STATEWIDE ELECTRICITY AND DEMAND CAPACITY SAVINGS FROM THE INTERNATIONAL ENERGY CONSERVATION CODE (IECC) ADOPTION FOR SINGLE-FAMILY RESIDENCES IN TEXAS (2002-2013)

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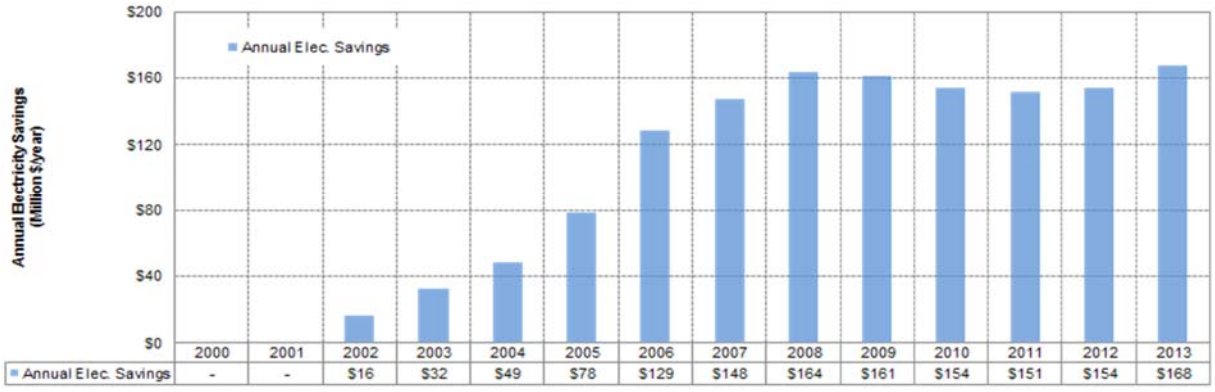
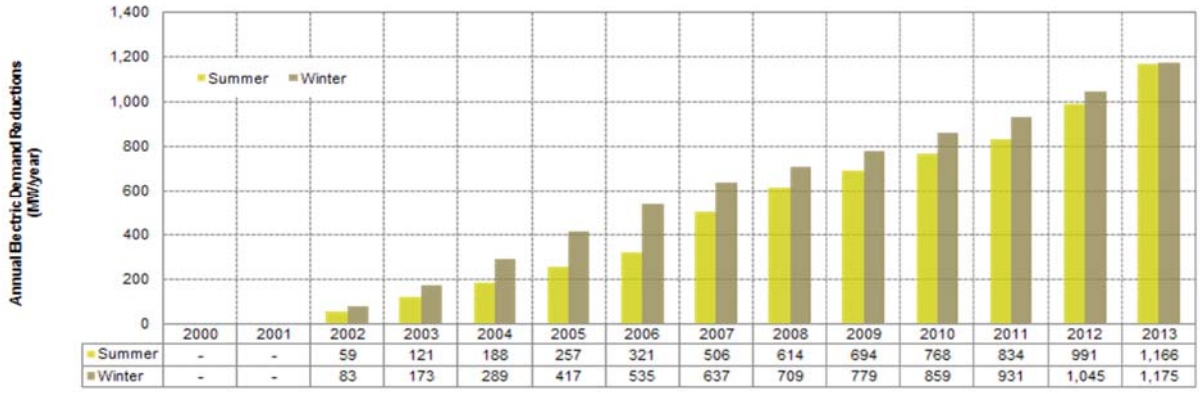
EXECUTIVE SUMMARY

This report present the statewide electricity and electric demand savings achieved from the adoption of the different International Energy Conservation Code (IECC) versions for single-family residences in Texas and the corresponding construction cost increases over the twelve-year period from 2002 through 2013. Using the Energy Systems Laboratory's International Code Compliance Calculator (IC3) simulation program, the annual electricity savings in 2013 are estimated to be $168 million, and the demand reductions in 2013 are estimated to be 1,166 MW for the summer and 1,175 MW for the winter periods. Since 2002, the cumulative statewide electricity and electric demand savings over the twelve-year period from 2002 to 2013 are $2,966 million for the summer ($1,403 million from electricity savings and $1,563 million from demand savings) and $2,977 million for the winter periods ($1,403 million from electricity savings and $1,574 million from demand savings), while the total implementation costs are estimated to be $1,060 million. Figures 1 and 2 show the annual statewide electricity savings and demand reductions, respectively. Figure 3 shows the cumulative statewide increased implementation costs with the cumulative statewide electricity and demand savings from code-compliant, single-family residences built between 2002 and 2013.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Annual Elec. Savings	-	-	$16	$32	$49	$78	$129	$148	$164	$161	$154	$151	$154	$168

Figure 1. Annual Statewide Electricity Savings from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Summer	-	-	59	121	188	257	321	506	614	694	768	834	991	1,166
Winter	-	-	83	173	289	417	535	637	709	779	859	931	1,045	1,175

Figure 2. Annual Statewide Electric Demand Reductions from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Capacity Savings	-	-	$111	$232	$387	$558	$717	$854	$949	$1,044	$1,151	$1,248	$1,400	$1,574
Elec. Savings	-	-	$16	$48	$97	$175	$304	$451	$615	$776	$930	$1,082	$1,236	$1,403
Cost	-	-	$64	$136	$218	$321	$422	$536	$610	$669	$729	$788	$914	$1,060

Figure 3. Cumulative Increased Costs, Statewide Electricity and Electric Demand Savings Associated with the IECC Code Adoption for Single-Family Residences in Texas: 2002-2013[1].

[1] For electric demand savings, the estimation for the winter periods ($1,574 million, cumulative) was displayed instead of summer ($1,563 million, cumulative).

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1 INTRODUCTION

In September 2001, Texas adopted the 2000 International Energy Conservation Code (IECC), including the 2001 Supplement as the first statewide energy code. During this period, several improved versions of IECC have been published and adopted by individual jurisdictions. The analysis shows the building energy code has substantially improved the energy efficiency of housing in Texas, resulting in reduced annual heating/cooling, which is reflected in the reduced utility bills for residential customers. This report presents an analysis of the statewide electricity and electric demand savings achieved from the adoption of the different IECC versions for single-family residences in Texas, including the corresponding construction cost increases over the twelve-year period from 2002 through 2013.

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 that was used for the analysis; the description of the base-case model used for simulation and cost assumptions for energy savings analysis. Section 3 provides the results of simulation, the annual energy savings and peak demand reductions per house associated with the IECC code adoption. Section 4 gives the estimation results of the annual, the cumulative statewide electricity use and the electric demand savings from the codes adoption. Section 5 provides a cost incremental analysis associated with the IECC codes adoption. Lastly, Section 6 includes a summary of the results of the report followed by references used to generate this report.

2 METHODOLOGY

This section describes the methodology and assumptions used in this study. Section 2.1 presents the overall approach adopted for the analysis. Section 2.2 describes the base-case building characteristics for the building-level analysis. Section 2.3 presents cost assumptions used in energy savings analysis.

2.1 Overview

The analysis consists of two parts: a building-level analysis and a state-level analysis. At the building-level analysis, the energy savings and peak demand reductions per house were calculated using the IC3 simulation program (BDL version 4.01.08[2] of IC3), which is based on the DOE-2.1e building energy simulation program and the appropriate TMY2 weather files for the three 2009 IECC Climate Zones across Texas (see Figure 4). The three selected Texas representative counties were: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4. For each representative county, a total of six simulations that include pre-code 1999 conditions and code-compliant conditions meeting the requirements of the 2001 IECC, the 2006 IECC, and the 2009 IECC were performed for the appropriate periods: four runs for (a) an electric/gas house (i.e., a gas-fired furnace for space heating, and a gas-fired water heater for domestic water heating) and the next four runs for (b) a electric/heat pump house (i.e., a house with a heat pump for space heating, and an electric water heater for domestic water heating). To estimate the heating savings, a heat pump system was selected for space heating of all-electric houses instead of electric-resistance heaters. Using these models, the energy savings and peak demand reductions per house compared to the pre-code building were then calculated for each climate zone.

At the state-level analysis, two different approaches were applied to calculate annual electricity and electric demand savings associated with the IECC codes adoption in Texas. To calculate the statewide electricity savings, the annual MWh savings from code-compliant, new single-family housing in Texas for years 2002 through 2013 reported in the Laboratory's Annual Reports submitted to the Texas Commission on Environmental Quality (TCEQ) were used (Haberl et al. 2002-2014). For the years 2002 through 2004, the annual electricity savings (MWh/year) were calculated for the 41 non-attainment and affected counties. From 2005 to 2013, the savings were calculated for all the counties in the Electric Reliability Council of Texas (ERCOT) region, which includes the 41 non-attainment and affected counties. The corresponding dollar to these electricity savings were estimated with the annual average electric prices in Texas published by the U.S. DOE EIA (2014) presented in Section 2.3.

To compute the statewide electric demand savings (i.e., the avoided construction cost of a peaking plant), the peak demand reductions per house calculated in the building-level analysis were multiplied by the number of new single-family houses built in each climate zone of each year and aggregated to annual totals using an annual degradation factor of 5%[3]. The 2001 IECC, 2006 IECC, and 2009 IECC were assumed to be adopted across Texas in the beginning of the years of 2002, 2007, and 2012, respectively in this analysis. A 20% initial discount factor[4] and a 7% transmission and distribution loss factor[5] were applied in the calculations. Although the assumption of these high levels of annual degradation and initial discount factors may not actually occur, they were chosen as a conservative estimate. To estimate the avoided construction cost of a peaking plant (i.e., capacity savings), the calculated demand savings in

[2] BDL version 4.01.08 was used for the years 2012 and 2013. BDL version 4.01.07 was used for the years 2002 through 2011.
[3] The annual degradation factor of 5% was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. 5% was taken from a study by Kats et al. (1996).
[4] The initial discount factor of 20% was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures.
[5] The T&D loss factor of 7% was used to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer.

MW were then multiplied by the average capital cost of natural gas combined cycle power plant, $1,165 per kW (Kaplan 2008) using a 15% reserve margin (Faruqui et al. 2007).

Real estate data obtained from the Real Estate Center, Texas A&M University (RECenter 2014) was used to determine the account for the total number of new single-family houses built in each year. Figure 5 shows the building permits per year for new single-family residences in Texas by climate zone. The ratio of electric/gas and heat pump houses constructed in Texas was determined using the annual surveys, National Association of Home Builders (NAHB) (NAHB 2001–2005 and 2009-2013)[6]. Figure 6 shows the ratio of the single family residences in Texas by type of heating system for Climate Zone 2 (CZ 2) and for Climate Zones 3 and 4 (CZ 3&4 combined).

Finally, an incremental cost analysis was conducted to determine if the savings justify the increased construction costs for upgrading to the new IECC versions. The increased costs for upgrading major residential building components and systems to comply with the 2001 IECC, the 2006 IECC, and the 2009 IECC were examined using R.S. Means Residential Cost Data (R.S. Means 2002 and 2007), the Building Codes Assistance Project (BCAP) Incremental Construction Cost Analysis for New Homes (Paquette et al. 2010), the American Council for an Energy-Efficient Economy (ACEEE) Consumer Guide to Home Energy Savings (Amann et al. 2007), and the previous similar incremental cost analysis studies in Texas (Malhotra et al. 2008; Kim et al. 2010). The construction characteristics published by the NAHB (2000) were used to define pre-code house conditions. The calculated per-house costs of implementation of the IECC were then multiplied by the number of new single-family houses in the ERCOT region (41 non-attainment and affected counties from 2002 to 2004 and all the counties in the ERCOT region from 2005 to 2013) and aggregated to cumulative total increased costs over the twelve-year period from 2002 to 2013.

[6] For the years from 2005 to 2007, the average percentage ratios of the years 2000-2004 and 2008-2009 were used because the information was not available in the NAHB survey reports. For the year 2013, the 2012 NAHB survey report was used because the 2013 NAHB survey report was not available.

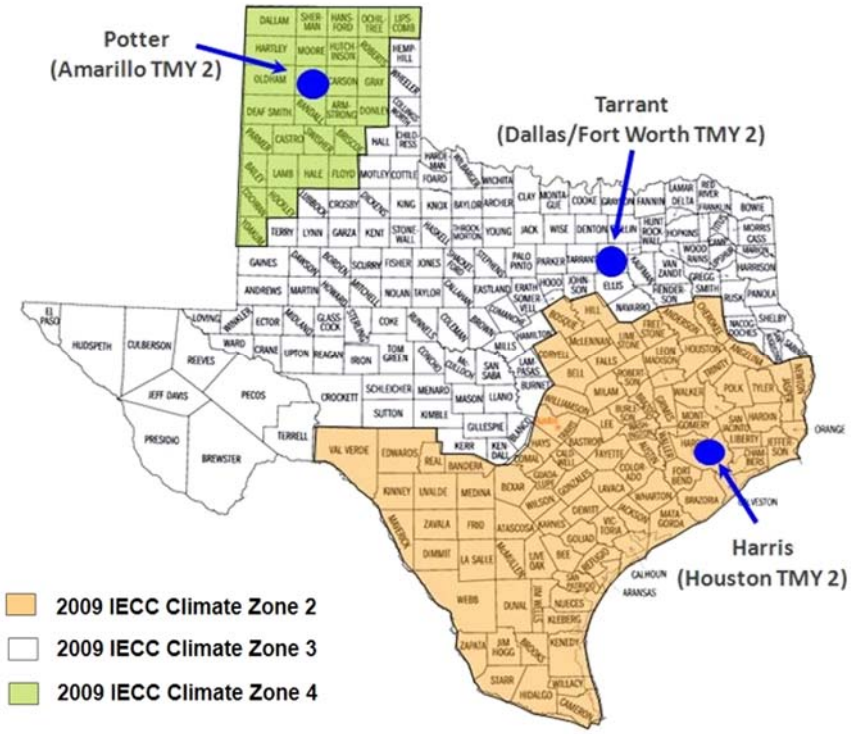


Figure 4. 2009 IECC Climate Zone Classification and Three Selected Representative Counties in Texas.

2.2 **Base-Case Building Description**

The base-case building used for a simulation in the building-level analysis 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 NAHB survey (NAHB 2003). The pre-code building envelope and system characteristics were determined based on the construction characteristics published by the NAHB (2000) for typical residential construction in East and West Texas for 1999. The code-compliant 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, and the 2009 IECC. Table 1 summarizes the base-case building characteristics used in the simulation model for each climate zone.

To facilitate a more accurate and realistic comparison between the codes, several modifications were applied to the simulations as follows[7]. For the 2001 IECC simulation, internal heat gains and interior shading fractions for winter were adjusted to match the values required in the 2006 and 2009 IECC: internal heat gains: 0.547 kW/house for lighting and 0.547 kW/house for equipment; and interior shading fraction for winter: 0.85. For all simulations, the thermostat set points were also modified to match the 2009 IECC specifications of 72°F for heating and 75°F for cooling with no set-back/set-up schedule as a more realistic estimate of savings.

2.3 **Cost Assumptions**

At the building-level analysis, the cost savings calculation was carried out based on utility costs of \$0.11/kWh for electricity and \$0.84/therm for natural gas (Climate Zone 2) and \$0.64/therm for natural gas (Climate Zone 3 and 4). The electric rate was determined based on the information compiled by the Public Utility Commission of Texas (PUCT 2010). For the natural gas rates, the annual average rates calculated for San Antonio (CPS Energy 2010), Dallas (Atmos Energy 2010a), and Amarillo (Atmos Energy 2010b) were used in the analysis for Climate Zones 2, 3, and 4, respectively. At the state-level analysis, the annual average prices of Texas residential electricity published by the U.S. DOE EIA (2014) were used: \$0.08/kWh for 2002; \$0.09/kWh for 2003; \$0.10/kWh for 2004; \$0.11/kWh for 2005; \$0.13/kWh for 2006; \$0.12/kWh for 2007; \$0.13/kWh for 2008; \$0.12/kWh for 2009; \$0.12/kWh for 2010; \$0.11/kWh for 2011; \$0.11/kWh for 2012; and \$0.11/kWh for 2013 (see Figure 7).

[7] These unifying modifications to the simulation inputs were necessary because the comparisons between the pre-code, 2001, 2006, and 2009 simulations could not be performed if different values were used.

Table 1. Base Case Building Description.

Characteristics	Pre-Code 1999			2001 IECC			2006 IECC			2009 IECC		
	CZ 2	CZ 3	CZ 4	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	Harris	Tarrant	Potter
Building												
Building Type	Single family, detached house											
Gross Area[2]	2,325 sq. ft. (48.21 ft. x 48.21 ft.)											
Number of Floors	1											
Floor to Floor Height (ft.)[2]	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)[1]	R-27.08	R-26.75		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)[1]	R-13.99	R-14.18		R-11	R-12/3 c.i.		R-11.8			R-11.8		
Slab Perimeter Insulation	None		R-6	None	R-6		None		R-10	None		R-10
Ground Reflectance	0.24 (Assuming grass)											
U-Factor of Glazing (Btu/hr-sq.ft.-°F)[1]	1.11	0.87		0.47	0.41		0.75	0.65	0.40	0.65	0.50	0.35
Solar Heat Gain Coefficient (SHGC)[1]	0.71	0.66		0.40	0.68		0.40			0.30		0.40
Window Area[2]	18% of conditioned floor area									15% of conditioned floor area		
Interior Shading	Sum 0.7 Win 0.85			Sum 0.7 Win 0.9 (Simulation adjustment[3]: 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	72°F Heating, 75°F Cooling			68°F Heating, 78°F Cooling, 5F setback/setup			68°F Heating, 78°F Cooling			72°F Heating, 75°F Cooling		
				(Simulation adjustment[3]: Heating 72F, Cooling 75F)								
Internal Heat Gains	1.095 kW			0.88 kW (Simulation adjustment[3]: 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[1]	(a) Electric/Gas House: SEER 11 AC, 0.80 AFUE furnace			(a) Electric/Gas House: SEER 10 AC[4], 0.78 AFUE			(a) Electric/Gas House: SEER 13 AC, 0.78 AFUE furnace					
	(b) Heat Pump House: SEER 11 AC, 6.8 HSPF			(b) Heat Pump House: SEER 10 AC[4], 6.8 HSPF			(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	0.80									0.88		
Supply Air Flow (CFM/ton)	360											
Infiltration Rate (SG)	SLA= 0.00057						SLA= 0.00036					

Note:

[1] The ceiling and wall insulation, glazing specifications, and HVAC system efficiencies for the pre-code houses were determined based on the NAHB Survey for typical residential construction in East and West Texas for 1999.

[2] For a fair comparison, the pre-code house was assumed to have the same floor area, ceiling height, and window areas as the 2001 IECC code-compliant house rather than following the NAHB survey results.

[3] To facilitate a more accurate and realistic comparison between the codes, several adjustments were applied to the 2001 and 2006 IECC codes.

[4] SEER 10 was used to comply with the 2001 IECC performance path.

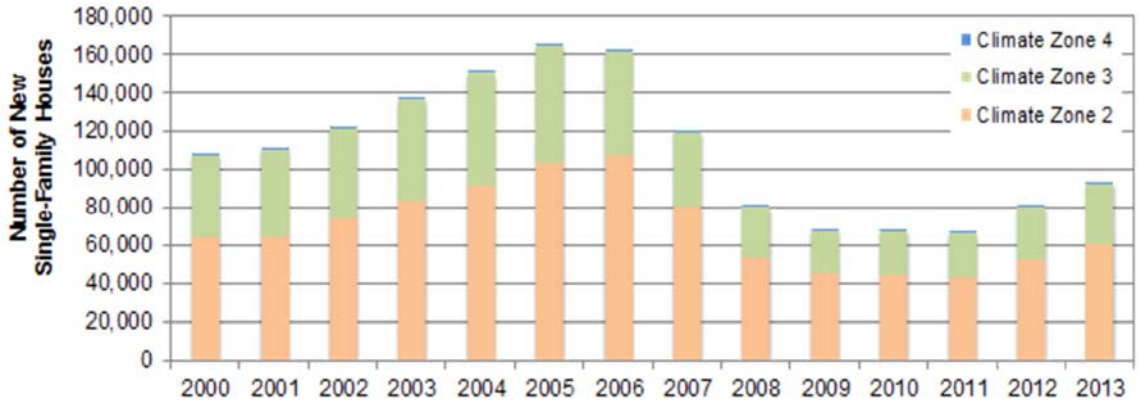
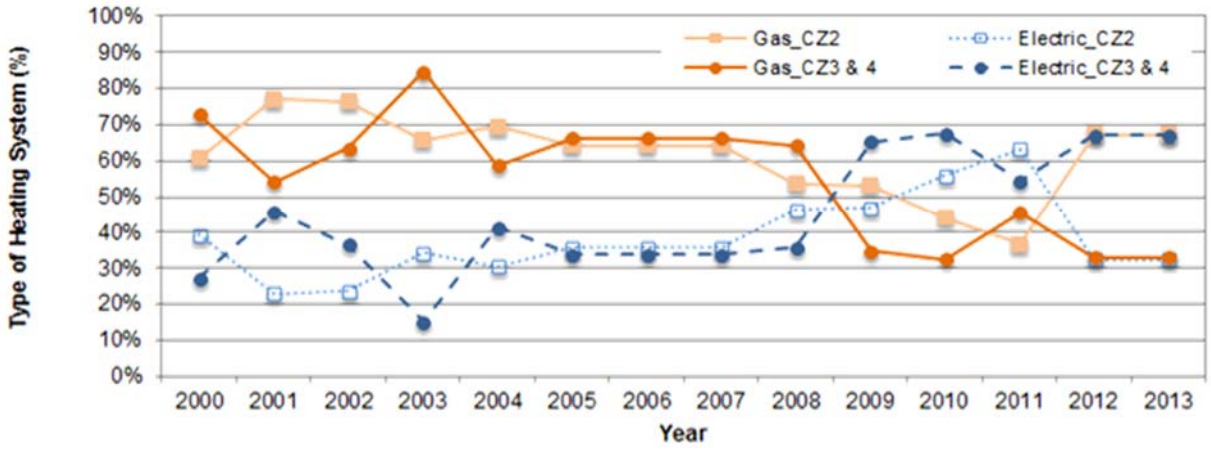


Figure 5. Number of Building Permits for New Single-Family Residences in Texas by Climate Zone.



Note: The 2012 NAHB data was used for the 2013 year.

Figure 6. Type of Heating System of New Single-Family Construction in Texas.

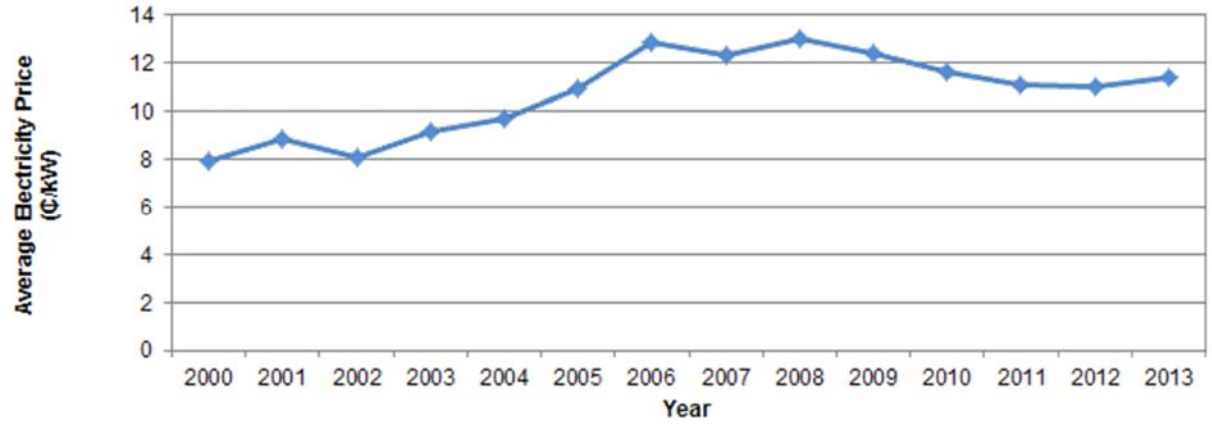


Figure 7. Annual Average Price of Electricity for Residential Customers in Texas.

3 ENERGY SAVINGS AND DEMAND REDUCTIONS PER HOUSE

This section presents the results of simulation and the annual per-house energy savings and peak demand reductions associated with the IECC code adoption in Texas. Table 2 summarizes the results of the energy savings analysis for Harris, Tarrant, and Potter Counties, including: the annual total site energy consumption (MMBtu/year and $/year by total and fuel types), as well as energy savings associated with the IECC code adoption. Table 3 presents summer and winter peak electric demand and reductions expected from 2001, 2006, and 2009 IECC adoption. The results are also graphically represented in Figure 8 through Figure 23.

3.1 Annual Per-House Energy Consumption

Across all counties, the pre-code houses reported the highest consumption with the following totals:

- For an electric/gas house:
  - 122.8 MMBtu/year for Harris County
  - 133.9 MMBtu/year for Tarrant County
  - 179.1 MMBtu/year for Potter County
- For a heat pump house:
  - 93.1 MMBtu/year for Harris County
  - 94.7 MMBtu/year for Tarrant County
  - 113.0 MMBtu/year for Potter County (Figure 8 and Figure 9)

Conversely, the 2006 IECC code-compliant house reported the lowest site energy consumption with these totals:

- For an electric/gas house:
  - 100.6 MMBtu/year for Harris County
  - 112.0 MMBtu/year for Tarrant County
  - 128.9 MMBtu/year for Potter County
- For a heat pump house:
  - 76.7 MMBtu/year for Harris County
  - 79.2 MMBtu/year for Tarrant County
  - 87.0 MMBtu/year for Potter County

The 2009 IECC code-compliant house reported the lowest site energy consumption with these totals:

- For an electric/gas house:
  - 89.9 MMBtu/year for Harris County
  - 98.6 MMBtu/year for Tarrant County
  - 123.7 MMBtu/year for Potter County
- For a heat pump house:
  - 68.2 MMBtu/year for Harris County
  - 69.9 MMBtu/year for Tarrant County
  - 80.0 MMBtu/year for Potter County

Figures 10 through 12 show the electricity use and natural gas use by month for each climate zone.

Similar trends were observed in the estimated annual utility bill of a house using $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 pre-code houses are expected to have the highest energy bills:

- For an electric/gas house:
  - $2,724/year for Harris County
  - $2,617/year for Tarrant County

    - $2,679/year for Potter County
- For a heat pump house:
    - $3,001/year for Harris County
    - $3,053/year for Tarrant County
    - $3,643/year for Potter County (Figure 13 and Figure 14).

Alternatively, the 2006 IECC code-compliant houses are expected to have the lowest energy bills:

- For an electric/gas house:
    - $2,237/year for Harris County
    - $2,192/year for Tarrant County
    - $2,145/year for Potter County
- For a heat pump house:
    - $2,473/year for Harris County
    - $2,553/year for Tarrant County
    - $2,805/year for Potter County

The 2009 IECC code-compliant houses are expected to have the lowest energy bills:

- For an electric/gas house:
    - $1,971/year for Harris County
    - $1,920/year for Tarrant County
    - $1,960/year for Potter County
- For a heat pump house:
    - $2,199/year for Harris County
    - $2,254/year for Tarrant County
    - $2,579/year for Potter County

3.2 **Annual Per-House Energy Savings from the Adoption of the 2001, 2006, and 2009 IECC**

The annual energy savings associated with the 2001, 2006, and 2009 IECC were calculated by comparisons to the respective pre-code cases:

- For an electric/gas house:
    - 14.232.9 MMBtu/year ($231$753/year) for Harris County
    - 13.735.3 MMBtu/year ($209$696/year) for Tarrant County
    - 31.455.4 MMBtu/year ($111$719/year) for Potter County
- For a heat pump house:
    - 7.524.9 MMBtu/year ($242$803/year) for Harris County
    - 7.424.8 MMBtu/year ($239$800/year) for Tarrant County
    - 9.733.0 MMBtu/year ($313$1,064/year) for Potter County (Figure 15 to Figure 18).

The corresponding percentage cost savings over a pre-code house are:

- For an electric/gas house:
    - 8.527.6% for Harris County
    - 8.026.6% for Tarrant County
    - 4.126.8% for Potter County
- For a heat pump house:
    - 8.126.7% for Harris County
    - 7.826.2% for Tarrant County
    - 8.629.2% for Potter County

For an electric/gas house, the natural gas savings (MMBtu/year) achieved from 2001 IECC is larger than electricity savings. In Potter County, the savings of all four versions of IECC codes are mainly from the savings in natural gas rather than electricity. However, due to the difference in the unit cost of electricity and gas, the dollar savings from electricity are higher than the savings from gas, except in Potter County. In Potter County, no electricity savings were observed from the 2001 IECC code adoption.

3.3 **Per-House Peak Demand Reductions from 2001, 2006, and 2009 IECC**

The pre-code houses reported the highest peak summertime demand:

- For an electric/gas house:
  - 6.7 kW for Harris County
  - 7.0 kW for Tarrant County
  - 7.0 kW for Potter County
- For a heat pump house:
  - 7.1 kW for Harris County
  - 7.3 kW for Tarrant County
  - 7.5 kW for Potter County (Figure 19 and Figure 20).

Not surprisingly, the 2009 IECC code-compliant house reported the lowest peak summertime demand:

- For an electric/gas house:
  - 3.8 kW for Harris County
  - 3.9 kW for Tarrant County
  - 4.0 kW for Potter County
- For a heat pump house:
  - 4.1 kW for Harris County
  - 4.2 kW for Tarrant County
  - 4.4 kW for Potter County

In the analysis, the same peak day was used regardless of the house type: September 16 for Harris County, August 13 for Tarrant County, and June 29 for Potter County.

In the winter, the peak electric demands were estimated for a heat pump house:

- A pre-code house, where the highest peak wintertime demands were found:
  - 11.3 kW for Harris County
  - 12.0 kW for Tarrant County
  - 17.9 kW for Potter County
- A 2009 IECC code-compliant house, where the lowest wintertime demands are:
  - 5.9 kW for Harris County
  - 6.4 kW for Tarrant County
  - 11.5 kW for Potter County

The peak days used in the analysis were: January 11 for Harris County, January 15 for Tarrant County, and January 7 for Potter County. Figure 21 and Figure 22 show the peak summer and winter day hourly electricity use of pre-code and code-compliance houses for each climate zone.

Finally, the peak electric demand reductions associated with the adoption of the 2001, 2006, and 2009 IECC were calculated for both summer and winter periods (Figure 23).

- For summer, the reductions in peak summertime electric demands are expected to happen in the afternoon between 3 to 5 pm for both electric/gas and heat pump houses:
  - 0.5-2.9 kW for Harris County
  - 0.6-3.0 kW for Tarrant County

    - 1.9-3.1 kW for Potter County

In Potter County, no demand savings are expected in summer from the 2001 IECC code adoption.

- For winter, the electric demand reductions were estimated for a heat pump house:
    - 3.1-5.4 kW for Harris County
    - 2.4-5.6 kW for Tarrant County
    - 4.0-6.4 kW for Potter County

The corresponding percentage summer electric demand reductions over a pre-code house are:

- For an electric/gas house:
    - 8.1-43.5% for Harris County
    - 8.4-43.5% for Tarrant County
    - 27.1-43.8% for Potter County
- For a heat pump house:
    - 7.7-41.7% for Harris County
    - 8.1-41.9% for Tarrant County
    - 25.8-41.6% for Potter County

In the winter, the percent reductions are:

- For a heat pump house:
    - 27.6-47.6% for Harris County
    - 19.6-47.0% for Tarrant County
    - 22.5-35.7% for Potter County

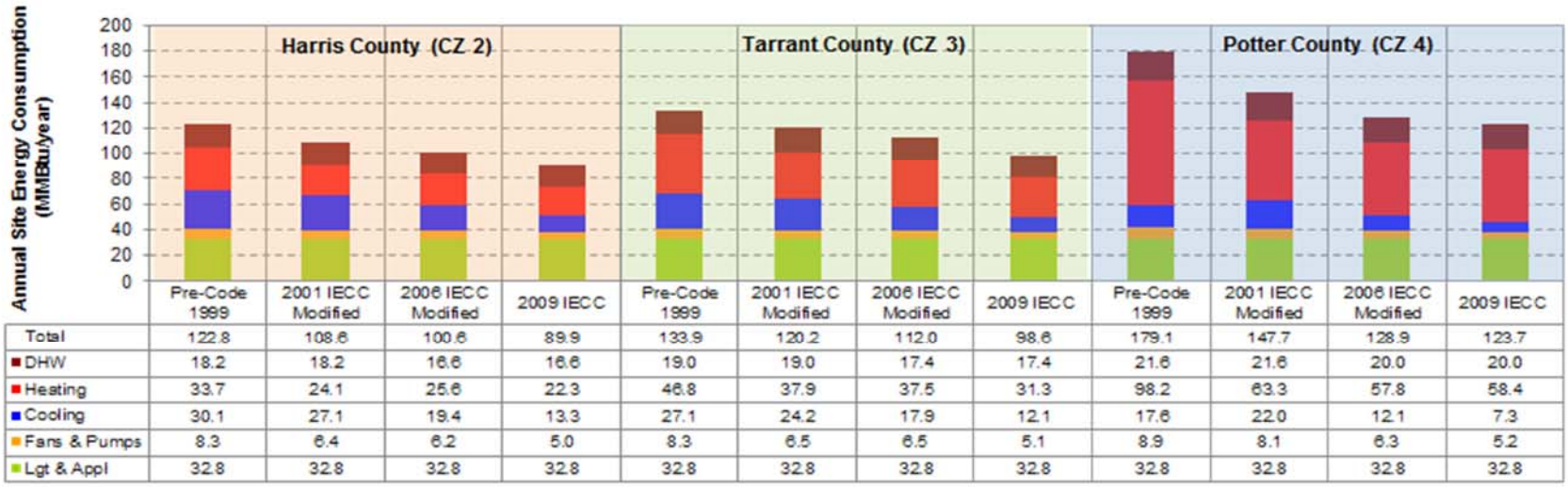
Table 2. Annual Per-House Energy Savings from IECC Code-Compliant, Single Family Residences in Texas.

Test Cases		Annual Total Site Energy Consumption (MMBtu/year)			Annual Total Site Energy Consumption ($/year)			Annual Total Energy Savings (MMBtu/year)			Annual Total Energy Savings ($/year)			
		Total	Elec.	NG	Total	Elec.	NG	Total	Elec.	NG	Total	Elec.	NG	% Savings vs. Pre-Code
(a) Electric/Gas House														
Harris County (CZ 2)	Pre-Code 1999	**122.8**	71.0	51.8	$2,724	$2,289	$435	-	-	-	-	-	-	-
	2001 IECC Modified	**108.6**	66.3	42.3	$2,493	$2,137	$355	14.2	4.7	9.5	$231	$152	$80	**8.5%**
	2006 IECC Modified	**100.6**	58.4	42.2	$2,237	$1,883	$354	22.2	12.6	9.6	$487	$406	$81	**17.9%**
	2009 IECC	**89.9**	51.0	38.9	$1,971	$1,644	$327	32.9	20.0	12.9	$753	$645	$108	**27.6%**
Tarrant County (CZ 3)	Pre-Code 1999	**133.9**	68.1	65.8	$2,617	$2,195	$421	-	-	-	-	-	-	-
	2001 IECC Modified	**120.2**	63.4	56.8	$2,407	$2,044	$364	13.7	4.7	9.0	$209	$152	$58	**8.0%**
	2006 IECC Modified	**112.0**	57.1	54.9	$2,192	$1,841	$351	21.9	11.0	10.9	$424	$355	$70	**16.2%**
	2009 IECC	**98.6**	49.9	48.7	$1,920	$1,609	$312	35.3	18.2	17.1	$696	$587	$109	**26.6%**
Potter County (CZ4)	Pre-Code 1999	**179.1**	59.3	119.8	$2,679	$1,912	$767	-	-	-	-	-	-	-
	2001 IECC Modified	**147.7**	62.8	84.9	$2,568	$2,025	$543	31.4	-3.5	34.9	$111	-$113	$223	**4.1%**
	2006 IECC Modified	**128.9**	51.1	77.8	$2,145	$1,647	$498	50.2	8.2	42.0	$533	$264	$269	**19.9%**
	2009 IECC	**123.7**	45.2	78.5	$1,960	$1,457	$502	55.4	14.1	41.3	$719	$455	$264	**26.8%**
(b) Heat Pump House														
Harris County (CZ 2)	Pre-Code 1999	**93.1**	93.1	-	$3,001	$3,001	-	-	-	-	-	-	-	-
	2001 IECC Modified	**85.6**	85.6	-	$2,760	$2,760	-	7.5	7.5	-	$242	$242	-	**8.1%**
	2006 IECC Modified	**76.7**	76.7	-	$2,473	$2,473	-	16.4	16.4	-	$529	$529	-	**17.6%**
	2009 IECC	**68.2**	68.2	-	$2,199	$2,199	-	24.9	24.9	-	$803	$803	-	**26.7%**
Tarrant County (CZ 3)	Pre-Code 1999	**94.7**	94.7	-	$3,053	$3,053	-	-	-	-	-	-	-	-
	2001 IECC Modified	**87.3**	87.3	-	$2,814	$2,814	-	7.4	7.4	-	$239	$239	-	**7.8%**
	2006 IECC Modified	**79.2**	79.2	-	$2,553	$2,553	-	15.5	15.5	-	$500	$500	-	**16.4%**
	2009 IECC	**69.9**	69.9	-	$2,254	$2,254	-	24.8	24.8	-	$800	$800	-	**26.2%**
Potter County (CZ4)	Pre-Code 1999	**113.0**	113.0	-	$3,643	$3,643	-	-	-	-	-	-	-	-
	2001 IECC Modified	**103.3**	103.3	-	$3,330	$3,330	-	9.7	9.7	-	$313	$313	-	**8.6%**
	2006 IECC Modified	**87.0**	87.0	-	$2,805	$2,805	-	26.0	26.0	-	$838	$838	-	**23.0%**
	2009 IECC	**80.0**	80.0	-	$2,579	$2,579	-	33.0	33.0	-	$1,064	$1,064	-	**29.2%**

Table 3. Annual Per-House Peak Electric Demand Reductions from IECC Code-Compliant, Single Family Residences in Texas.

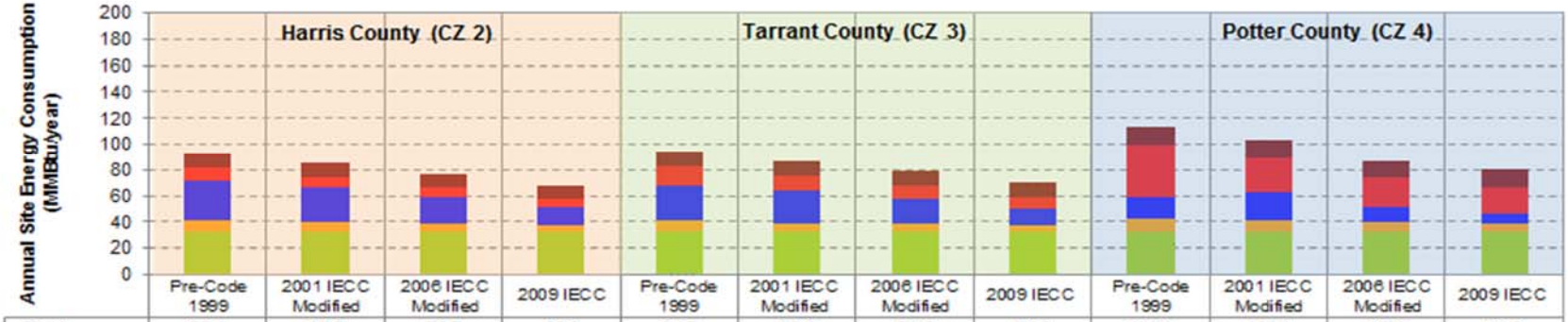
Test Cases		Summer Demand (kW)			Winter Demand (kW)		
		Peak Demand[1]	Reduction	% Reduction vs. Pre-Code	Peak Demand[2]	Reduction	% Reduction vs. Pre-Code
(a) Electric/Gas House							
Harris County (CZ 2)	Pre-Code 1999	6.7	-	-	-	-	-
	2001 IECC Modified	6.2	0.5	8.1%	-	-	-
	2006 IECC Modified	4.8	2.0	29.5%	-	-	-
	2009 IECC	3.8	2.9	43.5%	-	-	-
Tarrant County (CZ 3)	Pre-Code 1999	7.0	-	-	-	-	-
	2001 IECC Modified	6.4	0.6	8.4%	-	-	-
	2006 IECC Modified	5.1	1.9	27.2%	-	-	-
	2009 IECC	3.9	3.0	43.5%	-	-	-
Potter County (CZ4)	Pre-Code 1999	7.0	-	-	-	-	-
	2001 IECC Modified	7.0	0.0	0.0%	-	-	-
	2006 IECC Modified	5.1	1.9	27.1%	-	-	-
	2009 IECC	4.0	3.1	43.8%	-	-	-
(b) Heat Pump House							
Harris County (CZ 2)	Pre-Code 1999	7.1	-	-	11.3	-	-
	2001 IECC Modified	6.5	0.5	7.7%	8.2	3.1	27.6%
	2006 IECC Modified	5.1	2.0	28.4%	7.7	3.6	32.0%
	2009 IECC	4.1	3.0	41.7%	5.9	5.4	47.6%
Tarrant County (CZ 3)	Pre-Code 1999	7.3	-	-	12.0	-	-
	2001 IECC Modified	6.7	0.6	8.1%	9.6	2.4	19.6%
	2006 IECC Modified	5.4	1.9	26.3%	8.5	3.5	29.5%
	2009 IECC	4.2	3.0	41.9%	6.4	5.6	47.0%
Potter County (CZ4)	Pre-Code 1999	7.5	-	-	17.9	-	-
	2001 IECC Modified	7.5	0.0	0.0%	13.8	4.0	22.5%
	2006 IECC Modified	5.5	1.9	25.8%	12.2	5.6	31.4%
	2009 IECC	4.4	3.1	41.6%	11.5	6.4	35.7%

Note:
[1]Summer Peak Demand Date: (a) Electric/Gas House-September 16 (CZ 2), August 13 (CZ 3), and June 29 (CZ 4); and (b) Heat Pump House-September 16 (CZ 2), August 13 (CZ 3), and June 29 (CZ 4)
[2]Winter Peak Demand Date: (b) Heat Pump House-January 11 (CZ 2), January 15(CZ 3), and January 7 (CZ 4)



	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	122.8	108.6	100.6	89.9	133.9	120.2	112.0	98.6	179.1	147.7	128.9	123.7
DHW	18.2	18.2	16.6	16.6	19.0	19.0	17.4	17.4	21.6	21.6	20.0	20.0
Heating	33.7	24.1	25.6	22.3	46.8	37.9	37.5	31.3	98.2	63.3	57.8	58.4
Cooling	30.1	27.1	19.4	13.3	27.1	24.2	17.9	12.1	17.6	22.0	12.1	7.3
Fans & Pumps	8.3	6.4	6.2	5.0	8.3	6.5	6.5	5.1	8.9	8.1	6.3	5.2
Lgt & Appl	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8

Figure 8. Annual Site Energy Consumption by Different End Uses for a Pre-Code and Code-Compliant, Electric/Gas House in Texas.



	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	93.1	85.6	76.7	68.2	94.7	87.3	79.2	69.9	113.0	103.3	87.0	80.0
DHW	11.4	11.4	10.8	10.8	12.0	12.0	11.5	11.5	14.1	14.1	13.5	13.5
Heating	10.9	8.0	7.6	6.3	14.8	12.0	10.7	8.6	39.5	26.2	22.2	20.8
Cooling	30.1	27.1	19.4	13.3	27.1	24.2	17.9	12.1	17.6	22.0	12.1	7.3
Fans & Pumps	8.1	6.4	6.2	5.0	8.1	6.3	6.3	5.0	9.0	8.3	6.5	5.6
Lgt & Appl	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8

Figure 9. Annual Site Energy Consumption by Different End Uses for a Pre-Code and Code-Compliant, Heat Pump House in Texas.

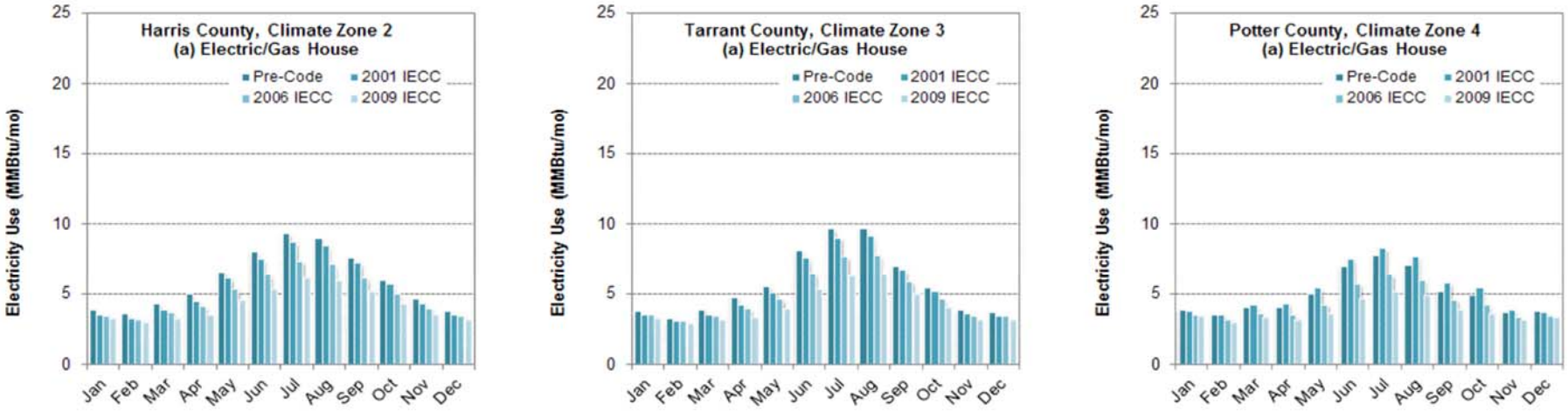


Figure 10. Monthly Electricity Use for a Pre-Code and Code-Compliant, Electric/Gas House in Texas.

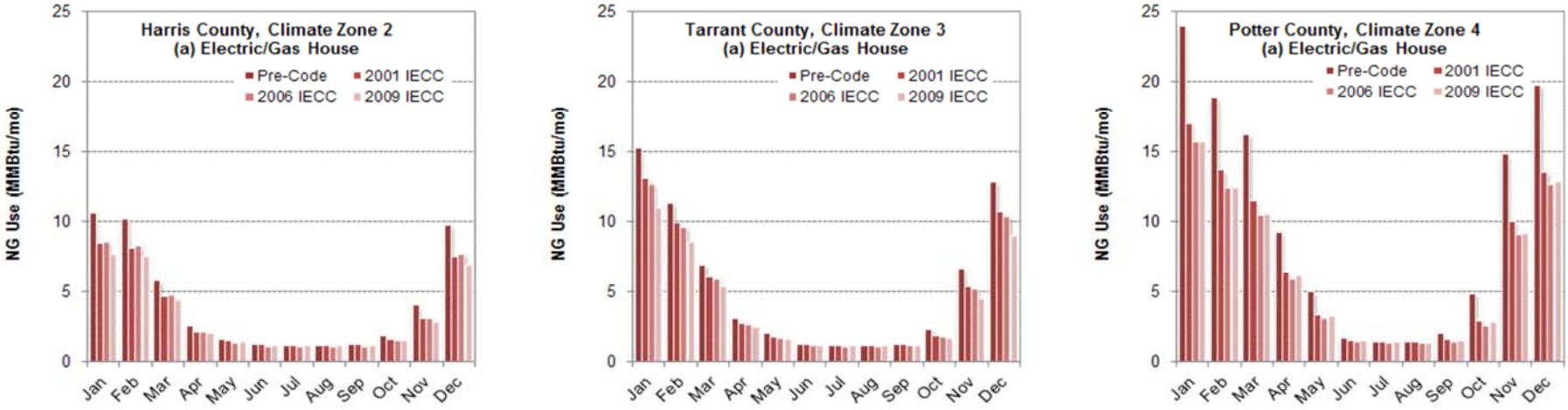


Figure 11. Monthly Natural Gas Use for a Pre-Code and Code-Compliant, Electric/Gas House in Texas.

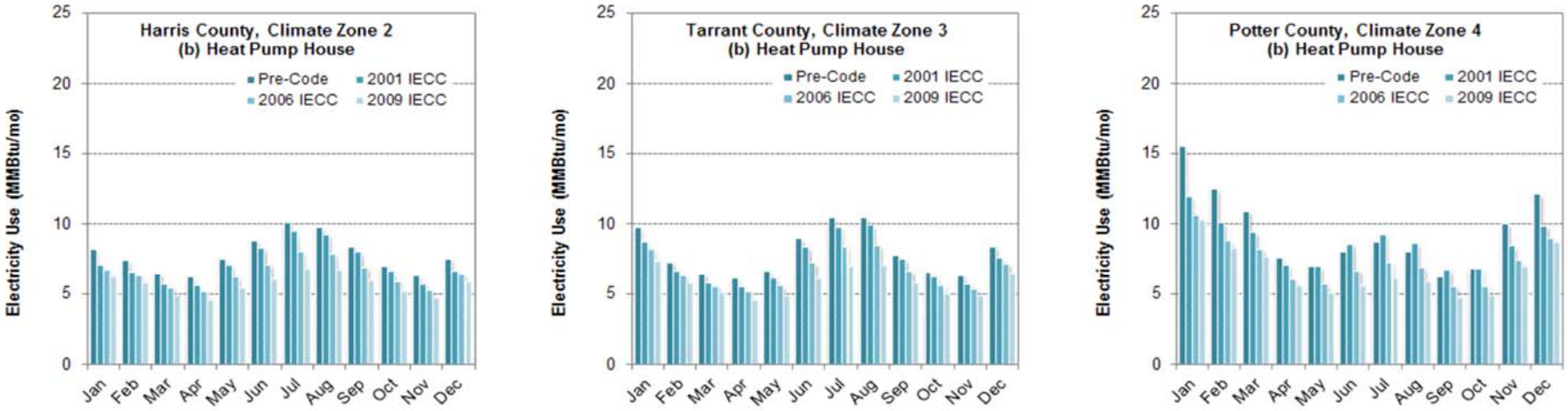
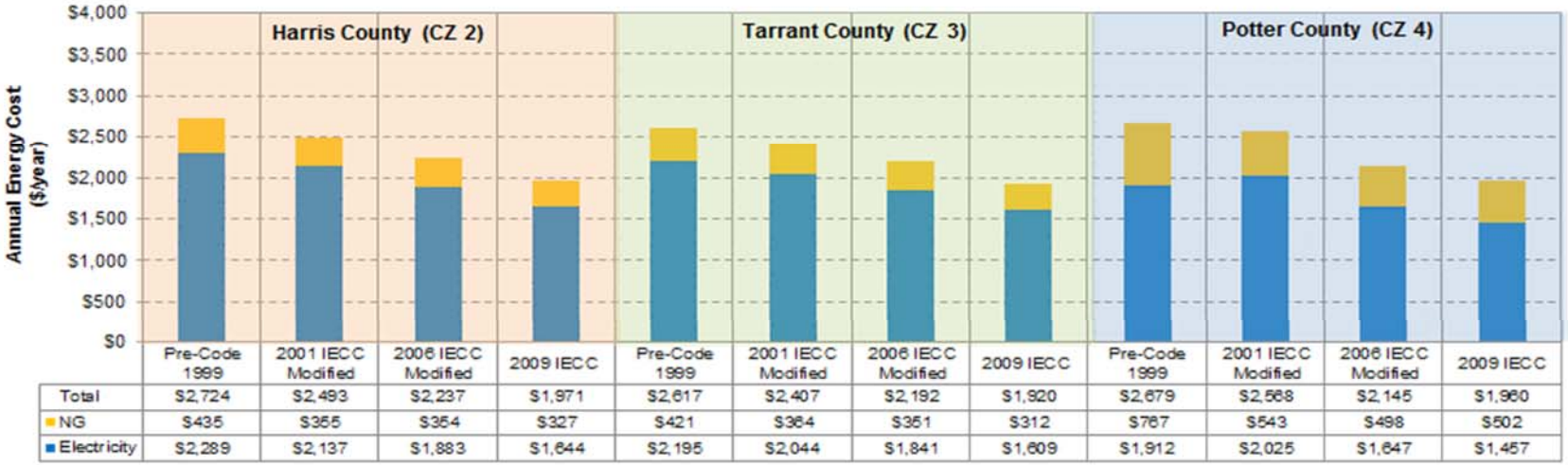
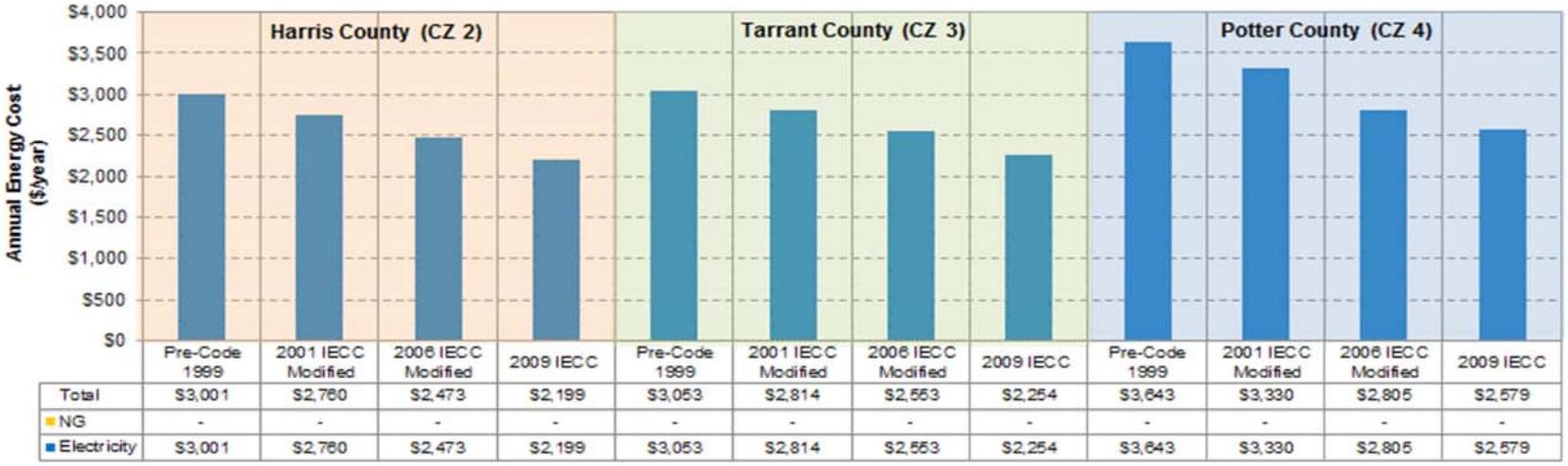


Figure 12. Monthly Electricity Use for a Pre-Code and Code-Compliant, Heat Pump House in Texas.



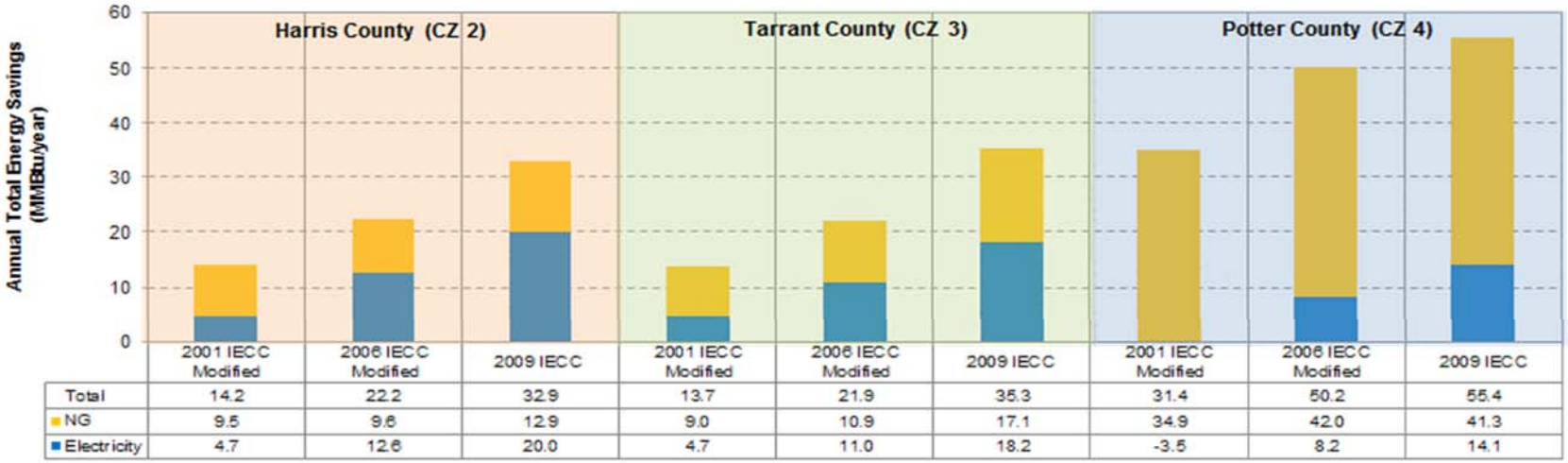
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	$2,724	$2,493	$2,237	$1,971	$2,617	$2,407	$2,192	$1,920	$2,679	$2,568	$2,145	$1,960
NG	$435	$355	$354	$327	$421	$364	$351	$312	$767	$543	$498	$502
Electricity	$2,289	$2,137	$1,883	$1,644	$2,195	$2,044	$1,841	$1,609	$1,912	$2,025	$1,647	$1,457

Figure 13. Annual Energy Bill by Fuel Type for a Pre-Code and Code-Compliant, Electric/Gas House in Texas.



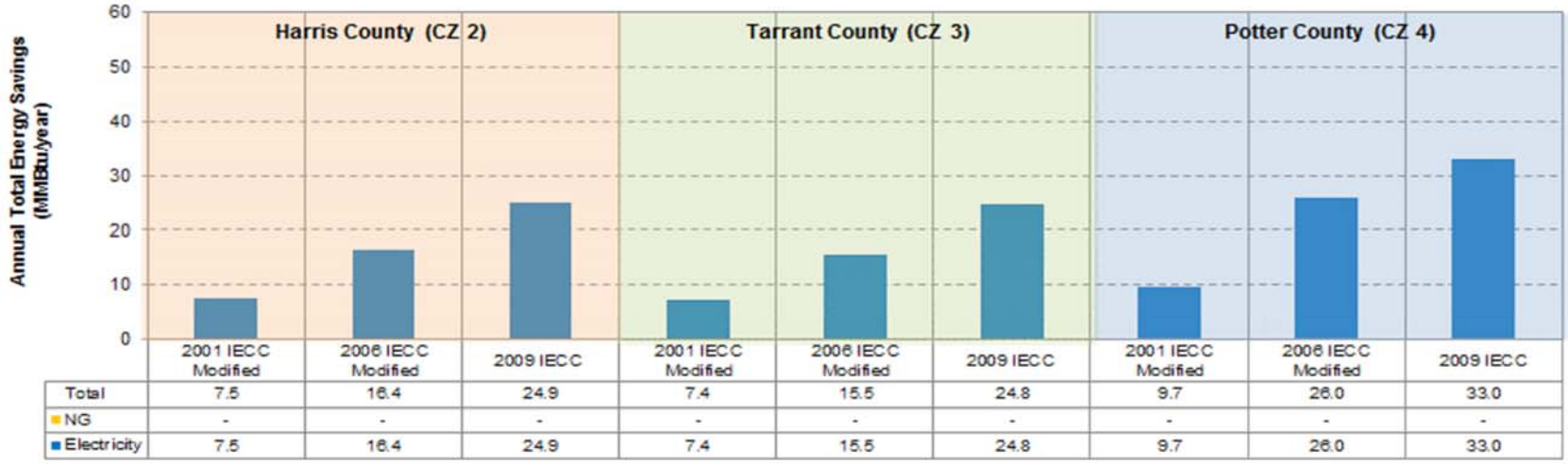
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	$3,001	$2,760	$2,473	$2,199	$3,053	$2,814	$2,563	$2,254	$3,643	$3,330	$2,805	$2,579
NG	-	-	-	-	-	-	-	-	-	-	-	-
Electricity	$3,001	$2,760	$2,473	$2,199	$3,053	$2,814	$2,563	$2,254	$3,643	$3,330	$2,805	$2,579

Figure 14. Annual Energy Bill by Fuel Type for a Pre-Code and Code-Compliant, Heat Pump House in Texas.



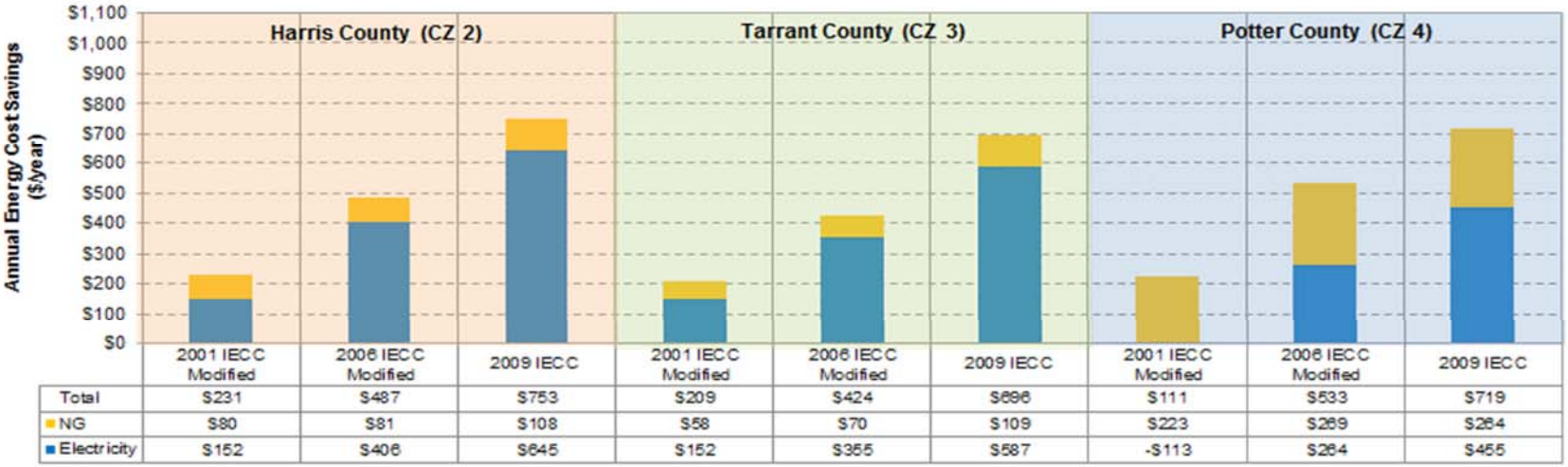
	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	14.2	22.2	32.9	13.7	21.9	35.3	31.4	50.2	55.4
NG	9.5	9.6	12.9	9.0	10.9	17.1	34.9	42.0	41.3
Electricity	4.7	12.6	20.0	4.7	11.0	18.2	-3.5	8.2	14.1

Figure 15. Annual Site Energy Savings per House from the 2001, 2006, and 2009 IECC Code-Compliant, Electric/Gas House in Texas.



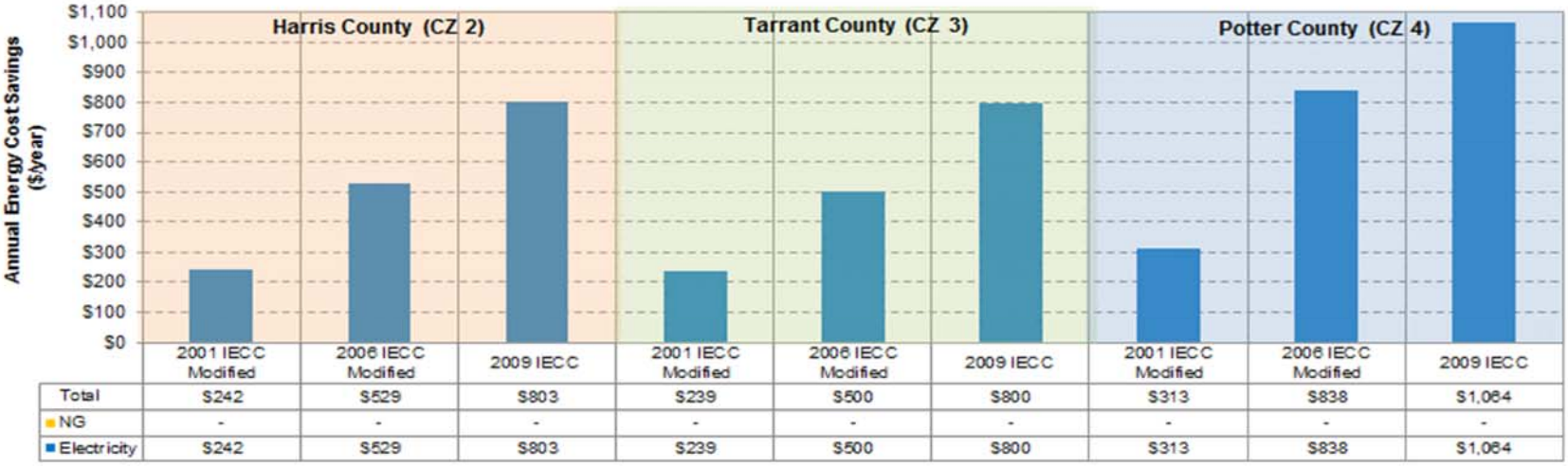
	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	7.5	16.4	24.9	7.4	15.5	24.8	9.7	26.0	33.0
NG	-	-	-	-	-	-	-	-	-
Electricity	7.5	16.4	24.9	7.4	15.5	24.8	9.7	26.0	33.0

Figure 16. Annual Site Energy Savings per House from the 2001, 2006, and 2009 IECC Code-Compliant, Heat Pump House in Texas.



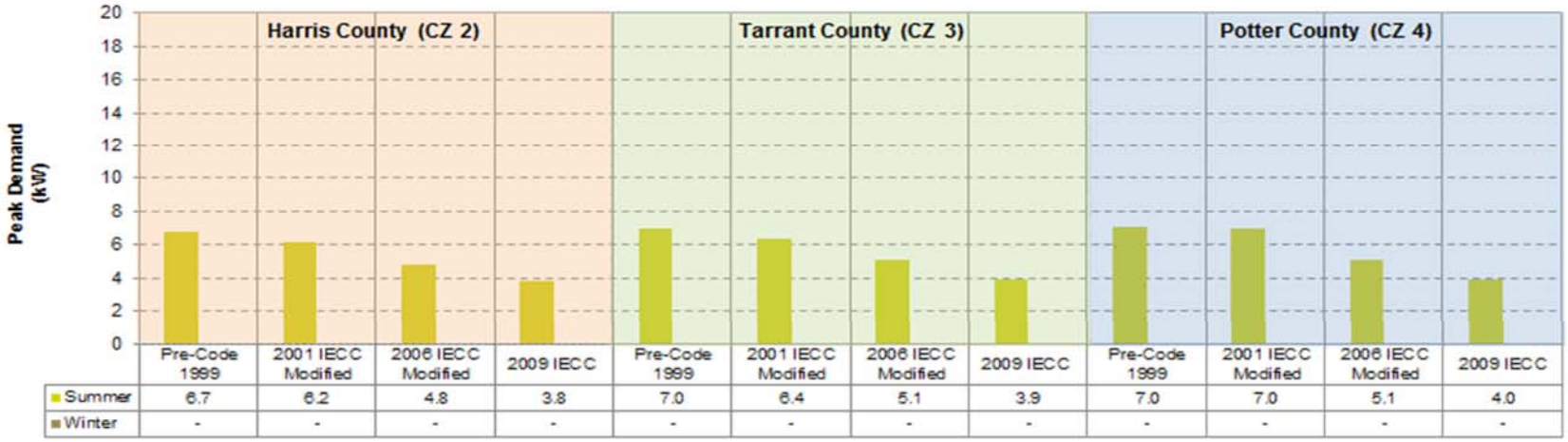
	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	$231	$487	$753	$209	$424	$696	$111	$533	$719
NG	$80	$81	$108	$58	$70	$109	$223	$269	$264
Electricity	$152	$406	$645	$152	$355	$587	-$113	$264	$455

Figure 17. Annual Energy Dollar Savings per House from the 2001, 2006, and 2009 IECC Code-Compliant, Electric/Gas House in Texas.



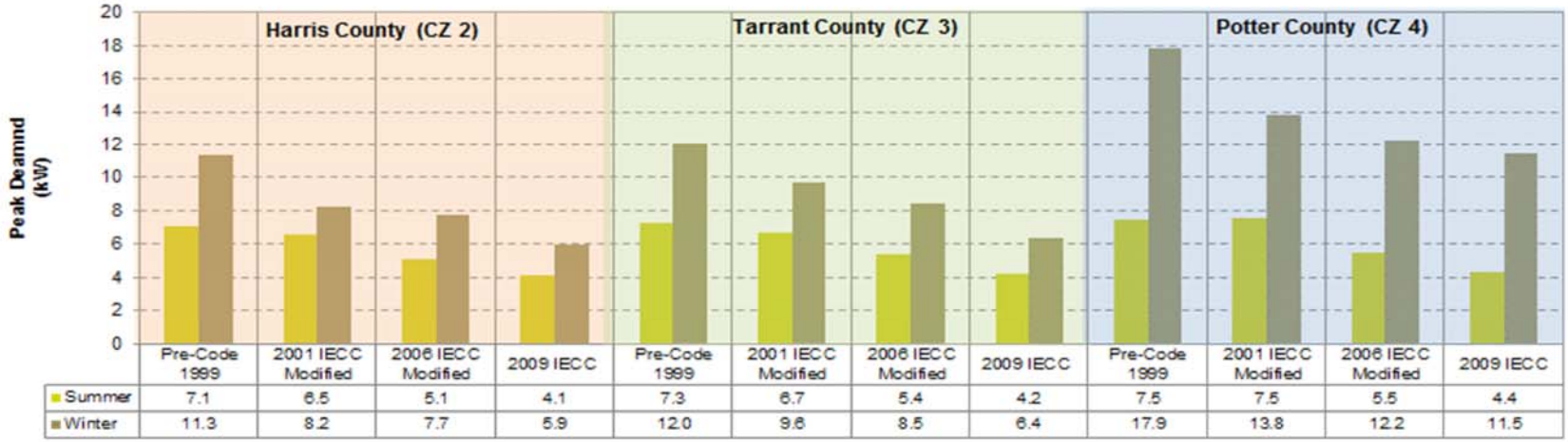
	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC	2001 IECC Modified	2006 IECC Modified	2009 IECC
Total	$242	$529	$803	$239	$500	$800	$313	$838	$1,064
NG	-	-	-	-	-	-	-	-	-
Electricity	$242	$529	$803	$239	$500	$800	$313	$838	$1,064

Figure 18. Annual Energy Dollar Savings per House from the 2001, 2006, and 2009 IECC Code-Compliant, Heat Pump House in Texas.



	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Summer	6.7	6.2	4.8	3.8	7.0	6.4	5.1	3.9	7.0	7.0	5.1	4.0
Winter	-	-	-	-	-	-	-	-	-	-	-	-

Figure 19. Peak Electric Demand for a Pre-Code and Code-Compliant, Electric/Gas House in Texas.



	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	2009 IECC
Summer	7.1	6.5	5.1	4.1	7.3	6.7	5.4	4.2	7.5	7.5	5.5	4.4
Winter	11.3	8.2	7.7	5.9	12.0	9.6	8.5	6.4	17.9	13.8	12.2	11.5

Figure 20. Peak Electric Demand for a Pre-Code and Code-Compliant, Heat Pump House in Texas.

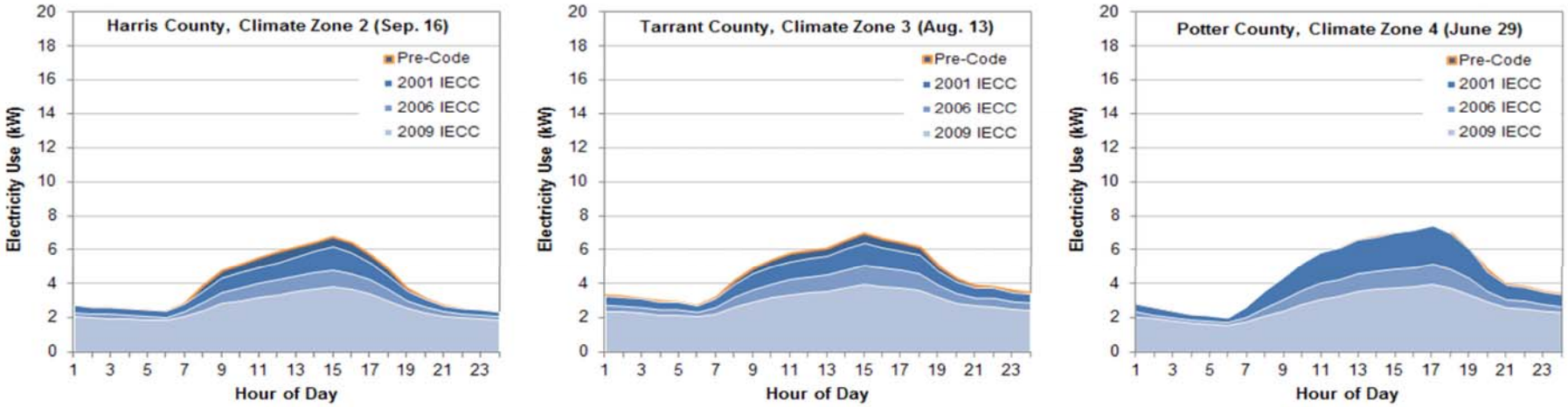


Figure 21. Peak Summer Day Hourly Electricity Use for a Pre-Code and Code-Compliant, House in Texas.

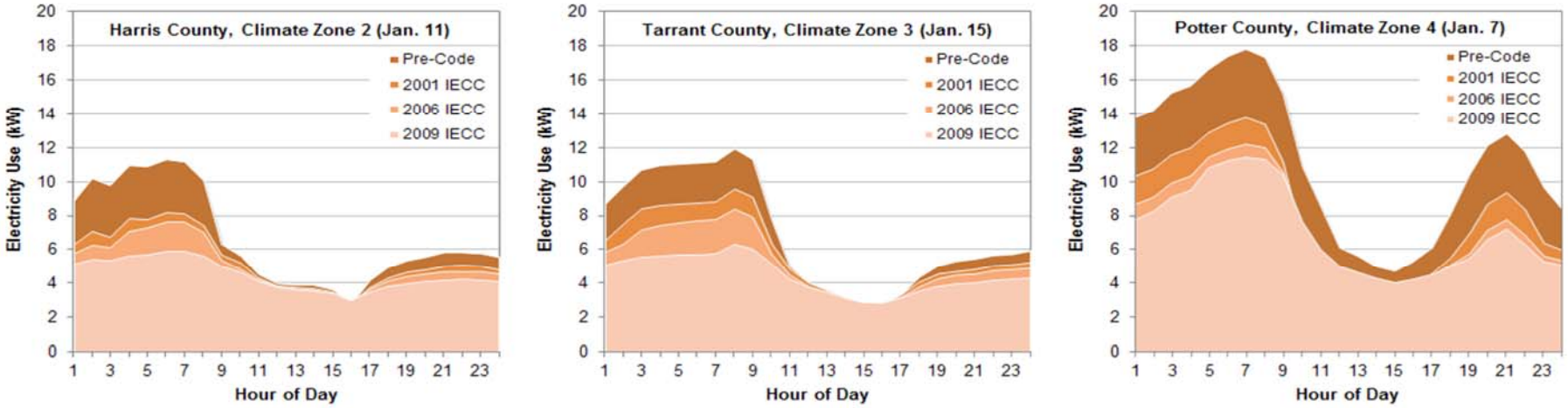


Figure 22. Peak Winter Day Hourly Electricity Use for a Pre-Code and Code-Compliant, Heat Pump House in Texas.

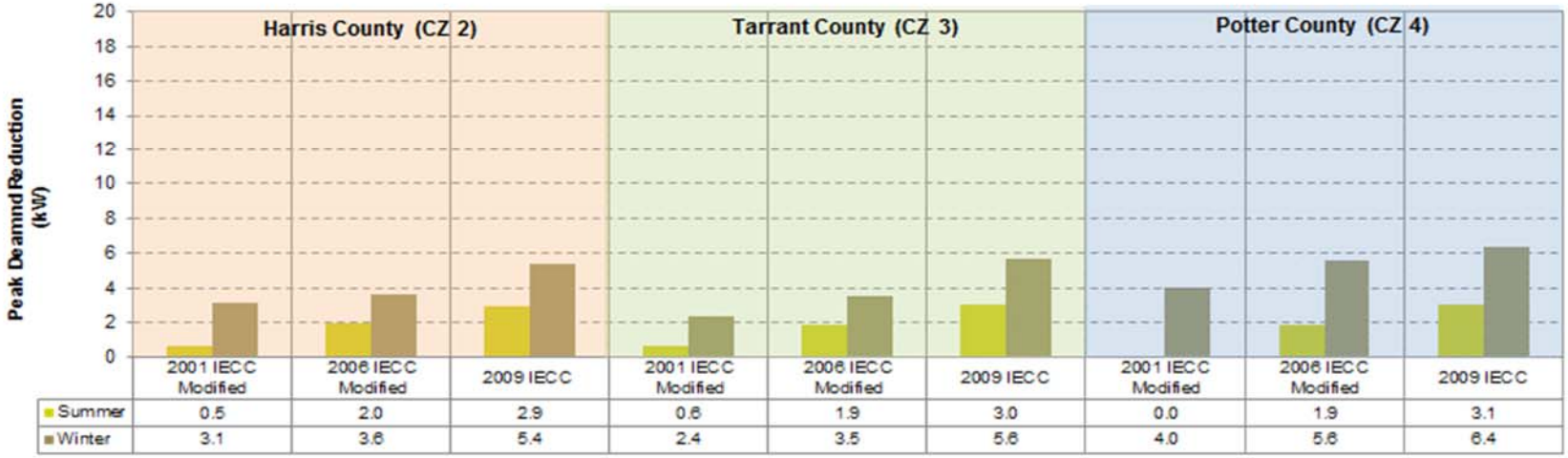


Figure 23. Peak Electric Demand Reductions per House from the 2001, 2006, and 2009 IECC Code-Compliant, Single-Family Residences in Texas.

4 STATEWIDE ELECTRICITY AND ELECTRIC DEMAND SAVINGS AND DEMAND REDUCTIONS

This section presents the estimations of the annual and cumulative statewide electricity savings and demand savings associated with the IECC code adoption over the past twelve years, 2002-2013. Table 4 presents the annual electricity savings (MWh/year) from code-compliant new single-family housing in Texas for years 2002 through 2013 reported in the Laboratory's Annual Reports submitted to the TCEQ (Haberl et al. 2002–2014),[8,9] and the corresponding electricity cost savings calculated using the annual average prices of Texas residential electricity published by the U.S. DOE EIA (2014). The electric demand savings from the reduced peak demands (i.e., avoided construction cost of a peaking plant) were also estimated using the average capital cost of natural gas combined cycle power plant: $1,165 per kW (Kaplan 2008). Table 5 presents the total number of new single-family houses built each year and the annual demand reductions expected from the code adoption since 2002. The results are also shown in Figure 24 through Figure 27.

A 20% initial discount factor, a 7% transmission and distribution loss factor, and a 5% annual degradation factor were applied in the calculations. To estimate the statewide electric demand reductions from the IECC code adoption, the 2001, 2006, and 2009 IECC were assumed to be adopted across Texas in 2002, 2007, and 2012, respectively. For capacity savings, a 15% reserve margin was applied in the calculations.

Finally, the annual electricity savings in 2013 are estimated to be $168 million (Figure 24)[10], and the total cumulative electricity savings over the period from 2002 to 2013 are estimated to be $1,403 million (Figure 25). The electric demand reductions in 2013 are estimated to be 1,166 MW for the summer and 1,175 MW for the winter periods[11] (Figure 26). The corresponding electric demand savings (i.e., avoided construction cost of a peaking plant) are estimated to be $1,563 million for the summer and $1,574 million for the winter periods from 2002 to 2013 (Figure 27).

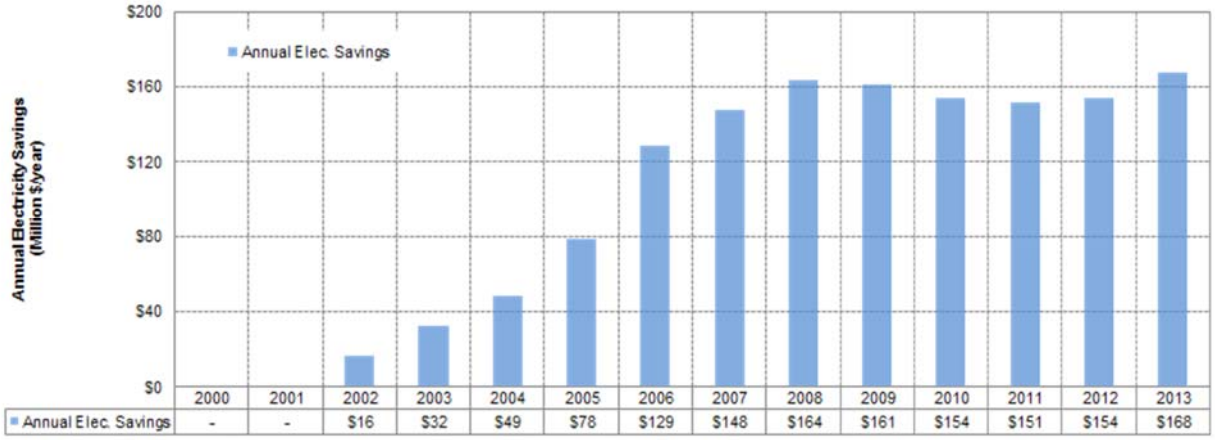
[8] The annual electricity savings (MWh/year) were reported for the 41 non-attainment and affected counties from 2002 to 2004 and for all the counties in ERCOT region (which includes the 41 non-attainment and affected counties) from 2005 to 2013.
[9] For 2009, 2012, and 2013, the annual electricity savings (MWh/year) were recalculated in this report to revise the savings reported in the 2009, 2012, and 2013 Annual Reports.
[10] The average first-year electricity savings per house is based on the calculated results of statewide electricity savings reported to TCEQ, which varied from $133 to $274 per year. For the entire analysis period from 2002 to 2013, the weighted-average first-year savings was $235. The difference in the calculated first-year savings at the state-level analysis (i.e., $133 to $274) versus the first-year building-level savings (i.e., $111 to $1,064) presented in the Table 2 of Section 3 of this report is due to several factors. The reasons for the difference include the fact that the savings of $133 to $274 accounts for the savings only from the electricity reduction and is a weighted-average savings across the state (i.e., weighted by the number of houses in each climate zone and by the type of heating system). On the other hand, the savings of $111 to $1,064 is a simulated savings that was calculated separately for each climate zone, as well as by the type of heating system. The higher value (i.e., $1,064) was calculated for a 2009 code-compliant heat pump house in Potter County, which occupies a very small fraction of the total new construction; the lower value (i.e., $111) was calculated for a 2001 code-compliant natural gas house in Potter County, which also occupies a very small fraction of the total new construction.
[11] The reductions in peak wintertime demands were estimated for houses with heat pump heating.

Table 4. Statewide Electricity Savings from the Code Adoption in New Houses since 2002.

	Year											
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Electricity Savings from New Construction of the Year (MWh/year)	201,159	159,736	166,243	241,167	325,621	251,182	126,482	117,879	105,141	124,174	127,246	169,008
Annual Total Electricity Savings (MWh/year)	201,159	350,838	499,036	713,846	1,001,051	1,197,537	1,256,764	1,301,063	1,326,731	1,366,174	1,402,481	1,474,187
Annual Average Electricity Rate ($/kWh)	0.08	0.09	0.10	0.11	0.13	0.12	0.13	0.12	0.12	0.11	0.11	0.11
Annual Total Electricity Savings (Million $)	$16	$32	$49	$78	$129	$148	$164	$161	$154	$151	$154	$168
2002-2013 Cumulative Electricity Savings (Million $)	$16	$48	$97	$175	$304	$451	$615	$776	$930	$1,082	$1,236	$1,403

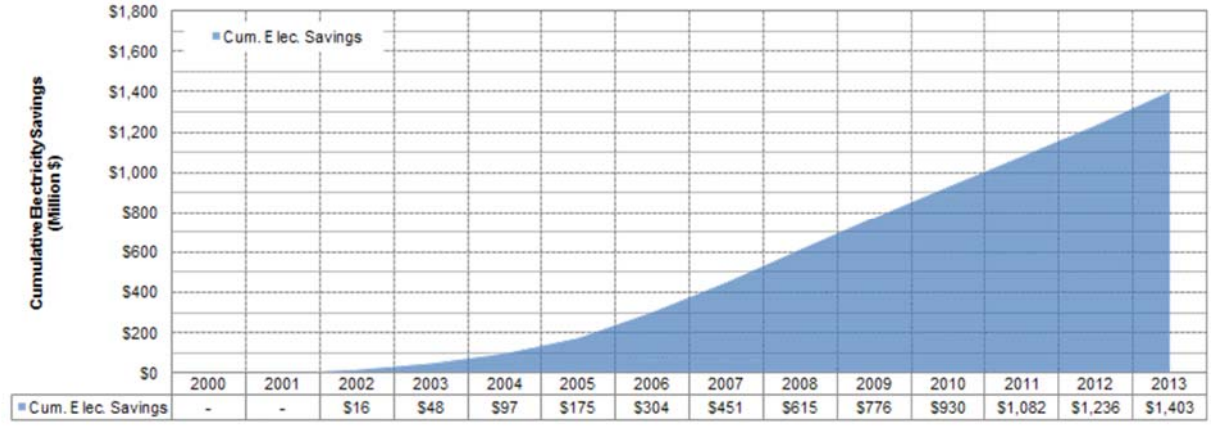
Table 5. Number of New Single-Family Houses in Texas and Demand Reductions from the Code Adoption in New Houses since 2002.

2009 IECC Climate Zone	Type of Heating System	Year											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of New Single-Family Houses per Year													
Zone 2	Electric/Gas House	56,803	55,274	64,011	67,067	69,102	51,787	28,619	24,401	19,811	16,243	35,882	41,024
	All Electric House	17,547	28,857	28,091	37,290	38,421	28,794	24,774	21,552	25,214	27,896	17,355	19,842
Zone 3	Electric/Gas House	30,314	44,501	34,239	40,240	36,138	26,051	17,414	7,487	7,302	10,186	9,222	10,520
	All Electric House	17,425	7,977	24,190	20,547	18,453	13,302	9,669	14,088	15,235	12,201	18,722	21,358
Zone 4	Electric/Gas House	523	750	500	701	601	547	368	233	210	331	246	242
	All Electric House	301	134	353	358	307	280	204	438	439	397	499	491
Total		122,913	137,493	151,384	166,203	163,022	120,761	81,048	68,199	68,211	67,254	81,926	93,477
Summer Demand Reduction (MW)													
Zone 2	Electric/Gas House	27	51	78	106	132	213	250	278	295	305	376	455
	All Electric House	8	21	33	49	64	110	146	175	208	243	272	306
Zone 3	Electric/Gas House	15	37	52	70	84	122	143	147	150	157	171	187
	All Electric House	9	12	24	33	40	60	72	91	110	124	165	210
Zone 4	Electric/Gas House	0	0	0	0	0	0.9	1.5	1.8	2.0	2.4	3.0	3.4
	All Electric House	0	0	0	0	0	0.5	0.8	1.4	2.1	2.6	3.8	4.9
Total		59	121	188	257	321	506	614	694	768	834	991	1,166
Winter Demand Reduction (MW)													
Zone 2	Electric/Gas House	-	-	-	-	-	-	-	-	-	-	-	-
	All Electric House	47	122	191	281	369	438	491	529	576	627	667	714
Zone 3	Electric/Gas House	-	-	-	-	-	-	-	-	-	-	-	-
	All Electric House	35	49	96	132	162	193	212	242	274	294	365	445
Zone 4	Electric/Gas House	-	-	-	-	-	-	-	-	-	-	-	-
	All Electric House	1.0	1.4	2.6	3.7	4.5	5.6	6.3	8.0	9.7	11.0	13.0	14.9
Total		83	173	289	417	535	637	709	779	859	931	1,045	1,175



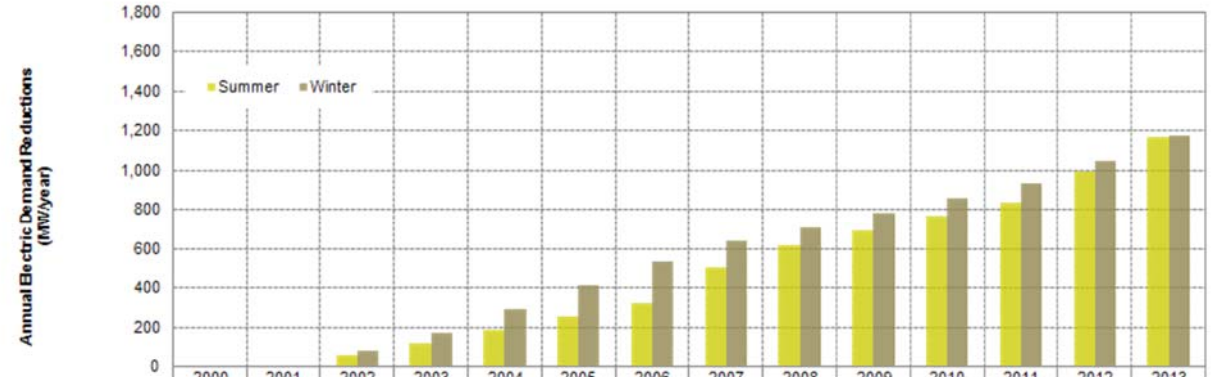
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Annual Elec. Savings	-	-	$16	$32	$49	$78	$129	$148	$164	$161	$154	$151	$154	$168

Figure 24. Annual Statewide Electricity Savings from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013.



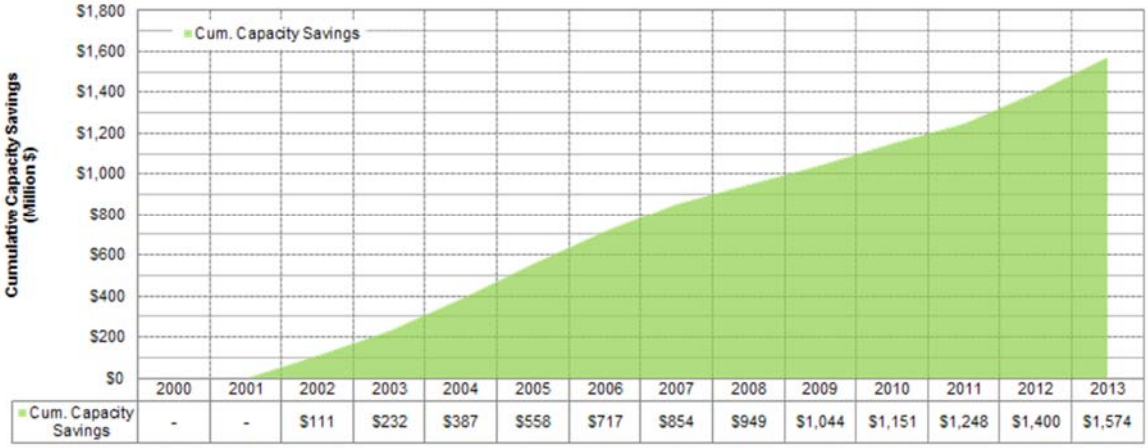
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Cum. Elec. Savings	-	-	$16	$48	$97	$175	$304	$451	$615	$776	$930	$1,082	$1,236	$1,403

Figure 25. Cumulative Electricity Savings from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Summer	-	-	59	121	188	257	321	506	614	694	768	834	991	1,166
Winter	-	-	83	173	289	417	535	637	709	779	859	931	1,045	1,175

Figure 26. Annual Statewide Electric Demand Reductions from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Cum. Capacity Savings	-	-	$111	$232	$387	$558	$717	$854	$949	$1,044	$1,151	$1,248	$1,400	$1,574

Figure 27. Cumulative Capacity Savings from the IECC Code Adoption for New Single-Family Residences in Texas: 2002-2013[12].

[12] For electric demand savings, the estimation for the winter periods ($1,574 million, cumulative) was displayed instead of summer ($1,563 million, cumulative).

5 INCREMENTAL COST ANALYSIS

This section presents the results of an incremental cost analysis to determine if the savings justify the increased construction costs for upgrading to the IECC. Table 6 presents the estimated per-house increased costs for upgrading major building components and systems to comply with the 2001 IECC, the 2006 IECC, and the 2009 IECC for each climate zone. The per-house increased construction costs, compared to pre-code construction, are estimated to be:

- For 2001 IECC
  - $600 for Climate Zone 2
  - $778 for Climate Zone 3
  - $1,215 for Climate Zone 4
- For 2006 IECC, the electric/gas and heat pump houses, respectively:
  - $1,002 and $902 for Climate Zone 2
  - $1,015 and $1,115 for Climate Zone 3
  - $1,644 and $1,744 for Climate Zone 4
- For 2009 IECC, the electric/gas and heat pump houses, respectively:
  - $1,606 and $1,506 for Climate Zone 2
  - $1,968 and $1,868 for Climate Zone 3
  - $2,410 and $2,310 for Climate Zone 4

Table 7 presents the statewide annual and cumulative totals of increased construction costs. Figure 28 shows the annual increased costs and the statewide electricity savings by the year the house was constructed. The annual statewide increased costs are estimated to range between $59 million and $146 million. For the houses built between 2002 and 2007, the cumulative electricity savings alone exceed the initial increased construction costs. If both electricity and electric demand savings are considered, the expected savings will be much higher. Figure 29 shows the cumulative statewide increased costs with the cumulative statewide electricity and demand savings from code-compliant, single-family residences built between 2002 and 2013. The cumulative statewide costs over the twelve year period from 2002 to 2013 are estimated to be $1,060 million while the cumulative electricity and demand savings are $2,966 million for the summer ($1,403 million from electricity savings and $1,563 million from demand savings) and $2,977 million for the winter periods ($1,403 million from electricity savings and $1,574 million from demand savings).

Table 6. Per-House Increased Construction Costs

Components	Pre-Code	2001 IECC	2006 IECC	2009 IECC	Change Per Sq. Ft. 2001 IECC	Change Per Sq. Ft. 2006 IECC	Change Per Sq. Ft. 2009 IECC	Sq. Ft /Linear Ft	Total Change 2001 IECC	Total Change 2006 IECC	Total Change 2009 IECC	Ref.
Climate Zone 2												
Ceiling Insulation	R-27	R-30	R-30	R-30	$ 0.09	$ 0.11	$ 0.11	2,548	$ 229	$ 280	$ 280	RSMeans 2002 and 2007
Window U/SHGC Factor	1.11/0.71	0.52/0.40	0.75/0.40	0.65/0.30	$ 1.50	$ 1.00	$ 1.50	247	$ 371	$ 247	$ 371	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	R-14	R-11	R-13	R-13	$ -	$ -	$ -	1,778	$ -	$ -	$ -	-
Slab Insulation	NR	NR	NR	NR	$ -	$ -	$ -	202	$ -	$ -	$ -	-
AC SEER	11	10	13	13	$ -	$ -	$ -		$ -	$ 300	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	0.54	0.54	0.59	0.59	$ -	$ -	$ -		$ -	$ 175	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	0.86	0.86	0.90	0.90	$ -	$ -	$ -		$ -	$ 75	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)
Improved Duct Sealing/Testing											$ 350	BCAP 2010
50% High Efficacy Lamps											$ 130	BCAP 2010
(a) Electric/Gas House Total									**$ 600**	**$ 1,002**	**$ 1,606**	
(b) All Electric House Total									**$ 600**	**$ 902**	**$ 1,506**	
Climate Zone 3												
Ceiling Insulation	R-27	R-30	R-30	R-30	$ 0.09	$ 0.11	$ 0.11	2,426	$ 218	$ 267	$ 267	RSMeans 2002 and 2007
Window U/SHGC Factor	0.87/0.66	0.50/0.40	0.65/0.40	0.50/0.30	$ 1.50	$ 1.00	$ 2.00	373	$ 560	$ 373	$ 746	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	R-14	R-11	R-13	R-13	$ -	$ -	$ -	1,814	$ -	$ -	$ -	-
Slab Insulation	NR	NR	NR	NR	$ -	$ -	$ -	197	$ -	$ -	$ -	-
AC SEER	11	10	13	13	$ -	$ -	$ -		$ -	$ 300	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	0.544	0.544	0.594	0.594	$ -	$ -	$ -		$ -	$ 175	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	0.86	0.86	0.90	0.90	$ -	$ -	$ -		$ -	$ 75	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)
Improved Duct Sealing/Testing											$ 350	BCAP 2010
50% High Efficacy Lamps											$ 130	BCAP 2010
(a) Electric/Gas House Total									**$ 778**	**$ 1,115**	**$ 1,968**	
(b) All Electric House Total									**$ 778**	**$ 1,015**	**$ 1,868**	
Climate Zone 4												
Ceiling Insulation	R-27	R-38	R-38	R-38	$ 0.27	$ 0.19	$ 0.19	2,426	$ 655	$ 461	$ 461	RSMeans 2002 and 2007
Window U/SHGC Factor	0.87/0.66	0.37/NR	0.40/NR	0.35/NR	$ 1.50	$ 1.50	$ 2.00	373	$ 560	$ 560	$ 746	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	R-14	R-11	R-12/3.125 c.i.	R-13	$ -	$ -	$ -	1,814	$ -	$ -	$ -	BCAP 2010
Slab Insulation	R-6, 2ft	R-6, 2ft	R-10, 2ft	R-10, 2ft	$ -	$ 1.26	$ 1.26	197	$ -	$ 248	$ 248	BCAP 2010 (R5 to R10: $1.26)
AC SEER	11	10	13	13	$ -	$ -	$ -	-	$ -	$ 300	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	0.544	0.544	0.594	0.594	$ -	$ -	$ -		$ -	$ 175	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	0.86	0.86	0.90	0.90	$ -	$ -	$ -		$ -	$ 75	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)
Improved Duct Sealing/Testing											$ 350	BCAP 2010
50% High Efficacy Lamps											$ 130	BCAP 2010
(a) Electric/Gas House Total									**$ 1,215**	**$ 1,744**	**$ 2,410**	
(b) All Electric House Total									**$ 1,215**	**$ 1,644**	**$ 2,310**	

Table 7.Statewide Increased Construction Costs

2009 IECC Climate Zone	Type of Heating System	Year											
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Zone 2	Electric/Gas House	$26	$26	$30	$40	$41	$51	$28	$23	$19	$16	$56	$64
	All Electric House	$8	$14	$13	$22	$23	$25	$22	$18	$22	$24	$25	$29
Zone 3	Electric/Gas House	$19	$27	$22	$28	$25	$25	$16	$7	$7	$9	$15	$18
	All Electric House	$11	$5	$16	$14	$13	$12	$8	$12	$12	$10	$29	$34
Zone 4	Electric/Gas House	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.01	$0.00	$0.00	$0.00	$0.00	$0.01
	All Electric House	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.01	$0.01
Annual Total Costs (Million $)		$64	$72	$81	$104	$101	$113	$74	$60	$60	$59	$126	$146
2002-2013 Cumulative Costs (Million $)		$64	$136	$218	$321	$422	$536	$610	$669	$729	$788	$914	$1,060

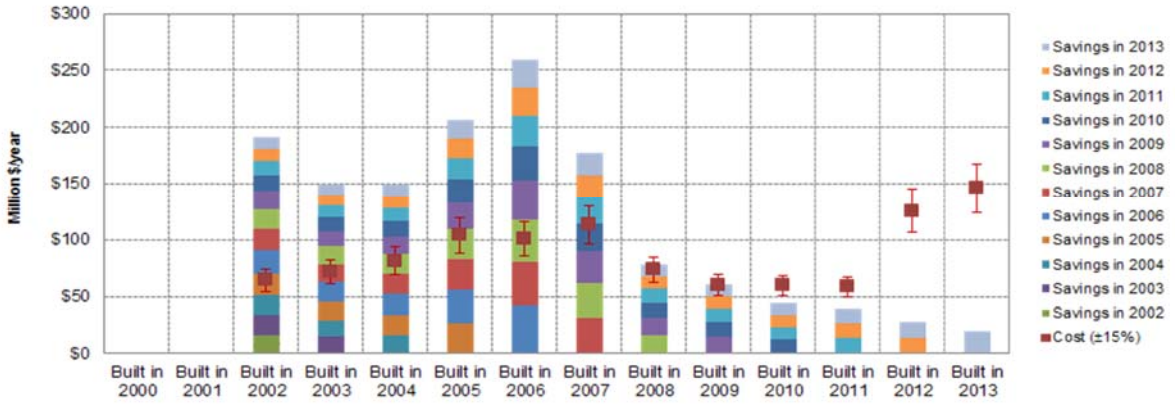


Figure 28. Annual Increased Costs and Statewide Electricity Savings by Construction Year of Houses.

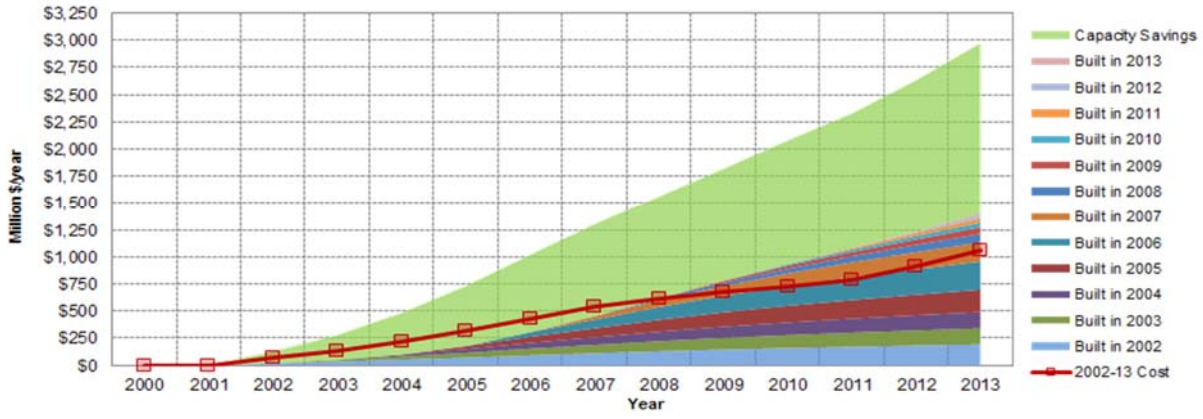


Figure 29. Cumulative Increased Costs and Statewide Electricity and Electric Demand Savings Associated with the IECC Code Adoption for Single-Family Residences in Texas: 2002-2013[13].

[13] For electric demand savings, the estimation for the winter periods ($1,574 million, cumulative) was displayed instead of summer ($1,563 million, cumulative).

6 SUMMARY

Statewide electricity savings and peak electric demand reductions achieved from the International Energy Conservation Code (IECC) adoption for single-family residences in Texas and the corresponding increase in construction costs over the twelve-year period from 2002 through 2013 are presented in this report. In the first part of the analysis, the impact of different versions of IECC (2001 IECC, 2006 IECC, and 2009 IECC) on energy savings and peak demand reductions were calculated at the individual building level using the IC3 simulation tool based on the DOE-2.1e program for three counties in Texas. The annual energy savings per house associated with the 2001, 2006, and 2009 IECC as compared to a pre-code house are:

- For an electric/gas house:
  - 14.2-32.9 MMBtu/year ($231-$753/year) for Harris County
  - 13.7-35.3 MMBtu/year ($209-$696/year) for Tarrant County
  - 31.4-55.4 MMBtu/year ($111-$719/year) for Potter County
- For a heat pump house:
  - 7.5-24.9 MMBtu/year ($242-$803/year) for Harris County
  - 7.4-24.8 MMBtu/year ($239-$800/year) for Tarrant County
  - 9.7-33.0 MMBtu/year ($313-$1,064/year) for Potter County

Demand reductions on the peak seasons are as follows:

- The peak summertime demand reductions per house for both electric/gas and heat pump houses are:
  - 0.5-2.9 kW for Harris County
  - 0.6-3.0 kW for Tarrant County
  - 1.9-3.1 kW for Potter County

In Potter County, no demand savings is expected in summer from the 2001 IECC code adoption.

- For winter, the demand reductions of a heat pump house are:
  - 3.1-5.4 kW for Harris County
  - 2.4-5.6 kW for Tarrant County
  - 4.0-6.4 kW for Potter County

To calculate the electricity cost savings at the statewide level, the annual MWh savings from code-compliant new single-family housing in Texas for years 2002 through 2013 which were reported in the Laboratory's Annual Reports to the TCEQ, were tabulated and multiplied by the annual average prices of Texas residential electricity published by the U.S. DOE EIA. To compute the statewide annual electric demand reductions, the peak demand reductions per house calculated in the building-level analysis were multiplied by the number of new single-family houses built in each climate zone of each year, and aggregated to annual totals with an annual degradation factor of 5%. To compute the avoided construction cost of a peaking plant (i.e., electric capacity savings), the calculated statewide electric demand savings in MW were multiplied by the average capital cost of a natural gas combined-cycle power plant, $1,165 per kW, with a 15% reserve margin.

As a result, the annual statewide electricity savings in 2013 are estimated to be $168 million, and the statewide electric demand reductions in 2013 are estimated to be 1,166 MW for the summer and 1,175 MW for the winter periods. Finally, the cumulative statewide electricity and electric capacity savings from the electric demand savings over the twelve year period from 2002 to 2013 are estimated to be $2,966 million for the summer ($1,403 million from electricity savings and $1,563 million from demand savings) and $2,977 million for the winter periods ($1,403 million from electricity savings and $1,574 million from demand savings), which exceeds the increased construction costs estimated to be $1,060 million.

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