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RECOMMENDATIONS FOR 15% ABOVE-CODE ENERGY EFFICIENCY MEASURES FOR COMMERCIAL OFFICE BUILDINGS

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

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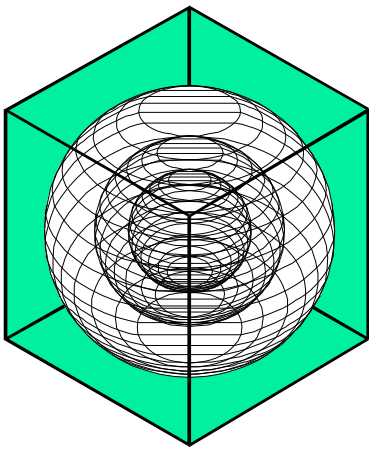

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Executive Summary

This report presents detailed information about the recommendations for achieving 15% above-code energy performance for commercial office buildings complying with ASHRAE Standard 90.1-1999[1]. To accomplish the 15% annual energy consumption reductions, ten measures were considered. After energy savings were determined for each measure, they were then placed in several groups to accomplish a minimum of 15% total annual energy consumption reduction. The analysis in this paper uses the total annual energy consumption of a simulated commercial building to determine the 15% above-code recommendations. The analysis also reports end-use energy use, including: heating, cooling, domestic hot water use, fans, heat rejection, equipment and lighting loads, and miscellaneous loads as defined by the BEPS and BEPU reports from the DOE-2 program. Since the 15% above-code savings use annual energy cost savings, these same measures will report greater savings when compared against total heating and cooling loads, which has been used in other above-code program recommendations.

[1] The analysis was conducted using OFFICE.inp version 1.66.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Base Case Building Description

The base-case building simulation model in this analysis is based on specifications in ASHRAE 90.1 1999. Table 1 summarizes the base-case building characteristics used in the DOE-2 simulation model. The simulation used the DOE-2 program and the TMY2 hourly weather data for Houston. Electricity costs were $0.119/kWh, demand charges were $5.00/kW, and costs for natural gas were $8.00/MCF.

1.1. Building Envelope, Lighting and Fenestration Characteristics

The analysis was performed for a 6-story office building (89,304 ft^2), with a 50% window-to-wall ratio that follows the prescriptive tables in ASHRAE 90.1-1999. Four perimeter zones and a central core zone were modeled for each floor.

Based on climate specific characteristics, the base case was modeled with a wall insulation of R-13 value and a roof insulation of R-15. The U-value of the windows in the base-case building was set at 1.22 Btu/hr ºF ft^2.[2] As per ASHRAE 90.1 1999, the SHGC of the base-case building set at 0.44 for the north orientation and 0.17 for the other orientations[3]. Window overhangs or shading were not used. The base-case building was modeled with a lighting power density (LPD) of 1.3 W/ft^2, which is the maximum value for office applications, allowed by ASHRAE 90.1-1999[4]. The electric lighting profile was set to the recommended profile from ASHRAE's Diversity Factor Toolkit (RP-1093), as shown in Figure 1 (Abushakra et al. 2001).

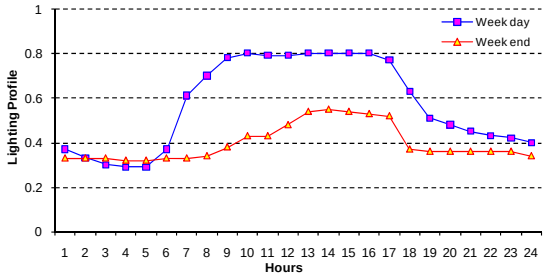


Figure 1: Base Case Lighting Profile for a Large Commercial Building (Source: Abushakra et al., 2001).

1.2. HVAC System Characteristics

The base-case building model used a variable air volume (VAV) system with terminal reheat that was set to have a total supply air static pressure of 2.5 inches of water (gauge), and has a constant supply air temperature of 55 ºF.

1.3. Plant Characteristics

The base-case building has one 160 ton (1.926 MBtu/hr) screw chiller[5] with a COP of 4.9, and a constant speed chilled water pump. Two options for the heating fuel type were considered: a) natural gas (natural gas hot water boiler for space heating, and natural gas water heater for service water heating) and b) electricity (electric resistance hot water boiler for space heating, and electric water heater for service water heating). In the other sections of this report, these buildings will be referred to as (a) electric/gas building and (b) all-electric building, respectively. For the electric/gas building, heating is provided by two 731 kBtu/hr hot water gas boilers[6] with an efficiency of 75%. For the all-electric building, heating was provided by an electric resistance boiler with an efficiency of 100%.

[2] ASHRAE Standard 90.1-1999, Table B-5(Climate zone for Houston), p. 95.
[3] ASHRAE Standard 90.1-1999, Table B-5(Climate zone for Houston), p. 95.
[4] ASHRAE Standard 90.1-1999, Table 9.3.1.1, p. 51.
[5] As required by ASHRAE 90.1-1999, Table 6.2.1C, p. 29, for chiller sizes between 100 tons and 300 tons.
[6] As required by ASHRAE 90.1-1999, Table 6.2.1F, p. 31.

Table 1: Base Case Building Description

CHARACTERISTIC	BASECASE ASSUMPTIONS		SOURCES
Building			
Building type	Office		
Gross area (sq. ft.)	89,304		Prototypical office building size and number of floors (Huang & Franconi, 1999, p.31)
Dimension (ft. x ft.)	122 x 122		
Number of floors	6		
Floor to floor height (ft.)	13		ASHRAE 90.1-1989-13.7.1 (p.105)
Construction			
Roof absorptance	0.7		ASHRAE 90.1-1999-11.4.2(b) (p.58)
Roof insulation R-value (hr-sq. ft.-°F/Btu)	15		ASHRAE 90.1-1999, Table B-5 (11.4.2(a)), (p.95)
Wall absorptance	0.7		ASHRAE 90.1-1989-13.7.3.3 (p.106)
Wall insulation R-value (hr-sq. ft.-°F/Btu)	13		ASHRAE 90.1-1999, Table B-5 (11.4.2(a)), (p.95)
Ground reflectance	0.2		ASHRAE 90.1-1989-13.7.3.3 (p.106)
U-Factor of glazing (Btu/hr-sq. ft.-°F)	1.22		ASHRAE 90.1-1999, Table B-5 (11.4.2(c)), (p.95)
Solar Heat Gain Coefficient (SHGC)	0.17		ASHRAE 90.1-1999, Table B-5 (11.4.2(c)), (p.95)
Window-to-wall ratio (%)	50		Average WWR of new construction (Huang & Franconi, 1999, p.31[1])
Space			
Area per person (ft^2/person) for office	275 (325 occupants)		ASHRAE 90.1-1989, Table 13-2, (p.103)
Occupancy schedule	8am-10pm (Monday - Saturday)		ASHRAE 90.1-1989, Table 13-3, (p.104)
Space temperature setpoint	70°F Heating / 75°F Cooling		ASHRAE 90.1-1989-13.7.6.2 (p.110)
Lighting load (W/ft2) for Office	1.3		ASHRAE 90.1-1999, Table 9.3.1.1, (p.51)
Lighting schedule	24 hours (Monday - Saturday)		Abushakra et al., 2001, (ASHRAE RP-1093, p.61)
Equipment load (W/ft2) for office	0.75		ASHRAE 90.1-1989, Table 13-4, (p.106)
Equipment schedule	24 hours (Monday - Saturday)		Abushakra et al., 2001, (ASHRAE RP-1093, p.62)
HVAC Systems			
HVAC system type	VAV with terminal reheat		ASHRAE 90.1-1999, Table 11.4.3A, (p.59, System2)
Number of HVAC units	5		Serving 5 thermal zones
Supply motor efficiency (%)	90		Kavanaugh, 2003 (p.38)
Supply fan efficiency (%)	61		ASHRAE 90.1-1989, Table 13-6, (p.108, System #5)
Supply fan total pressure (in W.G)	2.5		Info. by ESL CC engineers
Plant Equipment			
Chiller type	Screw		ASHRAE 90.1-1999, Table 6.2.1C, (p.29)
Chiller COP	4.9		ASHRAE 90.1-1999, Table 6.2.1C, (p.29)
Boiler type	Hot water boiler	Electric resistance boiler	ASHRAE 90.1-1999, Table 11.4.3A, (p.59, System2)
Boiler fuel type	Natural gas	Electricity	ASHRAE 90.1-1999, Table 11.4.3A, (p.59, System2)
Boiler thermal efficiency (%)	75	100	ASHRAE 90.1-1999, Table 6.2.1F, (p.31)
DHW fuel type	Natural gas		ASHRAE 90.1-1999, Table 7.2.2, (p.47)
DHW heater thermal efficiency (%)	80		ASHRAE 90.1-1999, Table 7.2.2, (p.47)

2. Energy Efficiency Measures (EEMs)

A total of 10 measures were considered to achieve a 15% annual energy consumption reduction when compared to code (ASHRAE 90.1, 1999) for the electric/gas and the all-electric buildings. These measures included improved glazing U-value, decreasing lighting power density, window shading, reducing static pressure, improving chiller COP, improving boiler efficiency, cold deck reset, VSDs on chilled and hot water pumps, and occupancy sensors for lighting control. After costs were determined for each measure, they were then placed in several groups to accomplish a minimum of 15% total annual energy consumption reduction. A list of all measures is provided in Table 2.

Table 2: Energy Efficiency Measures

	NATURAL GAS HEATING/NATURAL GAS DHW SYSTEM	ELECTRIC RESISTANCE HEATING / ELECTRIC DHW SYSTEM
A	**Envelope and Fenestration Measures**	
1	Improved Window Performance (U-factor = 0.45 Btu/hr-sqft C)	Improved Window Performance (U-factor = 0.45 Btu/hr-sqft C)
2	Improved lighting load (1W/sqft)	Improved lighting load (1W/sqft)
3	Occupancy sensors for lights	Occupancy sensors for lights (Using occupancy schedules)
4	Shading (ft) (From 0 ft to 2.5 ft)	Shading (ft) (From 0 ft to 2.5 ft)
B	**HVAC System Measures**	
5	Cold deck reset (Constant to variable)	Cold deck reset (From 55F to 60:55F; 55:85F)
6	Supply fan total pressure (From 2.5 inW.G. to 1.5 inW.G.)	Supply fan total pressure (From 2.5 inW.G. to 1.5 inW.G.)
C	**Plant Equipment Measures**	
7	Chiller COP (from 4.9 to 6.1)	Chiller COP (from 4.9 to 6.1)
8	Boiler efficiency (75% to 90%)	NA
9	VSD on chilled water loop	VSD on chilled water loop
10	VSD on hot water loop	VSD on hot water loop

3. Simulation Input

Table 3 and Table 4 list the inputs for simulating the measures in a representative office building located in Houston, Texas for an electric/gas building (Table 3) and an all-electric building (Table 4). Both systems had an electric chiller with a VAV air-handling unit. The values used for base case are presented in the first row of each of the tables. The subsequent rows present information used in each of the individual energy efficiency measures. The shaded boxes in each row indicate changes in input values of the measures being simulated.

4. Simulation Results

Table 5 and Table 6 summarize the annual energy use, energy costs[7], savings (both energy and dollars), implementation costs, and the calculated simple payback periods for the energy efficiency measures simulated for both the electric/gas building (Table 5), and the all-electric building (Table 6), for a building in Houston, Texas. In order to calculate the 15% above-code annual energy cost savings, the simulated electric and/or natural gas use was converted into total annual energy costs[8].

Figure 2 through Figure 7 graphically present the results of the simulations and cost analysis. Figure 2 and Figure 3 present the impact of energy efficiency measures on different energy uses; Figure 4 and Figure 5 present the first cost and the energy cost savings for different measures; Figure 6 and Figure 7 show the corresponding payback period in years.

4.1. Base Case Energy Use

The total annual energy consumption for the base-case building in Houston, Texas, was 5,658 MMBtu for the electric/gas building, and 5,554 MMBtu for the all-electric building.

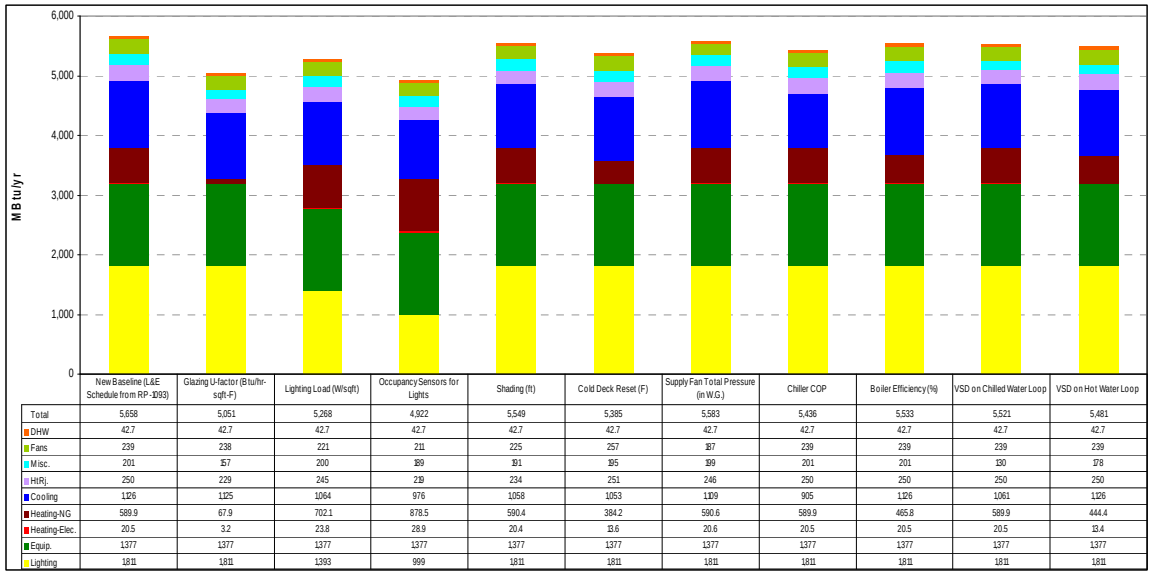
[7] The energy use shown was obtained from DOE-2's BEPS and BEPU report.
[8] This is required when simulating a code-compliant building that follows ASHRAE Standard 90.1-1999. For this analysis costs of $.119/kWh, $5/kW and $.80/therms were used.

Table 3: Specifications for an Electric/Gas Building.

EEM #	Energy Efficiency Measures	Glazing U-factor (Btu/hr-sqft-F)	Lighting Load (W/sqft)	Occupancy Sensors for Lights	Shading (ft)	Cold Deck Reset (F)	Supply Fan Total Pressure (in W.G.)	Chiller COP	Boiler Efficiency (%)	VSD on Chilled Water Loop	VSD on Hot Water Loop
	BaseCase	1.22	1.3	None	None	55	2.5	4.9	Efficiency	Constant Speed	Lighting Schedule
Envelope and fenestration measures											
1	Glazing U-factor (Btu/hr-sqft-F)	**0.45**	1.3	None	None	55	2.5	4.9	75	Constant Speed	Constant Speed
2	Lighting Load (W/sqft)	1.22	**1**	None	None	55	2.5	4.9	75	Constant Speed	Constant Speed
3	Occupancy Sensors for Lights	1.22	1.3	**Lit. Sch. = Occ. Sch.**	None	55	2.5	4.9	75	Constant Speed	Constant Speed
4	Shading (ft)	1.22	1.3	None	**2.5**	55	2.5	4.9	75	Constant Speed	Constant Speed
HVAC System Measures											
5	Cold Deck Reset (F)	1.22	1.3	None	None	**(60:55,55:85)**	2.5	4.9	75	Constant Speed	Constant Speed
6	Supply Fan Total Pressure (in W.G.)	1.22	1.3	None	None	55	**1.5**	4.9	75	Constant Speed	Constant Speed
Plant Equipment Measures											
7	Chiller COP	1.22	1.3	None	None	55	2.5	**6.1**	75	Constant Speed	Constant Speed
8	Boiler Efficiency (%)	1.22	1.3	None	None	55	2.5	4.9	**95**	Constant Speed	Constant Speed
9	VSD on Chilled Water Loop	1.22	1.3	None	None	55	2.5	4.9	75	**Variable Speed**	Constant Speed
10	VSD on Hot Water Loop	1.22	1.3	None	None	55	2.5	4.9	75	Constant Speed	**Variable Speed**

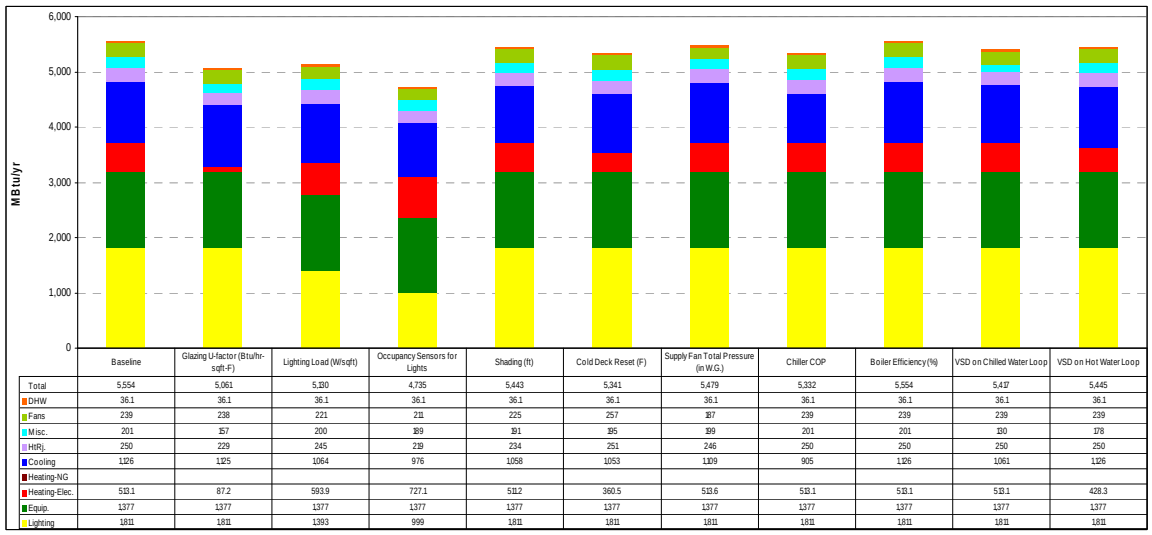
Table 4: Specifications for an All-Electric Building.

EEM #	Energy Efficiency Measures	Glazing U-factor (Btu/hr-sqft-F)	Lighting Load (W/sqft)	Occupancy Sensors for Lights	Shading (ft)	Cold Deck Reset (F)	Supply Fan Total Pressure (in W.G.)	Chiller COP	Boiler Efficiency (%)	VSD on Chilled Water Loop	VSD on Hot Water Loop
	BaseCase	1.22	1.3	None	None	55	2.5	4.9	100	Constant Speed	Lighting Schedule
Envelope and fenestration measures											
1	Glazing U-factor (Btu/hr-sqft-F)	**0.45**	1.3	None	None	55	2.5	4.9	100	Constant Speed	Constant Speed
2	Lighting Load (W/sqft)	1.22	**1**	None	None	55	2.5	4.9	100	Constant Speed	Constant Speed
3	Occupancy Sensors for Lights	1.22	1.3	**Lit. Sch. = Occ. Sch.**	None	55	2.5	4.9	100	Constant Speed	Constant Speed
4	Shading (ft)	1.22	1.3	None	**2.5**	55	2.5	4.9	100	Constant Speed	Constant Speed
HVAC System Measures											
5	Cold Deck Reset (F)	1.22	1.3	None	None	**(60:55,55:85)**	2.5	4.9	100	Constant Speed	Constant Speed
6	Supply Fan Total Pressure (in W.G.)	1.22	1.3	None	None	55	**1.5**	4.9	100	Constant Speed	Constant Speed
Plant Equipment Measures											
7	Chiller COP	1.22	1.3	None	None	55	2.5	**6.1**	100	Constant Speed	Constant Speed
8	Boiler Efficiency (%)	1.22	1.3	None	None	55	2.5	4.9	100	Constant Speed	Constant Speed
9	VSD on Chilled Water Loop	1.22	1.3	None	None	55	2.5	4.9	100	**Variable Speed**	Constant Speed
10	VSD on Hot Water Loop	1.22	1.3	None	None	55	2.5	4.9	100	Constant Speed	**Variable Speed**



	New Baseline (L&E Schedule from RP-1093)	Glazing U-factor (Btu/hr-sqft-F)	Lighting Load (W/sqft)	Occupancy Sensors for Lights	Shading (ft)	Cold Deck Reset (F)	Supply Fan Total Pressure (in W.G.)	Chiller COP	Boiler Efficiency (%)	VSD on Chilled Water Loop	VSD on Hot Water Loop
Total	5,658	5,051	5,268	4,922	5,549	5,385	5,583	5,436	5,533	5,521	5,481
DHW	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7
Fans	239	238	221	211	225	257	187	239	239	239	239
Misc.	201	157	200	189	191	195	199	201	201	130	178
HtRj.	250	229	245	219	234	251	246	250	250	250	250
Cooling	1,126	1,125	1,064	976	1,058	1,053	1,109	905	1,126	1,061	1,126
Heating-NG	589.9	67.9	702.1	878.5	590.4	384.2	590.6	589.9	465.8	589.9	444.4
Heating-Elec.	20.5	3.2	23.8	28.9	20.4	13.6	20.6	20.5	20.5	20.5	13.4
Equip.	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377
Lighting	1,811	1,811	1,393	999	1,811	1,811	1,811	1,811	1,811	1,811	1,811

Figure 2: Energy Use for Individual Energy Efficiency Measures (Electric/Gas) for Houston, Texas.



	Baseline	Glazing U-factor (Btu/hr-sqft-F)	Lighting Load (W/sqft)	Occupancy Sensors for Lights	Shading (ft)	Cold Deck Reset (F)	Supply Fan Total Pressure (in W.G.)	Chiller COP	Boiler Efficiency (%)	VSD on Chilled Water Loop	VSD on Hot Water Loop
Total	5,554	5,061	5,180	4,735	5,443	5,341	5,479	5,332	5,554	5,417	5,445
DHW	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
Fans	239	238	221	211	225	257	187	239	239	239	239
Misc.	201	157	200	189	191	195	199	201	201	130	178
HtRj.	250	229	245	219	234	251	246	250	250	250	250
Cooling	1,126	1,125	1,064	976	1,058	1,053	1,109	905	1,126	1,061	1,126
Heating-NG											
Heating-Elec.	513.1	87.2	593.9	727.1	511.2	360.5	513.6	513.1	513.1	513.1	428.3
Equip.	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377	1,377
Lighting	1,811	1,811	1,393	999	1,811	1,811	1,811	1,811	1,811	1,811	1,811

Figure 3: Energy Use for Individual Energy Efficiency Measures (All-Electric) for Houston, Texas.

4.2. Energy Savings from Various EEMs

For both building types, the implementation of occupancy sensors for lighting and improved glazing U-factors had the greatest individual impact on the total annual energy consumption of the building. The implementation of occupancy sensors in the electric/gas building yields an annual energy consumption savings of 736 MBtu (13%). This same measure in the all-electric building yields a savings of 819 MBtu (14.7%). Surprisingly, the implementation of shading strategies and reduction of the supply fan static pressure resulted in comparatively small annual savings. For the electric/gas building, the implementation of shading strategies yields an annual energy savings of 108 MBtu (1.9%). This same measure in the all-electric building yields a savings of 110 MBtu (2%).

Table 5: Summary of Annual Energy Use, Energy Costs, Savings, Implementation Costs, and Payback Periods for Houston, Texas (All-Electric).

EEM #	Energy Efficiency Measures	Energy Use (MBtu/yr)					Energy Use (Utility Units)			Energy Savings					Increased First Year Cost ($)	Payback
		Cooling	Heating	DHW	Other	Total	kWh/yr	therms/yr	$/yr	MBtu/yr	%	kWh/yr	therms/yr	$/yr		(yrs)
Envelope and Fenestration Measures																
Basecase		1,126	590	43	3,899	5,658	1,472,338	6,325	$196,566							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	1,125	68	43	3,815	5,051	1,447,640	1,106	$188,935	606	10.7%	24,698	5,219	$7,631	$95,130 - $174,150	12.5 - 22.8
2	Lighting Load (1.3 to 1.0 w/sq-ft)	1,064	702	43	3,460	5,268	1,325,451	7,447	$178,289	389	6.9%	146,887	-1,122	$18,277	$0 - $0	0.0 - 0.0
3	Occupancy Sensors Installation	976	879	43	3,024	4,922	1,172,190	9,211	$163,534	736	13.0%	300,148	-2,886	$33,032	$26,500 - $28,000	0.8 - 0.8
4	Shading (none to 2.5 ft overhangs)	1,058	590	43	3,859	5,549	1,440,495	6,331	$192,343	108	1.9%	31,843	-6	$4,223	$67,900 $110,000	16.1 - 26.0
HVAC System Measures																
Basecase		1,126	590	43	3,899	5,658	1,472,338	6,325	$196,566							
5	Cold Deck Reset	1,053	384	43	3,905	5,385	1,452,735	4,269	$192,679	273	4.8%	19,603	2,056	$3,887	$0 - $800	0.0 - 0.2
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1,109	591	43	3,841	5,583	1,450,195	6,333	$193,608	75	1.3%	22,143	-8	$2,958	$0 - $200	0.0 - 0.1
Plant Equipment Measures																
Basecase		1,126	590	43	3,899	5,658	1,472,338	6,325	$196,566							
7	Chiller COP (4.9 to 6.1)	905	590	43	3,899	5,436	1,407,487	6,325	$187,848	221	3.9%	64,851	0	$8,718	$16,000 - $18,000	1.8 - 2.1
8	Boiler Efficiency	1,126	466	43	3,899	5,533	1,472,338	5,084	$195,573	124	2.2%	-64,851	1,241	$993	$25,000 - $35,000	25.2 - 35.3
9	VSD on Chilled Water Pump (from Constant to VSD)	1,061	590	43	3,828	5,521	1,432,301	6,325	$191,681	137	2.4%	40,037	0	$4,885	$3,700 - $4,700	0.8 - 1.0
10	VSD on Hot Water Pump (from Constant to VSD)	1,126	444	43	3,868	5,481	1,463,265	4,871	$194,260	176	3.1%	9,073	1,454	$2,306	$4,000 - $5,000	1.7 - 2.2

Table 6: Summary of Annual Energy Use, Energy Costs, Savings, Implementation Costs, and Payback Periods for Houston, Texas (All-Electric).

EEM #	Energy Efficiency Measures	Energy Use (MBtu/yr)					Energy Use (Utility Units)			Energy Savings					Increased First Year Cost ($)	Payback
		Cooling	Heating	DHW	Other	Total	kWh/yr	therms /yr	$/yr	MBtu/yr	%	kWh/yr	therms /yr	$/yr		(yrs)
Envelope and Fenestration Measures																
Basecase		1,126	513	36	3,879	5,554	1,627,216	0	$214,554							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	1,125	87	36	3,812	5,061	1,482,815	0	$192,644	493	8.9%	144,401	0	$21,910	$95,130 - $174,150	4.3 - 7.9
2	Lighting Load (1.3 to 1.0 w/sq-ft)	1,064	594	36	3,436	5,130	1,503,067	0	$199,237	424	7.6%	124,149	0	$15,317	$0 - $0	0.0 - 0.0
3	Occupancy Sensors Installation	976	727	36	2,995	4,735	1,387,338	0	$187,476	819	14.7%	239,878	0	$27,078	$26,500 $0 $28,000	1.0 - 1.0
4	Shading (none to 2.5 ft overhangs)	1,058	511	36	3,838	5,443	1,594,868	0	$210,233	110	2.0%	32,348	0	$4,321	$67,900 $110,000	15.7 - 25.5
HVAC System Measures																
Basecase		1,126	513	36	3,879	5,554	1,627,216	0	$214,554							
5	Cold Deck Reset	1,053	0	36	4,252	5,341	1,564,931	0	$205,898	213	3.8%	62,285	0	$8,656	$0 - $800	0.0 - 0.1
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1,109	0	36	4,334	5,479	1,605,230	0	$211,638	75	1.4%	21,986	0	$2,916	$0 - $200	0.0 - 0.1
Plant Equipment Measures																
Basecase		1,126	513	36	3,879	5,554	1,627,216	0	$214,554							
7	Chiller COP (4.9 to 6.1)	905	0	36	4,392	5,332	1,562,366	0	$206,072	221	4.0%	64,850	0	$8,482	$16,000 - $18,000	1.8 - 2.1
8	Boiler Efficiency (Not Aplicable)	1,126	0	36	4,372	5,533	1,627,216	0	$214,554	0	0.0%	0	0	$0	NA - NA	0.0 - 0.0
9	VSD on Chilled Water Pump (from Constant to VSD)	1,061	0	36	4,320	5,417	1,587,179	0	$209,582	137	2.5%	40,037	0	$4,972	$3,700 - $4,700	0.7 - 0.9
10	VSD on Hot Water Pump (from Constant to VSD)	1,126	0	36	4,283	5,445	1,595,389	0	$210,594	109	2.0%	31,827	0	$3,960	$4,000 - $5,000	1.7 - 2.2

4.3. Cost Effectiveness of Various EEMs

Figure 4 (electric/gas) and Figure 5 (all-electric) show the increased costs and annual energy cost savings from the energy-efficiency measures for lowered energy consumption for the different measures adopted. For example, in an electric/gas building with an improved glazing U-factor, the estimated first costs increased by $134,640 and saved $7,631, which represents a payback period of 12 years. In contrast, installing occupancy sensors cost $27,250, which saved $33,031, for a simple payback of less than one year. For both system types, four measures had very favorable paybacks of less than four years. These include occupancy sensors, improved chiller COP, and VSDs on the hot and chilled water pumps. Figure 6 (electric/gas) and Figure 7 (all-electric) present the payback period in years for each of the measures implemented. Shading strategies did not perform well for both building types. The average first costs of installing shading strategies were $88,000 for both building types. However, the energy savings obtained from implementing these strategies was $4,233 for the electric/gas building and $4,321 for the all-electric building. The resulting average payback periods were 21 years for both building types.

4.4. 15% Above-Code Energy Savings

Figures 8 and 9 present the 15% above-code savings charts for an electric/gas building (Figure 8) and an all-electric building (Figure 9). These charts represent the final summary presentation of the detailed information previously shown in Tables 1 to 5 and Figures 4 to 7. In Figures 8 and 9 the results are presented for Houston, Texas, which are also applicable for Brazoria, Fort Bend, Galveston, Harris, Montgomery, and Waller counties. Similar results for other non-attainment[9] counties in Texas can be found in the attachment of this report or the Laboratory's Senate Bill 5 website (eslsb5.tamu.edu).

In these figures, the upper table summarizes the results for individual measures in terms of annual energy savings (percent and dollars/year), annual demand savings (percent and dollars/year), combined savings (energy and demand in dollars/year), and the estimated costs for each measure[10]. The second table in each figure summarizes the results obtained by implementing combinations of measures. Results are presented in terms of combined energy savings (percent and dollars/year), combined demand savings (percent and dollars/year), combined savings (energy plus demand in dollars/year), combined implementation costs (marginal and new system costs) and simple payback periods (years). NOx emissions reductions for each of the combinations are also presented in terms of annual NOx emission savings (lbs/year) and savings during the ozone season period (OSP)[11] (lbs/day). The maps of all the non-attainment and near non-attainment counties and specific counties for each page are included in the upper and lower figures.

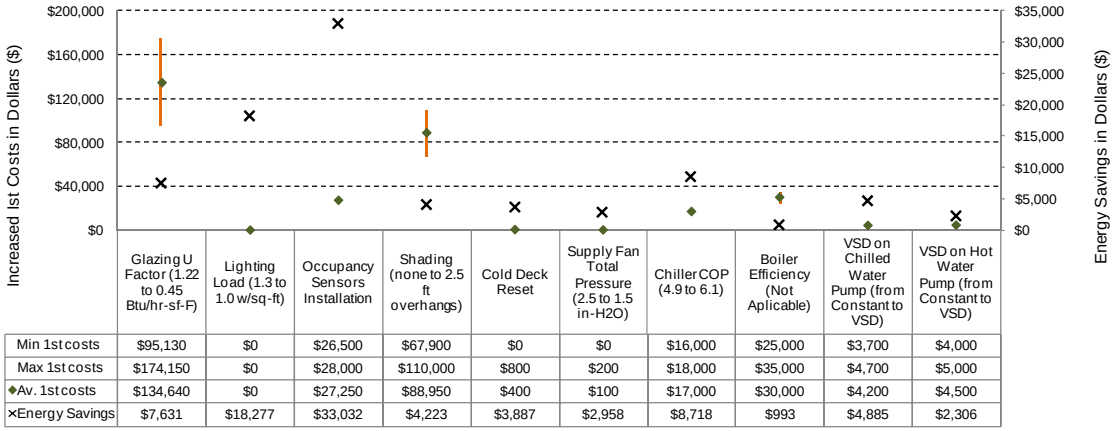
For the case of an electric/gas building, combining the measures of a glazing U-value of 0.45 Btu/hr-ft^2-°F and a lighting load of 1 W/ft^2 in combination 1 yields a combined energy savings of 20%. Combining the measures of installing occupancy sensors and a cold deck reset in combination 2 yields a combined energy savings of 19.6%. Combination 3 consists of implementing a low glazing U-value of 0.45 Btu/hr-ft^2-°F, a chiller COP of 6.1, a boiler efficiency of 95%, and a VSD on the chilled water pump which yields a combined energy savings of 16.8%.

For the case of an all-electric building, combining the measures of a glazing U-value of 0.45 Btu/hr-ft^2-°F and a lighting load of 1 W/ft^2 in combination 1 yields a combined energy savings of 18.5%. Combining the measures of installing occupancy sensors and a cold deck reset in combination 2 yields a combined energy savings of 19.8%. Combination 3 consists of implementing a low glazing U-value of 0.45 Btu/hr-ft^2-°F, a chiller COP of 6.1, and VSDs on the chilled water pump and hot water pump which yields a combined energy savings of 15.5%.

[9] The Clean Air Act and Amendments of 1990 define a "nonattainment area" as a locality where air pollution levels persistently exceed National Ambient Air Quality Standards, or that contributes to ambient air quality in a nearby area that fails to meet standards. (http://www.scorecard.org/env-releases/def/cap_naa.html)

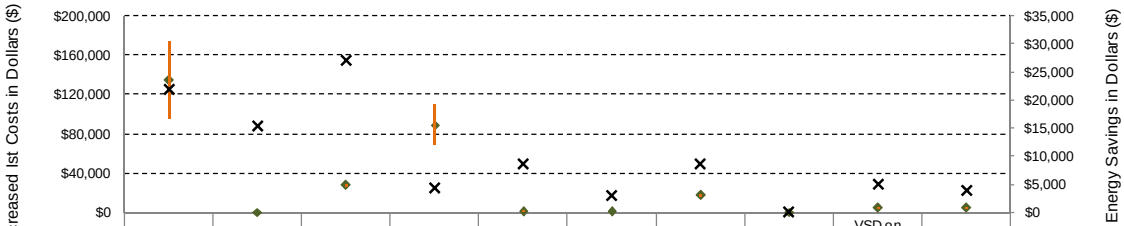
[10] The costs for measures are presented as marginal costs and new systems costs, where marginal costs represent the incremental costs to implement the measure by modifying an existing system. New system costs represent costs for newly installed measures.

[11] The Ozone Season Period (OSP) represents average daily savings during the hottest period of the year from mid-July to mid-September as defined by the U.S.E.P.A.



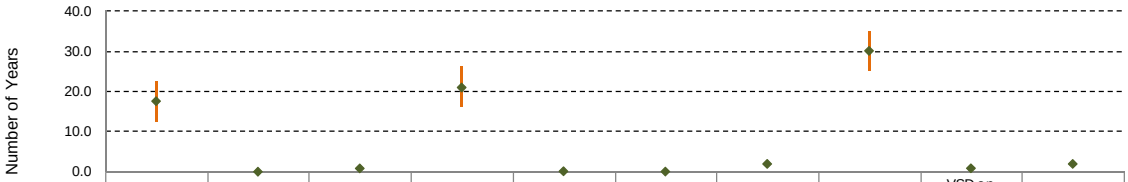
	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	Lighting Load (1.3 to 1.0 w/sq-ft)	Occupancy Sensors Installation	Shading (none to 2.5 ft overhangs)	Cold Deck Reset	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	Chiller COP (4.9 to 6.1)	Boiler Efficiency (Not Aplicable)	VSD on Chilled Water Pump (from Constant to VSD)	VSD on Hot Water Pump (from Constant to VSD)
Min 1st costs	$95,130	$0	$26,500	$67,900	$0	$0	$16,000	$25,000	$3,700	$4,000
Max 1st costs	$174,150	$0	$28,000	$110,000	$800	$200	$18,000	$35,000	$4,700	$5,000
◆Av. 1st costs	$134,640	$0	$27,250	$88,950	$400	$100	$17,000	$30,000	$4,200	$4,500
×Energy Savings	$7,631	$18,277	$33,032	$4,223	$3,887	$2,958	$8,718	$993	$4,885	$2,306

Figure 4: Increased First Costs and Energy Savings for the Selected Measures (Electric/Gas).



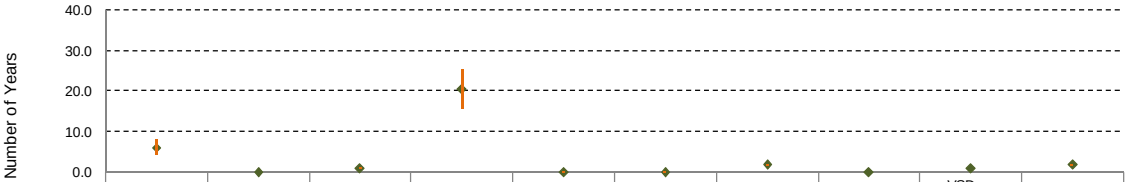
	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	Lighting Load (1.3 to 1.0 w/sq-ft)	Occupancy Sensors Installation	Shading (none to 2.5 ft overhangs)	Cold Deck Reset	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	Chiller COP (4.9 to 6.1)	Boiler Efficiency (Not Aplicable)	VSD on Chilled Water Pump (from Constant to VSD)	VSD on Hot Water Pump (from Constant to VSD)
Min 1st costs	$95,130	$0	$26,500	$67,900	$0	$0	$16,000	$0	$3,700	$4,000
Max 1st costs	$174,150	$0	$28,000	$110,000	$800	$200	$18,000	$0	$4,700	$5,000
◆Av. 1st costs	$134,640	$0	$27,250	$88,950	$400	$100	$17,000	$0	$4,200	$4,500
×Energy Savings	$21,910	$15,317	$27,078	$4,321	$8,656	$2,916	$8,482	$0	$4,972	$3,960

Figure 5: Increased First Costs and Energy Savings for the Selected Measures (All-Electric).



	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	Lighting Load (1.3 to 1.0 w/sq-ft)	Occupancy Sensors Installation	Shading (none to 2.5 ft overhangs)	Cold Deck Reset	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	Chiller COP (4.9 to 6.1)	Boiler Efficiency	VSD on Chilled Water Pump (from Constant to VSD)	VSD on Hot Water Pump (from Constant to VSD)
Min Years	12.5	0.0	0.8	16.1	0.0	0.0	1.8	25.2	0.8	1.7
Max Years	22.8	0.0	0.8	26.0	0.2	0.1	2.1	35.3	1.0	2.2
◆Av. Years	18	0	1	21	0	0	2	30	1	2

Figure 6: Payback Periods for the Selected Measures (Electric/Gas).



	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	Lighting Load (1.3 to 1.0 w/sq-ft)	Occupancy Sensors Installation	Shading (none to 2.5 ft overhangs)	Cold Deck Reset	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	Chiller COP (4.9 to 6.1)	Boiler Efficiency (Not Aplicable)	VSD on Chilled Water Pump (from Constant to VSD)	VSD on Hot Water Pump (from Constant to VSD)
Min Years	4.3	0.0	1.0	15.7	0.0	0.0	1.8	0.0	0.7	1.7
Max Years	7.9	0.0	1.0	25.5	0.1	0.1	2.1	0.0	0.9	2.2
◆Av Years	6	0	1	21	0	0	2	0	1	2

Figure 7: Payback Periods for the Selected Measures (All-Electric).

5. Description of Energy Efficiency Measures (EEMs)

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

5.1. Energy Efficiency Measure 1: Improved Glazing U-value (1.22 vs. 0.45)

Base Case
As per ASHRAE 90.1 1999, the U-value of the windows in the base-case building was set at 1.22 Btu/hr-ft^2-°F [12]. The SHGC of the base-case building was set at 0.44 for the north orientation and 0.17 for the other orientations[13]. Window overhangs or shading were not used.

Decreased Glazing U-value (from 1.22 to 0.45)
To improve the glazing performance, the U-value was reduced to 0.45 Btu/hr-ft^2-°F [14] from 1.22 Btu/hr-ft^2-°F (ASHRAE 2004). This U-value was chosen to minimize winter-time heat loss using available commercial glazing products. The SHGC of the base-case building remained at 0.44 for the north orientation and 0.17 for the other orientations[15].

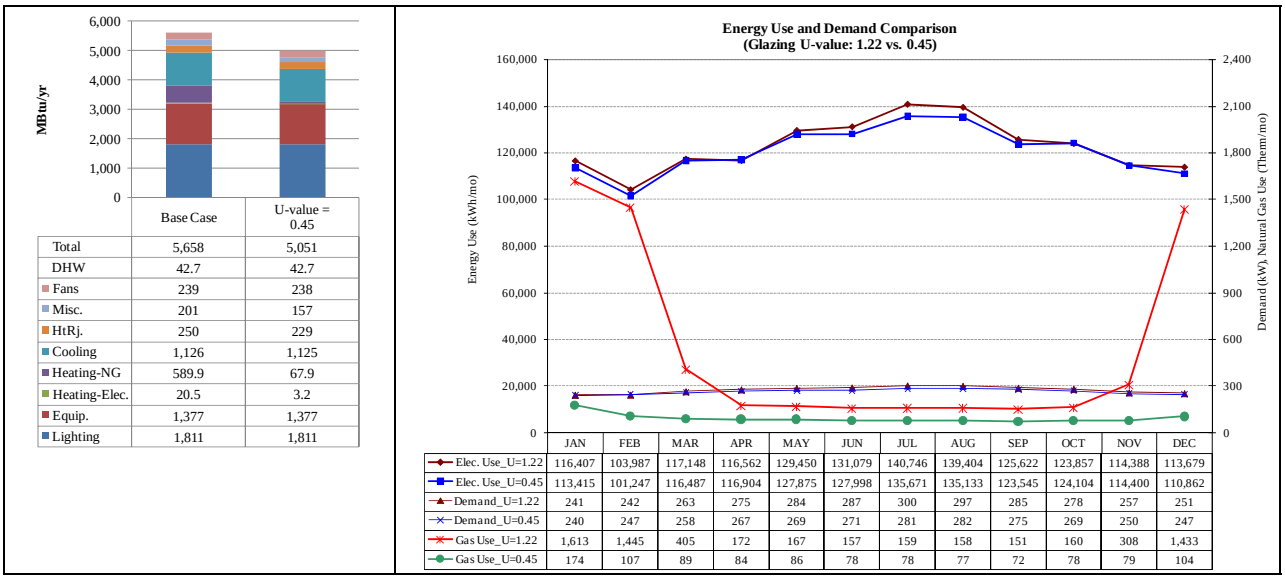
Energy Savings
Figure 8 and Figure 9 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 8 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,125 MMBtu/year.
- Reduced the space heating energy from 610 MMBtu/year to 71 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,051 MMBtu/year, i.e., 606.3 MMBtu/year of total energy savings,
- Reduced the electricity use from 1,472,338 kWh/year to 1,325,451 kWh/year, i.e., 24,698 kWh/year electricity savings,
- Reduced the gas use from 6,325 therms/year to 1,106 therms/year, i.e., 5,219 therms/year gas savings, and
- Reduced the peak demand from 3,260 kW to 3,156 kW.

Figure 9 shows that this measure applied to an all-electric base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,125 MMBtu/year,
- Reduced the space heating energy from 513.1 MMBtu/year to 87.2 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,061 MMBtu/year, i.e., 493 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,482,815 kWh/year, i.e., 144,401 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 3,238 kW.

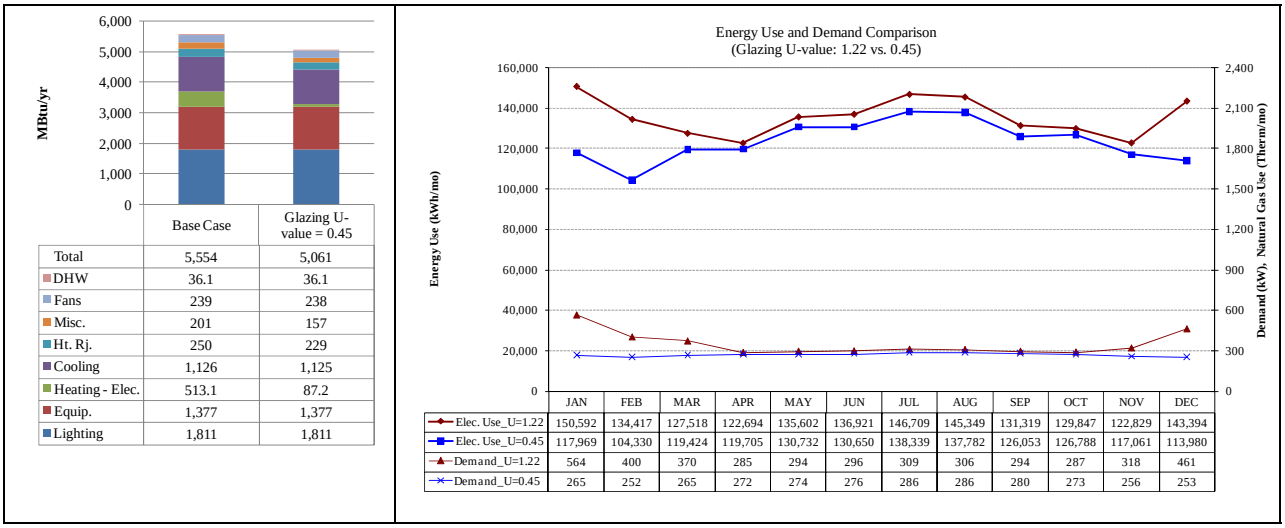
[12] ASHRAE Standard 90.1-1999, Table B-5(Climate zone for Houston), p. 95.
[13] ASHRAE Standard 90.1-1999, Table B-5(Climate zone for Houston), p. 95.
[14] From Table for Climate Zone 2 from Advanced Energy Design Guide for Small Office Buildings. Although this guide was developed for small office buildings, i.e., up to 20,000 ft^2, its use in this study was deemed appropriate.
[15] As required by ASHRAE 90.1-1999, Table 5.3, p. 24. (Derived from Table B-5, p. 95.)



	Base Case	U-value = 0.45
Total	5,658	5,051
DHW	42.7	42.7
Fans	239	238
Misc.	201	157
HtRj.	250	229
Cooling	1,126	1,125
Heating-NG	589.9	67.9
Heating-Elec.	20.5	3.2
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_U=1.22	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_U=0.45	113,415	101,247	116,487	116,904	127,875	127,998	135,671	135,133	123,545	124,104	114,400	110,862
Demand_U=1.22	241	242	263	275	284	287	300	297	285	278	257	251
Demand_U=0.45	240	247	258	267	269	271	281	282	275	269	250	247
Gas Use_U=1.22	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_U=0.45	174	107	89	84	86	78	78	77	72	78	79	104

Figure 8: Energy Use Comparison for Electric/Natural Gas Base Case (Glazing U-value, U = 1.22) and EEM (Glazing U-value, U = 0.45).



	Base Case	Glazing U-value = 0.45
Total	5,554	5,061
DHW	36.1	36.1
Fans	239	238
Misc.	201	157
Ht. Rj.	250	229
Cooling	1,126	1,125
Heating - Elec.	513.1	87.2
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_U=1.22	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_U=0.45	117,969	104,330	119,424	119,705	130,732	130,650	138,339	137,782	126,053	126,788	117,061	113,980
Demand_U=1.22	564	400	370	285	294	296	309	306	294	287	318	461
Demand_U=0.45	265	252	265	272	274	276	286	286	280	273	256	253

Figure 9: Energy Use Comparison for All-electric Base Case (Glazing U-value, U = 1.22) and EEM (Glazing U-value, U = 0.45).

Implementation Cost

Two sources, RSMeans and Advanced Energy Design Guide (AEDG), were used to find the cost information for the improved glazing U-value. The information used in the analysis is provided in Table 9. The total additional cost for the improved U-value ranges from about $ 95,130 to $174,154. The data sources are as follows.

1) RSMeans (2006)

Table 7 shows the cost information from 2006 RSMeans. Total increased cost for the double pane clear glass is $130,969 and for the double pane low-e coating with air is $174,154.

Table 7: Cost Information of Glazing U-value (2006 RSMeans).

	Type of Glass	Thickness	# Pane	U-value (Btu/hr-ft^2-°F)	Mat. Cost ($/ft^2)	Labor Cost ($/ft^2)	Total Unit Cost ($/ft^2)	Increased Unit Cost ($/ft)	Total Glass Area (ft2)	Total Glazing Cost ($)	Total Increased Cost ($)
Code	Clear plain	1/4"	1	1.025	5.65	3.16	8.81	-	13,176	116,081	0
Above-code	Clear plain	1/4"	2	0.474	13.70	5.05	18.75	9.94	13,176	247,050	130,969
Above-code	Clear with 1 low-e coating w/ air	1/4"	2	0.450	14.73	7.30	22.03	13.22	13,176	290,234	174,154

2) Development of the Advanced Energy Design Guide (AEDG) for Small Office Buildings (http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16250.pdf, p. E-1)

This report shows the cost information for the increased glazing U-value. *Figure 10* retrieved from the report shows the data of fenestration options. According to this report, the additional unit cost ($/ft^2) for the increased U-value is $7.22. Therefore, the total additional cost would be $95,131 for the building.

Table 8: Cost Information of Glazing U-value (Development of the Advanced Energy Design Guide for Small Office Buildings).

	U-value (Btu/hr- ft^2-°F)	Additional Cost ($/ft^2)	Total Glass Area (ft^2)	Total Increase in Cost ($)
Code	1.22	0	13,176	0
Above-code	0.46	7.22	13,176	95,131

Table 9: Cost Information and Payback Calculation for the Improved Glazing U-value.

Fenestration Measure		Total Glass Area (ft^2)	Increased Unit Cost ($/ft^2)	Total Increase Cost ($)	Referemce
Base Case	Clear single pane windows: U = 1.22	13,176	0	0	
EEM	Increased U-value: U = 0.45	13,176	$7.22 - $13.22	$ 95,130 - $174,154	

Data Base of Fenestration Options

No.	Name	U-Crit	U-Act	SC	SHGC	VLT	Kd	kWh	FC	U-fixed
1	Mtl/Clr	1.27	1.26	0.94	0.82	0.80	0.63	1.21	$0.00	1.22
2	Brk/Clr	1.08	1.15	0.91	0.79	0.80	0.63	1.21	$1.95	1.11
3	Vnl/Clr	0.90	1.02	0.84	0.73	0.77	0.62	1.23	$4.88	0.98
4	Mtl/Clr-Std-Clr	0.81	0.73	0.83	0.72	0.71	0.60	1.29	$3.90	0.72
5	Mtl/ClrSbe-Std-Clr	0.69	0.59	0.51	0.44	0.45	0.48	1.67	$5.27	0.57
6	Brk/Clr-Std-Clr	0.60	0.62	0.78	0.68	0.71	0.60	1.29	$5.85	0.60
7	Brk/ClrSbe-Std-Clr	0.49	0.48	0.46	0.40	0.45	0.48	1.67	$7.22	0.46
8	Brk/Clr-Ins-Clr	0.57	0.59	0.78	0.68	0.71	0.60	1.29	$6.34	0.57
9	Brk/ClrSbe-Ins-Clr	0.46	0.44	0.46	0.40	0.45	0.48	1.67	$7.71	0.43
10	Brk/Clr-Ins-ClrPye	0.48	0.45	0.74	0.64	0.66	0.58	1.34	$7.12	0.46
11	Brk/Clr-Ins-ClrSpe	0.46	0.44	0.64	0.56	0.66	0.58	1.34	$7.12	0.43
12	Brk/Clr-Ins-ClrSue	0.44	0.42	0.53	0.46	0.62	0.57	1.39	$7.12	0.42
13	Vnl/Clr-Std-Clr	0.53	0.51	0.72	0.63	0.68	0.59	1.32	$8.78	0.50
14	Vnl/ClrSbe-Std-Clr	0.42	0.37	0.41	0.36	0.43	0.47	1.71	$10.14	0.37
15	Vnl/Clr-Std-ClrPye	0.44	0.39	0.68	0.59	0.63	0.57	1.38	$9.56	0.40
16	Vnl/Clr-Std-ClrSpe	0.42	0.37	0.59	0.51	0.63	0.57	1.38	$9.56	0.37
17	Vnl/Clr-Std-ClrSue	0.41	0.36	0.47	0.41	0.60	0.56	1.42	$9.56	0.36
18	Vnl/Clr-Ins-Clr	0.50	0.48	0.72	0.63	0.68	0.59	1.32	$9.27	0.47
19	Vnl/ClrSbe-Ins-Clr	0.39	0.34	0.41	0.36	0.43	0.47	1.71	$10.63	0.34
20	Vnl/Clr-Ins-ClrPye	0.41	0.35	0.68	0.59	0.63	0.57	1.38	$10.05	0.37
21	Vnl/Clr-Ins-ClrSpe	0.39	0.33	0.59	0.51	0.63	0.57	1.38	$10.05	0.34
22	Vnl/Clr-Ins-ClrSue	0.38	0.32	0.47	0.41	0.60	0.56	1.42	$10.05	0.33
23	Brk/Clr-Ins-Clr-Ins-Clr	0.43	0.42	0.68	0.59	0.64	0.58	1.37	$10.24	0.42
24	Brk/Clr-Ins-V88-Ins-Clr	0.33	0.35	0.61	0.53	0.63	0.57	1.38	$14.14	0.30
25	Vnl/Clr-Ins-Clr-Ins-Clr	0.37	0.33	0.63	0.55	0.61	0.57	1.41	$13.17	0.33
26	Vnl/Clr-Ins-V88-Ins-Clr	0.28	0.26	0.55	0.48	0.61	0.57	1.41	$17.07	0.22

Figure 10: Data Base of Fenestration Options.
(http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16250.pdf, p. E-1)

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 24,698 kWh x $0.119/kWh = $ 2939.062
Gas cost savings = 5,219 therm x 0.1 (MCF/therm) x $8/MCF = $ 4592.72
Demand savings = 103.41 kW x $5.00/kW = $ 517.05
Total savings = *$ 8048.832*
Cost difference = *$ 95,130 ~ $174,154*
Simple Payback = **11.81 to 21.63 years**

(b) For All-Electric building:

Electricity cost savings = 144401 kWh x $0.119/kWh = $ 17,183.719
Demand savings = 945.2 kW x $5.00/kW = $ 4726
Total savings = *$ 21910*
Cost difference = *$ 95,130 ~ $174,154*
Simple Payback = **4.3 to 7.9 years**

5.2. Energy Efficiency Measure 2: Energy-Efficient Lighting (Decreasing Lighting Power Density from 1.3 W/ft^2 to 1.0 W/ft^2

Base Case

The base-case building was modeled with a lighting power density (LPD) of 1.3 W/ft^2, which is the maximum value for office applications allowed by ASHRAE 90.1-1999[16]. The electric lighting profile was set to the recommended profile from ASHRAE's Diversity Factor Toolkit (RP-1093), as shown in *Figure 11* (Abushakra et al. 2001).

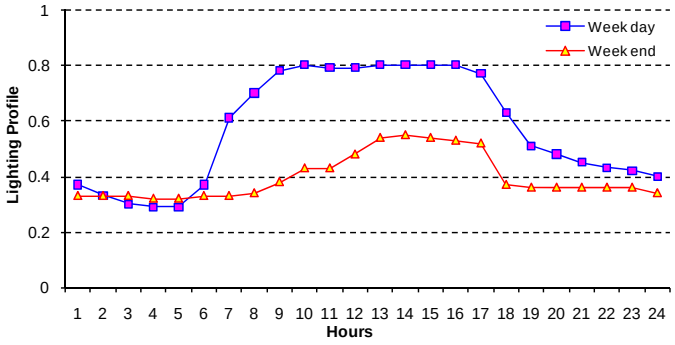


Figure 11: Base Case Lighting Profile for a Large Commercial Building (Source: Abushakra et al., 2001).

Improved Model with Energy-Efficient Lighting

The impact of energy-efficient lighting was determined by reducing the Lighting Power Density (LPD) from 1.3 W/ft^2 to 1.0 W/ft^2 [17]. There are a number of lighting systems available to meet the LPD requirements, including fixture type, fixture size, type of lens or louver, and mounting height. However, only the lamp type and ballast type were considered in this cost analysis.

Energy Savings

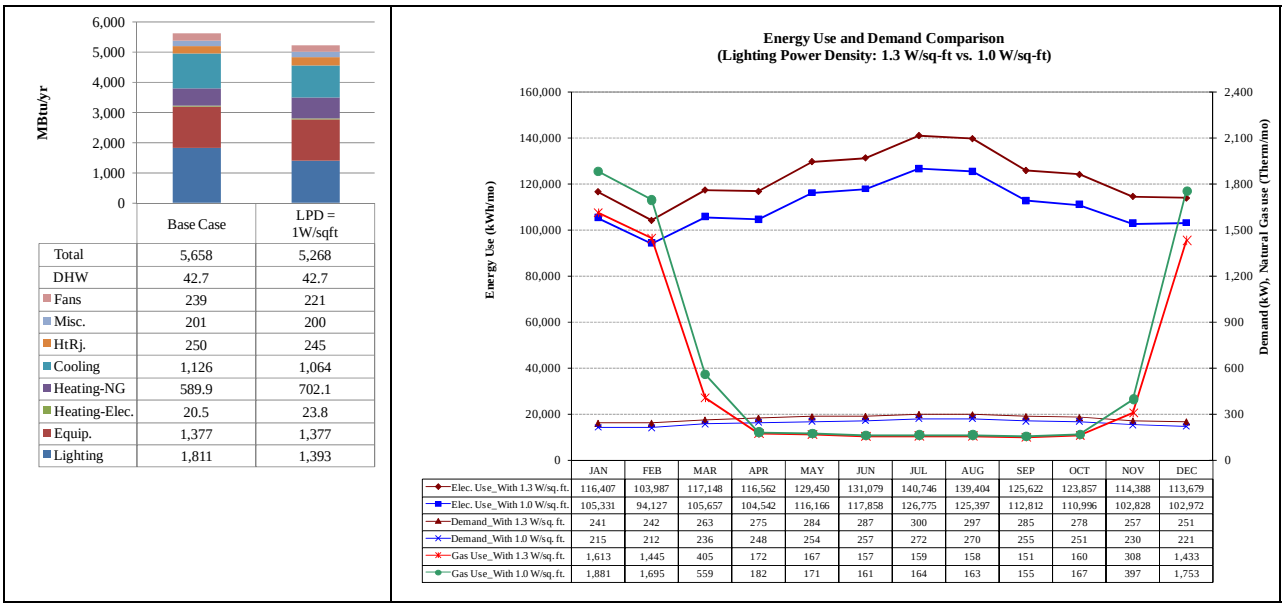
Figure 12 and Figure 13 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 12 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,063.5 MMBtu/year,
- Increased the space heating energy from 610 MMBtu/year to 726 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,268 MMBtu/year, i.e., 389 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1325451 kWh/year, i.e., 146887 kWh/year electricity savings,
- Increased the gas use from 6,325 therms/year to 7447 therms/year, i.e., 1122 therms/year increase in gas use, and
- Reduced the peak demand for July from 3260 kW to 2921 kW.

Figure 13 shows that this measure applied to an all-electric base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,063.5 MMBtu/year,
- Increased the space heating energy from 513.1 MMBtu/year to 594MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,130 MMBtu/year, i.e., 424 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,503,067 kWh/year, i.e., 124,149 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,074 kW.

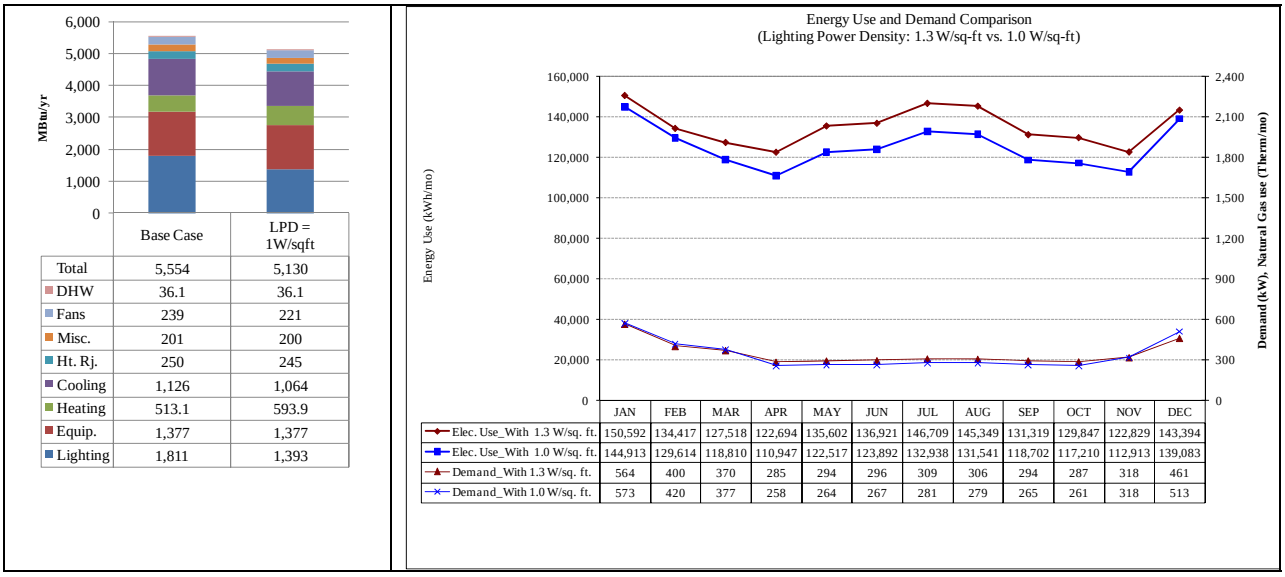
[16] ASHRAE Standard 90.1-1999, Table 9.3.1.1, p. 51.
[17] This is the recommended level in ASHRAE 90.1-2004 for general office space.



	Base Case	LPD = 1W/sqft
Total	5,658	5,268
DHW	42.7	42.7
Fans	239	221
Misc.	201	200
HtRj.	250	245
Cooling	1,126	1,064
Heating-NG	589.9	702.1
Heating-Elec.	20.5	23.8
Equip.	1,377	1,377
Lighting	1,811	1,393

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_With 1.3 W/sq.ft.	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_With 1.0 W/sq.ft.	105,331	94,127	105,657	104,542	116,166	117,858	126,775	125,397	112,812	110,996	102,828	102,972
Demand_With 1.3 W/sq.ft.	241	242	263	275	284	287	300	297	285	278	257	251
Demand_With 1.0 W/sq.ft.	215	212	236	248	254	257	272	270	255	251	230	221
Gas Use_With 1.3 W/sq.ft.	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_With 1.0 W/sq.ft.	1,881	1,695	559	182	171	161	164	163	155	167	397	1,753

Figure 12: Energy Use Comparison for Electric/Natural Gas Base Case (Lighting Power Density = 1.3W/ft^2) and EEM (Lighting Power Density = 1.0W/ft^2).



	Base Case	LPD = 1W/sqft
Total	5,554	5,130
DHW	36.1	36.1
Fans	239	221
Misc.	201	200
Ht. Rj.	250	245
Cooling	1,126	1,064
Heating	513.1	593.9
Equip.	1,377	1,377
Lighting	1,811	1,393

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_With 1.3 W/sq. ft.	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_With 1.0 W/sq. ft.	144,913	129,614	118,810	110,947	122,517	123,892	132,938	131,541	118,702	117,210	112,913	139,083
Demand_With 1.3 W/sq. ft.	564	400	370	285	294	296	309	306	294	287	318	461
Demand_With 1.0 W/sq. ft.	573	420	377	258	264	267	281	279	265	261	318	513

Figure 13: Energy Use Comparison for All-electric Base Case (Lighting Power Density = 1.3W/ft^2) and EEM (Lighting Power Density = 1.0W/ft^2).

Implementation Cost

There are a number of variables that can affect the installation cost of lighting systems in order to meet the LPD requirements as described above. Some of these are fixture type, fixture size, type of lens or louver, and mounting height. The cost analysis is simplified by considering the changes in general lighting systems and whole building LPD, and assuming other costs to be the same. Table 10 shows the details of the lighting system for the two scenarios. The lighting power density of 1.3 W/ft^2 can be achieved by fixtures with 3 – 34 Watt T12 lamps and magnetic ballast. To achieve the LPD of 1.0 W/ft^2, similar fixtures with 3 -32Watts T8 lamps and electronic ballast are required. It was assumed that the most common light fixtures currently used in new construction is the 2x4 recessed, lay-in luminaire that would accommodate both lamp types. This fixture would also contain painted white reflecting surfaces and an acrylic, prismatic lens, and satisfy the maximum allowed power density while providing 30-50 footcandles on the work plane, depending on mounting height and/or room configuration. Finally, the cost of lighting is obtained from online sources. Table 11 shows the cost of both base-case and energy-efficient lighting products. Assuming that the other costs (including fixture cost, labor cost, and cost of wiring and accessories) are the same, there is no increased cost estimate compared to the base case.

Table 10: Comparison between Base Case and Improved Model Lighting.

	Fixture	Lamp	Ballast	Watt/lamp	Watt/Fixture
Basecase	F43EE (3-48", 34W, T-12 Lamps Fixture)	F34T12	Magnetic-ES	34W	115W
Energy-efficient Lighting	F43ILL (3-48", 32W, T-8 Lamps Fixture)	F32T8	Instant Star Electronic	32W	85W

Table 11: Cost Information of Base Case and Energy-efficient Lighting Products.

	Lamp	Brand	Cost/unit[18]	Ballast	Brand	Cost/unit[19]
Basecase	F34T12 Fluorescent Bulb	Philips	$1.19-$1.99	277 Volt One or Two Lamp F34T12 Magnetic Ballast	Advance Transformer	$11.99-$21.49
Energy-efficient Lighting	F32T8 Fluorescent Bulb	GE	$1.29-$2.19	120-277 Volt Three Lamp F32T8 Electronic Ballast	Advance Transformer	$16.99-$24.99

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 146887 kWh x $0.119/kWh	= $ 17480
Gas cost savings = -1122 therm x 0.11 (MCF/therm) x $8/MCF	= - $ 987
Demand savings = 339 kW x $5.00/kW	= $ 1695
Total savings	= *$ 18187*
Cost difference	= *None*
Simple Payback	= **Immediate savings**

(b) For All-Electric building:

Electricity cost savings = 124149 kWh x $0.119/kWh	= $ 14773.7
Demand savings = 108.7 kW x $5.00/kW	= $ 543
Total savings	= *$ 15,317*
Cost difference	= *None*
Simple Payback	= **Immediate savings**

[18] http://www.bulbs.com/Fluorescent_Bulbs/results.aspx
[19] http://www.bulbs.com/Fluorescent_Ballasts_--_Linear/results.aspx

5.3. Energy Efficiency Measure 3: Installation of Occupancy Sensors for Lighting

Base Case
The base-case building is modeled with a lighting power density of 1.3 W/sq. ft., as required by ASHRAE 90.1-1999 (Table 9.3.1.1, p. 51). The electric lighting profile is adopted from RP-1093 Report (Large Buildings) and is shown in Figure 14.

Improved Model with Occupancy Sensors for Lighting
The energy impact from the installation of occupancy sensors for lighting is determined by specifying that the electric lighting profile is the same as the occupancy profile (Figure 15), which is adopted from ASHRAE 90.1-1989 (Table 13-3, p.104).

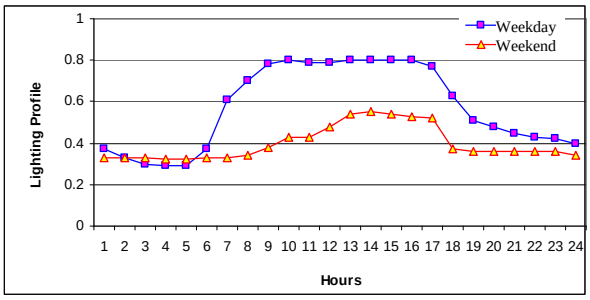


Figure 14: Base Case Lighting Profile.

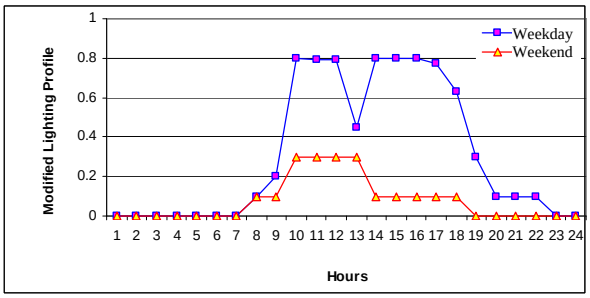


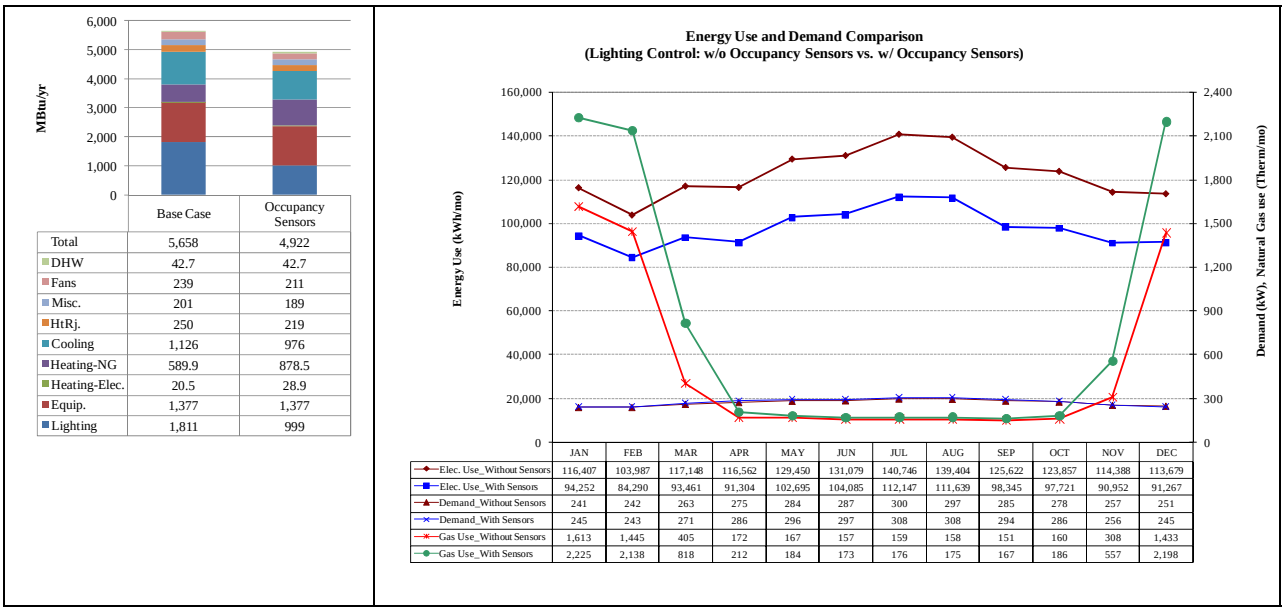
Figure 15: Modified Lighting Profile.

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

- Reduced the space cooling energy use from 1,126 MMBtu/year to 976 MMBtu/year,
- Increased the space heating energy from 610 MMBtu/year to 907.4 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 4921 MMBtu/year, i.e., 735.79 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1172190 kWh/year, i.e., 300148 kWh/year electricity savings,
- Increased the gas use from 6,325 therms/year to 9211 therms/year, i.e., 2886 therms/year increase in gas use, and
- Increased the demand from 3260 kW to 3335 kW.

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

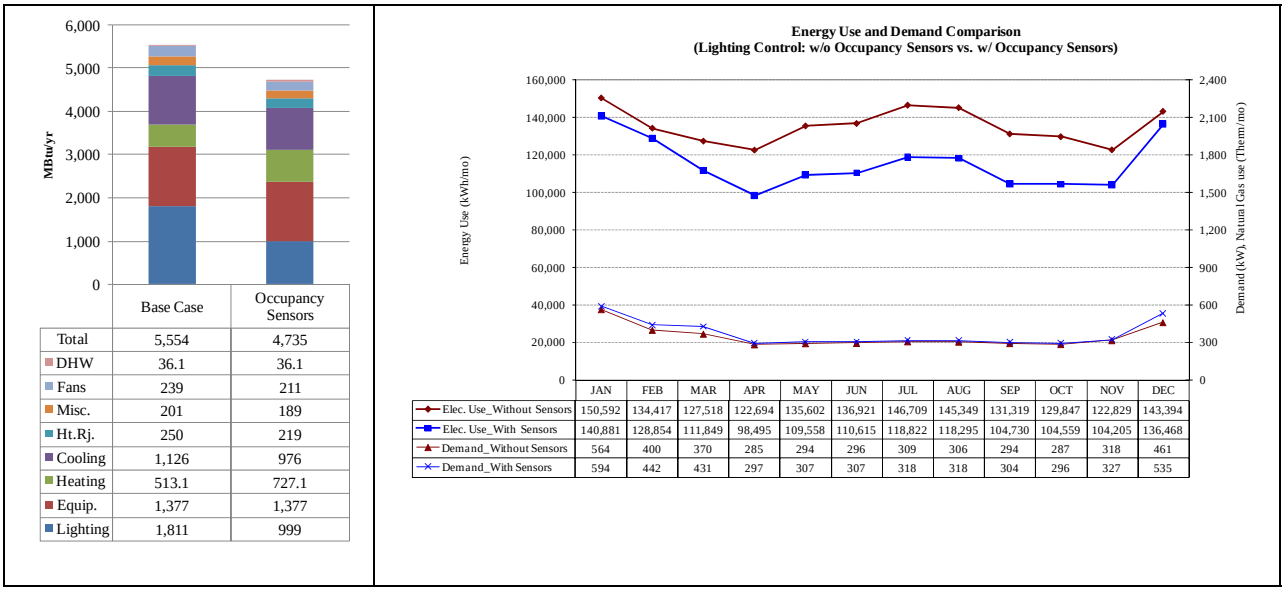
- Reduced the space cooling energy use from 1,126 MMBtu/year to 976 MMBtu/year,
- Increased the space heating energy from 513.1 MMBtu/year to 727MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 4,735 MMBtu/year, i.e., 819 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,387,338 kWh/year, i.e., 239,878 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,477 kW.



	Base Case	Occupancy Sensors
Total	5,658	4,922
DHW	42.7	42.7
Fans	239	211
Misc.	201	189
HtRj.	250	219
Cooling	1,126	976
Heating-NG	589.9	878.5
Heating-Elec.	20.5	28.9
Equip.	1,377	1,377
Lighting	1,811	999

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Without Sensors	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_With Sensors	94,252	84,290	93,461	91,304	102,695	104,085	112,147	111,639	98,345	97,721	90,952	91,267
Demand_Without Sensors	241	242	263	275	284	287	300	297	285	278	257	251
Demand_With Sensors	245	243	271	286	296	297	308	308	294	286	256	245
Gas Use_Without Sensors	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_With Sensors	2,225	2,138	818	212	184	173	176	175	167	186	557	2,198

Figure 16: Energy Use Comparison for Electric/Natural Gas Base Case (Without Occupancy Sensors) and EEM (Installing Occupancy Sensors).



	Base Case	Occupancy Sensors
Total	5,554	4,735
DHW	36.1	36.1
Fans	239	211
Misc.	201	189
Ht.Rj.	250	219
Cooling	1,126	976
Heating	513.1	727.1
Equip.	1,377	1,377
Lighting	1,811	999

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Without Sensors	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_With Sensors	140,881	128,854	111,849	98,495	109,558	110,615	118,822	118,295	104,730	104,559	104,205	136,468
Demand_Without Sensors	564	400	370	285	294	296	309	306	294	287	318	461
Demand_With Sensors	594	442	431	297	307	307	318	318	304	296	327	535

Figure 17: Energy Use Comparison for All-electric Base Case (Without Occupancy Sensors) and EEM (Installing Occupancy Sensors).

Implementation Cost

The cost analysis was based on an analysis for a typical floor (14,884 ft^2/floor) of a six-story office building having 89,304 ft^2 gross floor area. The area distribution and layout of spaces for the typical floor is assumed as shown in Figure 18[20] and Table 12[21], respectively. The type and coverage of occupancy sensors is determined from the product selection and installation guidelines[22,23]. These facilitated in determining the position and the number of occupancy sensors required for a typical floor. Finally, the cost of selected sensors is obtained from various sources as shown in Table 12. Table 12 also shows the cost of sensors (and power pack, if required) for a typical floor. This does not include the cost of labor and additional wiring. Thus, the total cost of sensors for a six-story office building is estimated at $27,229.

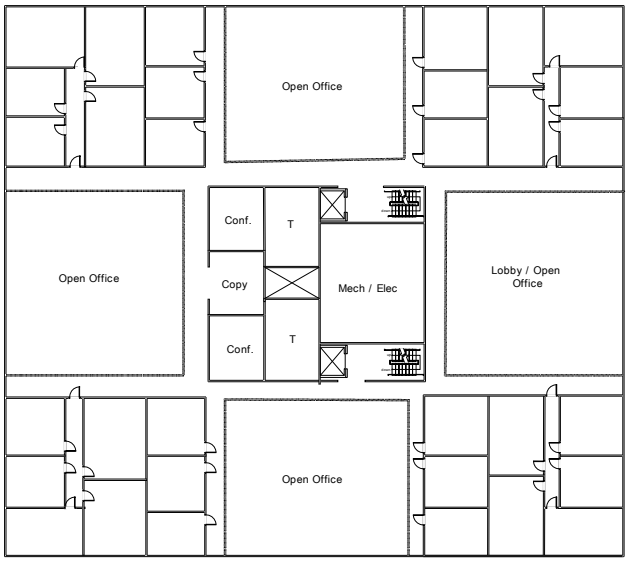


Figure 18: Layout of Spaces for Determining Position and Number of Occupancy Sensors.

Table 12: Details of Spaces and Occupancy Sensors Installed for a Typical Floor.

Space	Area Distribution	# of sensors	Remarks	Brand	Model	Cost/unit	Total cost
Open office	45%	4	Commercial Grade Multi-Tech, Ceiling-Mount	Leviton	ODC20-MRW	$179.97[24]	$719.88
Private office	25%	32	PIR, wall switch	Leviton	ODS15ID	$69.95[25]	$2,238.40
Lobby	5%	None	None	-	-	-	-
Corridor	10%	4	PIR Long Range Aisle Wall Mount + Power Pack	Leviton	OSWLR-I0W + OSP20-0D0	$150.51[26]	$602.04
Conference room	4%	4	Multi-Tech 500 sq. ft. Ceiling Mount + Power Pack	Leviton	OSC05-M0W + OSP20-0D0	$139.66[27]	$558.64
Copy room	2%	1	PIR, wall switch	Leviton	ODS15ID	$69.95	$69.95
Restrooms	5%	2	Multi-Tech 500 sq. ft. Ceiling Mount + Power Pack	Leviton	OSC05-M0W + OSP20-0D0	$139.66	$279.32
Mechanical/ electrical room	4%	1	PIR, wall switch	Leviton	ODS15ID	$69.95	$69.95
						Total	**$4,538.18**

[20] Source: eQuest default space distribution for an eight-story office building.
[21] The layout of spaces confirms the space distribution assumed for the typical floor.
[22] NEMA Guide to Lighting Controls.
[23] Leviton Occupancy Sensors Product Guide.
[24] http://www.twacomm.com/catalog/model_ODC20-MRW.htm?sid=BF03E11CEDBD9FB4C3B490D4606B483A
[25] http://www.homecontrols.com/cgi-bin/main/co_disp/displ/carfnbr/398/prrfnbr/1185/Wall-Switch-Occ-Sensor
[26] http://www.onestopbuy.com/OSWLR-I0W-5735.asp
[27] http://www.onestopbuy.com/OSC05-M0W-5712.asp

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 300148 kWh x $0.119/kWh	= $ 35,718
Gas cost savings = -2886 therm x 0.11 (MCF/therm) x $8/MCF	= - $ 2,540
Demand savings = -75.42 kW x $5.00/kW	= - $ 377
Total savings	= *$ 32,801*
Cost difference	= *$26,500 – 28,000*
Simple Payback	= **0.8 – 0.85 years**

(b) For All-Electric building:

Electricity cost savings = 239,878 kWh x $0.119/kWh	= $ 28,545.5
Demand savings = -293.5 kW x $5.00/kW	= $ -1468
Total savings	= *$ 27,078*
Cost difference	= *$ 26,500 ~ $28,000*
Simple Payback	= **1 year**

5.4. Energy Efficiency Measure 4: Windows Shading (No Overhangs vs. 2.5-foot Width of Overhangs)

Base Case
According to the ASHRAE 90.1-1999, the base-case office building has no window overhangs.

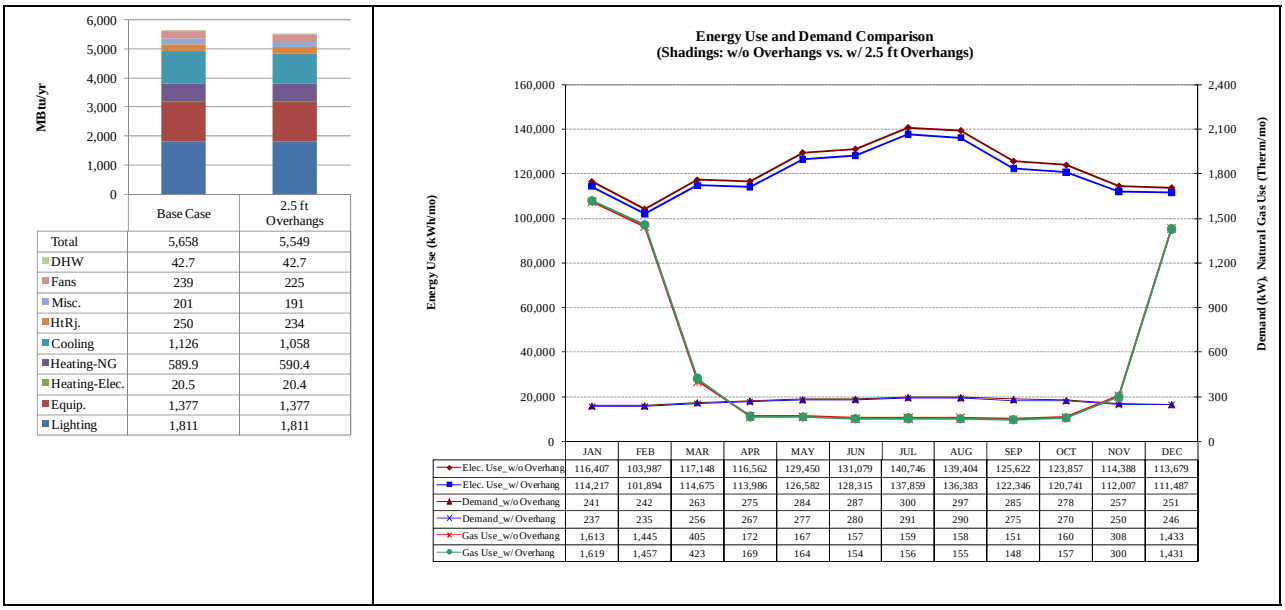
Window Shading
The impact of the addition of window shades was considered by adding window shades to all orientations (except north) using a projection factor of 0.5, as recommended by the ASHRAE Advanced Energy Design Guide for Small Office Buildings (ASHRAE 2004). Since the windows used in the base case simulation were set to a height of 5 feet, this resulted in shade that projected 2.5 feet, which was attached at the top of the window.

Energy Savings
Figure 19 and Figure 20 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 19 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1058 MMBtu/year,
- Increased the space heating energy from 610 MMBtu/year to 611 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5549 MMBtu/year, i.e., 108.14 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1440495 kWh/year, i.e., 31843 kWh/year electricity savings,
- Increased the gas use from 6,325 therms/year to 6331 therms/year, i.e., 6 therms/year increase in gas usage, and
- Reduced the demand from 3260 kW to 3172 kW.

Figure 20 shows that this measure applied to an all-electric base-case building:

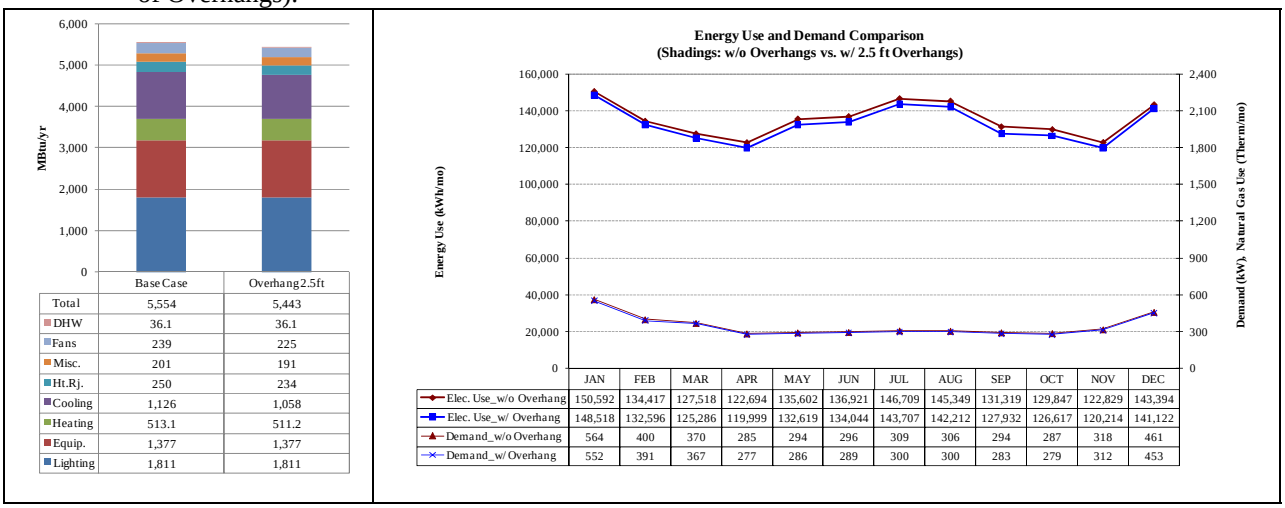
- Reduced the space cooling energy use from 1,126 MMBtu/year to 1058 MMBtu/year,
- Reduced the space heating energy from 513.1 MMBtu/year to 511 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,443 MMBtu/year, i.e., 110.4 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,594,868 kWh/year, i.e., 32,348 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,089 kW.



	Base Case	2.5 ft Overhangs
Total	5,658	5,549
DHW	42.7	42.7
Fans	239	225
Misc.	201	191
HtRj.	250	234
Cooling	1,126	1,058
Heating-NG	589.9	590.4
Heating-Elec.	20.5	20.4
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_w/o Overhang	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_w/ Overhang	114,217	101,894	114,675	113,986	126,582	128,315	137,859	136,383	122,346	120,741	112,007	111,487
Demand_w/o Overhang	241	242	263	275	284	287	300	297	285	278	257	251
Demand_w/ Overhang	237	235	256	267	277	280	291	290	275	270	250	246
Gas Use_w/o Overhang	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_w/ Overhang	1,619	1,457	423	169	164	154	156	155	148	157	300	1,431

Figure 19: Energy Use Comparison for Electric/Natural Gas Base Case (No Overhangs) and EEM (2.5-foot Width of Overhangs).



	Base Case	Overhang 2.5ft
Total	5,554	5,443
DHW	36.1	36.1
Fans	239	225
Misc.	201	191
Ht.Rj.	250	234
Cooling	1,126	1,058
Heating	513.1	511.2
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_w/o Overhang	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_w/ Overhang	148,518	132,596	125,286	119,999	132,619	134,044	143,707	142,212	127,932	126,617	120,214	141,122
Demand_w/o Overhang	564	400	370	285	294	296	309	306	294	287	318	461
Demand_w/ Overhang	552	391	367	277	286	289	300	300	283	279	312	453

Figure 20: Energy Use Comparison for All-electric Base Case (No Overhangs) and EEM (2.5-foot Width of Overhangs).

Implementation Cost

Three sources were used to find the cost information of window overhangs. Table 13 summarizes the cost information that is used in the analysis. The total additional cost for adding window overhangs is around $67,911 to $109,800. The data sources are as follows:

1. Estimation from a personal communication with Professor Larry Degelman of Texas A&M University was used to obtain the cost information of window overhangs. According to him, the increased unit cost for reinforced concrete overhangs would be $20/ft^2. The total area of overhangs is 5,490 ft^2, and the total increased cost will be $109,800.
2. The Business Case for Sustainable Design in Federal Facilities (U.S. DOE 2003): Appendix B (http://www1.eere.energy.gov/femp/pdfs/buscase_appendixb.pdf, p. B-10). According to Appendix B in this report, the increased unit cost for reinforced concrete overhangs would be $12.37/ft^2. The total area of overhangs is 5,490 ft^2, and the total increased cost will be $67,911.
3. Actual Cost Information from a Construction ("Construction bid for louvered overhang sun shades on a fire station project in College Station, Texas," October, 2006, Thomas Parker, AIA, Director, BRW Architects, Inc., 2700 Earl Rudder Freeway So., College Station, TX 77845, 979-694-1791): Actual construction cost information presents the increased cost for window overhangs. The type of overhang in this construction was louvered metal, which is relatively expensive compared to concrete type overhangs. The increase unit cost is $58/sq. ft., and the total increase cost will be $318,420. The cost information from this source is withdrawn for this cost information calculation.

Table 13: Cost Information of Windows Overhangs.

No.	Type of Overhangs	Increased Unit Costs ($/ft^2)	Length of Overhangs (ft)	Width of Overhang (ft)	Total Overhang Area (ft)	Total Increased Cost ($)	Source
1	3" reinforced concrete slab	20	2196	2.5	5490	109,800	Estimation from Prof. Degelman
2	3' closed overhangs	12.37	2196	2.5	5490	67,911	http://www1.eere.energy.gov/femp/pdfs/buscase_appendixb.pdf
3	Louvered metal overhangs	58	2196	2.5	5490	318,420	Construction bid for louvered overhang sun shades on a fire station project in College Station, Texas. October 2006.

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 31843 kWh x $0.119/kWh = $ 3789
Gas cost savings = -6 therm x 0.11 (MCF/therm) x $8/MCF = - $ 5.3
Demand savings = 87.67 kW x $5.00/kW = - $ 438
Total savings = *$ 4222.4*
Cost difference = *$67,900 - 110000*
Simple Payback = **16 - 26 years**

(b) For All-Electric building:

Electricity cost savings = 32,348 kWh x $0.119/kWh = $ 3,849.4
Demand savings = 94.3 kW x $5.00/kW = $ 471
Total savings = *$ 4,321*
Cost difference = *$ 67,900 ~ $110,000*
Simple Payback = **15.7 to 25.5 years**

5.5. Energy Efficiency Measure 5: Cold Deck Reset (Constant vs. Variable)

Base Case
The base-case building model has constant supply air temperature of 55 °F. The DOE-2 simulation showed the yearly total energy use of 5,658 MMBtu.

Cold Deck Schedule
To further improve the performance of the cooling system, the cold deck schedule was changed from a constant 55 °F to a schedule as shown in the graph in Figure 21. This saves cooling energy by maintaining the cold deck air temperature at 60 °F when the outdoor temperature is 55 °F or lower, and maintains the cold deck temperature at 55 °F when the outdoor temperature is 85 °F or higher[28]. The cold deck temperature decreases linearly from 60 °F to 55 °F as the outdoor temperature increases from 55 °F to 85 °F.

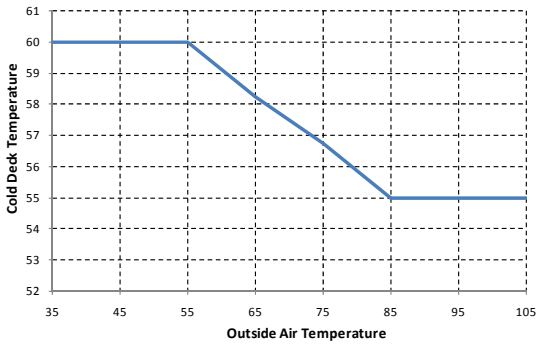


Figure 21: Cold Deck Temperature Schedule.

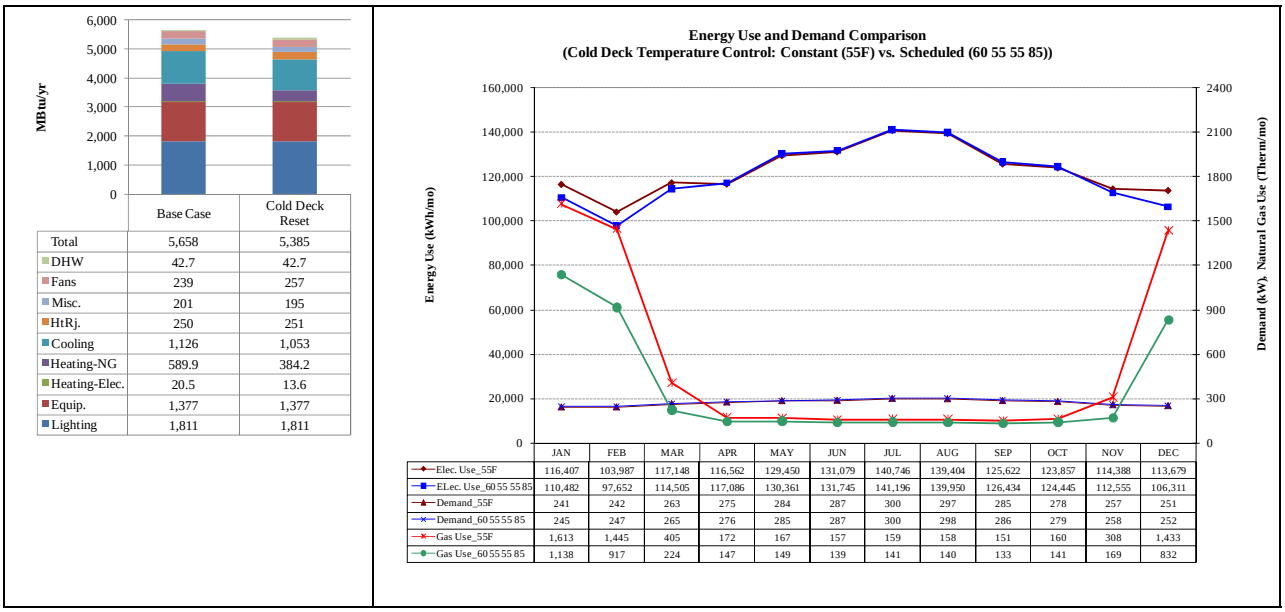
Energy Savings
Figure 22 and Figure 23 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. *Figure 22* shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1053 MMBtu/year,
- Reduced the space heating energy from 610 MMBtu/year to 398 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5385 MMBtu/year, i.e., 273 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1452735 kWh/year, i.e., 19603 kWh/year electricity savings,
- Reduced the gas use from 6,325 therms/year to 4269 therms/year, i.e., 2056 therms/year reduction in gas usage, and
- Increased the demand from 3260 kW to 3278 kW.

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

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1053 MMBtu/year,
- Reduced the space heating energy from 513.1 MMBtu/year to 361 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,341 MMBtu/year, i.e., 213 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,564,931 kWh/year, i.e., 62,285 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 3,934 kW.

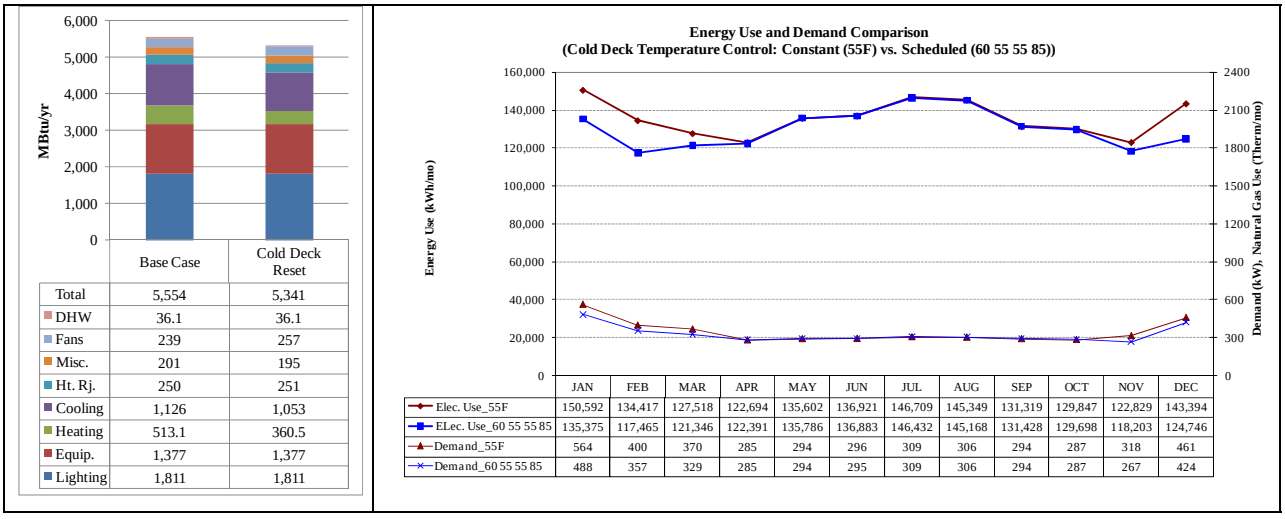
[28] This cold deck schedule was implemented based on settings revealed by a survey of the buildings at the Texas A&M University campus that had received Continuous Commissioning ® (CC®).



	Base Case	Cold Deck Reset
Total	5,658	5,385
DHW	42.7	42.7
Fans	239	257
Misc.	201	195
HtRj.	250	251
Cooling	1,126	1,053
Heating-NG	589.9	384.2
Heating-Elec.	20.5	13.6
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_55F	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
ELec. Use_60 55 55 85	110,482	97,652	114,505	117,086	130,361	131,745	141,196	139,950	126,434	124,445	112,555	106,311
Demand_55F	241	242	263	275	284	287	300	297	285	278	257	251
Demand_60 55 55 85	245	247	265	276	285	287	300	298	286	279	258	252
Gas Use_55F	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_60 55 55 85	1,138	917	224	147	149	139	141	140	133	141	169	832

Figure 22: Energy Use Comparison for Electric/Natural Gas Base Case (Cold Deck Temperature Control: Constant) and EEM (Cold Deck Temperature Control: 60, 55, 55, and 85 °F).



	Base Case	Cold Deck Reset
Total	5,554	5,341
DHW	36.1	36.1
Fans	239	257
Misc.	201	195
Ht. Rj.	250	251
Cooling	1,126	1,053
Heating	513.1	360.5
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_55F	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
ELec. Use_60 55 55 85	135,375	117,465	121,346	122,391	135,786	136,883	146,432	145,168	131,428	129,698	118,203	124,746
Demand_55F	564	400	370	285	294	296	309	306	294	287	318	461
Demand_60 55 55 85	488	357	329	285	294	295	309	306	294	287	267	424

Figure 23: Energy Use Comparison for All-electric Base Case (Cold Deck Temperature Control: Constant) and EEM (Cold Deck Temperature Control: 60, 55, 55, and 85 °F).

Implementation Cost
To implement the change in the cold deck reset schedule, a value range of 0-$800 was used for calculating the payback period.

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings	= 19603 kWh x $0.119/kWh	= $ 2332.757
Gas cost savings	= 2056 therm x 0.11 (MCF/therm) x $8/MCF	= - $ 1809.3
Demand savings	= -18.18 kW x $5.00/kW	= - $ 90.9
	Total savings	*= $ 4051.2*
	Cost difference	*= $0 - 800*
Simple Payback		= **0 – 0.2 years**

(b) For All-Electric building:

Electricity cost savings	= 62,285 kWh x $0.119/kWh	= $ 7,411.9
Demand savings	= 248.8 kW x $5.00/kW	= $ 1,244
	Total savings	*= $ 8,656*
	Cost difference	*= $ 0 ~ $800*
Simple Payback		= **0 to 0.1 years**

5.6. Energy Efficiency Measure 6: Supply Fan Total Pressure (2.5 W.G. to 1.5 W.G.)

Base Case
The base-case building model has supply air total static pressure of 2.5 W.G. This value was from a survey through CC® (Continuous Commissioning®) engineers as well as average values from the TAMU campus buildings.

Low Static Pressure
To improve the HVAC system's performance, the total supply fan static pressure was reduced to 1.5 inches of water (gauge) from the 2.5 inches of water (gauge) which was set for the base case simulation[29].

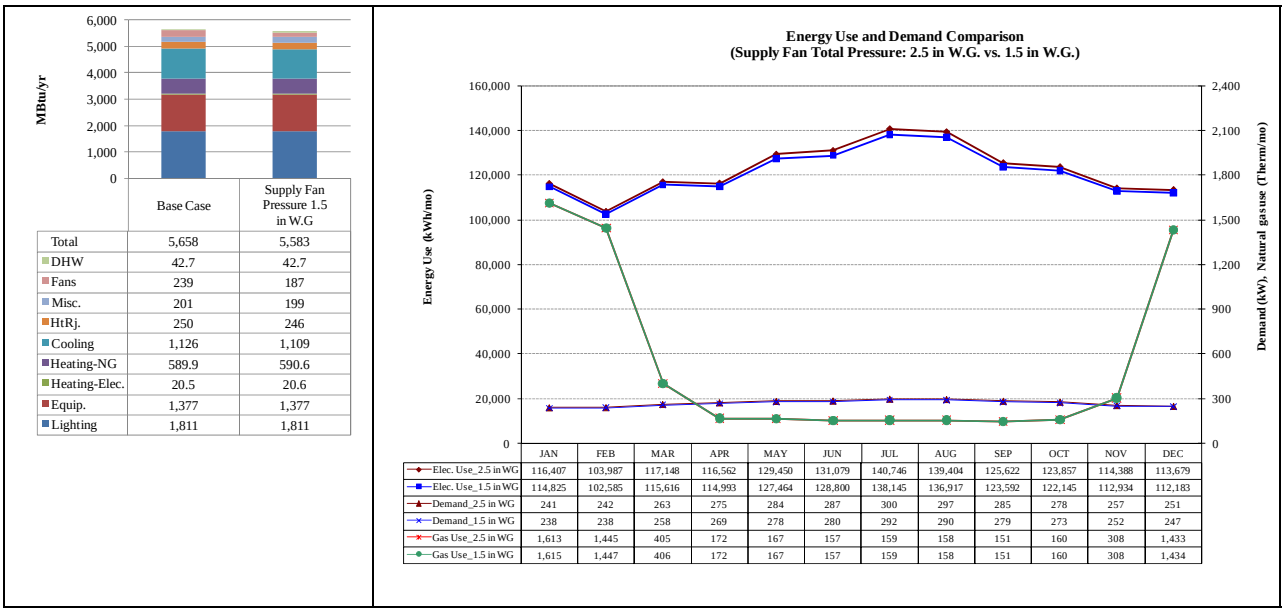
Energy Savings
Figure 24 and Figure 25 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 24 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1109 MMBtu/year,
- Increased the space heating energy from 610 MMBtu/year to 611 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,583 MMBtu/year, i.e., 75 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1450195 kWh/year, i.e., 22143 kWh/year electricity savings,
- Increased the gas use from 6,325 therms/year to 6333 therms/year, i.e., 8 therms/year increase in gas usage, and
- Reduced the demand from 3260 kW to 3194 kW.

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

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1109 MMBtu/year,
- Increased the space heating energy from 513.1 MMBtu/year to 513.6 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,479 MMBtu/year, i.e., 75 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,605,230 kWh/year, i.e., 21,986 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,123 kW.

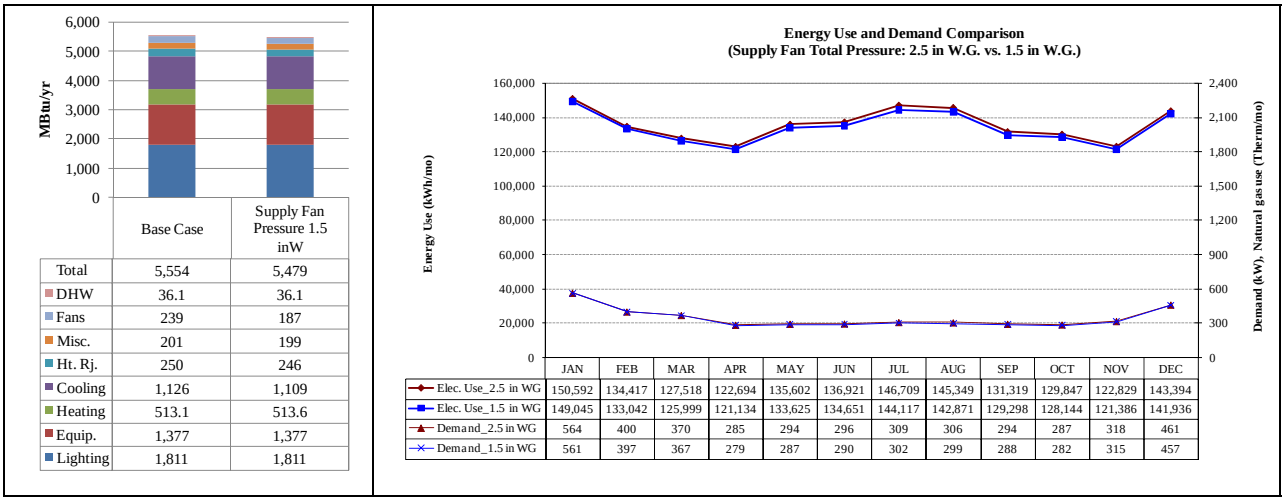
[29] The 1.5 inches of water (gauge) was a recommendation by the Laboratory's Continuous Commissioning ® (CC®) group. Continuous Commissioning ® and CC® are registered trademarks of the Texas A&M University System. This can be accomplished by: a larger sized ductwork, using low static filters and other such measures which reduce frictional losses in ducts. This pressure difference can also be achieved by slowing down the speed of the fans with no added first costs, assuming the indoor air quality conditions are met.



	Base Case	Supply Fan Pressure 1.5 in W.G
Total	5,658	5,583
DHW	42.7	42.7
Fans	239	187
Misc.	201	199
HtRj.	250	246
Cooling	1,126	1,109
Heating-NG	589.9	590.6
Heating-Elec.	20.5	20.6
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_2.5 in WG	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_1.5 in WG	114,825	102,585	115,616	114,993	127,464	128,800	138,145	136,917	123,592	122,145	112,934	112,183
Demand_2.5 in WG	241	242	263	275	284	287	300	297	285	278	257	251
Demand_1.5 in WG	238	238	258	269	278	280	292	290	279	273	252	247
Gas Use_2.5 in WG	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_1.5 in WG	1,615	1,447	406	172	167	157	159	158	151	160	308	1,434

Figure 24: Energy Use Comparison for Electric/Natural Gas Base Case (Supply Fan Total Pressure 2.5 in. WG) and EEM (Supply Fan Total Pressure 1.5 in. WG).



	Base Case	Supply Fan Pressure 1.5 inW
Total	5,554	5,479
DHW	36.1	36.1
Fans	239	187
Misc.	201	199
Ht. Rj.	250	246
Cooling	1,126	1,109
Heating	513.1	513.6
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_2.5 in WG	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_1.5 in WG	149,045	133,042	125,999	121,134	133,625	134,651	144,117	142,871	129,298	128,144	121,386	141,936
Demand_2.5 in WG	564	400	370	285	294	296	309	306	294	287	318	461
Demand_1.5 in WG	561	397	367	279	287	290	302	299	288	282	315	457

Figure 25: Energy Use Comparison for All-electric Base Case (Supply Fan Total Pressure 2.5 in. WG) and EEM (Supply Fan Total Pressure 1.5 in. WG).

Implementation Cost
To implement changes in static fan total pressure, a value range of 0-$200 was used to calculate the payback period.

Payback Calculation
(a) For Electric/gas building:

Electricity cost savings	= 22143 kWh x $0.119/kWh	= $ 2635.1
Gas cost savings	= -8 therm x 0.11 (MCF/therm) x $8/MCF	= - $ -7.1
Demand savings	= 65.81 kW x $5.00/kW	= $ 329.1
	Total savings	= *$ 2957.1*
	Cost difference	= *$0 - 200*
Simple Payback		= **0 – 0.06 years**

(b) For All-Electric building:

Electricity cost savings	= 21,986 kWh x $0.119/kWh	= $ 2616.3
Demand savings	= 59.9 kW x $5.00/kW	= $ 299
	Total savings	= *$ 2916*
	Cost difference	= *$ 0 ~ $200*
Simple Payback		= **0 to 0.1 years**

5.7. Energy Efficiency Measure 7: Chiller COP (COP 4.9 to COP 6.1)

Base Case
The base-case building has one 160-ton (1.926 MBtu/hr) screw chiller[30] with a COP of 4.9.

High COP screw chiller
To improve the performance of the building's chiller, the COP was raised from 4.9 to 6.1[31], which was set for the base-case building.

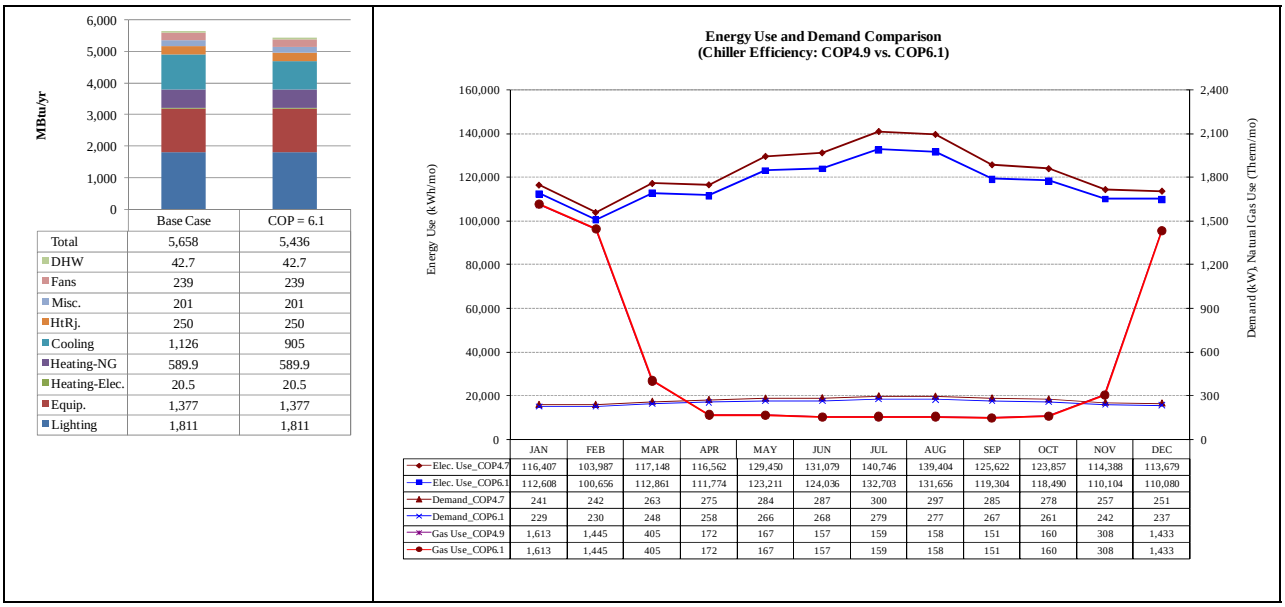
Energy Savings
Figure 26 and Figure 27 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 26 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 905 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,436 MMBtu/year, i.e., 221 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1407487 kWh/year, i.e., 64851 kWh/year electricity savings, and
- Reduced the demand from 3260 kW to 3060 kW.

Figure 27 shows that this measure applied to an all-electric base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 905 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,332 MMBtu/year, i.e., 221 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,562,366 kWh/year, i.e., 64,850 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,030 kW.

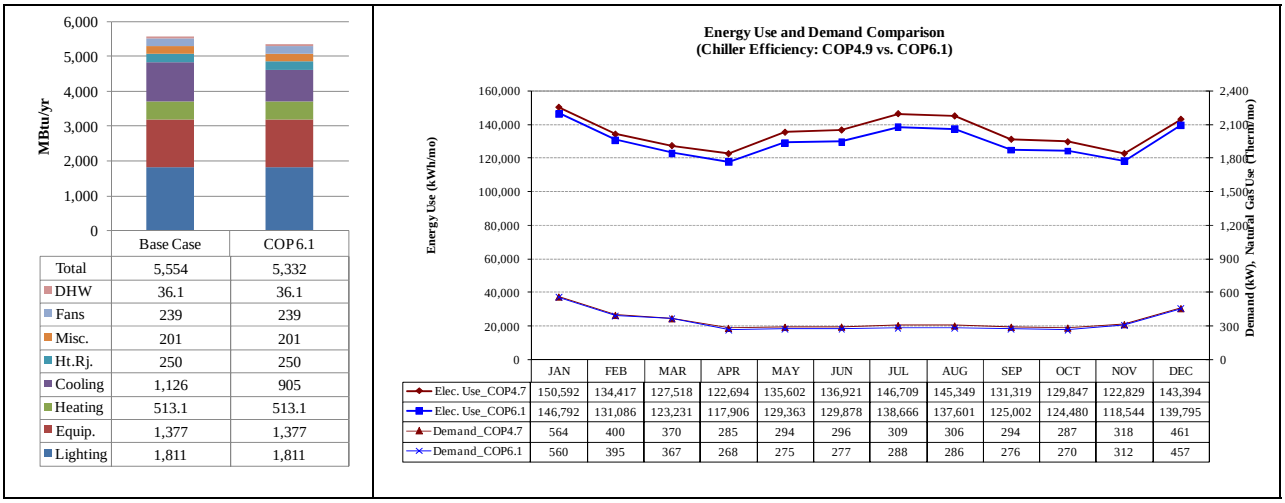
[30] As required by ASHRAE 90.1-1999, Table 6.2.1C, p.29, for chiller sizes between 100 tons and 300 tons.
[31] To find currently available high COP screw chillers, a literature review was performed. The EERE (Energy Efficiency and Renewable Energy) website of the Department of Energy has a guide 'How to buy an energy-efficient water-cooled electric chiller' (www1.eere.energy.gov/femp/pdfs/wc_chillers.pdf, p.1).



	Base Case	COP = 6.1
Total	5,658	5,436
DHW	42.7	42.7
Fans	239	239
Misc.	201	201
HtRj.	250	250
Cooling	1,126	905
Heating-NG	589.9	589.9
Heating-Elec.	20.5	20.5
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_COP4.7	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_COP6.1	112,608	100,656	112,861	111,774	123,211	124,036	132,703	131,656	119,304	118,490	110,104	110,080
Demand_COP4.7	241	242	263	275	284	287	300	297	285	278	257	251
Demand_COP6.1	229	230	248	258	266	268	279	277	267	261	242	237
Gas Use_COP4.9	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_COP6.1	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433

Figure 26: Energy Use Comparison for Electric/Natural Gas Base Case (Chiller COP 4.9) and EEM (Chiller COP 6.1).



	Base Case	COP 6.1
Total	5,554	5,332
DHW	36.1	36.1
Fans	239	239
Misc.	201	201
Ht.Rj.	250	250
Cooling	1,126	905
Heating	513.1	513.1
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_COP4.7	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_COP6.1	146,792	131,086	123,231	117,906	129,363	129,878	138,666	137,601	125,002	124,480	118,544	139,795
Demand_COP4.7	564	400	370	285	294	296	309	306	294	287	318	461
Demand_COP6.1	560	395	367	268	275	277	288	286	276	270	312	457

Figure 27: Energy Use Comparison for All-electric Base Case (Chiller COP 4.9) and EEM (Chiller COP 6.1).

Implementation Cost

For the chillers cost information, three major chiller companies (Trane, York, and Carrier) were contacted. The RSMeans database was also reviewed. Table 14 shows comparisons from the sources. The RSMeans (or CostWorks) database showed a total implementation cost of $74,250 for a 200-ton screw chiller, which includes equipment and labor cost. However, no COP comparisons were available from the RSMeans database. Mr. Oscar Peraza (oscar.peraza@york.com) from the York Company provided equipment cost information ($55,000), but no labor cost information was available. The detailed information was available from Mr. Scott McDonough (Scott.McDonough@carrier.utc.com) from the Carrier Company. As shown in Table 14, the total cost difference between two chillers was $17,000.

Table 14: Screw Chiller Equipment and Installation Cost Information

Information Sources	Screw Chiller (170 Ton) Carrier		Screw Chiller (160 Ton) YORK	(200 Ton) Cost Works
COP	4.7	6.1	5.03 COP	n/a
Equipment Cost	$66,000	$83,000	$55,000	$67,000
Labor Cost	$10,000	$10,000	n/a	$7,250
Total Cost	$76,000	$93,000	n/a	$74,250
Cost difference	$17,000			

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings	= 64851 kWh x $0.119/kWh	= $ 7717.3
Gas cost savings	= 0 therm x 0.11 (MCF/therm) x $8/MCF	= $ 0
Demand savings	= 200 kW x $5.00/kW	= $ 1000.5
	Total savings	= *$ 8717.719*
	Cost difference	= *$16,000 – 18,000*
Simple Payback		= **1.8 – 2 years**

(b) For All-Electric building:

Electricity cost savings	= 64,850 kWh x $0.119/kWh	= $ 7717.2
Demand savings	= 153.1 kW x $5.00/kW	= $ 765
	Total savings	= *$ 8482*
	Cost difference	= *$ 16,000 ~ $18,000*
Simple Payback		= **1.9 to 2.1 years**

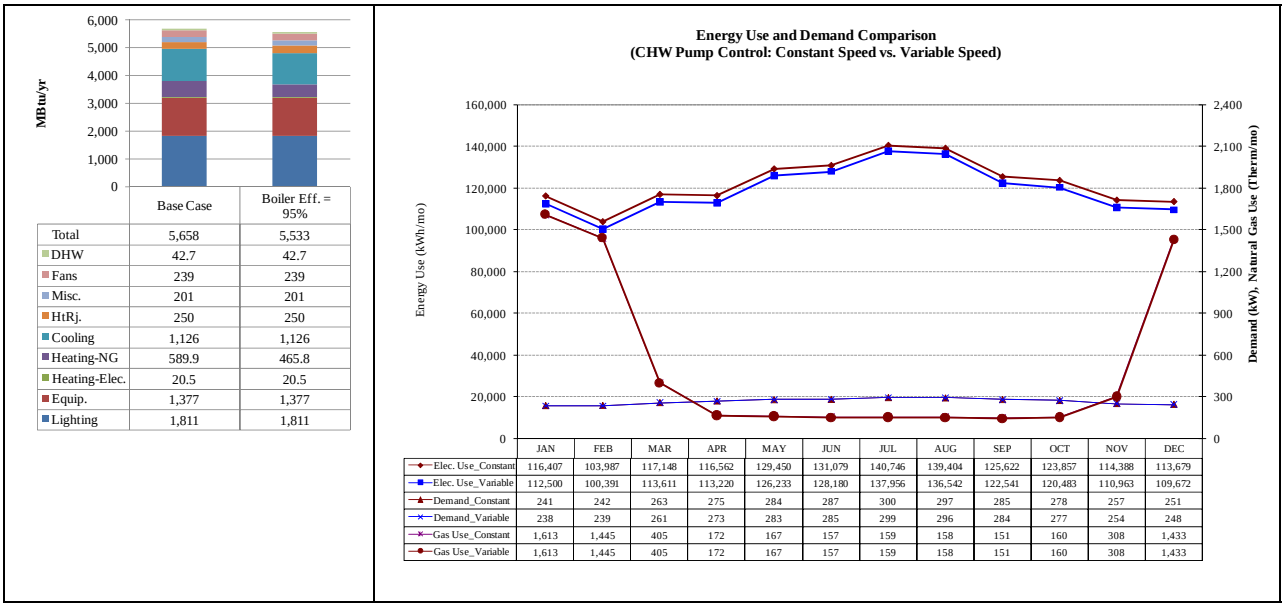
5.8. Energy Efficiency Measure 8: Boiler Efficiency (75% to 95%)

Base Case
The base-case building model has two hot water gas boilers, which have 731 kBtu/hr capacities each. ASHRAE 90.1-1999 (Table 6.2.1F, p.31) requires a minimum boiler thermal efficiency of 75%.

Efficient Boilers
The building's heating system efficiency was improved by increasing the natural gas boiler efficiency to 95% (condensing boiler) from 75% (conventional boiler), which was set for the base case simulation[32]. For the all-electric system, the boiler efficiency was set at 100% for the base case; hence, no changes were made to the boiler efficiency in the all-electric case.

Energy Savings
Figure 28 compares the annual energy use of a commercial building in Houston with base-case characteristics and with this measure:

- Reduced the space heating energy from 610 MMBtu/year to 486.3 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,534 MMBtu/year, i.e., 124 MMBtu/year of total energy savings, and
- Reduced the gas use from 6,325 therms/year to 5085 therms/year (i.e. 1241 therms/year decrease in gas usage).



	Base Case	Boiler Eff. = 95%
Total	5,658	5,533
DHW	42.7	42.7
Fans	239	239
Misc.	201	201
HtRj.	250	250
Cooling	1,126	1,126
Heating-NG	589.9	465.8
Heating-Elec.	20.5	20.5
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Constant	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_Variable	112,500	100,391	113,611	113,220	126,233	128,180	137,956	136,542	122,541	120,483	110,963	109,672
Demand_Constant	241	242	263	275	284	287	300	297	285	278	257	251
Demand_Variable	238	239	261	273	283	285	299	296	284	277	254	248
Gas Use_Constant	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_Variable	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433

Figure 28: Energy Use Comparison for Electric/Natural Gas Base Case (Boiler: Conventional, Efficiency 75%) and EEM (Boiler: Condensing, Efficiency 95%).

[32] The 95% efficiency was based on communications with Mr. Jeff Leep at Rheem Corporation.

Implementation Cost

Table 15 shows cost information for boilers from different makers. The Fulton website (www.fulton.com) provides market available condensing boilers for different sizes, but no cost information was available. Lochinvar boilers (Tom Watson, Twatson@Huntongroup.com) of 500 kBtu/hr capacities were priced at $6,424 for an 81% efficiency boiler and $11,479 for an 88% efficiency boiler (these are not condensing boilers, but conventional boilers). Laars boilers (Steve Aytes, Saytes@oslinnation.com) priced at $5,000 for 758 kBtu/hr capacities with 85% thermal efficiency and $20,000 with 95% thermal efficiency. The cost difference of $15,000 ($30,000 for two boilers) was used for the payback calculation. Table 15 provides the cost information that was used in the analysis.

Table 15: Boiler Equipment and Installation Cost Information

Maker	Type	Thermal Efficiency	Capacity	Cost
Market available efficient boilers	Fulton PHW-0500	95%	500 kBtu/hr	n/a
	Fulton PHW-1000	95%	1000 kBtu/hr	n/a
Lochinvar (Tom Watson, Twatson@Huntongroup.com)	CBN0495	81%	495 kBtu/hr	Equipment: $3424 Labor: $3000 Total: $6424 ==> Two Boilers Total: $12,848
Lochinvar (Tom Watson, Twatson@Huntongroup.com)	PBN0500	88%	500 kBtu/hr	Equipment: $8479 Labor: $3000 Total: $11,479 ==> Two Boilers Total: $22,958
Laars (Steve Aytes, Saytes@oslinnation.com)	Conventional	85%	758 kBtu/Hr	Equipment: $5,000
Laars (Steve Aytes, Saytes@oslinnation.com)	Condensing	95%	758 kBtu/Hr	Equipment: $20,000 (4 times the conventional boiler)

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 0 kWh x $0.119/kWh		= $ 0
Gas cost savings	= 1241 therm x 0.11 (MCF/therm) x $8/MCF	= $ 1092.08
Demand savings	= 0 kW x $5.00/kW	= $ 0
Total savings		= *$ 1092.08*
Cost difference		= *$ 25000 - 35000*
Simple Payback		= **22.89– 32.04 years**

5.9. Energy Efficiency Measure 9: VSD on Chilled Water Pump

Base Case
The base-case building model has a chilled water pump of constant speed.

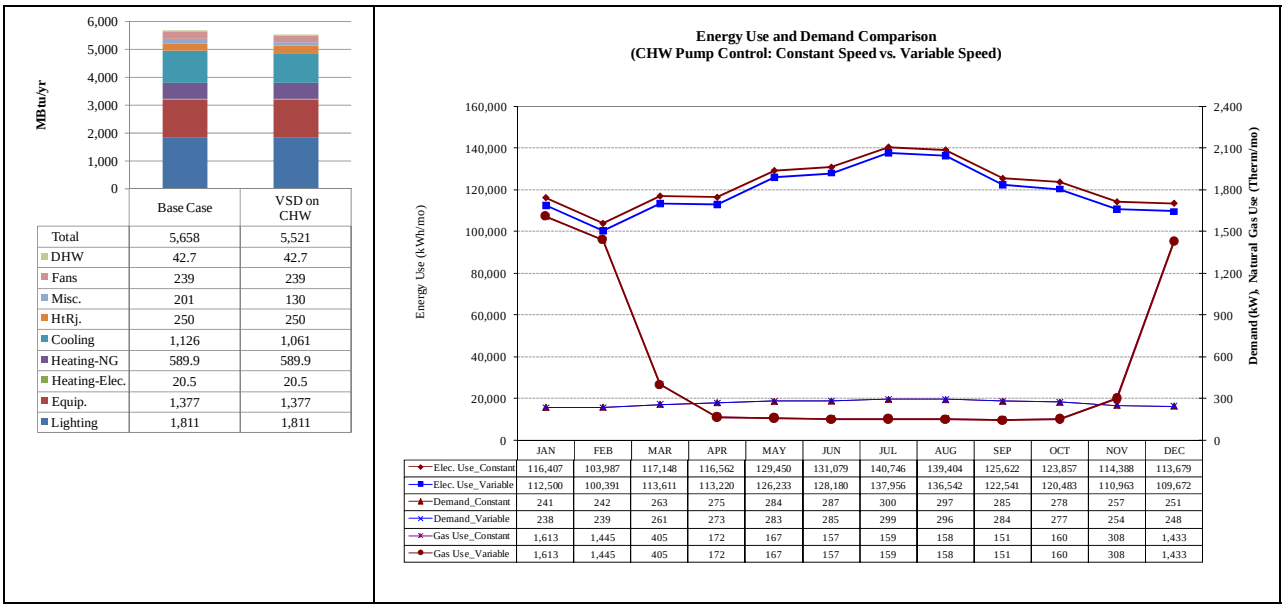
VSD Chilled Water Pump
To improve the performance of the cooling system, variable speed drives were included for the chilled water pumps.

Energy Savings
Figure 29 and Figure 30 compare the annual energy use of a commercial building in Houston with base-case characteristics and with this measure. Figure 29 shows that this measure applied to an electric/gas base-case building:

- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,061 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5,521 MMBtu/year, i.e., 137 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1432301 kWh/year, i.e., 40037 kWh/year electricity savings, and
- Reduced the peak demand for July from 3260 kW to 3235 kW.

Figure 30 shows that this measure applied to an all-electric base-case building:

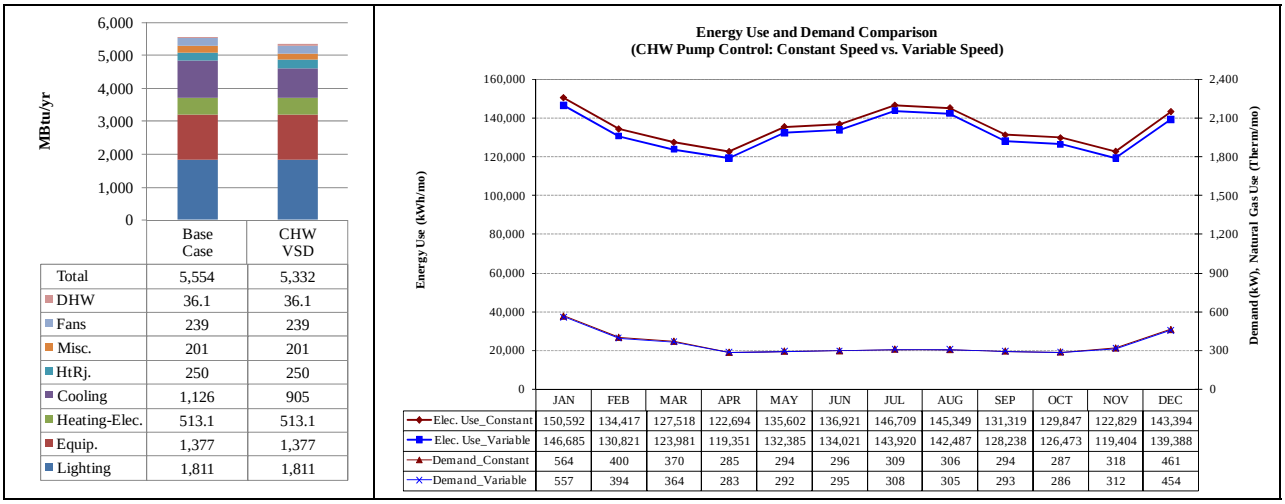
- Reduced the space cooling energy use from 1,126 MMBtu/year to 1,061 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,417 MMBtu/year, i.e., 137 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,587,179 kWh/year, i.e., 40,037 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,141 kW.



	Base Case	VSD on CHW
Total	5,658	5,521
DHW	42.7	42.7
Fans	239	239
Misc.	201	130
HtRj.	250	250
Cooling	1,126	1,061
Heating-NG	589.9	589.9
Heating-Elec.	20.5	20.5
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Constant	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_Variable	112,500	100,391	113,611	113,220	126,233	128,180	137,956	136,542	122,541	120,483	110,963	109,672
Demand_Constant	241	242	263	275	284	287	300	297	285	278	257	251
Demand_Variable	238	239	261	273	283	285	299	296	284	277	254	248
Gas Use_Constant	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_Variable	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433

Figure 29: Energy Use Comparison for Electric/Natural Gas Base Case (Constant Speed Drive on CHW pump) and EEM (VSD on CHW Pump).



	Base Case	CHW VSD
Total	5,554	5,332
DHW	36.1	36.1
Fans	239	239
Misc.	201	201
HtRj.	250	250
Cooling	1,126	905
Heating-Elec.	513.1	513.1
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Constant	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_Variable	146,685	130,821	123,981	119,351	132,385	134,021	143,920	142,487	128,238	126,473	119,404	139,388
Demand_Constant	564	400	370	285	294	296	309	306	294	287	318	461
Demand_Variable	557	394	364	283	292	295	308	305	293	286	312	454

Figure 30: Energy Use Comparison for All-electric Base Case (Constant Speed Drive on CHW pump) and EEM (VSD on CHW Pump).

Implementation Cost

Several VFD (Variable Frequency Drive) makers were reviewed on the internet websites. As shown in Table 16, VFDs from B&G were typical with the price of $4,000 including a 15 horse power pump, but not including labor cost. Also, RSMeans provides VFD and labor costs that were $3,175 (15HP) without the pump. For the payback calculation, RSMeans data of $3,175 was used as the implementation cost.

Table 16: Variable Speed Chilled Water Pump Equipment and Installation Cost Information

Maker	Type	Capacity	CHW / HW	Cost
B&G	1510-3E-15HP	340 GPM @ 85'	CHW Pump (1 VFD needed)	Equipment: Pump - $2,300 each VFD - $1,700 each (Need labor cost) RSMeans: $3175 (15HP VFD) = Labor and VFD

Payback Calculation

(a) For Electric/gas building:

Electricity cost savings = 40037 kWh x $0.119/kWh		= $ 4764.4
Gas cost savings	= 0 therm x 0.11 (MCF/therm) x $8/MCF	= $ 0
Demand savings	= 24.15 kW x $5.00/kW	= $ 120.75
	Total savings	= *$ 4885.15*
	Cost difference	= *$ 3,700- 4,700*
Simple Payback		= **0.75– 0.96 years**

(b) For All-Electric building:

Electricity cost savings = 40,037 kWh x $0.119/kWh		= $ 4,764.4
Demand savings	= 41.6 kW x $5.00/kW	= $ 208
	Total savings	= *$ 4,972*
	Cost difference	= *$ 3,700 ~ $4,700*
Simple Payback		= **0.7 to 0.9 years**

5.10. Energy Efficiency Measure 10: VSD on Hot Water Pump

Base Case
The base-case building model has two hot water boilers. Hence, two constant speed hot water pumps were used.

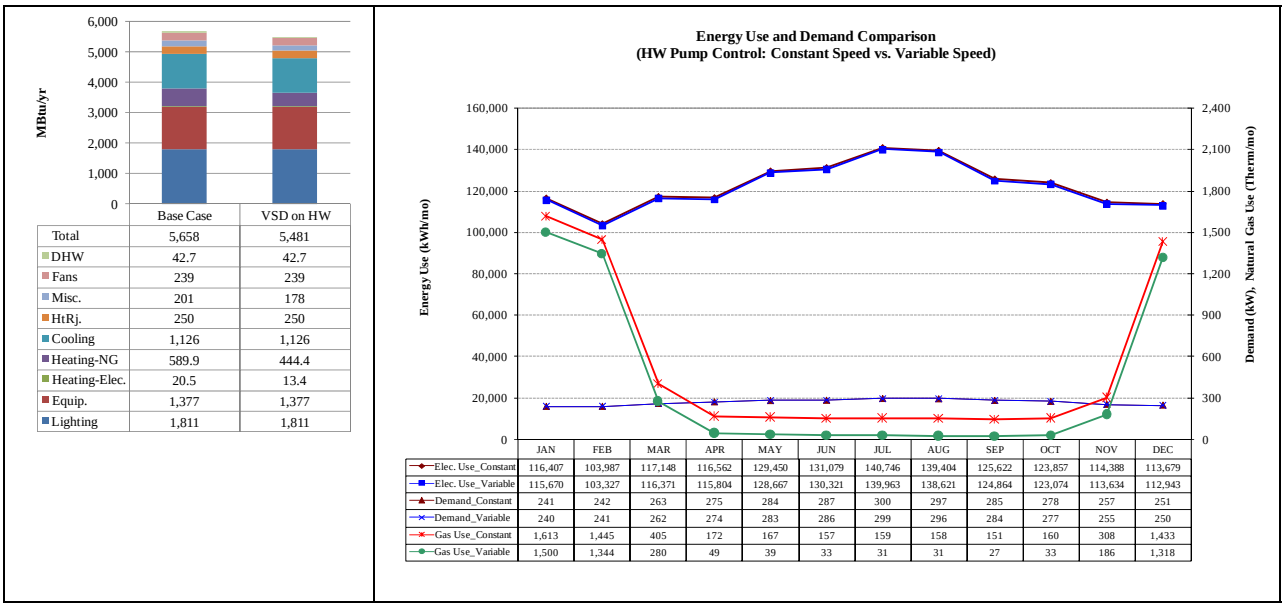
VSD Hot Water Pumps
To improve the performance of the heating system, variable speed drives were included for the hot water pumps.

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

- Reduced the space heating energy from 610 MMBtu/year to 458 MMBtu/year,
- Reduced the total energy use from 5,658 MMBtu/year to 5481 MMBtu/year, i.e., 176 MMBtu/year of total energy savings,
- Reduced the electricity use from 1472338 kWh/year to 1463265 kWh/year, i.e., 176.4 kWh/year electricity savings,
- Reduced the gas use from 6,325 therms/year to 4871 therms/year, i.e., 1454 therms/year gas savings, and
- Reduced the peak demand for July from 3260 kW to 3247 kW.

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

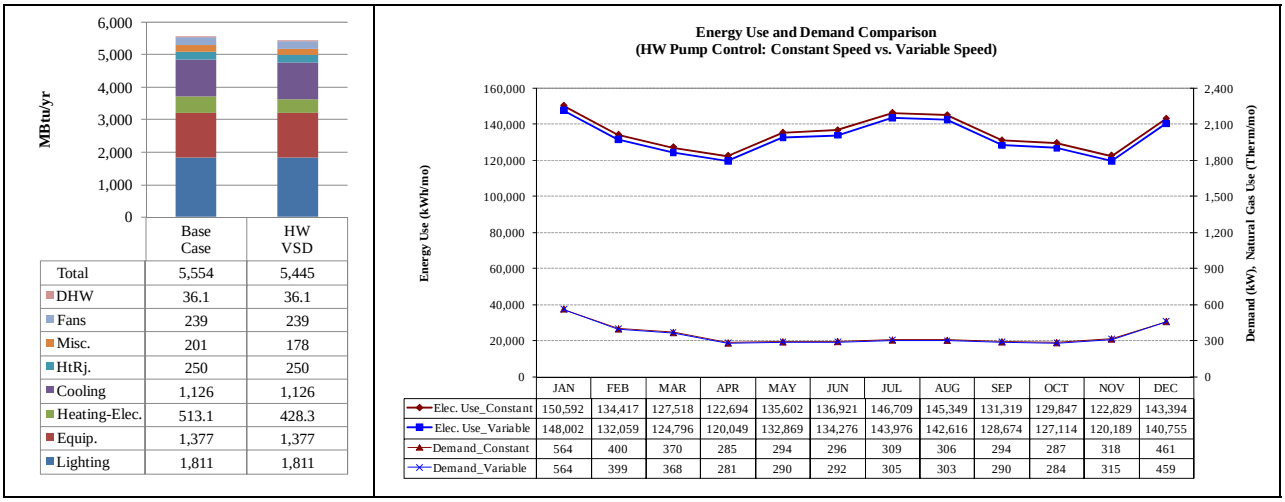
- Reduced the space heating energy from 513.1 MMBtu/year to 428.3 MMBtu/year,
- Reduced the total energy use from 5,554 MMBtu/year to 5,445 MMBtu/year, i.e., 109 MMBtu/year or total energy savings,
- Reduced the electricity use from 1,627,216 kWh/year to 1,595,389 kWh/year, i.e., 144,401 kWh/year electricity savings, and
- Reduced the peak demand from 4,183 kW to 4,149 kW.



	Base Case	VSD on HW
Total	5,658	5,481
DHW	42.7	42.7
Fans	239	239
Misc.	201	178
HtRj.	250	250
Cooling	1,126	1,126
Heating-NG	589.9	444.4
Heating-Elec.	20.5	13.4
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Constant	116,407	103,987	117,148	116,562	129,450	131,079	140,746	139,404	125,622	123,857	114,388	113,679
Elec. Use_Variable	115,670	103,327	116,371	115,804	128,667	130,321	139,963	138,621	124,864	123,074	113,634	112,943
Demand_Constant	241	242	263	275	284	287	300	297	285	278	257	251
Demand_Variable	240	241	262	274	283	286	299	296	284	277	255	250
Gas Use_Constant	1,613	1,445	405	172	167	157	159	158	151	160	308	1,433
Gas Use_Variable	1,500	1,344	280	49	39	33	31	31	27	33	186	1,318

Figure 31: Energy Use Comparison for Electric/Natural Gas Base Case (Constant Speed Drive on HW pump) and EEM (VSD on HW Pump).



	Base Case	HW VSD
Total	5,554	5,445
DHW	36.1	36.1
Fans	239	239
Misc.	201	178
HtRj.	250	250
Cooling	1,126	1,126
Heating-Elec.	513.1	428.3
Equip.	1,377	1,377
Lighting	1,811	1,811

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elec. Use_Constant	150,592	134,417	127,518	122,694	135,602	136,921	146,709	145,349	131,319	129,847	122,829	143,394
Elec. Use_Variable	148,002	132,059	124,796	120,049	132,869	134,276	143,976	142,616	128,674	127,114	120,189	140,755
Demand_Constant	564	400	370	285	294	296	309	306	294	287	318	461
Demand_Variable	564	399	368	281	290	292	305	303	290	284	315	459

Figure 32: Energy Use Comparison for All-electric Base Case (Constant Speed Drive on HW pump) and EEM (VSD on HW Pump).

Implementation Cost

Several VFD (Variable Frequency Drive) makers were reviewed on the web. As shown in Table 17, VFDs from B&G were typical with a price of $2,150 including a 5-horse power pump, but not including labor cost. Also, RSMeans provides VFD and labor costs that were $2,200 (5HP) without the pump. For the payback calculation, the VFD implementation cost of $2,200 was used for each hot water boiler pump. Two pumps were used, so the total VFD implementation cost was $4,400.

Table 17: Variable Speed Chilled Water Pump Equipment and Installation Cost Information and Payback Calculation

Maker	Type	Capacity	CHW / HW	Cost
B&G	1510-1.5BC-5HP	64 GPM @85'	HW Pump (2 VFDs needed)	Equipment: Pump - $1,400 each VFD - $750 each RSMeans: $2200 (5HP VFD) = Labor and VFD

(a) For Electric/gas building:

Electricity cost savings = 9073 kWh x $0.119/kWh		= $ 1079.68
Gas cost savings	= 1454 therm x 0.11 (MCF/therm) x $8/MCF	= $ 1279.52
Demand savings	= 12.63 kW x $5.00/kW	= $ 63.15
Total savings		= *$ 2422.36*
Cost difference		= *$ 4400*
Simple Payback		= **1.8 years**

(b) For All-Electric building:

Electricity cost savings = 31,827 kWh x $0.119/kWh		= $ 3,787
Demand savings	= 34.5 kW x $5.00/kW	= $ 172
Total savings		= *$ 3,960*
Cost difference		= *$ 4400*
Simple Payback		= **1.1 years**

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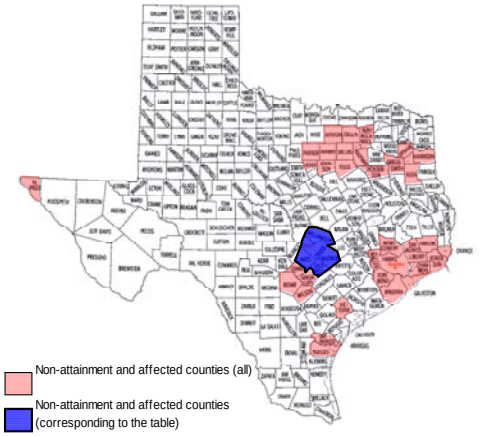
Appendix A

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 ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	13.2%	$9,512	3.1%	$502	$10,014	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	6.5%	$16,417	10.6%	$1,718	$18,135	$0 - $0	
3	Occupancy Sensors Installation	11.5%	$32,242	-3.6%	-$576	$31,667		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.6%	$3,261	2.4%	$395	$3,656		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	5.7%	$4,860	-0.8%	-$124	$4,736	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,733	2.1%	$337	$3,070	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.9%	$7,815	6.0%	$976	$8,791	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	2.4%	$1,121	0.0%	$0	$1,121	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,755	0.8%	$123	$4,877	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.3%	$1,649	0.3%	$47	$1,696	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
Combination 1										
1 Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	21.7%	$27,563	13.7%	$2,208	$29,771	$95,130 - $174,150		345	1.01	3.5 - 6.3
2 Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
Combination 2										
3 Occupancy Sensors Installation	19.6%	$39,109	-4.2%	-$678	$38,431		$26,500 - $28,000	498	1.35	0.7 - 0.7
5 Cold Deck Reset						$0 - $800				
Combination 3										
1 Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	17.1%	$17,201	8.8%	$1,425	$18,626	$95,130 - $174,150		213	0.70	7.9 - 13.2
7 Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8 Boiler Efficiency (75% to 95%)						$25,000 - $35,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

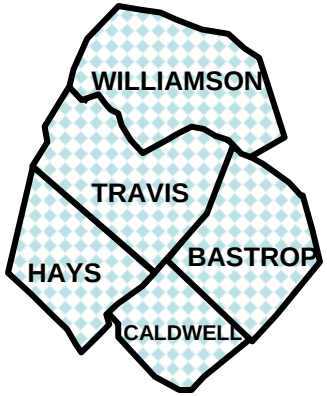
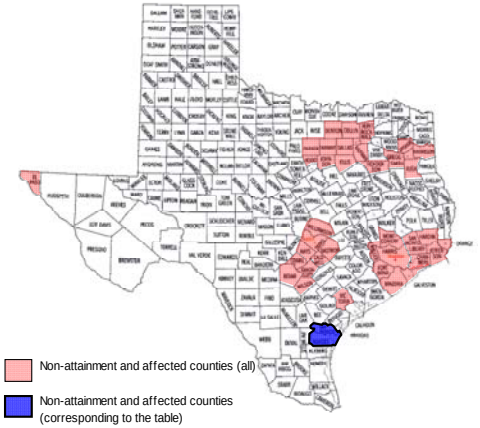


Table 1a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Bastrop, Caldwell, Hays, Travis and Williamson Counties

Natural Gas Heating (Nueces and San Patricio Counties)

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	6.5%	$5,867	3.3%	$543	$6,410	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	8.4%	$17,849	10.7%	$1,751	$19,600	$0 - $0	
3	Occupancy Sensors Installation	15.5%	$35,065	-3.0%	-$497	$34,568		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.8%	$3,556	2.5%	$413	$3,969		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	2.6%	$2,024	-1.0%	-$159	$1,865	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,731	2.0%	$324	$3,055	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.5%	$8,485	6.2%	$1,026	$9,511	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	1.0%	$423	0.0%	$0	$423	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.6%	$4,844	0.8%	$131	$4,976	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.8%	$1,236	0.2%	$35	$1,270	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	16.4%	$24,991	13.8%	$2,267	$27,257	$95,130 - $174,150		239	0.78	3.8 - 7.0
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.7%	$39,149	-3.8%	-$618	$38,531		$26,500 - $28,000	369	1.04	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	18.4%	$32,959	16.7%	$2,746	$35,704	$0 - $0		312	0.91	0.6 - 0.7
5	Cold Deck Reset						$0 - $800				
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

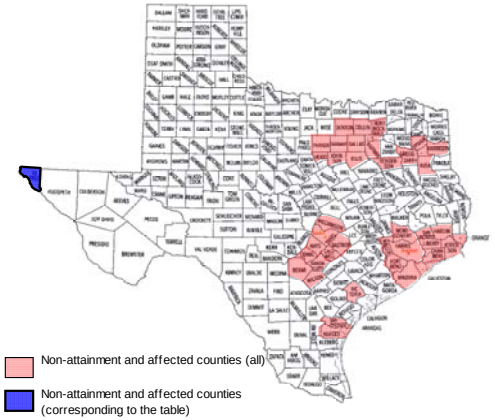
(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

Table 2a: 15% Above Code Savings (Commercial – 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 ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	0.0%	-$6	-0.1%	-$8	-$14	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	10.3%	$18,598	11.2%	$1,700	$20,297	$0 - $0	
3	Occupancy Sensors Installation	19.9%	$37,024	-3.5%	-$526	$36,498		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	3.1%	$5,469	3.5%	$530	$5,999		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	-1.3%	-$2,494	-2.1%	-$319	-$2,813	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.5%	$2,689	2.1%	$318	$3,008	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.1%	$7,162	5.4%	$819	$7,982	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	0.5%	$203	0.0%	$0	$203	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,214	0.8%	$127	$4,341	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	0.5%	$301	0.1%	$11	$312	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	16.6%	$29,884	19.4%	$2,931	$32,815	$0 - $0		N/A	N/A	2.8 - 4.3
4	Shading (none to 2.5 ft overhangs)							$67,900 - $110,000			
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
	Combination 2										
3	Occupancy Sensors Installation	19.9%	$37,024	-3.5%	-$526	$36,498		$26,500 - $28,000	N/A	N/A	0.72 - 0.76
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	16.6%	$29,850	17.2%	$2,600	$32,450	$0 - $0		N/A	N/A	0.12 - 0.16
4	Shading (none to 2.5 ft overhangs)							$67,900 $110,000			
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)						$0 - $200				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

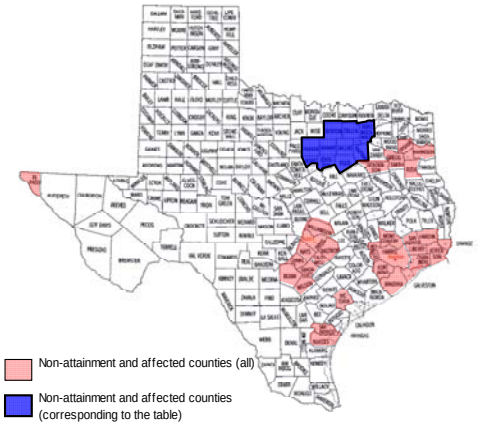
(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

Table 3a: 15% Above Code Savings (Commercial – 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 ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	17.8%	$12,718	2.6%	$406	$13,125	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	5.7%	$16,433	10.4%	$1,628	$18,061	$0 - $0	
3	Occupancy Sensors Installation	9.2%	$31,103	-3.9%	-$612	$30,491		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.8%	$3,802	2.5%	$391	$4,193		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	8.4%	$7,732	-0.4%	-$59	$7,673	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.3%	$2,667	1.9%	$302	$2,970	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.5%	$7,419	5.6%	$883	$8,302	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	3.5%	$1,685	0.0%	$0	$1,685	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$5,030	0.9%	$143	$5,173	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	3.0%	$2,293	0.4%	$66	$2,359	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	26.0%	$31,422	13.8%	$2,160	$33,582	$95,130 - $174,150		394	1.02	3.0 - 5.5
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	19.6%	$40,553	-3.8%	-$603	$39,950		$26,500 - $28,000	521	1.36	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	21.4%	$20,037	8.1%	$1,267	$21,305	$95,130 - $174,150		247	0.66	6.8 - 11.3
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8	Boiler Efficiency (75% to 95%)						$25,000 - $35,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

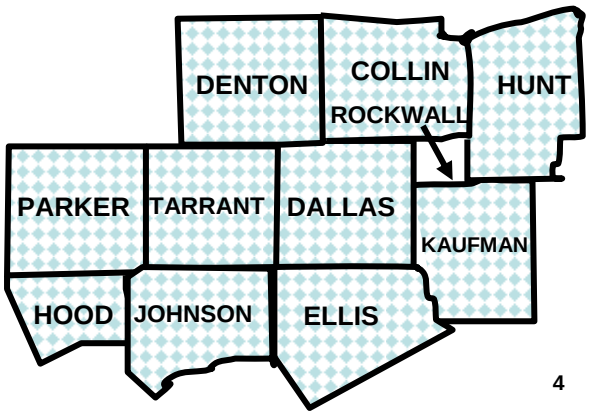
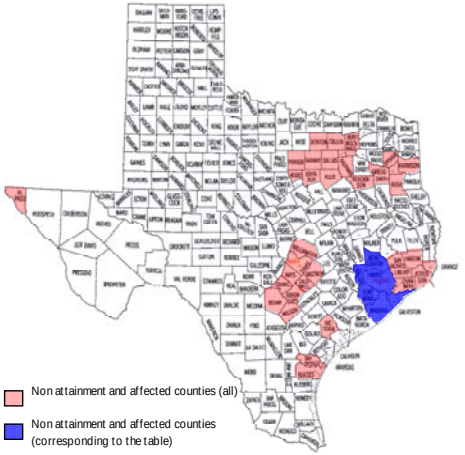


Table 4a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	10.7%	$7,114	3.2%	$517	$7,631	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	6.9%	$16,582	10.4%	$1,695	$18,277	$0 - $0	
3	Occupancy Sensors Installation	13.0%	$33,409	-2.3%	-$377	$33,032		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.9%	$3,785	2.7%	$438	$4,223		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	4.8%	$3,978	-0.6%	-$91	$3,887	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.3%	$2,629	2.0%	$329	$2,958	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.9%	$7,717	6.1%	$1,000	$8,718	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	2.2%	$993	0.0%	$0	$993	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,764	0.7%	$121	$4,885	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	3.1%	$2,243	0.4%	$63	$2,306	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	20.1%	$26,160	13.6%	$2,214	$28,374	$95,130 - $174,150		258	0.95	3.6 - 6.7
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	19.6%	$38,856	-3.4%	-$558	$38,299		$26,500 - $28,000	371	1.37	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	16.8%	$18,719	9.5%	$1,554	$20,273	$95,130 - $174,150		187	0.71	7.5 12.4
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8	Boiler Efficiency (75% to 95%)						$25,000 - $35,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

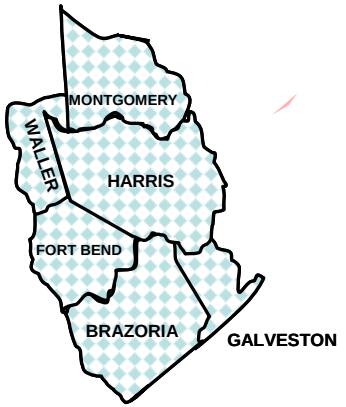
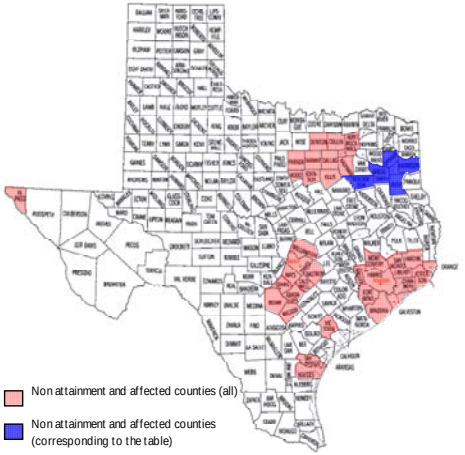


Table 5a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	14.5%	$8,849	1.2%	$184	$9,033	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	5.4%	$15,477	10.8%	$1,640	$17,117	$0 - $0	
3	Occupancy Sensors Installation	10.5%	$31,798	-3.1%	-$465	$31,334		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.7%	$3,491	2.6%	$400	$3,891		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	7.1%	$6,066	-0.9%	-$131	$5,936	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,870	2.3%	$357	$3,226	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.3%	$6,580	5.2%	$785	$7,365	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	2.8%	$1,270	0.0%	$0	$1,270	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.3%	$4,508	0.8%	$128	$4,636	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.3%	$1,663	0.3%	$48	$1,711	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	23.2%	$26,614	12.6%	$1,919	$28,533	$95,130 - $174,150		334	0.85	3.6 - 6.5
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.2%	$39,924	-3.2%	-$491	$39,433		$26,500 - $28,000	513	1.35	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	18.0%	$15,497	6.4%	$967	$16,465	$95,130 - $174,150		191	0.48	8.8 - 14.7
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8	Boiler Efficiency (75% to 95%)						$25,000 - $35,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

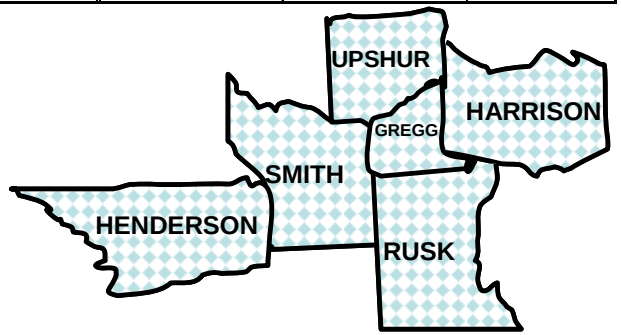
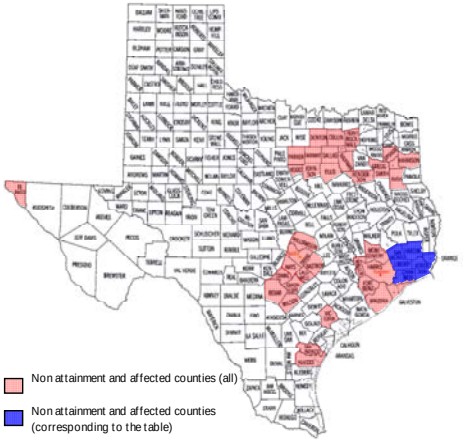


Table 6a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	9.8%	$6,661	2.0%	$326	$6,987	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	7.2%	$17,289	10.6%	$1,686	$18,975	$0 - $0	
3	Occupancy Sensors Installation	12.4%	$32,661	-3.6%	-$575	$32,086		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	2.2%	$4,215	2.5%	$392	$4,608		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	5.1%	$4,204	-0.9%	-$142	$4,063	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.3%	$2,583	1.9%	$301	$2,884	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.0%	$7,773	6.0%	$956	$8,729	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	1.8%	$804	0.0%	$0	$804	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,849	0.8%	$132	$4,981	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.0%	$1,416	0.3%	$40	$1,457	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	19.0%	$ 24,913.29	13.0%	$2,071	$26,984	$95,130 - $174,150		N/A	N/A	3.8 - 7.0
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.7%	$ 39,621.48	-3.9%	-$620	$39,002		$26,500 - $28,000	N/A	N/A	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.9%	$ 18,178.35	8.5%	$1,357	$19,535	$95,130 - $174,150		N/A	N/A	7.7 - 12.8
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8	Boiler Efficiency (75% to 95%)						$25,000 - $35,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

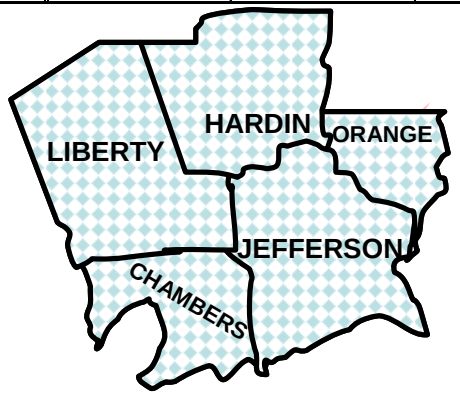
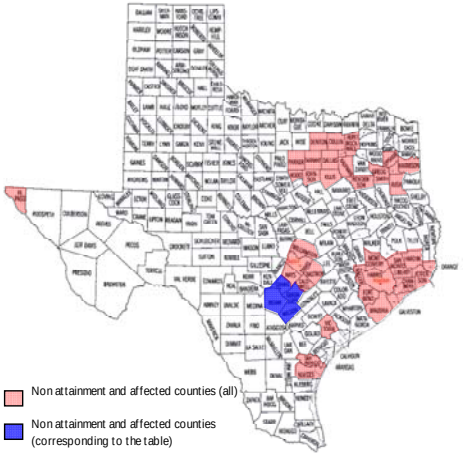


Table 7a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Chambers, Hardin, Jefferson, Liberty and Orange Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	11.6%	$8,404	3.2%	$522	$8,926	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	6.7%	$16,410	10.4%	$1,683	$18,093	$0 - $0	
3	Occupancy Sensors Installation	12.5%	$32,979	-3.2%	-$511	$32,468		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.7%	$3,451	2.7%	$431	$3,882		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	5.1%	$4,158	-0.7%	-$115	$4,042	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,739	2.1%	$342	$3,081	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.0%	$7,885	6.0%	$978	$8,863	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	2.1%	$965	0.0%	$0	$965	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,869	0.8%	$131	$5,001	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.1%	$1,516	0.3%	$43	$1,559	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	20.5%	$26,514	13.8%	$2,238	$28,751	$95,130 - $174,150		338	0.96	3.6 - 6.6
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.0%	$39,211	-3.6%	-$591	$38,619		$26,500 - $28,000	508	1.30	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.7%	$16,193	8.9%	$1,450	$17,643	$95,130 - $174,150		203	0.66	8.4 - 14.0
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
8	Boiler Efficiency (75% to 95%)						$25,000 - $35,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

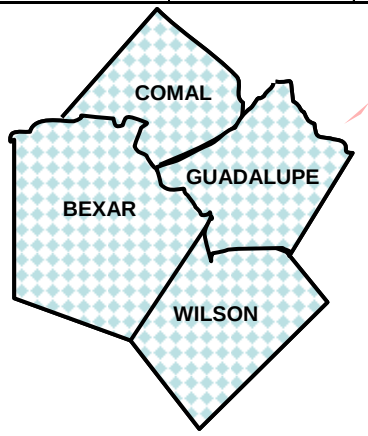
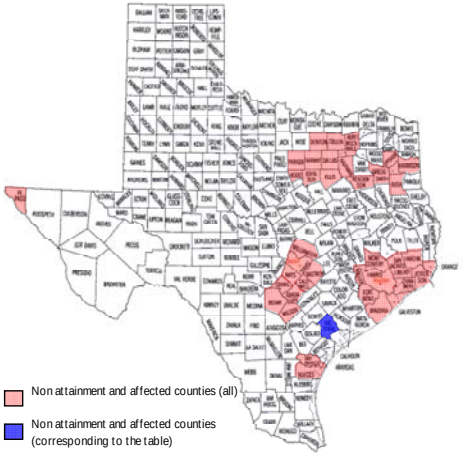


Table 8a: 15% Above Code Savings (Commercial – Natural Gas Heating) for Bexar, Comal, Guadalupe and Wilson Counties

Natural Gas Heating (Victoria County)

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	8.8%	$7,107	2.7%	$429	$7,536	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	7.8%	$17,638	10.5%	$1,691	$19,329	$0 - $0	
3	Occupancy Sensors Installation	14.3%	$34,302	-3.4%	-$544	$33,758		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	2.1%	$4,169	2.7%	$427	$4,595		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	3.6%	$2,835	-0.9%	-$150	$2,685	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,722	2.0%	$320	$3,043	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.2%	$8,021	6.0%	$956	$8,977	$16,000 - $18,000	
8	Boiler Efficiency (75% to 95%)	1.5%	$654	0.0%	$0	$654	$25,000 - $35,000	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,804	0.8%	$135	$4,939	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.5%	$1,723	0.3%	$48	$1,771	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	18.5%	$26,186	13.5%	$2,164	$28,350	$95,130 - $174,150		253	0.80	3.6 - 6.7
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.7%	$39,507	-3.6%	-$582	$38,924		$26,500 - $28,000	373	1.05	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	18.5%	$32,837	16.4%	$2,627	$35,464	$0 - $0		311	0.90	0.6 - 0.7
5	Cold Deck Reset						$0 - $800				
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

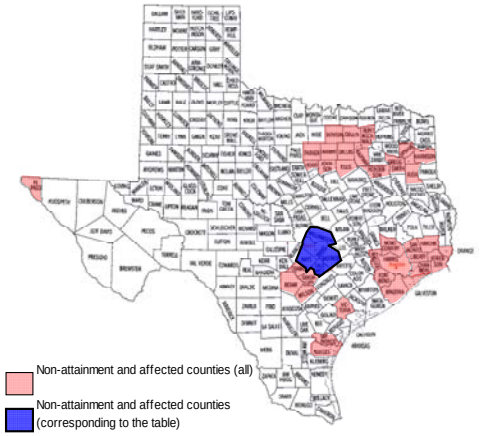
(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

Table 9a: 15% Above Code Savings (Commercial – 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 ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	10.9%	$21,300	26.3%	$5,663	$26,963	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	7.3%	$14,297	3.9%	$832	$15,128	$0 - $0	
3	Occupancy Sensors Installation	13.3%	$25,987	-8.0%	-$1,726	$24,261		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.6%	$3,188	2.4%	$508	$3,696		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	4.6%	$8,928	7.9%	$1,701	$10,628	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,720	1.5%	$319	$3,039	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.0%	$7,815	3.8%	$810	$8,625	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,755	1.0%	$205	$4,960	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.4%	$2,789	0.5%	$111	$2,901	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	19.8%	$38,610	32.8%	$7,065	$45,675	$95,130 - $174,150		492	1.12	2.5 - 4.5
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	19.9%	$38,849	2.2%	$478	$39,327		$26,500 - $28,000	495	1.32	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	16.6%	$32,496	30.8%	$6,642	$39,138	$95,130 - $174,150		414	0.92	3.5 - 6.1
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

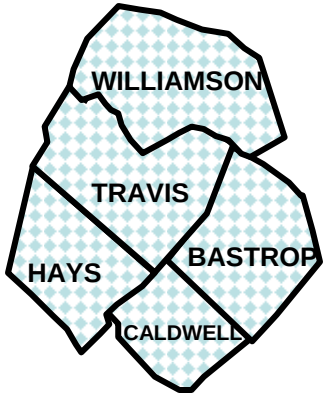
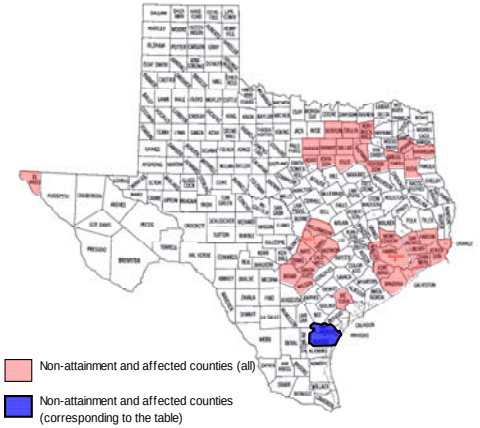


Table 1b: 15% Above Code Savings (Commercial - Electric Heating) for Bastrop, Caldwell, Hays, Travis and Williamson Counties

Electric Heating (Nueces and San Patricio Counties)

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	6.0%	$11,294	13.8%	$2,570	$13,864	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	8.9%	$16,677	5.9%	$1,105	$17,782	$0 - $0	
3	Occupancy Sensors Installation	16.6%	$31,192	-7.6%	-$1,419	$29,773		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.9%	$3,491	2.1%	$385	$3,875		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	2.1%	$3,950	4.1%	$765	$4,715	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,723	1.7%	$315	$3,038	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.5%	$8,485	5.0%	$930	$9,415	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.6%	$4,844	1.0%	$180	$5,024	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.1%	$2,075	0.5%	$95	$2,170	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.9%	$30,004	22.6%	$4,222	$34,226	$95,130 - $174,150		283	0.84	3.2 - 5.8
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.7%	$38,924	-1.1%	-$204	$38,720		$26,500 - $28,000	367	1.03	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	18.1%	$34,069	16.4%	$3,060	$37,128	$0 - $0		321	0.91	0.6 - 0.7
5	Cold Deck Reset						$0 - $800				
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

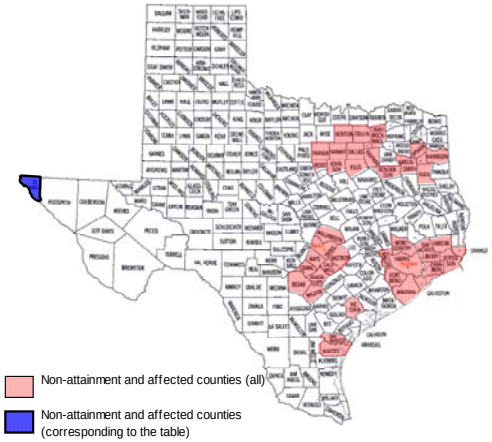
(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

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

Electric Heating (El Paso)

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	0.0%	$19	0.1%	$12	$31	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	10.4%	$18,043	9.1%	$1,512	$19,555	$0 - $0	
3	Occupancy Sensors Installation	20.3%	$35,271	-4.7%	-$783	$34,488		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	3.2%	$5,487	3.1%	$518	$6,005		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	-1.4%	-$2,421	-1.5%	-$256	-$2,677	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.5%	$2,689	1.7%	$288	$2,977	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.1%	$7,162	4.5%	$747	$7,909	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,214	0.9%	$155	$4,369	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	0.3%	$506	0.1%	$16	$523	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	16.8%	$29,194	16.0%	$2,665	$31,859	$0 - $0		N/A	N/A	2.9 - 4.4
4	Shading (none to 2.5 ft overhangs)							$67,900 - $110,000			
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
	Combination 2										
3	Occupancy Sensors Installation	20.3%	$35,271	-4.7%	-$783	$34,488		$26,500 - $28,000	N/A	N/A	0.75 - 0.79
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	16.8%	$29,142	14.4%	$2,399	$31,541	$0 - $0		N/A	N/A	0.13 - 0.17
4	Shading (none to 2.5 ft overhangs)							$67,900 $110,000			
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)						$0 - $200				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

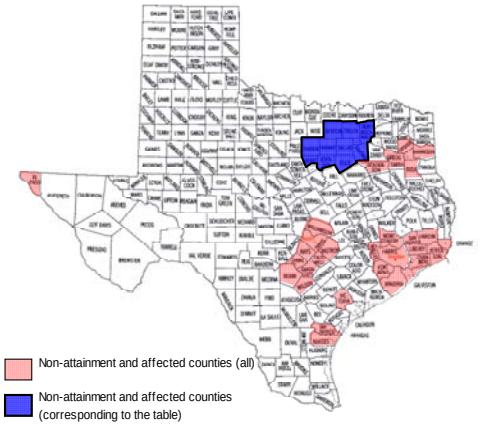
(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

Table 3b: 15% Above Code Savings (Commercial – 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 ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	14.3%	$28,975	27.7%	$6,042	$35,017	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	6.8%	$13,731	3.3%	$729	$14,460	$0 - $0	
3	Occupancy Sensors Installation	11.8%	$23,907	-6.5%	-$1,416	$22,491		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.9%	$3,792	2.3%	$501	$4,292		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	6.7%	$13,580	6.4%	$1,397	$14,977	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.3%	$2,643	1.4%	$300	$2,943	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.7%	$7,419	3.5%	$765	$8,184	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$5,030	1.0%	$223	$5,253	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.9%	$3,914	0.8%	$172	$4,086	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	23.1%	$46,774	33.0%	$7,185	$53,959	$95,130 - $174,150		601	1.16	2.0 - 3.7
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.1%	$40,592	2.6%	$569	$41,162		$26,500 - $28,000	521	1.34	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	17.9%	$36,160	31.5%	$6,855	$43,015	$95,130 - $174,150		465	0.81	3.1 - 5.3
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

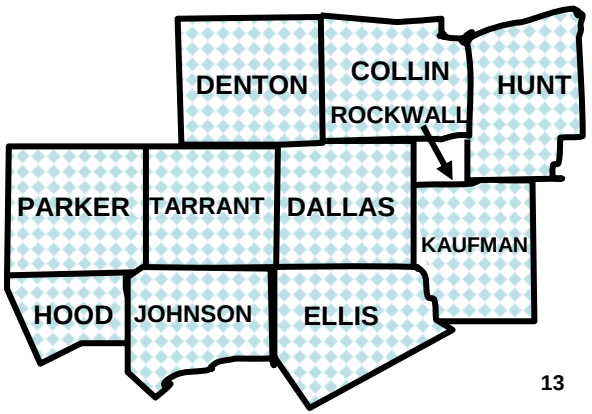
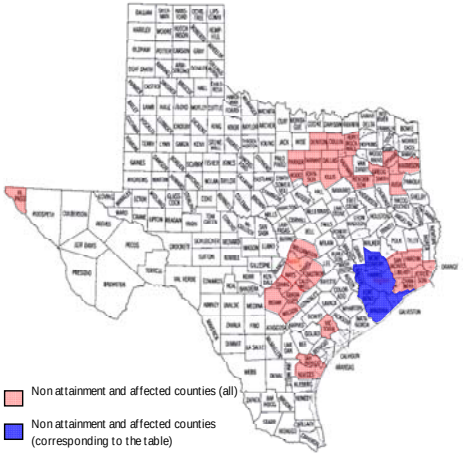


Table 4b: 15% Above Code Savings (Commercial – Electric Heating) for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall and Tarrant Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	8.9%	$17,184	22.6%	$4,726	$21,910	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	7.6%	$14,774	2.6%	$543	$15,317	$0 - $0	
3	Occupancy Sensors Installation	14.7%	$28,545	-7.0%	-$1,468	$27,078		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	2.0%	$3,849	2.3%	$471	$4,321		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	3.8%	$7,412	5.9%	$1,244	$8,656	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,616	1.4%	$299	$2,916	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.0%	$7,717	3.7%	$765	$8,482	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,764	1.0%	$208	$4,972	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	2.0%	$3,787	0.8%	$172	$3,960	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	18.5%	$35,763	29.8%	$6,237	$42,000	$95,130 - $174,150		341	1.08	2.7 - 4.9
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	19.8%	$38,343	0.0%	$5	$38,348		$26,500 - $28,000	366	1.36	0.7 - 0.8
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.5%	$30,066	27.7%	$5,793	$35,859	$95,130 - $174,150		287	0.90	4.0 - 6.7
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				
10	VSD on Hot Water Pump (from Constant to VSD)						$4,000 - $5,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

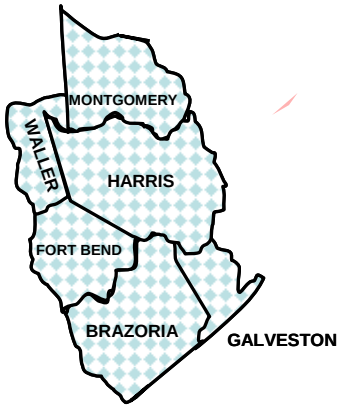
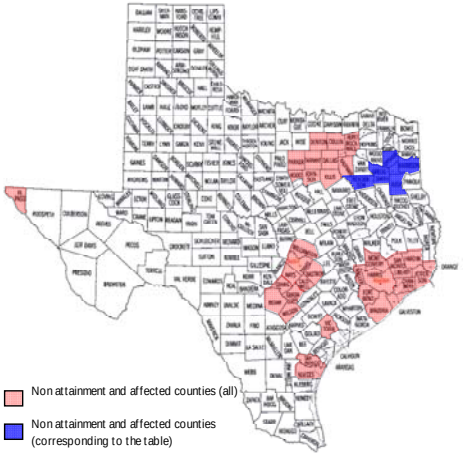


Table 5b: 15% Above Code Savings (Commercial – Electric Heating) for Brazoria, Fort Bend, Galveston, Harris, Montgomery and Waller Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	11.7%	$22,258	26.8%	$5,596	$27,854	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	6.6%	$12,484	1.4%	$285	$12,769	$0 - $0	
3	Occupancy Sensors Installation	13.0%	$24,749	-6.0%	-$1,253	$23,496		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.8%	$3,431	1.6%	$337	$3,769		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	5.6%	$10,563	6.5%	$1,364	$11,927	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.5%	$2,853	1.5%	$316	$3,169	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	3.5%	$6,580	2.8%	$581	$7,161	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.4%	$4,508	1.1%	$235	$4,743	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.5%	$2,823	0.5%	$112	$2,935	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
Combination 1											
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	20.6%	$39,107	34.1%	$7,111	$46,218	$95,130 - $174,150		502	0.96	2.4 - 4.5
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
Combination 2											
3	Occupancy Sensors Installation	20.7%	$39,359	3.9%	$805	$40,164		$26,500 - $28,000	506	1.32	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
Combination 3											
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.2%	$28,873	30.6%	$6,378	$35,251	$95,130 - $174,150		371	0.62	3.8 - 6.7
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

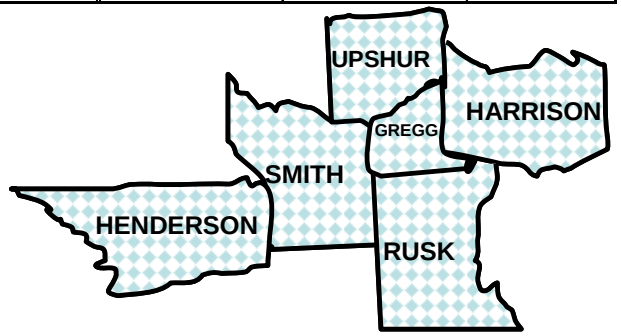
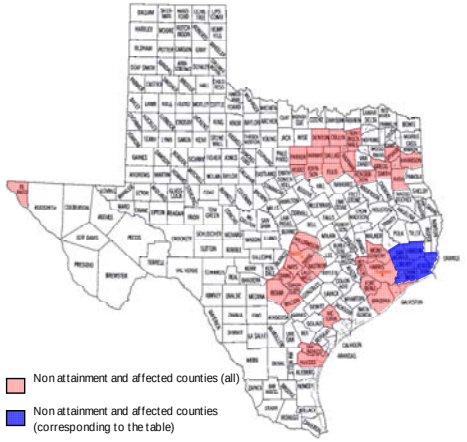


Table 6b: 15% Above Code Savings (Commercial – Electric Heating) for Gregg, Harrison, Henderson, Rusk, Smith and Upshur Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	8.2%	$15,613	20.6%	$4,108	$19,721	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	8.0%	$15,168	2.9%	$574	$15,741	$0 - $0	
3	Occupancy Sensors Installation	14.2%	$26,991	-5.9%	-$1,171	$25,820		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	2.3%	$4,276	2.0%	$398	$4,675		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	3.9%	$7,478	6.7%	$1,333	$8,811	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,572	1.5%	$293	$2,866	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.1%	$7,773	3.8%	$767	$8,540	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.6%	$4,849	1.1%	$214	$5,063	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.3%	$2,389	0.5%	$95	$2,484	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	17.6%	$33,270	28.6%	$5,709	$38,979	$95,130 - $174,150		N/A	N/A	2.9 - 5.2
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.9%	$39,589	3.9%	$785	$40,375		$26,500 - $28,000	N/A	N/A	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	16.2%	$30,704	27.6%	$5,506	$36,210	$95,130 - $174,150		N/A	N/A	6.0 - 10.0
4	Shading (none to 2.5 ft overhangs)							$67,900 - $110,000			
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

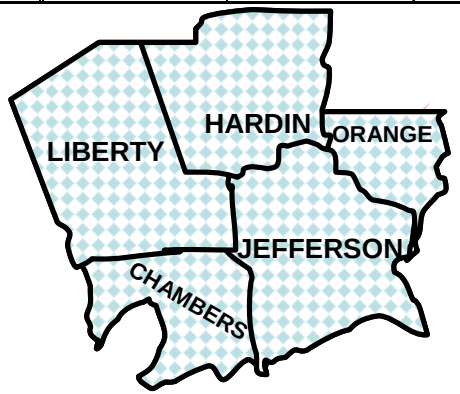
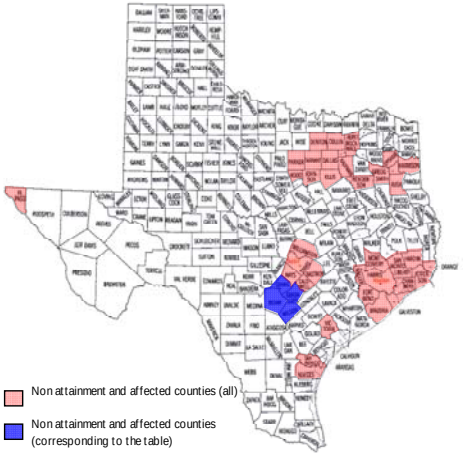


Table 7b: 15% Above Code Savings (Commercial – Electric Heating) for Chambers, Hardin, Jefferson, Liberty and Orange Counties

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

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($) Marginal Cost[1]	Estimated Cost ($) New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	9.7%	$18,753	22.8%	$4,701	$23,454	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	7.4%	$14,331	3.6%	$733	$15,064	$0 - $0	
3	Occupancy Sensors Installation	14.3%	$27,529	-5.6%	-$1,146	$26,383		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	1.8%	$3,455	2.0%	$422	$3,877		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	4.0%	$7,734	7.2%	$1,486	$9,220	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,732	1.5%	$315	$3,047	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.1%	$7,885	3.7%	$765	$8,650	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,869	1.0%	$215	$5,084	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.3%	$2,561	0.5%	$106	$2,666	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($) Marginal Cost[1]	Combined Estimated Cost ($) New System Cost[2]	Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	18.8%	$36,294	29.8%	$6,140	$42,434	$95,130 - $174,150		470	1.06	2.6 - 4.8
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.3%	$39,230	2.8%	$584	$39,814		$26,500 - $28,000	508	1.28	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	15.6%	$30,168	27.7%	$5,720	$35,888	$95,130 - $174,150		391	0.87	3.8 - 6.5
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

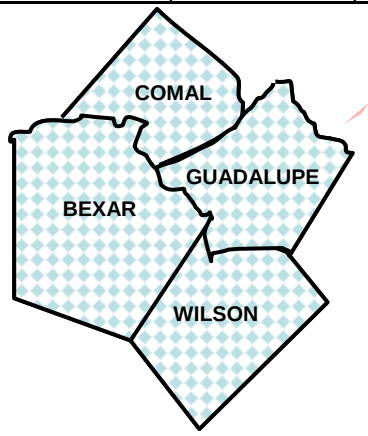
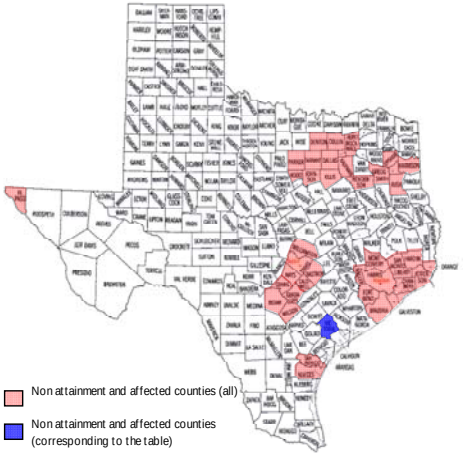


Table 8b: 15% Above Code Savings (Commercial – Electric Heating) for Bexar, Comal, Guadalupe and Wilson Counties

Electric Heating (Victoria County)

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)	Annual Energy Savings ($/year)	Annual Demand Savings (%)	Annual Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Estimated Cost ($)	
							Marginal Cost[1]	New System Cost[2]
A	**Envelope and Fenestration Measures**							
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	7.8%	$14,873	22.0%	$4,453	$19,326	$95,130 - $174,150	
2	Lighting Load (1.3 to 1.0 w/sq-ft)	8.4%	$15,980	3.9%	$791	$16,772	$0 - $0	
3	Occupancy Sensors Installation	15.7%	$29,680	-5.7%	-$1,154	$28,526		$26,500 - $28,000
4	Shading (none to 2.5 ft overhangs)	2.2%	$4,137	2.5%	$499	$4,635		$67,900 - $110,000
B	**HVAC System Measures**							
5	Cold Deck Reset	2.8%	$5,383	6.6%	$1,346	$6,729	$0 - $800	
6	Supply Fan Total Pressure (2.5 to 1.5 in-H2O)	1.4%	$2,708	1.5%	$301	$3,009	$0 - $200	
C	**Plant Equipment Measures**							
7	Chiller COP (4.9 to 6.1)	4.2%	$8,021	3.9%	$799	$8,820	$16,000 - $18,000	
8	Boiler Efficiency (Not Aplicable)	n/a	n/a	n/a	n/a	n/a	n/a - n/a	
9	VSD on Chilled Water Pump (from Constant to VSD)	2.5%	$4,804	1.1%	$218	$5,022	$3,700 - $4,700	
10	VSD on Hot Water Pump (from Constant to VSD)	1.5%	$2,899	0.6%	$127	$3,026	$4,000 - $5,000	



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[3]	Combined Energy Savings (%)	Combined Energy Savings ($/year)	Combined Demand Savings (%)	Combined Demand Savings ($/year)	Combined Savings (Energy+Demand) ($/year)	Combined Estimated Cost ($)		Combined Annual NOx Emissions Savings (lbs/year)	Combined Ozone Season Period NOx Emissions Savings (lbs/day)	Simple Estimated Payback (yrs)
							Marginal Cost[1]	New System Cost[2]			
	Combination 1										
1	Glazing U Factor (1.22 to 0.45 Btu/hr-sf-F)	17.6%	$33,449	29.8%	$6,047	$39,497	$95,130 - $174,150		315	0.88	2.8 - 5.2
2	Lighting Load (1.3 to 1.0 w/sq-ft)						$0 - $0				
	Combination 2										
3	Occupancy Sensors Installation	20.8%	$39,431	3.6%	$736	$40,167		$26,500 - $28,000	372	1.04	0.7 - 0.7
5	Cold Deck Reset						$0 - $800				
	Combination 3										
2	Lighting Load (1.3 to 1.0 w/sq-ft)	18.1%	$34,324	16.1%	$3,256	$37,579	$0 - $0		324	0.91	0.57 - 0.68
5	Cold Deck Reset						$0 - $800				
7	Chiller COP (4.9 to 6.1)						$16,000 - $18,000				
9	VSD on Chilled Water Pump (from Constant to VSD)						$3,700 - $4,700				

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 = $0.119/kWh
   Demand cost = $5.00/kW
   (Yearly demand cost = Sum of monthly demand cost for 12 months
   Natural gas cost = $0.80/therm

(Building Description)
- Building type: Office
- Gross area: 89,340 sq-ft
- Building dimension: 122ft x 122ft x 78ft (WxLxH)
- Number of floors: 6
- Floor-to-floor height: 13ft
- Window-to-wall ratio: 50%

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