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RECOMMENDATIONS FOR 2009 IECC 15% ABOVE CODE ENERGY EFFICIENCY MEASURES FOR RESIDENTIAL BUILDINGS

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

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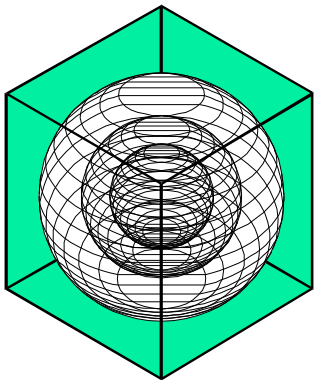

ENERGY SYSTEMS LABORATORY

Texas Engineering Experiment Station
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EXECUTIVE SUMMARY

In the 79th Legislature (2005) the Energy Systems Laboratory was required to develop three alternative methods for achieving 15% above-code energy savings in new residential, commercial and industrial construction. The Laboratory continues to work closely with code officials, energy raters, manufacturers, state officials and other stakeholders to develop cost effective energy efficiency measures.

This report presents detailed information about the recommendations for achieving 15% above-code energy performance, which are based on the 2009 International Energy Conservation Code (IECC), for single-family residences across the State of Texas. To estimate above-code savings (%) of energy efficiency measures, total source energy savings from heating, cooling, lighting, equipment, and DHW were considered for emissions reductions determination[1]. The recommendations were developed for three 2009 IECC climate zones in Texas along with simple payback calculations. This information is useful to homebuilders, utility demand side energy managers, homeowners and others who wish to construct residential buildings that exceed the minimum national energy code requirements.

The analysis was performed using an ESL simulation model based on the DOE-2.1e simulation of a 2009 IECC code-compliant, single family residence and the appropriate TMY2 weather files for seventeen counties in Texas for which TMY2 data is available. According to 2009 IECC Climate Zone, seventeen counties were categorized into three climate zones: Climate Zone 2, 3, and 4, and the 2009 IECC code-compliance base-case models were constructed for each climate zone. Two options based on the choice of heating fuel type were considered: (a) natural gas (gas-fired furnace for space heating, and gas water heater for domestic water heating), and (b) electricity (heat pump for space heating, and electric water heater for domestic water heating).

A total of eighteen measures based on the energy savings above the base-case house were selected. These measures include building envelope and fenestration, HVAC system, domestic hot water (DHW) system, lighting and renewable options. The implementation costs of each individual measure were also calculated along with simple payback calculations. These measures were then combined to achieve the total source energy savings of the group is 15% above the base-case 2009 code-compliant house. As a result, three example combinations were proposed for each base case ((a) electric/gas house and (b) all-electric house) in each climate zone. Each combination was formed to have a different payback period. Finally, the corresponding emissions savings of each combination were calculated based on the eGrid for Texas.

[1] The end-uses covered by the 2009 IECC include heating, cooling, and DHW energy only.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

This report presents detailed information about the recommendations for achieving 15% above-code energy performance, which are based on the 2009 International Energy Conservation Code (IECC), for single-family residences across the State of Texas. To estimate above-code savings (%) of energy efficiency measures, total source energy savings from heating, cooling, lighting, equipment, and DHW were considered for emissions reductions determination[2]. The recommendations were developed for three 2009 IECC climate zones in Texas along with simple payback calculations. This information is useful to homebuilders, utility demand side energy managers, homeowners and others who wish to construct residential buildings that exceed the minimum national energy code requirements. The analysis was performed using an ESL simulation model based on the DOE-2.1e simulation of a 2009 IECC code-compliant, single family residence and the appropriate TMY2 weather files for seventeen counties in Texas. Two options based on the choice of heating fuel type were considered: (a) natural gas (gas-fired furnace for space heating, and gas water heater for domestic water heating), and (b) electricity (heat pump for space heating, and electric water heater for domestic water heating). For the rest of this report, these houses will be referred to as (a) electric/gas house and (b) all-electric house, respectively.

1.1 Organization of the Report

The report is organized in the following order; Section 1 presents the introduction and purpose of the report. Section 2 presents the methodology, including overview, the base-case model used for simulation, and assumptions for cost analysis. Section 3 gives a brief description of eighteen individual energy efficiency measures and simulation input. Section 4 provides the results of simulation and cost analysis, including savings from individual measures along with the simple payback calculations and 15% above-code group measures. Lastly, Section 5 gives a detail description of the each individual measure, implementation cost of the measures and simple payback period for each individual measure.

[2] The end-uses covered by the 2009 IECC include heating, cooling, and DHW energy only.

2 METHODOLOGY

This section describes the methodology and assumptions used in this analysis to develop the recommendations for achieving 2009 IECC 15% above-code energy performance for single-family residences across the State of Texas. Section 2.1 presents an overall approach used in this analysis. Section 2.2 describes the base-case building characteristics. Section 2.3 presents assumptions used in cost analysis.

2.1 **Overview**

The analysis was performed using an ESL simulation model based on the DOE-2.1e simulation of a 2009 IECC code-compliant, single family residence and the appropriate TMY2 weather files. Seventeen counties in Texas for which TMY2 data is available (Figure 1) were selected and categorized into three climate zones (Climate Zone 2, 3, and 4) according to 2009 IECC Climate Zone classification. Table 1 shows the corresponding 2009 IECC climate zone and the TMY2 weather file of seventeen counties. Of seventeen counties, nine counties are classified as Climate Zone 2, and Climate Zone 3 includes seven counties. For Climate Zone 4, only Potter County was simulated with Amarillo TMY2 data.

The 2009 IECC code-compliance base-case models were constructed for each climate zone. Two options based on the choice of heating fuel type were considered: (a) natural gas (gas-fired furnace for space heating, and gas water heater for domestic water heating), and (b) electricity (heat pump for space heating, and electric water heater for domestic water heating)[3]. A total of eighteen energy efficiency measures were then applied to the base-case models to determine the savings of each measure. These measures were simulated by modifying the selected parameters used for the DOE-2 simulation model. The solar measures including solar PV and solar DHW were simulated using the PV-F Chart (Klein and Beckman 1994) and F-Chart (Klein and Beckman 1983) programs, respectively. The implementation costs of each measure were also calculated along with simple payback calculations.

To develop the recommendations by climate zone, the simulation results for seventeen counties were grouped according to the corresponding climate zone. The measures were then combined to achieve the total source energy savings of the group is 15% above the base-case 2009 code-compliant house. The results from individual measures and cost analysis were used to guide the selection of measures for this group analysis. Another set of simulations was performed with the selected measures applied in combination. As a result, three example combinations were proposed for each base case ((a) electric/gas house and (b) all-electric house) in each climate zone. Each combination was formed to have a different payback period. Finally, the corresponding emissions savings of each combination were calculated based on the eGrid for Texas.

[3] For the rest of this report, these houses will be referred to as (a) electric/gas house and (b) all-electric house, respectively

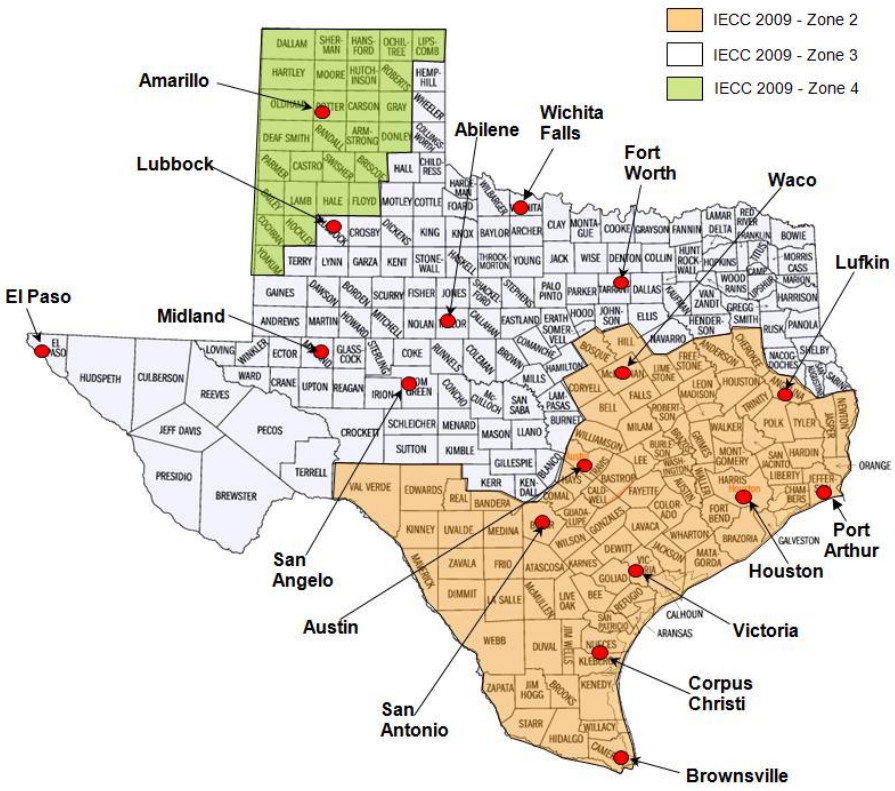


Figure 1. Available TMY2 Weather Files in Texas

Table 1. 2009 IECC Climate Zone and TMY2 Weather Data of Seventeen Selected Counties

2009 IECC Climate Zone		TMY2 Weather Files	County Name
2	2A	Austin (ATT)	Travis
	2A	Brownsville (BRO)	Cameron
	2A	Corpus Christi (CRP)	Nueces
	2A	Houston (IAH)	Harris
	2A	Lufkin (LFK)	Angelina
	2A	Port Arthur (BPT)	Jefferson
	2A	San Antonio (SAT)	Bexar
	2A	Victoria (VCT)	Victoria
	2A	Waco (ACT)	McLennan
3	3A	Fort Worth (DFW)	Tarrant
	3A	Wichita Falls (SPS)	Wichita
	3B	Abilene (ABI)	Taylor
	3B	El Paso (ELP)	El Paso
	3B	Lubbock (LBB)	Lubbock
	3B	Midland (MAF)	Midland
	3B	San Angelo (SJT)	Tom Green
4	4B	Amarillo (AMA)	Potter

2.2 Base-Case Building Description

The base-case building simulation model in this analysis is based on the *standard* design as defined in Chapter 4 of the 2009 IECC and certain assumptions, which are described throughout this document. The base-case building is a 2,325 sq. ft., square-shape, one story, single-family, detached house oriented N, S, E, W, with a floor-to-ceiling height of 8 feet. The house has an attic with a roof pitched at 23 degrees, which contains the HVAC systems and ductwork. The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2009 IECC. Table 2 summarizes the base-case building characteristics used in the DOE-2 simulation model for each climate zone.

2.3 Assumptions for Cost Analysis

The cost analysis for different measures was carried out based on utility costs of $0.11/kWh for electricity and $0.84/therm (Climate Zone 2) and $0.64/therm (Climate Zone 3 and 4) for natural gas. The electric rate was determined based on the information compiled by the Public Utility Commission of Texas[4]. For the natural gas, the annual average rates calculated for San Antonio[5], Dallas[6], and Amarillo[7] were used in the analysis for Climate Zone 2, 3, and 4, respectively.

[4] PUCT. 2010. *Average Annual Rate Comparison for Residential Electric Service: July 2010*. Austin, TX: Public Utility Commission of Texas. Retrieved September 30, 2010, from http://www.puc.state.tx.us/electric/rates/RESrate.cfm

[5] CPS Energy. 2010. *Fuel and Regulatory Charges*. San Antonio, TX: CPS Energy. Retrieved November 9, 2010, from http://www.cpsenergy.com/Residential/Billing_Payments/Fuel_and_Regulatory_Charges/index.asp

[6] Atmos Energy. 2010a. *Atmos Energy Tariffs for Mid-Tex: September 2010 Mid-Tex GCR Rates*. Dallas, TX: Atmos Energy. Retrieved September 30, 2010, from http://www.atmosenergy.com/about/tariffs.html?st=mtx&pass=1

[7] Atmos Energy. 2010b. *Atmos Energy Tariffs for West Texas: September 2010 Texas (West) GCA Rates*. Dallas, TX: Atmos Energy. Retrieved September 30, 2010, from http://www.atmosenergy.com/about/tariffs.html?st=TX&pass=1

Table 2. Base Case Building Description

Characteristics	Information Source	Assumptions			Comments
		2009 IECC Climate Zone: 2	2009 IECC Climate Zone: 3	2009 IECC Climate Zone: 4	
Building					
Building Type		Single family, detached house			
Gross Area	NAHB (2003)	2,325 sq. ft. (48.21 ft. x 48.21 ft.)			
Number of Floors	NAHB (2003)	1			
Floor to Floor Height (ft.)	NAHB (2003)	8			
Orientation		South facing			
Construction					
Construction	NAHB (2003)	Light-weight wood frame with 2x4 studs spaced at 16" on center			
Floor	NAHB (2003)	Slab-on-grade floor			
Roof Configuration	NAHB (2003)	Unconditioned, vented attic			
Roof Absorptance	2009 IECC, Table 405.5.2(1)	0.75			Solar reflectance SR= 0.25
Ceiling Insulation (hr-sq.ft.-°F/Btu)	2009 IECC, Table 402.1.3 (402.1.1)	R-27.84		R-32.51	
Wall Absorptance	2009 IECC, Table 405.5.2(1)	0.75			Assuming brick facia exterior
Wall Insulation (hr-sq.ft.-°F/Btu)	2009 IECC, Table 402.1.3 (402.1.1)	R-11.8			
Slab Perimeter Insulation	2009 IECC, Table 402.1.3 (402.1.1)	None		R-10	
Ground Reflectance	DOE2.1e User Manual (LBL 1993)	0.24			Assuming grass
U-Factor of Glazing (Btu/hr-sq.ft.-°F)	2009 IECC, Table 402.1.3	0.65	0.5	0.35	
Solar Heat Gain Coefficient (SHGC)	2009 IECC, Table 402.1.1	0.3		0.4	
Window Area	2009 IECC, Table 405.5.2 (1)	15% of conditioned floor area			This amounts to 348.75 sq. ft. window area and 22.61% window-to-wall area ratio for the assumed base case building configuration.
Exterior Shading		None			
Roof Radiant Barrier		No			Roof Radiant Barrier Emissivity=0.05
Slope of Roof		5:12			Steep slope (5:12 Slope of roof =23 degrees)
Space Conditions					
Space Temperature Set point	2009 IECC, Table 405.5.2 (1)	72°F Heating, 75°F Cooling, no set-back			
Internal Heat Gains	2009 IECC, Table 405.5.2 (1)	1.095 kW (modeled as 0.547 kW for lighting and 0.547 kW for equipment)			This assumes heat gains from lighting, equipment and occupants.
Number of Occupants	2009 IECC, Table 405.5.2 (1)	None			Assuming internal gains include heat gain from occupants
Mechanical Systems					
HVAC System Type		Gas & Electric Type: Electric cooling (air conditioner) and natural gas heating (gas fired furnace)			
		All Electric Type: Electric cooling and heating (air conditioner with heat pump)			
HVAC System Efficiency	2009 IECC, Table 503.2.3 (2), 503.2.3 (4)	Gas & Electric Type: SEER 13 AC, 0.78 AFUE furnace			
		All Electric Type: SEER 13 AC, 7.7 HSPF heat pump			
Cooling Capacity (Btu/hr)		55,800			500 sq. ft./ton
Heating Capacity (Btu/hr)		55,800			1.0 x cooling capacity
DHW System Type	Tank size from ASHRAE HVAC Systems and Equipment Handbook	Gas & Electric Type: 40-gallon tank type gas water heater with a standing pilot light			
		All Electric Type: 50-gallon tank type electric water heater (without a pilot light)			
DHW Heater Energy Factor	2009 IECC, Table 504.2	Gas & Electric Type: 0.594			Gas: 0.67-0.0019 V EF Electric: <=12 KW: 0.97-0.00132 V EF >12kW: 1.73V+155SL Btu/h Where V=storage volume (gal.)
		All Electric Type: 0.904			
Duct Location	NAHB (2003)	Unconditioned, vented attic			20-30%
Duct Leakage (%)	2009 IECC, Sec. 403.2.2	5.56% (supply) and 5.56% (return)			Total: 8 CFM/100 ft^2 to outdoor
Duct Insulation (hr-sq.ft.-°F/Btu)	2009 IECC, Sec. 403.2.1	R-8 (supply) and R-6 (return)			
HVAC Duct Static Pressure		1			
Supply Air Flow (CFM/ton)		360			
Infiltration Rate (SG)	2009 IECC, Table 405.5.2 (1), ASHRAE 119 Section 5.1	SLA= 0.00036			

3 ENERGY EFFICIENCY MEASURES (EEMs)

This section documents eighteen energy efficiency measures (EEMs) for achieving 15% above-code energy performance in single-family residential buildings. Section 3.1 gives a brief description of eighteen individual EEMs. Section 3.2 provides input parameters used in the simulation of each EEM.

3.1 **Individual EEMs**

Table 3 lists eighteen energy efficiency measures considered in this analysis. These include measures for the building envelope and fenestration, HVAC system, domestic hot water (DHW) system, lighting and renewable options. Two different options were considered: (a) an electric/gas house and (b) an all-electric house. These measures were simulated by modifying the selected parameters used for the DOE-2 simulation model.

3.2 **Simulation Input for Individual EEMs**

Table 4 to Table 6 list the input parameters used for the base case and individual EEMs for each climate zone. The two rows in which a whole row of cells are shaded present the parameters used in the base-case runs: (a) an electric/gas house and (b) an all-electric house. The remaining rows show the parameters used in the simulation of the individual energy efficiency measures. The shaded cells in each row indicate the change in the value of the parameter used to simulate the measure. A detailed description of these measures is included in Section 5.

Table 3. Energy Efficiency Measures

	EEM No	Electric/Gas House	All-Electric House
Envelope and Fenestration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	
	2	Sealed (Unvented) Attic	
	3	Window Shading (None to 2 ft. Eaves on All Sides)	
	4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)	
	5[1)]	Decreased Window SHGC (Climate Zone 2 & 3: from .3 to .2)	
	6	Decreased Window U Value (Climate Zone 2: from 0.65 to 0.3;Climate Zone 3: from 0.5 to 0.3; Climate Zone 4: from 0.35 to 0.3)	
	7[1)]	Decreased Window SHGC & U Value (Climate Zone 2: from .3 to .2 SHGC & from 0.65 to 0.3 U-Value;Climate Zone 3: from .3 to .2 SHGC & from 0.5 to 0.3 U-Value)	
HVAC System Measures	8	Relocate Mechanical Systems within Conditioned Space	
	9	Improved Air Conditioner SEER (from 13 to 15 SEER)	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF)
	10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)	-
Domestic Hot Water Measures	11	Tankless Gas Water Heater (without a Standing Pilot Light)	-
	12	Removal of Pilot Light from Domestic Hot Water System	-
	13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	
	14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	
Renewable Power	18	4 kW Photovoltaic Array	

1) EEM 5 and 7 were not applied to Climate Zone 4.

Table 4. Simulation Input Parameters for Individual EEMs (Climate Zone 2)

	EEM #	Energy Efficiency Measure (EEM)	Radiant Barrier	Supply Duct Leakage (%)	Return Duct Leakage (%)	Insulation on Roof	Fractional Leakage Area for House	Fractional Leakage Area for Attic	Shading				WWR% forSide Wall				SHGC	U-Value	R-Value supply	R-Value return	Ducts in Conditioned Space	Improved SEER	Improved AFUE	Energy Factor	Lighting (kW)	Improved HSPF
									Front	Right	Back	Left	Front	Back	Right	Left										
		(a) Electric/Gas House Base Case (Climate Zone 2)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	5	Decreased SHGC (CZ 2: from .3 to .2)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	6	Decreased U Value (CZ 2: from 0.65 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	**0.3**	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	7	Decreased SHGC (CZ 2: from .3 to .2) & U Value (CZ 2: from 0.65 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	**0.3**	8	6	ATTIC	13	0.78	0.594	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	**1000**	**1000**	**ROOM**	13	0.78	0.594	0.547	7.70
	9	Improved SEER (from 13 to 15)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	**15**	0.78	0.594	0.547	7.70
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	**0.93**	0.594	0.547	7.70
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	**0.748**	0.547	7.70
	12	Removal of Pilot Light from DHW	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	**0.660**	0.547	7.70
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
		(b) All-Electric House Base Case (Climate Zone 2)[1)]	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	5	Decreased SHGC (CZ 2: from .3 to .2)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	6	Decreased U Value (CZ 2: from 0.65 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	**0.3**	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	7	Decreased SHGC (CZ 2: from .3 to .2) & U Value (CZ 2: from 0.65 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	**0.3**	8	6	ATTIC	13	0.78	0.904	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	**1000**	**1000**	**ROOM**	13	0.78	0.904	0.547	7.70
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	**15**	0.78	0.904	0.547	**8.50**
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70

1) EEM 10,11 and 12 were not applied to All-Electric House.

Table 5. Simulation Input Parameters for Individual EEMs (Climate Zone 3)

	EEM #	Energy Efficiency Measure (EEM)	Radiant Barrier	Supply Duct Leakage (%)	Return Duct Leakage (%)	Insulation on Roof	Fractional Leakage Area for House	Fractional Leakage Area for Attic	Shading				WWR% forSide Wall				SHGC	U-Value	R-Value supply	R-Value return	Ducts in Conditioned Space	Improved SEER	Improved AFUE	Energy Factor	Lighting (kW)	Improved HSPF
									Front	Right	Back	Left	Front	Back	Right	Left										
		(a) Electric/Gas House Base Case (Climate Zone 3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.5	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	5	Decreased SHGC (CZ 3: from .3 to .2)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	6	Decreased U Value (CZ3: from 0.5 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	**0.3**	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	7	Decreased SHGC (CZ 3: from .3 to .2) & U Value (CZ3: from 0.5 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	**0.3**	8	6	ATTIC	13	0.78	0.594	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	**1000**	**1000**	**ROOM**	13	0.78	0.594	0.547	7.70
	9	Improved SEER (from 13 to 15)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	**15**	0.78	0.594	0.547	7.70
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	**0.93**	0.594	0.547	7.70
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	**0.748**	0.547	7.70
	12	Removal of Pilot Light from DHW	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	**0.660**	0.547	7.70
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.594	0.547	7.70
		(b) All-Electric House Base Case (Climate Zone 3)[1]	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.5	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	5	Decreased SHGC (CZ 3: from .3 to .2)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	6	Decreased U Value (CZ3: from 0.5 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	**0.3**	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	7	Decreased SHGC (CZ 3: from .3 to .2) & U Value (CZ3: from 0.5 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	**0.2**	**0.3**	8	6	ATTIC	13	0.78	0.904	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	**1000**	**1000**	**ROOM**	13	0.78	0.904	0.547	7.70
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	**15**	0.78	0.904	0.547	**8.50**
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.3	0.65	8	6	ATTIC	13	0.78	0.904	0.547	7.70

1) EEM 10,11 and 12 were not applied to All-Electric House.

Table 6. Simulation Input Parameters for Individual EEMs (Climate Zone 4)

	EEM #	Energy Efficiency Measure (EEM)	Radiant Barrier	Supply Duct Leakage (%)	Return Duct Leakage (%)	Insulation on Roof	Fractional Leakage Area for House	Fractional Leakage Area for Attic	Shading				WWR% forSide Wall				SHGC	U-Value	R-Value supply	R-Value return	Ducts in Conditioned Space	Improved SEER	Improved AFUE	Energy Factor	Lighting (kW)	Improved HSPF
									Front	Right	Back	Left	Front	Back	Right	Left										
		(a) Electric/Gas House Base Case (Climate Zone 4[1])	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	6	Decreased U Value (CZ4 from 0.35 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	**0.3**	8	6	ATTIC	13	0.78	0.594	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	**1000**	**1000**	**ROOM**	13	0.78	0.594	0.547	7.70
	9	Improved SEER (from 13 to 15)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	**15**	0.78	0.594	0.547	7.70
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	**0.93**	0.594	0.547	7.70
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	**0.748**	0.547	7.70
	12	Removal of Pilot Light from DHW	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	**0.660**	0.547	7.70
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.594	0.547	7.70
		(b) All-Electric House Base Case (Climate Zone 4[1])[2]	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	**Y**	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	2	Sealed (Unvented) Attic	N	**2.78%**	**2.78%**	**R**	**0.00027**	**0**	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	3	Window Shading (2ft overhang on all sides)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	N	5.56%	5.56%	C	0.00036	0.0033	**2**	**2**	**2**	**2**	**40.70**	**22.61**	**13.57**	**13.57**	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	6	Decreased U Value (CZ4 from 0.35 to 0.3)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	**0.3**	8	6	ATTIC	13	0.78	0.904	0.547	7.70
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	N	**0.00%**	**0.00%**	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	**1000**	**1000**	**ROOM**	13	0.78	0.904	0.547	7.70
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	**15**	0.78	0.904	0.547	**8.50**
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	**0.445**	7.70
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	**0.342**	7.70
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	**0.239**	7.70
Renewable Power Options	18	4 kW PV Array	N	5.56%	5.56%	C	0.00036	0.0033	0	0	0	0	22.61	22.61	22.61	22.61	0.4	0.35	8	6	ATTIC	13	0.78	0.904	0.547	7.70

1) EEM 5 and 7 were not applied to Climate Zone 4.

2) EEM 10,11 and 12 were not applied to All-Electric House.

4 RESULTS

This section presents the results of simulation and cost analysis. Section 4.1 provides the detailed results for three representative counties in each climate zone such as Harris County for Climate Zone 2, Tarrant County for Climate Zone 3 and Potter County for Climate Zone 4. The same analysis was performed for other fourteen counties, and to develop the recommendations by climate zone, the savings results of seventeen counties were grouped according to the corresponding 2009 IECC climate zone and presented in Section 4.2. Section 4.3 presents the group measures which are the combinations of individual measures for achieving 15% above-code savings based on the 2009 IECC.

4.1 Simulation Results for Individual Measures

Table 7 to Table 9 summarize the results of simulation and cost analysis for Harris, Tarrant, and Potter County, including: the annual source energy consumption for different end-uses, fuel types, and total, calculated energy and energy cost savings, increased cost of implementation (obtained from various resources listed in Appendix A[8]), and the calculated payback period for each measure. The annual site energy use was obtained from the BEPS report of the DOE-2 output and then converted to source energy[9]. Figure 2 to Figure 7 provide a graphical representation of the resultant energy consumption of the EEMs.

4.1.1 Base Case Energy Use

The base case total annual source energy consumption of an electric/gas house was 232.7 MMBtu/yr for Harris County, 238.9 MMBtu/yr for Tarrant County, and 255.0 MMBtu/yr for Potter County. This includes: 1) Harris County: 23.2% for cooling, 10.7% for heating, 44.5% for lighting and equipment, 13.7% for fans and pumps, and 7.8% for domestic water heating; 2) Tarrant County: 20.4% for cooling, 14.7% for heating, 43.4% for lighting and equipment, 13.5% for fans and pumps, and 8.0% for domestic water heating; and 3) Potter County: 11.4% for cooling, 26.7% for heating, 40.6% for lighting and equipment, 12.6% for fans and pumps, and 8.6% for domestic water heating.

The base case total annual source energy consumption of an all-electric house was 244.9 MMBtu/yr for Harris County, 250.0 MMBtu/yr for Tarrant County, and 282.5 MMBtu/yr for Potter County. This includes: 1) Harris County: 22.1% for cooling, 8.8% for heating, 42.3% for lighting and equipment, 12.9% for fans and pumps, and 13.9% for domestic water heating; 2) Tarrant County: 19.5% for cooling, 11.9% for heating, 41.5% for lighting and equipment, 12.6% for fans and pumps, and 14.5% for domestic water heating; and 3) Potter County: 10.3% for cooling, 26.2% for heating, 36.7% for lighting and equipment, 11.7% for fans and pumps, and 15.1% for domestic water heating.

This suggests that the measures that reduce lighting energy use would have the high impact on the total energy use, and for Potter County in Climate Zone 4, the measures that reduce the heating energy use would have higher impact on the total energy use compared to Climate Zone 2 and 3. It is also noted that since 2009 IECC code compliance is determined based on source energy consumption, measures that reduce electricity consumption will have more influence on above-code savings (%) than measures that decrease natural gas consumption for an electric/gas house.

4.1.2 Energy Savings from Various EEMs

Of eighteen measures, renewable energy option such as solar PV presented the most savings in the range of 24.4% to 29.0% for both types of houses across the counties. The replacements of existing incandescent lighting fixtures with Energy Star permanent CFL or fluorescent lamps also resulted in considerable energy savings ranging from: 10.2% to 14.7% with 75% replacements; from 6.9% to 9.7% with 50% replacements; and 3.6% to 5.0% with 25% replacements.

[8] The ranges of total implementation cost for some measures were modified according to the recommendations of stakeholders.
[9] The source energy multipliers used in this analysis were 3.16 for electricity and 1.1 for natural gas based on Section 405.3 of the 2009 IECC.

Locating the HVAC unit and ducts in the conditioned space resulted in a high savings of 8.0% to 9.4% in an electric/gas house and 6.3% to 6.7% in an all-electric house across the counties. The energy use reduction from improved AC efficiency[10] with a SEER 15 air-conditioner was more pronounced for Harris and Tarrant County: 6.7% and 6.0% in an electric/gas house and 7.1% and 6.7% in an all-electric house, respectively. For Potter County in Climate Zone 4, the resultant savings were 4.1% in an electric/gas house and 5.6% in an all-electric house. The savings from improved furnace efficiency with a 0.93 AFUE furnace for an electric/gas house were different by county: 1.7% for Harris County, 2.3% for Tarrant County, and 4.3% for Potter County.

Among the DHW measures, solar DHW measures were found more effective in an all-electric house than in an electric/gas house: (a) electric/gas house: 2.9% to 3.6% with a 32 sq. ft. collector and 4.6% to 5.7% with a 64 sq. ft. collector; and (b) all-electric house: 5.9% to 7.1% with a 32 sq. ft. collector and 8.8% to 10.3 with a 64 sq. ft. collector. Both the measures of tankless water heater and removal of pilot light from DHW for an electric/gas house resulted in small savings, less than 2%.

Among the envelope and fenestration measures, sealed (unvented) attics resulted in a good savings of 5.6% to 7.7% in an electric/gas house and 4.4% to 5.6% in an all-electric house. Not surprisingly, higher savings (7.7% in an electric/gas house and 5.6% in an all-electric house) were estimated for Potter County in Climate Zone 4. Improved windows by decreasing SHGC and U-value yielded a combined energy savings of: (a) electric/gas house: 7.9% for Harris County and 5.6% for Tarrant County and (b) all-electric house: 7.1% for Harris County and 5.6% for Tarrant County. For Potter County, decreasing SHGC measures (EEM 5 and 7) were not considered due to its negative savings because of the increased heating energy penalty. The addition of overhangs was more effective with a greater percentage of windows on the south and a lesser percentage of windows on the east and west. With the window redistribution, the total energy savings were 2.8% to 3.0% in an electric/gas house, and 2.6% to 2.9% in an all-electric house. Lastly, the savings from installing radiant barrier in attics were less than 2% for all cases.

4.1.3 Cost Effectiveness of Various EEMs

It should be noted that, due to the difference in the unit cost of electricity and gas, the energy cost savings for a measure are not always of the same order as the energy savings. These savings depend on the fuel type associated with the end use affected from that measure. Because of this, measures that reduced electricity use for space cooling or lighting and equipment in both types of houses and heating in the all-electric house resulted in significant energy cost savings compared to the measures that reduced only gas use. For example, the solar DHW measure with a 64 sq. ft. collector yielded a similar or higher above-code savings (%) than the lighting measure that replaces 25% of existing incandescent lamps with Energy Star permanent CFL or fluorescent lamps in an electric/gas house, but the cost savings were much smaller because the cost savings from the significant reduction in gas use was offset by the increased cost of electricity use for operating the pump.

For both types of houses, solar PV and lighting measures that showed a significant reduction in electricity use were very effective in reducing the overall energy cost. The measures that reduced electricity use for cooling and fans and pumps also resulted in high energy cost savings. These measures include sealed attic, improved windows, locating mechanical systems in the conditioned spaces, and improved AC efficiency. Solar DHW measures were effective only for the all-electric house.

To estimate the cost-effectiveness of measures, the implementation costs of each measure (obtained from various resources listed in Appendix A), were surveyed along with simple payback calculations. The cost-effectiveness of a measure depends upon the energy cost savings versus the cost of implementation. The most of the common measures had nearly equal payback periods for both type of houses, except for the

[10] For an all-electric house, this measure includes both improved cooling and heating efficiency using a 15 SEER and 8.5 HSPF heat pump.

solar DHW system. The solar DHW system was a cost-effective measure only for an all-electric house with a payback period of 14.6 to 20.2 years for Harris County; 11.4 to 16.2 years for Tarrant County; and 10.1 to 13.8 years for Potter County.

For both type of houses, the most cost-effective measures were lighting measures (EEM 15 to 17) with the shortest payback periods of 0.2 to 1.1 years across the counties. Improved window performance measures (EEM 5 to 7) yielded the second shortest payback periods (3.3 to 9.6 years) for Harris and Tarrant County. Installing radiant barrier in attics and improving the AC efficiency also yielded relatively short payback periods.

Table 7. Simulation Results for Individual EEMs (Harris County, Climate Zone 2)

	EEM #	Energy Efficiency Measure (EEM)	Source Energy Use by End-Uses (MMBtu/yr)						Source Energy Use by Fuel Types (MMBut/yr)		Savings Above Base case (Source %)			$ Savings ($/yr)	Increased Marginal Cost ($)	Increased New System Cost ($)	Payback (yrs)
			Cooling	Heating	Ltg & Equip	Fans &Pumps	DHW	Total	Elec.	Gas	Elec.	Gas	Total				
		(a) Electric/Gas House Base Case (Harris County)	54.0	24.9	103.6	31.9	18.3	232.7	189.6	43.1							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	51.5	24.2	103.6	30.3	18.3	228.0	185.5	42.5	2.2%	1.5%	2.0%	$47		$300 - $880	6.4 - 18.7
	2	Sealed (Unvented) Attic	49.3	19.8	103.6	28.8	18.3	219.8	181.7	38.1	4.2%	11.7%	5.6%	$119	$2,000 - $3,500		16.8 - 29.4
	3	Window Shading (2ft overhang on all sides)	49.9	25.7	103.6	30.0	18.3	227.6	183.6	44.0	3.2%	-2.0%	2.2%	$55		$800 - $1,000	14.7 - 18.3
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	49.6	25.2	103.6	29.4	18.3	226.1	182.6	43.5	3.7%	-0.8%	2.8%	$68		$800 - $1,000	11.7 - 14.6
	5	Decreased SHGC (CZ 2: from .3 to .2)	49.0	26.8	103.6	29.7	18.3	227.4	182.3	45.1	3.8%	-4.6%	2.3%	$59	$200 - $400		3.4 - 6.8
	6	Decreased U Value (CZ 2: from 0.65 to 0.3)	49.6	19.6	103.6	28.4	18.3	219.5	181.7	37.8	4.2%	12.2%	5.7%	$121	$600 - $900		5.0 - 7.4
	7	Decreased SHGC (CZ 2: from .3 to .2) & U Value (CZ 2: from 0.65 to 0.3)	44.6	21.6	103.6	26.2	18.3	214.3	174.4	39.8	8.0%	7.7%	7.9%	$180	$900 - $1,100		5.0 - 6.1
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	45.5	20.4	103.6	26.2	18.3	214.0	175.4	38.6	7.5%	10.5%	8.0%	$180	$1,000 - $7,000		5.6 - 39.0
	9	Improved SEER (from 13 to 15)	45.5	25.4	103.6	24.3	18.3	217.2	173.5	43.7	8.5%	-1.3%	6.7%	$160	$900 - $2,500		5.6 - 15.6
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	54.0	20.9	103.6	31.9	18.3	228.8	189.6	39.2	0.0%	9.2%	1.7%	$30	$800 - $1,300		26.5 - 43.0
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	54.0	24.9	103.6	31.9	14.4	228.9	189.6	39.3	0.0%	8.9%	1.7%	$29	$900 - $1,400		30.6 - 47.6
	12	Removal of Pilot Light from DHW	54.0	24.9	103.6	31.9	16.4	230.9	189.6	41.3	0.0%	4.3%	0.8%	$14	$100 - $500		7.0 - 35.0
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	54.0	24.9	103.6	36.3	7.1	226.0	194.0	32.0	-2.3%	25.8%	2.9%	$40		$2,200 - $3,000	55.0 - 75.0
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	54.0	24.9	103.6	36.3	3.1	222.0	194.0	27.9	-2.3%	35.2%	4.6%	$71		$3,200 - $4,000	45.1 - 56.4
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	51.8	26.2	93.9	31.0	18.3	221.1	176.6	44.4	6.8%	-3.1%	5.0%	$122	$25 - $110		0.2 - 0.9
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	49.9	27.5	84.1	30.3	18.3	210.1	164.3	45.8	13.3%	-6.1%	9.7%	$238	$50 - $215		0.2 - 0.9
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	47.7	28.9	74.3	29.4	18.3	198.6	151.4	47.2	20.2%	-9.4%	14.7%	$359	$70 - $320		0.2 - 0.9
Renewable Power Options	18	4 kW PV Array	37.0	24.9	71.0	21.9	18.3	172.9	129.8	43.1	31.5%	0.0%	25.7%	$610		$20,000 - $30,000	32.8 - 49.2
		(b) All-Electric House[1] Base Case (Harris County)	54.0	21.5	103.6	31.6	34.1	244.9	244.9	–							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	51.5	21.2	103.6	30.0	34.1	240.5	240.5	–	1.8%	–	1.8%	$45		$300 - $880	6.6 - 19.5
	2	Sealed (Unvented) Attic	49.3	18.0	103.6	29.1	34.1	234.2	234.2	–	4.4%	–	4.4%	$110	$2,000 - $3,500		18.2 - 31.9
	3	Window Shading (2ft overhang on all sides)	49.9	22.1	103.6	29.7	34.1	239.5	239.5	–	2.2%	–	2.2%	$55		$800 - $1,000	14.6 - 18.2
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	49.6	21.8	103.6	29.4	34.1	238.6	238.6	–	2.6%	–	2.6%	$65		$800 - $1,000	12.4 - 15.5
	5	Decreased SHGC (CZ 2: from .3 to .2)	49.0	22.8	103.6	29.4	34.1	238.9	238.9	–	2.5%	–	2.5%	$61	$200 - $400		3.3 - 6.5
	6	Decreased U Value (CZ 2: from 0.65 to 0.3)	49.6	18.0	103.6	28.4	34.1	233.8	233.8	–	4.5%	–	4.5%	$113	$600 - $900		5.3 - 8.0
	7	Decreased SHGC (CZ 2: from .3 to .2) & U Value (CZ 2: from 0.65 to 0.3)	44.6	19.3	103.6	25.9	34.1	227.5	227.5	–	7.1%	–	7.1%	$177	$900 - $1,100		5.1 - 6.2
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	45.5	18.3	103.6	27.2	34.1	228.8	228.8	–	6.6%	–	6.6%	$164	$1,000 - $7,000		6.1 - 42.6
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	45.5	20.2	103.6	24.0	34.1	227.5	227.5	–	7.1%	–	7.1%	$177	$1,200 - $2,500		6.8 - 14.1
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	54.0	21.5	103.6	36.0	15.2	230.4	230.4	–	5.9%	–	5.9%	$148		$2,200 - $3,000	14.8 - 20.2
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	54.0	21.5	103.6	36.0	8.2	223.4	223.4	–	8.8%	–	8.8%	$220		$3,200 - $4,000	14.6 - 18.2
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	51.8	22.4	93.9	30.7	34.1	232.9	232.9	–	4.9%	–	4.9%	$123	$25 - $110		0.2 - 0.9
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	49.9	23.4	84.1	30.0	34.1	221.5	221.5	–	9.5%	–	9.5%	$239	$50 - $215		0.2 - 0.9
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	47.7	24.0	74.3	29.1	34.1	209.2	209.2	–	14.6%	–	14.6%	$364	$70 - $320		0.2 - 0.9
Renewable Power Options	18	4 kW PV Array	40.8	16.2	78.3	23.9	25.8	185.1	185.1	–	24.4%	–	24.4%	$610		$20,000 - $30,000	32.8 - 49.2

1) EEM 10,11 and 12 were not applied to All-Electric House.

Table 8. Simulation Results for Individual EEMs (Tarrant County, Climate Zone 3)

	EEM #	Energy Efficiency Measure (EEM)	Source Energy Use by End-Uses (MMBtu/yr)						Source Energy Use by Fuel Type (MMBut/yr)		Savings Above Base case (Source %)			$ Savings ($/yr)	Increased Marginal Cost ($)	Increased New System Cost ($)	Payback (yrs)
			Cooling	Heating	Ltg & Equip	Fans &Pumps	DHW	Total	Elec.	Gas	Elec.	Gas	Total				
		(a) Electric/Gas House Base Case (Tarrant County)	48.7	35.2	103.6	32.2	19.1	238.9	184.5	54.3							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	46.1	34.5	103.6	30.7	19.1	234.1	180.4	53.7	2.2%	1.2%	2.0%	$46		$300 - $880	6.6 - 19.2
	2	Sealed (Unvented) Attic	44.9	28.6	103.6	29.1	19.1	225.3	177.6	47.7	3.8%	12.1%	5.7%	$109	$2,000 - $3,500		18.3 - 32.0
	3	Window Shading (2ft overhang on all sides)	44.6	36.6	103.6	30.0	19.1	234.0	178.2	55.8	3.4%	-2.6%	2.0%	$56		$800 - $1,000	14.2 - 17.8
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	43.9	35.4	103.6	29.7	19.1	231.8	177.3	54.6	3.9%	-0.4%	3.0%	$73		$800 - $1,000	11.0 - 13.7
	5	Decreased SHGC (CZ 3: from .3 to .2)	43.9	38.3	103.6	30.3	19.1	235.3	177.9	57.4	3.6%	-5.7%	1.5%	$50	$200 - $400		4.0 - 8.0
	6	Decreased U Value (CZ3: from 0.5 to 0.3)	43.9	33.0	103.6	29.1	19.1	228.8	176.6	52.1	4.3%	4.0%	4.2%	$93	$600 - $900		6.4 - 9.6
	7	Decreased SHGC (CZ 3: from .3 to .2) & U Value (CZ3: from 0.5 to 0.3)	39.2	36.3	103.6	27.2	19.1	225.4	170.0	55.4	7.9%	-2.0%	5.6%	$142	$900 - $1,100		6.3 - 7.8
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	41.1	28.9	103.6	26.5	19.1	219.3	171.3	48.1	7.2%	11.5%	8.2%	$172	$1,000 - $7,000		5.8 - 40.7
	9	Improved SEER (from 13 to 15)	41.1	36.0	103.6	24.6	19.1	224.5	169.4	55.1	8.2%	-1.4%	6.0%	$150	$900 - $2,500		6.0 - 16.6
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	48.7	29.6	103.6	32.2	19.1	233.3	184.5	48.7	0.0%	10.3%	2.3%	$33	$800 - $1,300		24.5 - 39.8
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	48.7	35.2	103.6	32.2	15.2	234.9	184.5	50.4	0.0%	7.3%	1.7%	$23	$900 - $1,400		39.1 - 60.8
	12	Removal of Pilot Light from DHW	48.7	35.2	103.6	32.2	17.3	237.0	184.5	52.5	0.0%	3.4%	0.8%	$11	$100 - $500		9.2 - 46.0
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	48.7	35.2	103.6	36.6	6.4	230.6	188.9	41.6	-2.4%	23.4%	3.5%	$32		$2,200 - $3,000	67.7 - 92.4
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	48.7	35.2	103.6	36.6	2.7	226.9	188.9	37.9	-2.4%	30.2%	5.0%	$51		$3,200 - $4,000	63.2 - 79.0
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	47.1	37.0	93.9	31.6	19.1	228.6	172.5	56.1	6.5%	-3.2%	4.3%	$112	$25 - $110		0.2 - 1.0
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	45.2	38.7	84.1	31.0	19.1	218.1	160.2	57.9	13.2%	-6.5%	8.7%	$228	$50 - $215		0.2 - 0.9
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	43.6	40.5	74.3	30.7	19.1	208.1	148.5	59.6	19.5%	-9.7%	12.9%	$337	$70 - $320		0.2 - 1.0
Renewable Power Options	18	4 kW PV Array	30.8	35.2	65.5	20.4	19.1	171.0	116.7	54.3	36.8%	0.0%	28.4%	$692		$20,000 - $30,000	28.9 - 43.3
		(b) All-Electric House[1] Base Case (Tarrant County)	48.7	29.7	103.6	31.6	36.3	250.0	250.0	–							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	46.1	29.4	103.6	30.0	36.3	245.5	245.5	–	1.8%	–	1.8%	$45		$300 - $880	6.6 - 19.5
	2	Sealed (Unvented) Attic	44.9	25.3	103.6	29.7	36.3	239.8	239.8	–	4.0%	–	4.0%	$103	$2,000 - $3,500		19.4 - 33.9
	3	Window Shading (2ft overhang on all sides)	44.6	30.7	103.6	29.4	36.3	244.6	244.6	–	2.1%	–	2.1%	$55		$800 - $1,000	14.6 - 18.2
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	43.9	29.7	103.6	29.1	36.3	242.7	242.7	–	2.9%	–	2.9%	$74		$800 - $1,000	10.8 - 13.5
	5	Decreased SHGC (CZ 3: from .3 to .2)	43.9	31.6	103.6	29.4	36.3	244.9	244.9	–	2.0%	–	2.0%	$52	$200 - $400		3.9 - 7.8
	6	Decreased U Value (CZ3: from 0.5 to 0.3)	43.9	28.1	103.6	28.4	36.3	240.5	240.5	–	3.8%	–	3.8%	$97	$600 - $900		6.2 - 9.3
	7	Decreased SHGC (CZ 3: from .3 to .2) & U Value (CZ3: from 0.5 to 0.3)	39.2	30.3	103.6	26.5	36.3	236.1	236.1	–	5.6%	–	5.6%	$142	$900 - $1,100		6.3 - 7.8
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	41.1	25.3	103.6	27.8	36.3	234.2	234.2	–	6.3%	–	6.3%	$161	$1,000 - $7,000		6.2 - 43.4
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	41.1	28.1	103.6	24.0	36.3	233.2	233.2	–	6.7%	–	6.7%	$171	$1,200 - $2,500		7.0 - 14.6
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	48.7	29.7	103.6	36.0	14.1	232.1	232.1	–	7.1%	–	7.1%	$193		$2,200 - $3,000	11.4 - 15.6
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	48.7	29.7	103.6	36.0	7.8	225.8	225.8	–	9.7%	–	9.7%	$246		$3,200 - $4,000	13.0 - 16.2
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	47.1	31.0	93.9	31.0	36.3	239.2	239.2	–	4.3%	–	4.3%	$110	$25 - $110		0.2 - 1.0
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	45.2	31.9	84.1	30.3	36.3	227.8	227.8	–	8.8%	–	8.8%	$226	$50 - $215		0.2 - 1.0
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	43.6	33.2	74.3	29.7	36.3	217.1	217.1	–	13.1%	–	13.1%	$335	$70 - $320		0.2 - 1.0
Renewable Power Options	18	4 kW PV Array	35.5	21.6	75.5	23.0	26.5	182.1	182.1	–	27.1%	–	27.1%	$692		$20,000 - $30,000	28.9 - 43.3

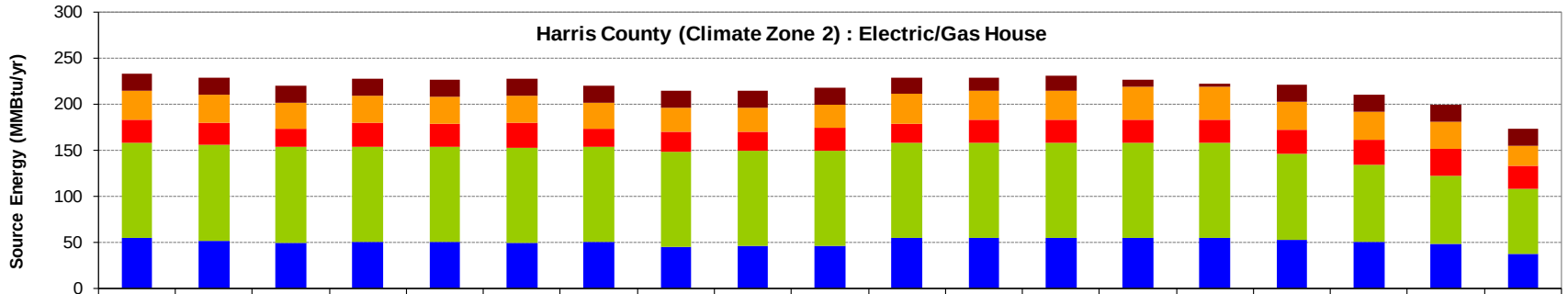
1) EEM 10,11 and 12 were not applied to All-Electric House.

Table 9. Simulation Results for Individual EEMs (Potter County, Climate Zone 4)

	EEM #	Energy Efficiency Measure (EEM)	Source Energy Use by End-Uses (MMBtu/yr)						Source Energy Use by Fuel Type (MMBut/yr)		Savings Above Base case (Source %)			$ Savings ($/yr)	Increased Marginal Cost ($)	Increased New System Cost ($)	Payback (yrs)
			Cooling	Heating	Ltg & Equip	Fans &Pumps	DHW	Total	Elec.	Gas	Elec.	Gas	Total				
		(a) Electric/Gas House Base Case (Potter County[1])	29.1	68.1	103.6	32.2	22.0	255.0	165.0	90.1							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	27.2	67.2	103.6	31.0	22.0	251.0	161.8	89.2	1.9%	1.0%	1.6%	$37		$300 - $880	8.0 - 23.6
	2	Sealed (Unvented) Attic	26.5	55.1	103.6	28.1	22.0	235.4	158.3	77.1	4.0%	14.4%	7.7%	$143	$2,000 - $3,500		14.0 - 24.4
	3	Window Shading (2ft overhang on all sides)	24.6	70.8	103.6	30.3	22.0	251.5	158.6	92.8	3.8%	-3.1%	1.4%	$48		$800 - $1,000	16.5 - 20.6
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	24.0	68.8	103.6	29.4	22.0	247.8	157.1	90.8	4.8%	-0.7%	2.8%	$77		$800 - $1,000	10.4 - 13.0
	6	Decreased U Value (CZ4 from 0.35 to 0.3)	29.4	64.8	103.6	31.6	22.0	251.4	164.6	86.8	0.2%	3.7%	1.4%	$22	$350 - $900		15.6 - 40.1
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	25.0	53.8	103.6	26.5	22.0	230.9	155.2	75.8	5.9%	15.9%	9.4%	$183	$1,000 - $7,000		5.5 - 38.2
	9	Improved SEER (from 13 to 15)	24.3	69.6	103.6	25.0	22.0	244.6	152.9	91.6	7.3%	-1.7%	4.1%	$114	$900 - $2,500		7.9 - 22.0
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	29.1	57.2	103.6	32.2	22.0	244.2	165.0	79.2	0.0%	12.1%	4.3%	$63	$800 - $1,300		12.6 - 20.5
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	29.1	68.1	103.6	32.2	18.2	251.2	165.0	86.2	0.0%	4.3%	1.5%	$22	$900 - $1,400		40.2 - 62.5
	12	Removal of Pilot Light from DHW	29.1	68.1	103.6	32.2	20.1	253.2	165.0	88.2	0.0%	2.1%	0.7%	$11	$100 - $500		9.2 - 46.0
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	29.1	68.1	103.6	36.6	8.5	245.9	169.4	76.6	-2.7%	15.0%	3.6%	$38		$2,200 - $3,000	58.2 - 79.4
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	29.1	68.1	103.6	36.6	3.1	240.5	169.4	71.1	-2.7%	21.0%	5.7%	$65		$3,200 - $4,000	49.0 - 61.2
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	27.5	70.5	93.9	31.9	22.0	245.8	153.3	92.5	7.1%	-2.7%	3.6%	$105	$25 - $110		0.2 - 1.0
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	26.2	72.9	84.1	31.6	22.0	236.8	141.9	94.9	14.0%	-5.4%	7.1%	$207	$50 - $215		0.2 - 1.0
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	25.0	75.5	74.3	31.6	22.0	228.3	130.8	97.5	20.7%	-8.2%	10.5%	$305	$70 - $320		0.2 - 1.0
Renewable Power Options	18	4 kW PV Array	16.0	68.1	57.1	17.8	22.0	181.0	90.9	90.1	44.9%	0.0%	29.0%	$756		$20,000 - $30,000	26.5 - 39.7
		(b) All-Electric House[2] Base Case (Potter County[1])	29.1	73.9	103.6	33.2	42.7	282.5	282.5	–							
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	27.2	73.0	103.6	31.9	42.7	278.4	278.4	–	1.5%	–	1.5%	$42		$300 - $880	7.2 - 21.0
	2	Sealed (Unvented) Attic	26.5	62.9	103.6	31.0	42.7	266.7	266.7	–	5.6%	–	5.6%	$161	$2,000 - $3,500		12.4 - 21.7
	3	Window Shading (2ft overhang on all sides)	24.6	75.8	103.6	31.3	42.7	278.1	278.1	–	1.6%	–	1.6%	$45		$800 - $1,000	17.7 - 22.2
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	24.0	73.9	103.6	30.3	42.7	274.6	274.6	–	2.8%	–	2.8%	$81		$800 - $1,000	9.9 - 12.4
	6	Decreased U Value (CZ4 from 0.35 to 0.3)	29.4	71.1	103.6	32.5	42.7	279.3	279.3	–	1.1%	–	1.1%	$32	$350 - $900		10.9 - 28.0
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	25.0	61.3	103.6	31.0	42.7	263.5	263.5	–	6.7%	–	6.7%	$193	$1,000 - $7,000		5.2 - 36.2
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	24.3	70.5	103.6	25.6	42.7	266.7	266.7	–	5.6%	–	5.6%	$161	$1,200 - $2,500		7.4 - 15.5
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	29.1	73.9	103.6	37.6	18.1	262.3	262.3	–	7.1%	–	7.1%	$217		$2,200 - $3,000	10.1 - 13.8
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	29.1	73.9	103.6	37.6	9.1	253.4	253.4	–	10.3%	–	10.3%	$297		$3,200 - $4,000	10.8 - 13.5
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	27.5	75.5	93.9	32.9	42.7	272.4	272.4	–	3.6%	–	3.6%	$103	$25 - $110		0.2 - 1.1
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	26.2	77.4	84.1	32.5	42.7	262.9	262.9	–	6.9%	–	6.9%	$200	$50 - $215		0.3 - 1.1
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	25.0	79.3	74.3	32.5	42.7	253.7	253.7	–	10.2%	–	10.2%	$293	$70 - $320		0.2 - 1.1
Renewable Power Options	18	4 kW PV Array	21.4	54.6	76.5	24.5	31.5	208.4	208.4	–	26.2%	–	26.2%	$756		$20,000 - $30,000	26.5 - 39.7

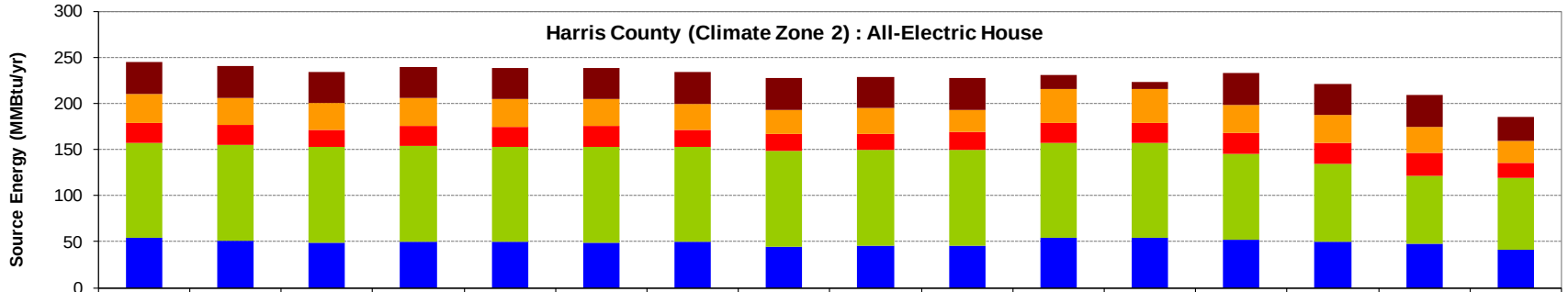
1) EEM 5 and 7 were not applied to Climate Zone 4.

2) EEM 10,11 and 12 were not applied to All-Electric House.



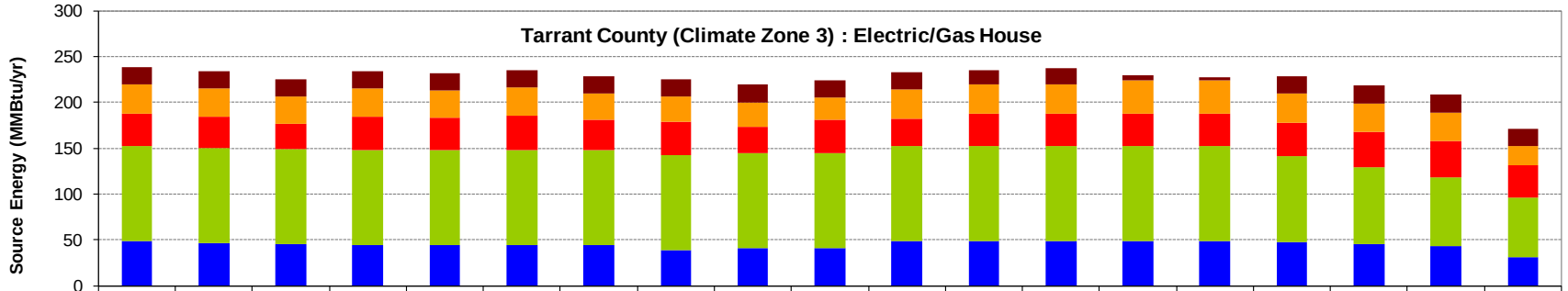
	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Total	232.7	228.0	219.8	227.6	226.1	227.4	219.5	214.3	214.0	217.2	228.8	228.9	230.9	226.0	222.0	221.1	210.1	198.6	172.9
DHW	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	14.4	16.4	7.1	3.1	18.3	18.3	18.3	18.3
Fans+Pumps	31.9	30.3	28.8	30.0	29.4	29.7	28.4	26.2	26.2	24.3	31.9	31.9	31.9	36.3	36.3	31.0	30.3	29.4	21.9
Heating	24.9	24.2	19.8	25.7	25.2	26.8	19.6	21.6	20.4	25.4	20.9	24.9	24.9	24.9	24.9	26.2	27.5	28.9	24.9
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	71.0
Cooling	54.0	51.5	49.3	49.9	49.6	49.0	49.6	44.6	45.5	45.5	54.0	54.0	54.0	54.0	54.0	51.8	49.9	47.7	37.0

Figure 2. Energy Use of Various EEMs for an Electric/Gas House in Harris County, TX



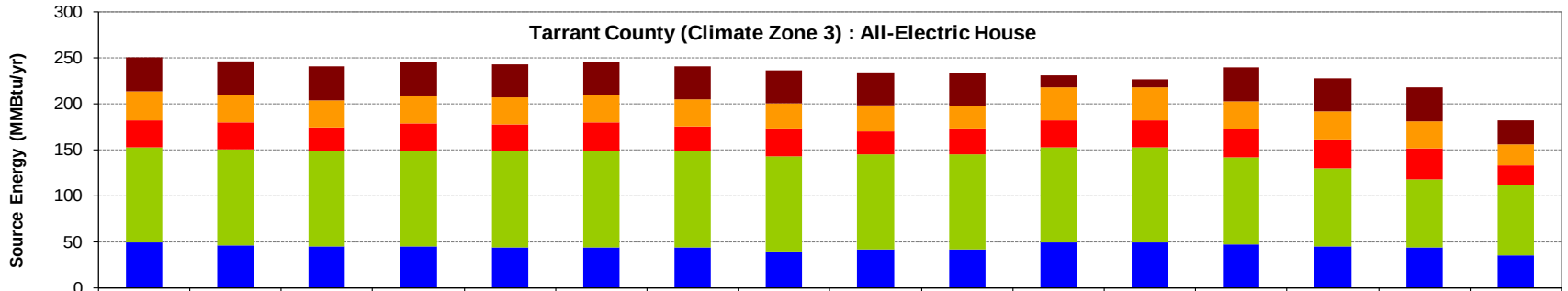
	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Total	244.9	240.5	234.2	239.5	238.6	238.9	233.8	227.5	228.8	227.5	230.4	223.4	232.9	221.5	209.2	185.1
DHW	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	15.2	8.2	34.1	34.1	34.1	25.8
Fans+Pumps	31.6	30.0	29.1	29.7	29.4	29.4	28.4	25.9	27.2	24.0	36.0	36.0	30.7	30.0	29.1	23.9
Heating	21.5	21.2	18.0	22.1	21.8	22.8	18.0	19.3	18.3	20.2	21.5	21.5	22.4	23.4	24.0	16.2
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	78.3
Cooling	54.0	51.5	49.3	49.9	49.6	49.0	49.6	44.6	45.5	45.5	54.0	54.0	51.8	49.9	47.7	40.8

Figure 3. Energy Use of Various EEMs for an All-Electric House in Harris County, TX



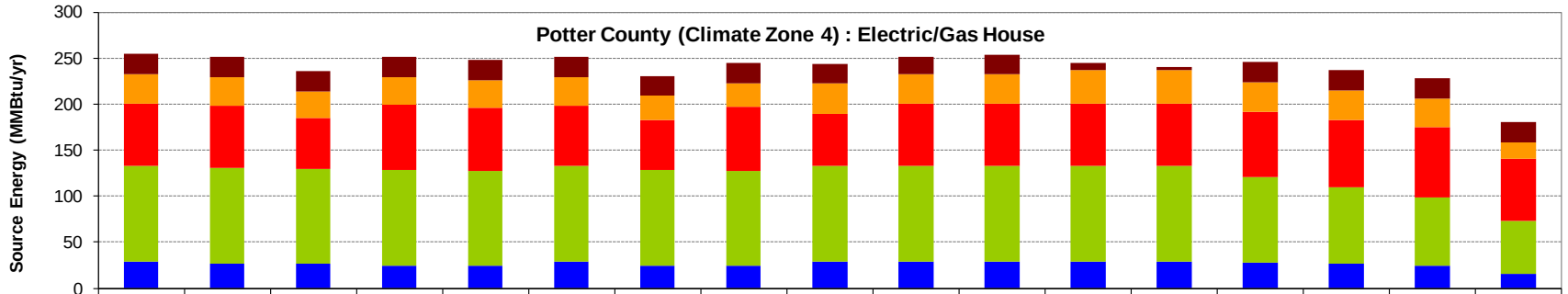
	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Total	238.9	234.1	225.3	234.0	231.8	235.3	228.8	225.4	219.3	224.5	233.3	234.9	237.0	230.0	226.9	228.6	218.1	208.1	171.0
DHW	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	15.2	17.3	5.8	2.7	19.1	19.1	19.1	19.1
Fans+Pumps	32.2	30.7	29.1	30.0	29.7	30.3	29.1	27.2	26.5	24.6	32.2	32.2	32.2	36.6	36.6	31.6	31.0	30.7	20.4
Heating	35.2	34.5	28.6	36.6	35.4	38.3	33.0	36.3	28.9	36.0	29.6	35.2	35.2	35.2	35.2	37.0	38.7	40.5	35.2
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	65.5
Cooling	48.7	46.1	44.9	44.6	43.9	43.9	43.9	39.2	41.1	41.1	48.7	48.7	48.7	48.7	48.7	47.1	45.2	43.6	30.8

Figure 4. Energy Use of Various EEMs for an Electric/Gas House in Tarrant County, TX



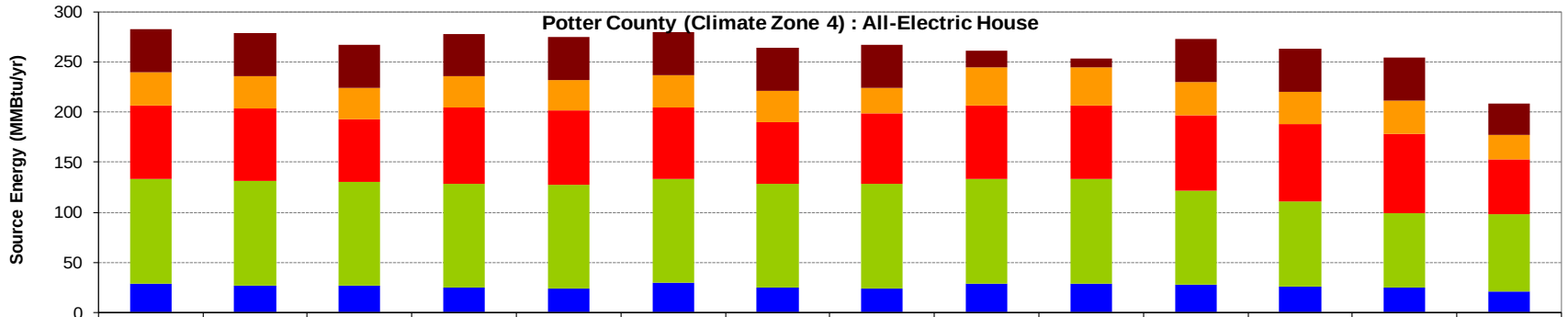
	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Total	250.0	245.5	239.8	244.6	242.7	244.9	240.5	236.1	234.2	233.2	231.1	225.8	239.2	227.8	217.1	182.1
DHW	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	36.3	13.0	7.8	36.3	36.3	36.3	26.5
Fans+Pumps	31.6	30.0	29.7	29.4	29.1	29.4	28.4	26.5	27.8	24.0	36.0	36.0	31.0	30.3	29.7	23.0
Heating	29.7	29.4	25.3	30.7	29.7	31.6	28.1	30.3	25.3	28.1	29.7	29.7	31.0	31.9	33.2	21.6
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	75.5
Cooling	48.7	46.1	44.9	44.6	43.9	43.9	43.9	39.2	41.1	41.1	48.7	48.7	47.1	45.2	43.6	35.5

Figure 5. Energy Use of Various EEMs for an All-Electric House in Tarrant County, TX



	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL
Total	255.0	251.0	235.4	251.5	247.8	251.4	230.9	244.6	244.2	251.2	253.2	245.2	240.5	245.8	236.8	228.3	181.0
DHW	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	18.2	20.1	7.8	3.1	22.0	22.0	22.0	22.0
Fans+Pumps	32.2	31.0	28.1	30.3	29.4	31.6	26.5	25.0	32.2	32.2	32.2	36.6	36.6	31.9	31.6	31.6	17.8
Heating	68.1	67.2	55.1	70.8	68.8	64.8	53.8	69.6	57.2	68.1	68.1	68.1	68.1	70.5	72.9	75.5	68.1
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	57.1
Cooling	29.1	27.2	26.5	24.6	24.0	29.4	25.0	24.3	29.1	29.1	29.1	29.1	29.1	27.5	26.2	25.0	16.0

Figure 6. Energy Use of Various EEMs for an Electric/Gas House in Potter County, TX



	Base Case	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL
Total	282.5	278.4	266.7	278.1	274.6	279.3	263.5	266.7	261.2	253.4	272.4	262.9	253.7	208.4
DHW	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7	17.0	9.1	42.7	42.7	42.7	31.5
Fans+Pumps	33.2	31.9	31.0	31.3	30.3	32.5	31.0	25.6	37.6	37.6	32.9	32.5	32.5	24.5
Heating	73.9	73.0	62.9	75.8	73.9	71.1	61.3	70.5	73.9	73.9	75.5	77.4	79.3	54.6
Lgt+Appl	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	103.6	93.9	84.1	74.3	76.5
Cooling	29.1	27.2	26.5	24.6	24.0	29.4	25.0	24.3	29.1	29.1	27.5	26.2	25.0	21.4

Figure 7. Energy Use of Various EEMs for an All-Electric House in Potter County, TX

4.2 **Energy and Cost Savings by Climate Zone**

The same analysis presented in Section 4.1 was performed for fourteen other counties. The savings results of seventeen counties were then grouped according to the corresponding 2009 IECC climate zone to develop the recommendations by climate zone. Of seventeen counties, nine counties are classified as Climate Zone 2, and Climate Zone 3 includes seven counties. For Climate Zone 4, only Potter County was considered. Table 10 and Table 11 summarize annual total above-code savings (source, %) and cost savings ($/year) by county and climate zone, respectively. The results of the cost analysis are also graphically represented in Figure 8 to Figure 19.

4.3 **15% Above-Code Energy Savings**

Grouped measures are the combination of individual measures. The results from individual measures and cost analysis were used to guide the selection of measures for this group analysis. The measures were combined to achieve the total source energy savings[11] of the group is 15% above the base-case 2009 code-compliant house. Because the measures are interdependent in many cases, the resultant savings of grouped measures are not always the same as the sum of the savings of the individual measures. In a similar fashion as the analysis of the individual measures, the group measures were simulated by modifying all the parameters of combined individual measures. Three example combinations were proposed for each base case ((a) electric/gas house with natural gas heating and (b) all-electric house with heat pump heating) in each climate zone and presented in Figure 20 to Figure 25.

In each figure, the first table summarizes the results obtained from individual measures in terms of annual source energy savings, energy cost savings, estimated costs for each measure implemented individually, and payback period. The second table summarizes the results obtained by implementing three combinations of measures to achieve 15% or more total energy savings, and includes: energy savings, energy cost savings, estimated costs, and payback period for each combination. Information regarding the ozone emissions for each of the combinations is also presented in terms of combined annual NOx, SO_2, and CO_2 emission savings.

The example groups represent one way of grouping to achieve 15% above the code. In this analysis, each combination was intended to have a different payback period. The most cost-effective combination has a payback period of: (a) electric/gas house: 0.9 to 3.2 years for Climate Zone 2, 0.8 to 2.9 years for Climate Zone 3, and 2.3 to 4.3 years for Climate Zone 4; and (b) all-electric house: 0.9 to 3.1 years for Climate Zone 2, 2.0 to 3.4 years for Climate Zone 3, and 2.9 to 6.3 years for Climate Zone 4. On the other hand, a payback period of the least cost-effective combination is: (a) electric/gas house: 7.0 to 26.5 years for Climate Zone 2, 7.5 to 29.9 years for Climate Zone 3, and 8.3 to 36.8 years for Climate Zone 4; and (b) all-electric house: 10.1 to 28.6 years for Climate Zone 2, 9.1 to 27.0 years for Climate Zone 3, and 8.6 to 22.4 years for Climate Zone 4.

[11] The estimated total source energy savings include heating, cooling, lighting, equipment, and DHW for emissions reductions determination.

Table 10. Summary of Annual Total Above-Code Savings (Source, %) by County and Climate Zone

	EEM #	Energy Efficiency Measure (EEM)	Climate Zone 2										Climate Zone 3								Climate Zone 4[1]
			By County									Min - Max	By County							Min - Max	
			CAM	NUE	VIC	BEX	HAR	JEF	TRA	ANG	MCL		TOM	MID	ELP	TAL	TAR	LUB	WIC		POT
(a) Electric/Gas House Base Case																					
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	1.6%	1.6%	2.0%	2.4%	2.0%	1.8%	2.1%	2.5%	2.1%	**1.6% - 2.5%**	2.1%	2.2%	3.1%	2.0%	2.0%	2.0%	1.6%	**1.6% - 3.1%**	**1.6%**
	2	Sealed (Unvented) Attic	5.4%	6.1%	5.4%	5.6%	5.6%	5.6%	5.4%	5.9%	6.6%	**5.4% - 6.6%**	6.2%	6.6%	6.3%	6.6%	5.7%	7.2%	7.2%	**5.7% - 7.2%**	**7.7%**
	3	Window Shading (2ft overhang on all sides)	2.6%	2.5%	2.3%	2.4%	2.2%	2.1%	2.2%	2.2%	2.0%	**2.0% - 2.6%**	2.0%	2.1%	2.8%	2.1%	2.0%	1.5%	1.6%	**1.5% - 2.8%**	**1.4%**
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	2.9%	2.9%	2.8%	2.9%	2.8%	2.9%	3.0%	2.8%	2.7%	**2.7% - 3.0%**	3.1%	2.8%	3.5%	3.0%	3.0%	2.7%	2.7%	**2.7% - 3.5%**	**2.8%**
	5	Decreased SHGC	3.2%	2.9%	2.7%	2.4%	2.3%	2.2%	2.4%	1.9%	1.7%	**1.7% - 3.2%**	1.5%	1.3%	2.3%	1.5%	1.5%	0.4%	0.9%	**0.4% - 2.3%**	-
	6	Decreased U Value	4.8%	5.1%	5.3%	6.2%	5.7%	5.8%	6.1%	6.1%	6.7%	**4.8% - 6.7%**	4.2%	4.3%	4.7%	4.4%	4.2%	4.3%	4.2%	**4.2% - 4.7%**	**1.4%**
	7	Decreased SHGC & U Value	8.2%	8.0%	8.1%	8.6%	7.9%	8.0%	8.4%	8.1%	8.4%	**7.9% - 8.6%**	5.5%	5.5%	6.6%	5.9%	5.6%	4.4%	5.1%	**4.4% - 6.6%**	-
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	7.5%	7.7%	7.7%	8.2%	8.0%	7.8%	8.2%	8.4%	8.5%	**7.5% - 8.5%**	8.4%	8.1%	7.6%	8.5%	8.2%	8.8%	9.3%	**7.6% - 9.3%**	**9.4%**
	9	Improved SEER (from 13 to 15)	8.5%	8.0%	7.2%	7.0%	6.7%	6.5%	6.8%	6.1%	6.2%	**6.1% - 8.5%**	5.6%	5.3%	6.1%	5.7%	6.0%	4.3%	5.6%	**4.3% - 6.1%**	**4.1%**
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	0.6%	1.0%	1.2%	1.7%	1.7%	1.7%	1.9%	2.1%	2.5%	**0.6% - 2.5%**	2.9%	3.0%	2.2%	2.9%	2.3%	4.0%	3.3%	**2.2% - 4.0%**	**4.3%**
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	1.6%	1.7%	1.7%	1.6%	1.7%	1.7%	1.6%	1.7%	1.6%	**1.6% - 1.7%**	1.6%	1.7%	1.7%	1.6%	1.7%	1.6%	1.5%	**1.5% - 1.7%**	**1.5%**
	12	Removal of Pilot Light from DHW	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	**0.8% - 0.8%**	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%	**0.7% - 0.8%**	**0.7%**
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	3.2%	3.2%	3.4%	3.6%	2.9%	3.3%	3.5%	3.5%	3.5%	**2.9% - 3.6%**	3.9%	4.3%	4.8%	3.8%	3.7%	4.0%	3.3%	**3.3% - 4.8%**	**3.8%**
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	4.3%	4.4%	4.7%	4.9%	4.6%	4.8%	4.8%	5.0%	4.8%	**4.3% - 5.0%**	5.3%	5.7%	6.0%	5.2%	5.0%	5.6%	4.7%	**4.7% - 6.0%**	**5.7%**
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	5.1%	5.0%	5.1%	4.7%	5.0%	4.8%	4.5%	4.5%	4.3%	**4.3% - 5.1%**	4.2%	4.1%	4.5%	4.1%	4.3%	3.8%	3.7%	**3.7% - 4.5%**	**3.6%**
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	10.3%	10.1%	9.9%	9.4%	9.7%	9.6%	9.2%	9.1%	8.5%	**8.5% - 10.3%**	8.4%	8.4%	9.0%	8.2%	8.7%	7.5%	7.4%	**7.4% - 9.0%**	**7.1%**
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.4%	15.0%	14.9%	13.9%	14.7%	14.3%	13.8%	13.7%	12.6%	**12.6% - 15.4%**	12.5%	12.3%	13.4%	12.3%	12.9%	11.1%	11.0%	**11.0% - 13.4%**	**10.5%**
Renewable Power Options	18	4 kW PV Array	25.5%	25.3%	26.7%	28.0%	25.7%	26.6%	27.4%	27.5%	27.3%	**25.3% - 28.0%**	29.6%	31.6%	34.9%	29.2%	28.4%	29.6%	26.3%	**26.3% - 34.9%**	**29.0%**
(b) All-Electric House[2] Base Case																					
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	1.5%	1.5%	1.7%	2.0%	1.8%	1.7%	1.9%	2.2%	2.0%	**1.5% - 2.2%**	1.8%	1.9%	2.7%	1.7%	1.8%	1.8%	1.6%	**1.6% - 2.7%**	**1.5%**
	2	Sealed (Unvented) Attic	4.6%	5.2%	4.4%	4.4%	4.4%	4.5%	4.0%	4.5%	4.8%	**4.0% - 5.2%**	4.3%	4.9%	4.6%	4.7%	4.0%	5.4%	5.6%	**4.0% - 5.6%**	**5.6%**
	3	Window Shading (2ft overhang on all sides)	2.5%	2.4%	2.3%	2.4%	2.2%	2.4%	2.2%	2.3%	2.2%	**2.2% - 2.5%**	2.2%	2.1%	3.1%	2.2%	2.1%	1.8%	1.8%	**1.8% - 3.1%**	**1.6%**
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	2.9%	2.8%	2.7%	2.8%	2.6%	3.0%	2.7%	2.7%	2.7%	**2.6% - 3.0%**	2.9%	2.9%	3.6%	2.7%	2.9%	2.7%	2.7%	**2.7% - 3.6%**	**2.8%**
	5	Decreased SHGC	3.1%	2.9%	2.9%	2.6%	2.5%	2.5%	2.5%	2.2%	2.1%	**2.1% - 3.1%**	1.8%	1.9%	2.8%	2.0%	2.0%	1.1%	1.4%	**1.1% - 2.8%**	-
	6	Decreased U Value	4.1%	4.3%	4.3%	5.1%	4.5%	4.7%	4.9%	4.9%	5.3%	**4.1% - 5.3%**	3.7%	3.9%	4.1%	3.7%	3.8%	3.8%	3.9%	**3.7% - 4.1%**	**1.1%**
	7	Decreased SHGC & U Value	7.5%	7.4%	7.3%	7.6%	7.1%	7.2%	7.5%	7.3%	7.5%	**7.1% - 7.6%**	5.5%	5.6%	6.5%	5.6%	5.6%	4.7%	5.2%	**4.7% - 6.5%**	-
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	6.8%	6.8%	6.7%	6.9%	6.6%	6.6%	6.8%	6.7%	6.7%	**6.6% - 6.9%**	6.3%	6.0%	5.9%	6.2%	6.3%	6.3%	7.3%	**5.9% - 7.3%**	**6.7%**
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	8.3%	8.0%	7.3%	7.4%	7.1%	7.0%	7.2%	6.7%	7.0%	**6.7% - 8.3%**	6.5%	6.1%	6.7%	6.4%	6.7%	5.7%	6.8%	**5.7% - 6.8%**	**5.6%**
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	6.3%	6.4%	6.8%	7.3%	5.9%	6.7%	7.1%	7.1%	7.1%	**5.9% - 7.3%**	7.8%	8.5%	9.3%	7.8%	7.6%	7.9%	7.0%	**7.0% - 9.3%**	**7.5%**
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	8.1%	8.4%	9.1%	9.2%	8.8%	9.2%	9.0%	9.6%	9.2%	**8.1% - 9.6%**	9.9%	10.6%	10.9%	10.0%	9.7%	10.5%	9.0%	**9.0% - 10.9%**	**10.3%**
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	5.0%	4.9%	5.1%	4.6%	4.9%	4.9%	4.5%	4.5%	4.4%	**4.4% - 5.1%**	4.0%	4.3%	4.5%	4.2%	4.3%	3.8%	3.8%	**3.8% - 4.5%**	**3.6%**
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	10.1%	10.0%	9.9%	9.3%	9.5%	9.9%	9.1%	9.2%	8.6%	**8.6% - 10.1%**	8.3%	8.4%	9.0%	8.2%	8.8%	7.5%	7.5%	**7.5% - 9.0%**	**6.9%**
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.2%	15.0%	14.9%	13.9%	14.6%	14.6%	13.8%	13.7%	13.1%	**13.1% - 15.2%**	12.4%	12.4%	13.5%	12.4%	13.1%	11.2%	11.3%	**11.2% - 13.5%**	**10.2%**
Renewable Power Options	18	4 kW PV Array	24.4%	24.3%	25.5%	26.6%	24.4%	25.5%	26.2%	26.2%	26.2%	**24.3% - 26.6%**	27.8%	29.7%	32.8%	27.7%	27.1%	27.7%	24.8%	**24.8% - 32.8%**	**26.2%**

1) EEM 5 and 7 were not applied to Climate Zone 4.

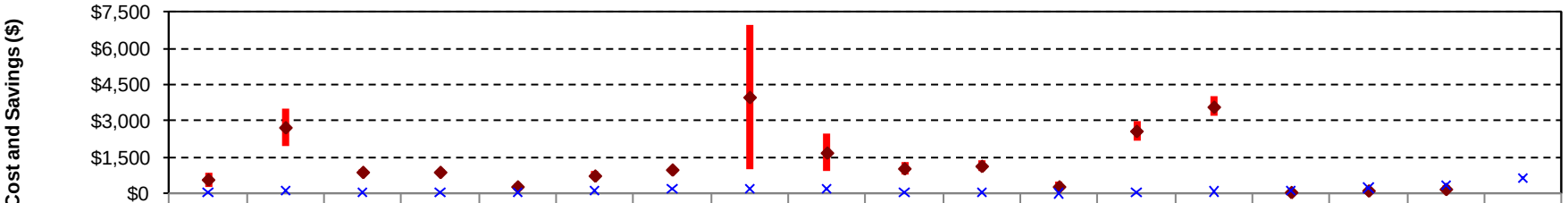
2) EEM 10,11 and 12 were not applied to All-Electric House.

Table 11. Summary of Annual Total Cost Savings ($/year) by County and Climate Zone

	EEM #	Energy Efficiency Measure (EEM)	Climate Zone 2										Climate Zone 3								Climate Zone 4[1]
			By County									Min - Max	By County							Min - Max	
			CAM	NUE	VIC	BEX	HAR	JEF	TRA	ANG	MCL		TOM	MID	ELP	TAL	TAR	LUB	WIC		POT
(a) Electric/Gas House Base Case																					
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	$38	$39	$45	$57	$47	$42	$49	$57	$51	**$38 - $57**	$47	$48	$66	$46	$46	$45	$40	**$40 - $66**	**$37**
	2	Sealed (Unvented) Attic	$128	$141	$116	$123	$119	$119	$119	$124	$145	**$116 - $145**	$116	$120	$115	$126	$109	$131	$148	**$109 - $148**	**$143**
	3	Window Shading (2ft overhang on all sides)	$65	$61	$55	$61	$55	$53	$57	$54	$52	**$52 - $65**	$57	$57	$73	$59	$56	$48	$51	**$48 - $73**	**$48**
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	$73	$70	$66	$72	$68	$68	$73	$66	$68	**$66 - $73**	$78	$71	$85	$75	$73	$71	$74	**$71 - $85**	**$77**
	5	Decreased SHGC	$81	$74	$67	$65	$59	$57	$64	$52	$51	**$51 - $81**	$53	$48	$68	$54	$50	$32	$41	**$32 - $68**	-
	6	Decreased U Value	$111	$116	$114	$137	$121	$122	$135	$128	$148	**$111 - $148**	$93	$93	$102	$98	$93	$92	$97	**$92 - $102**	**$22**
	7	Decreased SHGC & U Value	$199	$189	$185	$201	$180	$179	$199	$183	$200	**$179 - $201**	$141	$140	$163	$150	$142	$119	$140	**$119 - $163**	-
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	$183	$182	$174	$190	$180	$173	$190	$185	$195	**$173 - $195**	$172	$159	$153	$174	$172	$168	$201	**$153 - $201**	**$183**
	9	Improved SEER (from 13 to 15)	$211	$195	$172	$173	$160	$154	$169	$146	$159	**$146 - $211**	$143	$133	$148	$146	$150	$114	$154	**$114 - $154**	**$114**
	10	Improved Furnace Efficiency (from .78 to .93 AFUE)	$12	$18	$22	$32	$30	$30	$34	$38	$47	**$12 - $47**	$41	$41	$29	$41	$33	$58	$51	**$29 - $58**	**$63**
Domestic Hot Water Measures	11	Tankless Gas Water Heater (from .594 to .748 Energy Factor)	$30	$30	$29	$29	$29	$30	$30	$29	$30	**$29 - $30**	$22	$23	$23	$22	$23	$22	$22	**$22 - $23**	**$22**
	12	Removal of Pilot Light from DHW	$14	$15	$14	$14	$14	$14	$14	$14	$14	**$14 - $15**	$11	$11	$11	$11	$11	$11	$11	**$11 - $11**	**$11**
	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	$48	$46	$48	$55	$40	$47	$54	$50	$54	**$40 - $55**	$36	$40	$45	$35	$32	$38	$32	**$32 - $45**	**$38**
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	$68	$69	$72	$78	$71	$73	$78	$77	$79	**$68 - $79**	$56	$60	$61	$55	$51	$62	$52	**$51 - $62**	**$65**
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$130	$125	$123	$119	$122	$117	$116	$111	$113	**$111 - $130**	$112	$108	$113	$112	$112	$106	$108	**$106 - $113**	**$105**
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$259	$252	$239	$237	$238	$232	$234	$224	$222	**$222 - $259**	$223	$219	$226	$220	$228	$208	$216	**$208 - $228**	**$207**
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$388	$375	$362	$352	$359	$346	$352	$337	$330	**$330 - $388**	$334	$324	$338	$332	$337	$311	$323	**$311 - $338**	**$305**
Renewable Power Options	18	4 kW PV Array	$632	$618	$630	$686	$610	$625	$678	$651	$684	**$610 - $686**	$732	$765	$824	$729	$692	$748	$704	**$692 - $824**	**$756**
(b) All-Electric House[2] Base Case																					
Envelope and Fenetration Measures	1	Radiant Barrier in Attics (with Ducts in Attics)	$39	$39	$42	$52	$45	$42	$48	$55	$52	**$39 - $55**	$48	$48	$68	$45	$45	$48	$45	**$45 - $68**	**$42**
	2	Sealed (Unvented) Attic	$119	$132	$110	$113	$110	$110	$103	$113	$126	**$103 - $132**	$113	$126	$116	$123	$103	$145	$158	**$103 - $158**	**$161**
	3	Window Shading (2ft overhang on all sides)	$65	$61	$58	$61	$55	$58	$58	$58	$58	**$55 - $65**	$58	$55	$77	$58	$55	$48	$52	**$48 - $77**	**$45**
	4	Window Shading and Redistribution (2ft overhang on all sides, S=40.70%, N=22.61%, E/W = 13.57%)	$74	$71	$68	$71	$65	$74	$71	$68	$71	**$65 - $74**	$77	$74	$90	$71	$74	$74	$77	**$71 - $90**	**$81**
	5	Decreased SHGC	$81	$74	$71	$68	$61	$61	$65	$55	$55	**$55 - $81**	$48	$48	$71	$52	$52	$29	$39	**$29 - $71**	-
	6	Decreased U Value	$106	$110	$106	$132	$113	$116	$126	$123	$139	**$106 - $139**	$97	$100	$103	$97	$97	$103	$110	**$97 - $110**	**$32**
	7	Decreased SHGC & U Value	$193	$187	$181	$197	$177	$177	$193	$181	$197	**$177 - $197**	$145	$145	$164	$148	$142	$126	$148	**$126 - $164**	-
HVAC System Measures	8	Mechanical Systems Within Conditioned Spaces	$177	$174	$164	$177	$164	$161	$177	$168	$174	**$161 - $177**	$164	$155	$148	$164	$161	$171	$206	**$148 - $206**	**$193**
	9	Improved SEER (from 13 to 15) and Heat Pump Efficiency (from 7.70 to 8.50 HSPF)	$216	$203	$181	$190	$177	$171	$187	$168	$184	**$168 - $216**	$171	$158	$168	$168	$171	$155	$193	**$155 - $193**	**$161**
Domestic Hot Water Measures	13	Solar DHW System (32 sq. ft. collector, 65 gal tank)	$163	$162	$168	$187	$148	$165	$185	$177	$186	**$148 - $187**	$205	$218	$233	$207	$193	$213	$197	**$193 - $233**	**$217**
	14	Solar DHW System (64 sq. ft. collector, 65 gal tank)	$211	$213	$224	$238	$220	$225	$234	$238	$240	**$211 - $240**	$260	$274	$275	$262	$246	$284	$255	**$246 - $284**	**$297**
Lighting Measures	15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$129	$126	$126	$119	$123	$119	$116	$113	$116	**$113 - $129**	$106	$110	$113	$110	$110	$103	$106	**$103 - $113**	**$103**
	16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$261	$255	$245	$239	$239	$242	$235	$229	$226	**$226 - $261**	$219	$216	$226	$216	$226	$203	$213	**$203 - $226**	**$200**
	17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	$393	$380	$368	$358	$364	$358	$358	$342	$342	**$342 - $393**	$326	$319	$339	$326	$335	$303	$319	**$303 - $339**	**$293**
Renewable Power Options	18	4 kW PV Array	$632	$618	$630	$686	$610	$625	$678	$651	$684	**$610 - $686**	$732	$765	$824	$729	$692	$748	$704	**$692 - $824**	**$756**

1) EEM 5 and 7 were not applied to Climate Zone 4.

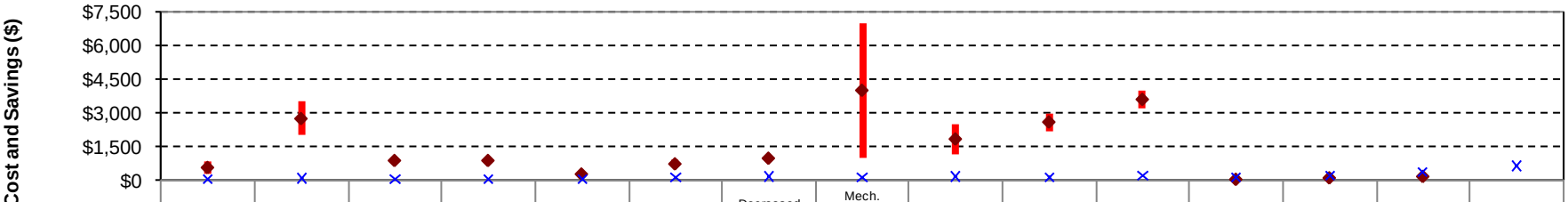
2) EEM 10,11 and 12 were not applied to All-Electric House.



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$200	$600	$900	$1,000	$900	$800	$900	$100	$2,200	$3,200	$25	$50	$70	$20,000
Maximum Cost	$880	$3,500	$1,000	$1,000	$400	$900	$1,100	$7,000	$2,500	$1,300	$1,400	$500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$300	$750	$1,000	$4,000	$1,700	$1,050	$1,150	$300	$2,600	$3,600	$68	$133	$195	$25,000
Minimum Energy Savings	$38	$116	$52	$66	$51	$111	$179	$173	$146	$12	$29	$14	$40	$68	$111	$222	$330	$610
Maximum Energy Savings	$57	$145	$65	$73	$81	$148	$201	$195	$211	$47	$30	$15	$55	$79	$130	$259	$388	$686
Average Energy Savings	$48	$131	$59	$70	$66	$130	$190	$184	$179	$30	$30	$15	$48	$74	$121	$241	$359	$648

Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

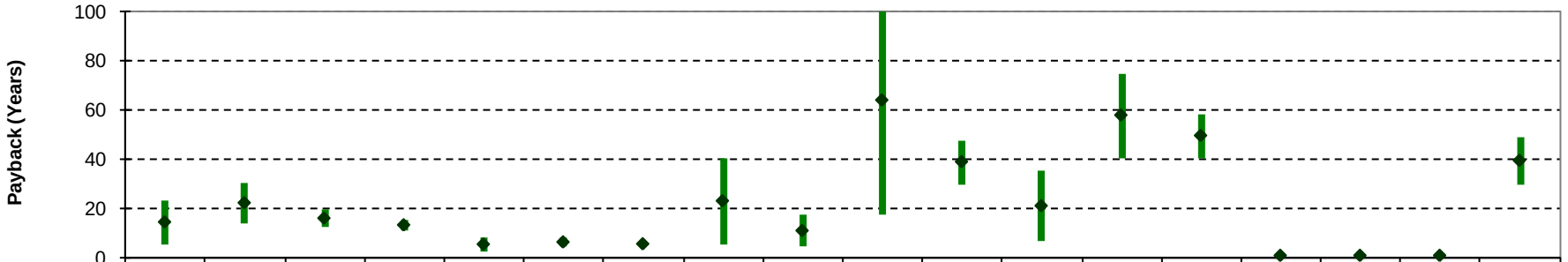
Figure 8. First Costs and Annual Energy Cost Savings for Various EEMs for an Electric/Gas House (Climate Zone 2)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$200	$600	$900	$1,000	$1,200	$2,200	$3,200	$25	$50	$70	$20,000
Maximum Cost	$880	$3,500	$1,000	$1,000	$400	$900	$1,100	$7,000	$2,500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$300	$750	$1,000	$4,000	$1,850	$2,600	$3,600	$68	$133	$195	$25,000
Minimum Energy Savings	$39	$103	$55	$65	$55	$106	$177	$161	$168	$148	$211	$113	$226	$342	$610
Maximum Energy Savings	$55	$132	$65	$74	$81	$139	$197	$177	$216	$187	$240	$129	$261	$393	$686
Ave. Energy Savings	$47	$118	$60	$70	$68	$123	$187	$169	$192	$168	$226	$121	$244	$368	$648

Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

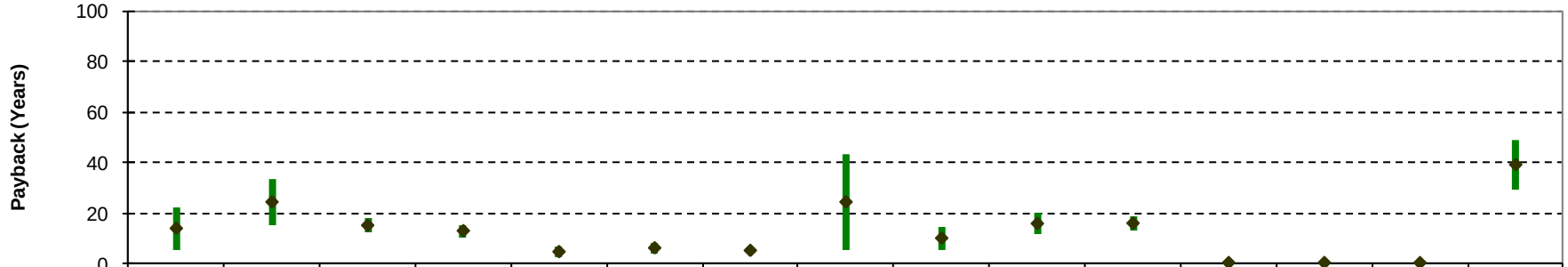
Figure 9. First Costs and Annual Energy Cost Savings for Various EEMs for an All-electric House (Climate Zone 2)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	5.2	13.8	12.3	10.9	2.5	4.0	4.5	5.1	4.3	17.0	29.8	6.6	40.3	40.3	0.2	0.2	0.2	29.2
Maximum	23.2	30.2	19.2	15.1	7.8	8.1	6.1	40.5	17.1	110.5	47.6	35.0	75.0	58.4	1.0	1.0	1.0	49.2
Average	14.2	22.0	15.8	13.0	5.2	6.1	5.3	22.8	10.7	63.8	38.7	20.8	57.7	49.4	0.6	0.6	0.6	39.2

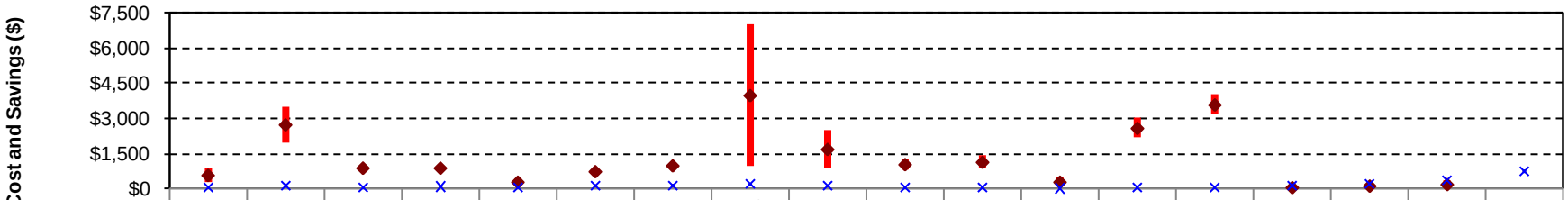
Note. A maximum payback period for the EEM "Improved furnace efficiency" is 110.5 years.

Figure 10. Payback Period for Various EEMs for an Electric/Gas House (Climate Zone 2)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	5.5	15.1	12.4	10.8	2.5	4.3	4.6	5.6	5.6	11.8	13.3	0.2	0.2	0.2	29.2
Maximum	22.7	33.9	18.2	15.5	7.3	8.5	6.2	43.4	14.9	20.2	19.0	1.0	1.0	0.9	49.2
Average	14.1	24.5	15.3	13.2	4.9	6.4	5.4	24.5	10.3	16.0	16.2	0.6	0.6	0.6	39.2

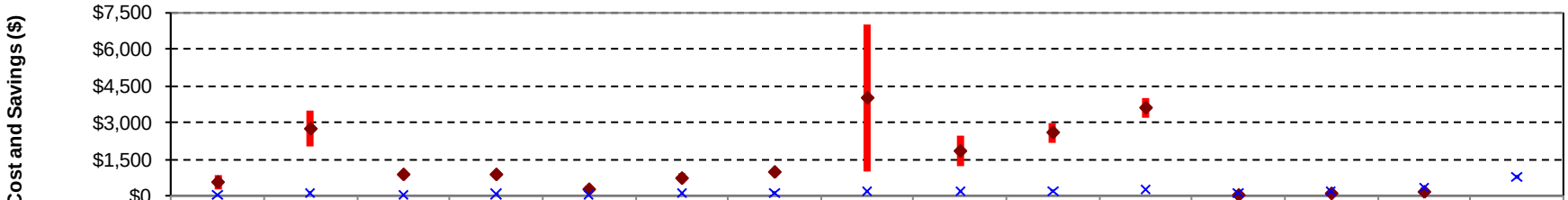
Figure 11. Payback Period for Various EEMs for an All-Electric House (Climate Zone 2)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$200	$600	$900	$1,000	$900	$800	$900	$100	$2,200	$3,200	$25	$50	$70	$20,000
Maximum Cost	$880	$3,500	$1,000	$1,000	$400	$900	$1,100	$7,000	$2,500	$1,300	$1,400	$500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$300	$750	$1,000	$4,000	$1,700	$1,050	$1,150	$300	$2,600	$3,600	$68	$133	$195	$25,000
Minimum Energy Savings	$40	$109	$48	$71	$32	$92	$119	$153	$114	$29	$22	$11	$32	$51	$106	$208	$311	$692
Maximum Energy Savings	$66	$148	$73	$85	$68	$102	$163	$201	$154	$58	$23	$11	$45	$62	$113	$228	$338	$824
Average Energy Savings	$53	$129	$61	$78	$50	$97	$141	$177	$134	$44	$23	$11	$39	$57	$110	$218	$325	$758

Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

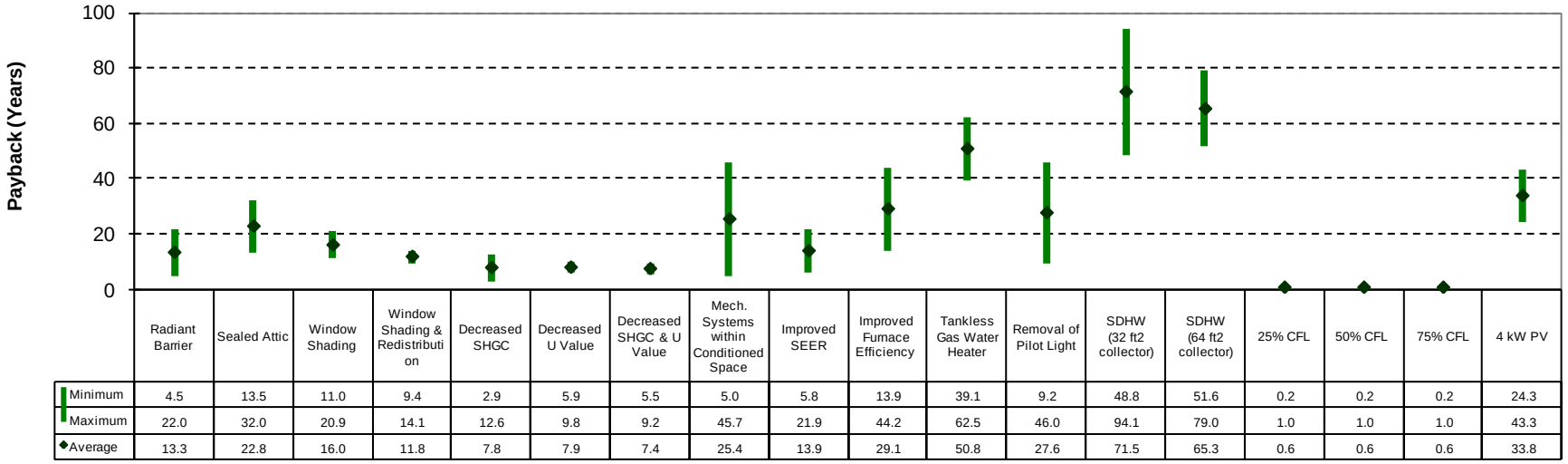
Figure 12. First Costs and Annual Energy Cost Savings for Various EEMs for an Electric/Gas House (Climate Zone 3)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$200	$600	$900	$1,000	$1,200	$2,200	$3,200	$25	$50	$70	$20,000
Maximum Cost	$880	$3,500	$1,000	$1,000	$400	$900	$1,100	$7,000	$2,500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$300	$750	$1,000	$4,000	$1,850	$2,600	$3,600	$68	$133	$195	$25,000
Minimum Energy Savings	$45	$103	$48	$71	$29	$97	$126	$148	$155	$193	$246	$103	$203	$303	$692
Maximum Energy Savings	$68	$158	$77	$90	$71	$110	$164	$206	$193	$233	$284	$113	$226	$339	$824
Ave. Energy Savings	$57	$131	$63	$81	$50	$104	$145	$177	$174	$213	$265	$108	$215	$321	$758

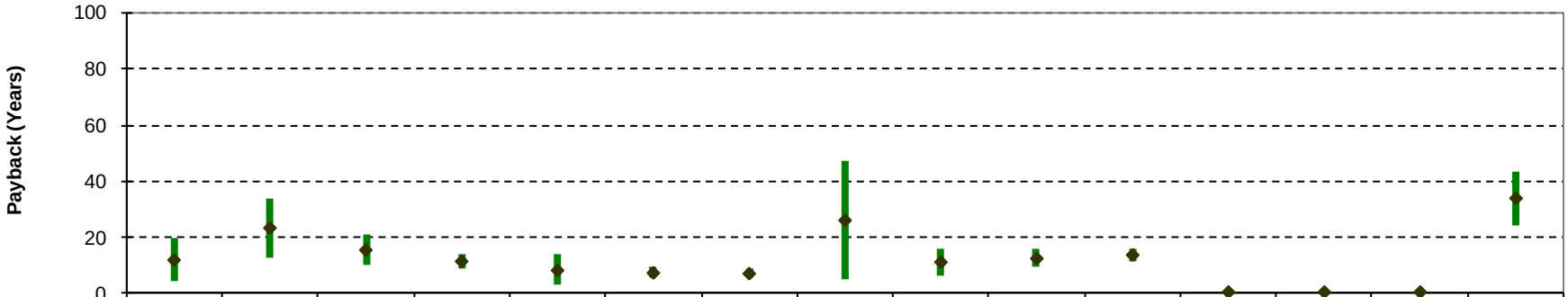
Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

Figure 13. First Costs and Annual Energy Cost Savings for Various EEMs for an All-Electric House (Climate Zone 3)



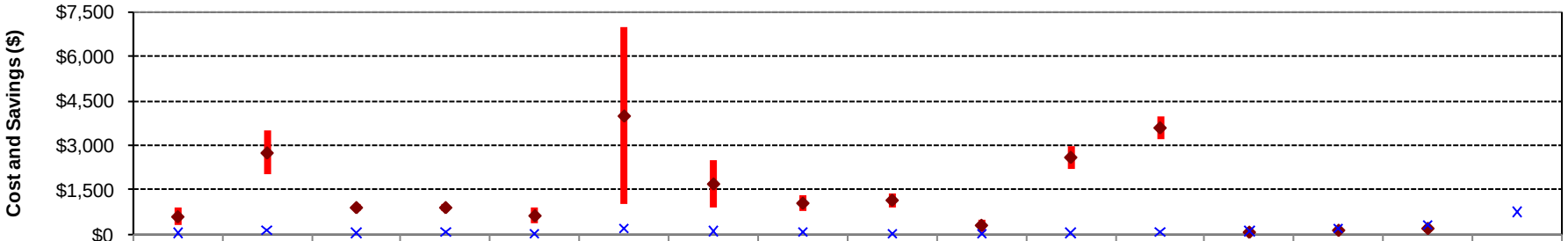
	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased SHGC	Decreased U Value	Decreased SHGC & U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	4.5	13.5	11.0	9.4	2.9	5.9	5.5	5.0	5.8	13.9	39.1	9.2	48.8	51.6	0.2	0.2	0.2	24.3
Maximum	22.0	32.0	20.9	14.1	12.6	9.8	9.2	45.7	21.9	44.2	62.5	46.0	94.1	79.0	1.0	1.0	1.0	43.3
Average	13.3	22.8	16.0	11.8	7.8	7.9	7.4	25.4	13.9	29.1	50.8	27.6	71.5	65.3	0.6	0.6	0.6	33.8

Figure 14. Payback Period for Various EEMs for an Electric/Gas House (Climate Zone 3)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased SHGC	Decreased U Value	Decreased Window SHGC & U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	4.4	12.7	10.3	8.9	2.8	5.5	5.5	4.8	6.2	9.4	11.3	0.2	0.2	0.2	24.3
Maximum	19.5	33.9	20.7	14.1	13.8	9.3	8.8	47.2	16.2	15.6	16.2	1.1	1.1	1.1	43.3
Average	12.0	23.3	15.5	11.5	8.3	7.4	7.2	26.0	11.2	12.5	13.8	0.7	0.7	0.7	33.8

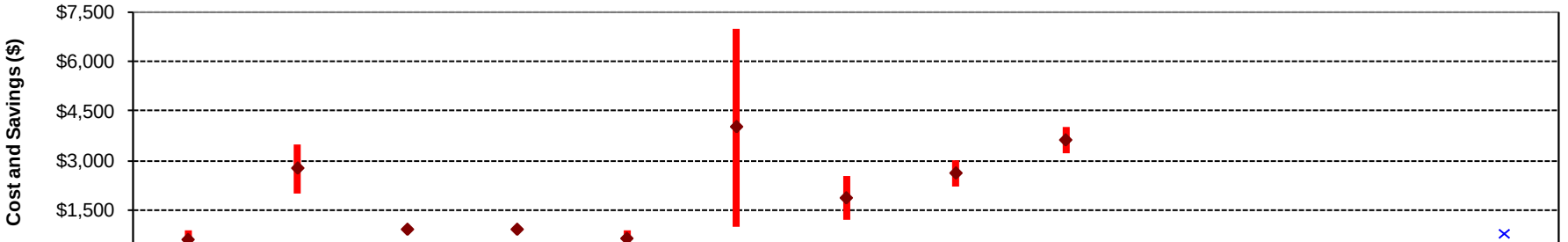
Figure 15. Payback Period for Various EEMs for an All-Electric House (Climate Zone 3)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$350	$1,000	$900	$800	$900	$100	$2,200	$3,200	$25	$50	$70	$20,000
maximum Cost	$880	$3,500	$1,000	$1,000	$900	$7,000	$2,500	$1,300	$1,400	$500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$625	$4,000	$1,700	$1,050	$1,150	$300	$2,600	$3,600	$68	$133	$195	$25,000
Energy Savings	$37	$143	$48	$77	$22	$183	$114	$63	$22	$11	$38	$65	$105	$207	$305	$756

Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

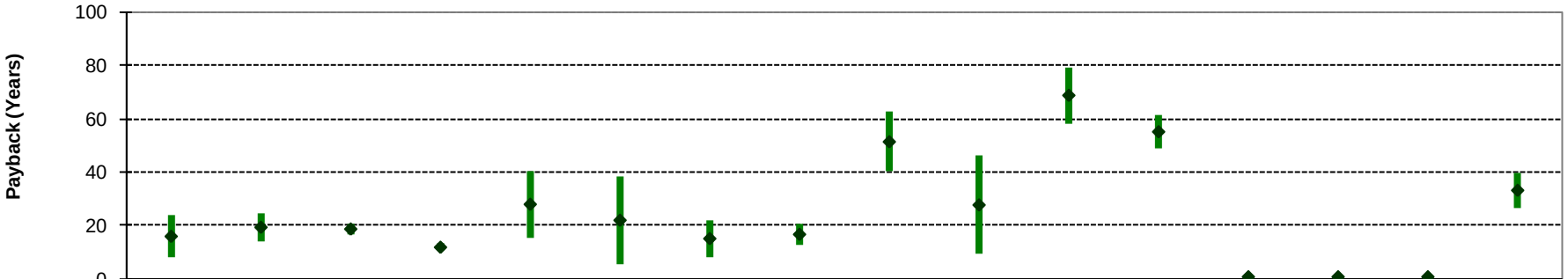
Figure 16. First Costs and Annual Energy Cost Savings for Various EEMs for an Electric/Gas House (Climate Zone 4)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum Cost	$300	$2,000	$800	$800	$350	$1,000	$1,200	$2,200	$3,200	$25	$50	$70	$20,000
Maximum Cost	$880	$3,500	$1,000	$1,000	$900	$7,000	$2,500	$3,000	$4,000	$110	$215	$320	$30,000
Average Cost	$590	$2,750	$900	$900	$625	$4,000	$1,850	$2,600	$3,600	$68	$133	$195	$25,000
Energy Savings	$42	$161	$45	$81	$32	$193	$161	$217	$297	$103	$200	$293	$756

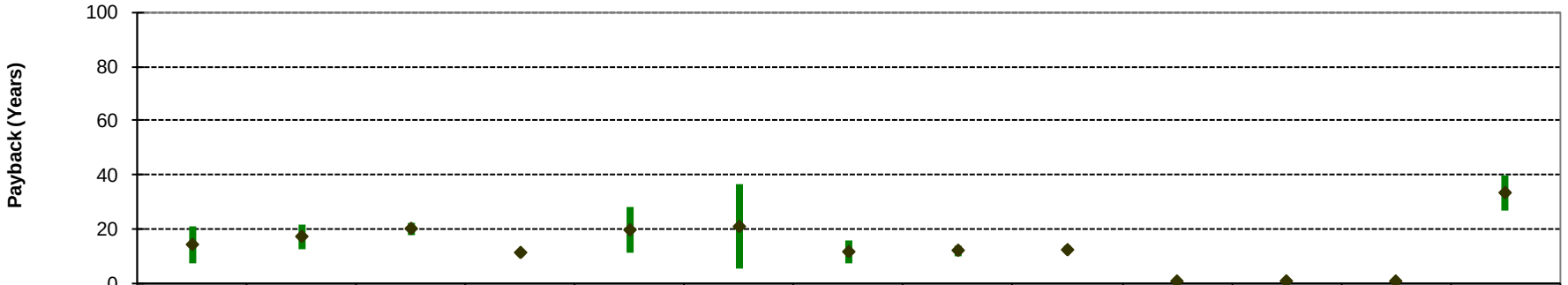
Note. Minimum to maximum cost for the EEM "4kW PV" which is not displayed in the plot is $20,000 to $30,000.

Figure 17. First Costs and Annual Energy Cost Savings for Various EEMs for an All-Electric House (Climate Zone 4)



	Radiant Barrier	Sealed Attic	Window Shading	Window Shading & Redistribution	Decreased U Value	Mech. Systems within Conditioned Space	Improved SEER	Improved Furnace Efficiency	Tankless Gas Water Heater	Removal of Pilot Light	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	8.0	14.0	16.5	10.4	15.6	5.5	7.9	12.6	40.2	9.2	58.2	49.0	0.2	0.2	0.2	26.5
Maximum	23.6	24.4	20.6	13.0	40.1	38.2	22.0	20.5	62.5	46.0	79.4	61.2	1.0	1.0	1.0	39.7
Average	15.8	19.2	18.6	11.7	27.9	21.9	15.0	16.6	51.4	27.6	68.8	55.1	0.6	0.6	0.6	33.1

Figure 18. Payback Period for Various EEMs for an Electric/Gas House (Climate Zone 4)



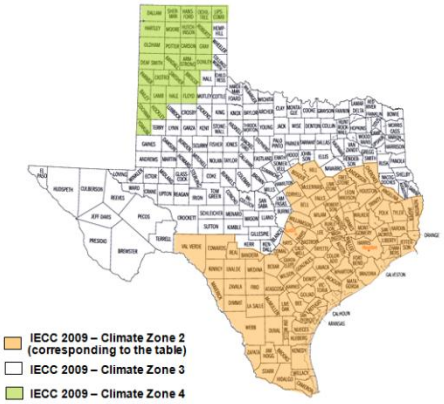
	Radiant Barrier	Sealed Attic	Window Shading	Window Shading and Redistribution	Decreased U Value	Mech. Systems within Conditioned Space	Improved Heat Pump Efficiency	SDHW (32 ft2 collector)	SDHW (64 ft2 collector)	25% CFL	50% CFL	75% CFL	4 kW PV
Minimum	7.2	12.4	17.7	9.9	10.9	5.2	7.4	10.1	10.8	0.2	0.3	0.2	26.5
Maximum	21.0	21.7	22.2	12.4	28.0	36.2	15.5	13.8	13.5	1.1	1.1	1.1	39.7
Average	14.1	17.1	20.0	11.2	19.5	20.7	11.5	12.0	12.2	0.7	0.7	0.7	33.1

Figure 19. Payback Period for Various EEMs for an All-Electric House (Climate Zone 4)

Natural Gas Heating (Climate Zone 2)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***a,b*** ;H:***h***)[7]	1.6% - 2.5%	$38 - $57		$300 - $880	5.2 - 23.2
2	Sealed (Unvented) Attic (L:***a,c,g*** ;H:***i***)	5.4% - 6.6%	$116 - $145	$2,000 - $3,500		13.8 - 30.2
3	Window Shading (None to 2 ft. Eaves on All Sides) (L:***i*** ;H:***a***)	2.0% - 2.6%	$52 - $65		$800 - $1,000	12.3 - 19.2
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides) (L:***i*** ;H:***g***)	2.7% - 3.0%	$66 - $73		$800 - $1,000	10.9 - 15.1
5	Decreased Window SHGC (Climate Zone 2: from 0.3 to 0.2) (L:***i*** ;H:***a***)	1.7% - 3.2%	$51 - $81	$200 - $400		2.5 - 7.8
6	Decreased Window U Value (Climate Zone 2: from 0.65 to 0.3) (L:***a*** ;H:***i***)	4.8% - 6.7%	$111 - $148	$600 - $900		4.0 - 8.1
7	Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L:***e*** ;H:***d***)	7.9% - 8.6%	$179 - $201	$900 - $1,100		4.5 - 6.1
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space (L:***a*** ;H:***i***)	7.5% - 8.5%	$173 - $195	$1,000 - $7,000		5.1 - 40.5
9	Improved Air Conditioner SEER (from 13 to 15 SEER) (L:***h*** ;H:***a***)	6.1% - 8.5%	$146 - $211	$900 - $2,500		4.3 - 17.1
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L:***a*** ;H:***i***)	0.6% - 2.5%	$12 - $47	$800 - $1,300		17.0 - 110.5
C	**Domestic Hot Water Measures**					
11	Tankless Gas Water Heater (without a Standing Pilot Light) (L:***a,d,g,i*** ;H:***b,c,e,f,h***)	1.6% - 1.7%	$29 - $30	$900 - $1,400		29.8 - 47.6
12	Removal of Pilot Light from Tank-Type Hot Water System (L=H:***a,b,c,d,e,f,g,h,i***)	0.8% - 0.8%	$14 - $15	$100 - $500		6.6 - 35.0
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L:***e*** ;H:***d***)	2.9% - 3.6%	$40 - $55		$2,200 - $3,000	40.3 - 75.0
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***a*** ;H:***h***)	4.3% - 5.0%	$68 - $79		$3,200 - $4,000	40.3 - 58.4
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a,c***)	4.3% - 5.1%	$111 - $130	$25 - $110		0.2 - 1.0
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	8.5% - 10.3%	$222 - $259	$50 - $215		0.2 - 1.0
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	12.6% - 15.4%	$330 - $388	$70 - $320		0.2 - 1.0
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array (L:***b*** ;H:***d***)	25.3% - 28.0%	$610 - $686		$20,000 - $30,000	29.2 - 49.2



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[5]	Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NOx Emissions Reduction	SO_2 Emissions Reduction	CO_2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
	Combination 1 (L:***i*** ;H:***a***)[7]								
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	15.0% - 17.1%	$378 - $430	$70 - $320		0.9 - 3.2	5.6 - 6.2	3.7 - 4.0	2.3 - 2.6
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***a,b*** ;H:***h***)				$300 - $880				
	Combination 2 (L:***f*** ;H:***a***)								
7	Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L:***e*** ;H:***d***)	15.0% - 16.6%	$333 - $406	$900 - $1,100		5.2 - 13.5	4.7 - 5.8	2.8 - 3.5	2.0 - 2.5
9	Improved Air Conditioner SEER (from 13 to 15 SEER) (L:***h*** ;H:***a***)			$900 - $2,500					
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***a,b*** ;H:***h***)				$300 - $880				
	Combination 3 (L:***f*** ;H:***g***)								
8	Relocate Mechanical Systems within Conditioned Space (L:***a*** ;H:***i***)	15.3% - 16.5%	$343 - $388	$1,000 - $7,000		7.0 - 26.5	4.8 - 5.4	2.7 - 3.2	2.1 - 2.4
7	Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L:***e*** ;H:***d***)			$900 - $1,100					
3	Window Shading (None to 2 ft. Eaves on All Sides) (L:***i*** ;H:***a***)				$800 - $1,000				

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
   * Energy Cost: Electricity = $0.11/kWh
     Natural gas = $0.84/therm
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. L = County with the lowest annual source energy savings; H = County with the highest annual source energy savings
   County code: ***a*** = Cameron; ***b*** = Nueces; ***c*** = Victoria; ***d*** = Bexar; ***e*** = Harris; ***f*** = Jefferson; ***g*** = Travis; ***h*** = Angelina; ***i*** = Mclennan

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

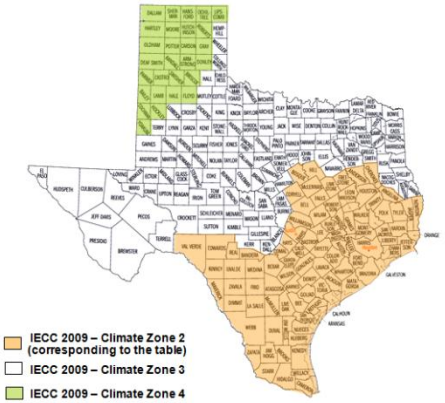
Table 1a: 2009 IECC 15% Above Code Savings (Residential - Natural Gas Heating) for Climate Zone 2

Figure 20. 2009 IECC 15% Above-Code Savings Chart for an Electric/Gas House in Climate Zone 2, TX

Heat Pump Heating (Climate Zone 2)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***a,b*** ;H:***h***)[7]	1.5% - 2.2%	$39 - $55		$300 - $880	5.5 - 22.7
2	Sealed (Unvented) Attic (L:***g*** ;H:***b***)	4.0% - 5.2%	$103 - $132	$2,000 - $3,500		15.1 - 33.9
3	Window Shading (None to 2 ft. Eaves on All Sides) (L:***e,g,i*** ;H:***a***)	2.2% - 2.5%	$55 - $65		$800 - $1,000	12.4 - 18.2
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides) (L:***e*** ;H:***f***)	2.6% - 3.0%	$65 - $74		$800 - $1,000	10.8 - 15.5
5	Decreased Window SHGC (Climate Zone 2: from 0.3 to 0.2) (L:***i*** ;H:***a***)	2.1% - 3.1%	$55 - $81	$200 - $400		2.5 - 7.3
6	Decreased Window U Value (Climate Zone 2: from 0.65 to 0.3) (L:***a*** ;H:***i***)	4.1% - 5.3%	$106 - $139	$600 - $900		4.3 - 8.5
7	Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L:***e*** ;H:***d***)	7.1% - 7.6%	$177 - $197	$900 - $1,100		4.6 - 6.2
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space (L:***e,f*** ;H:***d***)	6.6% - 6.9%	$161 - $177	$1,000 - $7,000		5.6 - 43.4
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:***h*** ;H:***a***)	6.7% - 8.3%	$168 - $216	$1,200 - $2,500		5.6 - 14.9
C	**Domestic Hot Water Measures**					
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L:***e*** ;H:***d***)	5.9% - 7.3%	$148 - $187		$2,200 - $3,000	11.8 - 20.2
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***a*** ;H:***h***)	8.1% - 9.6%	$211 - $240		$3,200 - $4,000	13.3 - 19.0
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***c***)	4.4% - 5.1%	$113 - $129	$25 - $110		0.2 - 1.0
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	8.6% - 10.1%	$226 - $261	$50 - $215		0.2 - 1.0
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	13.1% - 15.2%	$342 - $393	$70 - $320		0.2 - 0.9
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array (L:***b*** ;H:***d***)	24.3% - 26.6%	$610 - $686		$20,000 - $30,000	29.2 - 49.2



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[5]	Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NOx Emissions Reduction	SO2 Emissions Reduction	CO2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
	Combination 1 (L:***i*** ;H:***a,c***)[7]								
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***a***)	15.0% - 16.7%	$387 - $432	$70 - $320		0.9 - 3.1	5.6 - 6.2	3.5 - 3.9	2.3 - 2.6
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***a,b*** ;H:***h***)				$300 - $880				
	Combination 2 (L:***h*** ;H:***a***)								
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***i*** ;H:***c***)	17.3% - 19.4%	$429 - $503	$25 - $110		4.2 - 8.7	6.2 - 7.2	3.9 - 4.5	2.6 - 3.1
7	Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L:***e*** ;H:***d***)			$900 - $1,100					
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:***h*** ;H:***a***)			$1,200 - $2,500					
	Combination 3 (L:***a*** ;H:***h***)								
8	Relocate Mechanical Systems within Conditioned Space (L:***e,f*** ;H:***d***)	15.0% - 16.3%	$384 - $415	$1,000 - $7,000		10.1 - 28.6	5.5 - 6.0	3.5 - 3.7	2.3 - 2.5
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***a*** ;H:***h***)				$3,200 - $4,000				

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Energy Cost: Electricity = $0.11/kWh
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. L = County with the lowest annual source energy savings; H = County with the highest annual source energy savings
   County code: ***a*** = Cameron; ***b*** = Nueces; ***c*** = Victoria; ***d*** = Bexar; ***e*** = Harris; ***f*** = Jefferson; ***g*** = Travis; ***h*** = Angelina; ***i*** = Mclennan

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

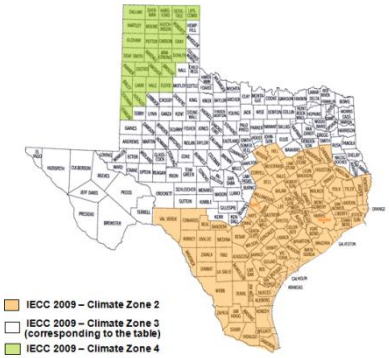
Table 1b: 2009 IECC 15% Above Code Savings (Residential - Heat Pump Heating) for Climate Zone 2

Figure 21. 2009 IECC 15% Above-Code Savings Chart for an All-Electric House in Climate Zone 2, TX

Natural Gas Heating (Climate Zone 3)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***p*** ;H:***l***)[7]	1.6% - 3.1%	$40 - $66		$300 - $880	4.5 - 22.0
2	Sealed (Unvented) Attic (L:***n*** ;H:***o***)	5.7% - 7.2%	$109 - $148	$2,000 - $3,500		13.5 - 32.0
3	Window Shading (None to 2 ft. Eaves on All Sides) (L:***o*** ;H:***l***)	1.5% - 2.8%	$48 - $73		$800 - $1,000	11.0 - 20.9
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides) (L:***o,p*** ;H:***l***)	2.7% - 3.5%	$71 - $85		$800 - $1,000	9.4 - 14.1
5	Decreased Window SHGC (Climate Zone 3: from 0.3 to 0.2) (L:***o*** ;H:***l***)	0.4% - 2.3%	$32 - $68	$200 - $400		2.9 - 12.6
6	Decreased Window U Value (Climate Zone 3: from 0.5 to 0.3) (L:***a,n,p*** ;H:***l***)	4.2% - 4.7%	$92 - $102	$600 - $900		5.9 - 9.8
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)	4.4% - 6.6%	$119 - $163	$900 - $1,100		5.5 - 9.2
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space (L:***l*** ;H:***p***)	7.6% - 9.3%	$153 - $201	$1,000 - $7,000		5.0 - 45.7
9	Improved Air Conditioner SEER (from 13 to 15 SEER) (L:***o*** ;H:***l***)	4.3% - 6.1%	$114 - $154	$900 - $2,500		5.8 - 21.9
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L:***l*** ;H:***o***)	2.2% - 4.0%	$29 - $58	$800 - $1,300		13.9 - 44.2
C	**Domestic Hot Water Measures**					
11	Tankless Gas Water Heater (without a Standing Pilot Light) (L:***p*** ;H:***k,l,n***)	1.5% - 1.7%	$22 - $23	$900 - $1,400		39.1 - 62.5
12	Removal of Pilot Light from Tank-Type Hot Water System (L:***p*** ;H:***j,k,l,m,n,o***)	0.7% - 0.8%	$11 - $11	$100 - $500		9.2 - 46.0
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L:***p*** ;H:***l***)	3.3% - 4.8%	$32 - $45		$2,200 - $3,000	48.8 - 94.1
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***p*** ;H:***l***)	4.7% - 6.0%	$51 - $62		$3,200 - $4,000	51.6 - 79.0
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***p*** ;H:***l***)	3.7% - 4.5%	$106 - $113	$25 - $110		0.2 - 1.0
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***p*** ;H:***l***)	7.4% - 9.0%	$208 - $228	$50 - $215		0.2 - 1.0
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***p*** ;H:***l***)	11.0% - 13.4%	$311 - $338	$70 - $320		0.2 - 1.0
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array (L:***p*** ;H:***l***)	26.3% - 34.9%	$692 - $824		$20,000 - $30,000	24.3 - 43.3



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[5]	Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NO_x Emissions Reduction	SO2 Emissions Reduction	CO2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
	Combination 1 (L:***o*** ;H:***l***)[7]								
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***p*** ;H:***l***)	15.0% - 19.4%	$417 - $491	$70 - $320		0.8 - 2.9	6.0 - 7.1	4.2 - 4.8	2.4 - 2.8
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)				$300 - $880				
	Combination 2 (L:***o*** ;H:***l***)								
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***p*** ;H:***l***)	16.0% - 17.1%	$383 - $422	$50 - $215		4.1 - 10.5	5.5 - 6.1	3.2 - 3.6	2.4 - 2.6
9	Improved Air Conditioner SEER (from 13 to 15 SEER) (L:***o*** ;H:***l***)			$900 - $2,500					
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L:***l*** ;H:***o***)			$800 - $1,300					
	Combination 3 (L:***n*** ;H:***p***)								
8	Relocate Mechanical Systems within Conditioned Space (L:***l*** ;H:***p***)	15.0% - 16.2%	$315 - $358	$1,000 - $7,000		7.5 - 29.9	4.5 - 5.1	1.9 - 2.4	2.1 - 2.5
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L:***l*** ;H:***o***)			$800 - $1,300					
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)			$900 - $1,100					

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
   * Energy Cost: Electricity = $0.11/kWh
     Natural gas = $0.64/therm
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. L = County with the lowest annual source energy savings; H = County with the highest annual source energy savings
   County code: ***j*** = Tom Green; ***k*** = Midland; ***l*** = El Paso; ***m*** = Taylor; ***n*** = Tarrant; ***o*** = Lubbock; ***p*** = Wichita

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

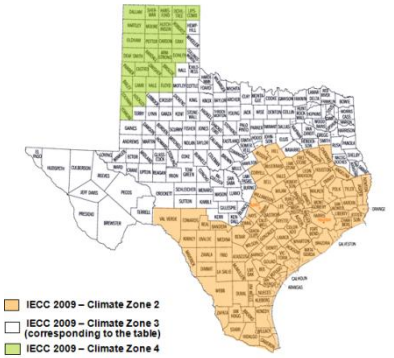
Table 2a: 2009 IECC 15% Above Code Savings (Residential - Natural Gas Heating) for Climate Zone 3

Figure 22. 2009 IECC 15% Above-Code Savings Chart for an Electric/Gas House in Climate Zone 3, TX

Heat Pump Heating (Climate Zone 3)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics) (L:***p*** ;H:***l***)[7]	1.6% - 2.7%	$45 - $68		$300 - $880	4.4 - 19.5
2	Sealed (Unvented) Attic (L:***n*** ;H:***p***)	4.0% - 5.6%	$103 - $158	$2,000 - $3,500		12.7 - 33.9
3	Window Shading (None to 2 ft. Eaves on All Sides) (L:***o*** ;H:***l***)	1.8% - 3.1%	$48 - $77		$800 - $1,000	10.3 - 20.7
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides) (L:***m,o,p*** ;H:***l***)	2.7% - 3.6%	$71 - $90		$800 - $1,000	8.9 - 14.1
5	Decreased Window SHGC (Climate Zone 3: from 0.3 to 0.2) (L:***o*** ;H:***l***)	1.1% - 2.8%	$29 - $71	$200 - $400		2.8 - 13.8
6	Decreased Window U Value (Climate Zone 3: from 0.5 to 0.3) (L:***j,m*** ;H:***l***)	3.7% - 4.1%	$97 - $110	$600 - $900		5.5 - 9.3
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)	4.7% - 6.5%	$126 - $164	$900 - $1,100		5.5 - 8.8
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space (L:***l*** ;H:***p***)	5.9% - 7.3%	$148 - $206	$1,000 - $7,000		4.8 - 47.2
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:***o*** ;H:***p***)	5.7% - 6.8%	$155 - $193	$1,200 - $2,500		6.2 - 16.2
C	**Domestic Hot Water Measures**					
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L:***p*** ;H:***l***)	7.0% - 9.3%	$193 - $233		$2,200 - $3,000	9.4 - 15.6
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***p*** ;H:***l***)	9.0% - 10.9%	$246 - $284		$3,200 - $4,000	11.3 - 16.2
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***o,p*** ;H:***l***)	3.8% - 4.5%	$103 - $113	$25 - $110		0.2 - 1.1
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***o,p*** ;H:***l***)	7.5% - 9.0%	$203 - $226	$50 - $215		0.2 - 1.1
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***o*** ;H:***l***)	11.2% - 13.5%	$303 - $339	$70 - $320		0.2 - 1.1
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array (L:***p*** ;H:***l***)	24.8% - 32.8%	$692 - $824		$20,000 - $30,000	24.3 - 43.3



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[5]	Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NO_x Emissions Reduction	SO2 Emissions Reduction	CO2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
	Combination 1 (L:***o*** ;H:***l***)[7]								
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***o*** ;H:***l***)	15.5% - 19.6%	$419 - $493	$70 - $320		2.0 - 3.4	6.0 - 7.1	3.8 - 4.5	2.5 - 3.0
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)			$900 - $1,100					
	Combination 2 (L:***o*** ;H:***l***)								
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:***o,p*** ;H:***l***)	16.7% - 20.3%	$451 - $516	$50 - $215		4.2 - 8.5	6.5 - 7.4	4.1 - 4.7	2.7 - 3.1
7	Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:***o*** ;H:***l***)			$900 - $1,100					
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:***o*** ;H:***p***)			$1,200 - $2,500					
	Combination 3 (L:***n*** ;H:***l***)								
8	Relocate Mechanical Systems within Conditioned Space (L:***l*** ;H:***p***)	16.0% - 16.9%	$407 - $461	$1,000 - $7,000		9.1 - 27.0	5.9 - 6.6	3.7 - 4.2	2.5 - 2.8
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:***p*** ;H:***l***)				$3,200 - $4,000				

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Energy Cost: Electricity = $0.11/kWh
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. L = County with the lowest annual source energy savings; H = County with the highest annual source energy savings
   County code: ***j*** = Tom Green; ***k*** = Midland; ***l*** = El Paso; ***m*** = Taylor; ***n*** = Tarrant; ***o*** = Lubbock; ***p*** = Wichita

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

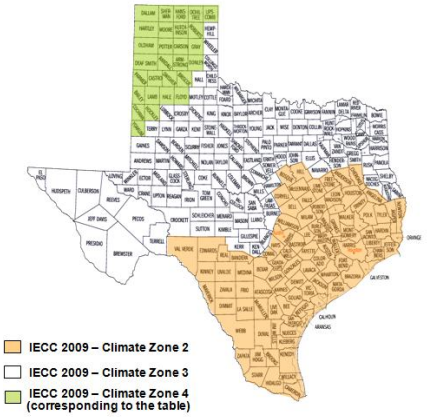
Table 2b: 2009 IECC 15% Above Code Savings (Residential - Heat Pump Heating) for Climate Zone 3

Figure 23. 2009 IECC 15% Above-Code Savings Chart for an All-Electric House in Climate Zone 3, TX

Natural Gas Heating (Climate Zone 4)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics)	1.6%	$37		$300 - $880	8.0 - 23.6
2	Sealed (Unvented) Attic	7.7%	$143	$2,000 - $3,500		14.0 - 24.4
3	Window Shading (None to 2 ft. Eaves on All Sides)	1.4%	$48		$800 - $1,000	16.5 - 20.6
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)	2.8%	$77		$800 - $1,000	10.4 - 13.0
6	Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)	1.4%	$22	$350 - $900		15.6 - 40.1
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space	9.4%	$183	$1,000 - $7,000		5.5 - 38.2
9	Improved Air Conditioner SEER (from 13 to 15 SEER)	4.1%	$114	$900 - $2,500		7.9 - 22.0
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)	4.3%	$63	$800 - $1,300		12.6 - 20.5
C	**Domestic Hot Water Measures**					
11	Tankless Gas Water Heater (without a Standing Pilot Light)	1.5%	$22	$900 - $1,400		40.2 - 62.5
12	Removal of Pilot Light from Tank-Type Hot Water System	0.7%	$11	$100 - $500		9.2 - 46.0
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	3.8%	$38		$2,200 - $3,000	58.2 - 79.4
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	5.7%	$65		$3,200 - $4,000	49.0 - 61.2
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	3.6%	$105	$25 - $110		0.2 - 1.0
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	7.1%	$207	$50 - $215		0.2 - 1.0
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	10.5%	$305	$70 - $320		0.2 - 1.0
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array	29.0%	$756		$20,000 - $30,000	26.5 - 39.7



Description of Combined Measures to Achieve 15% Above Code Savings

	Combination of Measures[5]	Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NOx Emissions Reduction	SO_2 Emissions Reduction	CO_2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
	Combination 1								
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.3%	$376	$70 - $320		2.3 - 4.3	5.4	3.1	2.4
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)			$800 - $1,300					
	Combination 2								
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.6%	$381	$50 - $215		4.6 - 10.5	5.5	3.1	2.4
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)			$800 - $1,300					
9	Improved Air Conditioner SEER (from 13 to 15 SEER)			$900 - $2,500					
	Combination 3								
8	Relocate Mechanical Systems within Conditioned Space	15.0%	$307	$1,000 - $7,000		8.3 - 36.8	4.4	1.9	2.2
9	Tankless Gas Water Heater (without a Standing Pilot Light)			$900 - $2,500					
1	Radiant Barrier in Attics (with Ducts in Attics)				$300 - $880				
6	Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)			$350 - $900					

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
   * Energy Cost: Electricity = $0.11/kWh
     Natural gas = $0.64/therm
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. In climate zone 4, the savings were calculated only for Potter.

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

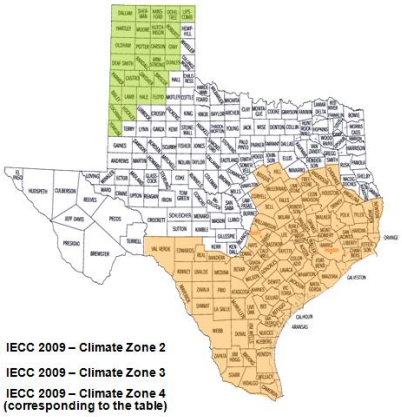
Table 3a: 2009 IECC 15% Above Code Savings (Residential - Natural Gas Heating) for Climate Zone 4[7]

Figure 24. 2009 IECC 15% Above-code Savings Chart for an Electric/Gas House in Climate Zone 4, TX

Heat Pump Heating (Climate Zone 4)

Description of Individual Measures

	Individual Measures	Annual Source Energy Savings (%)[1]	Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
				Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**					
1	Radiant Barrier in Attics (with Ducts in Attics)	1.5%	$42		$300 - $880	7.2 - 21.0
2	Sealed (Unvented) Attic	5.6%	$161	$2,000 - $3,500		12.4 - 21.7
3	Window Shading (None to 2 ft. Eaves on All Sides)	1.6%	$45		$800 - $1,000	17.7 - 22.2
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)	2.8%	$81		$800 - $1,000	9.9 - 12.4
6	Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)	1.1%	$32	$350 - $900		10.9 - 28.0
B	**HVAC System Measures**					
8	Relocate Mechanical Systems within Conditioned Space	6.7%	$193	$1,000 - $7,000		5.2 - 36.2
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF)	5.6%	$161	$1,200 - $2,500		7.4 - 15.5
C	**Domestic Hot Water Measures**					
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	7.5%	$217		$2,200 - $3,000	10.1 - 13.8
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	10.3%	$297		$3,200 - $4,000	10.8 - 13.5
D	**Lighting Measures**					
15	25% Energy Star Permanent CFL or Fluorescent Indoor Lamps	3.6%	$103	$25 - $110		0.2 - 1.1
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	6.9%	$200	$50 - $215		0.3 - 1.1
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	10.2%	$293	$70 - $320		0.2 - 1.1
E	**Renewable Power Measures**					
18	4 kW Photovoltaic Array	26.2%	$756		$20,000 - $30,000	26.5 - 39.7



Description of Combined Measures to Achieve 15% Above Code Savings

Combination of Measures[5]		Combined Source Energy Savings (%)[1]	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NOx Emissions Reduction	SO2 Emissions Reduction	CO2 Emissions Reduction
				Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr)[6]
Combination 1									
17	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.4%	$445	$70 - $320		2.9 - 6.3	6.4	4.0	2.7
9	Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF)			$1,200 - $2,500					
Combination 2									
16	50% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.7%	$453	$50 - $215		5.6 - 9.0	6.5	4.1	2.7
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)				$2,200 - $3,000				
1	Radiant Barrier in Attics (with Ducts in Attics)				$300 - $880				
Combination 3									
8	Relocate Mechanical Systems within Conditioned Space	17.0%	$491	$1,000 - $7,000		8.6 - 22.4	7.1	4.4	3.0
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)				$3,200 - $4,000				

Note:
1. Total souce energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Energy Cost: Electricity = $0.11/kWh
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs
7. In climate zone 4, the savings were calculated only for Potter.

[Building Description]
* Building type: Residential
* Gross area: 2,325 sq-ft.
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)

Table 3b: 2009 IECC 15% Above Code Savings (Residential - Heat Pump Heating) for Climate Zone 4[7]

Figure 25. 2009 IECC 15% Above-code Savings Chart for an All-Electric House in Climate Zone 4, TX

5 DESCRIPTION OF ENERGY EFFICIENCY MEASURES (EEMs)

This section includes a description of EEMs, their impact on the energy use, increased cost of implementation[12], and calculations for simple payback. The energy use of the house with base-case characteristics and with the EEM is plotted for three representative counties in each climate zone such as Harris County for Climate Zone 2, Tarrant County for Climate Zone 3 and Potter County for Climate Zone 4. This includes: (i) annual source energy use for different end-uses and total[13], and (ii) monthly source energy use for different fuel types: electricity and gas[14].

5.1 Envelope and Fenestration Measures

5.1.1 Radiant Barrier in Attics

Base Case: The base-case is simulated with radiant barrier option set to "No."

EEM 1: This measure is simulated with radiant barrier option set to "Yes."

Energy Savings: Figure 26 to Figure 31compare the energy use of a house with base-case characteristics and with the EEM 1 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that installing radiant barrier in attics would increase the cost by $300 - $880.

Table 12. Cost Information for Radiant Barrier

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	No Radiant Barrier	2,526 sq. ft. roof area	$0/sqft		
EEM 1	Radiant Barrier		$0.12-$0.35/sqft	$300-$880	Table Radiant Barrier - No. 1,2,3,4,5,6

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 381 kWh/year x $0.11/kWh = $42/year
Gas cost savings	= 6 therm/year x $0.84/therm = $5/year
Total energy cost savings	= $47/year
Implementation cost	= $300 - $880
Simple Payback	= **6.4 to 18.7 years**

(b) All-electric house:

Electricity cost savings	= 410 kWh/year x $0.11/kWh = $45/year
Implementation cost	= $300 - $880
Simple Payback	= **6.6 to 19.5 years**

[12] The ranges of total implementation cost for some measures were modified according to the recommendations of stakeholders.
[13] The annual site energy use for different end-uses and total was obtained from the BEPS report of the DOE-2 output and then converted to source energy. The source energy multipliers used in this analysis were 3.16 for electricity and 1.1 for natural gas based on Section 405.3 of the 2009 IECC.
[14] The monthly site energy use for different fuel types was obtained from the PS-B report of the DOE-2 output and then converted to source energy.

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 381 kWh/year x $0.11/kWh = $42/year
Gas cost savings	= 6 therm/year x $0.64/therm = $4/year
Total energy cost savings	= $46/year
Implementation cost	= $300 - $880
Simple Payback	= **6.6 to 19.2 years**

(d) All-electric house:

Electricity cost savings	= 410 kWh/year x $0.11/kWh = $45/year
Implementation cost	= $300 - $880
Simple Payback	= **6.6 to 19.5 years**

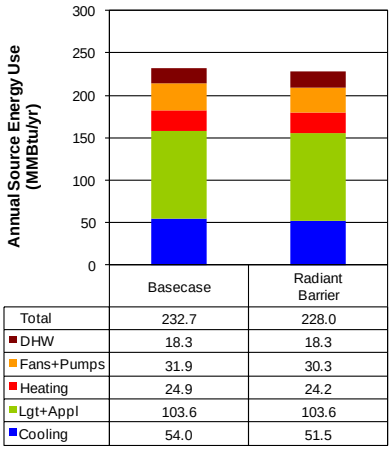
Potter County

(e) Electric/gas house:

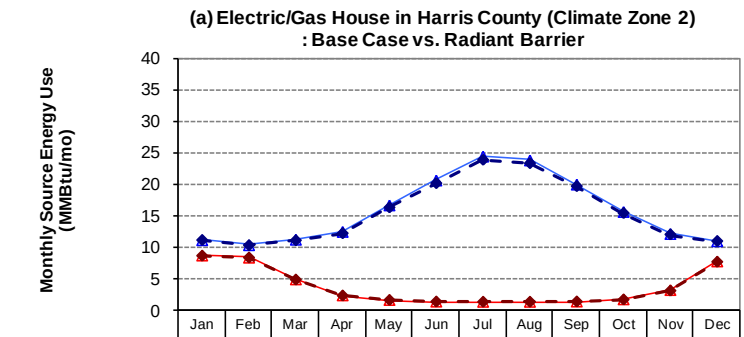
Electricity cost savings	= 293 kWh/year x $0.11/kWh = $32/year
Gas cost savings	= 8 therm/year x $0.64/therm = $5/year
Total energy cost savings	= $37/year
Implementation cost	= $300 - $880
Simple Payback	= **8.0 to 23.6 years**

(f) All-electric house:

Electricity cost savings	= 381 kWh/year x $0.11/kWh = $42/year
Implementation cost	= $300 - $880
Simple Payback	= **7.2 to 21.0 years**

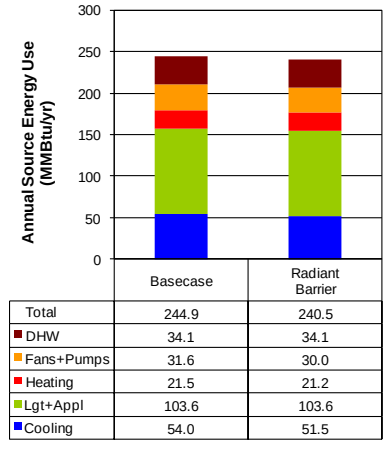


	Basecase	Radiant Barrier
Total	232.7	228.0
DHW	18.3	18.3
Fans+Pumps	31.9	30.3
Heating	24.9	24.2
Lgt+Appl	103.6	103.6
Cooling	54.0	51.5

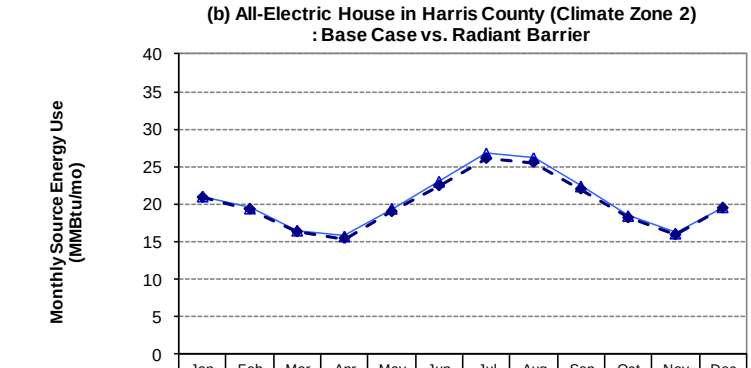


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.0	10.2	11.0	12.1	16.2	20.0	23.7	23.2	19.6	15.3	11.9	10.8
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.5	8.3	4.8	2.2	1.5	1.3	1.2	1.2	1.3	1.6	3.0	7.6

Figure 26. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 1 (Radiant Barrier) in Harris County (Climate Zone 2)

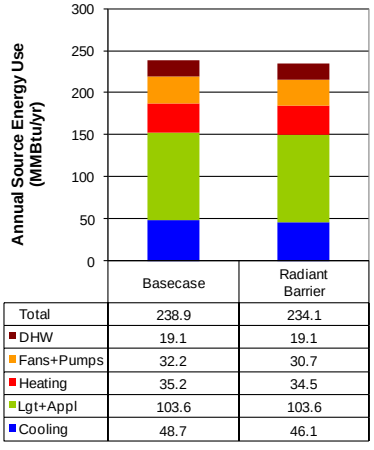


	Basecase	Radiant Barrier
Total	244.9	240.5
DHW	34.1	34.1
Fans+Pumps	31.6	30.0
Heating	21.5	21.2
Lgt+Appl	103.6	103.6
Cooling	54.0	51.5

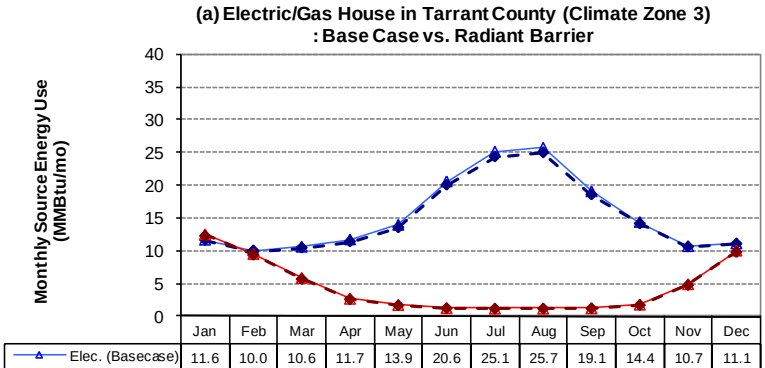


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	20.8	19.3	16.2	15.4	18.9	22.4	26.0	25.5	22.0	18.1	15.9	19.4

Figure 27. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 1 (Radiant Barrier) in Harris County (Climate Zone 2)

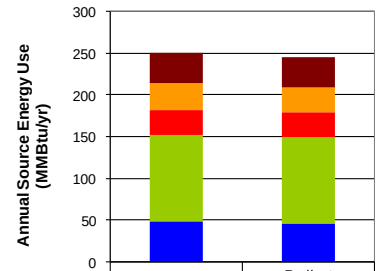


	Basecase	Radiant Barrier
Total	238.9	234.1
DHW	19.1	19.1
Fans+Pumps	32.2	30.7
Heating	35.2	34.5
Lgt+Appl	103.6	103.6
Cooling	48.7	46.1

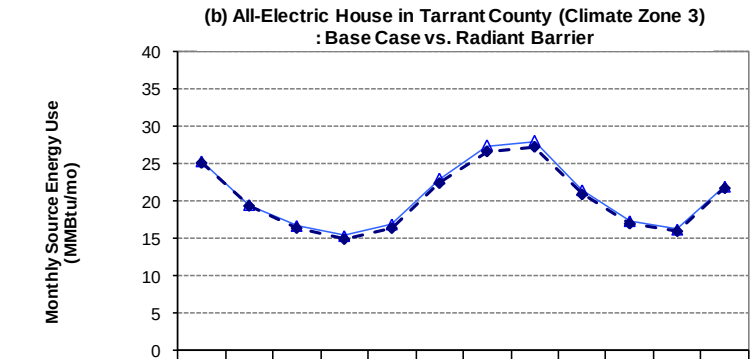


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.6	9.9	10.4	11.3	13.5	20.0	24.3	24.9	18.5	14.1	10.5	11.0
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.4	9.5	5.8	2.7	1.7	1.3	1.2	1.2	1.3	1.8	4.8	9.9

Figure 28. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 1 (Radiant Barrier) in Tarrant County (Climate Zone 3)

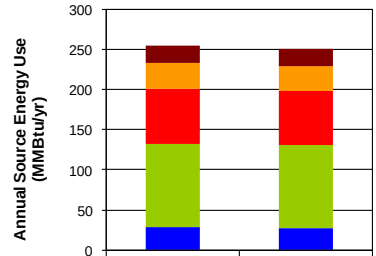


	Basecase	Radiant Barrier
Total	250.0	245.5
DHW	36.3	36.3
Fans+Pumps	31.6	30.0
Heating	29.7	29.4
Lgt+Appl	103.6	103.6
Cooling	48.7	46.1

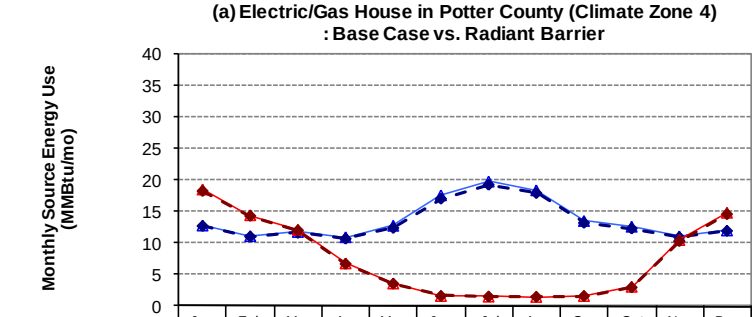


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	25.2	19.4	16.5	15.0	16.5	22.5	26.7	27.3	21.0	17.1	16.1	21.8

Figure 29. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 1 (Radiant Barrier) in Tarrant County (Climate Zone 3)

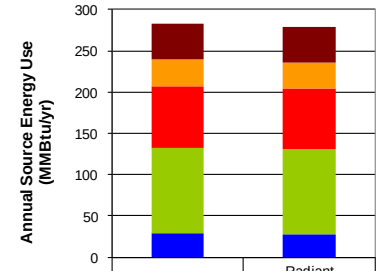


	Basecase	Radiant Barrier
Total	255.0	251.0
DHW	22.0	22.0
Fans+Pumps	32.2	31.0
Heating	68.1	67.2
Lgt+Appl	103.6	103.6
Cooling	29.1	27.2

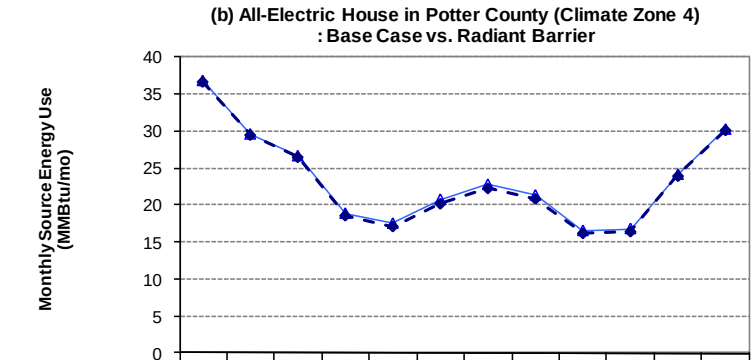


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.7	11.1	11.6	10.7	12.4	17.1	19.3	18.0	13.2	12.3	11.0	12.0
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.3	14.4	12.1	6.7	3.6	1.6	1.5	1.5	1.6	3.0	10.4	14.6

Figure 30. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 1 (Radiant Barrier) in Potter County (Climate Zone 4)



	Basecase	Radiant Barrier
Total	282.5	278.4
DHW	42.7	42.7
Fans+Pumps	33.2	31.9
Heating	73.9	73.0
Lgt+Appl	103.6	103.6
Cooling	29.1	27.2



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	36.6	29.4	26.4	18.6	17.1	20.2	22.2	20.8	16.2	16.4	23.9	30.1

Figure 31. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 1 (Radiant Barrier) in Potter County (Climate Zone 4)

5.1.2 Sealed Attic

Base Case: The base-case house has an unconditioned, vented attic with insulation above the ceiling. The attic and house were assumed to have a total of 7.75 ft^2 and 0.84 ft^2 of leakage area, respectively[15]. A total of 11.2% duct leakage was assumed for the base-case house[16].

EEM 2: This measure analyzed the energy savings that would occur if the house had a sealed (unvented) attic with insulation underside the roof. The attic was assumed to have no leakage area. The house was assumed to be 25% tighter than the base-case house, which corresponds to 0.63 ft^2 of leakage area. The duct leakage was decreased by half, which corresponds to a total of 5.6% duct leakage.

Energy Savings: Figure 32 to Figure 37compare the energy use of a house with base-case characteristics and with the EEM 2 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that sealing the attics would increase the cost by $2,000 - $3,500.

Table 13. Cost Information for Sealed Attic

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	Attic Not Sealed	2,325 sq. ft. conditioned floor area			Table Duct-2 - No. 1,2,3,4
EEM2	Attic Sealed		$1.0-$1.5/sqft	$2,000-$3,500	

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 732 kWh/year x $0.11/kWh = $81/year
Gas cost savings	= 46 therm/year x $0.84/therm = $39/year
Total energy cost savings	= $119/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **16.8 to 29.4 years**

(b) All-electric house:

Electricity cost savings	= 996 kWh/year x $0.11/kWh = $110/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **18.2 to 31.9 years**

[15] The infiltration rates for the house and attic are based on Table 405.5.2(1) of the 2009 IECC.
[16] The duct leakage rate requirements are based on Section 403.2.2 of the 2009 IECC.

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 645 kWh/year x $0.11/kWh = $71/year
Gas cost savings	= 60 therm/year x $0.64/therm = $38/year
Total energy cost savings	= $109/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **18.3 to 32.0 years**

(d) All-electric house:

Electricity cost savings	= 938 kWh/year x $0.11/kWh = $103/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **19.4 to 33.9 years**

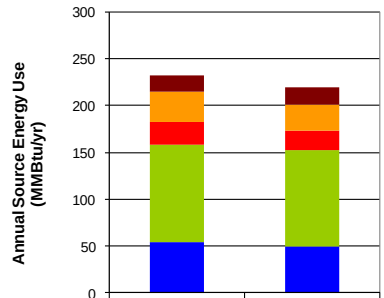
Potter County

(e) Electric/gas house:

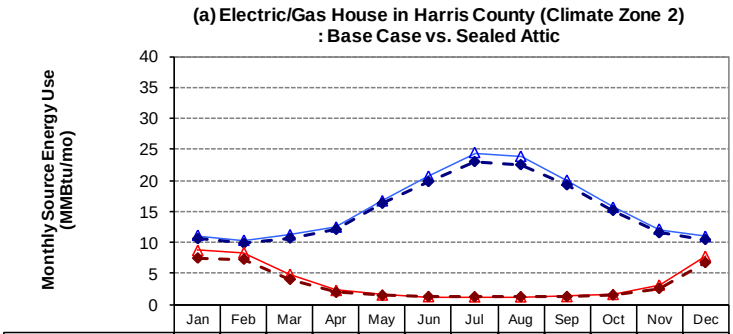
Electricity cost savings	= 615 kWh/year x $0.11/kWh = $68/year
Gas cost savings	= 118 therm/year x $0.64/therm = $76/year
Total energy cost savings	= $143/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **14.0 to 24.4 years**

(f) All-electric house:

Electricity cost savings	= 1465 kWh/year x $0.11/kWh = $161/year
Implementation cost	= $2,000 - $3,500
Simple Payback	= **12.4 to 21.7 years**

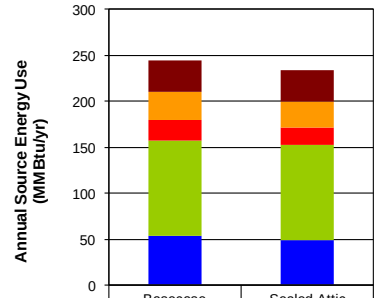


	Basecase	Sealed Attic
Total	232.7	219.8
DHW	18.3	18.3
Fans+Pumps	31.9	28.8
Heating	24.9	19.8
Lgt+Appl	103.6	103.6
Cooling	54.0	49.3

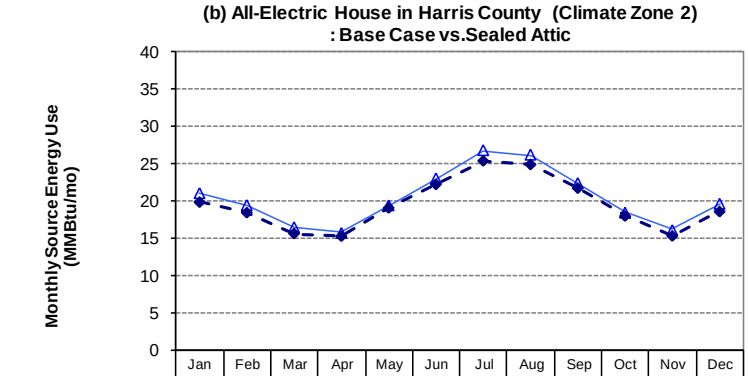


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	10.6	9.8	10.7	12.1	16.3	19.9	23.1	22.6	19.3	15.2	11.5	10.4
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	7.5	7.3	4.0	1.9	1.5	1.3	1.2	1.2	1.3	1.5	2.6	6.8

Figure 32. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 2 (Sealed Attic) in Harris County (Climate Zone 2)

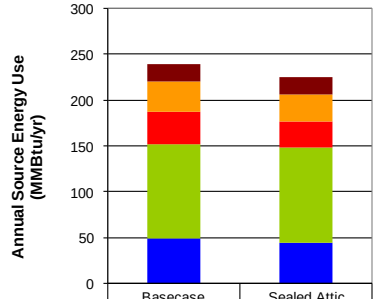


	Basecase	Sealed Attic
Total	244.9	234.2
DHW	34.1	34.1
Fans+Pumps	31.6	29.1
Heating	21.5	18.0
Lgt+Appl	103.6	103.6
Cooling	54.0	49.3

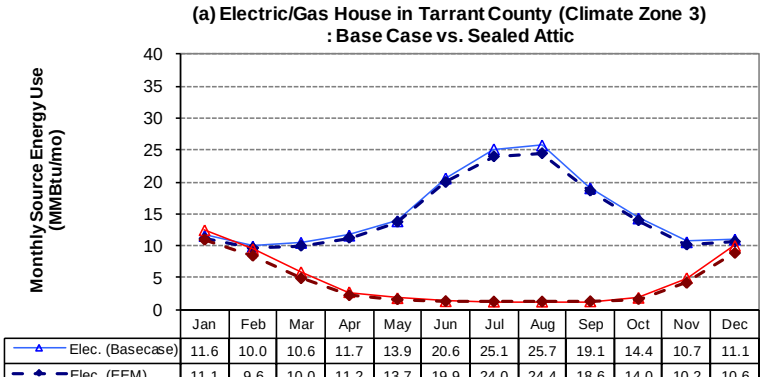


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	19.8	18.4	15.6	15.2	19.1	22.2	25.4	24.9	21.7	18.0	15.3	18.6

Figure 33. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 2 (Sealed Attic) in Harris County (Climate Zone 2)

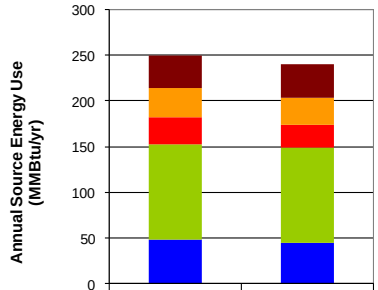


	Basecase	Sealed Attic
Total	238.9	225.3
DHW	19.1	19.1
Fans+Pumps	32.2	29.1
Heating	35.2	28.6
Lgt+Appl	103.6	103.6
Cooling	48.7	44.9

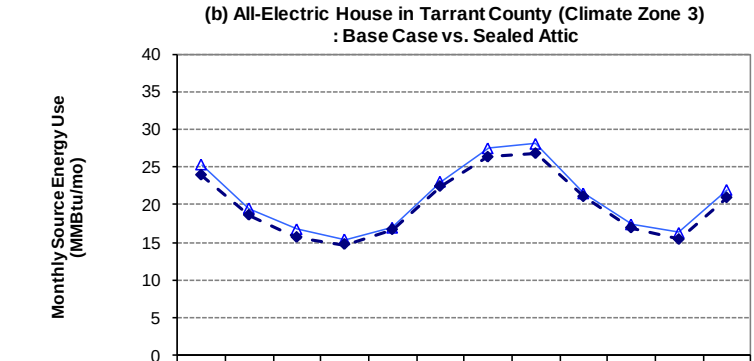


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.1	9.6	10.0	11.2	13.7	19.9	24.0	24.4	18.6	14.0	10.2	10.6
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	10.9	8.4	4.9	2.2	1.6	1.3	1.2	1.2	1.3	1.6	4.2	8.8

Figure 34. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 2 (Sealed Attic) in Tarrant County (Climate Zone 3)

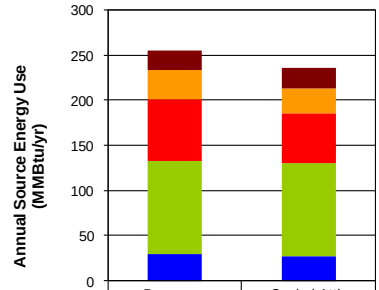


	Basecase	Sealed Attic
Total	250.0	239.8
DHW	36.3	36.3
Fans+Pumps	31.6	29.7
Heating	29.7	25.3
Lgt+Appl	103.6	103.6
Cooling	48.7	44.9

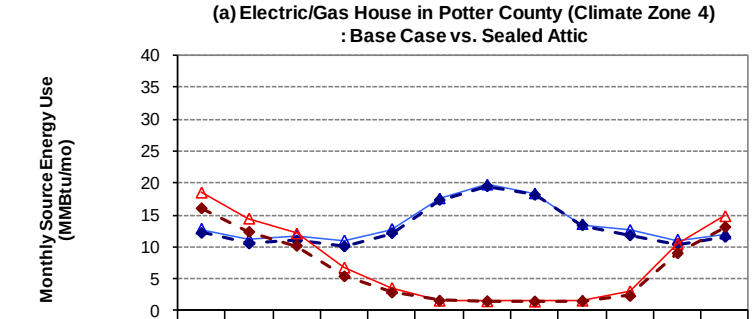


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	23.9	18.6	15.6	14.7	16.7	22.4	26.3	26.8	21.0	16.9	15.4	20.9

Figure 35. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 2 (Sealed Attic) in Tarrant County (Climate Zone 3)

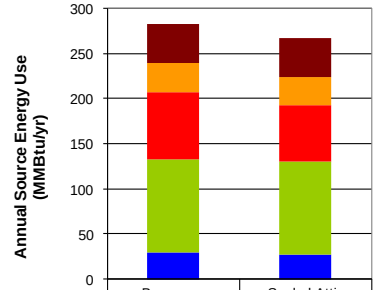


	Basecase	Sealed Attic
Total	255.0	235.4
DHW	22.0	22.0
Fans+Pumps	32.2	28.1
Heating	68.1	55.1
Lgt+Appl	103.6	103.6
Cooling	29.1	26.5

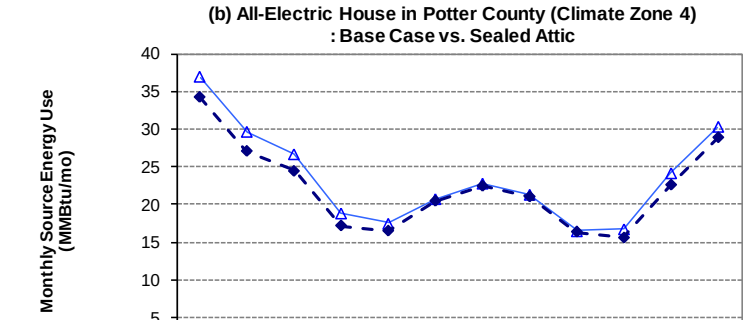


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.2	10.5	11.0	10.1	12.1	17.3	19.5	18.1	13.4	11.8	10.4	11.6
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	16.0	12.3	10.1	5.4	2.9	1.6	1.5	1.5	1.6	2.3	9.0	13.1

Figure 36. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 2 (Sealed Attic) in Potter County (Climate Zone 4)



	Basecase	Sealed Attic
Total	282.5	266.7
DHW	42.7	42.7
Fans+Pumps	33.2	31.0
Heating	73.9	62.9
Lgt+Appl	103.6	103.6
Cooling	29.1	26.5



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	34.3	27.1	24.4	17.2	16.5	20.5	22.4	21.0	16.3	15.6	22.6	28.9

Figure 37. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 2 (Sealed Attic) in Potter County (Climate Zone 4)

5.1.3 Window Shading

Base Case: The base-case is simulated without any window shading for the windows.

EEM 3: This measure was simulated by modeling 2 ft. roof overhangs on all four sides. The gross window area, orientation, and other characteristics were kept the same as the base-case house, which had no overhang.

Energy Savings: Figure 38 to Figure 43 compare the energy use of a house with base-case characteristics and with the EEM 3 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that adding 2 ft. of roof overhang would increase the cost by $800 - $1,000.

Table 14. Cost Information for Window Shading

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	No Window Shading	193 ft. perimeter	$4-$20/linear foot		Table Shading-1 - No. 4; Table Shading-2 - No. 1
EEM 3	2' Eaves		$8-$25/linear foot	$800-$1,000	Table Shading-1 - No. 4; Table Shading-2 - No. 2

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 557 kWh/year x $0.11/kWh = $61/year
Gas cost savings	= -8 therm/year x $0.84/therm = -$7/year
Total energy cost savings	= $55/year
Implementation cost	= $800 - $1,000
Simple Payback	= **14.7 to 18.3 years**

(b) All-electric house:

Electricity cost savings	= 498 kWh/year x $0.11/kWh = $55/year
Implementation cost	= $800 - $1,000
Simple Payback	= **14.6 to 18.2 years**

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 586 kWh/year x $0.11/kWh = $64/year
Gas cost savings	= -13 therm/year x $0.64/therm = -$8/year
Total energy cost savings	= $56/year
Implementation cost	= $800 - $1,000
Simple Payback	= **14.2 to 17.8 years**

(d) All-electric house:

Electricity cost savings	= 498 kWh/year x $0.11/kWh = $55/year
Implementation cost	= $800 - $1,000
Simple Payback	= **14.6 to 18.2 years**

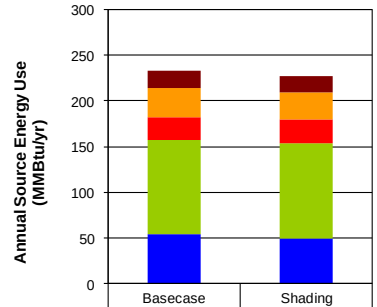
Potter County

(e) Electric/gas house:

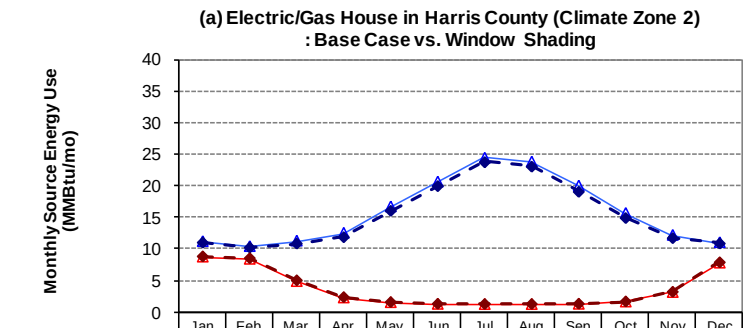
Electricity cost savings	= 586 kWh/year x $0.11/kWh = $64/year
Gas cost savings	= -25 therm/year x $0.64/therm = -$16/year
Total energy cost savings	= $48/year
Implementation cost	= $800 - $1,000
Simple Payback	= **16.5 to 20.6 years**

(f) All-electric house:

Electricity cost savings	= 410 kWh/year x $0.11/kWh = $45/year
Implementation cost	= $800 - $1,000
Simple Payback	= **17.7 to 22.2 years**

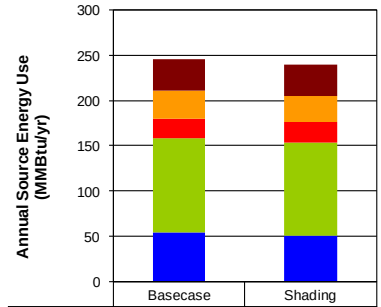


	Basecase	Shading
Total	232.7	227.6
DHW	18.3	18.3
Fans+Pumps	31.9	30.0
Heating	24.9	25.7
Lgt+Appl	103.6	103.6
Cooling	54.0	49.9

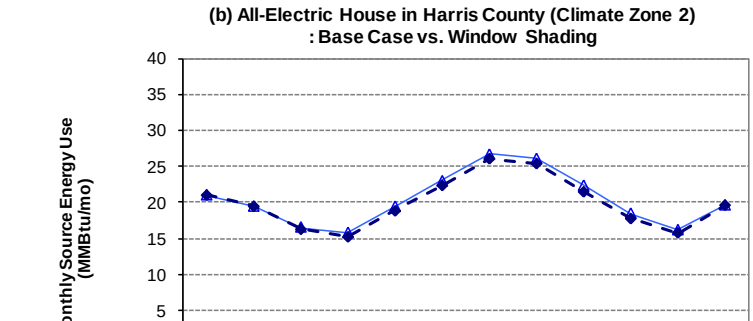


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.0	10.2	10.8	11.9	16.1	20.0	23.8	23.1	19.1	14.9	11.7	10.9
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.8	8.5	5.0	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.2	7.9

Figure 38. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 3 (Window Shading) in Harris County (Climate Zone 2)

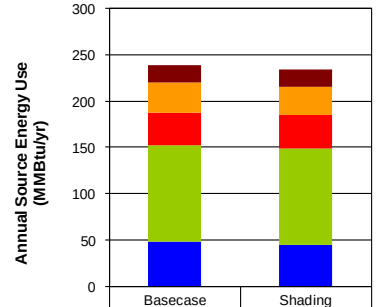


	Basecase	Shading
Total	244.9	239.5
DHW	34.1	34.1
Fans+Pumps	31.6	29.7
Heating	21.5	22.1
Lgt+Appl	103.6	103.6
Cooling	54.0	49.9

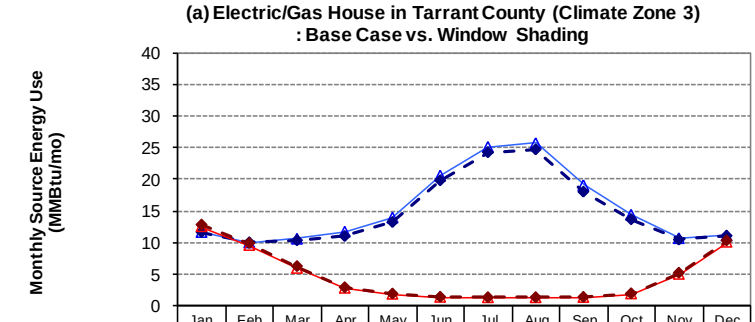


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	21.0	19.5	16.3	15.2	18.8	22.4	26.1	25.4	21.5	17.8	15.8	19.6

Figure 39. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 3 (Window Shading) in Harris County (Climate Zone 2)

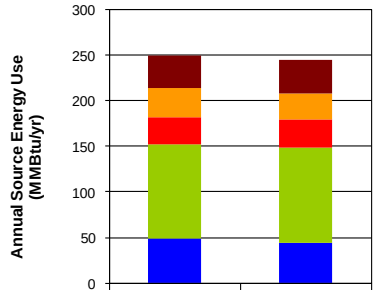


	Basecase	Shading
Total	238.9	234.0
DHW	19.1	19.1
Fans+Pumps	32.2	30.0
Heating	35.2	36.6
Lgt+Appl	103.6	103.6
Cooling	48.7	44.6

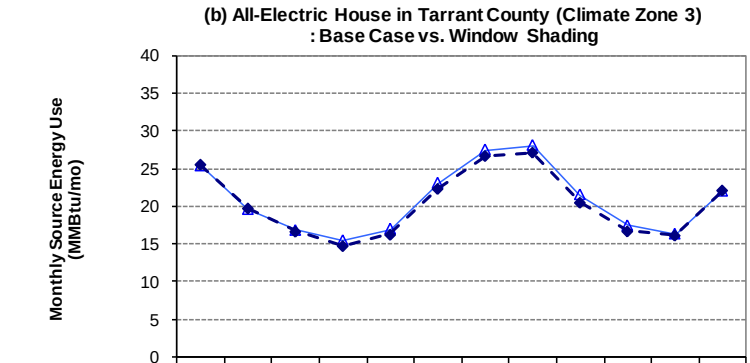


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.6	10.0	10.3	11.0	13.2	19.8	24.3	24.7	18.0	13.6	10.4	11.1
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.8	9.8	6.2	2.8	1.8	1.3	1.2	1.2	1.3	1.9	5.1	10.3

Figure 40. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 3 (Window Shading) in Tarrant County (Climate Zone 3)

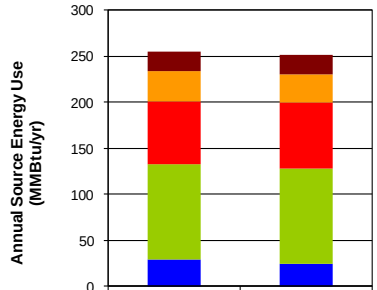


	Basecase	Shading
Total	250.0	244.6
DHW	36.3	36.3
Fans+Pumps	31.6	29.4
Heating	29.7	30.7
Lgt+Appl	103.6	103.6
Cooling	48.7	44.6

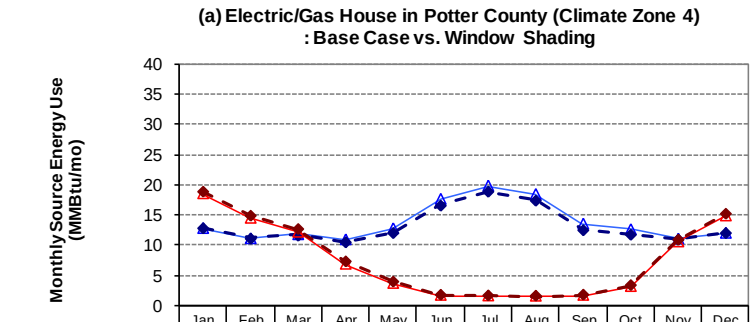


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	25.5	19.7	16.7	14.8	16.3	22.3	26.6	27.1	20.5	16.7	16.1	22.1

Figure 41. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 3 (Window Shading) in Tarrant County (Climate Zone 3)

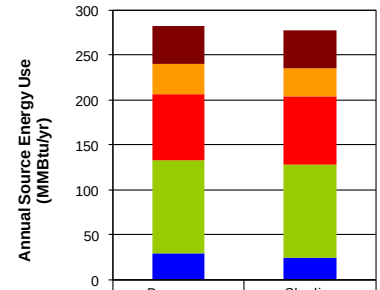


	Basecase	Shading
Total	255.0	251.5
DHW	22.0	22.0
Fans+Pumps	32.2	30.3
Heating	68.1	70.8
Lgt+Appl	103.6	103.6
Cooling	29.1	24.6

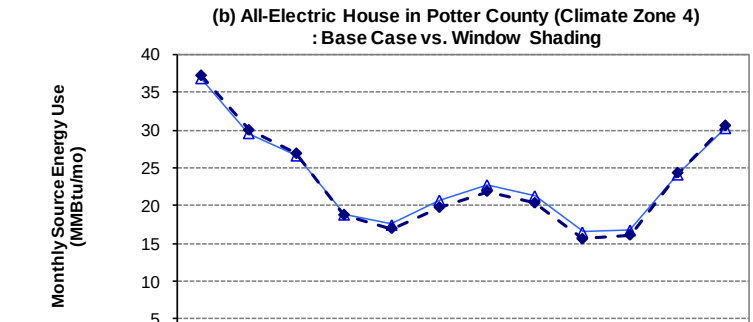


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.9	11.1	11.6	10.5	12.1	16.6	18.9	17.4	12.5	11.8	11.0	12.1
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.9	14.8	12.6	7.2	3.8	1.6	1.5	1.5	1.7	3.3	10.8	15.2

Figure 42. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 3 (Window Shading) in Potter County (Climate Zone 4)



	Basecase	Shading
Total	282.5	278.1
DHW	42.7	42.7
Fans+Pumps	33.2	31.3
Heating	73.9	75.8
Lgt+Appl	103.6	103.6
Cooling	29.1	24.6



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	37.2	29.9	26.8	18.7	16.9	19.7	21.8	20.3	15.5	16.0	24.3	30.5

Figure 43. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 3 (Window Shading) in Potter County (Climate Zone 4)

5.1.4 Window Shading and Redistribution

Base Case: The window-to-floor area ratio for the base-case house is 15%, equally distributed on all four sides. This translates to 22.6% window-to-wall area ratio equally distributed on all four sides.

EEM 4: For this measure, the house was simulated with the windows distributed 40.70% on the south, 22.61 % on the north, 13.57 % each on east and west orientations. A 2 ft. roof overhang was also included on all four sides.

Energy Savings: Figure 44 to Figure 49 compare the energy use of a house with base-case characteristics and with the EEM 4 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that adding 2 ft. of roof overhang would increase the cost by $800 - $1,000. However, considering window redistribution in a new construction would have no increased cost.

Table 15. Cost Information for Window Shading and Redistribution

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	No Window Shading	193 ft. perimeter	$4-$20/linear foot		Table Shading-1 - No. 4; Table Shading-2 - No. 1
EEM 4	2' Eaves		$8-$25/linear foot	$800-$1,000	Table Shading-1 - No. 4; Table Shading-2 - No. 2

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 645 kWh/year x $0.11/kWh = $71/year
Gas cost savings	= -3 therm/year x $0.84/therm = -$3/year
Total energy cost savings	= $68/year
Implementation cost	= $800 - $1,000
Simple Payback	= **11.7 to 14.6 years**

(b) All-electric house:

Electricity cost savings	= 586 kWh/year x $0.11/kWh = $65/year
Implementation cost	= $800 - $1,000
Simple Payback	= **12.4 to 15.5 years**

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 674 kWh/year x $0.11/kWh = $74/year
Gas cost savings	= -2 therm/year x $0.64/therm = -$1/year
Total energy cost savings	= $73/year
Implementation cost	= $800 - $1,000
Simple Payback	= **11.0 to 13.7 years**

(d) All-electric house:

Electricity cost savings	= 674 kWh/year x $0.11/kWh = $74/year
Implementation cost	= $800 - $1,000
Simple Payback	= **10.8 to 13.5 years**

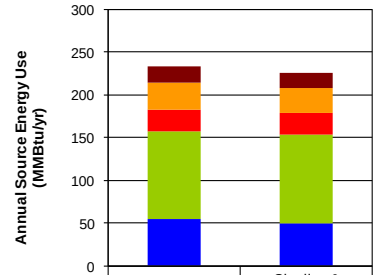
Potter County

(e) Electric/gas house:

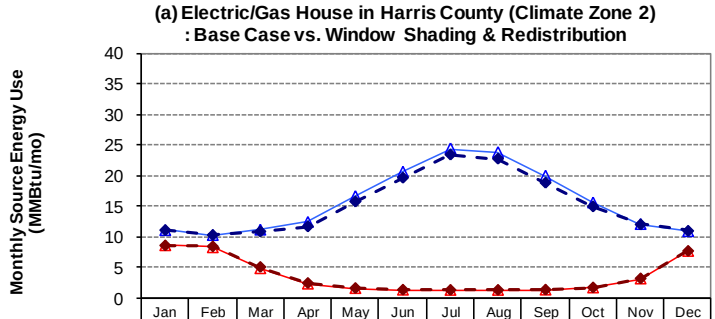
Electricity cost savings	= 732 kWh/year x $0.11/kWh = $81/year
Gas cost savings	= -6 therm/year x $0.64/therm = -$4/year
Total energy cost savings	= $77/year
Implementation cost	= $800 - $1,000
Simple Payback	= **10.4 to 13.0 years**

(f) All-electric house:

Electricity cost savings	= 733 kWh/year x $0.11/kWh = $81/year
Implementation cost	= $800 - $1,000
Simple Payback	= **9.9 to 12.4 years**

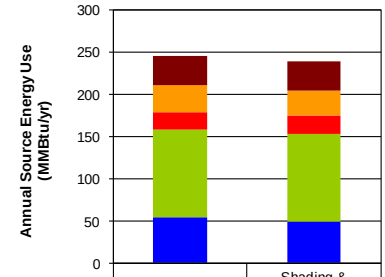


	Basecase	Shading & Redistribution
Total	232.7	226.1
DHW	18.3	18.3
Fans+Pumps	31.9	29.4
Heating	24.9	25.2
Lgt+Appl	103.6	103.6
Cooling	54.0	49.6

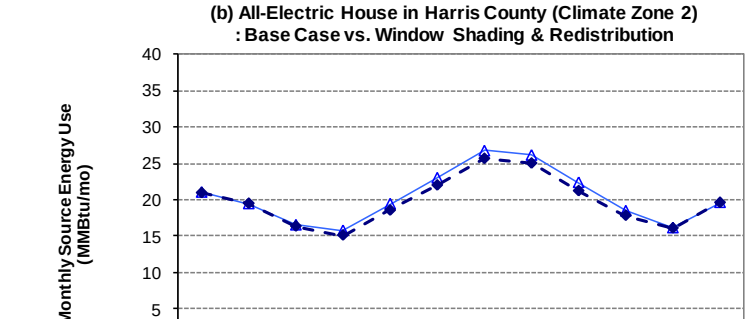


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.1	10.3	10.9	11.7	15.8	19.7	23.4	22.8	18.9	15.0	12.0	11.0
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.6	8.4	5.0	2.4	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7

Figure 44. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 4 (Shading and Redistribution) in Harris County (Climate Zone 2)

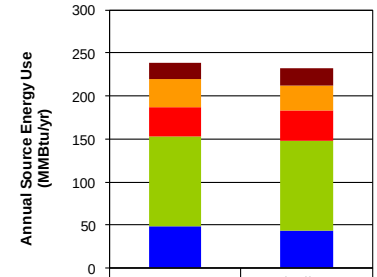


	Basecase	Shading & Redistribution
Total	244.9	238.6
DHW	34.1	34.1
Fans+Pumps	31.6	29.4
Heating	21.5	21.8
Lgt+Appl	103.6	103.6
Cooling	54.0	49.6

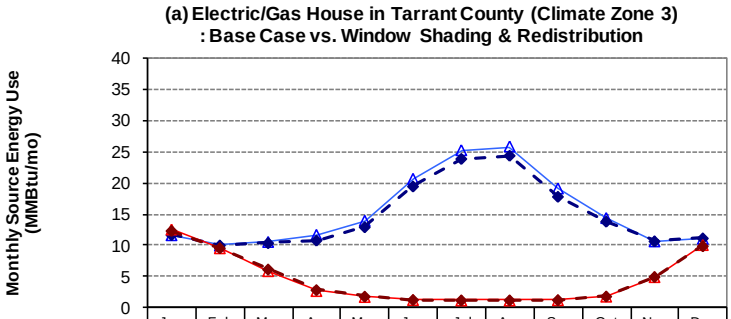


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	21.0	19.5	16.3	15.1	18.6	22.0	25.8	25.1	21.3	17.8	16.1	19.6

Figure 45. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 4 (Shading and Redistribution) in Harris County (Climate Zone 2)

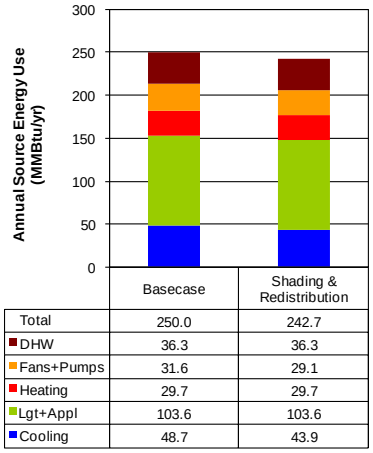


	Basecase	Shading & Redistribution
Total	238.9	231.8
DHW	19.1	19.1
Fans+Pumps	32.2	29.7
Heating	35.2	35.4
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9

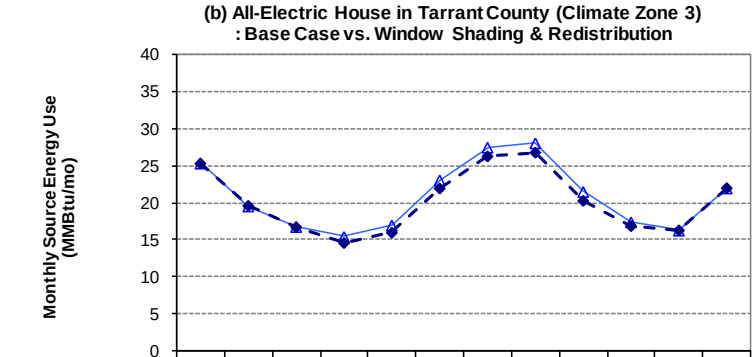


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.7	10.0	10.4	10.8	12.9	19.4	23.8	24.4	17.8	13.8	10.7	11.2
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.3	9.6	6.2	2.9	1.8	1.3	1.2	1.2	1.3	1.9	5.0	9.9

Figure 46. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 4 (Shading and Redistribution) in Tarrant County (Climate Zone 3)

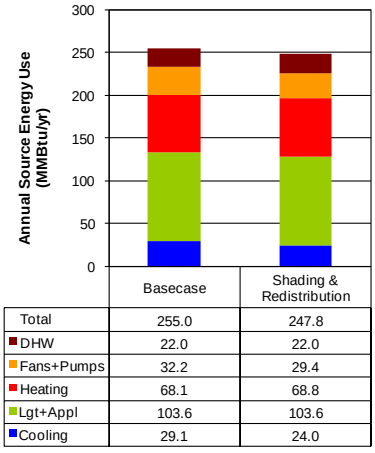


	Basecase	Shading & Redistribution
Total	250.0	242.7
DHW	36.3	36.3
Fans+Pumps	31.6	29.1
Heating	29.7	29.7
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9

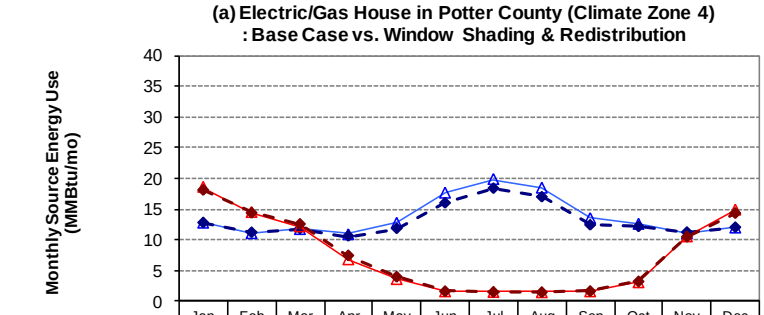


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	25.3	19.6	16.7	14.6	16.0	21.9	26.2	26.7	20.3	16.9	16.3	22.0

Figure 47. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 4 (Shading and Redistribution) in Tarrant County (Climate Zone 3)

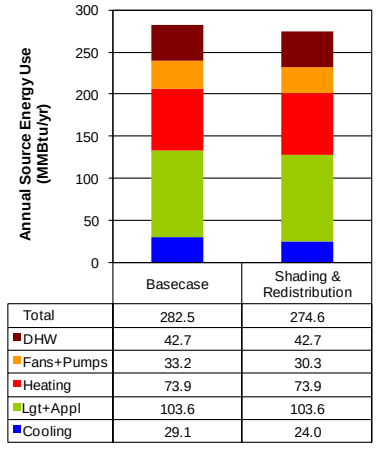


	Basecase	Shading & Redistribution
Total	255.0	247.8
DHW	22.0	22.0
Fans+Pumps	32.2	29.4
Heating	68.1	68.8
Lgt+Appl	103.6	103.6
Cooling	29.1	24.0

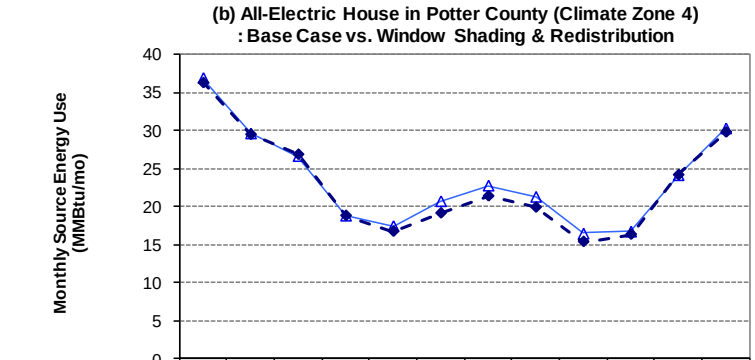


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.7	11.1	11.7	10.5	11.8	16.0	18.4	17.0	12.4	12.1	11.2	12.0
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.1	14.4	12.6	7.4	4.0	1.6	1.5	1.5	1.7	3.2	10.5	14.3

Figure 48. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 4 (Shading and Redistribution) in Potter County (Climate Zone 4)



	Basecase	Shading & Redistribution
Total	282.5	274.6
DHW	42.7	42.7
Fans+Pumps	33.2	30.3
Heating	73.9	73.9
Lgt+Appl	103.6	103.6
Cooling	29.1	24.0



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	36.4	29.6	26.9	18.8	16.7	19.1	21.4	19.9	15.4	16.3	24.2	29.9

Figure 49. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 4 (Shading and Redistribution) in Potter County (Climate Zone 4)

5.1.5 Decreased Window SHGC

Base Case: The base-case SHGC value is 0.30 for Harris and Tarrant County.

EEM 5: For the test case, a SHGC of 0.20 is taken for Harris and Tarrant County. For Potter County, this measure was not considered, due to negative savings because of the increased heating energy penalty.

Energy Savings: Figure 50 to Figure 53 compare the energy use of a house with base-case characteristics and with the EEM 5 for Harris and Tarrant County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that improving the SHGC of the fenestration system would increase the cost by $200 - $400.

Table 16. Cost Information for Decreased Window SHGC

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	0.3 SHGC	No. of (36"x60") windows: 23	$146-$153/Unit		Table Windows-1 -No 5,33
EEM 5	0.2 SHGC		$162/Unit	$200-$400	Table Windows-1 -No 9

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings = 674 kWh/year x $0.11/kWh = $74/year
Gas cost savings = -18 therm/year x $0.84/therm = -$15/year
Total energy cost savings = $59/year
Implementation cost = $200 - $400
Simple Payback = **3.4 to 6.8 years**

(b) All-electric house:

Electricity cost savings = 557 kWh/year x $0.11/kWh = $61/year
Implementation cost = $200 - $400
Simple Payback = **3.3 to 6.5 years**

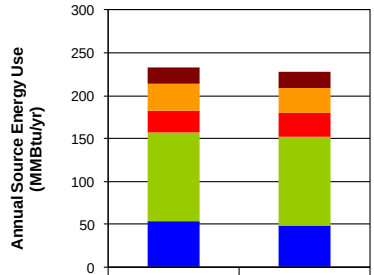
Tarrant County

(c) Electric/gas house:

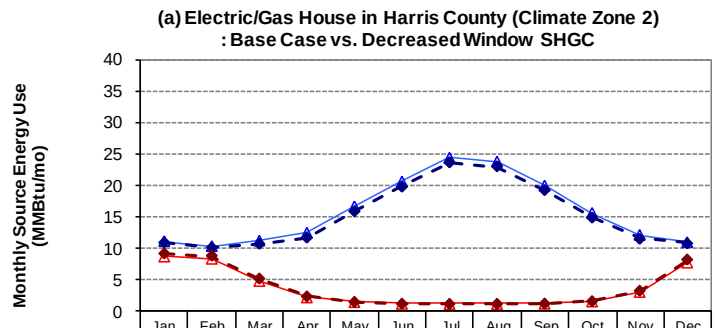
Electricity cost savings	= 615 kWh/year x $0.11/kWh = $68/year
Gas cost savings	= -28 therm/year x $0.64/therm = -$18/year
Total energy cost savings	= $50/year
Implementation cost	= $200 - $400
Simple Payback	= **4.0 to 8.0 years**

(d) All-electric house:

Electricity cost savings	= 469 kWh/year x $0.11/kWh = $52/year
Implementation cost	= $200 - $400
Simple Payback	= **3.9 to 7.8 years**

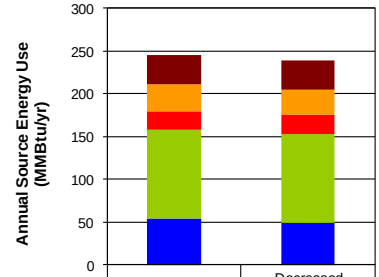


	Basecase	Decreased SHGC
Total	232.7	227.4
DHW	18.3	18.3
Fans+Pumps	31.9	29.7
Heating	24.9	26.8
Lgt+Appl	103.6	103.6
Cooling	54.0	49.0

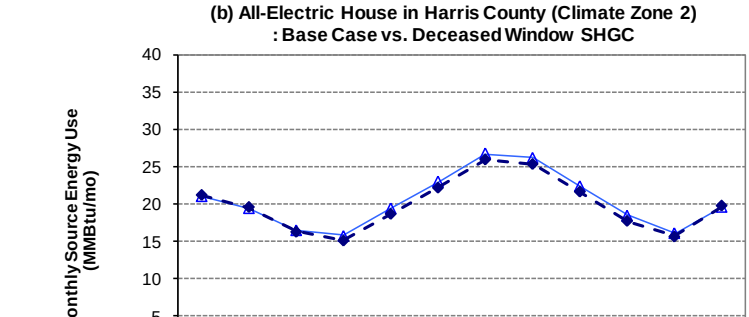


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.0	10.2	10.8	11.7	15.9	19.7	23.5	22.9	19.2	14.9	11.5	10.8
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	9.1	8.8	5.2	2.4	1.5	1.3	1.2	1.2	1.3	1.7	3.3	8.2

Figure 50. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 5 (Decreased SHGC) in Harris County (Climate Zone 2)

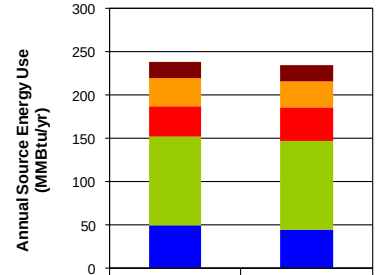


	Basecase	Decreased SHGC
Total	244.9	238.9
DHW	34.1	34.1
Fans+Pumps	31.6	29.4
Heating	21.5	22.8
Lgt+Appl	103.6	103.6
Cooling	54.0	49.0

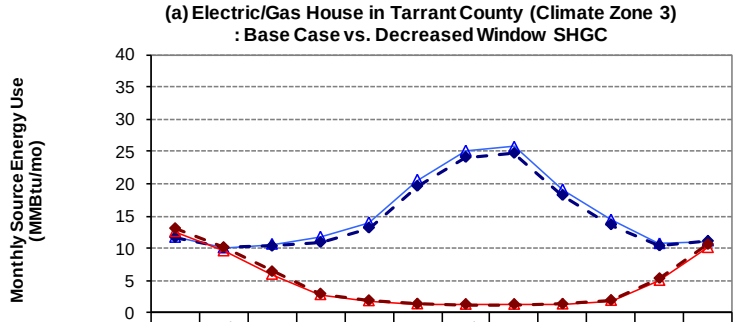


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	21.2	19.6	16.3	15.1	18.6	22.1	25.9	25.3	21.6	17.7	15.6	19.8

Figure 51. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 5 (Decreased SHGC) in Harris County (Climate Zone 2)

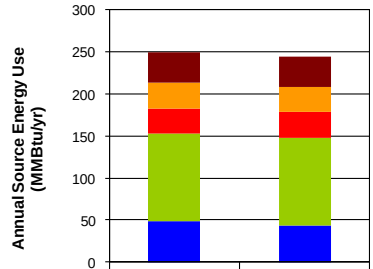


	Basecase	Decreased SHGC
Total	238.9	235.3
DHW	19.1	19.1
Fans+Pumps	32.2	30.3
Heating	35.2	38.3
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9

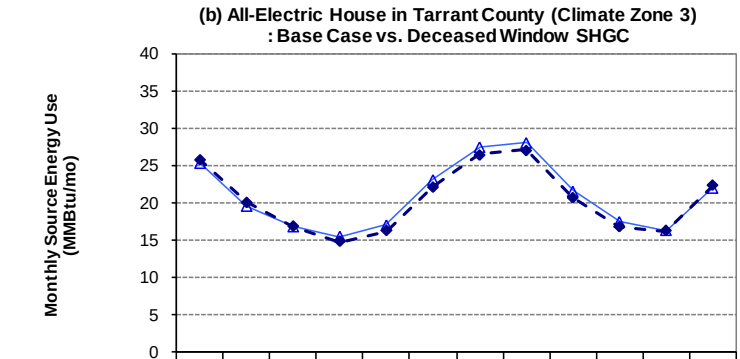


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.7	10.0	10.3	10.9	13.1	19.6	24.1	24.7	18.2	13.6	10.3	11.1
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	13.2	10.2	6.4	2.9	1.8	1.3	1.2	1.2	1.3	1.9	5.3	10.7

Figure 52. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 5 (Decreased SHGC) in Tarrant County (Climate Zone 3)



	Basecase	Decreased SHGC
Total	250.0	244.9
DHW	36.3	36.3
Fans+Pumps	31.6	29.4
Heating	29.7	31.6
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	25.8	20.0	16.8	14.7	16.2	22.1	26.4	27.0	20.6	16.7	16.2	22.3

Figure 53. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 5 (Decreased SHGC) in Tarrant County (Climate Zone 3)

5.1.6 Decreased Window U-Value

Base Case: The base-case U-Factor is taken as 0.65 Btu/h-sq. ft.-F for Harris County, 0.50 Btu/h-sq. ft.-F for Tarrant County, and 0.35 Btu/h-sq. ft.-F for Potter County.

EEM 6: For the test case, a U-Factor is taken as 0.30 Btu/h-sq. ft.-F.

Energy Savings: Figure 54 to Figure 59 compare the energy use of a house with base-case characteristics and with the EEM 6 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that improving the U-value of the fenestration system would increase the cost by $600 - $900 for Harris and Tarrant County and by $350 - $900 for Potter County.

Table 17. Cost Information for Decreased Window U-Value

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	CZ2: 0.65 U-Value	No. of (36"x60") windows: 23	-		Table Windows-1 -No1, 2
	CZ3: 0.5 U-Value		CZ3:$112/Unit		Table Windows-1 -No 12,13; Table Windows-3-No 2
	CZ4: 0.35 U-Value		CZ4(0.35 SHGC):$105~$130/Unit CZ4(0.3 SHGC):$110~$137/Unit		Table Windows-1 -No 31 Table Windows-2 -No 2; Table Windows-3 -No 3
EEM 6	0.3 U-Value		CZ2: $137~$153/Unit	$600-$900	Table Windows-1 -No 5,18,19,20,21,22,23; Table Windows-3-No 3
			CZ3: $137~$153/Unit		
			CZ4(0.35 SHGC):$146/Unit CZ4(0.3 SHGC):$153/Unit	$350-$900	Table Windows-1 -No 32,33,34,35 Table Windows-1 -No 5

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 732 kWh/year x $0.11/kWh = $81/year
Gas cost savings	= 48 therm/year x $0.84/therm = $40/year
Total energy cost savings	= $121/year
Implementation cost	= $600 - $900
Simple Payback	= **5.0 to 7.4 years**

(b) All-electric house:

Electricity cost savings	= 1026 kWh/year x $0.11/kWh = $113/year
Implementation cost	= $600 - $900
Simple Payback	= **5.3 to 8.0 years**

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 733 kWh/year x $0.11/kWh = $81/year
Gas cost savings	= 20 therm/year x $0.64/therm = $13/year
Total energy cost savings	= $93/year
Implementation cost	= $600 - $900
Simple Payback	= **6.4 to 9.6 years**

(d) All-electric house:

Electricity cost savings	= 879 kWh/year x $0.11/kWh = $97/year
Implementation cost	= $600 - $900
Simple Payback	= **6.2 to 9.3 years**

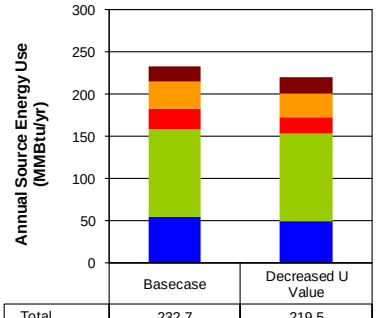
Potter County

(e) Electric/gas house:

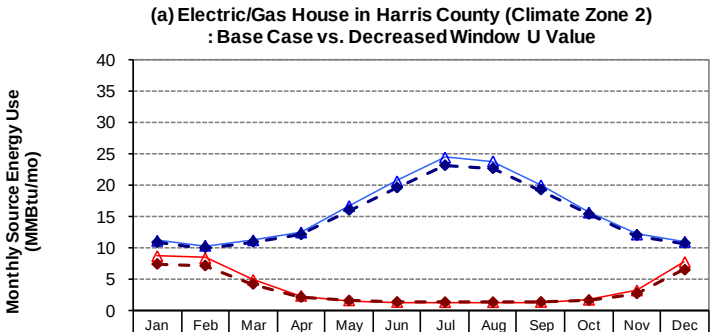
Electricity cost savings	= 29 kWh/year x $0.11/kWh = $3/year
Gas cost savings	= 30 therm/year x $0.64/therm = $19/year
Total energy cost savings	= $22/year
Implementation cost	= $350 - $900
Simple Payback	= **15.6 to 40.1 years**

(f) All-electric house:

Electricity cost savings	= 293 kWh/year x $0.11/kWh = $32/year
Implementation cost	= $350 - $900
Simple Payback	= **10.9 to 28.0 years**

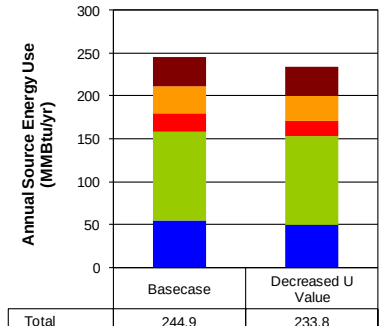


	Basecase	Decreased U Value
Total	232.7	219.5
DHW	18.3	18.3
Fans+Pumps	31.9	28.4
Heating	24.9	19.6
Lgt+Appl	103.6	103.6
Cooling	54.0	49.6

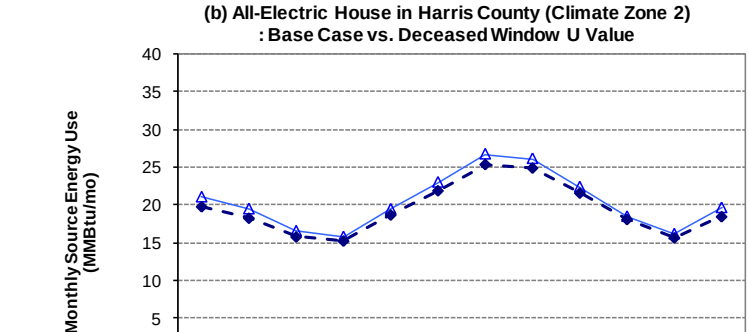


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	10.7	9.9	10.8	12.0	15.9	19.5	23.1	22.6	19.2	15.3	11.9	10.6
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	7.4	7.1	4.2	2.1	1.5	1.3	1.2	1.2	1.3	1.6	2.6	6.5

Figure 54. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 6 (Decreased U-Value) in Harris County (Climate Zone 2)

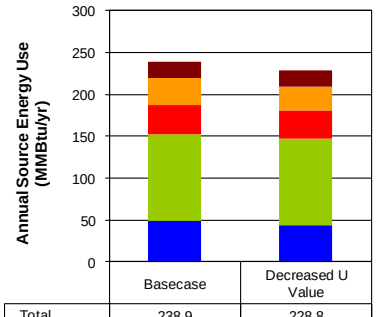


	Basecase	Decreased U Value
Total	244.9	233.8
DHW	34.1	34.1
Fans+Pumps	31.6	28.4
Heating	21.5	18.0
Lgt+Appl	103.6	103.6
Cooling	54.0	49.6

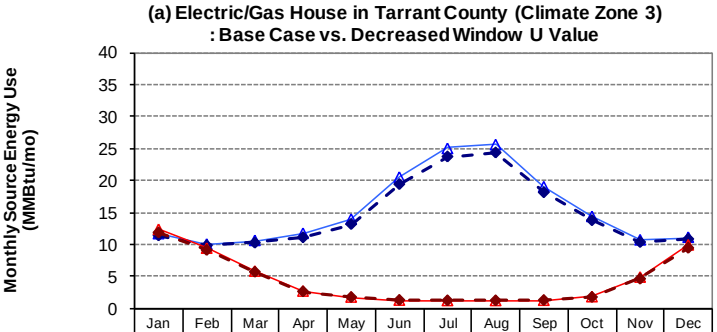


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	19.8	18.2	15.8	15.2	18.7	21.9	25.4	24.9	21.6	18.1	15.6	18.4

Figure 55. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 6 (Decreased U-Value) in Harris County (Climate Zone 2)

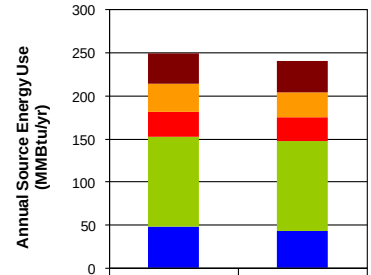


	Basecase	Decreased U Value
Total	238.9	228.8
DHW	19.1	19.1
Fans+Pumps	32.2	29.1
Heating	35.2	33.0
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9

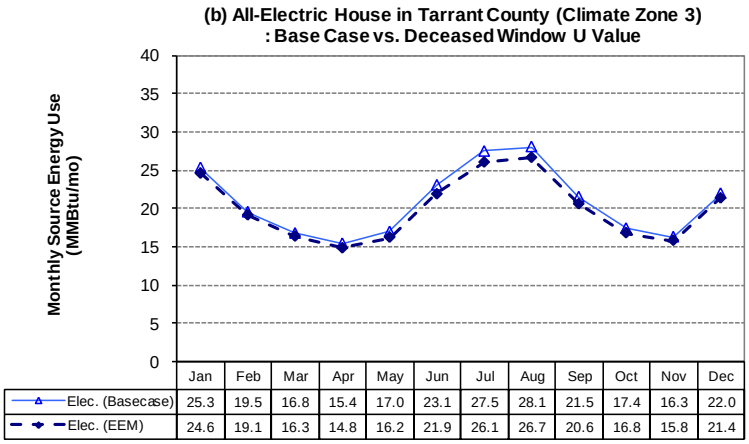


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.4	9.8	10.3	11.1	13.2	19.4	23.7	24.4	18.2	13.8	10.4	10.9
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	11.9	9.1	5.7	2.7	1.8	1.3	1.2	1.2	1.3	1.8	4.6	9.5

Figure 56. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 6 (Decreased U-Value) in Tarrant County (Climate Zone 3)

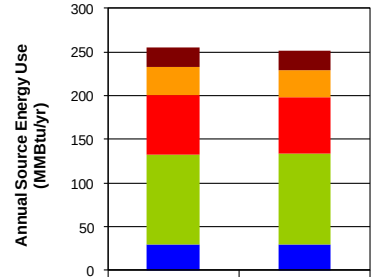


	Basecase	Decreased U Value
Total	250.0	240.5
DHW	36.3	36.3
Fans+Pumps	31.6	28.4
Heating	29.7	28.1
Lgt+Appl	103.6	103.6
Cooling	48.7	43.9

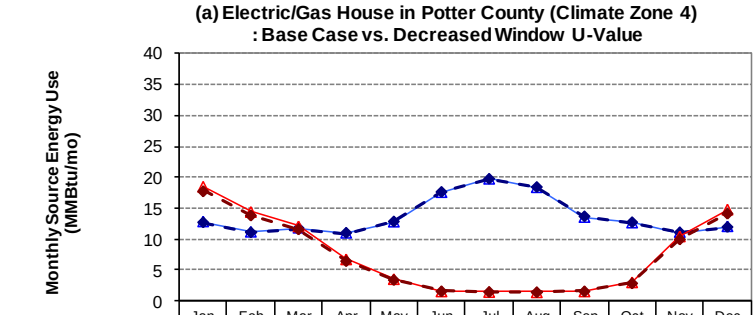


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	24.6	19.1	16.3	14.8	16.2	21.9	26.1	26.7	20.6	16.8	15.8	21.4

Figure 57. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 6 (Decreased U-Value) in Tarrant County (Climate Zone 3)

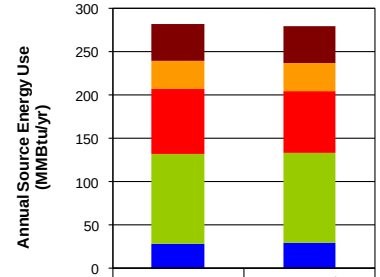


	Basecase	Decreased U Value
Total	255.0	251.4
DHW	22.0	22.0
Fans+Pumps	32.2	31.6
Heating	68.1	64.8
Lgt+Appl	103.6	103.6
Cooling	29.1	29.4

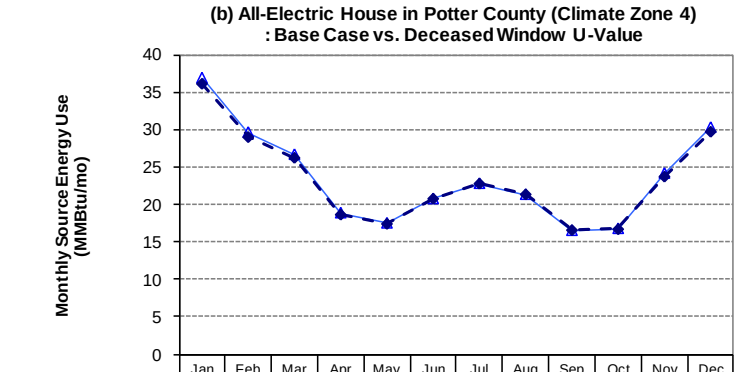


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.6	11.0	11.7	10.9	12.8	17.7	19.8	18.5	13.6	12.7	11.0	11.9
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	17.8	13.9	11.7	6.5	3.5	1.6	1.5	1.5	1.6	2.9	10.0	14.2

Figure 58. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 6 (Decreased U-Value) in Potter County (Climate Zone 4)



	Basecase	Decreased U Value
Total	282.5	279.3
DHW	42.7	42.7
Fans+Pumps	33.2	32.5
Heating	73.9	71.1
Lgt+Appl	103.6	103.6
Cooling	29.1	29.4



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	36.0	29.0	26.2	18.7	17.4	20.8	22.8	21.3	16.6	16.7	23.7	29.7

Figure 59. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 6 (Decreased U-Value) in Potter County (Climate Zone 4)

5.1.7 Decreased Window SHGC and U-Value

Base Case: The base-case U-Factor is taken as 0.65 Btu/h-sq. ft.-F for Harris County and 0.50 Btu/h-sq. ft.-F for Tarrant County and SHGC as 0.30 for both Harris and Tarrant County.

EEM 7: For the test case, a U-Factor of 0.30 Btu/h-sq. ft.-F and a SHGC of 0.2 are taken. For Potter County, this measure was not considered, due to negative savings because of the increased heating energy penalty.

Energy Savings: Figure 60 to Figure 63 compare the energy use of a house with base-case characteristics and with the EEM 7 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-2 and is summarized in the following table. It shows that improving the SHGC and U-value of the fenestration system would increase the cost by $900 - $1,100.

Table 18. Cost Information for Decreased Window SHGC and U-Value

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	CZ2: 0.3 SHGC and 0.65 U-Value	No. of (36"x60") windows: 23	-	$900-$1,100	Table Windows-1 -No1, 2
	CZ3:0.3 SHGC and 0.5 U-Value		CZ3: $112/Unit		Table Windows-1 -No 12,13; Table Windows-3-No 2
EEM7	CZ2 and CZ3: 0.2 SHGC and 0.3 U-Value		CZ2 and CZ3: $162/Unit		Table Windows-1 -No 7,8,9,10,11
					Table Windows-1 -No 24,25,26,27,28

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 1,407 kWh/year x $0.11/kWh = $155/year
Gas cost savings	= 30 therm/year x $0.84/therm = $25/year
Total energy cost savings	= $180/year
Implementation cost	= $900 - $1,100
Simple Payback	= **5.0 to 6.1 years**

(b) All-electric house:

Electricity cost savings	= 1,612 kWh/year x $0.11/kWh = $177/year
Implementation cost	= 900 - $1,100
Simple Payback	= **5.1 to 6.2 years**

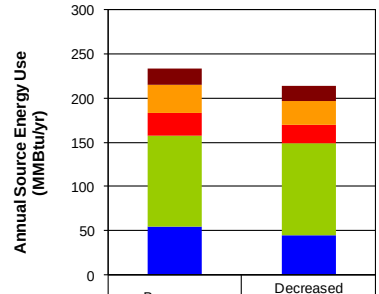
Tarrant County

(c) Electric/gas house:

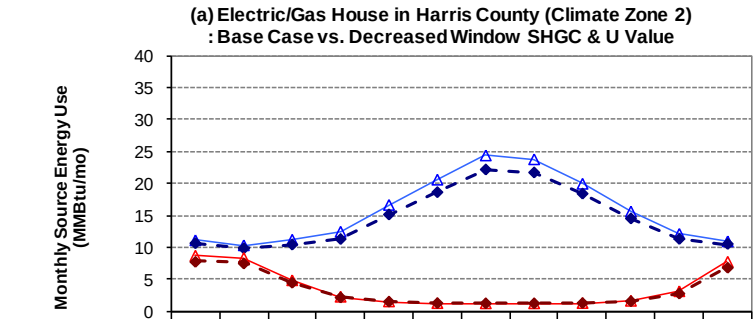
Electricity cost savings	= 1,348 kWh/year x $0.11/kWh = $148/year
Gas cost savings	= -10 therm/year x $0.64/therm = -$6/year
Total energy cost savings	= $142/year
Implementation cost	= 900 - $1,100
Simple Payback	= **6.3 to 7.8 years**

(d) All-electric house:

Electricity cost savings	= 1,290 kWh/year x $0.11/kWh = $142/year
Implementation cost	= 900 - $1,100
Simple Payback	= **6.3 to 7.8 years**

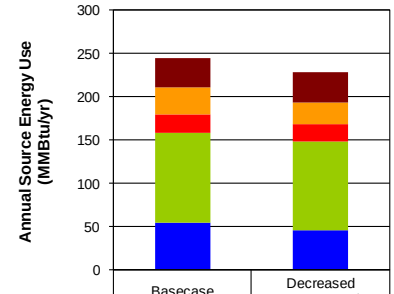


	Basecase	Decreased SHGC & U Value
Total	232.7	214.3
DHW	18.3	18.3
Fans+Pumps	31.9	26.2
Heating	24.9	21.6
Lgt+Appl	103.6	103.6
Cooling	54.0	44.6

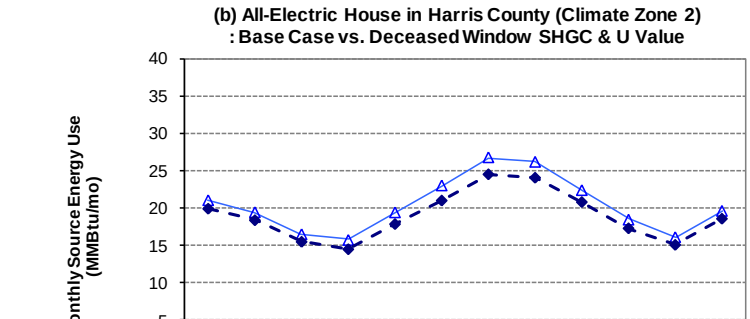


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	10.6	9.8	10.4	11.2	15.1	18.6	22.2	21.7	18.4	14.5	11.3	10.5
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	7.8	7.6	4.5	2.2	1.5	1.3	1.2	1.2	1.3	1.6	2.8	6.9

Figure 60. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 7 (Decreased SHGC and U-Value) in Harris County (Climate Zone 2)

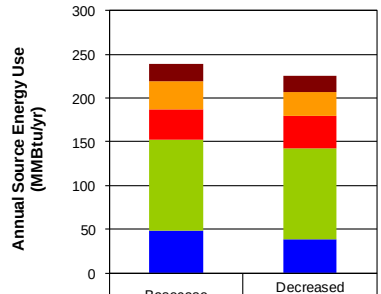


	Basecase	Decreased SHGC & U Value
Total	244.9	227.5
DHW	34.1	34.1
Fans+Pumps	31.6	25.9
Heating	21.5	19.3
Lgt+Appl	103.6	103.6
Cooling	54.0	44.6

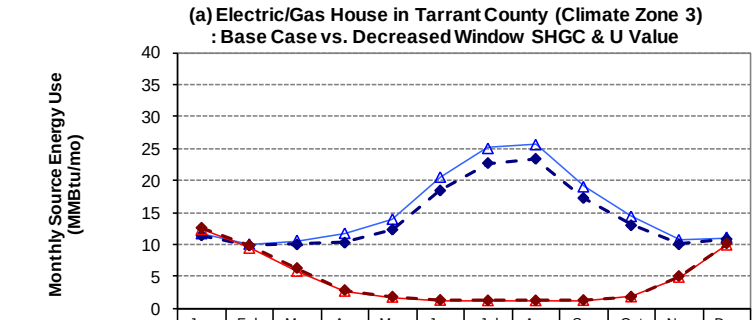


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	19.9	18.4	15.5	14.5	17.9	21.0	24.5	24.0	20.8	17.3	15.1	18.6

Figure 61. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 7 (Decreased SHGC and U-Value) in Harris County (Climate Zone 2)

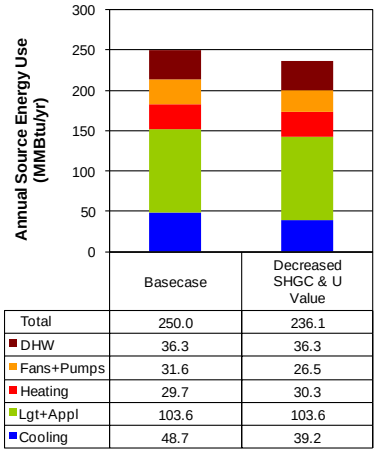


	Basecase	Decreased SHGC & U Value
Total	238.9	225.4
DHW	19.1	19.1
Fans+Pumps	32.2	27.2
Heating	35.2	36.3
Lgt+Appl	103.6	103.6
Cooling	48.7	39.2

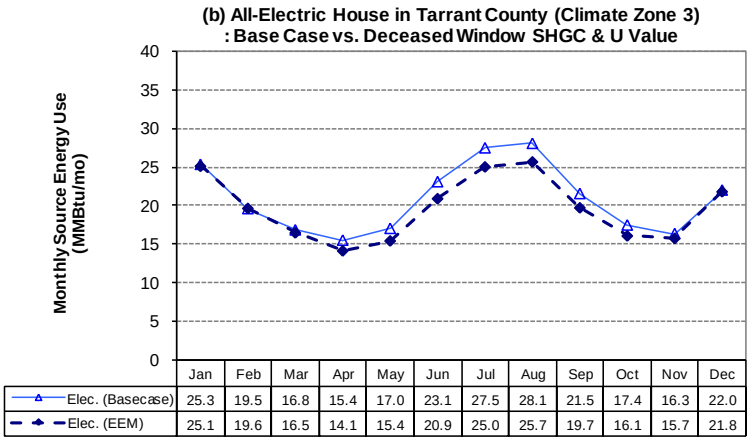


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.5	9.9	10.1	10.3	12.4	18.4	22.7	23.3	17.3	13.0	10.1	10.9
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.6	9.8	6.3	2.8	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.1

Figure 62. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 7 (Decreased SHGC and U-Value) in Tarrant County (Climate Zone 3)



	Basecase	Decreased SHGC & U Value
Total	250.0	236.1
DHW	36.3	36.3
Fans+Pumps	31.6	26.5
Heating	29.7	30.3
Lgt+Appl	103.6	103.6
Cooling	48.7	39.2



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	25.1	19.6	16.5	14.1	15.4	20.9	25.0	25.7	19.7	16.1	15.7	21.8

Figure 63. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 7 (Decreased SHGC and U-Value) in Tarrant County (Climate Zone 3)

5.2 HVAC System Measures

5.2.1 Mechanical Systems within Conditioned Space

Base Case: The base-case air distribution system which includes the HVAC unit and the ducts, is located in the unconditioned, vented attic. The attic was assumed to have a total of 7.75 ft^2 of leakage area (1 ft^2 per 300 ft^2 ceiling area[17]). The insulation for supply and return ducts are R-8 and R-6, respectively[18]. A total of 11.2% duct leakage was assumed for the base-case house[19].

EEM 8: This measure analyzed the energy savings that would occur if the HVAC system, including the supply and return ductwork, was moved from the attic location, assumed in the base-case house, to a location within the thermal envelope of the conditioned space.

Energy Savings: Figure 64 to Figure 69 compare the energy use of a house with base-case characteristics and with the EEM 8 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-3 and is summarized in the following table. It shows that relocating mechanical systems within conditioned space would increase the cost by $1,000 - $7,000.

Table 19. Cost Information for Mechanical Systems within Conditioned Space

HVAC System Measures		Capacity	Increased Cost/ Equipment Cost ($)	Labor Cost ($)	Total Increased Cost ($)	Reference Table (Table A-3)
Base Case	Duct in Unconditioned Space	2,325 conditioned floor area		n/a		Table Duct-1 - No. 1,2,3
EEM 8	Duct in Conditioned Space		$0.20/ft.		$1,000-$7,000	

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings = 1,319 kWh/year x $0.11/kWh = $145/year
Gas cost savings = 41 therm/year x $0.84/therm = $34/year
Total energy cost savings = $180/year
Implementation cost = $1,000 - $7,000
Simple Payback = **5.6 to 39.0 years**

(b) All-electric house:

Electricity cost savings = 1,495 kWh/year x $0.11/kWh = $164/year
Implementation cost = $1,000 - $7,000
Simple Payback = **6.1 to 42.6 years**

[17] The infiltration rate for an attic is based on Table 405.5.2(1) of the 2009 IECC.
[18] The insulation requirements are based on Section 403.2.1 of the 2009 IECC.
[19] The leakage rate requirements are based on Section 403.2.2 of the 2009 IECC.

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 1,231 kWh/year x $0.11/kWh = $135/year
Gas cost savings	= 57 therm/year x $0.64/therm = $36/year
Total energy cost savings	= $172/year
Implementation cost	= $1,000 - $7,000
Simple Payback	= **5.8 to 40.7 years**

(d) All-electric house:

Electricity cost savings	= 1,465 kWh/year x $0.11/kWh = $161/year
Implementation cost	= $1,000 - $7,000
Simple Payback	= **6.2 to 43.4 years**

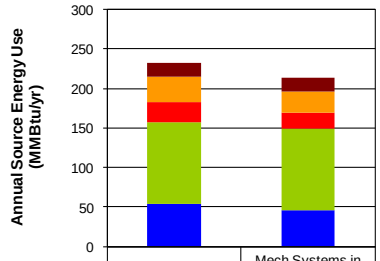
Potter County

(e) Electric/gas house:

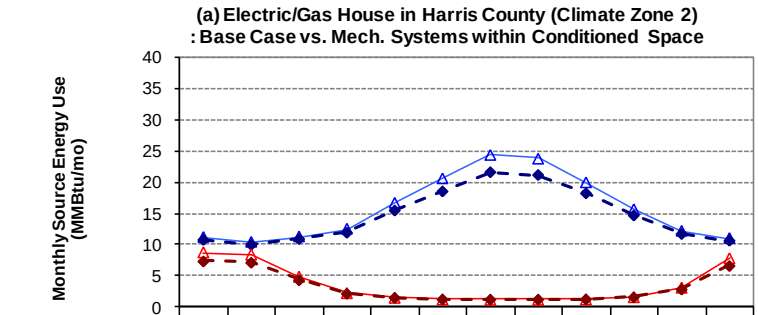
Electricity cost savings	= 909 kWh/year x $0.11/kWh = $100/year
Gas cost savings	= 130 therm/year x $0.64/therm = $83/year
Total energy cost savings	= $183/year
Implementation cost	= $1,000 - $7,000
Simple Payback	= **5.5 to 38.2 years**

(f) All-electric house:

Electricity cost savings	= 1,758 kWh/year x $0.11/kWh = $193/year
Implementation cost	= $1,000 - $7,000
Simple Payback	= **5.2 to 36.2 years**

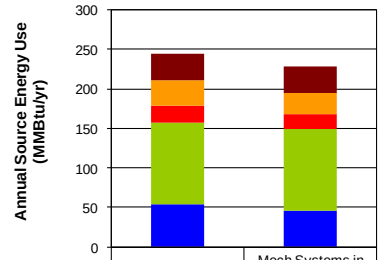


	Basecase	Mech Systems in Conditioned Spaces
Total	232.7	214.0
DHW	18.3	18.3
Fans+Pumps	31.9	26.2
Heating	24.9	20.4
Lgt+Appl	103.6	103.6
Cooling	54.0	45.5

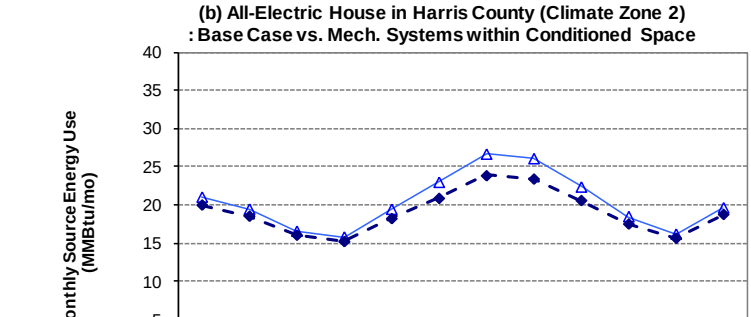


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	10.7	9.9	10.9	11.9	15.4	18.5	21.6	21.1	18.2	14.6	11.7	10.6
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	7.3	7.2	4.3	2.2	1.5	1.3	1.2	1.2	1.3	1.6	2.9	6.6

Figure 64. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Harris County (Climate Zone 2)

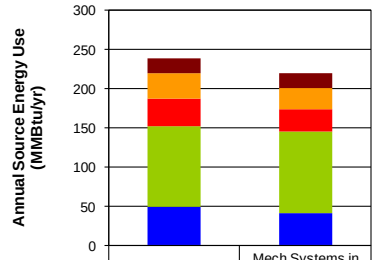


	Basecase	Mech Systems in Conditioned Spaces
Total	244.9	228.8
DHW	34.1	34.1
Fans+Pumps	31.6	27.2
Heating	21.5	18.3
Lgt+Appl	103.6	103.6
Cooling	54.0	45.5

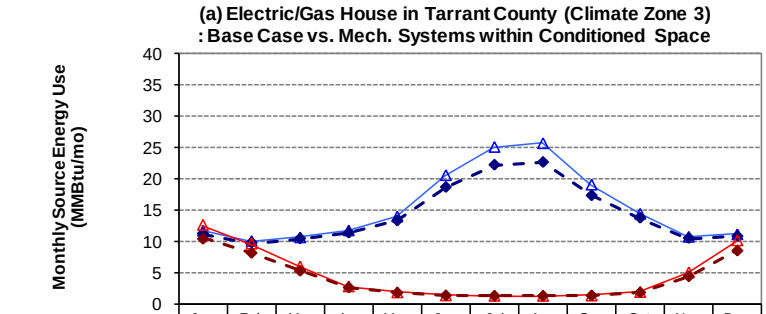


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	20.0	18.5	16.0	15.1	18.2	20.9	23.9	23.4	20.6	17.5	15.6	18.7

Figure 65. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Harris County (Climate Zone 2)

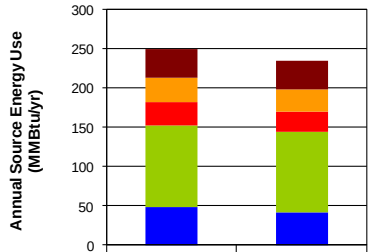


	Basecase	Mech Systems in Conditioned Spaces
Total	238.9	219.3
DHW	19.1	19.1
Fans+Pumps	32.2	26.5
Heating	35.2	28.9
Lgt+Appl	103.6	103.6
Cooling	48.7	41.1

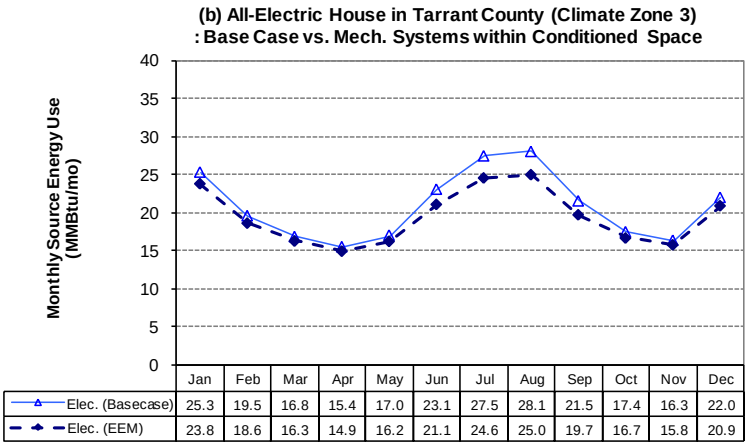


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.1	9.7	10.3	11.3	13.2	18.6	22.2	22.6	17.3	13.7	10.4	10.7
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	10.5	8.2	5.3	2.6	1.7	1.3	1.2	1.2	1.3	1.8	4.4	8.5

Figure 66. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Tarrant County (Climate Zone 3)

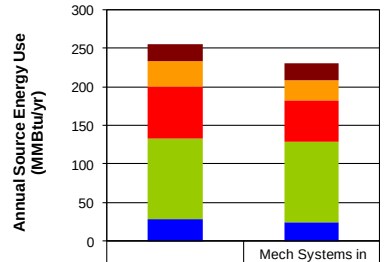


	Basecase	Mech Systems in Conditioned Spaces
Total	250.0	234.2
DHW	36.3	36.3
Fans+Pumps	31.6	27.8
Heating	29.7	25.3
Lgt+Appl	103.6	103.6
Cooling	48.7	41.1

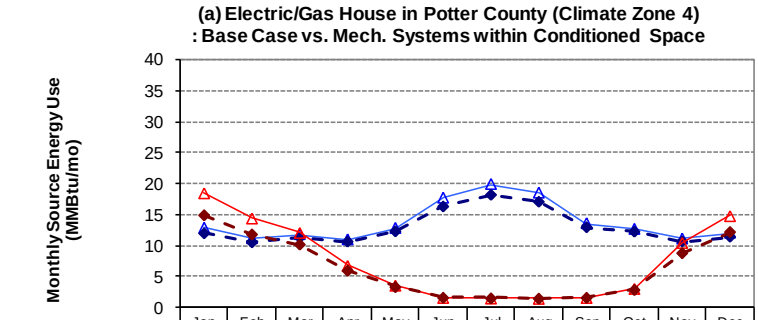


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	23.8	18.6	16.3	14.9	16.2	21.1	24.6	25.0	19.7	16.7	15.8	20.9

Figure 67. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Tarrant County (Climate Zone 3)

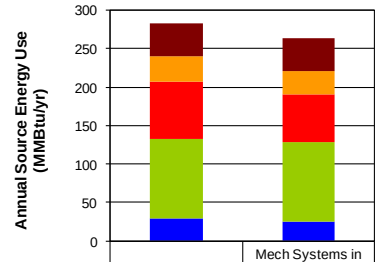


	Basecase	Mech Systems in Conditioned Spaces
Total	255.0	230.9
DHW	22.0	22.0
Fans+Pumps	32.2	26.5
Heating	68.1	53.8
Lgt+Appl	103.6	103.6
Cooling	29.1	25.0

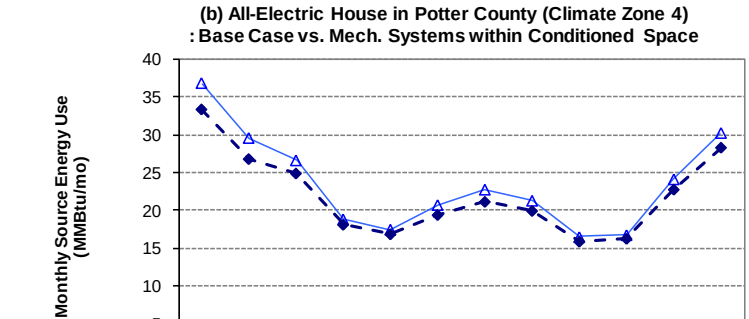


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	11.9	10.5	11.3	10.6	12.2	16.3	18.2	17.0	12.9	12.2	10.6	11.4
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	14.8	11.7	10.1	5.9	3.3	1.6	1.5	1.5	1.6	2.9	8.7	12.1

Figure 68. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Potter County (Climate Zone 4)



	Basecase	Mech Systems in Conditioned Spaces
Total	282.5	263.5
DHW	42.7	42.7
Fans+Pumps	33.2	31.0
Heating	73.9	61.3
Lgt+Appl	103.6	103.6
Cooling	29.1	25.0



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	33.3	26.8	24.9	18.1	16.9	19.4	21.1	19.9	15.9	16.3	22.7	28.3

Figure 69. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 8 (Mech. Systems in Conditioned Space) in Potter County (Climate Zone 4)

5.2.2 Improved Air Conditioner SEER

Base Case: For an electric/gas base case house, the HVAC system is comprised of a Seasonal Energy Efficiency Ratio (SEER) 13 air-conditioner and a gas-fired furnace with an Annual Fuel Utilization Efficiency (AFUE) of 0.78. For an all-electric house, the HVAC system is comprised of a heat pump with a Heating Seasonal Performance Factor (HSPF) of 7.7 and SEER 13. The capacity of the cooling system is 55,800 Btu/hr, which assumes 500 sq. ft. per ton. The capacity of the heating system is 55,800 Btu/hr, which assumes 1.0 times of the cooling capacity. The heating and cooling set-points were 72°F for winter and 75°F for summer, with no setback/setup.

EEM 9: For the test case, the SEER 13 air conditioner in an electric/gas base-case house was replaced with a similarly sized SEER 15 air conditioner. For an all-electric house, the SEER 13/HSPF 7.7 heat pump was replaced with a similarly sized SEER 15/HSPF 8.5 heat pump.

Energy Savings: Figure 70 to Figure 75 compare the energy use of a house with base-case characteristics and with the EEM 9 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-3 and is summarized in the following table. It shows that replacing a SEER 13 air conditioner with a SEER 15 air conditioner would increase the cost by $900 - $2,500 in an electric/gas house, and replacing a SEER 13/HSPF 7.7 heat pump with a SEER 15/HSPF 8.5 heat pump would increase the cost by $1,200 - $2,500 in all-electric house.

Table 20. Cost Information for Improved Air Conditioner SEER

HVAC System Measures		Capacity	Increased Cost/ Equipment Cost ($)	Labor Cost ($)	Total Increased Cost ($)	Reference Table (Table A-3)
ELECTRIC/GAS HOUSE						
Base Case	SEER 13 Air Conditioning System	5 ton	$3,300-$4,550 (Avg. $3,925)	n/a		Table Air Conditioning with Gas Heat - No. 1,2,5,9
EEM 9	SEER 15 Air Conditioning System		$4,800-$6,560		$900-$2,500	Table Air Conditioning with Gas Heat - No. 3,4,6,10
ALL-ELECTRIC HOUSE						
Base Case	7.7 HSPF/SEER 13 Heat Pump	5 ton	$1,500-$3,500	n/a		Table Heat Pump- No. 3,5,10,12,14,16,23
EEM9	8.5 HSPF/SEER 15 Heat Pump		$3,500-$6,000		$1,200-$2,500	Table Heat Pump- No. 1,11,13,20,21

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings = 1,495 kWh/year x $0.11/kWh = $164/year
Gas cost savings = -5 therm/year x $0.84/therm = -$4/year
Total energy cost savings = $160/year
Implementation cost = $900 - $2,500
Simple Payback = **5.6 to 15.8 years**

(b) All-electric house:

Electricity cost savings = 1,612 kWh/year x $0.11/kWh = $177/year
Implementation cost = $1,200 - $2,500
Simple Payback = **6.8 to 14.1 years**

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 14,071 kWh/year x $0.11/kWh = $155/year
Gas cost savings	= -7 therm/year x $0.64/therm = -$4/year
Total energy cost savings	= $150/year
Implementation cost	= $900 - $2,500
Simple Payback	= **6.0 to 16.6 years**

(d) All-electric house:

Electricity cost savings	= 1,553 kWh/year x $0.11/kWh = $171/year
Implementation cost	= $1,200 - $2,500
Simple Payback	= **7.0 to 14.6 years**

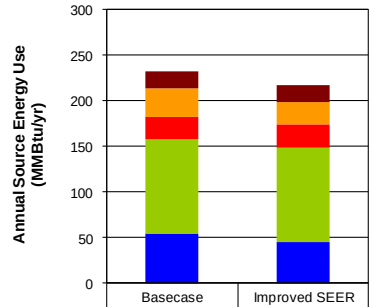
Potter County

(e) Electric/gas house:

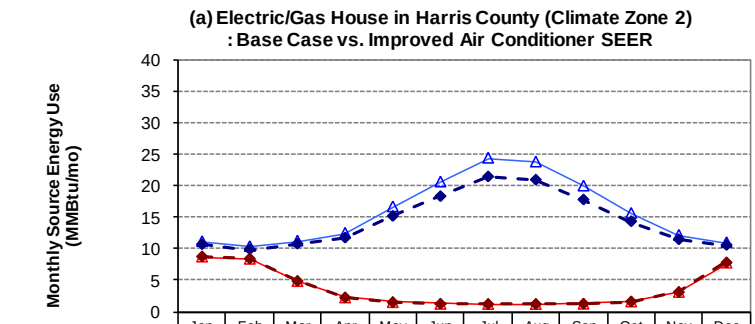
Electricity cost savings	= 1,114 kWh/year x $0.11/kWh = $123/year
Gas cost savings	= -14 therm/year x $0.64/therm = -$9/year
Total energy cost savings	= $114/year
Implementation cost	= $900 - $2,500
Simple Payback	= **7.9 to 22.0 years**

(f) All-electric house:

Electricity cost savings	= 1,465 kWh/year x $0.11/kWh = $161/year
Implementation cost	= $1,200 - $2,500
Simple Payback	= **7.4 to 15.5 years**

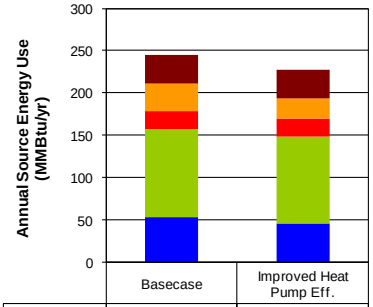


	Basecase	Improved SEER
Total	232.7	217.2
DHW	18.3	18.3
Fans+Pumps	31.9	24.3
Heating	24.9	25.4
Lgt+Appl	103.6	103.6
Cooling	54.0	45.5

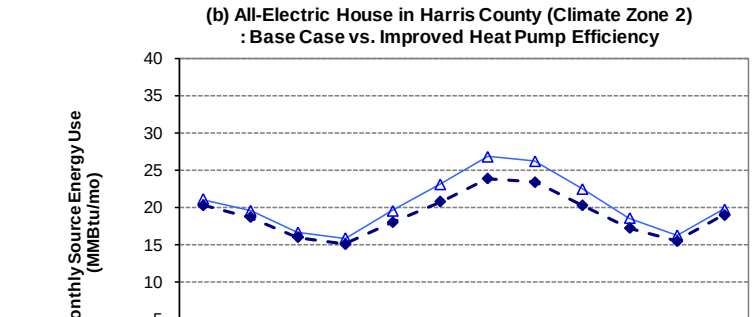


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	10.6	9.8	10.7	11.7	15.2	18.4	21.5	21.0	17.8	14.3	11.4	10.5
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.8	8.5	4.9	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.9

Figure 70. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 9 (Improved Air Conditioner SEER) in Harris County (Climate Zone 2)

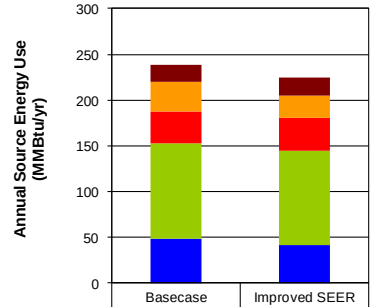


	Basecase	Improved Heat Pump Eff.
Total	244.9	227.5
DHW	34.1	34.1
Fans+Pumps	31.6	24.0
Heating	21.5	20.2
Lgt+Appl	103.6	103.6
Cooling	54.0	45.5

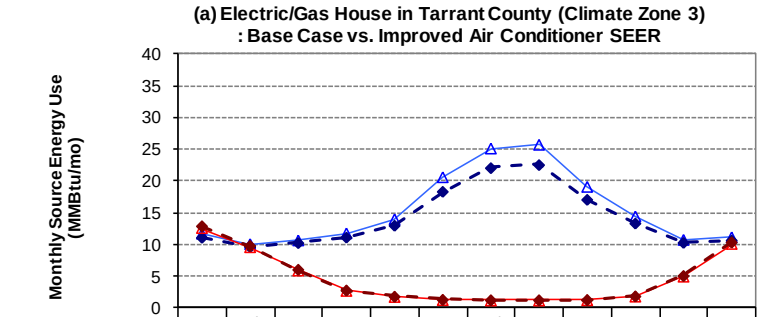


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM)	20.2	18.6	15.9	15.0	18.0	20.7	23.8	23.3	20.2	17.2	15.4	18.9

Figure 71. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 9 (Improved Heat Pump Efficiency) in Harris County (Climate Zone 2)

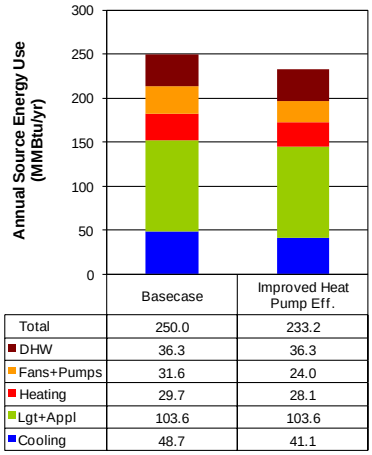


	Basecase	Improved SEER
Total	238.9	224.5
DHW	19.1	19.1
Fans+Pumps	32.2	24.6
Heating	35.2	36.0
Lgt+Appl	103.6	103.6
Cooling	48.7	41.1

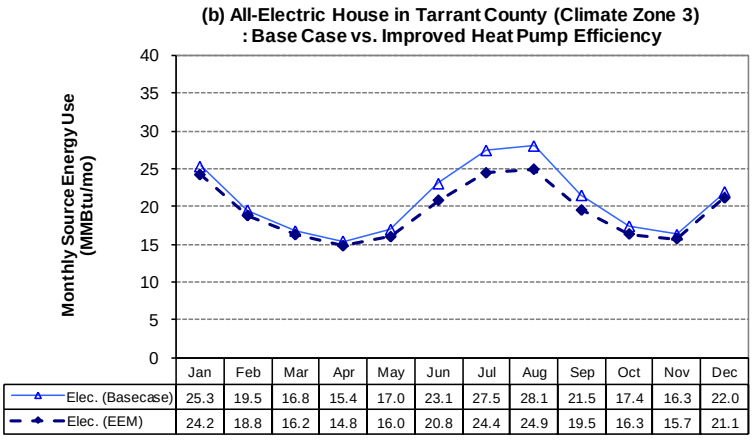


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.1	9.6	10.2	11.1	13.0	18.3	22.1	22.6	17.1	13.3	10.2	10.6
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.7	9.7	6.0	2.8	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.2

Figure 72. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 9 (Improved Air Conditioner SEER) in Tarrant County (Climate Zone 3)

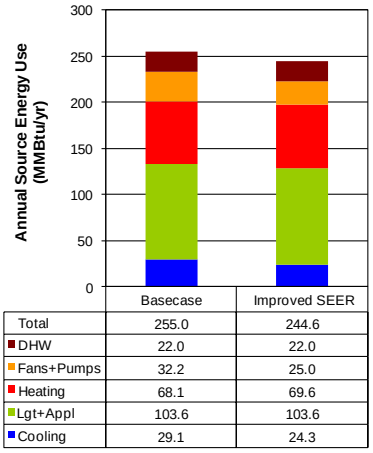


	Basecase	Improved Heat Pump Eff.
Total	250.0	233.2
DHW	36.3	36.3
Fans+Pumps	31.6	24.0
Heating	29.7	28.1
Lgt+Appl	103.6	103.6
Cooling	48.7	41.1

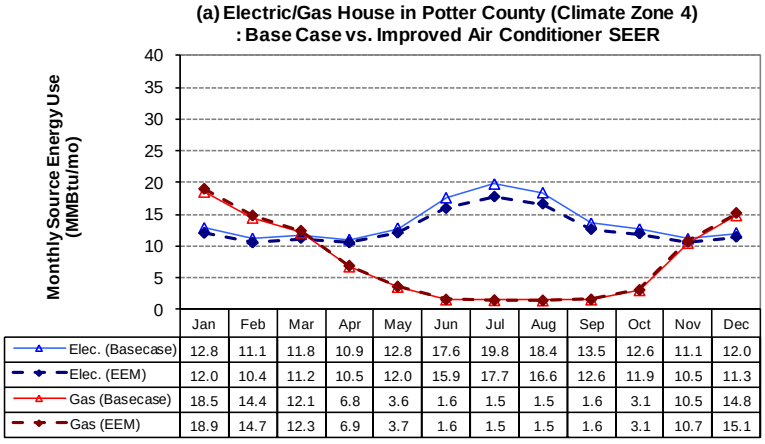


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	24.2	18.8	16.2	14.8	16.0	20.8	24.4	24.9	19.5	16.3	15.7	21.1

Figure 73. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 9 (Improved Heat Pump Efficiency) in Tarrant County (Climate Zone 3)

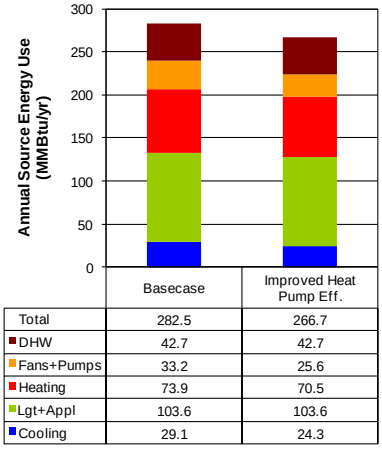


	Basecase	Improved SEER
Total	255.0	244.6
DHW	22.0	22.0
Fans+Pumps	32.2	25.0
Heating	68.1	69.6
Lgt+Appl	103.6	103.6
Cooling	29.1	24.3

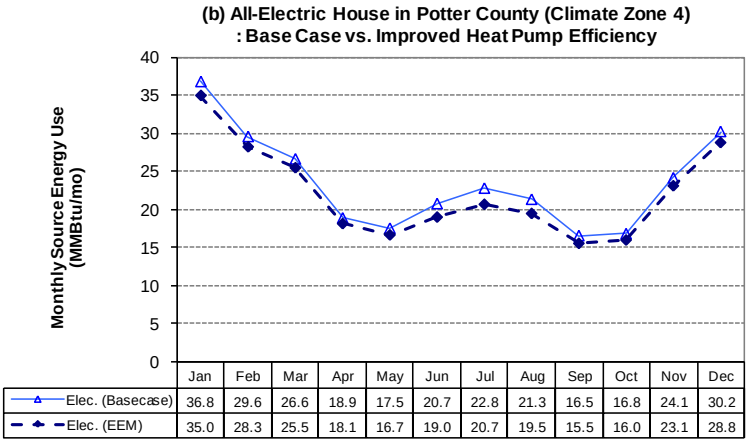


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.0	10.4	11.2	10.5	12.0	15.9	17.7	16.6	12.6	11.9	10.5	11.3
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.9	14.7	12.3	6.9	3.7	1.6	1.5	1.5	1.6	3.1	10.7	15.1

Figure 74. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 9 (Improved Air Conditioner SEER) in Potter County (Climate Zone 4)



	Basecase	Improved Heat Pump Eff.
Total	282.5	266.7
DHW	42.7	42.7
Fans+Pumps	33.2	25.6
Heating	73.9	70.5
Lgt+Appl	103.6	103.6
Cooling	29.1	24.3



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	35.0	28.3	25.5	18.1	16.7	19.0	20.7	19.5	15.5	16.0	23.1	28.8

Figure 75. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 9 (Improved Heat Pump Efficiency) in Potter County (Climate Zone 4)

5.2.3 Improved Furnace Efficiency

Base Case: This base case is same as the previous base case of EEM No.9.

EEM 10: For the test case, the gas-fired furnace in an electric/gas base-case house (0.78 AFUE) was replaced with a similarly sized condensing furnace with an AFUE of 0.93. This measure is applicable only for an electric/gas house that has a gas furnace.

Energy Savings: Figure 76 to Figure 78 compare the energy use of a house with base-case characteristics and with the EEM 10 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-3 and is summarized in the following table. It shows that replacing a 0.78 AFUE furnace with a 0.93 AFUE furnace in an electric/gas house would increase the cost by $800 - $1,300.

Table 21. Cost Information for Improved Furnace Efficiency

HVAC System Measures		Capacity	Increased Cost/ Equipment Cost ($)	Labor Cost ($)	Total Increased Cost ($)	Reference Table (Table A-3)
ELECTRIC/GAS HOUSE						
Base Case	0.78 AFUE Furnace (w/o pilot light)	55,800Btuh	$800-$2,700	n/a		Table Furnace - No. 3,8
EEM 10	0.93 AFUE Furnace (w/o pilot light)		$2,100-$3,500		$800-$1,300	Table Furnace- No. 2,9

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 0 kWh x $0.11/kWh = $0/year
Gas cost savings	= 36 therm x $0.84/therm = $30/year
Total energy cost savings	= $30/year
Implementation cost	= $800 - $1,300
Simple Payback	= **26.5 to 43.0 years**

Tarrant County

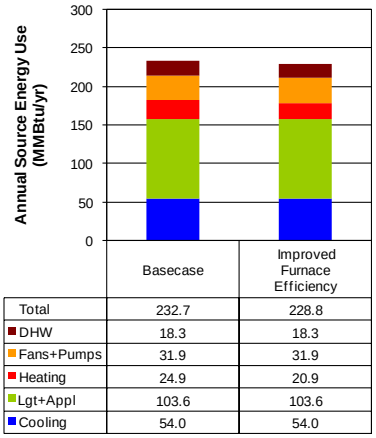
(b) Electric/gas house:

Electricity cost savings	= 0 kWh x $0.11/kWh = $0/year
Gas cost savings	= 51 therm x $0.64/therm = $33/year
Total energy cost savings	= $33/year
Implementation cost	= $800 - $1,300
Simple Payback	= **24.5 to 39.8 years**

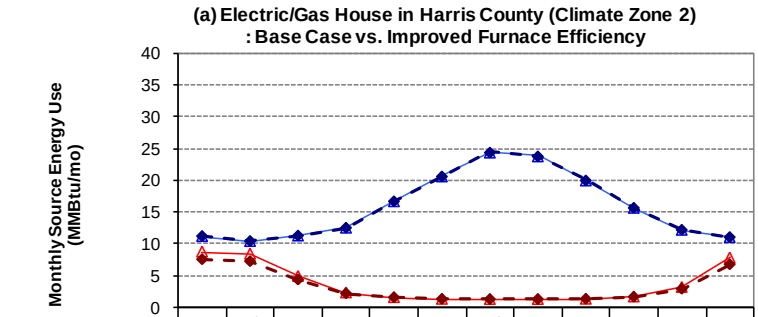
Potter County

(c) Electric/gas house:

Electricity cost savings	= 0 kWh x $0.11/kWh = $0/year
Gas cost savings	= 99 therm x $0.64/therm = $63/year
Total energy cost savings	= $63/year
Implementation cost	= $800 - $1,300
Simple Payback	= **12.6 to 20.5 years**

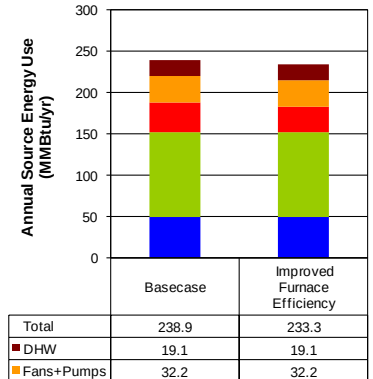


	Basecase	Improved Furnace Efficiency
Total	232.7	228.8
DHW	18.3	18.3
Fans+Pumps	31.9	31.9
Heating	24.9	20.9
Lgt+Appl	103.6	103.6
Cooling	54.0	54.0

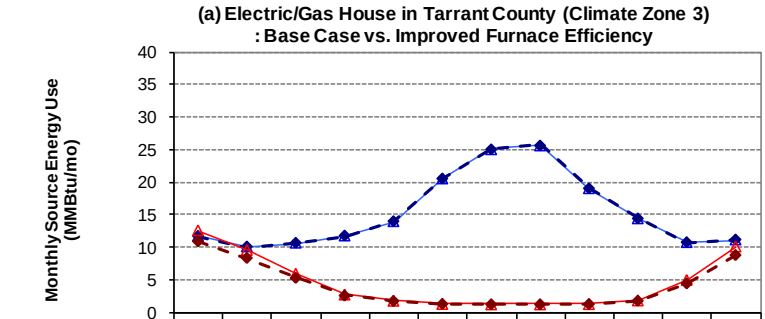


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	7.6	7.3	4.3	2.2	1.5	1.3	1.2	1.2	1.3	1.6	2.9	6.8

Figure 76. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 10 (Improved Furnace Efficiency) in Harris County (Climate Zone 2)

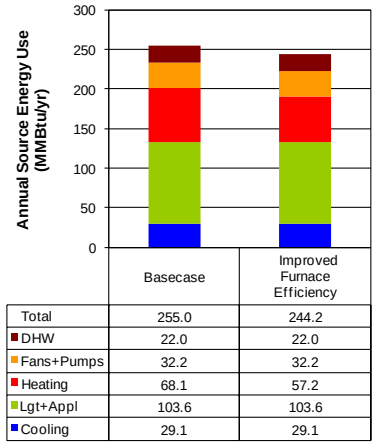


	Basecase	Improved Furnace Efficiency
Total	238.9	233.3
DHW	19.1	19.1
Fans+Pumps	32.2	32.2
Heating	35.2	29.6
Lgt+Appl	103.6	103.6
Cooling	48.7	48.7

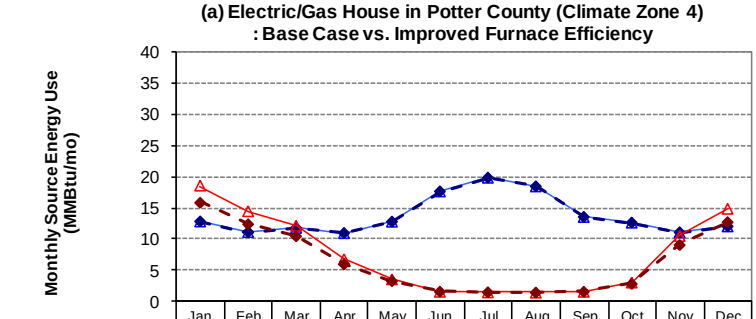


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	10.8	8.3	5.3	2.6	1.7	1.3	1.2	1.2	1.3	1.8	4.4	8.7

Figure 77. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 10 (Improved Furnace Efficiency) in Tarrant County (Climate Zone 3)



	Basecase	Improved Furnace Efficiency
Total	255.0	244.2
DHW	22.0	22.0
Fans+Pumps	32.2	32.2
Heating	68.1	57.2
Lgt+Appl	103.6	103.6
Cooling	29.1	29.1



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	15.9	12.4	10.5	6.0	3.3	1.6	1.5	1.5	1.6	2.9	9.1	12.8

Figure 78. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 10 (Improved Furnace Efficiency) in Potter County (Climate Zone 4)

5.3 **Domestic Hot Water Measures**

5.3.1 Tankless Gas Water Heater

Base Case: A storage tank-type domestic hot water (DHW) heater was simulated for the base-case house. For an electric/gas house, the DHW energy factor was set at 0.594. Energy factor ratings incorporate the energy usage of the pilot light in the gas DHW heater.

EEM 11: This measure was simulated by increasing the DHW energy factor from 0.594 to 0.748[20]. This measure is applicable only for an electric/gas house that has a gas DHW heater.

Energy Savings: Figure 79 to Figure 81 compare the energy use of a house with base-case characteristics and with the EEM 11 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-4 and is summarized in the following table. It shows that installing tankless gas water heater would increase the cost by $900 - $1,400.

Table 22. Cost Information for Tankless Gas Water Heater

DHW System Measures		Capacity	Equipment Cost ($)	Installation Cost ($)	Total Increased Cost ($)	Reference Table (Table A-4)
ELECTRIC/GAS HOUSE						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	$260-$360	$340-$530		Table Water Heater-1 - No. 9,10,11,12
EEM11	Tankless Gas Water Heater w/o pilot light	7.4 GPM	$830-$1,400	$640-$830	$900-$1400	Table Water Heater-1 - No. 1,2,3,4,5,6,7,8

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 35 therm/year x $0.84/therm = $29/year
Total energy cost savings	= $29/year
Implementation cost	= $900 - $1,400
Simple Payback	= **30.6 to 47.6 years**

Tarrant County

(b) Electric/gas house:

Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 36 therm/year x $0.64/therm = $23/year
Total energy cost savings	= $23/year
Implementation cost	= $900 - $1,400
Simple Payback	= **39.1 to 60.8 years**

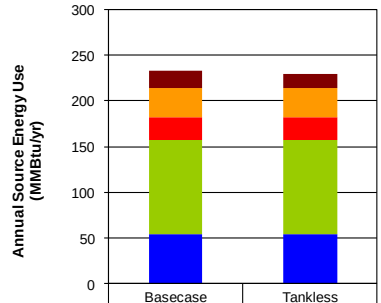
Potter County

(c) Electric/gas house:

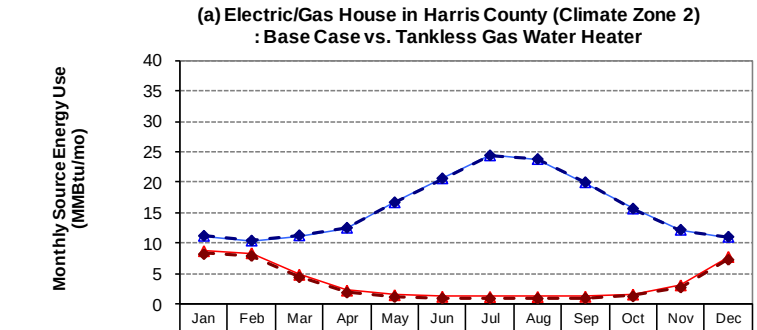
Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 35 therm/year x $0.64/therm = $22/year
Total energy cost savings	= $22/year

[20] The EF for the tankless water heater is based on a survey of manufacturers and recommendations of the 2008 California Building Energy Efficiency Standards.

Implementation cost = $900 - $1,400
Simple Payback = **40.2 to 62.5 years**

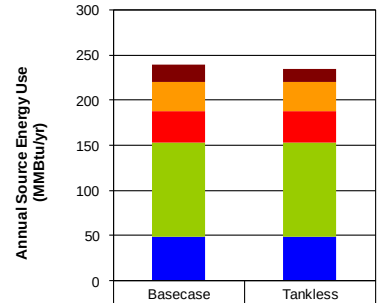


	Basecase	Tankless
Total	232.7	228.9
DHW	18.3	14.4
Fans+Pumps	31.9	31.9
Heating	24.9	24.9
Lgt+Appl	103.6	103.6
Cooling	54.0	54.0

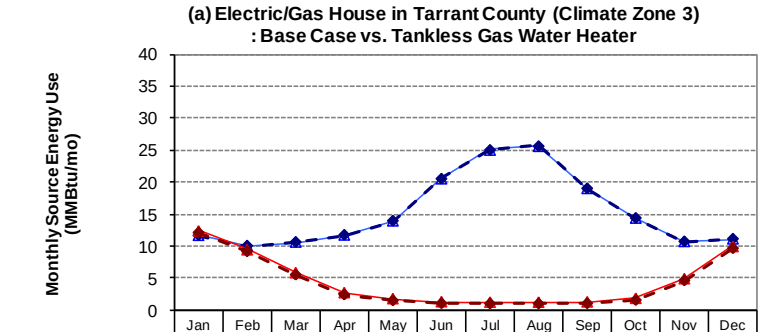


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.3	8.0	4.5	1.9	1.2	1.0	1.0	1.0	1.0	1.3	2.8	7.3

Figure 79. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 11 (Tankless Gas Water Heater) in Harris County (Climate Zone 2)

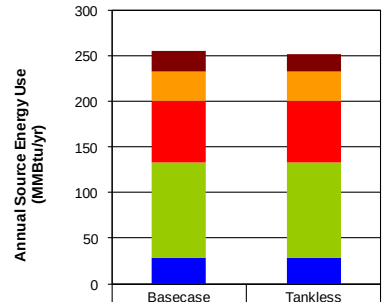


	Basecase	Tankless
Total	238.9	234.9
DHW	19.1	15.2
Fans+Pumps	32.2	32.2
Heating	35.2	35.2
Lgt+Appl	103.6	103.6
Cooling	48.7	48.7

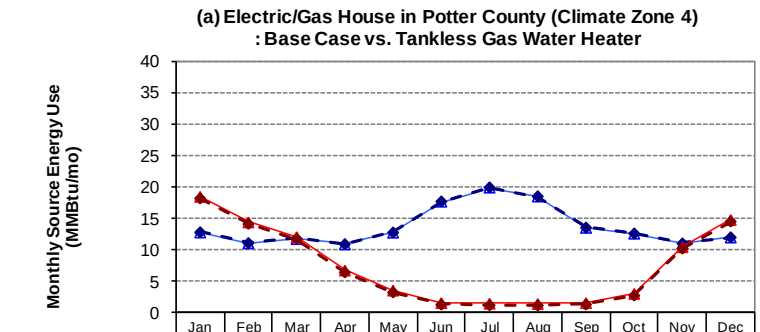


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.1	9.2	5.5	2.4	1.5	1.0	1.0	1.0	1.0	1.5	4.6	9.6

Figure 80. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 11 (Tankless Gas Water Heater) in Tarrant County (Climate Zone 3)



	Basecase	Tankless
Total	255.0	251.2
DHW	22.0	18.2
Fans+Pumps	32.2	32.2
Heating	68.1	68.1
Lgt+Appl	103.6	103.6
Cooling	29.1	29.1



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.1	14.1	11.7	6.4	3.3	1.4	1.3	1.2	1.4	2.8	10.2	14.5

Figure 81. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 11 (Tankless Gas Water Heater) in Potter County (Climate Zone 4)

5.3.2 Removal of Pilot Light from Tank-Type Hot Water System

Base Case: For an electric/gas house, the base-case DHW system is a 40-gallon, storage type with a standing pilot light that consumes 500 Btu/hr and a calculated energy factor of 0.594.

EEM 12: In order to simulate the impact of removing the pilot light, a higher energy factor of 0.660 was chosen. This measure is applicable only for an electric/gas house that has a gas DHW heater.

Energy Savings: Figure 82 to Figure 84 compare the energy use of a house with base-case characteristics and with the EEM 12 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-4 and is summarized in the following table. It shows that removal of pilot light from tank-type DHW system would increase the cost by $100 - $500.

Table 23. Cost Information for Removal of Pilot Light from Tank-Type Hot Water System

DHW System Measures		Capacity	Equipment Cost ($)	Installation Cost ($)	Total Increased Cost ($)	Reference Table (Table A-4)
ELECTRIC/GAS HOUSE						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	$260-$360	$340-$530		Table Water Heater-1 - No. 9,10,11,12
EEM12	Tanktype Gas Water Heater w/o pilot light	40/50 Gallon	$350-$800	$340-$530	$100-$500	Table Water Heater-1 - No. 15,19,20

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 17 therm/year x $0.84/therm = $14/year
Total energy cost savings	= $14/year
Implementation cost	= $100 - $500
Simple Payback	= **7.0 to 35.0 years**

Tarrant County

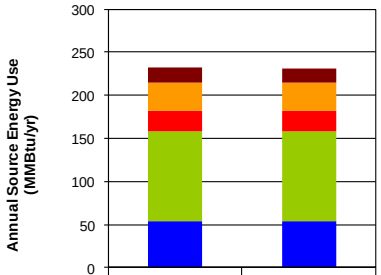
(b) Electric/gas house:

Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 17 therm/year x $0.64/therm = $11/year
Total energy cost savings	= $11/year
Implementation cost	= $100 - $500
Simple Payback	= **9.2 to 46.0 years**

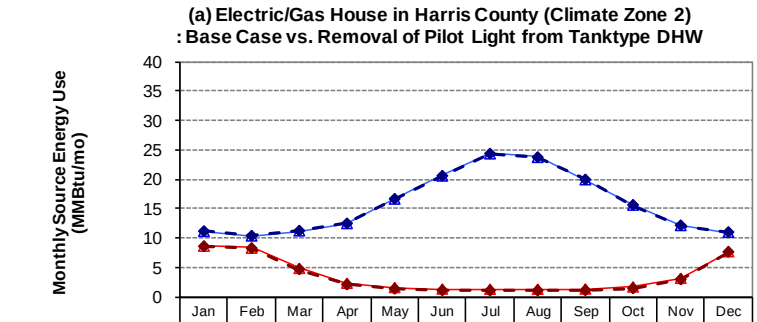
Potter County

(c) Electric/gas house:

Electricity cost savings	= 0 kWh/year x $0.11/kWh = $0/year
Gas cost savings	= 17 therm/year x $0.64/therm = $11/year
Total energy cost savings	= $11/year
Implementation cost	= $100 - $500
Simple Payback	= **9.2 to 46.0 years**

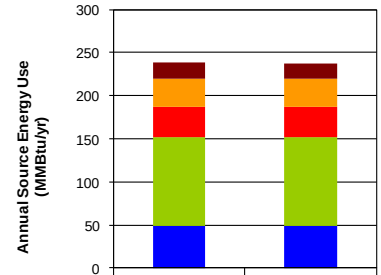


	Basecase	Removal of Pilot Light
Total	232.7	230.9
DHW	18.3	16.4
Fans+Pumps	31.9	31.9
Heating	24.9	24.9
Lgt+Appl	103.6	103.6
Cooling	54.0	54.0

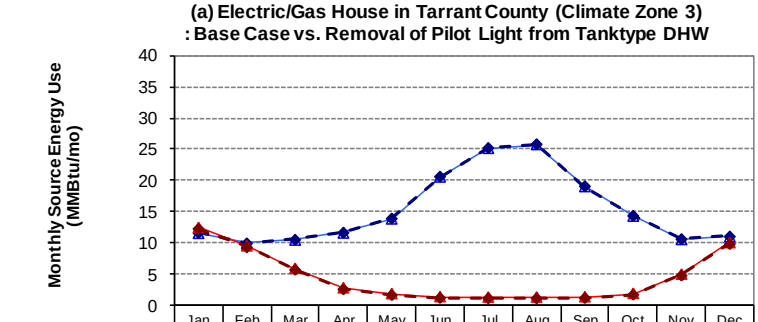


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM)	8.5	8.2	4.7	2.1	1.4	1.1	1.1	1.1	1.1	1.5	3.0	7.5

Figure 82. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 12 (Removal of Pilot Light from DHW) in Harris County (Climate Zone 2)

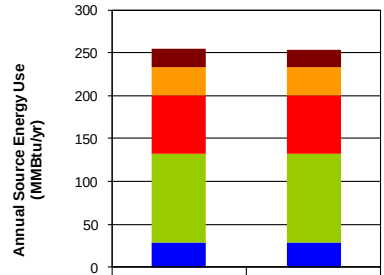


	Basecase	Removal of Pilot Light
Total	238.9	237.0
DHW	19.1	17.3
Fans+Pumps	32.2	32.2
Heating	35.2	35.2
Lgt+Appl	103.6	103.6
Cooling	48.7	48.7

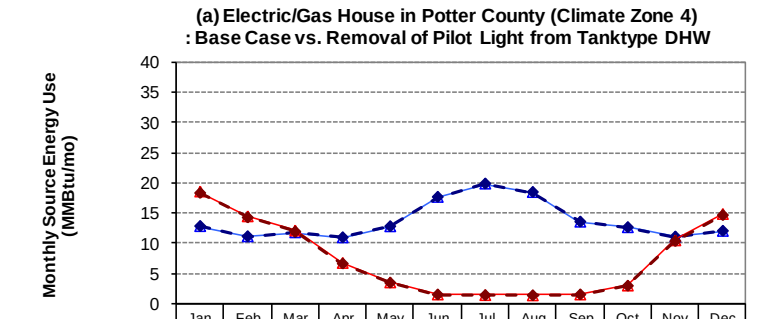


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM)	12.3	9.3	5.7	2.6	1.6	1.2	1.1	1.1	1.2	1.7	4.8	9.9

Figure 83. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 12 (Removal of Pilot Light from DHW) in Tarrant County (Climate Zone 3)



	Basecase	Removal of Pilot Light
Total	255.0	253.2
DHW	22.0	20.1
Fans+Pumps	32.2	32.2
Heating	68.1	68.1
Lgt+Appl	103.6	103.6
Cooling	29.1	29.1



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.3	14.3	11.9	6.6	3.5	1.5	1.4	1.4	1.5	2.9	10.4	14.7

Figure 84. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 12 (Removal of Pilot Light from DHW) in Potter County (Climate Zone 4)

5.3.3 Solar Domestic Hot Water System

Base Case: For an electric/gas house, the base-case DHW system is a 40-gallon, storage type with a standing pilot light that consumes 500 Btu/hr and a calculated energy factor of 0.594. For an all-electric house, the base-case DHW system is a 50-gallon, storage type electric water heater. The energy factor of the system is 0.904. The daily hot water use was calculated as 70 gallons/day, which assumes that the house has four bedrooms. The hot water supply temperature is 120°F. The method to simulate DHW in DOE-2.1e using the energy factor is based on Building America House Performance Analysis Procedures (NREL 2001) that assumes a constant hourly DHW use and eliminates the efficiency dependence on part-loads.

EEM 13-14: The test-case house was assumed to have a solar DHW system, which is comprised of one or two 32 sq. ft. of flat plate solar collectors. This measure was simulated using the F-Chart program (Klein and Beckman 1983). In this analysis, the collector tilt was assumed to be the same as the latitude of the location: 29.5 degrees for Harris County, 32.5 degrees for Tarrant County, and 25.2 degrees for Potter County. Any supplementary hot water heating was provided by the base-case water heating system. Also, additional electricity use was taken into account for operating the pump.

The details of the solar DHW system for EEM 14 (solar DHW with 64 sq. ft. collector) are as follows:

System : Alternate Energy Technologies EagleSun closed loop system
Model no. : DB-80-64

Solar Collector : Alternate Energy Technologies AE-32 glazed flat plate collector
Collector Size : 47.2 in x 97.2 in.
Number of collectors : 2
Gross Collector Area : 31.91 sq. ft. per collector
Aperture Area : 29.93 sq. ft. per collector

Storage tank/ Heat exchanger : Alternate Energy Technologies EagleSun TM80HE-1 solar hot water storage tank with heat exchanger
Capacity : 80 gallons
Dimensions : 58-3/4 inch height, 24-1/2 inch diameter
Insulation : R-17.3

Energy Savings: Figure 85 to Figure 90 compare the energy use of a house with base-case characteristics and with the EEM 13-14 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-4 and is summarized in the following table. It shows that installing a solar DHW system would increase the cost by $2,200 - $3,000 with 32 sq. ft collector and by $3,200 - $4,000 with 64 sq. ft collector.

Table 24. Cost Information for Solar Domestic Hot Water System

DHW System Measures		Capacity	Equipment Cost ($)	Installation Cost ($)	Total Increased Cost ($)	Reference Table (Table A-4)
Base Case	No Solar Water Heater		$0	$0		
EEM 13	Solar Water Heater(32 sq.ft collector)	65/80 Gallon	$2,200-$3,000	n/a	$2,200-$3,000	Table Solar Water Heater-1 No. 1,2,4
EEM 14	Solar Water Heater(64 sq.ft collector)	80 Gallon	$3,200-$4,000	n/a	$3,200-$4,000	Table Solar Water Heater-1 No. 2,4,5,6 Table Solar Collector-1 No. 1,2,3,4,5,6,7,8

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 101 therm/year x $0.84/therm = $85/year
Total energy cost savings	= $40/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **55.0 to 75.0 years**

(b) Electric/gas house:

Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 138 therm/year x $0.84/therm = $116/year
Total energy cost savings	= $71/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **45.1 to 56.4 years**

(c) All-electric house:

Electricity cost savings	= 1,348 kWh/year x $0.11/kWh = $148/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **14.8 to 20.2 years**

(d) All-electric house:

Electricity cost savings	= 1,998 kWh/year x $0.11/kWh = $220/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **14.6 to 18.2 years**

Tarrant County

(e) Electric/gas house:

Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 121 therm/year x $0.64/therm = $77/year
Total energy cost savings	= $32/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **67.7 to 92.4 years**

(f) Electric/gas house:

Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 149 therm/year x $0.64/therm = $95/year
Total energy cost savings	= $51/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **63.2 to 79.0 years**

(g) All-electric house:

Electricity cost savings	= 1,753 kWh/year x $0.11/kWh = $193/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **11.4 to 15.6 years**

(h) All-electric house:

Electricity cost savings	= 2,238 kWh/year x $0.11/kWh = $246/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **13.0 to 16.2 years**

Potter County

(i) Electric/gas house:

Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 129 therm/year x $0.64/therm = $83/year
Total energy cost savings	= $38/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **58.2 to 79.4 years**

(j) Electric/gas house:

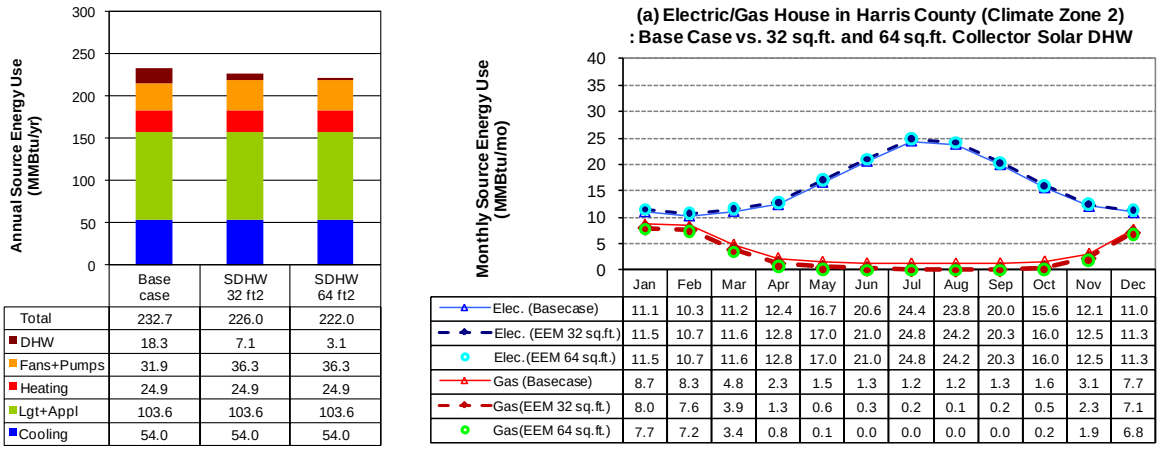
Electricity cost savings	= -408 kWh/year x $0.11/kWh = -$45/year
Gas cost savings	= 172 therm/year x $0.64/therm = $110/year
Total energy cost savings	= $65/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **49.0 to 61.2 years**

(k) All-electric house:

Electricity cost savings	= 1,975 kWh/year x $0.11/kWh = $217/year
Implementation cost	= $2,200 - $3,000
Simple Payback	= **10.1 to 13.8 years**

(l) All-electric house:

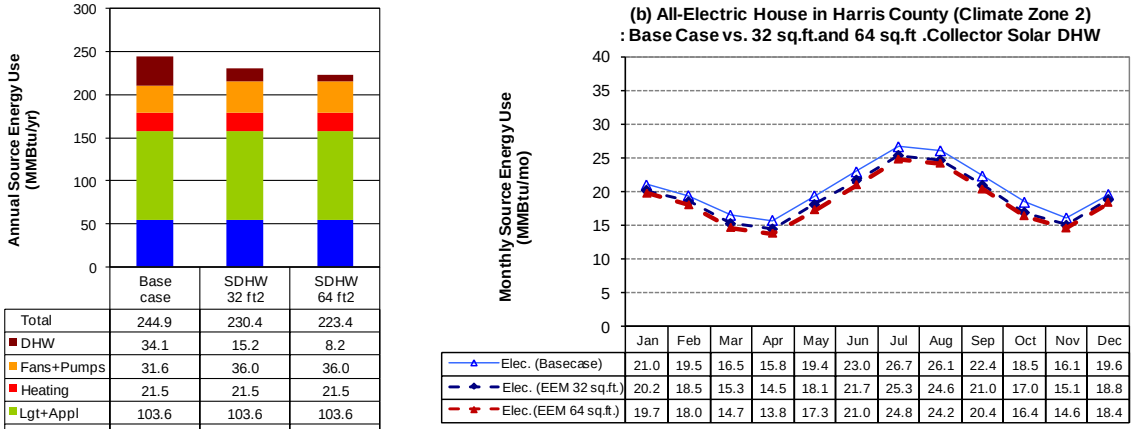
Electricity cost savings	= 2,701 kWh/year x $0.11/kWh = $297/year
Implementation cost	= $3,200 - $4,000
Simple Payback	= **10.8 to 13.5 years**



	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	232.7	226.0	222.0
DHW	18.3	7.1	3.1
Fans+Pumps	31.9	36.3	36.3
Heating	24.9	24.9	24.9
Lgt+Appl	103.6	103.6	103.6
Cooling	54.0	54.0	54.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM 32 sq.ft.)	11.5	10.7	11.6	12.8	17.0	21.0	24.8	24.2	20.3	16.0	12.5	11.3
Elec.(EEM 64 sq.ft.)	11.5	10.7	11.6	12.8	17.0	21.0	24.8	24.2	20.3	16.0	12.5	11.3
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas(EEM 32 sq.ft.)	8.0	7.6	3.9	1.3	0.6	0.3	0.2	0.1	0.2	0.5	2.3	7.1
Gas(EEM 64 sq.ft.)	7.7	7.2	3.4	0.8	0.1	0.0	0.0	0.0	0.0	0.2	1.9	6.8

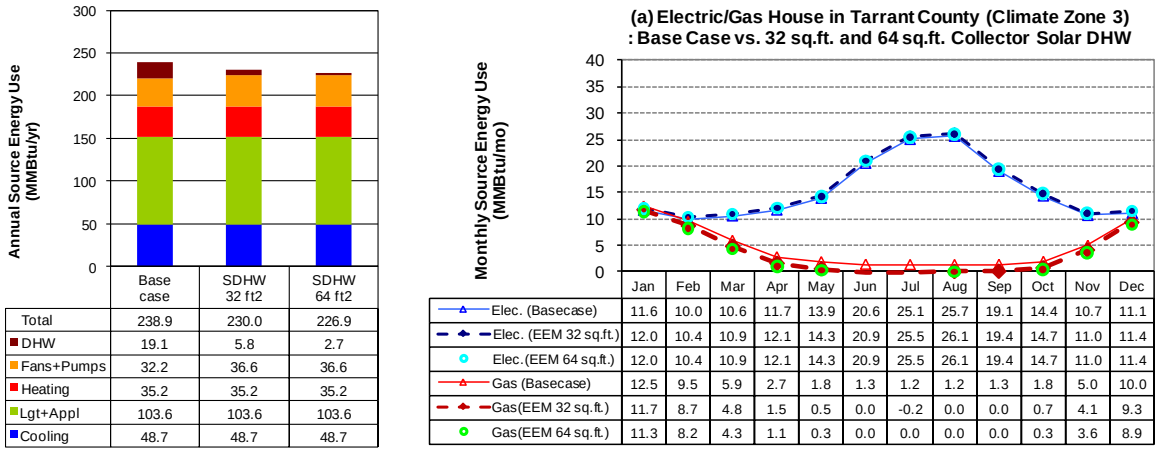
Figure 85. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 13-14 (Solar DHW) in Harris County (Climate Zone 2)



	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	244.9	230.4	223.4
DHW	34.1	15.2	8.2
Fans+Pumps	31.6	36.0	36.0
Heating	21.5	21.5	21.5
Lgt+Appl	103.6	103.6	103.6
Cooling	54.0	54.0	54.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM 32 sq.ft.)	20.2	18.5	15.3	14.5	18.1	21.7	25.3	24.6	21.0	17.0	15.1	18.8
Elec.(EEM 64 sq.ft.)	19.7	18.0	14.7	13.8	17.3	21.0	24.8	24.2	20.4	16.4	14.6	18.4

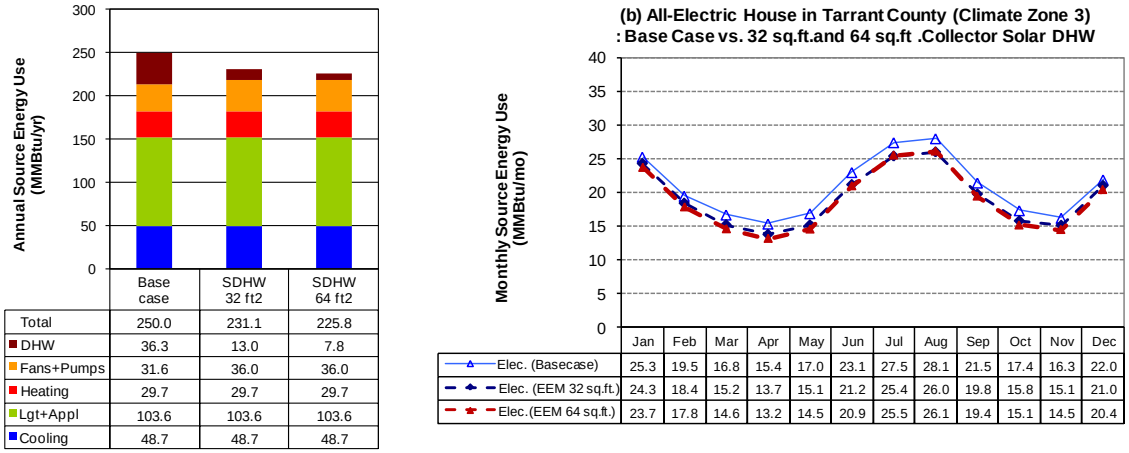
Figure 86. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 13-14 (Solar DHW) in Harris County (Climate Zone 2)



	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	238.9	230.0	226.9
DHW	19.1	5.8	2.7
Fans+Pumps	32.2	36.6	36.6
Heating	35.2	35.2	35.2
Lgt+Appl	103.6	103.6	103.6
Cooling	48.7	48.7	48.7

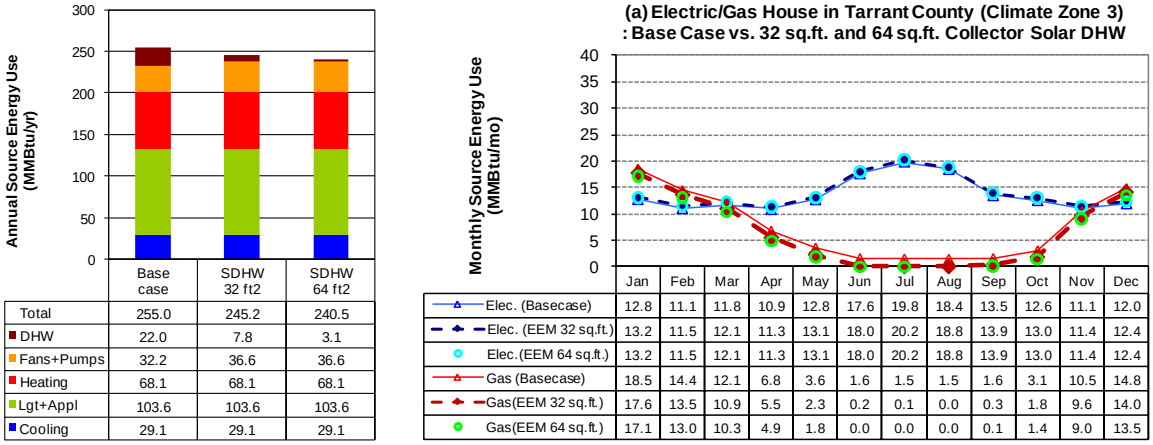
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM 32 sq.ft.)	12.0	10.4	10.9	12.1	14.3	20.9	25.5	26.1	19.4	14.7	11.0	11.4
Elec.(EEM 64 sq.ft.)	12.0	10.4	10.9	12.1	14.3	20.9	25.5	26.1	19.4	14.7	11.0	11.4
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas(EEM 32 sq.ft.)	11.7	8.7	4.8	1.5	0.5	0.0	-0.2	0.0	0.0	0.7	4.1	9.3
Gas(EEM 64 sq.ft.)	11.3	8.2	4.3	1.1	0.3	0.0	0.0	0.0	0.0	0.3	3.6	8.9

Figure 87. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 13-14 (Solar DHW) in Tarrant County (Climate Zone 3)



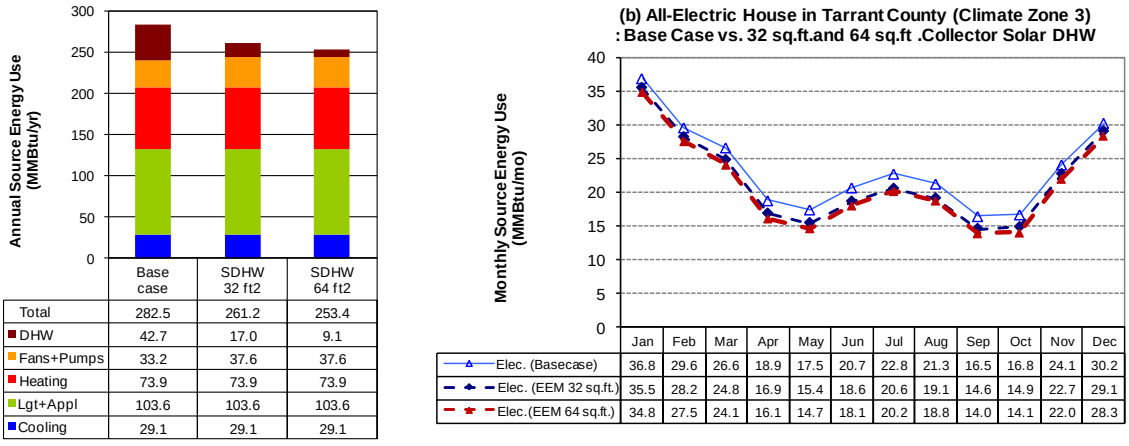
	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	250.0	231.1	225.8
DHW	36.3	13.0	7.8
Fans+Pumps	31.6	36.0	36.0
Heating	29.7	29.7	29.7
Lgt+Appl	103.6	103.6	103.6
Cooling	48.7	48.7	48.7

Figure 88. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 13-14 (Solar DHW) in Tarrant County (Climate Zone 3)



	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	255.0	245.2	240.5
DHW	22.0	7.8	3.1
Fans+Pumps	32.2	36.6	36.6
Heating	68.1	68.1	68.1
Lgt+Appl	103.6	103.6	103.6
Cooling	29.1	29.1	29.1

Figure 89. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 13-14 (Solar DHW) in Potter County (Climate Zone 4)



	Base case	SDHW 32 ft2	SDHW 64 ft2
Total	282.5	261.2	253.4
DHW	42.7	17.0	9.1
Fans+Pumps	33.2	37.6	37.6
Heating	73.9	73.9	73.9
Lgt+Appl	103.6	103.6	103.6
Cooling	29.1	29.1	29.1

Figure 90. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 13-14 (Solar DHW) in Potter County (Climate Zone 4)

5.4 **Lighting Measures**

5.4.1 EnergyStar Permanent CFL or Fluorescent Indoor Lamps

Base Case: 100% incandescent fixtures were assumed for the base-case house. Table 405.5.2 (1) of the 2009 IECC describes the internal heat gains to be 1.095 kW. It was assumed that 0.547 kW were allocated to heat gains from lighting, and 0.547 kW were allocated to heat gains from miscellaneous equipment.

EEM 15-17: To calculate the internal heat gains from lighting measures, an EnergyStar permanent CFL or fluorescent indoor lamp were assumed using 75% less energy than an incandescent lamp. The calculated internal heat gains by replacing the existing incandescent lighting fixtures with CFL or fluorescent lamps were 0.445 kW for 25% replacements, 0.342 kW for 50% replacement, and 0.239 kW for 75% replacements.

Energy Savings: Figure 91 to Figure 96 compare the energy use of a house with base-case characteristics and with the EEM 15 to 17 for Harris, Tarrant, and Potter County.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-5 and is summarized in the following table. It shows that replacing existing incandescent lamps with CFL or fluorescent lamps would increase the cost by $25 - $110 for 25% replacements, by $50 - $215 for 50% replacements, and $70 - $320 for 75% replacements.

Table 25. Cost Information for EnergyStar Permanent CFL or Fluorescent Indoor Lamps

Lighting Measures		Quantity		Unit Cost ($)		Total Increased Cost ($)	Reference Table (Table A-5)
		Incandescent	CFL	Incandescent	CFL		
Base Case	0% EnergyStar Permanent CFL or Fluorescent Lamps	28 ~ 56	0	$0.6-$1.3	$4.0-$8.9		Table Incandescent Lamps No. 1,2,3,4 Table CFL-Pin Type (w/ Lampholder) No. 1, 2,3,4,5
EEM15	25% EnergyStar Permanent CFL or Fluorescent Lamps	21 ~ 42	7 ~ 14			$25-$110	
EEM16	50% EnergyStar Permanent CFL or Fluorescent Lamps	14 ~ 28	14 ~ 28			$50-$215	
EEM17	75% EnergyStar Permanent CFL or Fluorescent Lamps	7 ~ 14	21 ~ 42			$70-$320	

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 1,202 kWh/year x $0.11/kWh = $132/year
Gas cost savings	= -12 therm/year x $0.84/therm = -$10/year
Total energy cost savings	= $122/year
Implementation cost	= $25 - $110
Simple Payback	= **0.2 to 0.9 years**

(b) Electric/gas house:

Electricity cost savings	= 2,345 kWh/year x $0.11/kWh = $258/year
Gas cost savings	= -24 therm/year x $0.84/therm = -$20/year
Total energy cost savings	= $238/year
Implementation cost	= $50 - $215
Simple Payback	= **0.2 to 0.9 years**

(c) Electric/gas house:

Electricity cost savings	= 3,546 kWh/year x $0.11/kWh = $390/year

Gas cost savings = -37 therm/year x $0.84/therm = -$31/year
Total energy cost savings = $359/year
Implementation cost = $70 - $320
Simple Payback = **0.2 to 0.9 years**

(d) All-electric house:
Electricity cost savings = 1,114 kWh/year x $0.11/kWh = $123/year
Implementation cost = $25 - $110
Simple Payback = **0.2 to 0.9 years**

(e) All-electric house:
Electricity cost savings = 2,169 kWh/year x $0.11/kWh = $239/year
Implementation cost = $50 - $215
Simple Payback = **0.2 to 0.9 years**

(f) All-electric house:
Electricity cost savings = 3,312 kWh/year x $0.11/kWh = $364/year
Implementation cost = $70 - $320
Simple Payback = **0.2 to 0.9 years**

Tarrant County

(g) Electric/gas house:
Electricity cost savings = 1,114 kWh/year x $0.11/kWh = $123/year
Gas cost savings = -16 therm/year x $0.64/therm = -$10/year
Total energy cost savings = $112/year
Implementation cost = $25 - $110
Simple Payback = **0.2 to 1.0 years**

(h) Electric/gas house:
Electricity cost savings = 2,257 kWh/year x $0.11/kWh = $248/year
Gas cost savings = -32 therm/year x $0.64/therm = -$20/year
Total energy cost savings = $228/year
Implementation cost = $50 - $215
Simple Payback = **0.2 to 0.9 years**

(i) Electric/gas house:
Electricity cost savings = 3,341 kWh/year x $0.11/kWh = $368/year
Gas cost savings = -48 therm/year x $0.64/therm = -$31/year
Total energy cost savings = $337/year
Implementation cost = $70 - $320
Simple Payback = **0.2 to 1.0 years**

(j) All-electric house:
Electricity cost savings = 996 kWh/year x $0.11/kWh = $110/year
Implementation cost = $25 - $110
Simple Payback = **0.2 to 1.0 years**

(k) All-electric house:
Electricity cost savings = 2,052 kWh/year x $0.11/kWh = $226/year
Implementation cost = $50 - $215
Simple Payback = **0.2 to 1.0 years**

(l) All-electric house:

Electricity cost savings	= 3,048 kWh/year x $0.11/kWh = $335/year
Implementation cost	= $70 - $320
Simple Payback	= **0.2 to 1.0 years**

Potter County

(m) Electric/gas house:

Electricity cost savings	= 1,084 kWh/year x $0.11/kWh = $119/year
Gas cost savings	= -22 therm/year x $0.64/therm = -$14/year
Total energy cost savings	= $105/year
Implementation cost	= $25 - $110
Simple Payback	= **0.2 to 1.0 years**

(n) Electric/gas house:

Electricity cost savings	= 2,140 kWh/year x $0.11/kWh = $235/year
Gas cost savings	= -44 therm/year x $0.64/therm = -$28/year
Total energy cost savings	= $207/year
Implementation cost	= $50 - $215
Simple Payback	= **0.2 to 1.0 years**

(o) Electric/gas house:

Electricity cost savings	= 3,165 kWh/year x $0.11/kWh = $348/year
Gas cost savings	= -67 therm/year x $0.64/therm = -$43/year
Total energy cost savings	= $305/year
Implementation cost	= $70 - $320
Simple Payback	= **0.2 to 1.0 years**

(p) All-electric house:

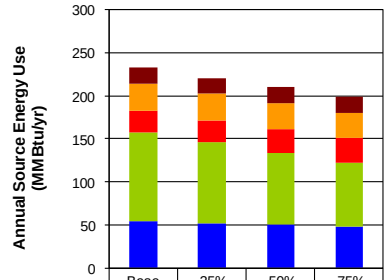
Electricity cost savings	= 938 kWh/year x $0.11/kWh = $103/year
Implementation cost	= $25 - $110
Simple Payback	= **0.2 to 1.1 years**

(q) All-electric house:

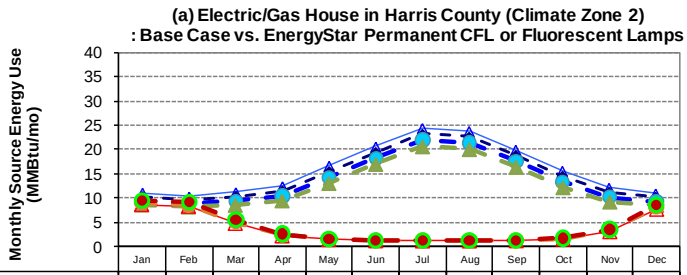
Electricity cost savings	= 1,817 kWh/year x $0.11/kWh = $200/year
Implementation cost	= $50 - $215
Simple Payback	= **0.3 to 1.1 years**

(r) All-electric house:

Electricity cost savings	= 2,667 kWh/year x $0.11/kWh = $293/year
Implementation cost	= $70 - $320
Simple Payback	= **0.2 to 1.1 years**

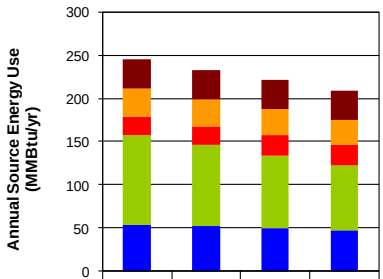


	Base case	25% CFL	50% CFL	75% CFL
Total	232.7	221.1	210.1	198.6
DHW	18.3	18.3	18.3	18.3
Fans+Pumps	31.9	31.0	30.3	29.4
Heating	24.9	26.2	27.5	28.9
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	54.0	51.8	49.9	47.7

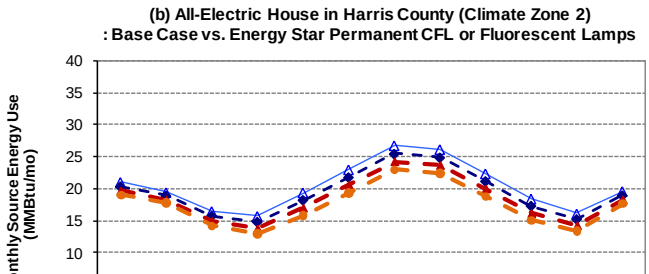


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.1	10.3	11.2	12.4	16.7	20.6	24.4	23.8	20.0	15.6	12.1	11.0
Elec. (EEM 25%)	10.3	9.6	10.3	11.4	15.5	19.4	23.2	22.6	18.8	14.5	11.1	10.1
Elec.(EEM 50%)	9.4	8.9	9.4	10.4	14.2	18.2	21.9	21.3	17.6	13.3	10.1	9.3
Elec.(EEM 75%)	8.6	8.1	8.5	9.4	13.0	17.0	20.7	20.1	16.4	12.2	9.2	8.4
Gas (Basecase)	8.7	8.3	4.8	2.3	1.5	1.3	1.2	1.2	1.3	1.6	3.1	7.7
Gas (EEM 25%)	8.9	8.6	5.0	2.4	1.6	1.3	1.2	1.2	1.3	1.7	3.2	8.0
Gas (EEM 50%)	9.5	9.2	5.5	2.6	1.6	1.3	1.2	1.2	1.3	1.7	3.5	8.6
Gas (EEM 75%)	9.5	9.2	5.5	2.6	1.6	1.3	1.2	1.2	1.3	1.7	3.5	8.6

Figure 91. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Harris County (Climate Zone 2)

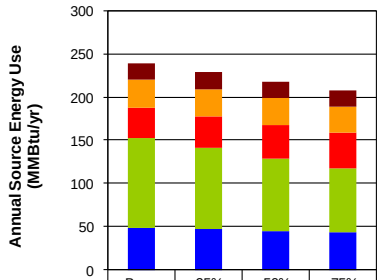


	Base case	25% CFL	50% CFL	75% CFL
Total	244.9	232.9	221.5	209.2
DHW	34.1	34.1	34.1	34.1
Fans+Pumps	31.6	30.7	30.0	29.1
Heating	21.5	22.4	23.4	24.0
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	54.0	51.8	49.9	47.7

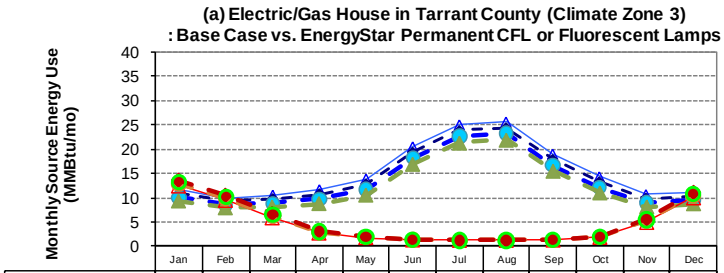


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	21.0	19.5	16.5	15.8	19.4	23.0	26.7	26.1	22.4	18.5	16.1	19.6
Elec. (EEM 25%)	20.4	18.9	15.7	14.8	18.2	21.8	25.5	24.9	21.2	17.3	15.2	19.0
Elec.(EEM 50%)	19.7	18.3	15.0	13.8	17.0	20.6	24.2	23.7	20.0	16.2	14.3	18.3
Elec. (EEM 75%)	19.0	17.8	14.2	12.9	15.8	19.4	23.0	22.4	18.8	15.1	13.4	17.6

Figure 92. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Harris County (Climate Zone 2)

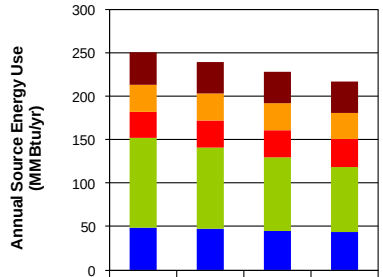


	Base case	25% CFL	50% CFL	75% CFL
Total	238.9	228.6	218.1	208.1
DHW	19.1	19.1	19.1	19.1
Fans+Pumps	32.2	31.6	31.0	30.7
Heating	35.2	37.0	38.7	40.5
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	48.7	47.1	45.2	43.6

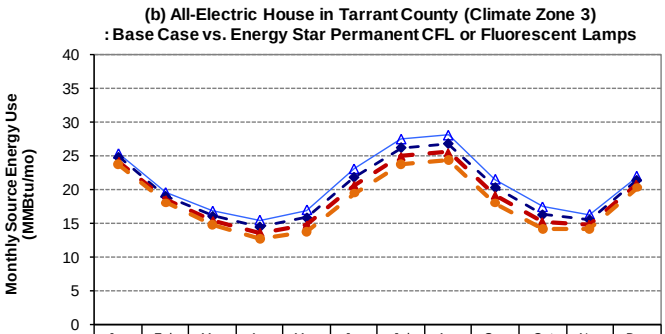


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	11.6	10.0	10.6	11.7	13.9	20.6	25.1	25.7	19.1	14.4	10.7	11.1
Elec. (EEM 25%)	10.9	9.3	9.7	10.7	12.8	19.4	23.9	24.5	17.9	13.2	9.8	10.3
Elec.(EEM 50%)	10.1	8.6	8.9	9.8	11.7	18.2	22.6	23.2	16.7	12.1	9.0	9.5
Elec.(EEM 75%)	9.3	7.9	8.1	8.8	10.6	17.0	21.4	22.0	15.5	11.0	8.1	8.8
Gas (Basecase)	12.5	9.5	5.9	2.7	1.8	1.3	1.2	1.2	1.3	1.8	5.0	10.0
Gas (EEM 25%)	12.8	9.8	6.1	2.8	1.8	1.3	1.2	1.2	1.3	1.9	5.2	10.4
Gas (EEM 50%)	13.2	10.1	6.4	3.0	1.9	1.3	1.2	1.2	1.3	2.0	5.4	10.7
Gas (EEM 75%)	13.6	10.5	6.7	3.1	2.0	1.3	1.2	1.2	1.3	2.0	5.7	11.0

Figure 93. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Tarrant County (Climate Zone 3)

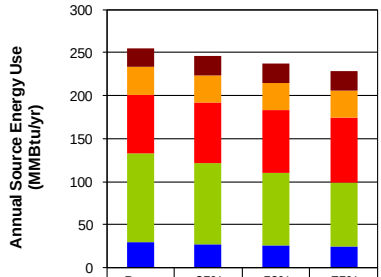


	Base case	25% CFL	50% CFL	75% CFL
Total	250.0	239.2	227.8	217.1
DHW	36.3	36.3	36.3	36.3
Fans+Pumps	31.6	31.0	30.3	29.7
Heating	29.7	31.0	31.9	33.2
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	48.7	47.1	45.2	43.6

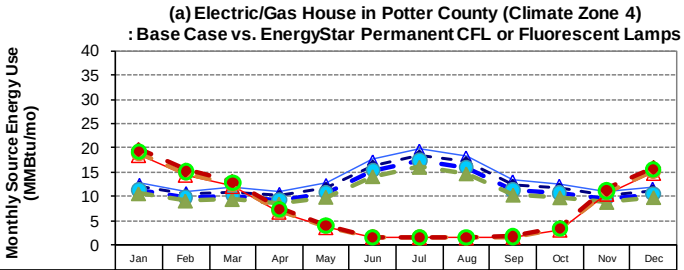


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM 25%)	24.8	19.0	16.1	14.5	15.9	21.9	26.2	26.8	20.3	16.3	15.6	21.4
Elec.(EEM 50%)	24.3	18.5	15.4	13.6	14.8	20.6	25.0	25.6	19.2	15.2	14.9	20.8
Elec. (EEM 75%)	23.7	18.0	14.7	12.7	13.7	19.4	23.7	24.3	18.0	14.2	14.2	20.3

Figure 94. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Tarrant County (Climate Zone 3)

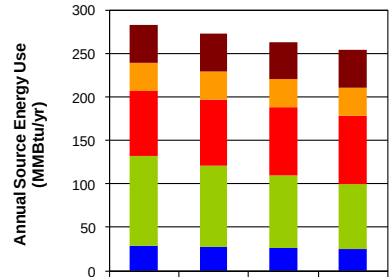


	Base case	25% CFL	50% CFL	75% CFL
Total	255.0	245.8	236.8	228.3
DHW	22.0	22.0	22.0	22.0
Fans+Pumps	32.2	31.9	31.6	31.6
Heating	68.1	70.5	72.9	75.5
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	29.1	27.5	26.2	25.0

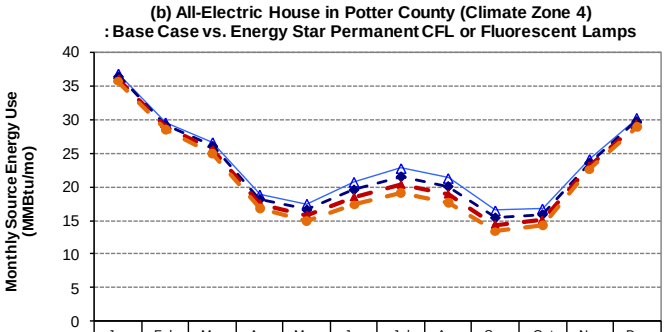


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM 25%)	12.1	10.4	11.0	10.1	11.8	16.5	18.6	17.2	12.4	11.6	10.3	11.3
Elec.(EEM 50%)	11.3	9.7	10.2	9.3	10.8	15.3	17.4	16.0	11.4	10.7	9.5	10.5
Elec.(EEM 75%)	10.6	9.1	9.4	8.4	9.8	14.2	16.1	14.8	10.3	9.7	8.8	9.8
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM 25%)	18.9	14.8	12.4	7.1	3.8	1.6	1.5	1.5	1.7	3.3	10.8	15.2
Gas (EEM 50%)	19.3	15.1	12.8	7.3	3.9	1.7	1.5	1.5	1.7	3.4	11.2	15.6
Gas (EEM 75%)	19.7	15.4	13.1	7.6	4.1	1.7	1.5	1.5	1.8	3.6	11.5	16.0

Figure 95. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Potter County (Climate Zone 4)



	Base case	25% CFL	50% CFL	75% CFL
Total	282.5	272.4	262.9	253.7
DHW	42.7	42.7	42.7	42.7
Fans+Pumps	33.2	32.9	32.5	32.5
Heating	73.9	75.5	77.4	79.3
Lgt+Appl	103.6	93.9	84.1	74.3
Cooling	29.1	27.5	26.2	25.0



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM 25%)	36.4	29.2	26.1	18.2	16.6	19.6	21.6	20.1	15.4	15.9	23.6	29.8
Elec.(EEM 50%)	36.1	28.8	25.5	17.5	15.7	18.5	20.3	18.9	14.4	15.1	23.1	29.3
Elec. (EEM 75%)	35.7	28.4	25.0	16.8	14.9	17.3	19.1	17.6	13.3	14.2	22.6	28.8

Figure 96. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 15-17 (CFL or Fluorescent Lamps) in Potter County (Climate Zone 4)

5.5 **Renewable Power Measures**

5.5.1 4kW Photovoltaic Array

Base Case: There are no PV panels installed for the base-case.

EEM 18: The test-case house was assumed to be grid-connected with a 4kW PV array of Kyocera multi-crystalline solar cells (16% efficiency). The analysis of long-term PV performance was conducted using PV F-Chart program (Klein and Beckman 1994) and the appropriate TMY2 weather files: Houston TMY2 data for Harris County, Dallas/Fort Worth TMY2 data for Tarrant County, and Amarillo TMY2 data for Potter County. In this analysis, the array tilt was assumed to be the same as the latitude of the location: 29.5 degrees for Harris County, 32.5 degrees for Tarrant County, and 25.2 degrees for Potter County.

The details of the PV array are as follows:

PV modules : Kyocera KD210GX-LP (210Watt) or Kyocera KD205GX-LP (205Watts) (Multi-crystalline solar cells)
Efficiency : 16%
Panel Size : 1500 mm x 990 mm (59.1 in x 39 in.)

For the analysis of the PV system using PV F-Chart, following parameters were used.

Cell Temperature at NOCT conditions : 120.2 deg.F (49 deg.C)
Array reference efficiency : 0.16
Array reference temperature : 77 deg.F (25 deg.C)
Array temperature coefficient : 2.389 x 10^-3 A/deg.C
Power tracking efficiency : 0.9
Power conditioning efficiency : 0.88
Array area : 320 sq. ft.
Array slope : (based on the location)
Array azimuth : 0 (south)

Energy Savings: Figure 97 to Figure 102 compare the energy use of a house with base-case characteristics and with the EEM 18 for Harris, Tarrant, and Potter County. For this measure, the annual source energy use of the house with base-case characteristics and with the EEM is plotted for different fuel types only.

Implementation Cost: The cost information for this measure is obtained using the sources listed in Table A-6 and is summarized in the following table. It shows that installing 4kW photovoltaic array would increase the cost by $20,000 - $30,000.

Table 26. Cost Information for 4kW Photovoltaic Array

Renewable Power Meausres		Capacity	Equipment Cost ($)	Installation Cost ($)	Total Increased Cost ($)	Reference Table (Table A-6)
Base Case	No PV Array		$0	$0		
EEM18	4kW PV	4kW	$10,000-$20,000	$10,000	$20,000-$30,000	Table Solar PV-1 No. 1, 2,3,4,5

Payback Calculation:

Harris County

(a) Electric/gas house:

Electricity cost savings	= 5,546 kWh/year x $0.11/kWh = $610/year
Gas cost savings	= 0 therm/year x $0.84/therm = $0/year
Total energy cost savings	= $610/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **32.8 to 49.2 years**

(b) All-electric house:

Electricity cost savings	= 5,546 kWh/year x $0.11/kWh = $610/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **32.8 to 49.2 years**

Tarrant County

(c) Electric/gas house:

Electricity cost savings	= 6,294 kWh/year x $0.11/kWh = $692/year
Gas cost savings	= 0 therm/year x $0.64/therm = $0/year
Total energy cost savings	= $692/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **28.9 to 43.3 years**

(d) All-electric house:

Electricity cost savings	= 6,294 kWh/year x $0.11/kWh = $692/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **28.9 to 43.3 years**

Potter County

(e) Electric/gas house:

Electricity cost savings	= 6,872 kWh/year x $0.11/kWh = $756/year
Gas cost savings	= 0 therm/year x $0.64/therm = $0/year
Total energy cost savings	= $756/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **26.5 to 39.7 years**

(f) All-electric house:

Electricity cost savings	= 6,872 kWh/year x $0.11/kWh = $756/year
Implementation cost	= $20,000 - $30,000
Simple Payback	= **26.5 to 39.7 years**

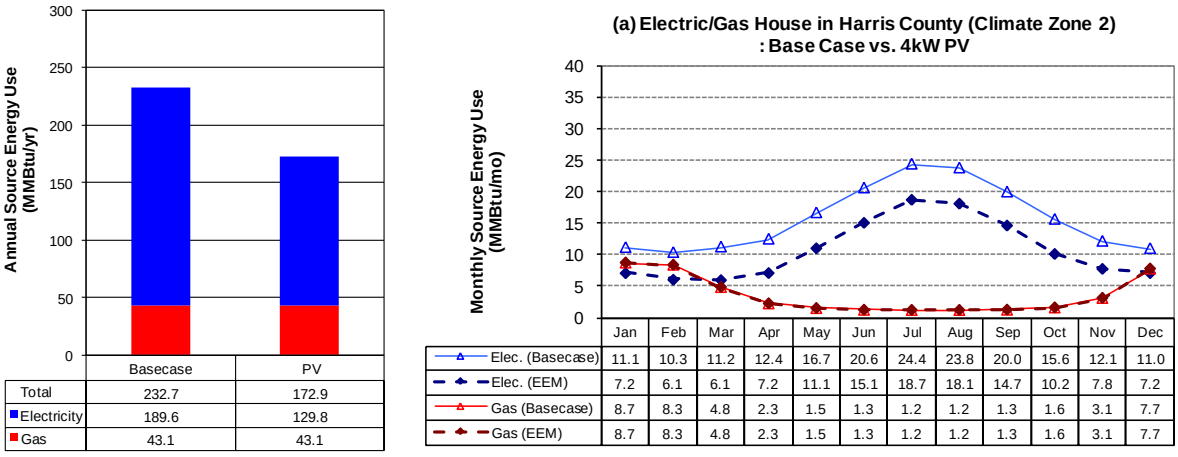


Figure 97. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 18 (4kW PV) in Harris County (Climate Zone 2)

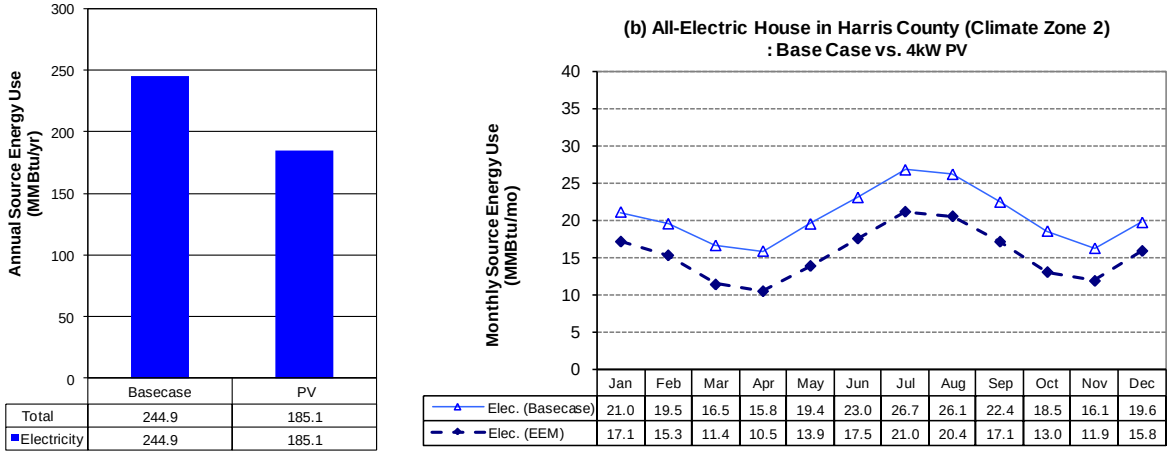


Figure 98. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 18 (4kW PV) in Harris County (Climate Zone 2)

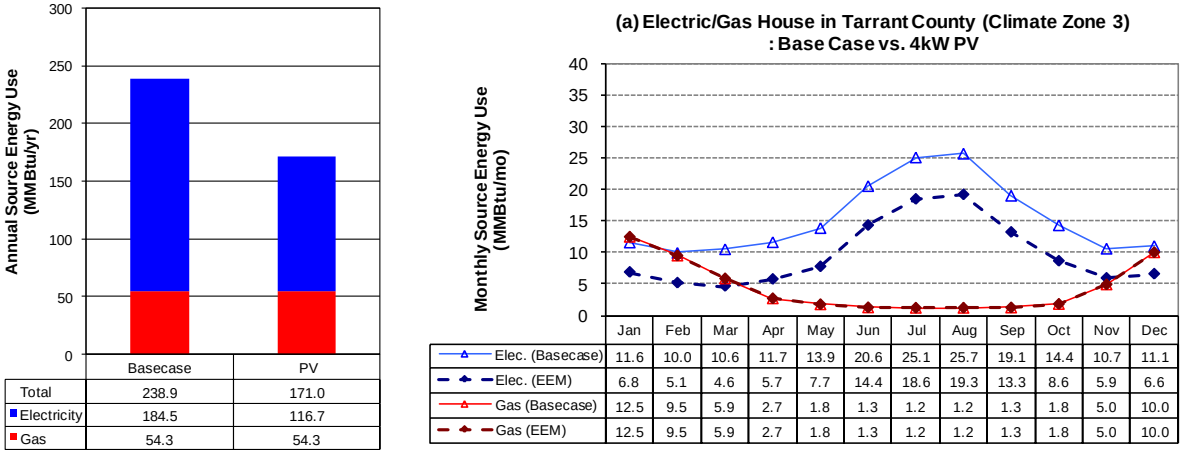
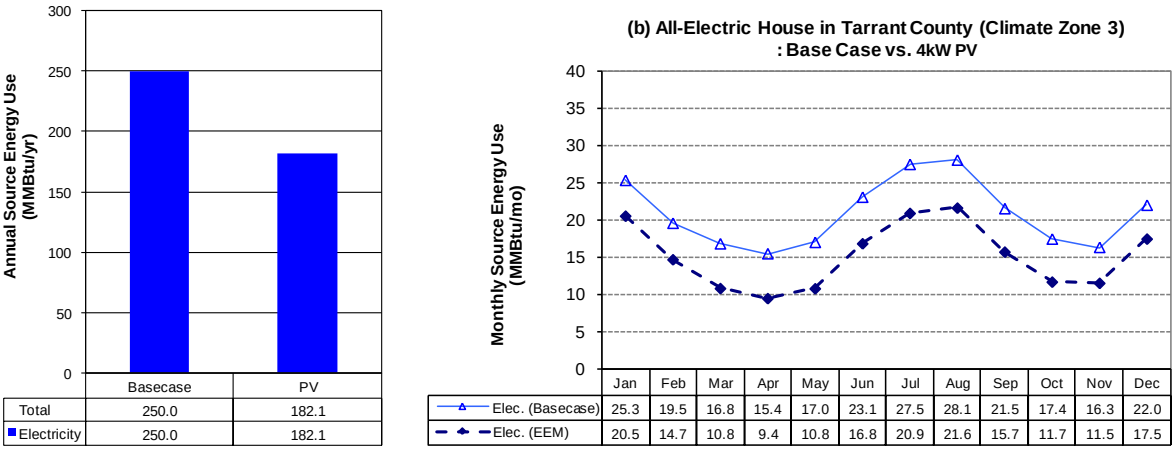


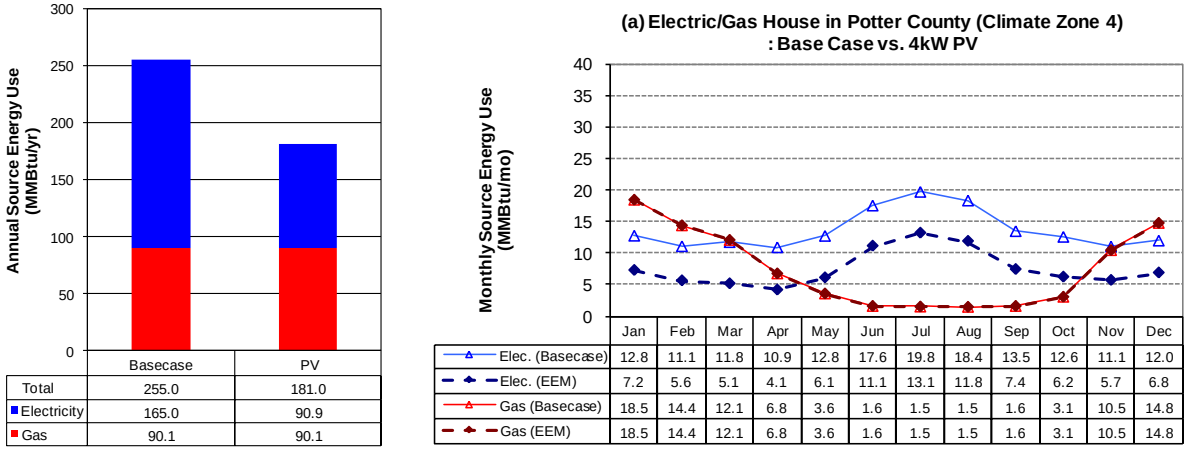
Figure 99. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 18 (4kW PV) in Tarrant County (Climate Zone 3)



	Basecase	PV
Total	250.0	182.1
Electricity	250.0	182.1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	25.3	19.5	16.8	15.4	17.0	23.1	27.5	28.1	21.5	17.4	16.3	22.0
Elec. (EEM)	20.5	14.7	10.8	9.4	10.8	16.8	20.9	21.6	15.7	11.7	11.5	17.5

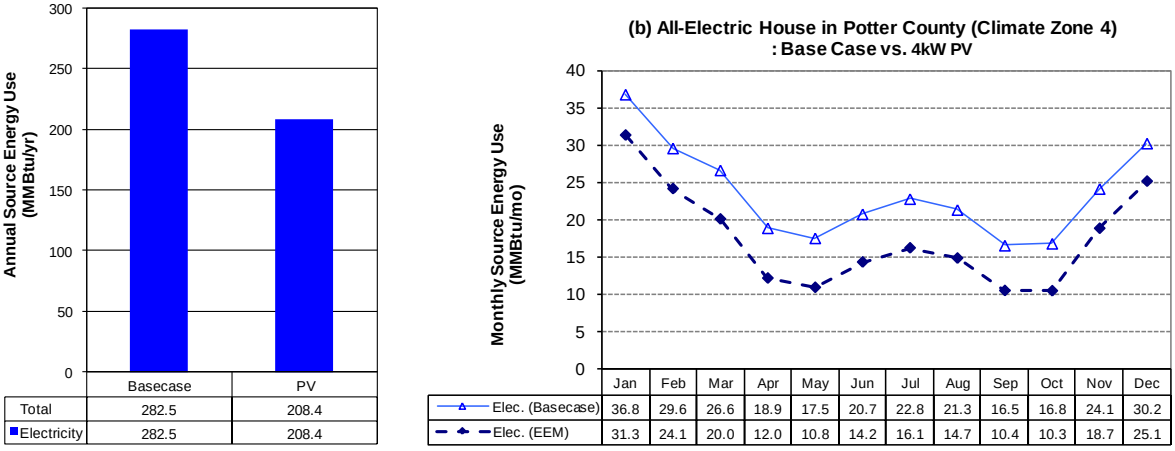
Figure 100. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 18 (4kW PV) in Tarrant County (Climate Zone 3)



	Basecase	PV
Total	255.0	181.0
Electricity	165.0	90.9
Gas	90.1	90.1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	12.8	11.1	11.8	10.9	12.8	17.6	19.8	18.4	13.5	12.6	11.1	12.0
Elec. (EEM)	7.2	5.6	5.1	4.1	6.1	11.1	13.1	11.8	7.4	6.2	5.7	6.8
Gas (Basecase)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8
Gas (EEM)	18.5	14.4	12.1	6.8	3.6	1.6	1.5	1.5	1.6	3.1	10.5	14.8

Figure 101. Annual Source Energy Consumption and Monthly Energy Distribution for an Electric/Gas Base-Case House and EEM 18 (4kW PV) in Potter County (Climate Zone 4)



	Basecase	PV
Total	282.5	208.4
Electricity	282.5	208.4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Elec. (Basecase)	36.8	29.6	26.6	18.9	17.5	20.7	22.8	21.3	16.5	16.8	24.1	30.2
Elec. (EEM)	31.3	24.1	20.0	12.0	10.8	14.2	16.1	14.7	10.4	10.3	18.7	25.1

Figure 102. Annual Source Energy Consumption and Monthly Energy Distribution for an All-Electric Base-Case House and EEM 18 (4kW PV) in Potter County (Climate Zone 4)

REFERENCES

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APPENDIX A COST INFORMATION

Appendix A provides the implementation cost of each EEM obtained from various resources. The ranges of total implementation cost for some measures were modified according to the recommendations of stakeholders. Table A-1 summarizes the cost information for all measures, and the detailed product information and resources are listed in Table A-2 to Table A-6.

Table A-1. Summary of the Cost Information

Envelope and Fenestration Measures		Dimensions /Quantity	Unit Cost ($)	Total Increased Cost ($)	Reference Table (Table A-2)
Base Case	No Radiant Barrier	2,526 sq. ft. roof area	$0/sqft		
EEM 1	Radiant Barrier		$0.12-$0.35/sqft	$300-$880	Table Radiant Barrier - No. 1,2,3,4,5,6
Base Case	Attic Not Sealed	2,325 sq. ft. conditioned floor area			Table Duct-2 - No. 1,2,3,4
EEM2	Attic Sealed		$1.0-$1.5/sqft	$2,000-$3,500	
Base Case	No Window Shading	193 ft. perimeter	$4-$20/linear foot		Table Shading-1 - No. 4; Table Shading-2 - No. 1
EEM 3	2' Eaves		$8-$25/linear foot	$800-$1,000	Table Shading-1 - No. 4; Table Shading-2 - No. 2
Base Case	No Window Shading	193 ft. perimeter	$4-$20/linear foot		Table Shading-1 - No. 4; Table Shading-2 - No. 1
EEM 4	2' Eaves		$8-$25/linear foot	$800-$1,000	Table Shading-1 - No. 4; Table Shading-2 - No. 2
Base Case	0.3 SHGC	No. of (36"x60") windows: 23	$146-$153/Unit		Table Windows-1 -No 5,33
EEM 5	0.2 SHGC		$162/Unit	$200-$400	Table Windows-1 -No 9
Base Case	CZ2: 0.65 U-Value	No. of (36"x60") windows: 23	-		Table Windows-1 -No1, 2
	CZ3: 0.5 U-Value		CZ3:$112/Unit		Table Windows-1 -No 12,13; Table Windows-3-No 2
	CZ4: 0.35 U-Value		CZ4(0.35 SHGC):$105~$130/Unit		Table Windows-1 -No 31
			CZ4(0.3 SHGC):$110~$137/Unit		Table Windows-2 -No 2; Table Windows-3 -No 3
EEM 6	0.3 U-Value		CZ2: $137~$153/Unit	$600-$900	Table Windows-1 -No 5,18,19,20,21,22,23; Table Windows-3-No 3
			CZ3: $137~$153/Unit		
			CZ4(0.35 SHGC):$146/Unit	$350-$900	Table Windows-1 -No 32,33,34,35
			CZ4(0.3 SHGC):$153/Unit		Table Windows-1 -No 5
Base Case	CZ2: 0.3 SHGC and 0.65 U-Value	No. of (36"x60") windows: 23	-		Table Windows-1 -No1, 2
	CZ3:0.3 SHGC and 0.5 U-Value		CZ3: $112/Unit		Table Windows-1 -No 12,13; Table Windows-3-No 2
EEM7	CZ2 and CZ3: 0.2 SHGC and 0.3 U-Value		CZ2 and CZ3: $162/Unit	$900-$1,100	Table Windows-1 -No 7,8,9,10,11
					Table Windows-1 -No 24,25,26,27,28

Table A-1. Summary of the Cost Information (*Continued*)

HVAC System Measures		Capacity	Increased Cost/ Equipment Cost ($)	Labor Cost ($)	Total Increased Cost ($)	Reference Table (Table A-3)
ELECTRIC/GAS HOUSE						
Base Case	Duct in Unconditioned Space	2,325 conditioned floor area		n/a		Table Duct-1 - No. 1,2,3
EEM 8	Duct in Conditioned Space		$0.20/ft.		$1,000-$7,000	
Base Case	SEER 13 Air Conditioning System	5 ton	$3,300-$4,550 (Avg. $3,925)	n/a		Table Air Conditioning with Gas Heat - No. 1,2,5,9
EEM 9	SEER 15 Air Conditioning System		$4,800-$6,560		$900-$2,500	Table Air Conditioning with Gas Heat - No. 3,4,6,10
Base Case	0.78 AFUE Furnace (w/o pilot light)	55,800Btuh	$800-$2,700	n/a		Table Furnace - No. 3,8
EEM 10	0.93 AFUE Furnace (w/o pilot light)		$2,100-$3,500		$800-$1,300	Table Furnace- No. 2,9
ALL-ELECTRIC HOUSE						
Base Case	Duct in Unconditioned Space	2,325 conditioned floor area		n/a		Table Duct-1 - No. 1,2,3
EEM 8	Duct in Conditioned Space		$0.20/ft.		$1,000-$7,000	
Base Case	7.7 HSPF/SEER 13 Heat Pump	5 ton	$1,500-$3,500	n/a		Table Heat Pump- No. 3,5,10,12,14,16,23
EEM9	8.5 HSPF/SEER 15 Heat Pump		$3,500-$6,000		$1,200-$2,500	Table Heat Pump- No. 1,11,13,20,21
DHW System Measures		**Capacity**	**Equipment Cost ($)**	**Installation Cost ($)**	**Total Increased Cost ($)**	**Reference Table (Table A-4)**
ELECTRIC/GAS HOUSE						
Base Case	Tanktype Gas Water Heater w/ pilot light	40/50 Gallon	$260-$360	$340-$530		Table Water Heater-1 - No. 9,10,11,12
EEM11	Tankless Gas Water Heater w/o pilot light	7.4 GPM	$830-$1,400	$640-$830	$900-$1400	Table Water Heater-1 - No. 1,2,3,4,5,6,7,8
EEM12	Tanktype Gas Water Heater w/o pilot light	40/50 Gallon	$350-$800	$340-$530	$100-$500	Table Water Heater-1 - No. 15,19,20
Base Case	No Solar Water Heater		$0	$0		
EEM 13	Solar Water Heater(32 sq.ft collector)	65/80 Gallon	$2,200-$3,000	n/a	$2,200-$3,000	Table Solar Water Heater-1 No. 1,2,4
EEM 14	Solar Water Heater(64 sq.ft collector)	80 Gallon	$3,200-$4,000	n/a	$3,200-$4,000	Table Solar Water Heater-1 No. 2,4,5,6 Table Solar Collector-1 No. 1,2,3,4,5,6,7,8
ALL-ELECTRIC HOUSE						
Base Case	No Solar Water Heater		$0	$0		
EEM 13	Solar Water Heater(32 sq.ft collector)	65/80 Gallon	$2,200-$3,000	n/a	$2,200-$3,000	Table Solar Water Heater-1 No. 1,2,4
EEM 14	Solar Water Heater(64 sq.ft collector)	80 Gallon	$3,200-$4,000	n/a	$3,200-$4,000	Table Solar Water Heater-1 No. 2,4,5,6 Table Solar Collector-1 No. 1,2,3,4,5,6,7,8

Lighting Measures		Quantity		Unit Cost ($)		Total Increased Cost ($)	Reference Table (Table A-5)
		Incandescent	CFL	Incandescent	CFL		
Base Case	0% EnergyStar Permanent CFL or Fluorescent Lamps	28 ~ 56	0	$0.6-$1.3	$4.0-$8.9		Table Incandescent Lamps No. 1,2,3,4 Table CFL-Pin Type (w/ Lampholder) No. 1, 2,3,4,5
EEM15	25% EnergyStar Permanent CFL or Fluorescent Lamps	21 ~ 42	7 ~ 14			$25-$110	
EEM16	50% EnergyStar Permanent CFL or Fluorescent Lamps	14 ~ 28	14 ~ 28			$50-$215	
EEM17	75% EnergyStar Permanent CFL or Fluorescent Lamps	7 ~ 14	21 ~ 42			$70-$320	

Renewable Power Meausres		Capacity	Equipment Cost ($)	Installation Cost ($)	Total Increased Cost ($)	Reference Table (Table A-6)
Base Case	No PV Array		$0	$0		
EEM18	4kW PV	4kW	$10,000-$20,000	$10,000	$20,000-$30,000	Table Solar PV-1 No. 1, 2,3,4,5

Table A-2. Cost Information for Envelope and Fenestration Measures

Radiant Barrier

	Manufacturer	Description	Material ($/500 sqft)	Material ($/sqft)	Pictures	Source
1		Perforated Radiant Barrier is the latest discovery in supreme attic insulation. It consists of a single layer of poly, sandwiched between two sheets of perforated reflective foil.	$73.99	$0.15		http://www.buyfoilinsulation.com/Radiant-Barrier-Perforated-4-x-125-500-sq-ft-?sc=8&category=38
2		"REFLECTIX" RADIANT BARRIER 48" x 125'; Covers 500 sq. ft.; Scrim reinforced perforated.; Use on attic rafters; Reflects 97% radiant energy; Reduces heat during summer and retains heat during winter; Non-toxic & non-carcinogenic.; Not affected by moisture or humidity.; Does not promote growth of mold or mildew.; No special clothing or tools for installation.	$80.99	$0.16		http://www.acehardwareoutlet.com/(dv23awuekfph0v55abyxa245)/productdetails.aspx?sku=5269238&source=GoogleBase
3	Ra-flet	Ra-flect Radiant Barrier (Premium)	$67.00	$0.13		http://www.raflect.com/
4	EcoFoil	Radiant Barrier - Solid	$73.99	$0.15		http://www.buyfoilinsulation.com/Radiant-Barrier-Solid-4x125-500-sq-ft-?sc=11&category=66
5	Innovative insulation	RADIANT BARRIER. Super R Diamond	$59.50	$0.12		http://www.radiantbarrier.com/index.htm?src=adwords&?adg=radiantbarrier&gclid=CLPjndP74KACFRQdswodTiNQLw
6	Innovative insulation	RADIANT BARRIER, Super R Plus (Heavy Duty)	$74.50	$0.15		

Duct-2

No.	Description	Area (ft2)	Material	Roof Venting	Air Sealing at the Top Floor Ceiling	Downsizing Cooling Equipment	Total Increased Construction Cost ($)	Sources
1	Vented Attic	4500	$1,500.00	$750.00	$750.00	$0.00	$ 4500 ($1.0 per ft2)	http://jobsite.buildig.com/articles/greener-building/unvented-attic.aspx
	Unvented Attic		$ 9000 ($2 per ft2)	$0.00	$0.00	-$1,500.00		
2	Unvented Attic	-					$600.00	http://www.ornl.gov/info/ornlreview/v40_2_07/36960-v1.pdf
3	Vented Attic	2325	$.5-$.7 per ft2	n/a	n/a	n/a	$2000-$4000	http://www.toolbase.org/pdf/techinv/insulationalternatives_techspec.pdf
	Unvented Attic	2526	$1.25-$2.25 per ft2	n/a	n/a	n/a		
4	Sealed attics (sometimes referred to as "unvented cathedralized attics") have their insulation and air pressure boundary at the plane of the roof (and gable ends) instead of at the ceiling plane.	2325	$1.0-$1.5 per ft2				$2300-$3500	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspec.pdf

Shading-1

No.	Eave Construction	2007 Unit cost ($/linear foot)	2010 Unit cost ($/linear foot)	Perimeter (ft)	Total Cost ($/house)	Increased Cost	2007 Source	2010 Source
1	Wood Eave with open Soffit including blocking, screened 2" holes for ventilation with paint	$15.28		193	$2,949.04		http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf	http://www.osfm.fire.ca.gov/strucfireengineer/pdf/bml/wuiproducts.pdf http://osfm.fire.ca.gov/strucfireengineer/pdf/CBC/EaveVentPolicy0901Final4Feb09.pdf
2	Wood Eave with enclosed Soffit including blocking, screened 2" holes for ventilation with paint	$19.37		193	$3,738.41			
3	Wood-framed eave with enclosed, stucco-covered Soffit incl. blocking, screened 2" holes for ventilation with paint.	$33.26		193	$6,419.18			
4	Average width of eave: 16 inch	$23.00	$4.00	193	$772.00			dale@jeffersonchristian.net (this will send a message to his phone and he will call back)
	2 ft eave	$39.00	$8.00	193	$1,544.00	$800.00	Paige, Jefferson Christian Custom Homes, August 2006.	

Shading-2 (2 ft Eave, Estimated based on 2007 Survey)

No.	Eave Construction	Procedure	UNIT	Quantity	Unit Cost (Material)	Total Cost (Material)	Unit Cost (Labor)	Total Cost (Labor)	Total Cost ($/LF)	Source
1	Eave with enclosed soffit $ per LF (Assuming eave length as 16 inch)	Install 2"x4" side supports at wall and fascia	LF	3	0.38	1.14	1.73	5.19	6.33	http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf#search=%22Cost-Benefit%20Evaluation%20of%20Proposed%20California%22
		Install 3/8" plywood soffit	SF	1.5	1.36	2.04	1.48	2.22	4.26	
		Install vent screen, 3"	LF	1	0.44	0.44	1.99	1.99	2.43	
		Drill 2" 0 hole	EA	2			2.8	5.6	5.6	
		Paint, primer with 2 finish coats	SF	2	0.34	0.68	0.38	0.76	1.44	
		Total Cost				**4.3**		**15.76**	**20.06**	
2	Increasing Eave Length to 2ft	Install 2"x4" side supports at wall and fascia	LF	4	0.38	1.52	1.73	6.92	8.44	
		Install 3/8" plywood soffit	SF	2	1.36	2.72	1.48	2.96	5.68	
		Install vent screen, 3"	LF	1	0.44	0.44	1.99	1.99	2.43	
		Drill 2" 0 hole	EA	2			2.8	5.6	5.6	
		Paint, primer with 2 finish coats	SF	2	0.34	0.68	0.38	0.76	1.44	
		Increased Roof Area	SF	1.5	1	1.5			**1.5**	
		Total Cost				**6.86**		**18.23**	**25.09**	
	Increased cost per house:		**Total perimeter**	**193**					**970.79**	

Windows-1 (2010 Survey)

Item	No.	U-Value	SHGC	Total Unit Cost ($/Unit)	Description	Window Type	Frame	Glazing Type	Remark
Climate Zone 2 Base Case	1	0.59	0.29		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spaces, 1/8 RLE7138, Air, 1/8 RLE7138; with flat grids	MI Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
	2	0.56	0.32		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spaces, 1/8 RLE7138, Air, 1/8 RLE7138; without grids	
Climate Zone 2 EEM	3	0.6	0.2		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 1/8" Clear (Inside), Air, 1/8 Tinted Low E (Outside); with	
	4	0.57	0.24		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 1/8" Clear (Inside), Air, 1/8 Tinted Low E (Outside);	
	5	0.3	0.27	$153	Tech View 270	Single-Hung	Vinyl	no grids, Low-E 270, Argon	Enercon Windows & Hardware 1312 W Villa Maria Rd Bryan, TX 77801 979-823-3639 (Brad Beard 3-31-2010)
	6	0.3	0.25	$208	CertainTeed Bryn Mawr	Single-Hung	Vinyl	no grids, Low-E, Argon	
	7	0.31	0.19		200 Series Tilt-Wash Double-Hung	Double-Hung	Wood	Tempered, Low-E SmartSun™ Tempered with Finelight™	Anderson Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
	8	0.29	0.18		400 Series Woodwright® Full- Frame Double-Hung Window	Double-Hung	Wood	HP Low-E4® Sun with Finelight™ Grilles	
	9	0.28	0.2	$162	Tech View (CertainTeed Generic) 366	Single-Hung	Vinyl	no grids, Low-E 366, Argon	Enercon Windows & Hardware 1312 W Villa Maria Rd Bryan, TX 77801 979-
	10	0.27	0.23		Simonton ProFinish Contractor	Casement		no grids; Low-E 270/Lami (.060); Argon	Simonton Windows 1-800-SIMONTON or A&A Home Craftsman 361-289-0058 (arthur-mills1@hotmail.com)
	11	0.27	0.17		Simonton ProFinish Contractor	Casement		no grids; Low-E366/Lami (.060); Argon	
Climate Zone 3 Base Case	12	0.5	0.28	$423	RAM S900 W/SOLAR BAN 60 CSMT 1LT	Casement	Alum., painted,	Interior Glaze, Low-E, No Argon, Insulated Glass	Ram Windows (Barbara 281-495-9056, ext 14; 3/25-26/2010)
	13	0.49	0.36		MI Windows and Doors, Series 3540	Single-Hung	Vinyl	3/16" clear insulated glass (outside), 3/16" gray tint (inside) with flat	MI Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
	14	0.5	0.25		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 1/8" Clear (Inside), Argon, 1/8 LOE366 (Outside); without	
	15	0.53	0.25		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 3/32" Clear (Inside), Argon, 3/32 LOE366 (Outside);	
Climate Zone 3 EEM	16	0.53	0.22		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 1/8" Clear (Inside), Argon, 1/8 LOE366 (Outside); with flat	
	17	0.55	0.23		MI Windows and Doors, Series TX165 Non-Thermal	Single-Hung	Aluminum	Duraseal Spacer, 3/32" Clear (Inside), Argon, 3/32 LOE366 (Outside); with	
	18	0.3	0.27	$153	Tech View 270	Single-Hung	Vinyl	no grids, Low-E 270, Argon	Enercon Windows & Hardware 1312 W Villa Maria Rd Bryan, TX 77801 979-
	19	0.3	0.28		Simonton ProFinish Contractor	Single-Hung		no grids, Low-E 270/Lami (.060); Krypton; intercept spacer	Simonton Windows 1-800-SIMONTON or A&A Home Craftsman 361-289-0058 (arthur-mills1@hotmail.com)
	20	0.29	0.27		Simonton ProFinish Contractor	Single-Hung		no grids, TiAC36/Lami (.060); Krypton; intercept spacer	
	21	0.29	0.27		Simonton ProFinish Contractor	Double-Hung		no grids, TiAC36/Clear; Krypton; intercept spacer	
	22	0.31	0.28		Simonton ProFinish Contractor	Double-Hung		no grids, TiAC36/Lami (.060); Krypton; Super spacer	
	23	0.3	0.31		MI Windows and Doors, Series 3540	Single-Hung	Vinyl	1/8|030PVB|1/8 Clear, Argon, 1/8" Low-E; without grids	MI Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-
	24	0.31	0.19		200 Series Tilt-Wash Double-Hung	Double-Hung	Wood	Tempered, Low-E SmartSun™ Tempered with Finelight™	Anderson Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
	25	0.29	0.18		400 Series Woodwright® Full- Frame Double-Hung Window	Double-Hung	Wood	HP Low-E4® Sun with Finelight™ Grilles	
	26	0.28	0.2	$162	Tech View (CertainTeed Generic) 366	Single-Hung	Vinyl	no grids, Low-E 366, Argon	Enercon Windows & Hardware 1312 W Villa Maria Rd Bryan, TX 77801 979-
	27	0.27	0.23		Simonton ProFinish Contractor	Casement		no grids; Low-E 270/Lami (.060); Argon	Simonton Windows 1-800-SIMONTON or A&A Home Craftsman 361-289-0058 (arthur-mills1@hotmail.com)
	28	0.27	0.17		Simonton ProFinish Contractor	Casement		no grids; Low-E366/Lami (.060); Argon	

Windows-1 (2010 Survey) *(Continued)*

Item	No.	U-Value	SHGC	Total Unit Cost ($/Unit)	Description	Window Type	Frame	Glazing Type	Remark
Climate Zone 4 Base Case	29	0.46	0.53		200 Series Tilt-Wash Double- Hung Window	Double-Hung	Wood	Tempered, Clear Dual Pane, with Finelight™Grilles	Anderson Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
	30	0.44	0.53		Anderson 200 Series Casement	Casement	Wood	Clear Dual Pane Tempered with Finelight™ Grilles	
	31	0.35	0.37		MI Windows and Doors, Series 3540	Single-Hung	Vinyl	1/8 Tinted Lo-E, Airspace, 1/8|030PVB|1/8 Clear; without grids	MI Windows; Probuild Co LLC - 23518 Coons Rd Tomball, TX 77375 (281 351-9883) Dave Weir (Aggie) 832-928-0519
Climate Zone 4 EEM	32	0.31	0.38		MI Windows and Doors, Series 3540	Single-Hung	Vinyl	1/8 Tinted Lo-E, Argon, 1/8|030PVB|1/8 Clear; without grids	
	33	0.31	0.34	$146	American Craftsman Single Hung Vinyl Windows	Single-Hung	Vinyl	5/8", insulated, Low-E, Argon, Screen	Home Depot (Charles, 3/31/2010)
	34	0.33	0.42		Simonton ProFinish Contractor	Casement		Clear/Clear; Air fill, Intercept spacer	Simonton Windows 1-800-SIMONTON or A&A Home Craftsman 361-289-0058 (arthur-mills1@hotmail.com)
	35	0.32	0.42		Simonton ProFinish Contractor	Casement		Clear/Clear; Air fill, Super spacer	

Windows-2 (2007 Survey)

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	SHGC	Daylight Transmittance	2007 Price ($)	Manufacturer /Distributor	Contact Person
1	Thermflect/Argon, Low-Conductance Spacer, Double Pane	Vinyl	Single-Hung w/o Grid	36" X 60"	0.31	0.25	0.29	0.71	Builder's Cost: $170	CertainTeed http://www.certainteed.com	Enercon Windows & Hardware 1312 W Villa Maria, Bryan, Texas 77801 (979) 823-3639 Communication with Oscar Beard on 05/17/2006.
2	Air-filled, Low-e, Double Pane	Aluminum	Single-Hung w/o Grid	36" X 60"	0.37		0.29	0.67	Builder's Cost: $110	Atrium Companies, Inc, HR Windows®	
3	Air-filled, Double Pane	Aluminum	Single-Hung w/o Grid	36" X 60"	0.52		0.6	0.81	Builder's Cost: $82	Atrium Companies, Inc, HR Windows®	

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

Windows-3 (2007 Survey)

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	SHGC	Daylight Transmittance	2007 Price ($)	Manufacturer/Distributor	Contact Person
1	Air-filled	Aluminum	Single-Hung w/ Grid	36" X 60"	0.67		0.68	0.7	$88.00	MI Windows and Doors- BetterBilt	LOWE'S OF BRYAN, TX #0103 3225 FREEDOM BLVD. BRYAN, TX 77802 (979) 774-4141 Visiting Date: 5/25/2006
2	Air-filled low-e	Aluminum	Single-Hung w/ Grid	36" X 60"	0.55		0.33	0.55	$112.00	MI Windows and Doors- BetterBilt	
3	Air filled low-e	Vinyl	Single-Hung w/o Grid	36" X 60"	0.35		0.32	0.58	$137.00	Pella - ThermaStar	
4	Argon-filled low-e	Vinyl	Single-Hung w/o Grid	36" X 60"	0.33		0.31	0.58	$210.40	Pella - ThermaStar	
5	Air-filled low-e	Wood	Double-Hung w/o Grid	36" X 60"					$243.00	Pella	

Note: All windows listed above are insulated window unit.

Windows-4 (2010 Survey)

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	SHGC	Visible Trans-mittance	Item #	2010 Price ($)	Manufacturer/Distributor	Contact Person
1	Air-filled low-e	Aluminum	Single-Hung w/ Grid	36" X 60"	0.55		0.33	0.55	6963	$106.00	MI Windows and Doors- BetterBilt	LOWE'S OF BRYAN, TX #0103 3225 FREEDOM BLVD. BRYAN, TX 77802 (979) 774-4141 Visiting Date: 4/14/2010
2	Air-filled	Aluminum	Single-Hung w/ No Grid	36" X 60"	0.66		0.68	0.7	109933	$81.00	MI Windows and Doors- BetterBilt	
3	Air-filled	Aluminum	Single-Hung w/ Grid	36" X 60"	0.68		0.61	0.63	108482	$106.00	MI Windows and Doors- BetterBilt	
4	Air-filled low-e	Vinyl	Single-Hung w/o Grid	36" X 60"	0.34		0.28	0.51	194900	$148.00	Pella - ThermaStar	

Windows-5 (2010 Survey)

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	SHGC	Visible Trans-mittance	2010 Price ($)	Manufacturer/Distributor	Contact Person
1	Low-e glass	Aluminum	Single-Hung w/ Grid	36" X 60"	0.35		0.34		$105.00	H-R	Home Depot 1615 University Drive East,College Station,TX,(979)595-1188 Visiting Date: 4/14/2010
2	Low-e glass	Aluminum	Single-Hung w/ Grid	36" X 60"	0.35		0.34		$130.00	H-R	
3	Low-e glass	Vinyl	Single-Hung w/ Grid	36" X 60"	0.35		0.34		$177.00	H-R	

Note: The information above was provided by service assistant in Home Depot and there are no product samples

Windows-6 (2010 Survey)

No.	Glazing Type	Frame	Window Style	Window Size	Total Unit U Value	Center of Glass U-Value	SHGC	Visible Trans-mittance	2010 Price ($)	Manufacturer/Distributor	Contact Person
1	LOE 366/Argon	Vinyl	Single-Hung w/ Grid	36" X 60"	0.28		0.2	0.47		BURRIS WINDOW	Enercon Windows & Hardware 1312 W Villa Maria, Bryan, Texas 77801 (979) 823-3639 Communication with Tom Ferguson on 4/14/2010.
2	Argon	Vinyl	Double-Hung w/o Grid	36" X 60"	0.3		0.25	0.46		Certain Teed	

Note: The prices were not provided by Tom Ferguson and he said only the owner who might be available on Friday (4/16/2010) would give the price.

Table A-3. Cost Information for HVAC Measures

Duct-1

No.	Description	Conditioned Floor Area (ft2)	HVAC Material*	HVAC Labor	Incremental Framing Cost ($)	Incremental Drywall Cost ($)	Total Increased Construction Cost ($)	Sources
1	Side-by-side comparison of two identical single-story homes where ductwork was installed after drywall was complete using a bulkhead dropped down from the ceiling,which ran along the long axis of the house; Supply branches, perpendicular to the supply line, were fitted with high-throw diffusers placed at room interior walls						**$230.00**	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspec.pdf
2	Duct in Unconditioned Space		$252.00	$103.00	n/a	n/a	**$355.00**	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspec.pdf
	Duct in Conditioned Space		$201.00	$100.00	$50.00	$282.00	**$633.00**	
3	In the affordable home with simple floor plan, ducts were created with trunk line spanning length of home in constructed bulkhead along first-floor ceiling; Registers off the trunk line serve both floors. A central return was provided at the landing of an open stairway	2325	Increased cost: $0.2 per ft2				**$465.00**	http://www.toolbase.org/pdf/techinv/ductsinconditionedspace_techspec.pdf

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

Air Conditioning with Gas Heat

Item	No.	2007 Price	2010 Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	2007 Source and Contact Info		2010 Information/Contact
Air Conditioning with Gas Heat (Carrier)	1	$4,550	approx $5100	Carrier	Electric for cooling, gas for heating	Condenser: 24ABR360 Coil: CNRHP6024 Furnace: 58STA110-1-22	13 SEER/ 80%AFUE	5 ton	R-22 phase out refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com(Date: 05/12/2006)	Central Texas Air Conditioning Service Inc (979) 846-4660 Communication with Jerry Anthony on 05/12/2005.	**Central Texas Air cthreadgill@centraltexasair.com(Chris Threadgill)**
	2	$5,424	approx $5100	Carrier	Electric for cooling, gas for heating	Condenser: 24ABa360 Coil: CNRHP6024 Furnace: 58STA110-1-22	13 SEER/ 80%AFUE	5 ton	R-410A EPA compliant refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com(Date: 05/12/2006)		
	3	$6,276	approx $6400	Carrier	Electric for cooling, gas for heating	Out of stock, no longer available	15 SEER/ 80% AFUE	5 ton	R-22 phase out refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com(Date: 05/12/2006)		
	4	$6,561	approx $6400	Carrier	Electric for cooling, gas for heating	Condenser: 24ACA560 Coil: CNRHP6024 Furnace: 58STA110-1-22	15 SEER/ 80%AFUE	5 ton	R-410A EPA compliant refrigerant; Pilot-free PowerHeat™ ignition		http://www.residential.carrier.com(Date: 05/12/2006)		
Air Conditioning with Gas Heat (Lennox)	5	$3,933	**$3,987**	**Lennox**	**Electric for cooling, gas for heating**		13 SEER/ 80%AFUE	**5 ton**	**Ref. Type: R-22, Gas Furnace: 135000 Btu/hr**		**http://www.smarterwayinc.com/res_systems/gas_furnace/Lennox.asp**	**Barker's Htg & Cooling Inc 400 Graham Rd College Station, TX 77840 (979-690-2278)**	**Barker's Htg & Cooling Inc 400 Graham Rd College Station, TX 77840 (979-690-2278) Contacted Phillip on 3-15-2010**
	6	$5,786	**$6,295**	**Lennox**	**Electric for cooling, gas for heating**	**XE-16 series**	**15 SEER/ 80%AFUE**	**5 ton**	**Ref. Type: R-410A, Gas Furnace: 135000 Btu/hr**		**http://www.smarterwayinc.com/res_systems/gas_furnace/Lennox.asp**		
Air Conditioning with Gas Heat (All Makers)	7	$4,500	**will call back, but figure ↑10% increase**	All Makers	Electric for cooling, gas for heating	n/a	13 SEER/ 80%AFUE	5 ton	$1,300 / Ton including duct work $6,500 for 5-ton unit with duct work $4,500 for 5-5on unit without duct work		Aggieland A/C & Heating	**979-696-1333 (Tommy)**	**979-696-1333 (Tommy) 3-16-2010**
	8	$6,200		All Makers	Electric for cooling, gas for heating	n/a	15 SEER/ 80%AFUE	5 ton	$1,615 / Ton including duct work $8,075 for 5-ton unit with work $6,200 for 5-ton unit without duct work		Aggieland A/C & Heating	**979-696-1333 (Tommy)**	**979-696-1333 (Tommy) 3-16-2010**
	9	$12,000	**4500 + $12/sqft+misc equip (300)**	All Makers	Electric for cooling, gas for heating	n/a	13 SEER/ 80%AFUE	5 ton	$12,000 includes duct work.		ACC-Aggieland Climate Control	**979-450-2653 (Jose Rodrigueg)**	**ACC-Aggieland Climate Control 3-16-2010 Talked to Clay.**
	10	$13,000	**5500 +12/ft for duct +300**	All Makers	Electric for cooling, gas for heating	n/a	15 SEER/ 80%AFUE	5 ton	$13,000 includes duct work.		ACC-Aggieland Climate Control	**979-450-2653 (Jose Rodrigueg)**	**ACC-Aggieland Climate Control 3-16-2010 Talked to Clay.**
	11	$3,300	**10-15% increase**	**All Makers**	**Electric for cooling, gas for heating**	**n/a**	**13 SEER/ 80%AFUE**	**5 ton**	**$1,500 / Ton including duct work. $7,500 for 5-ton unit with duct work $3,300 for 5-ton unit (No Duct Work & No Labor)**		**IntelAir Heating & Cooling LLC**	**979-219-2767 (Eric Burch)**	**Intelair Heating & Cooling LLC (979) 219-2767 no website**
	12	$4,800		**All Makers**	**Electric for cooling, gas for heating**	**n/a**	**15 SEER/ 80%AFUE**	**5 ton**	**$1,800 / Ton including duct work $9,000 for 5-ton unit with duct work $4,800 for 5-ton unit (No Duct Work & No Labor)**		**IntelAir Heating & Cooling LLC**	**979-219-2767 (Eric Burch)**	**Intelair Heating & Cooling LLC (979) 219-2767 no website**

NOTE: New code for CSJF 13, you have to use R-8 insulation on duct. So most people just use SEER 14 and that way they can stick with R-6. This is for new systems. Old systems with old duct work can be grandfathered.

Furnace

Item	No.	20007 Price	2010 Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	2007 Source and Contact Info		2010 Information/Contact
Gas Furnace (Carrier- up to 96.6% AFUE)	1	-	$3700 - 4800	Carrier	Natural Gas	58MVB	96.6% AFUE	40,000 - 120,000 BTUH	Infinity 96 Gas Furnace; Muitipoise, condensing, direct vent/non direct vent gas furnace; Variable speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)		Central Texas Air Conditioning Service Inc (979) 846-4660 threadgill@centraltexasair.com (Chris Threadgill))
	2	About $1000 increase in cost	$3,460.00	Carrier	Natural Gas	58MTB	93% AFUE	38,000 - 128,000 BTUH	Performance 93 Gas Furnace; Muitipoise, condensing, direct vent/non direct vent; 4-5 speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)		Malek Service - 10464 State Highway 30 College Station, TX 77845 Phone:979-776-2222 Fax:979-776-2282 Contact: Robin (3-24-2010)
	3		$2,700.00	Carrier	Natural Gas	58CTA, 58CTX	80% AFUE	40,000 - 154,000 BTUH	Performance 80 Gas Furnace; Induced-combustion; Enhanced comfort control with dual stages of heating; 4-5 speed blower; Pilot-free PowerHeat™ ignition.		http://www.residential.carrier.com/products/furnaces/gas/index.shtml (Date: 5/11/2006)		
Gas Furnace (Goodman- 80% to 93% AFUE)	4	$1063/$768	-	Goodman	Natural Gas	GMV81155CXA/GMS81155CNA	80% AFUE	115,000 BTUH	GMV8 Series 80% AFUE Two-Stage, Variable-Speed/GMS8/GDS8 Series 80% AFUE Single-Stage, Multi-Speed; Upflow /Horiz.		http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp		does not seem to be available anymore
	5	$1,658.00	-	Goodman	Natural Gas	GMV91155DXA	93% AFUE	115,000 BTUH	GMV9/GCV9 Series 93% AFUE Two-Stage, Variable-Speed, Upflow /Horiz.		http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp		does not seem to be available anymore
Gas Furnace (Rheem- 80% to 93% AFUE)	6	$1,200.00	~10% increase	Rheem	Natural Gas	RGPN15EARJR	80% AFUE	125,000BTUH	Rheem® Natural / Propane Gas Furnaces			A Top Tech, (979) 696-1333	979-696-1333 (Tommy) 3-16-2010
	7	$2100/$2300		Rheem	Natural Gas	RGRA12ERAJS/RGFD12ERCMS	93% AFUE	120,000 BTUH	Rheem® 1-Stage Multi-Speed / Rheem® Modulating Variable Speed				
Gas Furnace (Lennox- 80% to 93% AFUE)	8	$1,314.00	$827.00	Lennox	Natural Gas	G40UH60D135	80% AFUE	132,000 BTUH	Up/Horiz		Barkers Heating and Cooling, http://www.smarterwayinc.com/res_components/gas_furnace/lennox.asp	(979) 690-2278 (Charlie)	Barker's Htg & Cooling Inc (979) 690-2278 (Phillip 3-15-2010)
	9	$2492/$2043	2753 / 2042	Lennox	Natural Gas	G61MPV60D135/G61MP60D135	94% AFUE	132,000 BTUH	Lennox Signature® Collection G61V 94+% AFUE Two-Stage, Variable-Speed Furnaces/Lennox Signature® Collection G61 94.1% AFUE Two-Stage, Multi-Speed Furnaces. Up/Horiz./Down				
AC/Furnace (Goodman)	10	-	$2,502.00	Goodman		GSC130601/CAPF4860C6/GMS80905CN	13 SEER, 80% AFUE	5 ton (90,000 Btu/h)	Air Conditioning/Gas Furnace System		https://www.expresshvac.com		Express HVAC
	11	-	$3,075.00	Goodman		GSC140601/CAPF4860D6/GKS91155DX	14 SEER, 92.1% AFUE	5 ton (115,000 Btu/hr)	Air Conditioning/Gas Furnace System		http://acdirect.com/ (Date: 05/11/2006)		Express HVAC
	12	-	$15,560.00	Goodman		GMVC80704BX	14 SEER, 92.1% AFUE	5 ton (115,000 Btu/hr)	Goodman GPG13601401A -13 Seer- 5 TON Cooling / 138,000 BTU Heating		http://acdirect.com/ (Date: 05/11/2006)		http://www.alpinehomeair.com

Heat Pump

Item	No.	2007 Price	2010 Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	2007 Source and Contact Info		2010 Information/Contact
Heat Pump (Carrier - Up to 19 SEER and 9.5 HSPF)	1	-	4890 (including labor)	Carrier	Electric	25HPA3	15 SEER/8.5 HSPF	Heating Capacity: 18,000 - 60,000 Btu/h Cooling Capacity: 1.5 - 5 tons	Carrier Performance Series Heat Pump; Versatile heating and cooling heat pump for maximum home comfort; Up to 15 SEER and 9.0 HSPF; Models include 25HPA5, 25HPA4, 25HPA3, 25HPR3, 38YXA, 38YZA, 38YSP.		http://www.residential.carrier.com/products/acheatpumps/heatpumps/index.shtml (Date: 5/12/2006)		http://www.champion-hvac.com/hp-carrier.htm
	2	-	4200 (including labor)	Carrier	Electric	25HCA3	13 SEER/8 HSPF	Heating Capacity: 18,000 - 60,000 Btu/h Cooling Capacity: 1.5 - 5 tons	Carrier Comfort Series Heat Pump Economical heating and cooling heat pump for optimal home comfort; Up to 14 SEER and 8.5 HSPF; Models include 25HCA4, 25HCA3, 25HCR3, 38YRA, 38YSA.		http://www.residential.carrier.com/products/acheatpumps/heatpumps/index.shtml (Date: 5/12/2006)		http://www.champion-hvac.com/hp-carrier.htm
Heat Pump (Goodman)	3	$3,189.00	1500-2800	Goodman	Electric	GSH130601A ARUF061	13 SEER/8.5 HSPF	Heating Capacity: 55000 Btu/h Cooling Capacity: 5 ton	Goodman 5 Ton 13 Seer Air Conditioning System with Heat Pump; One Goodman fully charged outdoor heat pump air conditioning condensing unit; One matched indoor air handling unit; One supplemental heating element.		Price: http://acdirect.com/ (Date: 05/11/2006) Product: http://www.goodmanmfg.com/		Google Products
	4	$3,492.00	not found	Goodman	Electric	GSH140601A AEPF4260	14.5 SEER/8.5 HSPF	Heating Capacity: 55000 Btu/h Cooling Capacity: 5 ton	Goodman 5.0 Ton 14.5 Seer Air Conditioning System with Heat Pump: One Goodman fully charged outdoor heat pump air conditioning condensing unit ; One matched indoor air handling unit, multi-position including evaporator cooling coil ; One supplemental heating element up to 15 Kw (10Kw up to 3 Ton)		http://acdirect.com/heat_pump_goodman_heat_pump_rudd_heat_pump_.php (Date: 07/31/06)		
Heat Pump (Ruud)	5	$3,591.00	~10% increase	Ruud	Electric	UPNE-060JAZ UHLA-HM6024JA	13 SEER/8.5 HSPF	Heating Capacity: 57000 Btu/h Cooling Capacity: 5 ton	Achiever by Ruud 5 Ton 13 Seer Variable Speed Air Conditioning System with Heat Pump; One Ruud UPNE series 13 SEER heat pump condenser; One matched indoor air handling unit; One Ruud supplemental electric heating kit.		Price: http://acdirect.com/ (Date: 05/11/2006) Product: http://www.ruudac.com		979-696-1333 (Tommy) 3-16-2010
	6	$4,366.00		Ruud	Electric		14 SEER/8.5 HSPF		One Ruud UPNE series 14 SEER heat pump condenser One Ruud factory-matched indoor air handler One Ruud supplemental electric heating kit (with electric heat and heat pumps)		http://acdirect.com/xcart/product.php?productid=290 (Date: 07/31/06)		
Heat Pump (Rheem)	7	$4,400.00	~10% increase	Rheem	Electric		13 SEER	5 ton	Price includes labor but not duct work			A Top Tech (979) 696-1333	979-696-1333 (Tommy) 3-16-2010
	8	$5,100.00	~10% increase	Rheem	Electric		14 SEER	5 ton	Price includes labor but not duct work				
	9	$6,100.00	~10% increase	Rheem	Electric		16 SEER	5 ton	Price includes labor but not duct work				
Heat Pump (All Makers)	10	$5,000.00	~10% increase	All Makers	Electric.	n/a	13 SEER/8.5 HSPF	5 ton	$1400 / Ton including duct work $7000 for 5-ton unit with duct work $5000 for 5-ton unit without duct work		Aggieland A/C & Heating	979-696-1333 (Tommy)	left 979-696-1333 (Tommy) 3-16-2010
	11	$7,000.00		All Makers	Electric.	n/a	15 SEER/8.5 HSPF	5 ton	$1800 / Ton including duct work $9000 for 5-5on unit with duct work $7000 for 5-ton unit without duct work		Aggieland A/C & Heating	979-696-1333 (Tommy)	le979-696-1333 (Tommy) 3-16-2010
	12	$3,600.00	~1200 increase	All Makers	Electric.	n/a	13 SEER/ 8.5 HSPF	5 ton	$1,800 / Ton including duct work $9000 for 5-ton unit with duct work $3600 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC	979-219-2767 (Eric Burch)	Talked to Clay.
	13	$5,800.00		All Makers	Electric.	n/a	15 SEER/ 8.5 HSPF	5 ton	$2,000 / Ton including duct work $10000 for 5-ton unit with duct work $5800 for 5-ton unit (No Duct Work & No Labor)		IntelAir Heating & Cooling LLC	979-219-2767 (Eric Burch)	Talked to Clay.

Heat Pump *(Continued)*

Item	No.	2007 Price	2010 Price	Brand	Type of Fuel	Model	Efficiency	Capacity	Description	Pictures	2007 Source and Contact Info		2010 Information/Contact
Heat Pump (Trane)	14	$4,050.00	$1,955.00	Trane	Electric	2TWR3060A1	13 SEER/ 8.5 HSPF	5 ton	$2700 for installation		JC Innovative Services	979-778-9990 (John Gipson)	JG Innovative Services 222 Marino Road Bryan, TX 77808 979-778-9990 (David) 3-16-2010
	15	$4,950.00	no longer made	Trane	Electric.	2TWZ9060B1	15 SEER/ 8.75HSPF	5 ton	$3300 for installation		JC Innovative Services	979-778-9990 (John Gipson)	JG Innovative Services 222 Marino Road Bryan, TX 77808 979-778-9990 (David) 3-16-2010
Heat Pump (Lennox)	16	$3,584.00	$3,383.00	Lennox	Electric	XP13 series	13 SEER/ 8.5 HSPF	5 ton	installation = ~$8,250		http://www.smarterwayinc.com/res_systems/heat_pump/heatpump1.asp#Lennox		Barker's Htg & Cooling Inc 400 Graham Rd College Station, TX 77840 (979-690-2278) Contacted Phillip on 3-15 and 3-16 2010
	17	$5,872.00	$4,059.00	Lennox	Electric.	XP 16 series	16 SEER/ 8.75HSPF	5 ton	R-410 xp16-060 installatiopn = ~$11,250		http://www.smarterwayinc.com/res_systems/heat_pump/heatpump1.asp#Lennox		
Heat Pump - Carrier	18	-	$11,000.00	Carrier	Electric	25HPA6	16.5 SEER/9.5 HSPF	Heating Capacity: 24,000 - 60,000Btu/h Cooling Capacity: 2 - 5 tons	Carrier Performance Series Heat Pump; Versatile heating and cooling heat pump for maximum home comfort; Up to 15 SEER and 9.0 HSPF; Models include 25HPA5 (15SEER/8,5HSPF)and 25HPA6		http://www.residential.carrier.com/products/acheatpumps/heatpumps/performance.shtml	Central Texas AC Service - 1910 Greenfield Plaza, Bryan, TX 77802 (979) 846-4660	Central Texas Air Conditioning Service Inc (979) 846-4660 threadgill@centraltexasair.com (Chris Threadgill)) 3-18-2010
	19	-	$16,247.00	Carrier	Electric	25HNA9	19 SEER/9.5 HSPF	Heating Capacity: 24,000 - 60,000Btu/h Cooling Capacity: 2 - 5 tons	Carrier's exclusive Infinity® Series heat pump has two stages, operating with less power longer. And we engineered it to team with an Infinity Series furnace to create an economical HYBRID HEAT® dual fuel system, which saves you year-round. 25 HNA6 has 16.6 SEER/9.3 HSPF		http://www.residential.carrier.com/products/acheatpumps/heatpumps/infinity.shtml	Central Texas AC Service - 1910 Greenfield Plaza, Bryan, TX 77802 (979) 846-4660	
	20	-	$7,159.00	Carrier	Electric	25HBB5	15 SEER/8.8 HSPF	Heating Capacity: 18,000 - 60,000Btu/h Cooling Capacity: 1.5 - 5 tons	The Base heat pump is our most economical way to provide year-round home comfort. Its efficient cooling system, with up to 15.0 SEER, reverses during cooler weather for low-cost electric heat.		http://www.residential.carrier.com/products/acheatpumps/heatpumps/infinity.shtml	Central Texas AC Service - 1910 Greenfield Plaza, Bryan, TX 77802 (979) 846-4660	
Heat Pump TRANE	21	-	3500-5000	Trane	Electric	4TWB4060E	up to 15 SEER/ up to 8.5 HSPF	Cooling Capacity: 60,000 Btu/h (Nomial 5 tons)	price depends on inside unit, square footage, plans, windows, orientation (most installers will ask you for all this information before you buuy a unit. Check the J-book specifications.		http://www.trane.com/Residential/Products/Heat-Pumps		Climate Masters of BCS 979-985-5839 spoke with Richard.
	22	-	8000-10000	Trane	Electric	4TWZ0060A	up to 19 SEER/ up to 9 HSPF	Nominal Capacity: 5 tons	2 stage compressor "Cadillac." must be used with communicator. Price does not include duct work.		http://www.trane.com/Residential/Products/Heat-Pumps		
Rheem® Heat Pump Self-Contained Package Units	23		$3,520.00	Rheem	Electric	Rheem RQNJA060JK000	13 SEER	5 ton					HVAC\ExpressHVAC.pdf OR http://www.expresshvac.com/res_systems/package/HVAC_package.asp
	24		$3,779.00	Rheem	Electric	Rheem RQPMA060JK000	14 SEER	5 ton					

Table A-4. Cost Information for DHW Measures

Water Heater -1

Item	No.	2007 Price	2010 Price	Brand	Type of Fuel	Model	Energy Factor	Capacity	Description	Pictures	Source	Contact Person	2010 Contact Info
Tankless Gas Water Heater	1	$999.00	$865.00	Paloma	Natural Gas	Model PTG-74PVN	0.82	7.4 GPM	Whole Home 7.4 GPM Natural Gas Tankless Water Heater With Remote Control; Electronic iginition; Supplies hot w ater for 2 to 3 applications; 199,900 BTU burner.		http://w w w .homedepot.com/ (Date: 05/09/2006)		Home Depot no longer carries NG Paloma Brand . Try http://w w w .heater-store.com
	2		$1050, w ith tax credit	Paloma	Natural Gas	PH-28RIFS	0.82	8.5 GPM	Paloma 7.4 Series Residential Indoor Gas Tankless Water Heater. Remote controller included. Optional remote controllers available. Model for indoor installations only.		http://w w w .palomaw aterheaters. com/products.html#residential		http://w w w .besthotw aterheaters. com/catalogue_product.php?id=327
	3	$949.00	$1,294.00	Bosch AquaStar	Natural Gas	Model 250SX-NG	0.85	6.4 GPM	Whole House Gas Tankless Water Heater; Electronic iginition; Supplies hot w ater for 2 applications.		http://w w w .homedepot.com/ (Date: 05/09/2006)	Internet Price	Amazon.com
	4		$835.00	Bosch AquaStar	Natural Gas	Model 125FX	0.78	4.6GPM			http://w w w .boschhotw ater.com/Portals/7/Marketing/125FX.pdf		Click here to see brochure; see also http://w w w .amazon.com/Bosch-AquaStar-Natural-Tankless-NG/dp/B0006GVNT0
	5	$929.00	$1,149.00	Rheem	Natural Gas	RTG-74PVN	0.82	7.4 GPM	Rheem Tankless 7.4 GPM- Indoor Tankless Water Heater- 7.4 Gallon; 19000-199,900 btuh.		http://w w w .hmw allace.com/index.asp?PageAction=VIEWPROD&ProdID=2016 (Date: 05/15/2006)		http://w w w .amazon.com/RHEEM-199KBTU-Tankless-Heater-RTG74PVN/dp/B0015B4J50/ref=sr_1_1?ie=UTF8&s=hi&qid=1268338131&sr=1-1
	6	$1,397.00	$1,397.00	Takagi	Natural Gas	T-KD20	0.84 (85% thermal efficiency)	6.9 GPM	First hour rating: 240 GPH. Min 20,000 Btu Max 185,000 Btu. Outlet Temp: 95-180°F. No pilot light. (Qualify for $300 TAX credit)		http://w w w .tanklessw aterheaters .com/takagitk1.html; http://w w w .designerplumbing.com		http://blujay.com/?page=ad&adid=1536668&cat=11060000
	7	$1457/$1401	$899.00	Takagi	Natural Gas	T-K1S/T-K2	85% thermal efficiency	6.9 GPM	First hour rating: 240 GPH. Min 20,000 Btu Max 190,000 Btu. Outlet Temp: 95-180°F. Electronic ignition. No pilot light. (Qualify for $300 TAX credit)		http://w w w .tanklessw aterheaters .com/takagitk1.html; http://w w w .designerplumbing.com		http://blujay.com/?page=ad&adid=1536658&cat=11060000
	8	$2,297.00	$1,460.00	Takagi	Natural Gas	T-M1	0.81 (82.4% thermal efficiency)	9.6 GPM	First hour rating: 300 GPH. Min 25,000 Btu Max 235,000 Btu. Outlet Temp: 95-180°F. Electronic ignition. No pilot light. (Qualify for $300 TAX credit)		http://w w w .tanklessw aterheaters .com/takagitk1.html; http://w w w .designerplumbing.com		http://w w w .tanklessw aterheaters direct.com/shop/tanklessw aterheaters/takagi/takagitm1buy.asp
Tank-type Gas Water Heater w ith Pilot light	9	$377.99($409.99)	$520.00	Kenmore	Natural Gas	#33926(#33916)		40(50) Gallon	Kenmore Pow er Miser 9, 40(50) gal. Gas Water Heater; Hourly input -40,000 BTU.		http://w w w .sears.com/ (Date: 05/09/2006)		http://instant-w ater-heaters.dev hub.com
	10	$215.95($232.50)	$269.90	State	Natural Gas	GS6 40YBRT	0.60 (0.59)	38	Select® Standard Vent Gas Water Heaters; Feature C3 Technology™ that protects against accidental ignition of flammable vapors like those from gasoline; Green Choice™ gas burner produces 33% low er NOx emissions than standard burners		http://w w w .statew aterheaters.com/lit/spec/res-gas.html#ondemand	CITY SUPPLY COMPANY, INC. HOUSTON, TX 77003 B: 713-224-1643 This company no longer sells this product line.	CITY SUPPLY COMPANY, INC. http://w w w .citysupplyplumbing.com 1800-CITYSUPP spoke w ith Ken
	11	$325.00	$260.00	Rheem	Natural Gas	22V40F1	0.6	40 Gallon	Guardian Fury® Gas Water Heaters.		http://w w w .rheem.com/consumer/catalogRes_detail.asp?id=76 (Date: 05/15/2006) 2010 Price from Amazon	HUGHES 541 GRAHAM ROAD COLLEGE STATION, TX 77845 Phone: (979) 690-7636 Fax: (979) 690-7821 Communication w ith Barney on	Amazon
	12	$310.00	$356.97	A.O. Smith	Natural Gas	GCV50	0.58	50 Gallon	ProMax gas w ater heaters. Hourly input: 40000Btu/h.		http://w w w .hotw ater.com/lit/spec/media/res_gas/ARG-SS002-0405N.pdf (Date: 5/17/2006)	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication w ith John on 5/17/2006	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication w ith John on 3-15-2010

Water Heater -1 *(Continued)*

Item	No.	2007 Price	2010 Price	Brand	Type of Fuel	Model	Energy Factor	Capacity	Description	Pictures	Source	Contact Person	2010 Contact Info
Tank-type Gas Water Heater with Electronic Ignition	13	$757.50	upgraded, see note for new product info.	State	Natural Gas	PR6 40 XCVIT	0.62	40 Gallon	Select®Power-Vent residenital gas water heater; hourly input-40000Btu; Equipped with nearly-indestructible silicon nitride hot surface igniter.		http://www.stateind.com/lit/media/spec/res-gas/SPVG6-1-4.pdf (Date: 05/10/2006)	STATE Water Heaters 1-800-365-0024 ACT PIPE & SUPPLY, INC. 6900 WEST SAM HOUSTON PARKWAY NORTH HOUSTON, TX 77041 B: 713-937-0600 713-933-0426 (Eckhard)	ACT Pipe & Supply (832-467-8900) Alex
	14	$817.50	not available!	State	Natural Gas	PR6 40 XBPDT	0.59(0.58)	40 Gallon	Select®Power Direct-Vent residenital gas water heater; hourly input-40000Btu; Equipped with nearly-indestructible silicon nitride hot surface igniter.		http://www.stateind.com/lit/media/spec/res-gas/SPDVG5-1-4.pdf (Date: 5/10/2006)		
	15	$585.00	307.14+ tax	Rheem	Natural Gas	42VRP40 (22VR40 is not nat gas; 42 is for propane)	0.64	40 Gallon	PowerVent High Efficiency, Induced Draft Gas Water Heater; Electronic ignition system		http://www.rheem.com/consumer/catalogRes_detail.asp?id=68 (Date: 5/15/2006)	HUGHES 541 GRAHAM ROAD COLLEGE STATION, TX 77845 Phone: (979) 690-7636 Fax: (979) 690-7821 Communication with Barney on 05/15/2006.	(HD Supply) HUGHES 541 GRAHAM ROAD COLLEGE STATION, TX 77845 Phone: (979) 690-7636 Spoke with Ernesto; left a message for Barney about #14.
	16	$565.00	speical order only	Ruud	Natural Gas	PVP40FW	0.62	40 Gallon	PowerVent Induced Draft Gas Water Heater with the Guardian System™; Electronic ignition system		http://www.rheem.com/consumer/catalogRes_detail.asp?id=68&brand=Ruud (Date: 5/15/2006)		
	17	$985.00	price pending	A.O. Smith	Natural Gas	GPDH-50/GPDT-50	0.58	50 Gallon	Power House® Sealed Shot Power Direct-Vent Gas Water Heaters; horizontal and vertical venting options up to 45 feet; Advanced Intelli-Vent gas control valve with rugged silicon nitride hot surface igniter; Closed-combustion, two-pipe system draws clean combustion air from outside, vents outside the home; Environmentally friendly Green Choice™ gas burner reduces NOx emissions by 33% compared to standard burners; Hourly input: 40000/65000Btu/h		http://www.hotwater.com/lit/spec/media/res_gas/A7521.pdf (Date: 5/17/2006)	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication with John on 5/17/2006	Valley Supply, College Station, TX (979) 779-7042 (979) 823-5522 (FAX) Communication with John on 3-15-2010
	18	$1,200.00	1464.71 +Plus tax	A.O. Smith	Natural Gas	GPHE-50	90% Thermal Efficiency	50 Gallon	Vertex™ Power-Vent Gas Water Heaters; Money-saving 90% thermal efficiency; Endless hot water means homeowners will always get "one more hot shower"; Hot water output similar to larger, less efficient 75-gallon unit; Equipped with nearly indestructible silicon nitride hot surface ignitor – no standing pilot; Hourly input: 76000 Btu/h.		http://www.hotwater.com/lit/spec/media/res_gas/ARGSS01306.pdf (Date: 5/17/2006)	David Cunningham Hugh M. Cunningham 137555 Benchmark Dallas , TX 75234 B/ 972-888-3808 F/ 972-888-3838	Cunningham does NOT give price information directly. Referred to local Bryan vendor: Feguson 979 774 1389 (Matt)
	19	-	$800.00	Reliance	Natural Gas	SKU: 671147 Model 6-50-YBVIT UPC	0.65	50 Gallon	50 Gallon, Natural Gas, Power Vent Water Heater, Electronic Ignition, Vents With 3" PVC, CPVC Or ABS Schedule 40 Piping, 40,000 BTU's Energy Factor .65, Dimensions: 69-3/4" Tall x 20" Diameter, 6 Year Tank & Parts Warranty, FVIR Approved.				True Value Hardware Store
	20	-	$800.00	Kenmore	Natural Gas	153.33205	0.65	50 Gallon	Kenmore 50 Gallon Tall Natural Gas Water Heater ENERGY STAR qualified appliance. The electronics on this Kenmore natural gas hot water heater make it easy to operate, and the electric ignition of the gas burner will increase your overall savings, energy-w				Sears.com
	21	-	this product no longer made	Maytag	Natural Gas	HR6 50 XOVIT	0.61	50 Gallon					
Tank-type Electric Water Heater	22	$269.99($299.99)		Kenmore	Electric	#32946(#32154)		40(50) Gallon	Kenmore Power Miser 9(12), 40(50) gallon Electric Water Heater; Kilowatt Hrs. per Year-4721(4622).		http://www.sears.com/ (Date: 05/09/2006)		
	23	$188.00			Electric			55 Gallon			http://www.toolbase.org/ToolbaseResources/level4TechInv.aspx?ContentDetailID=599&BucketID=6&CategoryID=9	TOOLBASE Techspecs, by the NAHB Research Center for the Partnership for Advancing Technology in Housing (PATH).	
Tankless Electric Water Heater	24	$585.00			Electric			Whole House			http://www.toolbase.org/ToolbaseResources/level4TechInv.aspx?ContentDetailID=599&BucketID=6&CategoryID=9	TOOLBASE Techspecs, by the NAHB Research Center for the Partnership for Advancing Technology in Housing (PATH).	
	25	$750/$775		Stiebel Eltron	Electric	Tempra 29/36		4.5 GPM	Single phase 150 amp residential electric water heater.		http://www.tanklesswaterheaters.com/stiebeleltron.html	Retail Price	
	26	$749.00		EEMAX	Electric	Series Three	99% Efficiency	4.0 GPM	EEMAX Series Three Residential Heater Single phase 150 amp residential electric water heater.		http://www.tanklesswaterheaters.com/eemaxheaters.html	Retail Price	
	27	$596.00		PowerStar	Electric	AE125	0.95	3.5 GPM	PowerStar AE125 Electric Whole House Tankless; Provides up to 3.5 gallons per minute(50 degree temp rise) for water usage at 105° F: 2 sinks or 1 shower.		http://www.tanklesswater.com/ (Date: 05/09/2006)		

Solar Water Heater -1

Item	No.	2010 Price	Brand	Model	Type of Fuel	Capacity	Energy Factor	Description	Pictures	2007 Source and Contact Info		2010 Information/Contact
Solar Water Heater	1	$2,154.00	SunEarth	EP6632	-	66 gallon		SunEarth Active Solar Water Heater For temperate climate zones Open Loop System: 66 gal w / 4x8 Solar Panel		Solar Direct	http://shop.solardirect.com/product_info.php?products_id=190	
	2	$2,345.00	SunEarth	EP8040	-	80 gallon		SunEarth Active Solar Water Heater For temperate climate zones Open Loop System: 80 gal w 4x10 Solar Panel		Solar Direct	http://shop.solardirect.com/product_info.php?products_id=191	
	3	$3,536.00	SunEarth	EP12064		120 gallon		SunEarth Active Solar Water Heater For temperate climate zones Open Loop System: 120 gal w 4x8 Solar Panel		Solar Direct	http://shop.solardirect.com/product_info.php?products_id=192	
	4	$2,728.38	Alternate Energy Technologies LLC	IPV-80-40	-	80 gallon		40 Sqft Collector		Alternative Energy Store	http://www.altestore.com/store/Solar-Water-Heaters/Climate-freezes-Closed-Loop-Systems/Closed-Loop-Systems-for-1-4-People/Closed-Loop-PV-Powered-w-Tank/AET-PV-w-	http://www.altestore.com/store/Solar-Water-Heaters/Climate-freezes-Closed-Loop-Systems/Closed-Loop-Systems-for-1-4-People/Closed-Loop-PV-Powered-w-Tank/AET-PV-w-
	5	$3,493.00	Alternate Energy Technologies LLC	IPV-80-64		80 gallon		64 sqft Sqft Collector		Alternative Energy Store		http://www.altestore.com/store/Solar-Water-Heaters/Climate-freezes-Closed-Loop-Systems/Closed-Loop-Systems-for-1-4-People/Closed-Loop-PV-Powered-w-Tank/AET-PV-w-
	6	$6,000 with installtion	American Solar Works; Rheem (tank)	ASW 58A-20/25/30		80 gallon		48 Sqft Collector, 1000 per collector. Tank with heat exchanger = 1300 . Controller 250, misc		Texas Green Energy		TEXAS GREEN ENERGY, INC. 5930 Piper Lane College Station, TX 77845 Contact: Adam Burke Phone: 979-209-0010 Fax: 866-365-1965
	7	$7,300.00	American Solar Works; Rheem (tank)	ASW 58A-20/25/31		120 gallon		80 Sqft Collector		Texas Green Energy		TEXAS GREEN ENERGY, INC. 5930 Piper Lane College Station, TX 77845 Contact: Adam Burke Phone: 979-209-0010 Fax: 866-365-1965

Solar Collector -1

Item	No.	2010 Price	Brand	Model	Type	Dim.	Capacity	Description	Sources
Solar Collector	1	$858	Alternate Energy Technologies	AE-32	AET 4 X 8 Ae-Series, Crystal Clear Collector	4x8	32 sqft	Alternate Energy Technologies AE- Series Solar Collectors: Glazing: 1 sheet of solite glass, 1/8" or 5/32" thick with 0.01% iron oxide content. Transmittance: 91.0%, Flow Rate: 0.5 to 1.8 GPM recommended	http://www.altestore.com/store/Solar-Water-Heaters/Collectors-Mounts-and-System-Components/AET-Collectors-Rack-Mounts/AET-4-X-8-Ae-Series-Crystal-Clear-Collector/p103/
	2	$915	Alternate Energy Technologies	MSC-32	AET 4X8 Msc-Series, Crystal Clear Collector	4x8	32 sqft	Alternate Energy Technologies Morning Star™ (MSC) Series Solar Water Heating Collectors: Glazing: 1 sheet of low iron tempered glass, 1/8" thick with 0.01% iron oxide content. (5/32" on MSC-40) Transmittance: 91.0%, Flow Rate: 0.5 to 1.8 GPM recommended	http://www.altestore.com/store/Solar-Water-Heaters/Collectors-Mounts-and-System-Components/AET-Collectors-Rack-Mounts/AET-4X8-Msc-Series-Crystal-Clear-Collector/p177/
	3	$1,716	Alternate Energy Technologies	AE-32	AET 4 X 8 Ae-Series, Crystal Clear Collector	(4x8) *2	64 sqft	Alternate Energy Technologies AE- Series Solar Collectors: Glazing: 1 sheet of solite glass, 1/8" or 5/32" thick with 0.01% iron oxide content. Transmittance: 91.0%, Flow Rate: 0.5 to 1.8 GPM recommended	http://www.altestore.com/store/Solar-Water-Heaters/Collectors-Mounts-and-System-Components/AET-Collectors-Rack-Mounts/AET-4-X-8-Ae-Series-Crystal-Clear-Collector/p103/
	4	$1,830	Alternate Energy Technologies	MSC-32	AET 4X8 Msc-Series, Crystal Clear Collector	(4x8) *2	64 sqft	Alternate Energy Technologies Morning Star™ (MSC) Series Solar Water Heating Collectors: Glazing: 1 sheet of low iron tempered glass, 1/8" thick with 0.01% iron oxide content. (5/32" on MSC-40) Transmittance: 91.0%, Flow Rate: 0.5 to 1.8 GPM recommended	http://www.altestore.com/store/Solar-Water-Heaters/Collectors-Mounts-and-System-Components/AET-Collectors-Rack-Mounts/AET-4X8-Msc-Series-Crystal-Clear-Collector/p177/
	5	$998	Chromagen	CR-130	Chromagen Collector Active Solar Water Heater Panel w /Mounting Hardware One 4 x 8 Collector	4x8	32 sqft	Product Applications: Solar Domestic Hot Water Heater System, Work alongside your conventional water heater, Designed for all climates, System collectors designed to mount on roof, Installs on all roof types: shingle, wood shake, metal and title	http://shop.solardirect.com/product_info.php?cPath=69_71_84_72_87&products_id=657
	6	$1,040	Heliodyne	Gobi 408	GOBI 408 Solar Water Collector, Set of two 4 x 8 collectors	4x8	32 sqft	Model 408-002 Black paint coating: Adequate heat absorption in ideal climate regions, Best for warm climates with ample solar radiation, The black paint collectors should only be used in ideal climates (such as Hawaii.) Model 408-001 Blue sputtered coating: Optimal heat absorption with minimal emission, Suitable for all types of installations, and regions, Recommended for cool climates (add $140)	http://shop.solardirect.com/product_info.php?products_id=530
	7	$1,996	Chromagen	CR-130	Chromagen Collector Active Solar Water Heater Panel w /Mounting Hardware One 4 x 8 Collector	(4x8) *2	64 sqft	Product Applications: Solar Domestic Hot Water Heater System, Work alongside your conventional water heater, Designed for all climates, System collectors designed to mount on roof, Installs on all roof types: shingle, wood shake, metal and title	http://shop.solardirect.com/product_info.php?cPath=69_71_84_72_87&products_id=657
	8	$2,080	Heliodyne	Gobi 408	GOBI 408 Solar Water Collector, Set of two 4 x 8 collectors	(4x8) *2	64 sqft	Model 408-002 Black paint coating: Adequate heat absorption in ideal climate regions, Best for warm climates with ample solar radiation, The black paint collectors should only be used in ideal climates (such as Hawaii.) Model 408-001 Blue sputtered coating: Optimal heat absorption with minimal emission, Suitable for all types of installations, and regions, Recommended for cool climates (add $140)	http://shop.solardirect.com/product_info.php?products_id=530

Table A-5. Cost Information for Lighting Measures

Incandescent Lamps

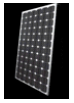
No.	Brand	Model	Description	Unit Wattage (W/unit)	Unit Price ($/unit)	Pictures	Source
1	GE LIGHTING	60A15/CF	Incandescent Lamp, Lamp Designation 60A15/CF CD2, Watts 60, Voltage 120, Lamp Shape A15, Ceiling Fan, Medium Base, Rated Average Life Hours 1500, Lumens 650, Maximum Overall Length 3 1/2 In, Diameter 1 7/8 In	60	$1.31		http://www.idealtruevalue.com/servlet/the-49352/Detail
2	Philips	374694	Incandescent - Lamps/Light Bulbs Lamp Code: A19 BulbStyle: Arbitrary Standard Wattage: 60 Voltage: 120 Base Type: Med. Base Style: Medium Lumens: 890 Color: Frost	60	$0.60		http://www1.mscdirect.com/CGI/NNSRIT?PMPXNO=551063&PMT4NO=82145666
3	Halco	6321	60 Watt - A19 Light Bulb - Frosted - 5,000 Life Hours - 130 Volt - Brass Base - Halco Lighting 6321	60	$0.55-$0.65		http://www.1000bulbs.com/60-Watt-Incandescents/837/
4	Westinghouse	WIB33321	This Westinghouse incandescent light bulb has a type A 15 lamp size, which measures 1-7/8" diameter. Standard E-26 base makes this incandescent light fit in most light bulb sockets. C-9 incandescent filament offers efficient lighting. Provides an average life of up to 2500 hours.	60	$0.74		http://www.globalindustrial.com/p/electrical/bulbs/incandescent/a-15-60w-frosted-sb-130v-2pk-box?utm_source=nextag&utm_medium=cpc&utm_campaign=Incandescent-Bulbs-nextag&infoParam.campaignId=WI

CFL-Pin Type (w/ Lampholder)

No.	Brand	Model	Description	Unit Wattage (W/unit)	Unit Price ($/unit)	Total Unit Price ($/unit)	Pictures	Source
1	Sylvania	FC13-GX2335S	13W 3500 Kelvin 2 Pin GX23 Base Compact Fluorescent Light Bulb	13	$1.77-$1.98	$3.99-$4.20		http://www.1000bulbs.com/333/
	Maris	FMP13H-BASE_(10_X_2.22)	13W 2PIN FLUORESCENT BIAX LAMP HOLDER (GX23 BASE) - CASE PACK QTY 10		$2.22			http://marisusa.com/zen-cart/index.php?main_page=product_info&cPath=135_138_139&products_id=4124
2	LITETRONICS	LT 59520	13 watt T4 2-Pin (GX23-2) Base 5,000K Double Tube Compact Fluorescent Litetronics Light Bulb	13	$2.73	$5.02		http://www.elightbulbs.com/Litetronics-59520-L-12164-13W-T4-D-GX23-2-5000K-Double-Tube-2-Pin-Base-Compact-Fluorescent-Light-Bulb
	Satco	80-1506	13 Watt 2-Pin Lampholder w/Uno Thread and Ring, Height: 1-1/2", Push-In Terminals, Solid Wire w/U-Channel 1/8IP Hickey, GX23 Twin, GX23-2 Quad, 75W-600V Socket		$2.29			http://www.lightbulbemporium.com/satco_80_1506_13w_2_pin_fluorescent_lampholder.asp
3	Howard Industries	QT18/27	18W Double Tube 2 pin CF lamp, G24d-2 base, 827 color by Howard Lighting CF18D/827	18	$3.15	$6.15		http://www.needabulb.com/18W-Double-Tube-2-pin-CF-lamp-G24d-2-base-827-color-by-Howard-Lighting-CF18D827-P565357C20.aspx
	Leviton	26725-202	G24d-2 Base, 18W 2-Pin, 10mm Compact Fluorescent Lampholder, Vertical, Bottom Snap-In, Green Color Code, Quick-Connect 18AWG Solid or Str. Tinned - White Body		$3.00			http://www.google.com/products/catalog?hl=en&q=2+pin+G24d-2+base+lampholder+18W&cid=10417353620847550492&ei=3nbDS6_cOI2i2ASairSsAg&sa=title&ved=0CAcQ8wIwADgA#p
4	Global Consumer	FC13-GX2350OD	13W 5000 Kelvin 2 Pin GX23 Base Compact Fluorescent Light Bulb	13	$1.34-$1.91	$6.34-$6.91		http://www.1000bulbs.com/37899/
	GAYNOR	1185-13-HSC	13Watt,for base GX23 or GX23-2		$5.00			http://egaynor.com/_get_item.php?style=1185-HSC
5	Silver	PLD13/E/SP27K	Silver Compact Fluorescent G24Q-1, 4 Pin, 13W 2700k Bulb 25pcs	13	$3.24-$3.90	$8.19-$8.85		http://www.compactfluorescentusa.com/Silver-Compact-Fluorescent-G24Q-1-4-Pin-13W-2700k-Bulb-25pcs-7280-prod.htm
	Leviton	26725-411	Leviton Compact Fluorescent Lamp Holder CFL Light Socket G24q-1 GX24q-1 Base Bottom Screw Mount 10W 13W 4-Pin 26725-411		$4.95			http://www.fruitridgetools.com/storefrontprofiles/processfeed.aspx?sfid=13676&i=23078678&mpid=8171&dfid=1

Table A-6. Cost Information for Renewable Power Measures

Solar PV -1

Item	No.	2010 Price ($/panel)	# of Panels for 4 kW	Price ($/4kW)	Brand	Model	Module Efficiency	Capacity (W)	Area (sqft)	Description	Pictures	Sources
Solar PV	1	$565.00	20	$11,300.00	KYOCERA	KD210GX-LP	16.0%	210	16	Multi-crystalline silicon cells		http://www.innovativesolar.com/solar-modules-196/kyocera-201/kd210gx-lpu-337.html
	2	$455.00	23	$10,465.00	YINGU SOLAR	YL175	13.5% (Cell: 15.0%)	175	13.9	High efficiency crystalline solar cell		http://www.innovativesolar.com/solar-modules-196/yingli-solar-241/175-watt-964.html
	3	$880.00	22	$19,360.00	SANYO	190	18.8% (Cell: 16.4%)	190	12.5	Hybrids of single crystalline silicon surrounded by ultra-thin amorphous silicon layers		http://www.gogreensolar.com/products/sanyo-hit-190-watt-solar-panel-hip-190ba19?utm_source=google-product-search
	4	$550.00	25	$13,750.00	Suntech	STP160S 24/A	14.1%	160	13.7	Monocrystalline silicon solar cells		http://www.innovativesolar.com/solar-modules-196/suntech-206/160-watt-aluminum-931.html
	5	$732.95	18	$13,193.10	SHARP	ND-U230C1	14.1%	230	17.5	Polycrystalline silicon		http://www.ecodirect.com/Sharp-ND-U230C1-230-Watt-24-Volt-p/sharp-nd-u230c1.htm