm/year gas savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-1, and is summarized in the following table. It shows that replacing a gas water heater with a standing pilot light with one without a standing pilot light would increase the cost by \$200 to \$600.

Table 10. Cost Information for Water Heaters without a Pilot Light.

DHW System Measures		Capacity	Equipment Cost (\$)	Installation Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-1)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	\$310-\$410 (Avg: \$360)	\$240		Table Water Heater-1 - No. 7,8,9,10. Water Heater-2 - No. 3,5.
EEM3	Tanktype Gas Water Heater w/o pilot light	40 Gallon	\$565-\$985	\$240	\$200-\$600	Table Water Heater-1 - No. 11,12,15,16

Payback Calculation:

Electric/gas house:

$$\begin{aligned}
 \text{Gas cost savings} &= 43 \text{ therm} \times \$1/\text{therm} = \$43 \\
 \text{Implementation cost} &= \$200 - \$600 \\
 \text{Simple Payback} &= \underline{\underline{4.7 \text{ to } 14.0 \text{ years}}}
 \end{aligned}$$

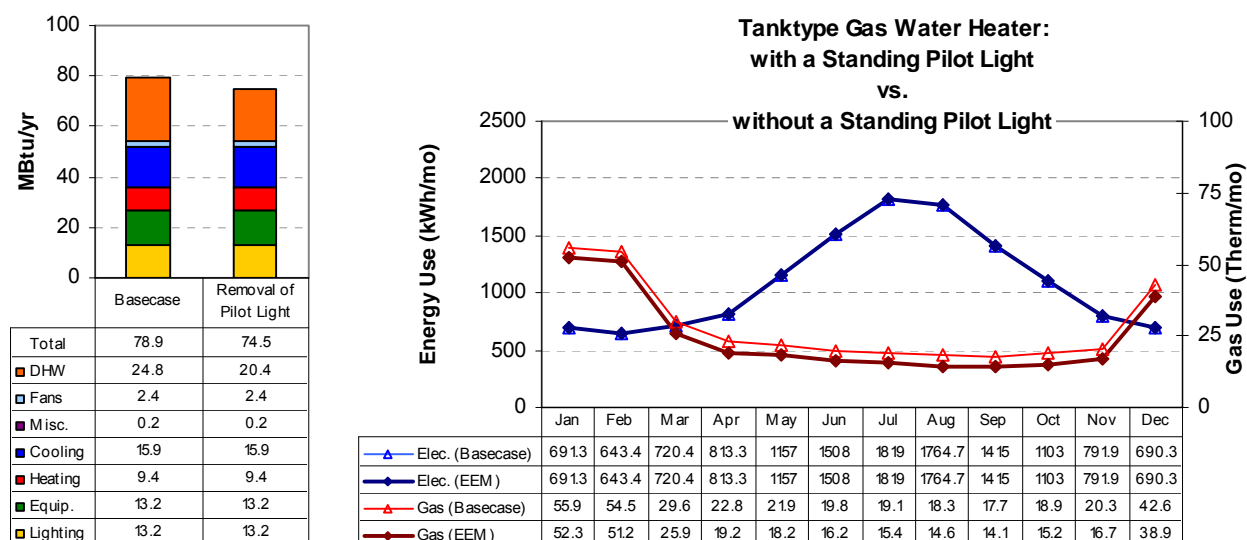


Figure 13. Energy Use Comparison for Base Case (tanktype gas water heater, with a standing pilot light, EF = 0.544,) and EEM (tanktype gas water heater, no pilot light, EF = 0.544).

5.4. HVAC Unit and Ducts in the Conditioned Space

Base Case: The base-case air distribution system, which includes the HVAC unit and the ducts, is located in the unconditioned, vented attic. The attic was assumed to have an air infiltration rate of 15 ACH¹². The insulation for supply and return ducts are R-8 and R-4, respectively¹³. A 10% duct leakage was assumed for the base-case house¹⁴.

EEM 4: This measure analyzed the energy savings that would occur if the HVAC system including the supply and return ductwork was moved from the attic location assumed in the base-case house to a location within the thermal envelope of the conditioned space.

Energy Savings: Figure 14 and Figure 15 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 14 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 11.3 MMBtu/year,
- Reduced the heating energy use from 9.4 MMBtu/year to 7.2 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 72.2 MMBtu/year, i.e., 6.7 MMBtu/year or 8.5% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 11,785 kWh/year, i.e., 1,330 kWh/year electricity savings,
- Reduced the gas use from 341 therm/year to 320 therm/year, i.e., 21 therm/year gas savings.

Figure 15 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 11.3 MMBtu/year,

¹² This infiltration rate was chosen to match measured data by Kim (2006).

¹³ This requirement can be found in Table 503.3.3.3 (ICC 2001)

¹⁴ This is based on the information found in Parker et al. (1993).

- Reduced the heating energy use from 6.3 MMBtu/year to 5.3 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 58.2 MMBtu/year, i.e., 5.5 MMBtu/year or 8.7% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 17,038 kWh/year, i.e., 1,615 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-2 and summarized in the following table. It shows that locating duct in the conditioned space would increase the cost by \$1,000 to \$7,000.

Table 11. Cost Information for Relocation of Ductwork from Attic to Conditioned Space.

Air Distribution System Measures			Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-2)
Base Case	Duct in unconditioned space	2,325 sq. ft. conditioned floor area	\$0.20/ft.	\$1,000-\$7,000*	Table Duct-3 - No. 1, 2, 3.
EEM4	Duct in conditioned space				

Payback Calculation:

(a) Electric/gas house:

Electricity cost savings	= 1,330 kWh/year x 0.15/kWh = \$200/year
Gas cost savings	= 21 therm/year x \$1/therm = \$21/year
Total energy cost savings	= \$221
Implementation cost	= \$1,000-\$7,000
Simple Payback	= <u>4.5 to 31.7 years</u>

(b) All-electric house:

Electricity cost savings	= 1,615 kWh/year x \$0.15/kWh = \$242/year
Implementation cost	= \$1,000-\$7,000
Simple Payback	= <u>4.1 to 28.9 years</u>

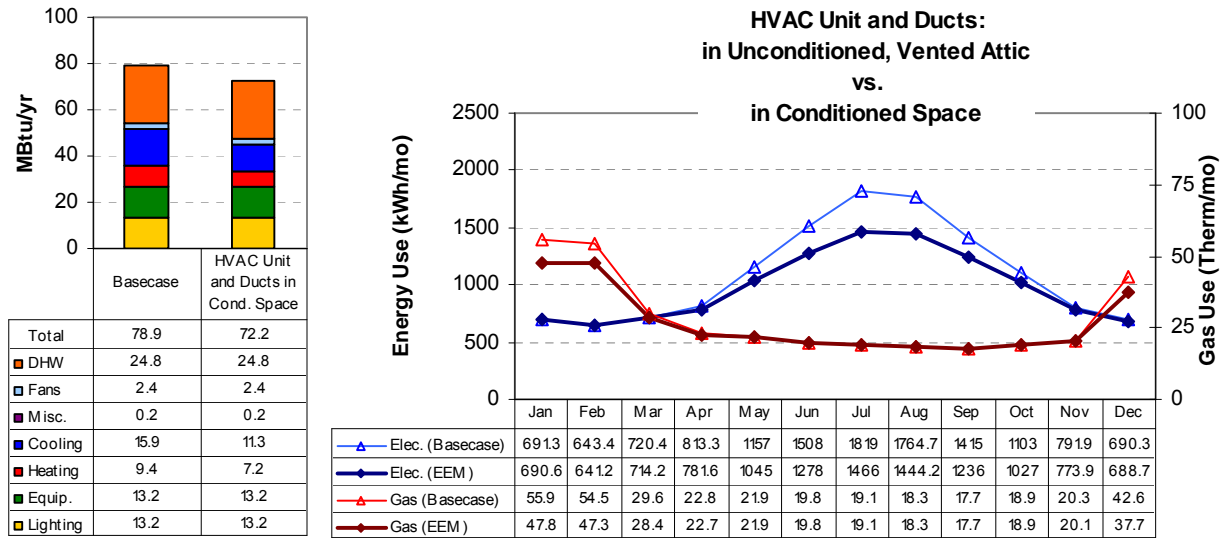


Figure 14. Energy Use Comparison for Base Case (HVAC unit and ducts in unconditioned, vented attic) and EEM (HVAC unit and ducts in conditioned space) in an Electric/Gas House.

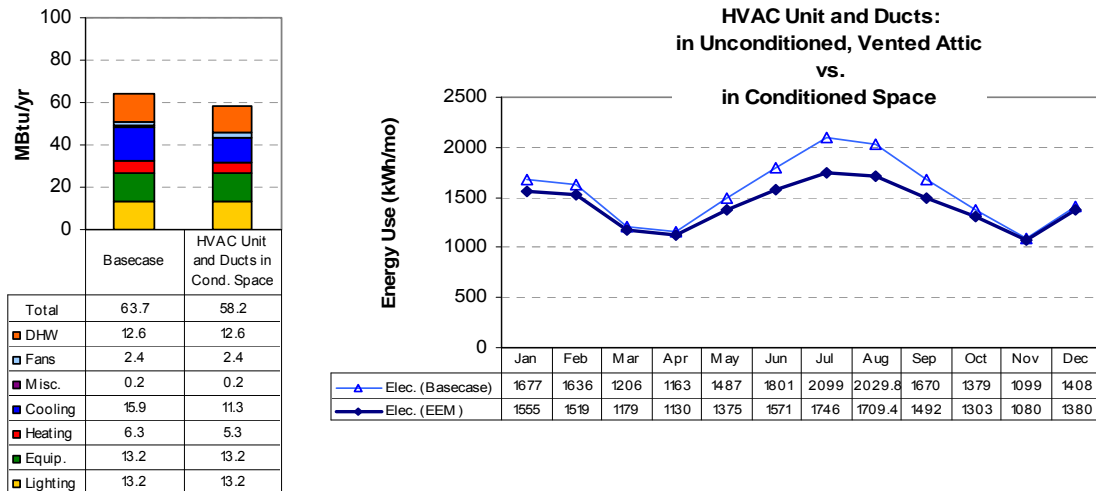


Figure 15. Energy Use Comparison for Base Case (HVAC unit and ducts in unconditioned, vented attic) and EEM (HVAC unit and ducts in conditioned space) in an All-electric House.

5.5. Improved Duct Sealing

(From 10% Duct Leakage to 5% Duct leakage)

Base Case: The base-case air distribution system, which includes the HVAC unit and the ducts, is located in the unconditioned, vented attic. The attic was assumed to have an air infiltration rate of 15 ACH. The insulation for supply and return ducts are R-8 and R-4, respectively. A 10% duct leakage was assumed for the base-case house.

EEM 5: This measure was simulated by changing the 10% duct leakage of the base-case house to a 5% duct leakage. In this analysis it was assumed that the ducts remained in the attic and that the improved duct sealing was accomplished with foil-backed butyl tape and mastic to seal the duct leaks.

Energy Savings: Figure 16 and Figure 17 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 16 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.5 MMBtu/year,
- Reduced the heating energy use from 9.4 MMBtu/year to 8.4 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 75.5 MMBtu/year, i.e., 3.4 MMBtu/year or 4.3% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,403 kWh/year, i.e., 712 kWh/year electricity savings,
- Reduced the gas use from 341 therm/year to 331 therm/year, i.e., 10 therm/year gas savings.

Figure 17 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.5 MMBtu/year,
- Reduced the heating energy use from 6.3 MMBtu/year to 5.6 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 60.6 MMBtu/year, i.e., 3 MMBtu/year or 4.8% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 17,762 kWh/year, i.e., 891 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-2, and is summarized in the following table. It shows that improved duct sealing would increase the cost by \$450 to \$650.

Table 12. Cost Information for Methods Implemented to Minimize Duct Leakage.

Air Distribution System Measures			Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-2)
Base Case	9% duct leakage	628 sq. ft. supply and 117 sq. ft. return duct area	\$110 (material) + \$330 (installation)	\$450-\$650*	Table Duct-2 - No. 1, 2.
EEM5	0% duct leakage				

Payback Calculation:

(a) Electric/gas house:

$$\begin{aligned}
 \text{Electricity cost savings} &= 712 \text{ kWh/year} \times 0.15/\text{kWh} = \$107/\text{year} \\
 \text{Gas cost savings} &= 10 \text{ therm/year} \times \$1/\text{therm} = \$10/\text{year} \\
 \text{Total energy cost savings} &= \$117
 \end{aligned}$$

Implementation cost = \$450 - \$650
 Simple Payback = **3.9 to 5.6 years**

(b) All-electric house:
 Electricity cost savings = 891 kWh/year x \$0.15/kWh = \$134/year
 Implementation cost = \$450 - \$650
 Simple Payback = **3.4 to 4.9 years**

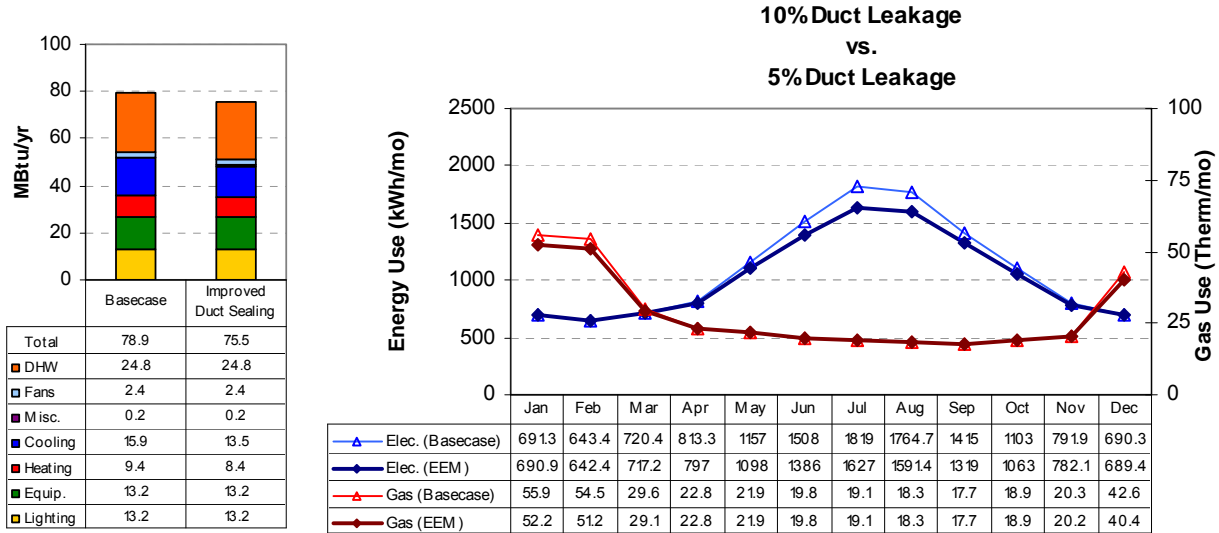


Figure 16. Energy Use Comparison for Base Case (10% duct leakage) and EEM (5% duct leakage) in an Electric/Gas House.

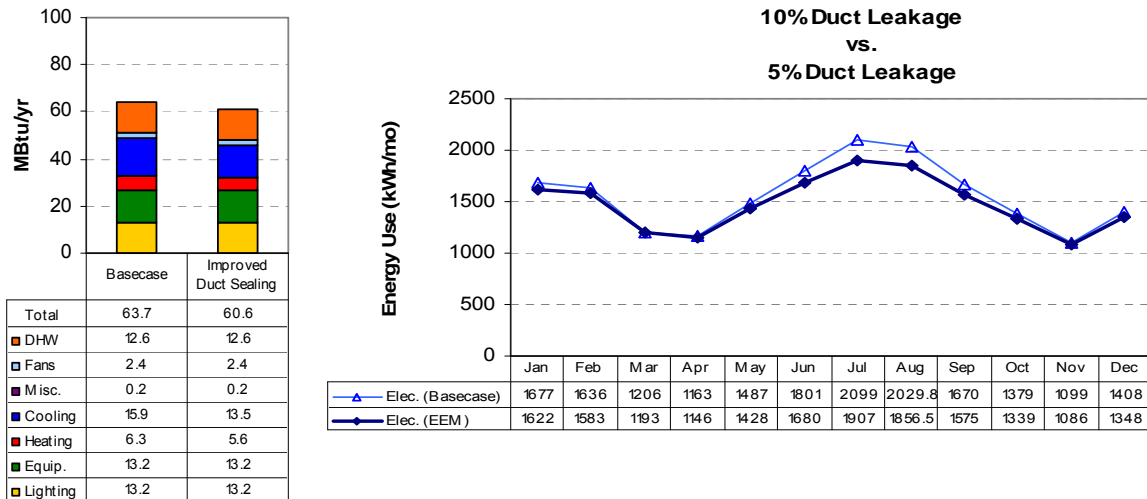


Figure 17. Energy Use Comparison for Base Case (10% duct leakage) and EEM (5% duct leakage) in an All-electric House.

5.6. Increased Air-tightness

(Infiltration rate reduced from 0.46 Air-changes/hr to 0.35 Air-changes/hr)

Base case: The base-case building is assumed to have lightweight wood frame construction with 2x4 foot studs spaced at 16" on center, a slab-on-grade floor and an unconditioned, vented attic. The air infiltration rate was 0.47 ACH for Houston¹⁵, which is based on the weather factor specified in ASHRAE Standard 136 (ASHRAE 1993)¹⁶.

EEM 6: This measure was simulated by specifying a fixed infiltration rate of 0.35 ACH (compared to 0.47 ACH for the base case), which is the minimum ventilation rate required by ASHRAE Standard 62 (ASHRAE 2001).

Energy Savings: Figure 18 and Figure 19 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 18 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 15.4 MMBtu/year,
- Reduced the heating energy use from 9.4 MMBtu/year to 8.3 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2.3 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 77.2 MMBtu/year, i.e., 1.7 MMBtu/year or 2.1% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,956 kWh/year, i.e., 159 kWh/year electricity savings,
- Reduced the gas use from 341 therm/year to 330 therm/year, i.e., 11 therm/year gas savings.

Figure 19 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 15.4 MMBtu/year,
- Reduced the heating energy use from 6.3 MMBtu/year to 5.7 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2.3 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 62.5 MMBtu/year, i.e., 1.1 MMBtu/year or 1.8% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 18,321 kWh/year, i.e., 332 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-3, and is summarized in the following table. It shows that increased air tightness would increase the cost by \$350 to \$1,500.

Table 13. Cost Information for Improving Air Tightness of the Building.

Envelope and Fenestration Measures		Dimensions/Quantity	Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-3)
Base Case	Infiltration Rate: 0.462 ACH	2325 sq. ft. conditioned floor area	\$150-\$500 (material) + \$200-\$500 (blower door test)	\$350-\$1,500*	-
EEM6	Increased Air Tightness- infiltration Rate: 0.35 ACH				Table Increased Air-tightness - No. 1, 2.

¹⁵ The air infiltration rate for different locations ranged from 0.43 ACH to 0.94 ACH.

¹⁶ This requirement can be found in Section 402.1.3.10, p. 65.

Payback Calculation:

(a) Electric/gas house:

Electricity cost savings	= 159 kWh/year x 0.15/kWh = \$24/year
Gas cost savings	= 11 therm/year x \$1/therm = \$11/year
Total energy cost savings	= \$35
Implementation cost	= \$350 - \$1,500
Simple Payback	= <u>10.0 to 43.0 years</u>

(b) All-electric house:

Electricity cost savings	= 332 kWh/year x \$0.15/kWh = \$50/year
Implementation cost	= \$350 - \$1,500
Simple Payback	= <u>7.0 to 30.1 years</u>

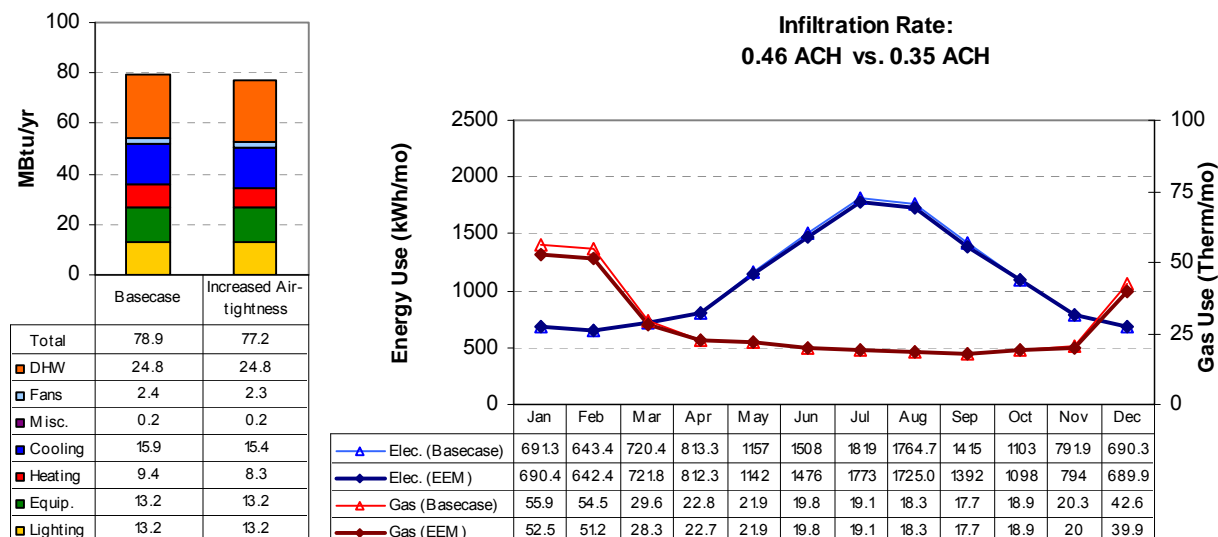


Figure 18. Energy Use Comparison for Base Case (infiltration rate = 0.46 ACH) and EEM (infiltration rate = 0.35 ACH) in an Electric/Gas House.

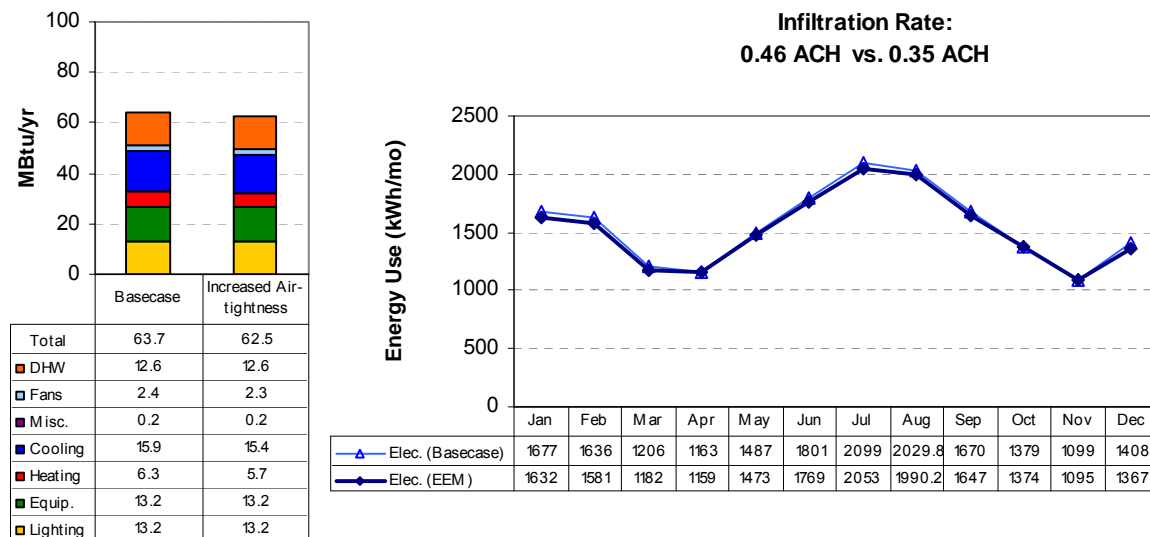


Figure 19. Energy Use Comparison for Base Case (infiltration rate = 0.46 ACH) and EEM (infiltration rate = 0.35 ACH) in an All-electric House.

5.7. Window Shading

(From no shading to 4 ft. roof overhangs on all sides)

Base-Case Windows: The base-case house has a window area equal to 18% of the floor area distributed equally on all four sides with no exterior shading¹⁷. Based on the climate-specific characteristics for the standard design, the base-case house was modeled with 0.47 Btu/h-sq. ft.-°F fenestration system U-factor and 0.40 fenestration system solar heat gain coefficient (SHGC)¹⁸. The fenestration characteristics were simulated by creating custom windows with double pane, low-e glazing and aluminum frames with thermal break, using the WINDOW5 program¹⁹.

EEM 7: This measure was simulated by modeling 4 ft. roof overhangs on all four sides. The gross window area, orientation, and other characteristics were kept the same as the base-case house, which did not have overhangs. The depth of overhangs was determined from the recommendations by Malhotra and Haberl (2006). However, the overhang depth on all sides is not optimized for construction cost.

Energy savings: Figure 20 and Figure 21 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 20 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.0 MMBtu/year,
- Increased the heating energy use from 9.4 MMBtu/year to 11.0 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 77.2 MMBtu/year, i.e., 1.7 MMBtu/year or 2.1% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,150 kWh/year, i.e., 965 kWh/year electricity savings,
- Increased the gas use from 341 therm/year to 358 kWh/year, i.e., 17 therm/year increased gas use.

Figure 21 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.0 MMBtu/year,
- Increased the heating energy use from 6.3 MMBtu/year to 7.2 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 61.3 MMBtu/year, i.e., 2.3 MMBtu/year or 3.7% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 17,965 kWh/year, i.e., 688 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-3, and is summarized in the following table. It shows that adding 4 ft. roof overhangs would increase the cost by \$3,100 to \$3,500.

¹⁷ These requirements are specified in Section 402.1.1, p. 63, and Section 402.1.3.1.1 and 402.1.3.1.3, p. 64, of the 2001 IECC.

¹⁸ These requirements are specified in Table 402.1.1 (2), p. 63 and Section 402.1.3.1.4, p. 64. (The fenestration system U-factor is 0.47 Btu/h-ft²-°F for all the counties analyzed (0.44 Btu/h-ft²-°F for El Paso). The fenestration system SHGC for all climates analyzed is 0.40.)

¹⁹ More information on the Window 5 program can be found at <http://windows.lbl.gov/software/window/window.html>.

Table 14. Cost Information for Providing Roof Eaves.

Envelope and Fenestration Measures		Dimensions/Quantity	Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-3)
Base Case	No Window Shading	193 ft. perimeter	\$16-\$23/linear foot	\$3,100-\$3,500	Table Shading-1 - No. 1, 2, 3, 4, Table Shading-2 -No. 1
EEM7 and EEM8	4' Eaves		\$34-\$39/linear foot		Table Shading-1 - No. 4, Table Shading-2 -No. 2

Payback Calculation:

(a) Electric/gas house:

Electricity cost savings	= 965 kWh/year x 0.15/kWh = \$145/year
Gas cost increase	= -17 therm/year x \$1/therm = -\$17/year
Total energy cost savings	= \$128
Implementation cost	= \$3,100 - \$3,500
Simple Payback	= <u>24.3 to 27.4 years</u>

(b) All-electric house:

Electricity cost savings	= 688 kWh/year x \$0.15/kWh = \$103/year
Implementation cost	= \$3,100 - \$3,500
Simple Payback	= <u>30.0 to 33.9 years</u>

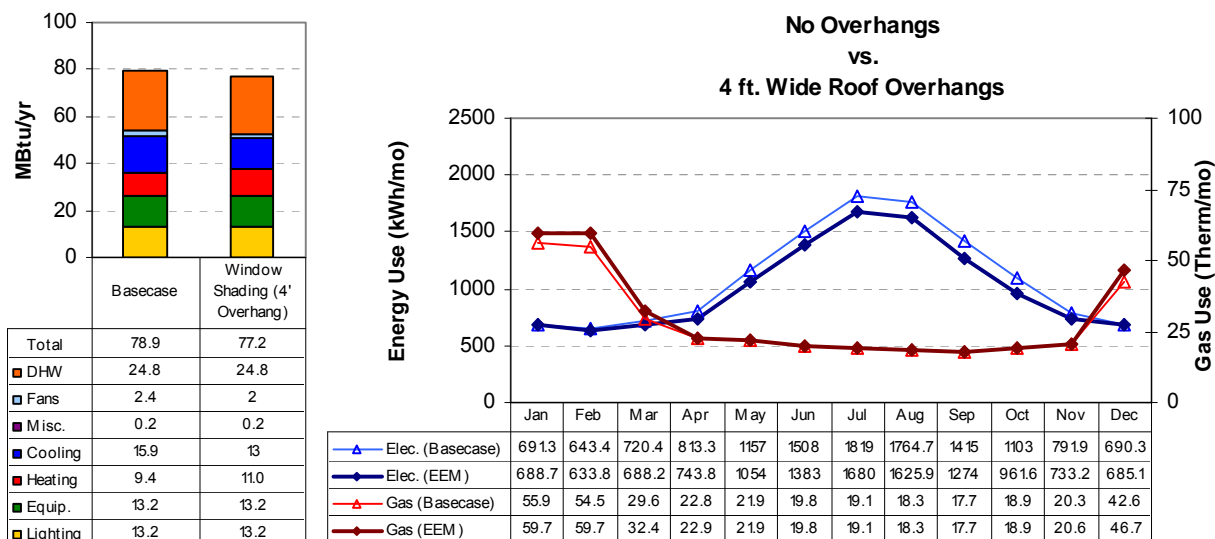


Figure 20. Energy Use Comparison for Base Case (no shading) and EEM (4 ft. wide roof overhangs) in an Electric/Gas House.

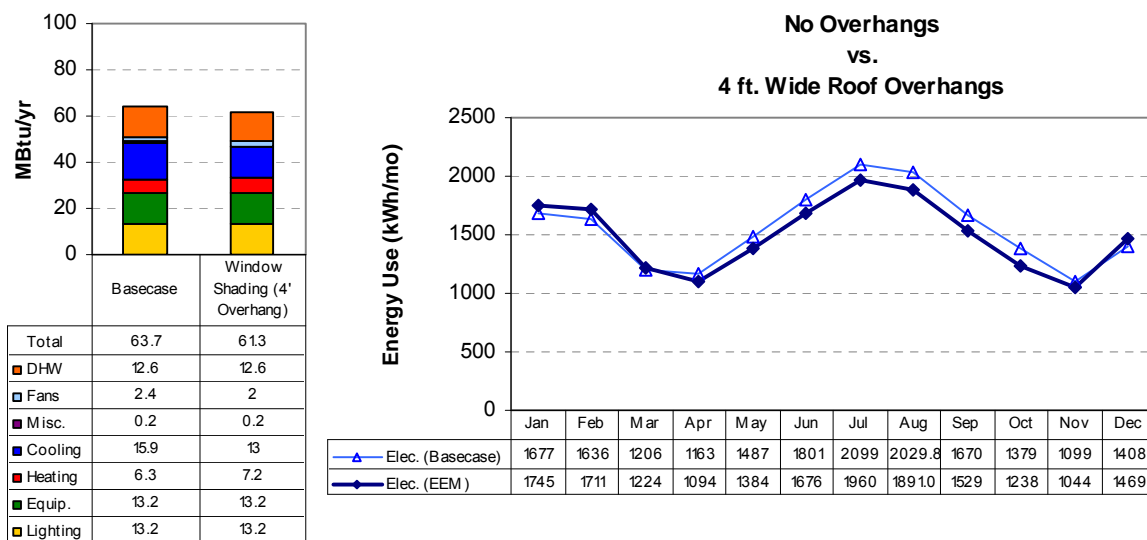


Figure 21. Energy Use Comparison for Base Case (no shading) and EEM (4 ft. wide roof overhangs) in an All-electric House.

5.8. Window Shading and Redistribution

(From equal windows on all sides and no shading to 45% windows on the South with 4 ft. roof overhangs on all sides)

Base-case Windows: The base-case house has a window area equal to 18% of the floor area distributed equally on all four sides with no exterior shading. Based on the climate-specific characteristics for the standard design, the base-case house was modeled with 0.47 Btu/h-sq. ft.-°F fenestration system U-factor and 0.40 fenestration system solar heat gain coefficient (SHGC). The fenestration characteristics were simulated by creating custom windows with double pane, low-e glazing and aluminum frames with thermal break, using the WINDOW5 program.

EEM 8: For this measure, the house was simulated with the same window area as the base-case house (i.e., an 18% window-to-wall area distributed 25% on each orientation) with the windows distributed 45% on the south, 25% on the north, 15% each on east and west orientations. A 4 ft. roof overhang was also included on all four sides.

Energy Savings: Figure 22 and Figure 23 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 22 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 12.7 MMBtu/year,
- Increased the heating energy use from 9.4 MMBtu/year to 10.2 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 1.9 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 76 MMBtu/year, i.e., 2.8 MMBtu/year or 3.6% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,047 kWh/year, i.e., 1,068 kWh/year electricity savings,
- Increased the gas use from 341 therm/year to 349 therm/year, i.e., 8 therm/year increased gas use.

Figure 23 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 12.7 MMBtu/year,
- Increased the heating energy use from 6.3 MMBtu/year to 6.7 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 1.9 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 60.5 MMBtu/year, i.e., 3.2 MMBtu/year or 5.0% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 17,714 kWh/year, i.e., 939 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-3, and is summarized in the following table. It shows that adding 4-foot roof overhangs would increase the cost by \$3,100 to \$3,500. However, considering window redistribution in a new construction would have no increased cost.

Table 15. Cost Information for Providing Roof Eaves.

Envelope and Fenestration Measures		Dimensions/Quantity	Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-3)
Base Case	No Window Shading	193 ft. perimeter	\$16-\$23/linear foot	\$3,100-\$3,500	Table Shading-1 - No. 1, 2, 3, 4, Table Shading-2 -No. 1
EEM7 and EEM8	4' Eaves		\$34-\$39/linear foot		Table Shading-1 - No. 4, Table Shading-2 -No. 2

Payback Calculation:

(a) Electric/gas house:

Electricity cost savings	= 1,068 kWh/year x 0.15/kWh = \$160/year
Gas cost increase	= 8 therm/year x \$1/therm = -\$8/year
Total energy cost savings	= \$1502
Implementation cost	= \$3,100 - \$3,500
Simple Payback	= <u>20.4 to 23.0 years</u>

(b) All-electric house:

Electricity cost savings	= 939 kWh/year x \$0.15/kWh = \$141/year
Implementation cost	= \$3,100 - \$3,500
Simple Payback	= <u>22 to 24.8 years</u>

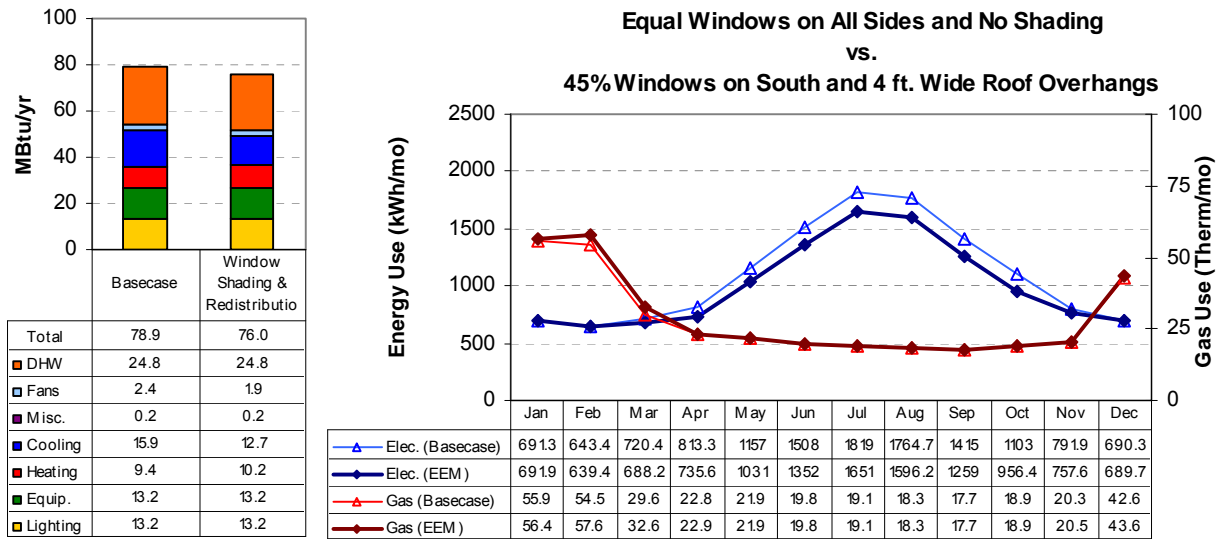


Figure 22. Energy Use Comparison for Base Case (equal windows on all four sides and no shading) and EEM (45% windows on the south and 4 ft. wide roof overhangs) in an Electric/Gas House.

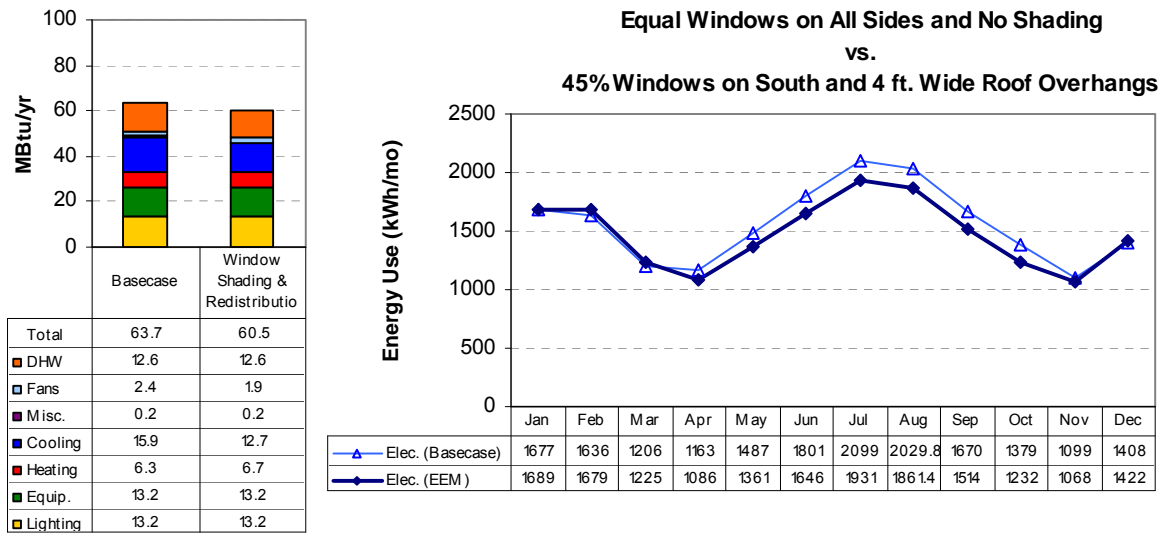


Figure 23. Energy Use Comparison for Base Case (equal windows on all four sides and no shading) and EEM (45% windows on the south and 4 ft. wide roof overhangs) in an All-electric House.

5.9. Improved Window Performance

(From 0.47 U-factor and 0.40 SHGC to 0.42 U-factor and 0.33 SHGC)

Base-case Windows: The base-case house has a window area equal to 18% of the floor area distributed equally on all four sides with no exterior shading. Based on the climate-specific characteristics for the standard design, the base-case house was modeled with 0.47 Btu/h-sq. ft.-°F fenestration system U-factor and 0.40 fenestration system solar heat gain coefficient (SHGC). The fenestration characteristics were simulated by creating custom windows with double pane, low-e glazing and aluminum frames with thermal break, using the WINDOW5 program.

EEM 9: For this measure, the base-case house was simulated with custom windows that were argon-filled, double-pane, low-e glazing with a 0.42 Btu/h-sq. ft.-°F fenestration system U-factor, and a 0.33 SHGC. The frame type remained the same as the base-case house.

Energy Savings: Figure 24 and Figure 25 compare the energy use of a house in Houston with base-case characteristics and with this measure. Figure 24 shows that this measure applied to an electric/gas base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.9 MMBtu/year,
- Increased the heating energy use from 9.4 MMBtu/year to 9.5 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2.1 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 76.8 MMBtu/year, i.e., 2.1 MMBtu/year or 2.6% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,458 kWh/year, i.e., 657 kWh/year electricity savings,
- Increased the gas use from 341 therm/year to 343 therm/year, i.e., 2 therm/year increased gas use.

Figure 25 shows that this measure applied to an all-electric base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.9 MMBtu/year,
- Increased the heating energy use from 6.3 MMBtu/year to 6.4 MMBtu/year,
- Reduced the fan energy use from 2.4 MMBtu/year to 2.1 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 61.6 MMBtu/year, i.e., 2.1 MMBtu/year or 3.3% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 18,042 kWh/year, i.e., 611 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-3, and is summarized in the following table. It shows that replacing the base-case windows with improved windows would increase the cost by \$800 to \$1,100.

Table 16. Cost Information for High-performance Windows.

Envelope and Fenestration Measures		Dimensions/Quantity	Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-3)
Base Case	Air Filled, Double Pane, Aluminum Frame	No. of (36"x60") windows: 27	\$96-\$112 per window	\$800-\$1,100*	Table Windows-Summary- No. 2, 4.
EEM9	Argon Filled Glazing and Vinyl Frame		\$170-\$210 per window		Table Windows-Summary- No. 1, 3.

Payback Calculation:

(a) Electric/gas house:

$$\begin{aligned}
 \text{Electricity cost savings} &= 657 \text{ kWh} \times \$0.15/\text{kWh} = \$99 \\
 \text{Gas cost increase} &= -2 \text{ therm} \times \$1/\text{therm} = -\$2 \\
 \text{Total energy cost savings} &= \$97 \\
 \text{Implementation cost} &= \$800 - \$1,100 \\
 \text{Simple Payback} &= \underline{\mathbf{8.3 \text{ to } 11.4 \text{ years}}}
 \end{aligned}$$

(b) All-electric house:

$$\begin{aligned}
 \text{Electricity cost savings} &= 611 \text{ kWh} \times \$0.15/\text{kWh} = \$92 \\
 \text{Implementation cost} &= \$800 - \$1,100 \\
 \text{Simple Payback} &= \underline{\mathbf{8.7 \text{ to } 12.0 \text{ years}}}
 \end{aligned}$$

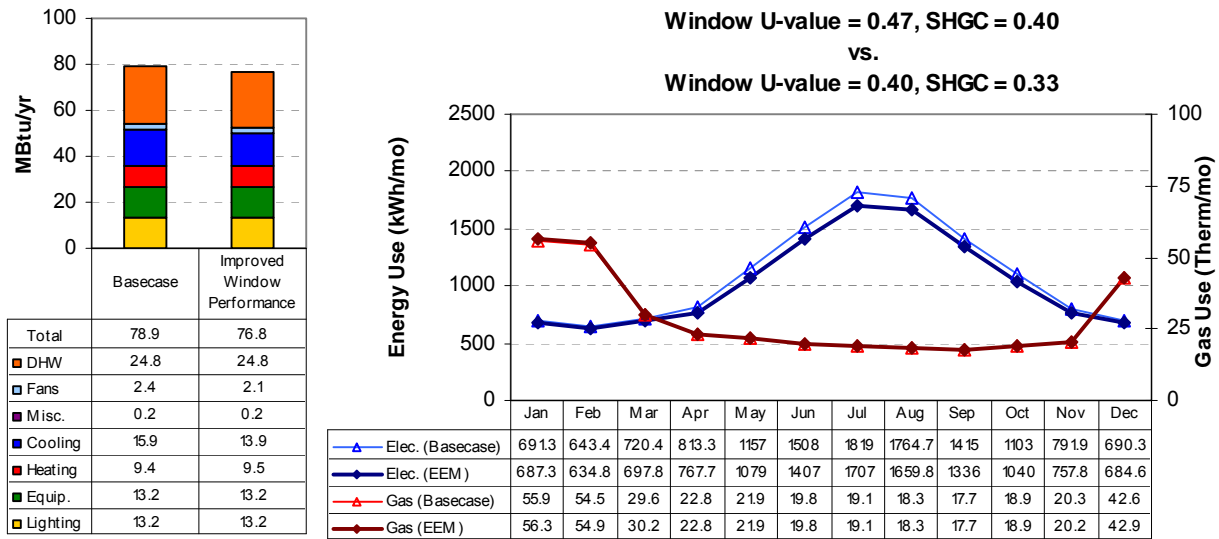


Figure 24. Energy Use Comparison for Base Case (window U-value = 0.47, SHGC = 0.4) and EEM (window U-value = 0.40, SHGC = 0.33) in an Electric/Gas House.

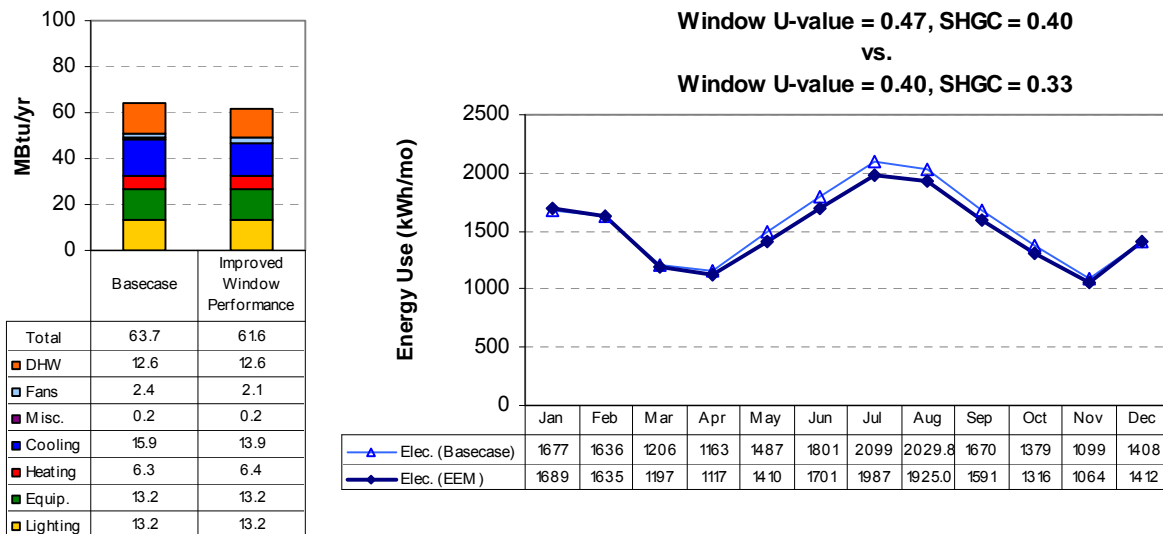


Figure 25. Energy Use Comparison for Base Case (window U-value = 0.47, SHGC = 0.4) and EEM (window U-value = 0.40, SHGC = 0.33) in an All-electric House.

5.10. Improved Air Conditioner Efficiency

(From SEER 13 to SEER 15)

Base Case: For an electric/gas house, the base-case HVAC system includes a central air-conditioning system and a gas-fired furnace for space heating. The base-case HVAC system is comprised of a SEER 13 air-conditioner and a gas-fired, forced-air furnace of 0.78 Annual Fuel Utilization Efficiency (AFUE)²⁰. The capacity of the cooling system is 55,800 Btu/hr, which assumes 500 sq. ft. per ton. The capacity of the heating system is 72,540 Btu/hr, which assumes 1.3 times of the cooling capacity. The heating and cooling set-points were 68°F for winter and 78°F for summer, with a 5°F setback/setup (for winter and summer, respectively) for six hours early in the morning²¹.

EEM 10: For this analysis, the SEER 13 air conditioner in the electric/gas base-case house was replaced with a similarly sized SEER 15 air conditioner.

Energy savings: Figure 26 compares the energy use of a house in Houston with base-case characteristics and with this measure. It shows that this measure applied to the base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.8 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 76.8 MMBtu/year, i.e., 2.1 MMBtu/year or 2.7% total energy savings, and
- Reduced the electricity use from 13,115 kWh/year to 12,495 kWh/year, i.e., 620 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-4, and is summarized in the following table. It shows that in an electric/gas house, replacing a SEER 13 air conditioner with a SEER 15 air conditioner would increase the cost by \$900 to \$2,500.

Table 17. Cost Information for Upgrading the Air Conditioner.

HVAC System Measures		Capacity	Equipment Cost (\$)	Labor Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-4)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	SEER 13 Air Conditioning System	5 ton	\$3,300-\$4,550 (Avg. \$3925)	n/a	\$900-\$2,500	Table Air Conditioning with Gas Heat - No. 1,2,5,7,11
EEM 11	SEER 15 Air Conditioning System		\$4,800-\$6,560			Table Air Conditioning with Gas Heat - No. 3,4,6,8,12

Payback Calculation:

All-electric house:

$$\begin{aligned} \text{Electricity cost savings} &= 620 \text{ kWh} \times \$0.15/\text{kWh} = \$93 \\ \text{Implementation cost} &= \$900 - \$2,500 \end{aligned}$$

²⁰ The efficiency of HVAC system is determined by NAECA 2006.

²¹ As defined by Table 402.1.3.5, p. 64, of the 2001 IECC.

Simple Payback

= 9.7 to 26.9 years

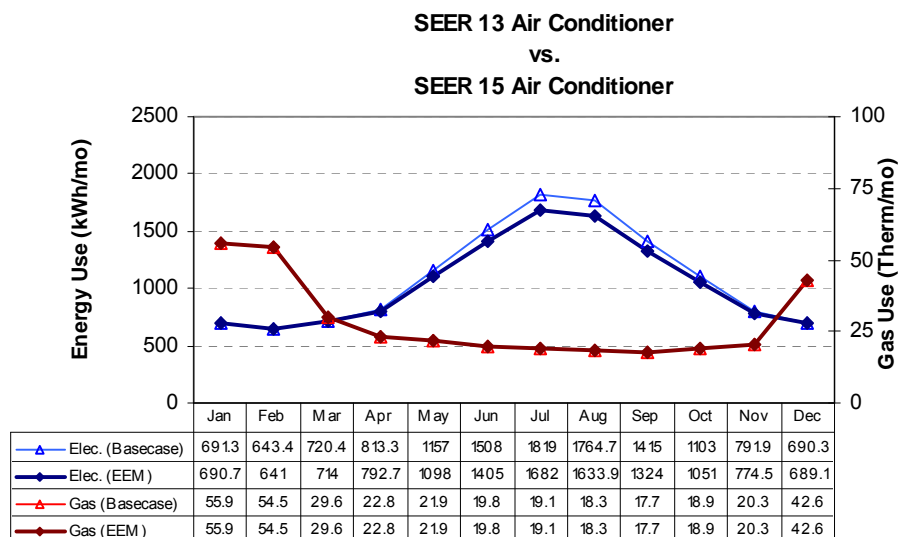
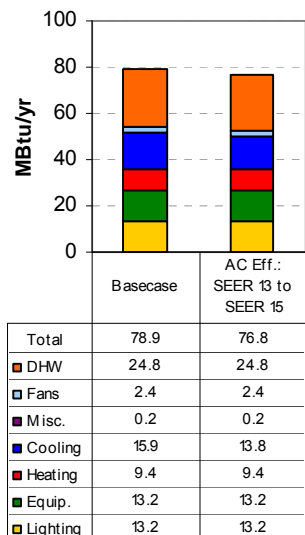


Figure 26. Energy Use Comparison for Base Case (SEER 13 air-conditioner) and EEM (SEER 15 air-conditioner).

5.11. **Improved Furnace Efficiency**

(From 0.78 AFUE to 0.93 AFUE)

Base Case: For an electric/gas house, the base-case HVAC system includes a central air-conditioning system and a gas-fired furnace for space heating. The base-case HVAC system is comprised of a SEER 13 air-conditioner and a gas-fired, forced-air furnace of 0.78 Annual Fuel Utilization Efficiency (AFUE). The capacity of the cooling system is 55,800 Btu/hr, which assumes 500 sq. ft. per ton. The capacity of the heating system is 72,540 Btu/hr, which assumes 1.3 times of cooling capacity. The heating and cooling set-points were 68°F for winter and 78°F for summer, with a 5°F setback/setup (for winter and summer, respectively) for six hours early in the morning.

EEM 11: For this analysis, the gas-fired furnace in the electric/gas base-case house (0.78 AFUE) was replaced with a similarly sized furnace with an AFUE of 0.93.

Energy Savings: Figure 27 compares the energy use of a house in Houston with base-case characteristics and with this measure. It shows that this measure applied to the base-case house:

- Reduced the heating energy use from 9.4 MMBtu/year to 7.8 MMBtu/year,
- Reduced the total energy use from 78.9 MMBtu/year to 77.4 MMBtu/year, i.e., 1.5 MMBtu/year or 1.9% total energy savings, and
- Reduced the gas use from 341 therm/year to 326 therm/year, i.e., 15 therm/year gas savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-4, and is summarized in the following table. It shows that in an electric/gas house, replacing a 0.78 AFUE furnace with a 0.93 AFUE furnace would increase the cost by \$600 to \$1,500.

Table 18. Cost Information for Upgrading the Furnace.

HVAC System Measures		Capacity	Equipment Cost (\$)	Labor Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-4)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	0.78 AFUE Furnace (w/o pilot light)	70,000 Btuh	\$770-\$1,310 (Avg. \$1040)	n/a	\$600-\$1,500	Table Furnace - No. 3,4,6,8
EEM 10	0.93 AFUE Furnace (w/o pilot light)		\$1,660-\$2,500			Table Furnace- No. 2,5,7,9

Payback Calculation:

Electric/gas house:

Gas cost savings	= 15 therm x \$1 /therm = \$15
Implementation cost	= \$600 - \$1,500
Simple Payback	= <u>40.0 to 100.0 years</u>

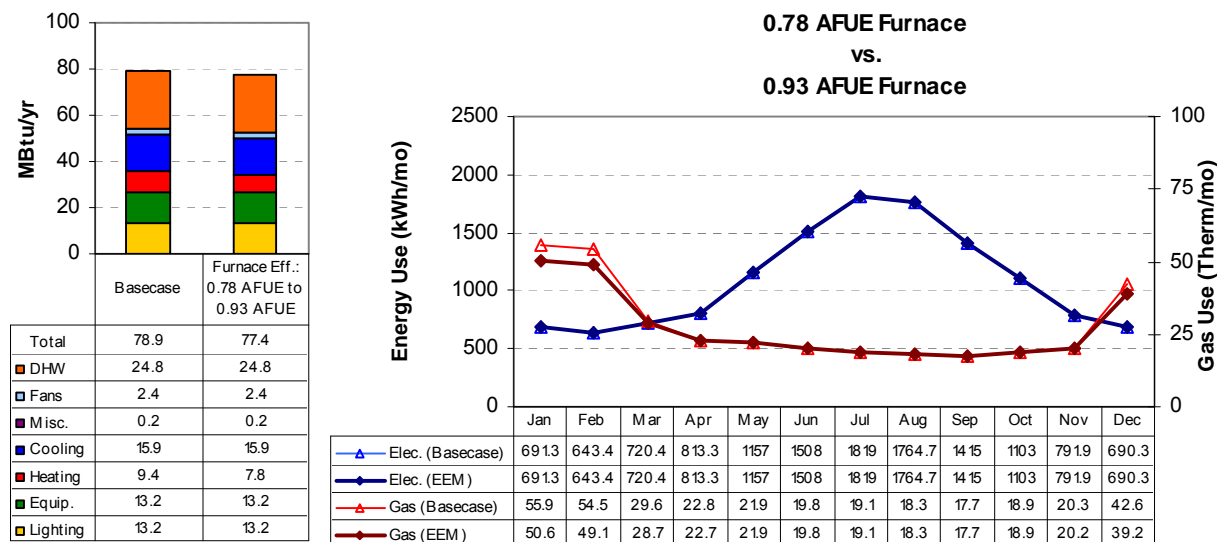


Figure 27. Energy Use Comparison for Base Case (0.78 AFUE furnace) and EEM (0.93 AFUE furnace).

5.12. Improved Efficiency of Air Conditioner with a Heat Pump

(From SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)

Base Case: For an all-electric house, the base-case HVAC system includes a central air-conditioning system with a heat pump for space heating. The base-case HVAC system is comprised of a SEER 13 air conditioner with a heat pump of 7.7 Heating Season Performance Factor (HSPF). For both types of houses, the capacity of the cooling system is 55,800 Btu/hr, which assumes 500 sq. ft. per ton. The capacity of the heating system is 72,540 Btu/hr, which assumes 1.3 times of cooling capacity. The heating and cooling set-points were 68°F for winter and 78°F for summer, with a 5°F setback/setup (for winter and summer, respectively) for six hours early in the morning.

EEM 12: For an all-electric house, the base-case heat pump with an HSPF of 7.7 was replaced with a similarly-sized heat pump with an HSPF of 8.5.

Energy Savings: Figure 28 compares the energy use of a house in Houston with base-case characteristics and with this measure. It shows that this measure applied to the base-case house:

- Reduced the cooling energy use from 15.9 MMBtu/year to 13.8 MMBtu/year,
- Reduced the heating energy use from 6.3 MMBtu/year to 5.8 MMBtu/year,
- Reduced the total energy use from 63.7 MMBtu/year to 61.1 MMBtu/year, i.e., 2.6 MMBtu/year or 4.1% total energy savings, and
- Reduced the electricity use from 18,653 kWh/year to 17,895 kWh/year, i.e., 758 kWh/year electricity savings.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Appendix B-4, and is summarized in the following table. It shows that in an all-electric house, replacing a SEER 13 air conditioner with a 7.7 HSPF heat pump with a SEER 15 air conditioner with an 8.5 HSPF heat pump would increase the cost by \$1,500-\$2,400.

Table 19. Cost Information for Upgrading the Air Conditioner with a Heat Pump.

HVAC System Measures		Capacity	Equipment Cost (\$)	Labor Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix B-4)
HEAT PUMP/ELECTRIC DHW SYSTEM						
Base Case	8.5 HSPF/SEER 13 Heat Pump	5 ton	\$3,600-\$4,400 (Avg. \$4,000)	n/a	\$1,500-\$2,400	Table Heat Pump - No. 5, 7, 10, 12, 14, 16
EEM 12	8.5 HSPF/SEER 15 Heat Pump		\$5,000-\$6,400			Table Heat Pump- No. 6, 8, 9, 11, 13, 15, 17

Payback Calculation:

All-electric house:

Electricity cost savings = 758 kWh x \$0.15/kWh = \$114
 Implementation cost = \$1,500-\$2,400
 Simple Payback = **13.2 to 21.1 years**

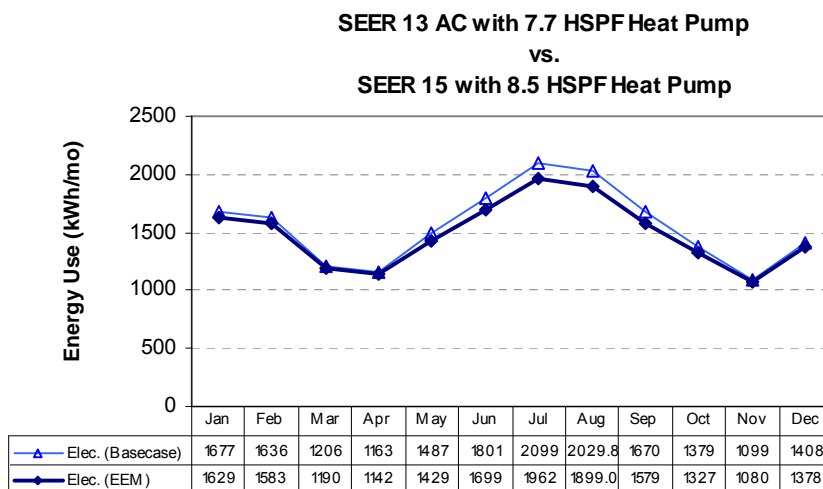
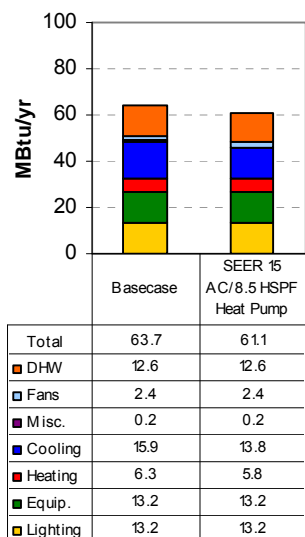


Figure 28. Energy Use Comparison for Base Case (SEER 13 air conditioner with a 7.7 HSPF heat pump) and EEM (SEER 15 air conditioner with an 8.5 HSPF heat pump).

References

- ASHRAE. 1993. *ANSI/ASHRAE Standard 136-1993 (RA 2006) - A Method of Determining Air Change Rates in Detached Dwellings*. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
- ASHRAE. 2001. *ANSI/ASHRAE Standard 62-2001 Ventilation for Acceptable Indoor Air Quality*. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
- ASHRAE. 2003. *ASHRAE Handbook - HVAC Applications*. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
- ICC. 1999. *2000 International Energy Conservation Code*. Falls Church, VA: International Code Council, Inc.
- ICC. 2001. *2001 Supplement to the International Energy Conservation Code*. Falls Church, VA: International Code Council, Inc.
- Kim, S. 2006. *An Analysis of International Energy Conservation Code (IECC)-Compliant Single-Family Residential Energy Use*. Ph.D. Dissertation, Department of Architecture, College Station, TX: Texas A&M University.
- Klein, S.A., W.A. Beckman. 1983. *F-Chart Solar Energy System Analysis: DOS Version 5.6*. F-Chart Software. Middleton, WI. www.fchart.com.
- LBL. 1993. *DOE-2 BDL Summary Version 2.1E*. LBL Report No. 349346. Berkeley, CA: Lawrence Berkeley Laboratory.
- Malhotra, M. and J. Haberl. 2006. An Analysis of Maximum Residential Energy Efficiency in Hot and Humid Climates. *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates, Orlando, FL*.
- Malhotra, M., J. Mukhopadhyay, B. Liu, J. Haberl, C. Culp, B. Yazdani. 2007. Recommendations for 15% Above-Code Energy Efficiency Measures for Single-Family Residences. *Proceedings of the 15.5 Symposium on Improving Building Systems in Hot & Humid Climates, San Antonio, TX*.
- NAECA. 2006. *National Appliance Energy Conservation Act*.
- NAHB. 2003. *The Builders Practices Survey Reports*. National Association of Home Builders. Upper Marlboro, MD: NAHB Research Center.
- NREL. 2001. Building America House Performance Analysis Procedures. (NREL/TP-550-27754) Golden, CO: National Renewable Energy Laboratory. p.34
- Parker, D., P. Fairey, L. Gu. 1993. Simulation of the Effects of Duct Leakage and Heat Transfer on Residential Space Cooling Energy Use. *Energy and Buildings*, 20(2):97-113.

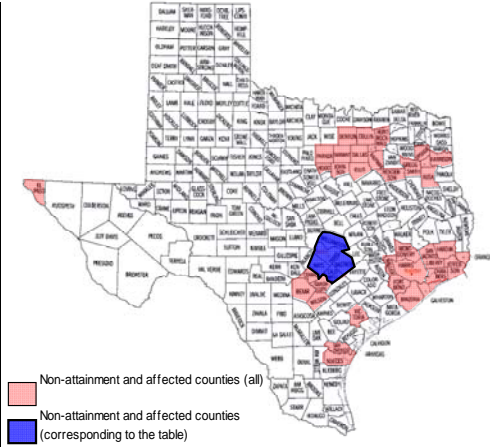
Appendix A

15% Above-code Measures for 41 Non-attainment and Affected Counties

Natural Gas Heating (Bastrop, Caldwell, Hays, Travis and Williamson Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.0%	\$73	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	16.9%	\$91		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.3%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.4%	\$216	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.1%	\$109		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.46 to 0.35 Air-changes/hr)	2.3%	\$34		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	2.1%	\$139		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.0%	\$167		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.6%	\$104	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.7%	\$98	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	2.2%	\$18	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	17.4%	\$289	\$1,000 - \$3,500		2.83	0.016	6.9 - 36.4
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	21.0%	\$201		\$2,900 - \$5,200	1.10	0.010	16.7 - 29.2
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	16.9%	\$393	\$200 - \$600		3.92	0.023	10.9 - 28.2
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

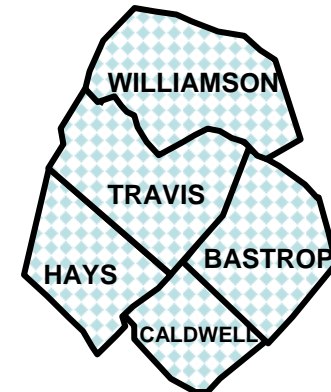


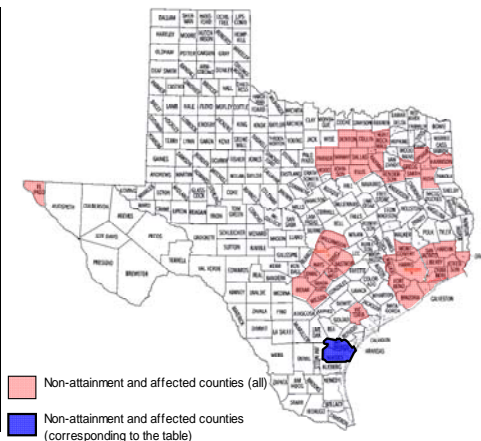
Table 1a: 15% Above Code Savings (Residential – Natural Gas Heating) for Bastrop, Caldwell, Hays, Travis and Williamson Counties



Natural Gas Heating (Nueces and San Patricio Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.0%	\$69	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	14.8%	\$67		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.7%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	9.3%	\$293	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	5.0%	\$160		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)	2.5%	\$58		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	3.8%	\$154		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.9%	\$175		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.3%	\$113	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	3.6%	\$123	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	0.6%	\$5	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	18.3%	\$362	\$1,000 - \$3,500		2.84	0.016	5.5 - 29.0
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	22.9%	\$329		\$2,900 - \$5,200	1.97	0.015	12.9 - 25.3
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
10 Air Conditioner (SEER 13 to SEER 15)				\$900 - \$2,500			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	16.8%	\$378	\$200 - \$600		2.93	0.018	4.1 - 24.1
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)				\$350 - \$1,500			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%



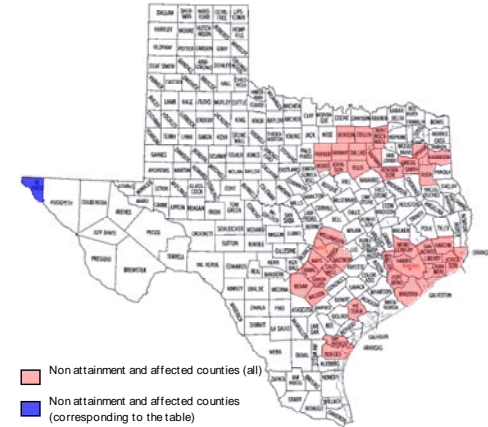
Table 2a: 15% Above Code Savings (Residential – Natural Gas Heating) for Nueces and San Patricio Counties



Natural Gas Heating (El Paso)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	10.3%	\$79	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	23.0%	\$130		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.7%	\$44	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	5.2%	\$104	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	2.3%	\$46		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.43 to 0.35 Air-changes/hr)	1.4%	\$12		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	1.0%	\$121		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.2%	\$165		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.44 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	0.1%	\$75	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.1%	\$72	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	2.0%	\$15	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
1 Tankless Gas Water Heater (without a Standing Pilot Light)	15.5%	\$183	\$1,000 - \$3,500		0.92	0.002	10.9 - 57.3	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
Combination 2								
2 Solar Domestic Hot Water System	23.0%	\$130		\$2,900 - \$5,200	0.00	0.005	25.7 - 44.9	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
Combination 3								
3 Removal of Pilot Light from Domestic Hot Water System	17.1%	\$349	\$200 - \$600		0.62	0.001	15.9 - 43.3	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
6 Reduced Air Infiltration (0.43 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
10 Air Conditioner (SEER 13 to SEER 15)			\$900 - \$2,500					

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%



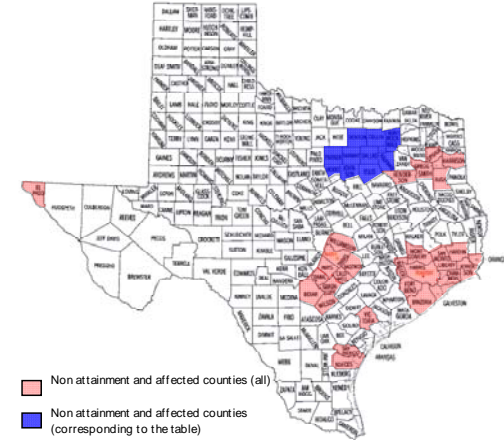
Table 3a: 15% Above Code Savings (Residential – Natural Gas Heating) for El Paso County



Natural Gas Heating (Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	8.8%	\$78	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	16.7%	\$100		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	4.9%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	9.0%	\$208	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.4%	\$105		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)	4.1%	\$54		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	0.3%	\$112		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	3.2%	\$155		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	1.6%	\$88	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.2%	\$84	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	3.4%	\$30	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	17.8%	\$286	\$1,000 - \$3,500		2.79	0.017	7.0 - 36.8
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	21.2%	\$205		\$2,900 - \$5,200	1.05	0.010	16.3 - 28.5
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	17.1%	\$293	\$200 - \$600		2.87	0.018	5.3 - 31.1
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)				\$350 - \$1,500			

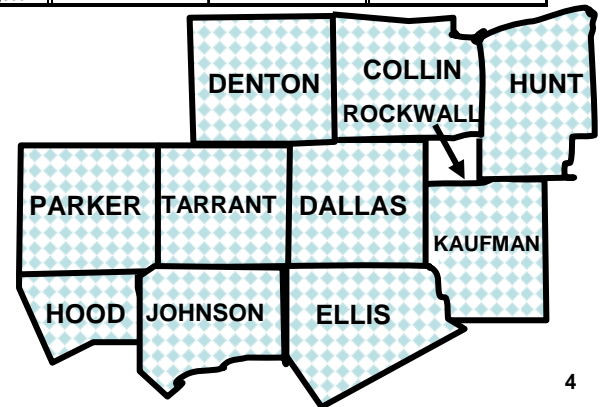
Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

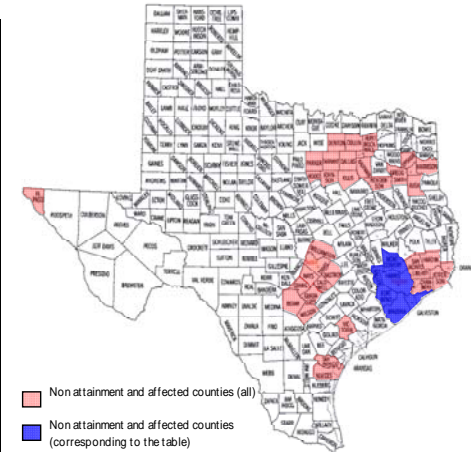
Table 4a: 15% Above Code Savings (Residential – Natural Gas Heating) for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties



Natural Gas Heating (Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.3%	\$73	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	15.2%	\$74		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.5%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.5%	\$221	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.3%	\$117		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.46 to 0.35 Air-changes/hr)	2.1%	\$35		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	2.1%	\$128		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	3.6%	\$152		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.6%	\$97	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.7%	\$93	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	1.9%	\$15	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	17.8%	\$295	\$1,000 - \$3,500		2.39	0.018	6.8 - 35.7
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	21.8%	\$269		\$2,900 - \$5,200	1.50	0.011	15.8 - 31.0
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
10 Air Conditioner (SEER 13 to SEER 15)			\$900 - \$2,500				
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	16.8%	\$383	\$200 - \$600		2.99	0.025	11.2 - 29.0
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

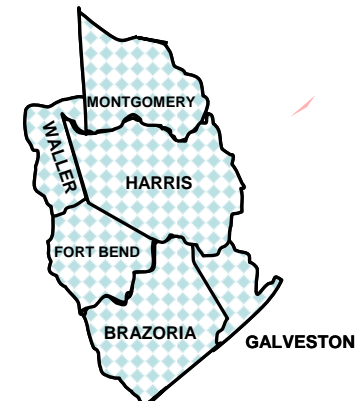


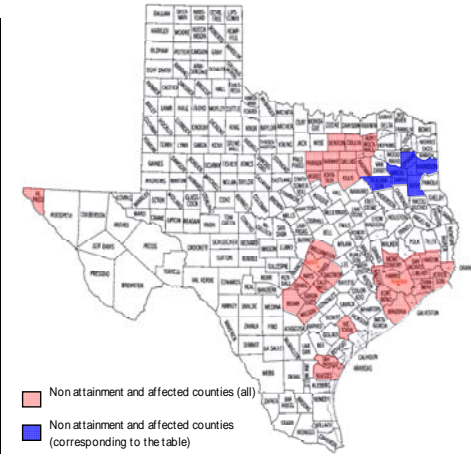
Table 5a: 15% Above Code Savings (Residential – Natural Gas Heating) for Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties



Natural Gas Heating (Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.5%	\$76	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	16.7%	\$87		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.4%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.7%	\$225	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.4%	\$118		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)	2.7%	\$40		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	1.8%	\$129		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	3.9%	\$159		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.4%	\$95	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.5%	\$89	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	2.2%	\$17	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
1 Tankless Gas Water Heater (without a Standing Pilot Light)	18.2%	\$301	\$1,000 - \$3,500		2.96	0.018	6.7 - 34.9	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
Combination 2								
2 Solar Domestic Hot Water System	21.1%	\$205		\$2,900 - \$5,200	1.19	0.011	16.3 - 28.5	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
Combination 3								
3 Removal of Pilot Light from Domestic Hot Water System	19.2%	\$419	\$200 - \$600		4.20	0.025	11.1 - 30.1	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				

Note:

1. Marginal cost = new system cost - original system cost
2. New system cost = new system cost only
3. See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
4. Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

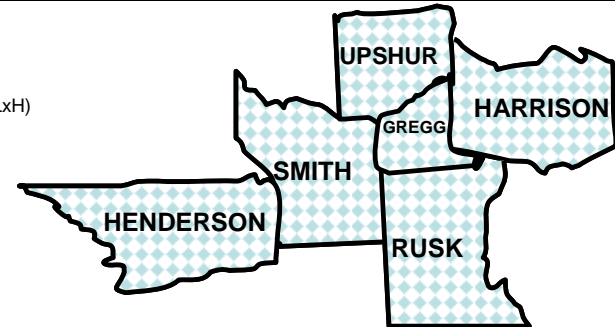


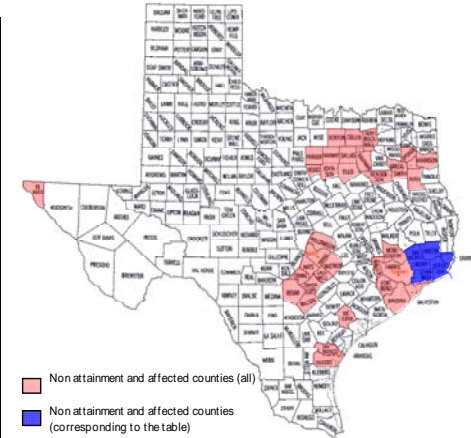
Table 6a: 15% Above Code Savings (Residential – Natural Gas Heating) for Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties



Natural Gas Heating (Chambers, Hardin, Jefferson, Liberty and Orange Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.5%	\$74	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	15.9%	\$78		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.6%	\$44	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.5%	\$232	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.4%	\$125		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.45 to 0.35 Air-changes/hr)	2.3%	\$36		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	2.1%	\$129		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	3.9%	\$160		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.5%	\$96	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.7%	\$93	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	1.7%	\$14	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	18.0%	\$306	\$1,000 - \$3,500		0.85	0.002	6.5 - 34.3
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	22.6%	\$280		\$2,900 - \$5,200	0.07	0.004	15.2 - 29.8
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
10 Air Conditioner (SEER 13 to SEER 15)				\$900 - \$2,500			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	17.0%	\$397	\$200 - \$600		0.51	0.001	10.8 - 28.0
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

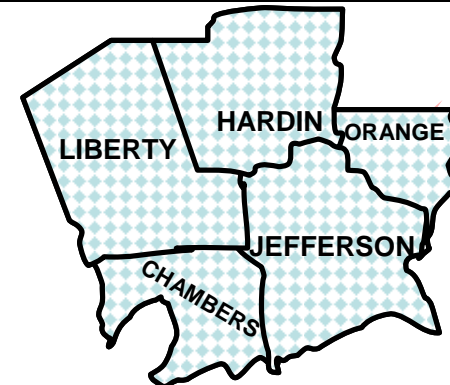


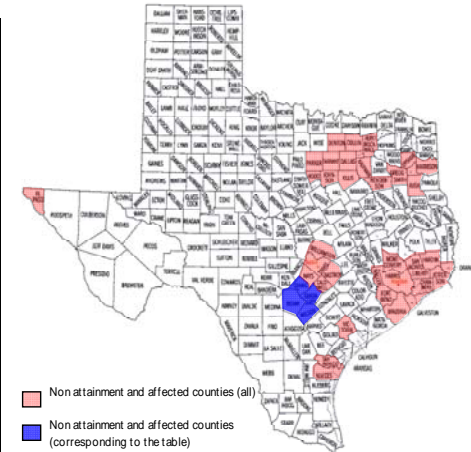
Table 7a: 15% Above Code Savings (Residential – Natural Gas Heating) for Chambers, Hardin, Jefferson, Liberty and Orange Counties



Natural Gas Heating (Bexar, Comal, Guadalupe and Wilson Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.2%	\$73	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	17.4%	\$92		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.5%	\$43	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.1%	\$212	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.0%	\$108		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.47 to 0.35 Air-changes/hr)	2.3%	\$36		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	2.4%	\$140		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.0%	\$165		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.8%	\$104	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	2.8%	\$98	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	1.9%	\$15	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	17.3%	\$285	\$1,000 - \$3,500		2.83	0.016	7.0 - 36.8
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	21.5%	\$201		\$2,900 - \$5,200	1.10	0.010	16.7 - 29.1
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	16.7%	\$387	\$200 - \$600		3.91	0.022	11.1 - 28.7
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			

Note:

1. Marginal cost = new system cost - original system cost
2. New system cost = new system cost only
3. See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
4. Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

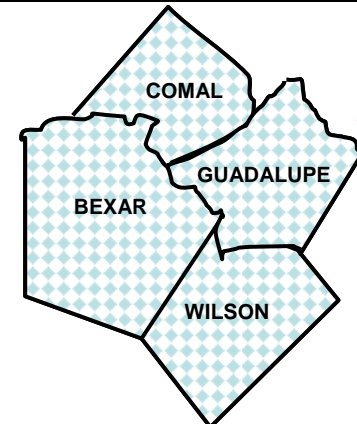


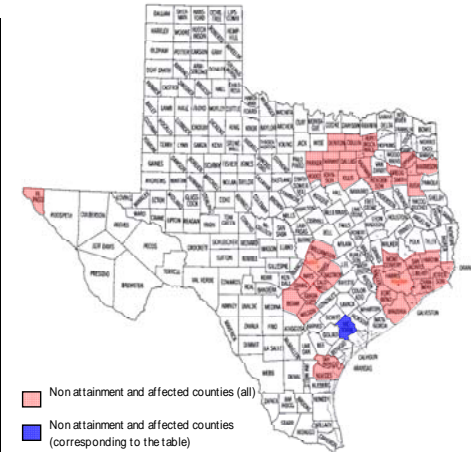
Table 8a: 15% Above Code Savings (Residential – Natural Gas Heating) for Bexar, Comal, Guadalupe and Wilson Counties



Natural Gas Heating (Victoria County)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year) ⁴	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Gas Water Heater (without a Standing Pilot Light)	9.3%	\$71	\$1,000 - \$3,500	
2 Solar Domestic Hot Water System	15.9%	\$76		\$2,900 - \$5,200
3 Removal of Pilot Light from Domestic Hot Water System	5.7%	\$44	\$200 - \$600	
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.3%	\$237	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.3%	\$125		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)	2.5%	\$46		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	3.0%	\$143		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.3%	\$166		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.9%	\$105	\$800 - \$1,100	
D HVAC System Measures				
10 Air Conditioner (SEER 13 to SEER 15)	3.1%	\$104	\$900 - \$2,500	
11 Furnace (0.78 AFUE to 0.93 AFUE)	1.1%	\$9	\$600 - \$1,500	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
1 Tankless Gas Water Heater (without a Standing Pilot Light)	17.6%	\$308	\$1,000 - \$3,500		2.44	0.015	6.5 - 34.1
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
Combination 2							
2 Solar Domestic Hot Water System	23.0%	\$290		\$2,900 - \$5,200	1.60	0.014	14.6 - 28.8
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
10 Air Conditioner (SEER 13 to SEER 15)				\$900 - \$2,500			
Combination 3							
3 Removal of Pilot Light from Domestic Hot Water System	17.3%	\$410	\$200 - \$600		3.16	0.020	10.5 - 27.1
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%



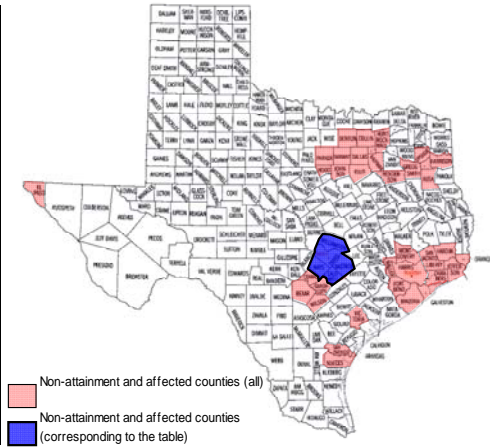
Table 9a: 15% Above Code Savings (Residential – Natural Gas Heating) for Victoria County



Electric Heating (Bastrop, Caldwell, Hays, Travis and Williamson Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$43	\$700 - \$1,400	
2 Solar Domestic Hot Water System	12.2%	\$350		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	7.5%	\$216	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.5%	\$127		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.46 to 0.35 Air-changes/hr)	1.7%	\$49		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	4.1%	\$117		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.6%	\$160		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.4%	\$98	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.2%	\$119	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
2 Solar Domestic Hot Water System	16.7%	\$478		\$2,900 - \$5,200	1.29	0.018	7.0 - 12.2	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
Combination 2								
1 Tankless Electric Water Heater	16.1%	\$462	\$700 - \$1,400		4.68	0.026	13.6 - 30.9	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400				
Combination 3								
1 Tankless Electric Water Heater	15.8%	\$451	\$700 - \$1,400		4.56	0.024	14.5 - 20.1	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$800 - \$1,100				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400				

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

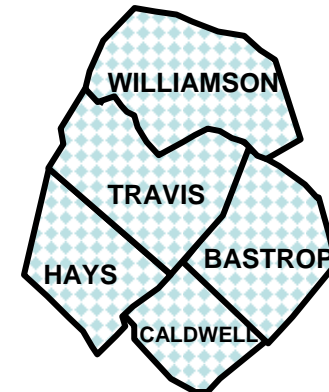


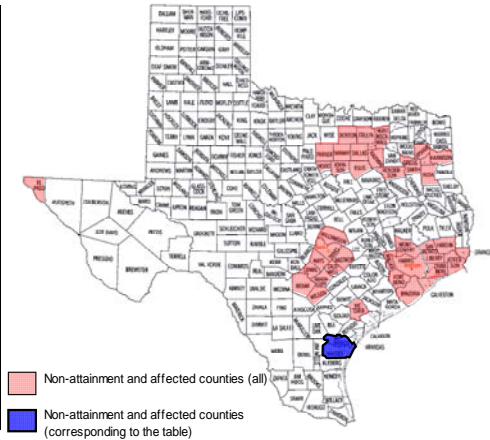
Table 1b: 15% Above Code Savings (Residential – Electric Heating) for Bastrop, Caldwell, Hays, Travis and Williamson Counties



Electric Heating (Nueces and San Patricio Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.4%	\$40	\$700 - \$1,400	
2 Solar Domestic Hot Water System	10.2%	\$289		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	10.6%	\$300	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	5.8%	\$165		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)	2.5%	\$70		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	5.0%	\$141		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	6.0%	\$169		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.9%	\$110	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.6%	\$130	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
2 Solar Domestic Hot Water System	16.1%	\$453		\$2,900 - \$5,200	1.23	0.016	7.4 - 12.9
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 2							
1 Tankless Electric Water Heater	16.6%	\$468	\$700 - \$1,400		3.50	0.020	10.3 - 25.4
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
Combination 3							
1 Tankless Electric Water Heater	16.0%	\$452	\$700 - \$1,400		3.38	0.019	8.4 - 15.6
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)				\$350 - \$1,500			
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$800 - \$1,100			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400				

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%



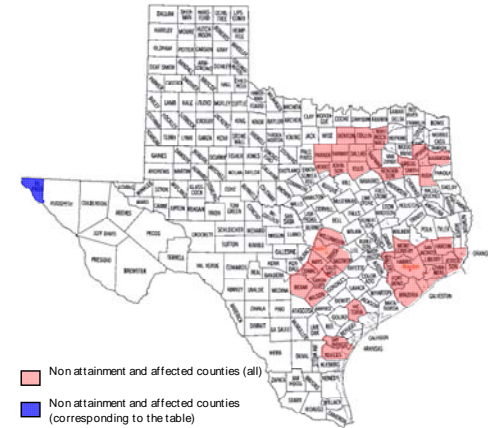
Table 2b: 15% Above Code Savings (Residential – Electric Heating) for Nueces and San Patricio Counties



Electric Heating (El Paso)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.7%	\$46	\$700 - \$1,400	
2 Solar Domestic Hot Water System	17.3%	\$460		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	3.5%	\$93	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	2.3%	\$61		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.43 to 0.35 Air-changes/hr)	0.9%	\$25		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	3.3%	\$88		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.6%	\$150		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.44 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	1.8%	\$47	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	3.4%	\$90	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
2 Solar Domestic Hot Water System	17.3%	\$460		\$2,900 - \$5,200	N/A	N/A	6.3 - 11.3	
Combination 2								
1 Tankless Electric Water Heater	13.6%	\$363	\$700 - \$1,400		N/A	N/A	20.5 - 46.5	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
6 Reduced Air Infiltration (0.43 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
9 Improved Windows (U-factor: 0.44 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$800 - \$1,100				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400					
Combination 3								
1 Tankless Electric Water Heater	13.0%	\$348	\$700 - \$1,400		N/A	N/A	19.8 - 30.3	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
6 Reduced Air Infiltration (0.43 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
9 Improved Windows (U-factor: 0.44 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$800 - \$1,100				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400					

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

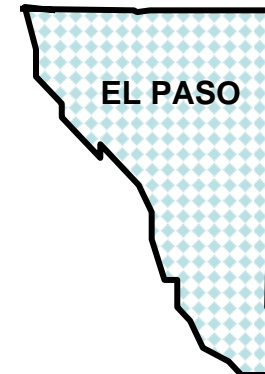


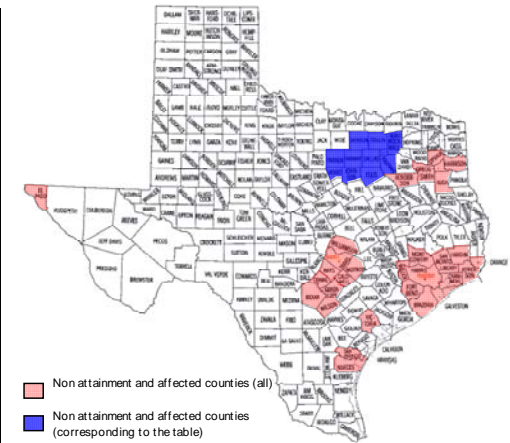
Table 3b: 15% Above Code Savings (Residential – Electric Heating) for El Paso County



Electric Heating (Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$45	\$700 - \$1,400	
2 Solar Domestic Hot Water System	12.9%	\$376		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	5.8%	\$171	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.4%	\$129		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)	2.6%	\$77		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	2.8%	\$82		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	4.9%	\$143		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	2.6%	\$76	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.0%	\$117	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
2 Solar Domestic Hot Water System	17.3%	\$505		\$2,900 - \$5,200	1.32	0.019	6.6 - 11.6	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
Combination 2								
1 Tankless Electric Water Heater	15.0%	\$438	\$700 - \$1,400		4.47	0.030	14.4 - 32.6	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400				
Combination 3								
1 Tankless Electric Water Heater	15.5%	\$452	\$700 - \$1,400		4.60	0.023	13.5 - 20.9	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400					

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

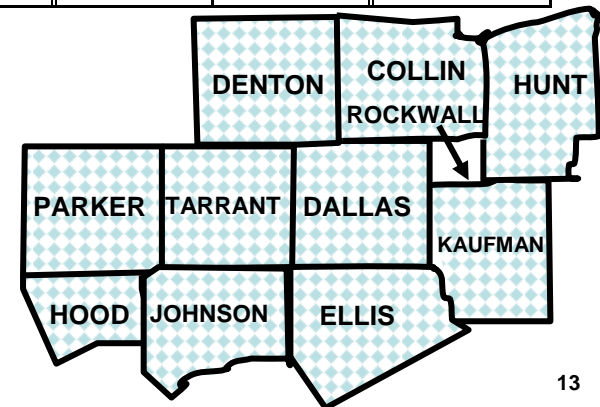


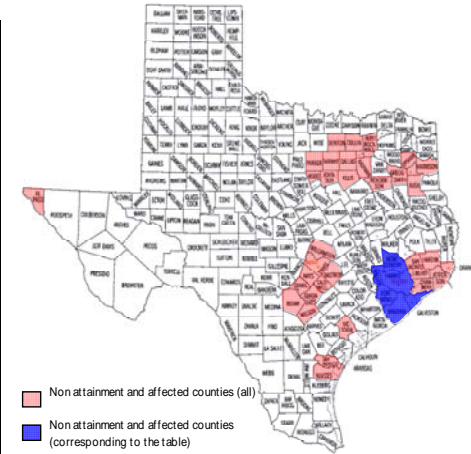
Table 4b: 15% Above Code Savings (Residential – Electric Heating) for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties



Electric Heating (Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$42	\$700 - \$1,400	
2 Solar Domestic Hot Water System	10.9%	\$304		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.7%	\$242	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.8%	\$134		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.46 to 0.35 Air-changes/hr)	1.8%	\$50		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	3.7%	\$103		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.0%	\$141		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.3%	\$92	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.1%	\$114	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
2 Solar Domestic Hot Water System	15.7%	\$438		\$2,900 - \$5,200	1.01	0.020	7.6 - 13.4
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 2							
1 Tankless Electric Water Heater	15.4%	\$431	\$700 - \$1,400		3.26	0.029	9.3 - 27.6
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)			\$800 - \$1,100				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400				
Combination 3							
1 Tankless Electric Water Heater	15.1%	\$422	\$700 - \$1,400		3.19	0.026	14.5 - 22.4
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
6 Reduced Air Infiltration (0.46 to 0.35 Air-changes/hr)				\$350 - \$1,500			
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

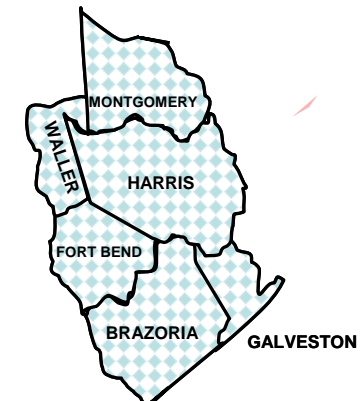


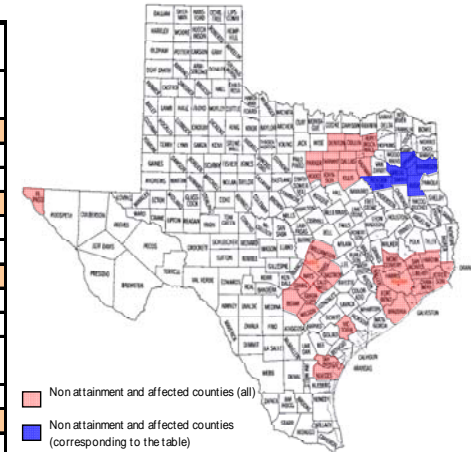
Table 5b: 15% Above Code Savings (Residential – Electric Heating) for Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties



Electric Heating (Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.6%	\$44	\$700 - \$1,400	
2 Solar Domestic Hot Water System	12.4%	\$341		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	6.9%	\$191	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.6%	\$128		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)	1.9%	\$52		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	4.0%	\$110		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.5%	\$150		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.3%	\$90	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	3.9%	\$107	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)	
			Marginal Cost ¹	New System Cost ²				
Combination 1								
2 Solar Domestic Hot Water System	17.0%	\$470		\$2,900 - \$5,200	1.31	0.020	7.1 - 12.5	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
Combination 2								
1 Tankless Electric Water Heater	16.7%	\$461	\$700 - \$1,400		4.69	0.029	14.4 - 34.3	
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000					
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400				
Combination 3								
1 Tankless Electric Water Heater	16.8%	\$464	\$700 - \$1,400		4.73	0.026	14.9 - 22.8	
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650				
6 Reduced Air Infiltration (0.51 to 0.35 Air-changes/hr)				\$350 - \$1,500				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500				
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$800 - \$1,100				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400					

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

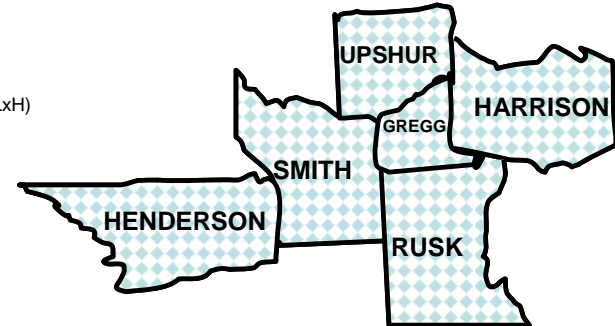


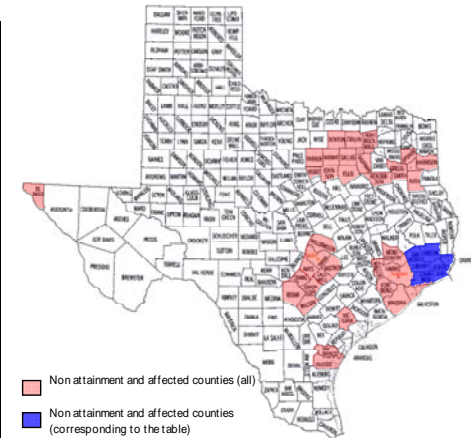
Table 6b: 15% Above Code Savings (Residential – Electric Heating) for Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties



Electric Heating (Chambers, Hardin, Jefferson, Liberty and Orange Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$43	\$700 - \$1,400	
2 Solar Domestic Hot Water System	11.4%	\$314		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	9.1%	\$251	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	5.0%	\$139		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.45 to 0.35 Air-changes/hr)	1.9%	\$53		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	3.8%	\$104		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.3%	\$147		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.3%	\$90	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.1%	\$112	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
2 Solar Domestic Hot Water System	16.4%	\$453		\$2,900 - \$5,200	N/A	N/A	7.4 - 12.9
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 2							
1 Tankless Electric Water Heater	15.7%	\$434	\$700 - \$1,400		N/A	N/A	8.4 - 26.4
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)				\$450 - \$650			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400			
Combination 3							
1 Tankless Electric Water Heater	15.6%	\$431	\$700 - \$1,400		N/A	N/A	14.2 - 21.9
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
6 Reduced Air Infiltration (0.45 to 0.35 Air-changes/hr)				\$350 - \$1,500			
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

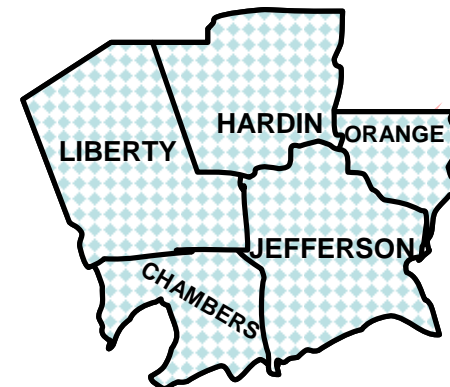


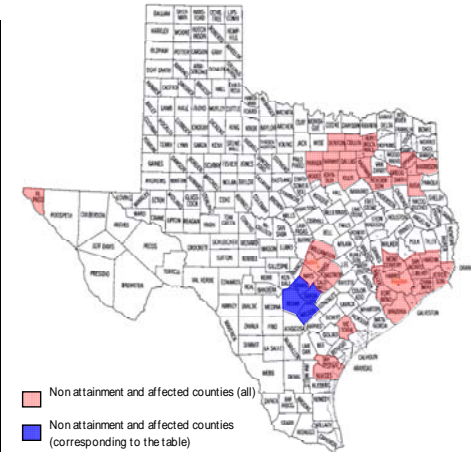
Table 7b: 15% Above Code Savings (Residential – Electric Heating) for Chambers, Hardin, Jefferson, Liberty and Orange Counties



Electric Heating (Bexar, Comal, Guadalupe and Wilson Counties)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$43	\$700 - \$1,400	
2 Solar Domestic Hot Water System	12.5%	\$355		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	8.3%	\$237	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.4%	\$126		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.47 to 0.35 Air-changes/hr)	1.9%	\$53		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	4.0%	\$115		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.4%	\$155		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.4%	\$98	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.2%	\$119	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
2 Solar Domestic Hot Water System	16.9%	\$481		\$2,900 - \$5,200	1.30	0.018	7.0 - 12.2
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 2							
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	21.5%	\$201	\$1,000 - \$7,000		4.47	0.025	24.4 - 57.7
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$800 - \$1,100				
Combination 3							
1 Tankless Electric Water Heater	16.7%	\$387	\$700 - \$1,400		4.48	0.022	15.8 - 24.4
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
6 Reduced Air Infiltration (0.47 to 0.35 Air-changes/hr)				\$350 - \$1,500			
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)				\$1,500 - \$2,400			

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%

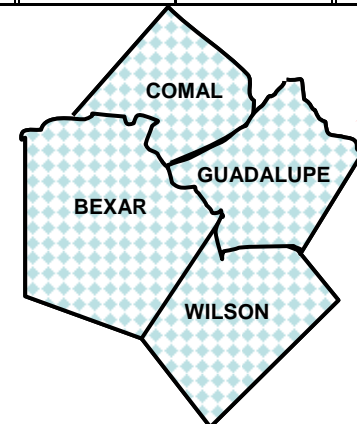


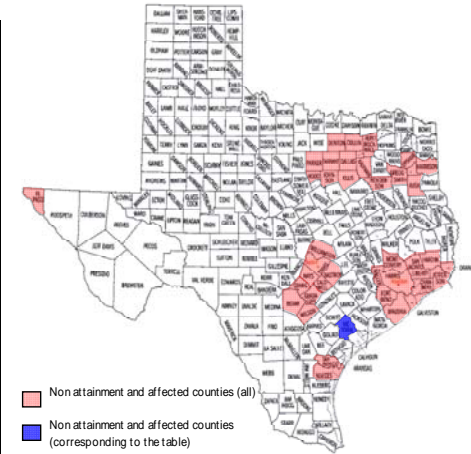
Table 8b: 15% Above Code Savings (Residential – Electric Heating) for Bexar, Comal, Guadalupe and Wilson Counties



Electric Heating (Victoria County)

Description of Individual Measures

Individual Measures	Annual Energy Savings (%)	Annual Energy Savings (\$/year)	Estimated Cost (\$)	
			Marginal Cost ¹	New System Cost ²
A Domestic Hot Water Measures				
1 Tankless Electric Water Heater	1.5%	\$41	\$700 - \$1,400	
2 Solar Domestic Hot Water System	11.3%	\$312		\$2,900 - \$5,200
B Air Distribution System Measures				
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space	9.1%	\$250	\$1,000 - \$7,000	
5 Improved Duct Sealing (10% to 5% Duct Leakage)	4.9%	\$135		\$450 - \$650
C Envelope and Fenestration Measures				
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)	2.2%	\$60		\$350 - \$1,500
7 Window Shading (None to 4 ft. Eaves on All Sides)	4.5%	\$124		\$3,100 - \$3,500
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)	5.7%	\$158		\$3,100 - \$3,500
9 Improved Windows (U-factor: 0.47 to 0.42 Btu/h-sf-F, SHGC: 0.4 to 0.33)	3.7%	\$101	\$800 - \$1,100	
D HVAC System Measures				
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)	4.2%	\$116	\$1,500 - \$2,400	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures ³	Combined Energy Savings (%)	Combined Energy Savings (\$/year)	Combined Estimated Cost (\$)		Combined Annual NO _x Emissions Savings (lbs/year)	Combined Ozone Season Period NO _x Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
			Marginal Cost ¹	New System Cost ²			
Combination 1							
2 Solar Domestic Hot Water System	16.2%	\$447		\$2,900 - \$5,200	1.01	0.015	7.5 - 13.1
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
Combination 2							
1 Tankless Electric Water Heater	15.0%	\$414	\$700 - \$1,400		3.09	0.019	11.6 - 28.8
4 Relocate HVAC Unit including Supply and Return Ducts in Conditioned Space			\$1,000 - \$7,000				
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
Combination 3							
1 Tankless Electric Water Heater	16.2%	\$447	\$700 - \$1,400		3.09	0.019	13.6 - 21.1
5 Improved Duct Sealing (10% to 5% Duct Leakage)				\$450 - \$650			
6 Reduced Air Infiltration (0.49 to 0.35 Air-changes/hr)				\$350 - \$1,500			
8 Window Shading and Redistribution (Equal Windows on All Four Sides with No Shading to 45% Windows on the South with 4ft. Eaves on All Four Sides)				\$3,100 - \$3,500			
12 Air Conditioner with Heat Pump (SEER 13/7.7 HSPF to SEER 15/8.5 HSPF)			\$1,500 - \$2,400				

Note:

- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
 - * Energy Cost: Electricity cost = \$0.15/kWh
 - Natural gas cost = \$1.00/therm
- Savings depend on fuel mix used. See detailed writeup

(Building Description)

- * Building type: Residential
- * Gross area: 2,323 sq-ft.
- * Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- * Number of floors: 1
- * Floor-to-floor height: 8ft
- * Window-to-wall ratio: 18%



Table 9b: 15% Above Code Savings (Residential – Electric Heating) for Victoria County



Appendix B

Cost Information

Appendix B-1: Summary of Cost Information

DHW System Measures		Capacity	Equipment Cost (\$)	Installation Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix A)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	\$310-\$410 (Avg: \$360)	\$240		Table Water Heater-1 - No. 7,8,9,10. Water Heater-2 - No. 3,5.
EEM1	Tankless Gas Water Heater w/o pilot light	7.4 GPM	\$930-\$1,460	\$720-\$1,200	\$1,000-\$3,500*	Table Water Heater-1 - No. 1,2,3,4,5,6.
EEM2	Solar Water Heater	80 Gallon	\$3,300	\$2,500	\$2,900-\$5,200*	Table Solar Water Heater - No. 1, 2, 3
EEM3	Tanktype Gas Water Heater w/o pilot light	40 Gallon	\$565-\$985	\$240	\$200-\$600	Table Water Heater-1 - No. 11,12,15,16
HEAT PUMP/ELECTRIC DHW SYSTEM						
Base Case	Tanktype Elec. Water Heater	40/50 Gallon	\$270-\$385 (Avg: \$330)	\$240		Table Water Heater-1 - No. 17,18. Water Heater-2 - No. 2.
EEM1	Tankless Elec. Water Heater	3.5-4.5 GPM	\$585-\$750	\$720-\$1,200	\$700-\$1,400	Table Water Heater-1 - No. 19, 20, 21, 22.
EEM2	Solar Water Heater	80 Gallon	\$3,300	\$2,500	\$2,900-\$5,200*	Table Solar Water Heater - No. 1, 2, 3
EEM3	Heat Pump Water Heater	80/120 Gallon	\$1,400-\$2,000	\$300-\$700	\$400-\$800*	Table Water Heater-3 - No. 1, 2, 3, 4, 5, 6.
Air Distribution System Measures			Cost (\$)		Total Increased Cost (\$)	Reference Table (Appendix B)
Base Case	Duct in unconditioned space	2,325 sq. ft. conditioned floor area	\$0.20/ft.		\$1,000-\$7,000*	Table Duct-3 - No. 1,2,3.
EEM4	Duct in conditioned space					
Base Case	9% duct leakage	628 sq. ft. supply and 117 sq. ft. return duct area	\$110 (material) + \$330 (installation)		\$450-\$650*	Table Duct-2 - No. 1,2.
EEM5	0% duct leakage					
Envelope and Fenestration Measures		Dimensions/Quantity	Cost (\$)		Total Increased Cost (\$)	Reference Table (Appendix C)
Base Case	Infiltration Rate: 0.462 ACH	2325 sq. ft. conditioned floor area	\$150-\$500 (material) + \$200-\$500 (blower door test)		\$350-\$1,500*	-
EEM6	Increased Air Tightness-infiltration Rate: 0.35 ACH					
Base Case	No Window Shading	193 ft. perimeter	\$16-\$23/linear foot		\$3,100-\$3,500	Table Shading-1 - No. 1, 2, 3, 4, Table Shading-2 -No. 1
EEM7 and EEM8	4' Eaves		\$34-\$39/linear foot			
Base Case	Air Filled, Double Pane, Aluminum Frame	No. of (36"x60") windows: 27	\$96-\$112 per window		\$800-\$1,100*	Table Windows-Summary- No. 2,4.
EEM9	Argon Filled Glazing and Vinyl Frame		\$170-\$210 per window			
HVAC System Measures		Capacity	Equipment Cost (\$)	Labor Cost (\$)	Total Increased Cost (\$)	Reference Table (Appendix D)
NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM						
Base Case	0.78 AFUE Furnace (w/o pilot light)	70,000 Btuh	\$770-\$1,310 (Avg. \$1040)	n/a	\$600-\$1,500	Table Furnace - No. 3,4,6,8
EEM 10	0.93 AFUE Furnace (w/o pilot light)		\$1,660-\$2,500			
Base Case	SEER 13 Air Conditioning System	5 ton	\$3,300-\$4,550 (Avg. \$3925)	n/a	\$900-\$2,500	Table Air Conditioning with Gas Heat - No. 1,2,5,7,11
EEM 11	SEER 15 Air Conditioning System		\$4,800-\$6,560			
HEAT PUMP/ELECTRIC DHW SYSTEM						
Base Case	8.5 HSPF/SEER 13 Heat Pump	5 ton	\$3,600-\$4,400 (Avg. \$4,000)	n/a	\$1,500-\$2,400	Table Heat Pump - No. 5,7,10,12,14, 16
EEM 12	8.5 HSPF/SEER 15 Heat Pump		\$5,000-\$6,400			

Appendix B-2: Cost of DHW Systems

Water Heater -1											
Item	No.	Price	Brand	Type of Fuel	Model	Energy Factor	Capacity	Description	Pictures	Source	Contact Person
Tankless Gas Water Heater	1	\$999.00	Paloma	Natural Gas	Model PTG-74PVN	0.82	7.4 GPM	Whole Home 7.4 GPM Natural Gas Tankless Water Heater With Remote Control; Electronic ignition; Supplies hot water for 2 to 3 applications; 199,900 BTU burner.		http://www.homedepot.com/ (Date: 05/09/2006)	Internet Price
	2	\$949.00	Bosch AquaStar	Natural Gas	Model 250SX-NG	0.85	6.4 GPM	Whole House Gas Tankless Water Heater; Electronic ignition; Supplies hot water for 2 applications.		http://www.homedepot.com/ (Date: 05/09/2006)	Internet Price
	3	\$929.00	Rheem	Natural Gas	RTG-74PVN	0.82	7.4 GPM	Rheem Tankless 7.4 GPM- Indoor Tankless Water Heater- 7.4 Gallon; 19000-199,900 btuh.		http://www.hmwallace.com/index.asp?PageAction=VIEWPROD&ProdID=2016 (Date: 05/15/2006)	Internet Price
	4	\$1,397.00	Takagi	Natural Gas	T-KD20	0.84 (85% thermal efficiency)	6.9 GPM	First hour rating: 240 GPH. Min 20,000 Btu Max 185,000 Btu. Outlet Temp: 95-180°F. No pilot light. (Qualify for \$300 TAX credit)		http://www.tanklesswaterheaters.com/takagitk1.html ; http://www.designerplumbing.com	Retail Price
	5	\$1457/\$1401	Takagi	Natural Gas	T-K1S/T-K2	85% thermal efficiency	6.9 GPM	First hour rating: 240 GPH. Min 20,000 Btu Max 190,000 Btu. Outlet Temp: 95-180°F. Electronic ignition. No pilot light. (Qualify for \$300 TAX credit)		http://www.tanklesswaterheaters.com/takagitk1.html ; http://www.designerplumbing.com	Retail Price
	6	\$2,297.00	Takagi	Natural Gas	T-M1	0.81 (82.4% thermal efficiency)	9.6 GPM	First hour rating: 300 GPH. Min 25,000 Btu Max 235,000 Btu. Outlet Temp: 95-180°F. Electronic ignition. No pilot light. (Qualify for \$300 TAX credit)		http://www.tanklesswaterheaters.com/takagitk1.html ; http://www.designerplumbing.com	Retail Price
Tank-type Gas Water Heater with Pilot light	7	\$377.99(\$409.99)	Kenmore	Natural Gas	#33926(#33916)		40(50) Gallon	Kenmore Power Miser 9, 40(50) gal. Gas Water Heater; Hourly input -40,000 BTU.		http://www.sears.com/ (Date: 05/09/2006)	
	8	\$215.95(\$232.50)	State	Natural Gas	GS6 40YBRT	0.60 (0.58)	40 (50) Gallon	Select® Standard Vent Gas Water Heaters; Feature C3 Technology™ that protects against accidental ignition of flammable vapors like those from gasoline; Green Choice™ gas burner produces 33% lower NOx emissions than standard burners		http://www.statewaterheaters.com/imedia/spec/res-gas/SSG43-4.pdf (Date: 05/11/2006)	CITY SUPPLY COMPANY, INC. HOUSTON, TX 77003 B: 713-224-1643
	9	\$325.00	Rheem	Natural Gas	22V40F	0.6	40 Gallon	Guardian Fury® Gas Water Heaters.		http://www.rheem.com/consumer/cataloqRes_detail.asp?id=76 (Date: 05/15/2006)	HUGHES 541 GRAHAM ROAD COLLEGE STATION, TX 77845 Phone: (979) 690-7636 Fax: (979) 690-7821 Communication with Barney on 05/15/2006.
	10	\$310.00	A.O. Smith	Natural Gas	GCV50	0.58	50 Gallon	ProMax gas water heaters. Hourly input: 40000Btu/h.		http://www.hotwater.com/lit/spec/imedia/res_gas/ARG-SS002-0405N.pdf (Date: 5/17/2006)	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication with John on 5/17/2006

Tank-type Gas Water Heater with Electronic Ignition	11	\$757.50	State	Natural Gas	PR6 40 XCVIT	0.61	40 Gallon	Select [®] Power-Vent residential gas water heater; hourly input-40000Btu; Equipped with nearly-indestructible silicon nitride hot surface igniter.		http://www.stateind.com/it/media/spec/res-gas/SPVG6-1-4.pdf (Date: 05/10/2006)	STATE Water Heaters 800-365-0024 ACT PIPE & SUPPLY, INC. 6900 WEST SAM HOUSTON PARKWAY NORTH HOUSTON, TX 77041 B: 713-937-0600 713-933-0426 (Eckhard)	1-	
	12	\$817.50	State	Natural Gas	PR6 40 XBDT	0.59(0.58)	40 Gallon	Select [®] Power Direct-Vent residential gas water heater; hourly input-40000Btu; Equipped with nearly-indestructible silicon nitride hot surface igniter.		http://www.stateind.com/it/media/spec/res-gas/SPDVG5-1-4.pdf (Date: 5/10/2006)			
	13	\$585.00	Rheem	Natural Gas	42VRP40	0.64	40 Gallon	PowerVent High Efficiency, Induced Draft Gas Water Heater; Electronic ignition system		http://www.rheem.com/consumer/catalogRes_detail.asp?id=68 (Date: 5/15/2006)	HUGHES 541 GRAHAM ROAD COLLEGE STATION, TX 77845 Phone: (979) 690-7636 Fax: (979) 690-7821 Communication with Barney on 05/15/2006.		
	14	\$565.00	Ruud	Natural Gas	PVP40F	0.62	40 Gallon	PowerVent Induced Draft Gas Water Heater with the Guardian System™; Electronic ignition system		http://www.rheem.com/consumer/catalogRes_detail.asp?id=68&brand=Ruud (Date: 5/15/2006)			
	15	\$985.00	A.O. Smith	Natural Gas	GPDH-50/GPDT-50	0.58	50 Gallon	Power House [®] Sealed Shot Power Direct-Vent Gas Water Heaters; horizontal and vertical venting options up to 45 feet; Advanced Intelli-Vent gas control valve with rugged silicon nitride hot surface igniter; Closed-combustion, two-pipe system draws clean combustion air from outside, vents outside the home; Environmentally friendly Green Choice™ gas burner reduces NOx emissions by 33% compared to standard burners; Hourly input: 40000/65000Btu/h.		http://www.hotwater.com/it/spec/media/res_gas/A7521.pdf (Date: 5/17/2006)	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication with John on 5/17/2006		
	16	\$1,200.00	A.O. Smith	Natural Gas	GPHE-50	90% Thermal Efficiency	50 Gallon	Vertex™ Power-Vent Gas Water Heaters; Money-saving 90% thermal efficiency. Endless hot water means homeowners will always get "one more hot shower"; Hot water output similar to larger, less efficient 75-gallon unit; Equipped with nearly indestructible silicon nitride hot surface igniter – no standing pilot; Hourly input: 76000 Btu/h.		http://www.hotwater.com/it/spec/media/res_gas/ARGSS01306.pdf (Date: 5/17/2006)	David Cunningham Hugh M. Cunningham 137555 Benchmark Dallas, TX 75234 B/ 972-888-3808 F/ 972-888-3838 Communication on 5/17/2006		
Tank-type Electric Water Heater	17	\$269.99(\$299.99)	Kenmore	Electric	#32946(#32154)		40(50) Gallon	Kenmore Power Miser 9(12), 40(50) gallon Electric Water Heater; Kilowatt Hrs. per Year- 4721(4622).		http://www.sears.com/ (Date: 05/09/2006)			
	18	\$188.00		Electric			55 Gallon			http://www.toolbase.org/ToolbaseResources/level4TechInv.aspx?ContentDetailID=699&BucketID=6&CategoryID=9	TOOLBASE Techspecs, by the NAHB Research Center for the Partnership for Advancing Technology in Housing (PATH).		
Tankless Electric Water Heater	19	\$585.00		Electric			Whole House			http://www.toolbase.org/ToolbaseResources/level4TechInv.aspx?ContentDetailID=699&BucketID=6&CategoryID=9	TOOLBASE Techspecs, by the NAHB Research Center for the Partnership for Advancing Technology in Housing (PATH).		
	20	\$750/\$775	Stiebel Eltron	Electric	Tempra 29/36		4.5 GPM	Single phase 150 amp residential electric water heater.		http://www.tanklesswaterheaters.com/stiebeltron.html	Retail Price		
	21	\$749.00	EEMAX	Electric	Series Three	99% Efficiency	4.0 GPM	EEMAX Series Three Residential Heater Single phase 150 amp residential electric water heater.		http://www.tanklesswaterheaters.com/eemaxheaters.html	Retail Price		
	22	\$596.00	PowerStar	Electric	AE125	0.95	3.5 GPM	PowerStar AE125 Electric Whole House Tankless; Provides up to 3.5 gallons per minute(50 degree temp rise) for water usage at 105° F: 2 sinks or 1 shower.		http://www.tanklesswater.com/ (Date: 05/09/2006)			

Water Heater -2

Item	No.	Price	Fuel Type	Description	Installation Cost	Energy Savings	Life	Source	Contact Person
Tankless Water Heater	1	\$200-\$1500	Gas/Electric	From \$200 for small electric undersink unit to over \$1500 for high capacity gas fired unit	2-4 Times higher than the tank type.	Electric tankless water heaters cost 10-20% less to operate than comparable tank-type heaters. Gas savings may be about 20-40%.	Tankless: 20 years Tanktype: 10-15 years	http://www.toolbase.org/Techinventory/TechDetails.aspx?ContentDetailID=979&BucketID=6&CategoryID=13	
Tankless Water Heater	2				3 times the tank-type.	Installation cost for tank type is about \$240 (3 hours). The installation cost for tankless water heater is about \$640-1200 (8 to 15 hours).			All State Plumbing (979-268-4300)
Tank-Type Water Heater	3	\$383.00	Gas	Average Price		Energy Consumption: 234 Therms/year	9 years	10 CFR Part 430, Energy Conservation Program for Consumer Products, Energy Conservation Standards for Water Heaters, Final Rule, Federal Register, Part III, Department of Energy, Office of Energy Efficiency and Renewable Energy.	
Tank-Type Water Heater	4	\$380.00	Electric	Average Price		Energy Consumption: 3,459 kWh/year	14 years		
Tank-Type Water Heater	5	\$501.00	Gas	Average Price for New Water Heater after the 2004 water heater standards take effect		Compare to item 2, estimated price increase (efficiency only) is \$58. Annual utility bill savings is \$12.74. Simple payback is 3.6 year. Average net savings over appliance life is \$30. Energy savings per year is 22 therms.	9 years		
Tank-Type Water Heater	6	\$486.00	Electric	Average Price for New Water Heater after the 2004 water heater standards take effect		Compare to item 3, estimated price increase (efficiency only) is \$101. Annual utility bill savings is \$13.05. Simple payback is 7.4 year. Average net savings over appliance life is \$23. Energy savings per year is 188 kWh.	14 years		

Water Heater -3

Item	No.	Price	Brand	Type of Fuel	Model	Energy Factor	Capacity	Description	Pictures	Source	Contact Person
Heat Pump Water Heater	1	\$600-\$2000 for the HPWH, \$300-700 for installation		Electric						Federal Technology Alert, US Department of Energy, 1995	
	2	\$1,425.00	DEC-Therma-Stor	Electric	HP-80	2.5	First hour rating: 62 gallons.	Ambient Air HPWH. Tank size: 80 Gallon. Water heating capacity: 10600 Btu/hr. Cooling Capacity: 7500 Btu/hr. Electrical Power Input: 0.8 kW.		Federal Technology Alert, US Department of Energy, 1995	
	3	\$1,748.00	DEC-Therma-Stor	Electric	HP-120-18-30	2.5	First hour rating: 99 gallons.	Ambient Air HPWH. Tank size: 120 Gallon. Water heating capacity: 10600 Btu/hr. Cooling Capacity: 7700 Btu/hr. Electrical Power Input: 6.8 kW.		Federal Technology Alert, US Department of Energy, 1995	
	4	\$2,082.00	DEC-Therma-Vent	Electric	HP-VAC-80	2.1	First hour rating: 70 gallons.	Exhaust Air HPWH. Tank size: 80 Gallon. Water heating capacity: 8300 Btu/hr. Cooling Capacity: 7000 Btu/hr. Electrical Power Input: 1.2 kW.		Federal Technology Alert, US Department of Energy, 1995	
	5	\$2,229.00	DEC-Therma-Vent	Electric	HP-VAC-120	2.2	First hour rating: 103 gallons.	Exhaust Air HPWH. Tank size: 120 Gallon. Water heating capacity: 8300 Btu/hr. Cooling Capacity: 7000 Btu/hr. Electrical Power Input: 1.1 kW.		Federal Technology Alert, US Department of Energy, 1995	
	6	\$1521 (\$175 for installation)	DEC-Therma-Vent	Electric	VHP-80	2.5	First hour rating: 64 gallons.	Exhaust Air HPWH. Tank size: 80 Gallon. Water heating capacity: 7100 Btu/hr. Cooling Capacity: 6000 Btu/hr. Electrical Power Input: 3.3 kW.		Federal Technology Alert, US Department of Energy, 1995	

Appendix B-3: Cost of Air Distribution System Measures

Duct-2

Improved Duct Sealing:

No.	Description	Material Cost (\$/ft ²)	Labor Cost (\$/ft)	Conditioned Floor Area (ft ²)	Supply Duct Area (ft ²)	Return Duct Area (ft ²)	Total Material Cost (\$)	Total Labor Cost (\$)	Total Cost (\$)	Sources
1	Using metal foil backed butyl tape and mastic to seal duct leaks.	\$0.15	\$0.45	2325	628	116	\$111.60	\$334.80	\$446.40	http://epb.lbl.gov/Publications/lbl-38537.pdf
2	Repairing the duct system								\$200.00	Cummings, J.B., J.J. Tooley Jr., M. Moyer, and R. Dunsmore. 1990. "Impacts of Duct Leakage on Infiltration Rates, Space Conditioning Energy Use, and Peak Electrical Demand in Florida Homes". Proc. ACEEE Summer Study 1994. 9:65-76.

Duct-3

Duct in Conditioned Space

No.	Description	Conditioned Floor Area (ft ²)	HVAC Material *	HVAC Labor	Incremental Framing Cost (\$)	Incremental Drywall Cost (\$)	Total Increased Construction Cost (\$)	Sources
1	Side-by-side comparison of two identical single-story homes where ductwork was installed after drywall was complete using a bulkhead dropped down from the ceiling, which ran along the long axis of the house; Supply branches, perpendicular to the supply line, were fitted with high-throw diffusers placed at room interior walls						\$230.00	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspeg.pdf
2	Duct in Unconditioned Space		\$252.00	\$103.00				http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspeg.pdf
	Duct in Conditioned Space		\$201.00	\$100.00	\$50.00	\$282.00	\$278.00	
3	In the affordable home with simple floor plan, ducts were created with trunk line spanning length of home in constructed bulkhead along first-floor ceiling; Registers off the trunk line serve both floors. A central return was provided at the landing of an open stairway	2325	Increased cost: \$0.2 per ft ²				\$465.00	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspeg.pdf

*Material cost savings include shorter duct runs and smaller diameter duct line.

Appendix B-4: Cost of Envelope and Fenestration Measures

Increased Air-tightness

No.	Method for increasing air-tightness	Unit cost (\$/windows or Door)	# of Windows	# of Doors	Total Cost - weather strip (\$)	Blower Door Test	Total Cost (\$/house)	Source
1	Weather Strip - Window	0.5 ~ 12 (Windows)	27	-	\$14-\$324	-	\$350-\$1000	http://www.mme.state.va.us/de/hbchap4.html
	Weather Strip - Window	\$4.6 ~ \$8 (Material Only)	27	-	\$124.2 - \$216	-		Lowes 3225 FREEDOM BLVD. BRYAN, TX 77802 (979) 774-4141
	Weather Strip - Window	\$20 (Material \$15 + Labor \$5)	27	-	\$540	-		Enercon Manufacturing (Mr. Oscar Beard) 1312 W Villa Maria Rd. Bryan, TX. 77801
	Weather Strip - Door	8~15 (Door)	-	3	\$24-\$45	-		http://www.mme.state.va.us/de/hbchap4.html
	Blower door test	-	-	-	-	\$200-\$500		http://www.powerhousetv.com/stellent2/groups/public/documents/pub/phtv_se_we_gs_000530.hcsp
2	Air sealing package (Blower door test included)	-	-	-	-	-	\$500 - \$1000	http://www.nbnnews.com/NBN/issues/2006-03-06/Research/index.html

Windows-Summary

	No.	Description	Total Conditioned Floor Area (ft2)	Total Windows Area (ft2)	Number of Windows (36"X60")	Unit Cost (\$)	Total Cost (\$)	Increased Cost (\$)	Source
Builders' Cost	1	Thermflect/Argon, Low-Conductance Spacer, Double Pane	2325	418	27	\$170.00	\$4,590.00	\$2,000	Builder's Cost: CertainTeed http://www.certainteed.com , Table Windows-2, No.1
	2	Air Filled, Double Pane, Aluminum Frame	2325	418	27	\$96.00	\$2,592.00		Builder' Cost: Atrium Companies, Inc, HR Windows® (Average of No.2 and No. 3 in Table Windows-1).
Lowe's	3	Argon Filled Glazing and Vinyl Frame	2325	418	27	\$210.00	\$5,670.00	\$2,700	Lowe's: Pella - ThernaStar, Table Windows-2, No.5
	4	Air Filled, Double Pane, Aluminum Frame	2325	418	27	\$112.00	\$3,024.00		Lowe's: MI Windows and Doors- BetterBilt, Table Windows-2, No.2.

Windows-1

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	Solar Heat Gain Coefficient (SHGC)	Daylight Transmittance	Price (\$)	Manufacturer /Distributor	Contact Person
1	Thermflect/Argon, Low-Conductance Spacer, Double Pane	Vinyl	Single-Hung w/o Grid	36" X 60"	0.31	0.25	0.29	0.71	Builder's Cost: \$170	CertainTeed http://www.certainteed.com	Enercon Windows & Hardware 1312 W Villa Maria, Bryan, Texas 77801 (979) 823-3639 Communication with Oscar Beard on 05/17/2006.
2	Air-filled, Low-e, Double Pane	Aluminum	Single-Hung w/o Grid	36" X 60"	0.37		0.29	0.67	Builder's Cost: \$110	Atrium Companies, Inc, HR Windows®	
3	Air-filled, Double Pane	Aluminum	Single-Hung w/o Grid	36" X 60"	0.52		0.6	0.81	Builder's Cost: \$82	Atrium Companies, Inc, HR Windows®	

1. Tested in accordance with NFRC 100-97. Data applicable for double-pane insulating units using either double-strength double pane glass with a 1/2" air space or single-strength glass with 9/16" air space.

Windows-2

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	Solar Heat Gain Coefficient (SHGC)	Daylight Transmittance	Price (\$)	Manufacturer/Distributor	Contact Person
1	Air-filled	Aluminum	Single-Hung w/ Grid	36" X 60"	0.67		0.68	0.7	\$88.00	MI Windows and Doors- BetterBit	LOWE'S OF BRYAN, TX #0103 3225 FREEDOM BLVD. BRYAN, TX 77802 (979) 774-4141 Visiting Date: 5/25/2006
2	Air-filled low-e	Aluminum	Single-Hung w/ Grid	36" X 60"	0.55		0.33	0.55	\$112.00	MI Windows and Doors- BetterBit	
3	Air filled low-e	Vinyl	Single-Hung w/o Grid	36" X 60"	0.35		0.32	0.58	\$137.00	Pella - ThermaStar	
4	Argon-filled low-e	Vinyl	Single-Hung w/o Grid	36" X 60"	0.33		0.31	0.58	\$210.40	Pella - ThermaStar	
5	Air-filled low-e	Wood	Double-Hung w/o Grid	36" X 60"					\$243.00	Pella	

Note: All windows listed above are insulated window unit.

Shading-1





No.	Eave Construction	Unit cost (\$/linear foot)	Perimeter (ft)	Total Cost (\$/house)	Increased Cost	Source
1	Wood Eave with open Soffitt including blocking, screened 2" holes for ventilation with paint.	\$15.28	193	\$2,949.04		http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf
2	Wood Eave with enclosed Soffitt including blocking, screened 2" holes for ventilation with paint.	\$19.37	193	\$3,738.41		http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf
3	Wood-framed eave with enclosed, stucco-covered Soffitt incl. blocking, screened 2" holes for ventilation with paint.	\$33.26	193	\$6,419.18		http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf
4	Average width of eave: 16 inch	\$23.00	193	\$4,439.00		http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf
	4 ft eave	\$39.00	193	\$7,527.00	\$3,088.00	Paige, Jefferson Christian Custom Homes, August 2006.

Shading-2

		Procedure	UNIT	Quantity	Unit Cost (Material)	Total Cost (Material)	Unit Cost (Labor)	Total Cost (Labor)	Total Cost (\$/LF)	Source
1	Eave with enclosed soffit \$ per LF (Assuming eave length as 1ft)	Install 2"x4" side supports at wall and fascia	LF	2	0.38	0.76	1.73	3.46	4.22	http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf#search=%22Cost-Benefit%20Evaluation%20of%20Proposed%20California%22
		Install 3/8" plywood soffit	SF	1	1.36	1.36	1.48	1.48	2.84	
		Install vent screen, 3"	LF	1	0.44	0.44	1.99	1.99	2.43	
		Drill 2" 0 hole	EA	2			2.8	5.6	5.6	
		Paint, primer with 2 finish coats	SF	2	0.34	0.68	0.38	0.76	1.44	
		Total Cost					3.24		13.29	
2	Increasing Eave Length to 4ft	Install 2"x4" side supports at wall and fascia	LF	5	0.38	1.9	1.73	8.65	10.55	http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf#search=%22Cost-Benefit%20Evaluation%20of%20Proposed%20California%22
		Install 3/8" plywood soffit	SF	4	1.36	5.44	1.48	5.92	11.36	
		Install vent screen, 3"	LF	1	0.44	0.44	1.99	1.99	2.43	
		Drill 2" 0 hole	EA	2			2.8	5.6	5.6	
		Paint, primer with 2 finish coats	SF	2	0.34	0.68	0.38	0.76	1.44	
		Increased Roof Area	SF	3	1	3			3	
Total Cost					11.46		22.92	34.38		
3	Increased cost per house:		Total perimeter	193					3445.05	





Appendix B-5: Cost of HVAC System Measures



Air Conditioning with Gas Heat System

Item	No.	Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	Source
Air Conditioning with Gas Heat (Carrier)	1	\$4,550.00	Carrier	Electric for cooling, gas for heating	Condenser: 24ABR360 Coil: CNRHP6024 Furnace: 58STA110 1-22	13 SEER/ 80%AFUE	5 ton	R-22 phase out refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com (Date: 05/12/2006)
	2	\$5,424.00	Carrier	Electric for cooling, gas for heating	Condenser: 24ABa360 Coil: CNRHP6024 Furnace: 58STA110 1-22	13 SEER/ 80%AFUE	5 ton	R-410A EPA compliant refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com (Date: 05/12/2006)
	3	\$6,276.00	Carrier	Electric for cooling, gas for heating	Out of stock, no longer available	15 SEER/ 80% AFUE	5 ton	R-22 phase out refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com (Date: 05/12/2006)
	4	\$6,561.00	Carrier	Electric for cooling, gas for heating	Condenser: 24ACA560 Coil: CNRHP6024 Furnace: 58STA110 1-22	15 SEER/ 80%AFUE	5 ton	R-410A EPA compliant refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com (Date: 05/12/2006)
Air Conditioning with Gas Heat (Carrier)	5	\$3,933.00	Lennox	Electric for cooling, gas for heating		13 SEER/ 80%AFUE	5 ton	Ref. Type: R-22, Gas Furnace: 135000 Btu/hr		http://www.smartenvavinc.com/res_systems/gas_furnace/Lennox.asp
	6	\$5,786.00	Lennox	Electric for cooling, gas for heating		15 SEER/ 80%AFUE	5 ton	Ref. Type: R-410A, Gas Furnace: 135000 Btu/hr		http://www.smartenvavinc.com/res_systems/gas_furnace/Lennox.asp

Air Conditioning with Gas Heat (All Makers)	7	\$4,500.00	All Makers	Electric for cooling, gas for heating	n/a	13 SEER/ 80%AFUE	5 ton	\$1,300 / Ton including duct work \$6,500 for 5-ton unit with duct work \$4,500 for 5-ton unit without duct work		Aggieland A/C & Heating
	8	\$6,200.00	All Makers	Electric for cooling, gas for heating	n/a	15 SEER/ 80%AFUE	5 ton	\$1,615 / Ton including duct work \$8,075 for 5-ton unit with work \$6,200 for 5-ton unit without duct work		Aggieland A/C & Heating
	9		All Makers	Electric for cooling, gas for heating	n/a	13 SEER/ 80%AFUE	5 ton	\$12,000 includes duct work.		ACC-Aggieland Climate Control
	10		All Makers	Electric for cooling, gas for heating	n/a	15 SEER/ 80%AFUE	5 ton	\$13,000 includes duct work.		ACC-Aggieland Climate Control
	11	\$3,300.00	All Makers	Electric for cooling, gas for heating	n/a	13 SEER/ 80%AFUE	5 ton	\$1,500 / Ton including duct work. \$7,500 for 5-ton unit with duct work \$3,300 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC
	12	\$4,800.00	All Makers	Electric for cooling, gas for heating	n/a	15 SEER/ 80%AFUE	5 ton	\$1,800 / Ton including duct work \$9,000 for 5-ton unit with duct work \$4,800 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC



Heat Pump

Item	No.	Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	Source
Heat Pump (Carrier - Up to 19 SEER and 9.5 HSPF)	1		Carrier	Electric	25HPA3	13 SEER/8.5 HSPF	Heating Capacity: 18,000 - 60,000 Btu/h Cooling Capacity: 1.5 - 5 tons	Carrier Performance Series Heat Pump; Versatile heating and cooling heat pump for maximum home comfort; Up to 15 SEER and 9.0 HSPF; Models include 25HPA5, 25HPA4, 25HPA3, 25HPR3, 38YXA, 38YZA, 38YSP.		http://www.residential.carrier.com/products/acheatpumps/heatpumps/index.shtml (Date: 5/12/2006)
	2		Carrier	Electric	25HCA3	13 SEER/8 HSPF	Heating Capacity: 18,000 - 60,000 Btu/h Cooling Capacity: 1.5 - 5 tons	Carrier Comfort Series Heat Pump Economical heating and cooling heat pump for optimal home comfort; Up to 14 SEER and 8.5 HSPF; Models include 25HCA4, 25HCA3, 25HCR3, 38YRA, 38YSA.		http://www.residential.carrier.com/products/acheatpumps/heatpumps/index.shtml (Date: 5/12/2006)
Heat Pump (Goodman)	3	\$3,189.00	Goodman	Electric	GSH130601A ARUF061	13 SEER/8.5 HSPF	Heating Capacity: 55000 Btu/h Cooling Capacity: 5 ton	Goodman 5 Ton 13 Seer Air Conditioning System with Heat Pump; One Goodman fully charged outdoor heat pump air conditioning condensing unit; One matched indoor air handling unit; One supplemental heating element.		Price: http://acdirect.com/ (Date: 05/11/2006) Product: http://www.goodmanmfg.com/
	4	\$3,492.00	Goodman	Electric	GSH140601A AEPF4260	14.5 SEER/8.5 HSPF	Heating Capacity: 55000 Btu/h Cooling Capacity: 5 ton	Goodman 5.0 Ton 14.5 Seer Air Conditioning System with Heat Pump; One Goodman fully charged outdoor heat pump air conditioning condensing unit; One matched indoor air handling unit, multi-position including evaporator cooling coil; One supplemental heating element up to 15 Kw (10Kw up to 3 Ton).		http://acdirect.com/heat_pump_goodman_heat_pump_rudd_heat_pump.php (Date: 07/31/06)

Heat Pump (Ruud)	5	\$3,591.00	Ruud	Electric	UPNE-060JAZ UHLA-HM6024JA	13 SEER/8.5 HSPF	Heating Capacity: 57000 Btu/h Cooling Capacity: 5 ton	Achiever by Ruud 5 Ton 13 Seer Variable Speed Air Conditioning System with Heat Pump; One Ruud UPNE series 13 SEER heat pump condenser; One matched indoor air handling unit; One Ruud supplemental electric heating kit.		Price: http://acdirect.com/ (Date: 05/11/2006) Product: http://www.ruudac.com
	6	\$4,366.00	Ruud	Electric		14 SEER/8.5 HSPF		One Ruud UPNE series 14 SEER heat pump condenser One Ruud factory-matched indoor air handler One Ruud supplemental electric heating kit (with electric heat and heat pumps)		http://acdirect.com/xcart/product.php?productid=290 (Date: 07/31/06)
Heat Pump (Rheem)	7	\$4,400.00	Rheem	Electric		13 SEER	5 ton	Price includes labor but not duct work		
	8	\$5,100.00	Rheem	Electric		14 SEER	5 ton	Price includes labor but not duct work		
	9	\$6,100.00	Rheem	Electric		16 SEER	5 ton	Price includes labor but not duct work		
Heat Pump (All Makers)	10	\$5,000.00	All Makers	Electric.	n/a	13 SEER/8.5 HSPF	5 ton	\$1400 / Ton including duct work \$7000 for 5-ton unit with duct work \$5000 for 5-ton unit without duct work		Aggieland A/C & Heating
	11	\$7,000.00	All Makers	Electric.	n/a	15 SEER/8.5 HSPF	5 ton	\$1800 / Ton including duct work \$9000 for 5-5on unit with duct work \$7000 for 5-ton unit without duct work		Aggieland A/C & Heating
	12	\$3,600.00	All Makers	Electric.	n/a	13 SEER/ 8.5 HSPF	5 ton	\$1,800 / Ton including duct work \$9000 for 5-ton unit with duct work \$3600 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC
	13	\$5,800.00	All Makers	Electric.	n/a	15 SEER/ 8.5 HSPF	5 ton	\$2,000 / Ton including duct work \$10000 for 5-ton unit with duct work \$5800 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC
Heat Pump (Trane)	14	\$4,050.00	Trane	Electric	2TWR306081	13 SEER/ 8.5 HSPF	5 ton	\$2700 for installation		JC Innovative Services
	15	\$4,950.00	Trane	Electric.	2TWZ9060B1	15 SEER/ 8.75HSPF	5 ton	\$3300 for installation		JC Innovative Services
Heat Pump (Lennox)	16	\$3,584.00	Lennox	Electric		13 SEER/ 8.5 HSPF	5 ton	R-22		http://www.smarterwvinc.com/res_systems/heat_pump/heatpump1.asp#Lennox
	17	\$5,872.00	Lennox	Electric.		16 SEER/ 8.75HSPF	5 ton	R-410		http://www.smarterwvinc.com/res_systems/heat_pump/heatpump1.asp#Lennox

Furnace

Item	No.	Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	Source
Gas Furnace (Carrier- up to 96.6% AFUE)	1		Carrier	Natural Gas	58MVB	96.6% AFUE	40,000 - 120,000 BTUH	Infinity 96 Gas Furnace; Multipoise, condensing , direct vent/non direct vent gas furnace; Variable speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)
	2	About \$1000 increase in cost	Carrier	Natural Gas	58MTB	93% AFUE	38,000 - 128,000 BTUH	Performance 93 Gas Furnace; Multipoise, condensing , direct vent/non direct vent; 4-5 speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)
	3		Carrier	Natural Gas	58CTA, 58CTX	80% AFUE	40,000 - 154,000 BTUH	Performance 80 Gas Furnace; Induced-combustion; Enhanced comfort control with dual stages of heating; 4-5 speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)
Gas Furnace (Goodman- 80% to 93% AFUE)	4	\$1063/\$768	Goodman	Natural Gas	GMV81155CX/GMS81155CNA	80% AFUE	115,000 BTUH	GMV8 Series 80% AFUE Two-Stage, Variable-Speed/GMS8/GDS8 Series 80% AFUE Single-Stage, Multi-Speed; Upflow/Horiz.		http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp
	5	\$1,658.00	Goodman	Natural Gas	GMV91155DXA	93% AFUE	115,000 BTUH	GMV9/GCV9 Series 93% AFUE Two-Stage, Variable-Speed, Upflow/Horiz.		http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp
Gas Furnace (Rheem- 80% to 93% AFUE)	6	\$1,200.00	Rheem	Natural Gas	RGPN15EARJR	80% AFUE	125,000BTUH	Rheem® Natural / Propane Gas Furnaces		
	7	\$2100/\$2300	Rheem	Natural Gas	RGRA12ERAJS/RGFD12ERCMS	93% AFUE	120,000 BTUH	Rheem® 1-Stage Multi-Speed / Rheem® Modulating Variable Speed		
Gas Furnace (Lennox- 80% to 93% AFUE)	8	\$1,314.00	Lennox	Natural Gas	G40UH60D135	80% AFUE	132,000 BTUH	Up/Horiz		Barkers Heating and Cooling, http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp
	9	\$2492/\$2043	Lennox	Natural Gas	G61MPV60D135/G61MP60D135	94% AFUE	132,000 BTUH	Lennox Signature® Collection G61V 94+% AFUE Two-Stage, Variable-Speed Furnaces/Lennox Signature® Collection G61 94.1% AFUE Two-Stage, Multi-Speed Furnaces. Up/Horiz./Down		

Electric Furnace (Goodman)	10	\$943/\$1975	Goodman	Electric			51,200 BTUH	Goodman 5 Ton Standard Electric Furnace Air Handler; One Goodman indoor air handling heating unit (ARUF060-00A-1), multi-position including evaporator cooling coil; One Goodman matched heat strip element for field installation into indoor unit		http://acdirect.com/ (Date: 05/11/2006)
	11	1330/\$2623	Goodman	Electric			51,200 BTUH	Goodman 3.5 - 5 Ton Variable Speed Electric Furnace Air Handler; One Goodman indoor air handling heating unit (AEPT060-00A-1), multi-position including evaporator cooling coil; One Goodman matched heat strip element for field installation into indoor unit		http://acdirect.com/ (Date: 05/11/2006)