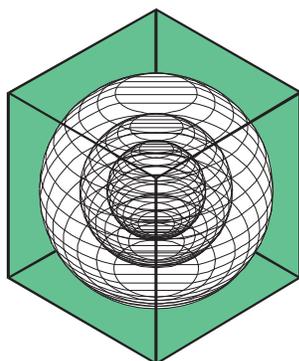


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**ESTIMATES OF ENERGY COST SAVINGS
ACHIEVED FROM 2009 IECC CODE-COMPLIANT,
SINGLE-FAMILY RESIDENCES IN TEXAS**

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EXECUTIVE SUMMARY

This report presents estimates of the energy cost savings to be achieved from 2009 International Energy Conservation Code (IECC) code-compliant, single-family residences in Texas compared to the pre-2009 IECC codes, including: the 2001 IECC¹, the 2006 IECC, and the 2006 IECC w/ Houston amendments (w/ HA)². A series of simulations were performed using an ESL simulation model (BDL version 4.01.07 of IC3) based on the DOE-2.1e simulation and the appropriate TMY2 weather files for three counties representing three 2009 IECC Climate Zones across Texas: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4. Two options based on the choice of heating fuel type were considered: (a) an electric/gas house (gas-fired furnace for space heating, and gas water heater for domestic water heating), and (b) a heat pump house (heat pump for space heating, and electric water heater for domestic water heating).

The base-case building was assumed to be a 2,325 sq. ft., square-shape, one story, single-family, detached house with a floor-to-ceiling height of 8 feet. The house has an attic with a roof pitched at 23 degrees. The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2001 IECC, the 2006 IECC, the 2006 IECC w/HA, and the 2009 IECC. In addition, to facilitate a better comparison with the 2009 code, several modifications were applied to the pre-2009 IECC codes³.

As a result, the estimated annual energy cost savings⁴ per house associated with the 2009 IECC compared to the 2001 and 2006 IECC are: (a) an electric/gas house: \$462/year and \$206/year for Harris County, \$432/year and \$216/year for Tarrant County, and \$576/year and \$153/year for Potter County and (b) a heat pump house: \$490/year and \$203/year for Harris County, \$487/year and \$226/year for Tarrant County, and \$680/year and \$155/year for Potter County. The corresponding % savings of total energy cost of a 2009 IECC code-compliant house are: (a) an electric/gas house: 22.7% and 10.1% for Harris County, 21.8% and 10.9% for Tarrant County, and 28.9% and 7.7% for Potter County and (b) a heat pump house: 21.6% and 8.9% for Harris County, 20.9% and 9.7% for Tarrant County, and 25.7% and 5.8% for Potter County.

¹ 2001 IECC is used to designate the 2000 IECC including the 2001 Supplement.

² 2006 IECC w/ HA was considered only for Harris County in Climate Zone 2.

³ For all pre-2009 codes, the thermostat set points were modified to match the 2009 specifications of 72°F for heating and 75°F for cooling with no set-back/set-up schedule. For 2001 IECC, internal heat gains and interior shading fraction for winter were also changed to match the values provided in the 2009 IECC: internal heat gains: 0.547 kW for lighting and 0.547 kW for equipment; and interior shading fraction for winter: 0.85.

⁴ The annual energy cost savings were estimated with \$0.11/kWh for electricity and \$0.84/therm (Climate Zone 2) and \$0.64/therm (Climate Zone 3 and 4) for natural gas.

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1 INTRODUCTION

This report presents estimates of the energy cost savings to be achieved from 2009 International Energy Conservation Code (IECC) code-compliant, single-family residences in Texas compared to the pre-2009 IECC codes, including: the 2001 IECC⁵, the 2006 IECC, and the 2006 IECC w/ Houston amendments (w/ HA)⁶. A series of simulations were performed using an ESL simulation model (BDL version 4.01.07 of IC3) based on the DOE-2.1e simulation and the appropriate TMY2 weather files for three counties representing three 2009 IECC Climate Zones across Texas: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4. Two options based on the choice of heating fuel type were considered: (a) an electric/gas house (gas-fired furnace for space heating, and gas water heater for domestic water heating), and (b) a heat pump house (heat pump for space heating, and electric water heater for domestic water heating).

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 provides the results of simulation and the annual energy cost and savings associated with the 2009 IECC. Lastly, Section 4 gives a summary.

⁵ 2001 IECC is used to designate the 2000 IECC including the 2001 Supplement.

⁶ 2006 IECC w/ HA was considered only for Harris County in Climate Zone 2.

2 METHODOLOGY

This section describes the methodology and assumptions used in this analysis to estimate the energy cost savings to be achieved from 2009 IECC code-compliant, single-family residences in Texas compared to the pre-2009 IECC codes (the 2001 IECC, the 2006 IECC, and the 2006 IECC w/ HA). 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 (BDL version 4.01.07 of IC3) based on the DOE-2.1e simulation of the 2001, 2006, 2006 w/HA, and 2009 IECC code-compliant, single family residences and the appropriate TMY2 weather files. Three counties in Texas representing three 2009 IECC Climate Zones across Texas were selected: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4 (Figure 1). For each representative county, a total of six simulations that comply with the corresponding requirements of the 2001 IECC, the 2006 IECC, and the 2009 IECC were executed: three runs for (a) an electric/ gas house (gas-fired furnace for space heating, and gas water heater for domestic water heating) and the next three runs for (b) a heat pump house (heat pump for space heating, and electric water heater for domestic water heating). For Harris County, the 2006 IECC w/ HA was also considered.

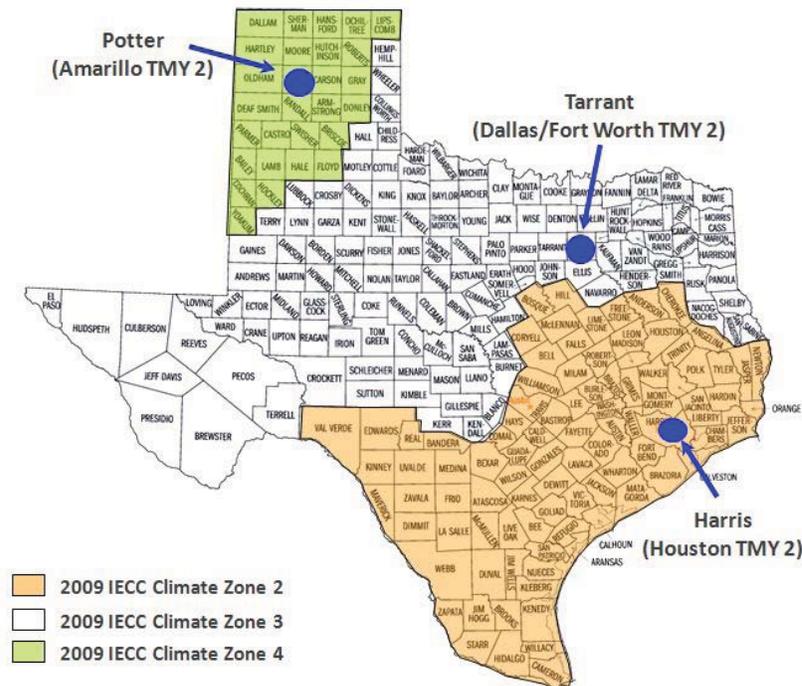


Figure 1. 2009 IECC Climate Zone Classification and Three Selected Counties in Texas.

2.2 Base-Case Building Description

The base-case building is a 2,325 sq. ft., square-shape, one story, single-family, detached house with a floor-to-ceiling height of 8 feet. The house has an attic with a roof pitched at 23 degrees. The wall construction is light-weight wood frame with 2x4 studs at 16" on center with a slab-on-grade-floor, which is typical construction according to the National Association of Home Builders - survey (NAHB 2003). The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2001 IECC, the 2006 IECC, the 2006 IECC w/HA⁷, and the 2009 IECC. Table 1 summarizes the base-case building characteristics used in the simulation model for each climate zone.

To facilitate a better comparison with the 2009 code, several modifications were applied to the pre-2009 IECC codes. For all pre-2009 codes, the thermostat set points were modified to match the 2009 specifications of 72°F for heating and 75°F for cooling with no set-back/set-up schedule. For 2001 IECC, internal heat gains and interior shading fraction for winter were also changed to match the values provided in the 2009 IECC: internal heat gains: 0.547 kW for lighting and 0.547 kW for equipment; and interior shading fraction for winter: 0.85.

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 Texas⁸. For the natural gas, the annual average rates calculated for San Antonio⁹, Dallas¹⁰, and Amarillo¹¹ were used in the analysis for Climate Zone 2, 3, and 4, respectively.

⁷ The building characteristics of the 2006 IECC w/ HA code house are same as the 2006 IECC code-compliant house for Harris County (Climate Zone 2) except an infiltration rate. For 2006 IECC w/ HA, the Specific Leakage Area (SPL) was set as 0.00062, and this value was established during a telephonic conversation with Houston officials.

⁸ 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>

⁹ 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

¹⁰ 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>

¹¹ 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 1. Base Case Building Description.

Characteristics	2001 IECC			2006 IECC			2009 IECC		
	CZ 2	CZ 3	CZ 4	CZ 2	CZ 3	CZ 4	CZ 2	CZ 3	CZ 4
	Harris	Tarrant	Potter	Harris	Tarrant	Potter	Harris	Tarrant	Potter
Building									
Building Type	Single family, detached house								
Gross Area	2,325 sq. ft. (48.21 ft. x 48.21 ft.)								
Number of Floors	1								
Floor to Floor Height (ft.)	8								
Orientation	South facing								
Construction									
Construction	Light-weight wood frame with 2x4 studs spaced at 16" on center								
Floor	Slab-on-grade floor								
Roof Configuration	Unconditioned, vented attic								
Roof Absorptance	0.75								
Ceiling Insulation (hr-sq.ft.-°F/Btu)	R-30	R-38		R-27.84	R-32.51		R-27.84		R-32.51
Wall Absorptance	0.75 (Assuming brick facia exterior)								
Wall Insulation (hr-sq.ft.-°F/Btu)	R-11	R-12/3.125		R-11.8			R-11.8		
Slab Perimeter Insulation	None	R-6		None	R-10		None		R-10
Ground Reflectance	0.24 (Assuming grass)								
U-Factor of Glazing (Btu/hr-sq.ft.-°F)	0.47	0.41		0.75	0.65	0.40	0.65	0.50	0.35
Solar Heat Gain Coefficient (SHGC)	0.40	0.68		0.40			0.30		0.40
Window Area	18% of conditioned floor area						15% of conditioned floor area		
Interior Shading	Sum 0.7 Win 0.9 (Simulation: Sum 0.7, Win 0.85)			Summer 0.7, Winter 0.85					
Exterior Shading	None								
Roof Radiant Barrier	No								
Slope of Roof	5:12 (= 23 degrees)								
Space Conditions									
Space Temperature Set point	68°F Heating, 78°F Cooling, 5F setback (Simulation: Heating 72F, Cooling 75F)						72°F Heating, 75°F Cooling		
Internal Heat Gains	0.88 kW (Simulation: 1.095 kW)			1.095 kW (0.547 kW for lighting and 0.547 kW for equipment)					
Number of Occupants	None (Assuming internal gains include heat gain from occupants)								
Mechanical Systems									
HVAC System Type	(a) Electric/Gas House: Electric cooling (air conditioner) and natural gas heating (gas fired furnace)								
	(b) Heat Pump House: Electric cooling and heating (air conditioner with heat pump)								
HVAC System Efficiency	(a) Electric/Gas House: SEER 10 AC, 0.78 AFUE furnace			(a) Electric/Gas House: SEER 13 AC, 0.78 AFUE furnace					
	(b) Heat Pump House: SEER 10 AC, 6.8 HSPF heat pump			(b) Heat Pump House: 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	(a) Electric/Gas House: 40-gallon tank type gas water heater with a standing pilot light								
	(b) Heat Pump House: 50-gallon tank type electric water heater (without a pilot light)								
DHW Heater Energy Factor	(a) Electric/Gas House: 0.544			(a) Electric/Gas House: 0.594					
	(b) Heat Pump House: 0.864			(b) Heat Pump House: 0.904					
Duct Distribution System Efficiency (DSE)	0.80						0.88		
Supply Air Flow (CFM/ton)	360								
Infiltration Rate (SG)	SLA= 0.00057			SLA= 0.00036					

Note: The building characteristics of the 2006 IECC w/ HA code house are same as the 2006 IECC code-compliant house for Harris County (Climate Zone 2) except an infiltration rate. For 2006 IECC w/ HA, the Specific Leakage Area (SPL) was set as 0.00062, and this value was established during a telephonic conversation with Houston officials. To comply with the 2006 IECC w/HA, the proposed house needs to demonstrate 15% less energy consumption than the corresponding code house.

3 RESULTS

This section presents the results of simulation and the annual energy cost and savings associated with the 2009 IECC. Table 2 summarizes the results of simulation and cost savings analysis for Harris, Tarrant, and Potter counties, including: the annual site energy consumption (by total and different fuel types and end-uses); and the annual energy cost and savings associated with the 2009 IECC. The results are also graphically represented in Figure 2 through Figure 5.

3.1 Annual Total Energy Consumption

Across the counties, the 2001 IECC code-compliant house reported the maximum consumption with a total of (a) an electric/gas house: 108.6 MMBtu/year for Harris County, 120.2 MMBtu/year for Tarrant County, and 147.7 MMBtu/year for Potter County and (b) a heat pump house: 85.6 MMBtu/year for Harris County, 87.3 MMBtu/year for Tarrant County, and 103.3 MMBtu/year for Potter County. Except a heat pump house in Harris County, the 2009 IECC code-compliant house reported the minimum site energy consumption with a total of (a) an electric/gas house: 91.1 MMBtu/year for Harris County, 99.6 MMBtu/year for Tarrant County, and 123.9 MMBtu/year for Potter County and (b) a heat pump house: 72.2 MMBtu/year for Tarrant County and 82.2 MMBtu/year for Potter County. In Harris County, the 2006 IECC w/HA code-compliant heat pump house¹² reported slightly less energy consumption (68.7 MMBtu/year) than the 2009 IECC compliant house (70.4 MMBtu/year).

3.2 Annual Total Energy Cost

Similar trends were observed in the annual energy costs estimated with \$0.11/kWh for electricity and \$0.84/therm (Climate Zone 2) and \$0.64/therm (Climate Zone 3 and 4) for natural gas. Across the counties, the 2001 IECC code-compliant houses were expected to have the highest energy bills: (a) an electric/gas house: \$2,493/year for Harris County, \$2,407/year for Tarrant County, and \$2,568/year for Potter County and (b) a heat pump house: \$2,760/year for Harris County, \$2,814/year for Tarrant County, and \$3,330/year for Potter County. Except Harris County, the 2009 IECC code-compliant houses were expected to have the lowest energy bills: (a) an electric/gas house: \$1,976/year for Tarrant County and \$1,992/year for Potter County and (b) a heat pump house: \$2,328/year for Tarrant County and \$2,650/year for Potter County. In Harris County, the 2006 IECC w/HA code-compliant houses were expected to have lower energy bills for both an electric/gas house (\$2,019/year¹³) and a heat pump house (\$2,214/year) than the 2009 IECC compliant houses (\$2,031/year for an electric/gas house and \$2,270/year for a heat pump house).

3.3 Annual Energy and Cost Savings from 2009 IECC

At last, the annual energy and cost savings associated with the 2009 IECC were calculated compared to the 2001 and 2006 IECC, respectively: (a) an electric/gas house: 17.5 MMBtu/year (\$462/year) and 9.5 MMBtu/year (\$206/year) for Harris County, 20.6 MMBtu/year (\$432/year) and 12.4 MMBtu/year (\$216/year) for Tarrant County, and 23.8 MMBtu/year (\$576/year) and 5.0 MMBtu/year (\$153/year) for Potter County and (b) a heat pump house: 15.2 MMBtu/year (\$490/year) and 6.3 MMBtu/year (\$203/year) for Harris County, 7.0 MMBtu/year (\$226/year) and 15.1 MMBtu/year (\$487/year) for Tarrant County, and 21.1 MMBtu/year (\$680/year) and 4.8 MMBtu/year (\$155/year) for Potter County. The corresponding % savings of total energy cost of a 2009 IECC code-compliant house are: (a) an electric/gas house: 22.7% and 10.1% for Harris County, 21.8% and 10.9% for Tarrant County, and 28.9%

¹² To comply with the 2006 IECC w/HA, the proposed house needs to demonstrate 15% less energy consumption than the corresponding code house.

¹³ It should be noted that, due to the difference in the unit cost of electricity and gas, the energy cost savings are not always of the same order as the energy savings.

and 7.7% for Potter County and (b) a heat pump house: 21.6% and 8.9% for Harris County, 20.9% and 9.7% for Tarrant County, and 25.7% and 5.8% for Potter County.

Table 2. Annual Total Energy and Cost Savings Achieved from the 2009 IECC Code-Compliant, Single Family Residences in Texas.

Test Cases		Annual Site Energy Consumption (MMBtu/year)								Energy Savings from 2009 IECC (MMBtu/year)	Annual Total Energy Cost (\$/year)	Energy Cost Savings from 2009 IECC (\$/year)	% Savings vs. 2009 IECC
		Total	Electricity	Gas	Cooling	Heating	Lgt+Appl	Fans & Pumps	DHW				
(a) Electric/Gas House													
Harris County (CZ 2)	2001 IECC Modified	108.6	66.3	42.3	27.1	24.1	32.8	6.4	18.2	17.5	\$2,493	\$462	22.7%
	2006 IECC Modified	100.6	58.4	42.2	19.4	25.6	32.8	6.2	16.6	9.5	\$2,237	\$206	10.1%
	2006 IECC w/ HA Modified	93.9	51.6	42.3	14.2	25.7	32.8	4.7	16.6	2.8	\$2,019	-\$12	-0.6%
	2009 IECC	91.1	53.1	38.0	15.5	21.4	32.8	4.9	16.6	-	\$2,031	-	-
Tarrant County (CZ 3)	2001 IECC Modified	120.2	63.4	56.8	24.2	37.9	32.8	6.5	19.0	20.6	\$2,407	\$432	21.8%
	2006 IECC Modified	112.0	57.1	54.9	17.9	37.5	32.8	6.5	17.4	12.4	\$2,192	\$216	10.9%
	2009 IECC	99.6	51.8	47.8	14.0	30.4	32.8	5.0	17.4	-	\$1,976	-	-
Potter County (CZ4)	2001 IECC Modified	147.7	62.8	84.9	22.0	63.3	32.8	8.1	21.6	23.8	\$2,568	\$576	28.9%
	2006 IECC Modified	128.9	51.1	77.8	12.1	57.8	32.8	6.3	20.0	5.0	\$2,145	\$153	7.7%
	2009 IECC	123.9	46.4	77.5	8.5	57.5	32.8	5.2	20.0	-	\$1,992	-	-
(b) Heat Pump House													
Harris County (CZ 2)	2001 IECC Modified	85.6	85.6	-	27.1	8.0	32.8	6.4	11.4	15.2	\$2,760	\$490	21.6%
	2006 IECC Modified	76.7	76.7	-	19.4	7.6	32.8	6.2	10.8	6.3	\$2,473	\$203	8.9%
	2006 IECC w/ HA Modified	68.7	68.7	-	14.2	6.3	32.8	4.5	10.8	-1.7	\$2,214	-\$55	-2.4%
	2009 IECC	70.4	70.4	-	15.5	6.6	32.8	4.9	10.8	-	\$2,270	-	-
Tarrant County (CZ 3)	2001 IECC Modified	87.3	87.3	-	24.2	12.0	32.8	6.3	12.0	15.1	\$2,814	\$487	20.9%
	2006 IECC Modified	79.2	79.2	-	17.9	10.7	32.8	6.3	11.5	7.0	\$2,553	\$226	9.7%
	2009 IECC	72.2	72.2	-	14.0	9.0	32.8	5.0	11.5	-	\$2,328	-	-
Potter County (CZ4)	2001 IECC Modified	103.3	103.3	-	22.0	26.2	32.8	8.3	14.1	21.1	\$3,330	\$680	25.7%
	2006 IECC Modified	87.0	87.0	-	12.1	22.2	32.8	6.5	13.5	4.8	\$2,805	\$155	5.8%
	2009 IECC	82.2	82.2	-	8.5	21.9	32.8	5.6	13.5	-	\$2,650	-	-

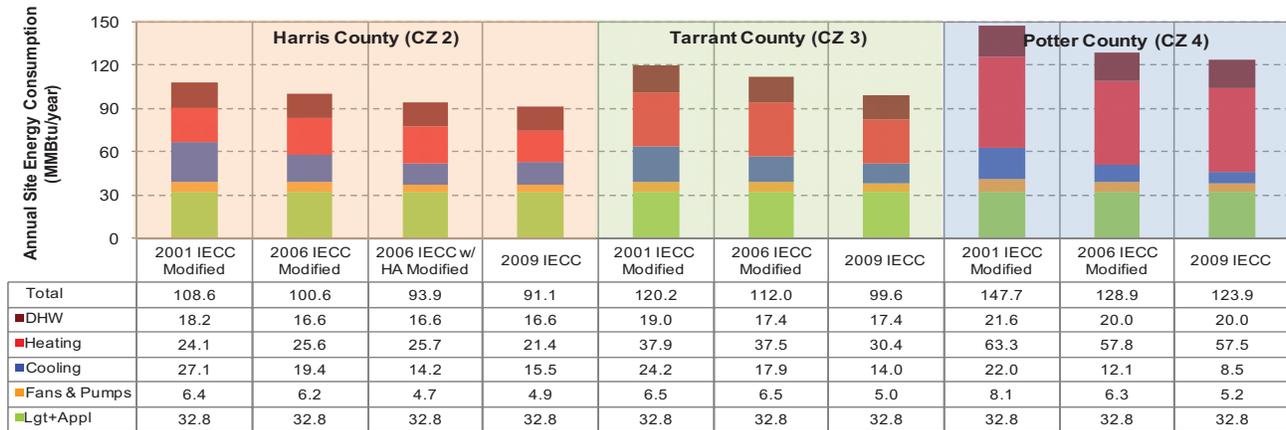


Figure 2. Annual Site Energy Consumption by Different End Uses for a Code-Compliant, Electric/Gas House in Texas.

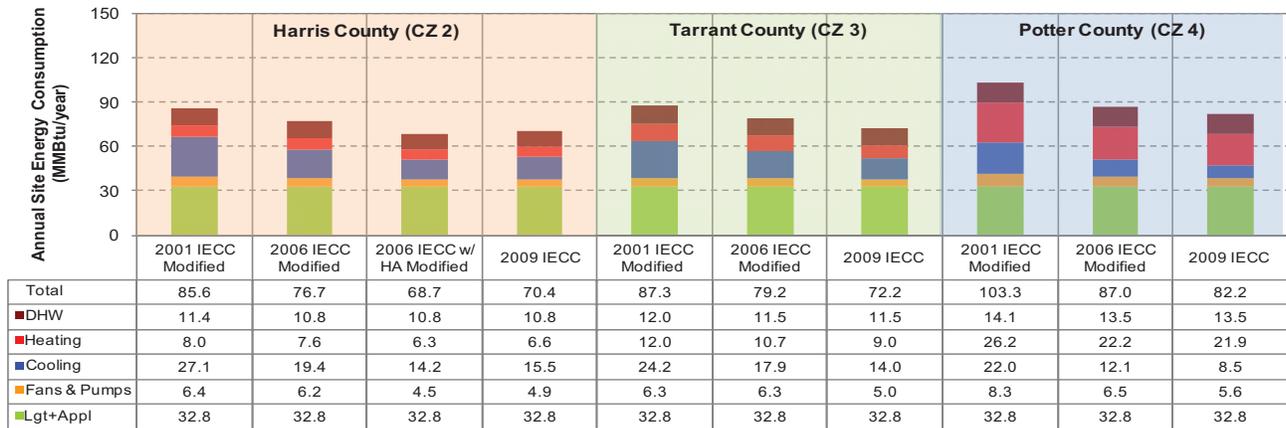


Figure 3. Annual Site Energy Consumption by Different End Uses for a Code-Compliant, Heat Pump House in Texas.

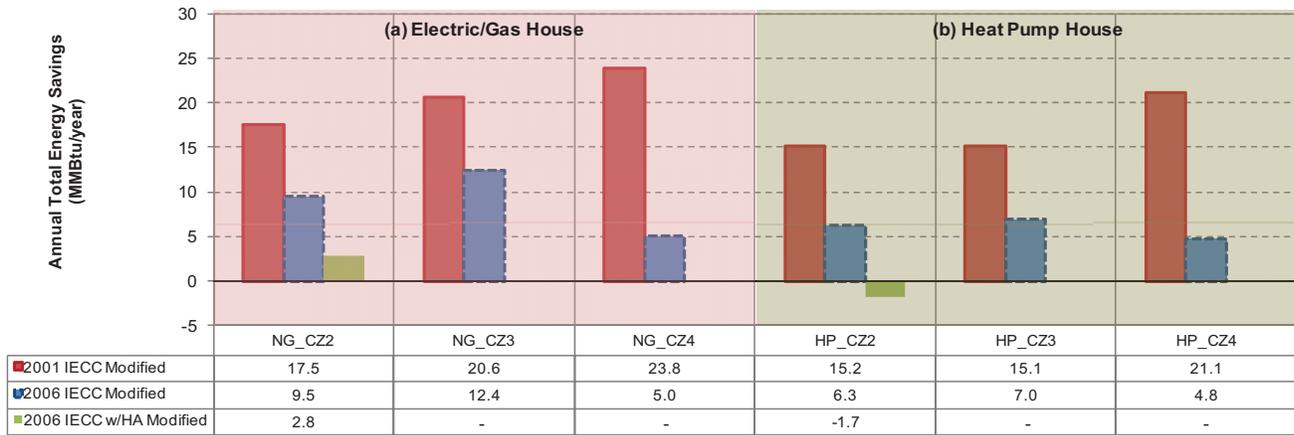
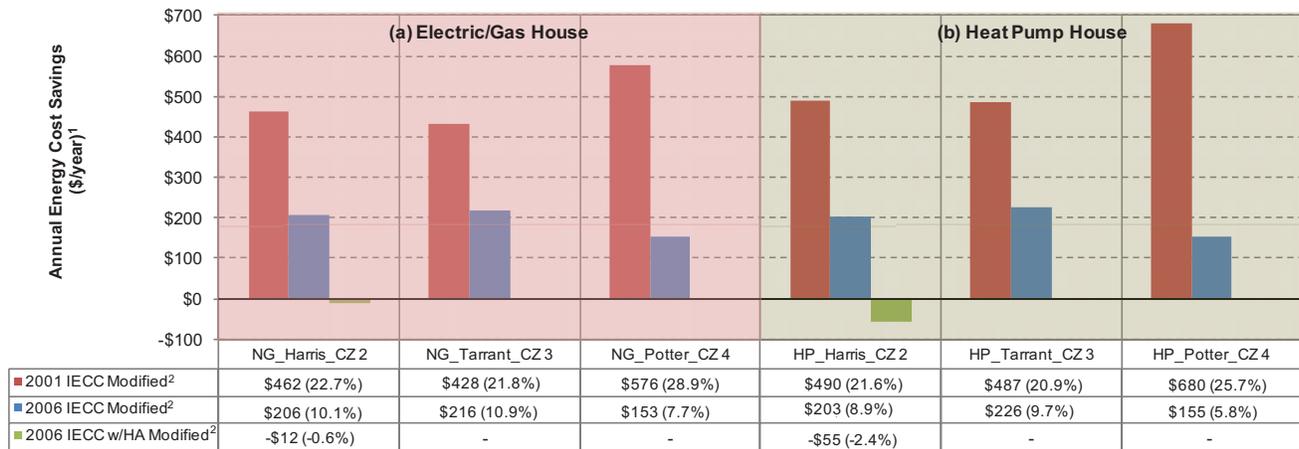


Figure 4. Annual Total Site Energy Savings per House Associated with the 2009 IECC Code Compliance Versus Pre-2009 IECC Codes.



Note: Numbers in parentheses are % cost savings of a total energy cost of a 2009 IECC code-compliant house.

¹Savings depend on fuel mix used.

* Energy cost: Electricity = \$0.11/kWh

Natural gas = \$0.84/therm for Harris County (CZ 2) and \$0.64/therm for Tarrant County (CZ 3) and Potter County (CZ 4)

²Modifications to the pre-2009 IECC codes for a fair comparison with the 2009 IECC code.

* Thermostat set points: 72°F for heating and 75°F for cooling with no set-back/set-up schedule

* Internal heat gains: 0.547 kW for lighting and 0.547 kW for equipment

* Interior shading fraction for winter: 0.85

[Annual total energy cost (\$/year) of 2009 IECC code house]

* Electric/Gas House: \$2,031 for Harris (CZ 2), \$1,976 for Tarrant (CZ 3), and \$1,992 for Potter County (CZ 4)

* Heat Pump House: \$2,270 for Harris (CZ 2), \$2,328 for Tarrant (CZ 3), and \$2,650 for Potter County (CZ 4)

[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% for 2009 IECC compliance houses and 18% for all pre-2009 IECC compliance houses



Figure 5. Annual Total Energy Cost Savings per House Associated with the 2009 IECC Code Compliance Versus Pre-2009 IECC Codes.

4 SUMMARY

The annual energy cost savings associated with the 2009 IECC code-compliant, single-family residences compared to the pre-2009 IECC codes (2001 IECC , 2006 IECC, and 2006 IECC w/ HA) were estimated for three representative counties in Texas. The estimated savings compared to the 2001 and 2006 IECC are: a) an electric/gas house: \$462/year and \$206/year for Harris County, \$432/year and \$216/year for Tarrant County, and \$576/year and \$153/year for Potter County and (b) a heat pump house: \$490/year and \$203/year for Harris County, \$487/year and \$226/year for Tarrant County, and \$680/year and \$155/year for Potter County. The corresponding % savings of total energy cost of a 2009 IECC code-compliant house are: (a) an electric/gas house: 22.7% and 10.1% for Harris County, 21.8% and 10.9% for Tarrant County, and 28.9% and 7.7% for Potter County and (b) a heat pump house: 21.6% and 8.9% for Harris County, 20.9% and 9.7% for Tarrant County, and 25.7% and 5.8% for Potter County.

The 2001 IECC code-compliant houses in Potter were expected to achieve the largest energy cost savings from meeting the requirements in the 2009 IECC while the smallest savings were expected for the 2006 IECC code-compliant houses in Potter. The 2006 IECC w/ HA code-compliant houses in Harris County were expected to have slightly lower energy bills than the 2009 IECC compliant houses.

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