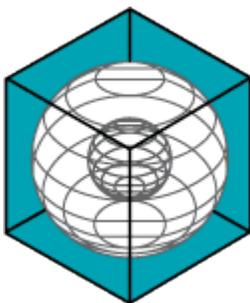


**A COMPARISON OF BUILDING ENERGY CODE STRINGENCY:
2009 IRC VERSUS 2012 IRC
FOR SINGLE-FAMILY RESIDENCES IN TEXAS**

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EXECUTIVE SUMMARY

The Laboratory was requested to perform a detailed technical analysis comparing the stringency of the Texas Building Energy Performance Standards (TBEPS), based on Chapter 11 of the 2009 International Residential Code (2009 IRC) for single-family residential construction to the 2012 International Residential Code (2012 IRC). The residential provisions in Chapter 11 of the 2012 IRC are identical to the 2012 IECC. This report presents the results of the required analysis using the relevant 2009 IECC residential (Chapters 1-4) provisions, which is one of the two paths to comply with the 2009 IRC per Section N1101.2 of the code. A series of simulations were performed using an ESL single-family simulation model (BDL version 4.01.08 of International Code Compliance Calculator (IC3)) based on the DOE-2.1e program and the appropriate TMY2 weather files for three counties representing three 2009 and 2012 IECC Climate Zones across Texas: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4.

The analysis has determined that the residential provisions of 2012 IECC are more stringent than the 2009 IECC, which is one of the compliance options of the TBEPS based on the 2009 IRC. Figure 1 presents the calculated annual source energy consumption of the modified 2009 IECC and 2012 IECC code-compliant, (a) electric/gas houses and (b) all-electric houses for three selected counties in Texas. The estimated annual source energy savings associated with the 2012 IECC compared to the modified 2009 IECC¹ are:

- (a) For an electric/gas house:
 - 24.7 MMBtu/yr (10.6 kBtu/ft²·yr) for Harris County,
 - 34.8 MMBtu/yr (15.0 kBtu/ft²·yr) for Tarrant County, and
 - 40.3 MMBtu/yr (17.3 kBtu/ft²·yr) for Potter County.
- (b) For a heat pump house:
 - 19.3 MMBtu/yr (8.3 kBtu/ft²·yr) for Harris County,
 - 28.7 MMBtu/yr (12.3 kBtu/ft²·yr) for Tarrant County, and
 - 34.4 MMBtu/yr (14.8 kBtu/ft²·yr) for Potter County.

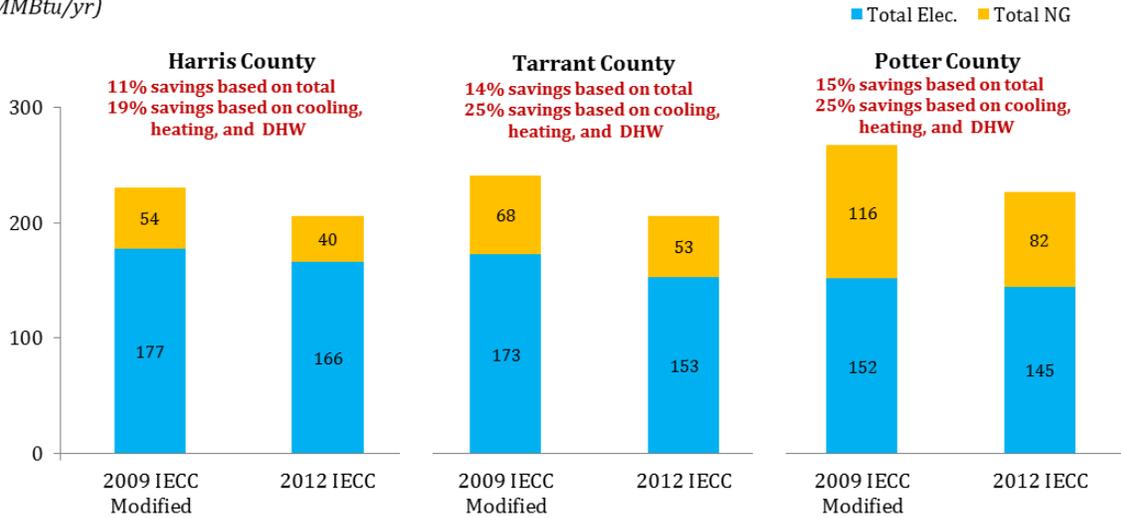
The corresponding percentage savings based on cooling, heating and domestic hot water consumption of the modified 2009 IECC code-compliant house are²:

- (a) For an electric/gas house:
 - 19% for Harris County,
 - 25% for Tarrant County, and
 - 25% Potter County.
- (b) For a heat pump house:
 - 14% for Harris County,
 - 20% for Tarrant County, and
 - 19% for Potter County.

¹ The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2009 and 2012 IECC performance path analysis per Section 405 of the 2009 IECC and Section R405 of the 2012 IECC. To facilitate a better comparison between two codes, the following modifications were applied to the 2009 IECC codes: 1) Interior shading fractions were modified to match the values provided in the 2012 IECC; and 2) The mechanical ventilation rate, which is the same as the 2012 IECC code-compliant house, was added in addition to the air leakage rate to determine an air exchange rate of a house.

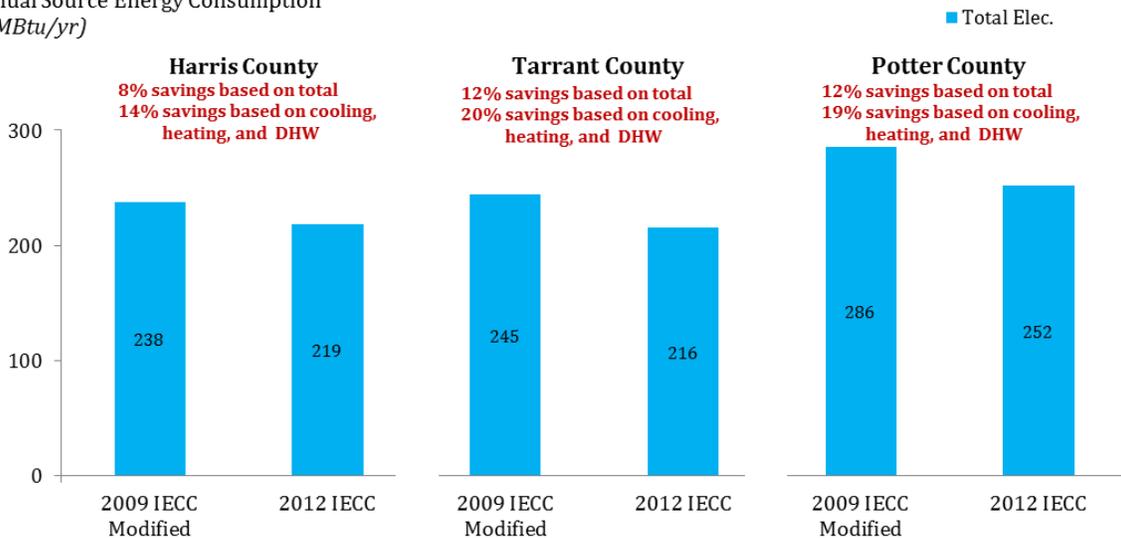
² The end-uses covered by the 2009 and 2012 IECC include heating, cooling, and DHW energy only per Section 405.1 of the 2009 IECC and Section R405.1 of the 2012 IECC.

Annual Source Energy Consumption (MMBtu/yr)



(a) Electric/Gas House

Annual Source Energy Consumption (MMBtu/yr)



(b) All-Electric House

Note: Base-case simulation assumptions: Analysis used single-family house, 2,325 ft², single-story, four bedrooms, slab-on-grade, ducts in the unconditioned vented attic, window-to-floor ratio: 15%, windows equally distributed (N, E, S, W), and no exterior shading. All other building envelope and system characteristics as specified in the 2009 and 2012 IECC performance path analysis per Section 405 of the 2009 IECC and Section R405 of the 2012 IECC.

Figure 1. Annual Source Energy Consumption by Fuel Type for Modified 2009 IECC and 2012 IECC Code-Compliant, (a) Electric/Gas Houses (upper figure) and (b) All-Electric Houses (below figure) in Three Counties in Texas.

TABLE OF CONTENTS

1 INTRODUCTION 1
 1.1 Organization of the Report 1
2 METHODOLOGY 2
 2.1 Overview 2
 2.2 Base-Case Building Description..... 3
3 RESULTS 6
 3.1 Annual Total Site Energy Consumption..... 6
 3.2 Peak Summertime and Wintertime Demands..... 6
 3.3 Annual Total Source Energy Consumption..... 7
 3.4 Peak Demand Savings from the 2012 IECC..... 8
 3.5 Annual Source Energy Savings from the 2012 IECC..... 8
4 SUMMARY 25
REFERENCES 26

LIST OF TABLES

Table 1. Base Case Building Description. 5

Table 2. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC:
Harris County for Climate Zone 2..... 10

Table 3. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC:
Tarrant County for Climate Zone 3..... 11

Table 4. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC:
Potter County in Climate Zone 4..... 12

Table 5. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Harris County
for Climate Zone 2. 13

Table 6. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Tarrant
County for Climate Zone 3..... 14

Table 7. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Potter County
for Climate Zone 4. 15

LIST OF FIGURES

Figure 1. Annual Source Energy Consumption by Fuel Type for Modified 2009 IECC and 2012 IECC Code-Compliant, (a) Electric/Gas Houses (upper figure) and (b) All-Electric Houses (below figure) in Three Counties in Texas. iii

Figure 2. 2009 and 2012 IECC Climate Zone Classification and Three Selected Counties in Texas. 2

Figure 3. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Harris County for Climate Zone 2. 16

Figure 4. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Tarrant County for Climate Zone 3. 17

Figure 5. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Potter County for Climate Zone 4. 18

Figure 6. Monthly Electricity and Natural Gas Use for the Modified 2009 and 2012 Code-Compliant, Electric/Gas House in Texas. 19

Figure 7. Monthly Electricity Use for the Modified 2009 and 2012 Code-Compliant, All-Electric House in Texas. 20

Figure 8. Peak Summer Day Hourly Electricity Use and Demand Savings for the Modified 2009 and 2012 Code-Compliant House in Texas 21

Figure 9. Peak Winter Day Hourly Electricity Use and Demand Savings for the Modified 2009 and 2012 Code-Compliant, All-Electric House in Texas 21

Figure 10. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Harris County for Climate Zone 2. 22

Figure 11. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Tarrant County for Climate Zone 3. 23

Figure 12. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Potter County for Climate Zone 4. 24

1 INTRODUCTION

This report presents the results of a detailed technical analysis comparing the stringency of the Texas Building Energy Performance Standards (TBEPS), based on Chapter 11 of the 2009 International Residential Code (2009 IRC) for single-family residential construction to the 2012 International Residential Code (2012 IRC). The residential provisions in Chapter 11 of the 2012 IRC are identical to the 2012 IECC. The analysis used the relevant 2009 IECC residential (Chapters 1-4) provisions, which is one of the two paths to comply with the 2009 IRC per Section N1101.2 of the code.

A series of simulations were performed using an ESL single-family simulation model (BDL version 4.01.08 of International Code Compliance Calculator (IC3)) based on the DOE-2.1e program and the appropriate TMY2 weather files for three counties representing three 2009 and 2012 IECC Climate Zones across Texas: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4. The base-case building was assumed to be a 2,325 sq. ft., square-shape, one story, single-family, detached house. The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2009 and 2012 IECC performance path analysis per Section 405 of 2009 IECC and Section R405 of 2012 IECC. In addition, to facilitate a better comparison between two codes, several modifications were applied to the 2009 IECC codes³. 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) an all-electric 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 and the base-case model used for simulation. Section 3 provides the results of simulation and the annual energy savings associated with the 2012 IECC. Lastly, Section 4 gives a summary.

³ To facilitate a better comparison between two codes, the following modifications were applied to the 2009 IECC codes: 1) Interior shading fractions were modified to match the values provided in the 2012 IECC; and 2) The mechanical ventilation rate, which is the same as the 2012 IECC code-compliant house, was added in addition to the air leakage rate to determine an air exchange rate of a house.

2 METHODOLOGY

This section describes the methodology and assumptions used in this analysis to determine the stringency of the 2009 and 2012 IECC. Section 2.1 presents an overall approach used in this analysis. Section 2.2 describes the base-case building characteristics.

2.1 Overview

The analysis was performed using an ESL single-family simulation model (BDL version 4.01.08 of IC3) based on the DOE-2.1e program of the 2009 IECC and the 2012 IECC code-compliant residences and the appropriate TMY2 weather files. Three counties in Texas representing three 2009 and 2012 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 2). For each representative county, A series of simulations that comply with the corresponding requirements of the 2009 IECC and the 2012 IECC were executed: for (a) an electric/ gas house (gas-fired furnace for space heating, and gas water heater for domestic water heating) and for (b) an all-electric house (heat pump for space heating, and electric water heater for domestic water heating).

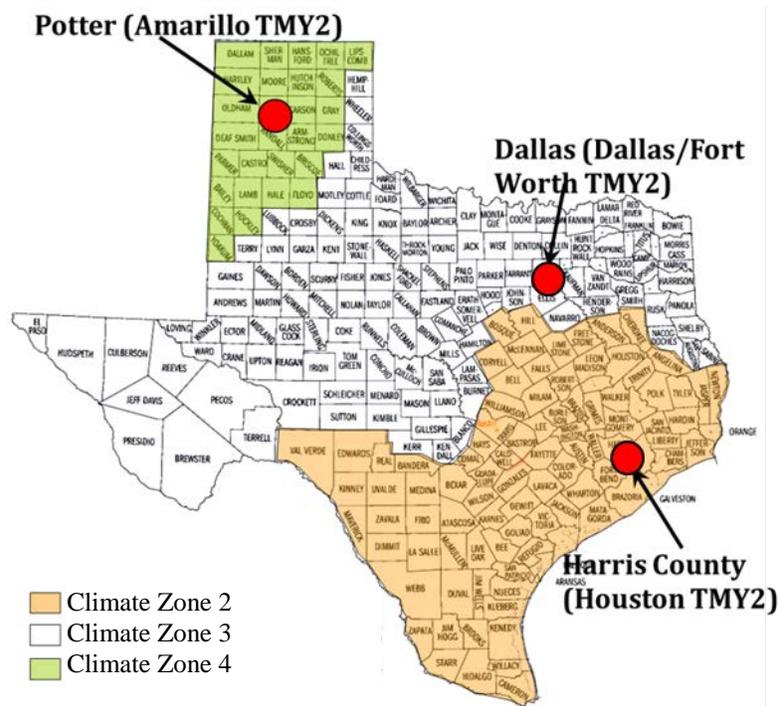


Figure 2. 2009 and 2012 IECC Climate Zone Classification and Three Selected Counties in Texas.

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 2009 and 2012 IECC performance path analysis per Section 405 of the 2009 IECC and Section R405 of the 2012 IECC.

Table 1 summarizes the base-case building characteristics used in the simulation model for each climate zone. To facilitate a better comparison between two codes, a second set of simulations for the 2009 IECC were created and labeled '2009 IECC Modified' in this table. Two modifications were applied to the 2009 IECC codes. First, interior shading fractions were modified to match the values provided in the 2012 IECC: 0.87 for Climate Zone 2 and 3 and 0.84 for Climate Zone 4). Secondly, the mechanical ventilation rate, which is the same as the 2012 IECC code-compliant house (60.75 cfm (0.20 ACH)⁴), was added in addition to the air leakage rate to determine an air exchange rate of a house. The performance path analysis of the 2012 IECC (Section R405) requires that the mechanical ventilation rate shall be in addition to the air leakage rate to determine an air exchange rate of a house while the 2009 IECC does not have any specifications regarding the mechanical ventilation rate for its standard reference house.

Several changes were made in the 2012 IECC. The building envelope and systems components that have different specifications from the 2009 IECC are highlighted in light orange in Table 1. These changes include:

- 1) Increased roof/ceiling insulation
 - Climate Zone 2: From U-0.035 (R-28.9) to U-0.030 (R-33.7)
 - Climate Zone 3: From U-0.035 (R-28.9) to U-0.030 (R-33.7)
 - Climate Zone 4: From U-0.030 (R-33.7) to U-0.026 (R-38.8)
- 2) Increased wall insulation
 - Climate Zone 2: U-0.082 (R-11.8) for both codes (no changes)
 - Climate Zone 3: From U-0.082 (R-11.8) to U-0.057 (R-18.9)
 - Climate Zone 4: From U-0.082 (R-11.8) to U-0.057 (R-18.9)
- 3) Decreased glazing U-factor
 - Climate Zone 2: From U-0.65 to U-0.40
 - Climate Zone 3: From U-0.50 to U-0.35
 - Climate Zone 4: U-0.35 for both codes (no changes)
- 4) Decreased glazing SHGC
 - Climate Zone 2: From 0.30 to 0.25
 - Climate Zone 3: From 0.30 to 0.25
 - Climate Zone 4: 0.40 for both codes (no changes)
- 5) Interior shading fraction (assumptive input for performance path analysis)⁵
 - Climate Zone 2: From 0.7 for summer and 0.85 for winter to 0.87 for both seasons

⁴ 60.75 cfm (0.20 ACH) was calculated using: $0.01 \times \text{Conditioned Floor Area} + 7.5 \times (\text{Number of bedrooms} + 1)$.

⁵ The fractions for the 2012 IECC were calculated using: $0.92 - (0.21 \times \text{SHGC of the standard reference design})$

- Climate Zone 3: From 0.7 for summer and 0.85 for winter to 0.87 for both seasons
 - Climate Zone 4: From 0.7 for summer and 0.85 for winter to 0.84 for both seasons
- 6) Reduced air leakage⁶
- Climate Zone 2: From 7 ACH50 to 5 ACH50
 - Climate Zone 3: From 7 ACH50 to 3 ACH50
 - Climate Zone 4: From 7 ACH50 to 3 ACH 50
- 7) Added mechanical ventilation rate (standard reference house input for performance path analysis)⁷
- Climate Zones 2, 3, and 4: No input, from 0 to 60.75 cfm (0.20 ACH)⁸
- 8) Reduced duct leakage
- Climate Zones 2, 3, and 4: From 8 cfm per 100 sq.ft. of conditioned floor are (CFA) of duct leakage to outdoors (11.2 %) to 4 cfm per 100 sq.ft. of CFA of total duct leakage (4.2%)⁹

⁶ A testing is optional in 2009 IECC, while it is mandatory in the 2012 IECC.

⁷ The performance path analysis of the 2012 IECC (Section R405) requires that the mechanical ventilation rate shall be in addition to the air leakage rate to determine an air exchange rate of a house while the 2009 IECC does not have any specifications regarding the mechanical ventilation rate for its standard reference house. In the 2012 IECC, mechanical ventilation system is required for the houses that have an air infiltration rate less than 5 ACH when tested with a blower door at a pressure of 0.2 inch w.c (50 Pa) per Section R403.5 of 2012 IECC and Section R 303.4 of 2012 IRC. Since the 2012 IECC requires the tested air leakage rate of not exceeding 5 ACH in Climate Zones 1 and 2 and 3 ACH in Climate Zones 3 through 8, to comply with the 2012 IECC, the houses need to be provided with appropriate ventilation rate based on the Table M1507.3.3(1) of the 2012 IRC.

⁸ 60.75 cfm (0.20 ACH) was calculated using: $0.01 \times \text{Conditioned Floor Area} + 7.5 \times (\text{Number of bedrooms} + 1)$.

⁹ The 2012 IECC includes only 'total duct leakage' option, which is 4 cfm per 100 sq.ft. of conditioned floor area (CFA) per Section R403.2.2. For an input of International Code Compliance Calculator (IC3), 3 cfm per 100 sq.ft. of CFA was assumed for 'duct leakage to outdoors,' which results in 4.2% duct leakage.

Table 1. Base Case Building Description.

| Characteristics | 2009 IECC | | | 2009 IECC Modified ¹ | | | 2012 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-28.9 | R-33.7 | | R-28.9 | R-33.7 | | R-33.7 | R-38.8 | |
| Wall Absorptance | 0.75 (Assuming brick facia exterior) | | | | | | | | |
| Wall Insulation (hr-sq.ft.-°F/Btu) | R-11.8 | | | R-11.8 | | | R-11.8 | R-18.9 | |
| Slab Perimeter Insulation | None | | R-10 | None | | R-10 | None | | R-10 |
| Ground Reflectance | 0.24 (Assuming grass) | | | | | | | | |
| U-Factor of Glazing (Btu/hr-sq.ft.-°F) | 0.65 | 0.50 | 0.35 | 0.65 | 0.50 | 0.35 | 0.40 | 0.35 | 0.35 |
| Solar Heat Gain Coefficient (SHGC) | 0.30 | | 0.40 | 0.30 | | 0.40 | 0.25 | | 0.40 |
| Window Area | 15% of conditioned floor area | | | 15% of conditioned floor area | | | 15% of conditioned floor area | | |
| Interior Shading | Summer 0.7, Winter 0.85 | | | (Simulation adjustment ¹ : 0.87) | (Simulation adjustment ¹ : 0.874) | | 0.87 | | 0.84 |
| 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 | | | | | | | | |
| Internal Heat Gains | 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) | | | | | | | | |
| Air Leakage (SG) | SLA= 0.00036 (0.28 ACH for Harris, 0.31 ACH for Tarrant, and 0.40 ACH for Potter) | | | SLA= 0.00036 (0.28 ACH for Harris, 0.31 ACH for Tarrant, and 0.40 ACH for Potter) | | | SLA= 0.00025 (0.20 ACH) | SLA= 0.00015 (0.13 ACH for Tarrant and 0.17 ACH for Potter) | |
| Mechanical Ventilation ² | - | | | (Simulation adjustment ¹ : 60.75 cfm (0.20 ACH)) | | | 60.75 cfm (0.20 ACH) | | |
| Mechanical Systems | | | | | | | | | |
| HVAC System Type | (a) Electric/Gas House: Electric cooling (air conditioner) and natural gas heating (gas fired furnace) (b) All-Electric House: Electric cooling and heating (air conditioner with heat pump) | | | | | | | | |
| HVAC System Efficiency | (a) Electric/Gas House: SEER 13 AC, 0.78 AFUE furnace (b) All-Electric House: SEER 13 AC, 7.7 HSPF | | | | | | | | |
| 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) All-Electric House: 50-gallon tank type electric water heater (without a pilot light) | | | | | | | | |
| DHW Heater Energy Factor | (a) Electric/Gas House: 0.594 (b) All-Electric House: 0.904 | | | | | | | | |
| Duct Distribution System Efficiency ³ | 11.2% duct leakage ⁴ , R-6/R-6 duct insulation | | | 11.2% duct leakage ⁴ , R-6/R-6 duct insulation | | | 4.2% duct leakage ⁵ , R-6/R-6 duct insulation | | |
| Supply Air Flow (CFM/ton) | 360 | | | | | | | | |

Note:

¹To facilitate a more accurate and realistic comparison between the codes, two adjustments were applied to the 2009 IECC codes.

²Air exchange rate = air leakage rate in addition to the mechanical ventilation rate per 2012 IECC Table R405.5.2(1).

³The mechanical systems of the houses were assumed to be located in unconditioned, vented attic, which requires a duct leakage test in the 2009 and 2012 IECC.

⁴Calculated from a maximum duct leakage to outdoors specified in 2009 IECC Sec. 403.2.2: 8 cfm per 100 sq.ft. of CFA .

⁵Calculated from a maximum total duct leakage specified in 2012 IECC Sec. R403.2.2: 4 cfm per 100 sq.ft. of CFA .

3 RESULTS

This section presents the results of simulation and examines the annual source energy savings associated with the 2012 IECC step-by-step for (a) an electric/ gas house (gas-fired furnace for space heating, and gas water heater for domestic water heating) and for (b) an all-electric house (heat pump for space heating, and electric water heater for domestic water heating). Table 2 to 4 show the input of step-by-step simulations for Harris, Tarrant, and Potter counties. Table 5 to 7 summarize the results of simulations for each county, including: the annual site energy consumption (by different end-uses, fuel types, and the total); the annual source energy consumption by fuel types and the total, and the calculated source energy percentage savings associated with the 2012 IECC above the modified 2009 IECC code-compliant base cases. The results are also graphically represented in Figure 3 to 12: the annual site energy consumption by end-uses in Figure 3 to 5; the monthly site energy consumption by fuel types in Figures 6 and 7; the peak summer and winter day hourly electricity use and demand savings in Figures 8 and 9; and the annual source energy consumption by fuel types in Figure 10 to 12.

3.1 Annual Total Site Energy Consumption

Across all counties the 2012 IECC code-compliant house reported less site energy consumption than both the 2009 IECC and the modified 2009 IECC with these totals:

- (a) For an electric/gas house:
 - 89.1 MMBtu/yr (38.3 kBtu/ft²·yr) for Harris County,
 - 96.5 MMBtu/yr (41.5 kBtu/ft²·yr) for Tarrant County, and
 - 120.5 MMBtu/yr (51.8 kBtu/ft²·yr) for Potter County.
- (b) For an all-electric house:
 - 69.2 MMBtu/yr (29.8 kBtu/ft²·yr) for Harris County,
 - 68.3 MMBtu/yr (29.4 kBtu/ft²·yr) for Tarrant County, and
 - 79.6 MMBtu/yr (34.2 kBtu/ft²·yr) for Potter County.

The modified 2009 IECC code-compliant house reported the following site energy totals:

- (a) For an electric/gas house:
 - 104.8 MMBtu/yr (45.1 kBtu/ft²·yr) for Harris County,
 - 116.7 MMBtu/yr (50.2 kBtu/ft²·yr) for Tarrant County, and
 - 153.1 MMBtu/yr (65.8 kBtu/ft²·yr) for Potter County.
- (b) For an all-electric house:
 - 75.3 MMBtu/yr (32.4 kBtu/ft²·yr) for Harris County,
 - 77.4 MMBtu/yr (33.3 kBtu/ft²·yr) for Tarrant County, and
 - 90.5 MMBtu/yr (38.9 kBtu/ft²·yr) for Potter County.

3.2 Peak Summertime and Wintertime Demands

The 2012 IECC code-compliant houses reported lower peak summertime demands:

- (a) For an electric/gas house:
 - 4.1 kW for Harris County,
 - 3.8 kW for Tarrant County, and
 - 3.9 kW for Potter County.
- (b) For an all-electric house:
 - 4.4 kW for Harris County,
 - 4.1 kW for Tarrant County, and
 - 4.3 kW for Potter County.

Not surprisingly, the modified 2009 IECC houses reported higher peak summertime demands:

- (a) For an electric/gas house:
 - 5.0 kW for Harris County,
 - 5.1 kW for Tarrant County, and
 - 4.6 kW for Potter County.
- (b) For an all-electric house:
 - 5.3 kW for Harris County,
 - 5.4 kW for Tarrant County, and
 - 5.0 kW for Potter County.

In the analysis, the same peak day was used regardless of the house type: August 20 for Harris County, July 29 for Tarrant County, and June 29 for Potter County.

In the winter, the peak electric demands were estimated for an all-electric house only. For the 2012 IECC code-compliant houses, where lower wintertime demands are:

- (b) For an all-electric house:
 - 6.3 kW for Harris County,
 - 6.3 kW for Tarrant County, and
 - 12.3 kW for Potter County.

For the modified 2009 IECC code-compliant houses, where higher peak wintertime demands were found:

- (b) For an all-electric house:
 - 10.5 kW for Harris County,
 - 11.0 kW for Tarrant County, and
 - 17.2 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.

3.3 Annual Total Source Energy Consumption

To calculate source energy consumption, the multipliers of 3.16 for electricity and 1.1 for natural gas were applied to site energy use per Section 405.3 of the 2009 IECC and Section R405.3 of the 2012 IECC. Across all counties the 2012 IECC code-compliant house reported less source energy consumption than both the 2009 IECC and the modified 2009 IECC with these totals:

- (a) For an electric/gas house:
 - 206.2 MMBtu/yr (88.7 kBtu/ft²·yr) for Harris County,
 - 206.1 MMBtu/yr (88.7 kBtu/ft²·yr) for Tarrant County, and
 - 227.0 MMBtu/yr (97.6 kBtu/ft²·yr) for Potter County.
- (b) For an all-electric house:
 - 218.7 MMBtu/yr (94.1 kBtu/ft²·yr) for Harris County,
 - 215.9 MMBtu/yr (92.9 kBtu/ft²·yr) for Tarrant County, and
 - 251.6 MMBtu/yr (108.2 kBtu/ft²·yr) for Potter County.

The modified 2009 IECC code-compliant house reported the following source energy totals:

- (a) For an electric/gas house:
 - 230.9 MMBtu/yr (99.3 kBtu/ft²·yr) for Harris County,
 - 240.9 MMBtu/yr (103.6 kBtu/ft²·yr) for Tarrant County, and
 - 267.3 MMBtu/yr (115.0 kBtu/ft²·yr) for Potter County.
- (b) For an all-electric house:
 - 238.0 MMBtu/yr (102.4 kBtu/ft²·yr) for Harris County,

- 244.6 MMBtu/yr (105.2 kBtu/ft²·yr) for Tarrant County, and
- 286.0 MMBtu/yr (123.0 kBtu/ft²·yr) for Potter County.

3.4 Peak Demand Savings from the 2012 IECC

The peak electric demand reductions associated with the 2012 IECC were calculated for both summer and winter periods. For summer, the reductions in peak summertime electric demands are expected to happen in the afternoon between 3 to 5 pm:

- (a, b) For both electric/gas and an all-electric house:
- 0.9 kW for Harris County,
 - 1.3 kW for Tarrant County, and
 - 0.7 kW for Potter County.

For winter, the electric demand reductions were estimated for an all-electric house only:

- (b) For an all-electric house:
- 4.2 kW for Harris County,
 - 4.7 kW for Tarrant County, and
 - 4.9 kW for Potter County.

The corresponding percentage summer electric demand savings over the modified 2009 IECC code-compliant houses are:

- (a) For an electric/gas house:
- 18% for Harris County,
 - 26% for Tarrant County, and
 - 16% for Potter County.
- (b) For an all-electric house:
- 17% for Harris County,
 - 24% for Tarrant County, and
 - 14% for Potter County.

In the winter, the percent savings are:

- (b) For an all-electric house:
- 40% for Harris County,
 - 43% for Tarrant County, and
 - 29% for Potter County.

3.5 Annual Source Energy Savings from the 2012 IECC

The annual source energy savings associated with the 2012 IECC were calculated by comparisons to the respective, modified 2009 IECC code-compliant houses:

- (a) For an electric/gas house:
- 24.7 MMBtu/yr (10.6 kBtu/ft²·yr) for Harris County,
 - 34.8 MMBtu/yr (15.0 kBtu/ft²·yr) for Tarrant County, and
 - 40.3 MMBtu/yr (17.3 kBtu/ft²·yr) for Potter County.
- (b) For an all-electric house:
- 19.3 MMBtu/yr (8.3 kBtu/ft²·yr) for Harris County,
 - 28.7 MMBtu/yr (12.3 kBtu/ft²·yr) for Tarrant County, and
 - 34.4 MMBtu/yr (14.8 kBtu/ft²·yr) for Potter County.

The corresponding percentage savings based on cooling, heating and domestic hot water consumption of the modified 2009 IECC code-compliant house are¹⁰:

- (a) For an electric/gas house:
 - 19% for Harris County,
 - 25% for Tarrant County, and
 - 25% Potter County.
- (b) For an all-electric house:
 - 14% for Harris County,
 - 20% for Tarrant County, and
 - 19% for Potter County.

For an electric/gas house, the largest energy savings were from the measures of decreased window U-value (6.6%) and decreased duct leakage (6.3%) for Harris County and from the measure of decreased infiltration for both Tarrant and Potter counties (11.3% for Tarrant and 15.7% for Potter). For an all-electric house, the largest impacts on the savings were from the measure of decreased duct leakage (5.2%) for Harris County and decreased infiltration for both Tarrant and Potter counties (7.8% for Tarrant and 12.3% for Potter).

¹⁰ The end-uses covered by the 2009 and 2012 IECC include heating, cooling, and DHW energy only per Section 405.1 of the 2009 IECC and Section R405.1 of the 2012 IECC.

Table 2. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC: Harris County for Climate Zone 2.

| | | INPUT PARAMETERS FOR HARRIS COUNTY (CZ 2) | | | | | | | | |
|---------|---|---|--------------------------------|--------------------------------|--------------|--------------|------------------|--------------|---------------------|---------------------|
| Run No. | Test Cases | SLA for House | Winter Interior Shade Fraction | Summer Interior Shade Fraction | Roof R-Value | Wall R-Value | Glazing U-Factor | Glazing SHGC | Supply Duct Leakage | Return Duct Leakage |
| | 2009 IECC NG House for Harris (CZ 2) | 0.00036 | 0.85 | 0.70 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00060 | 0.87 | 0.87 | 33.7 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 2 | Decreased Window U-Value | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.40 | 0.30 | 0.056 | 0.056 |
| 3 | Decreased Window SHGC | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.25 | 0.056 | 0.056 |
| 4 | Decreased Infiltration | 0.00049 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 5 | Decreased Duct Leakage | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.021 | 0.021 |
| | 2012 IECC | 0.00049 | 0.87 | 0.87 | 33.7 | 11.8 | 0.40 | 0.25 | 0.021 | 0.021 |
| | 2009 IECC HP House for Harris (CZ 2) | 0.00036 | 0.85 | 0.70 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00060 | 0.87 | 0.87 | 33.7 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 2 | Decreased Window U-Value | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.40 | 0.30 | 0.056 | 0.056 |
| 3 | Decreased Window SHGC | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.25 | 0.056 | 0.056 |
| 4 | Decreased Infiltration | 0.00049 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.056 | 0.056 |
| 5 | Decreased Duct Leakage | 0.00060 | 0.87 | 0.87 | 28.9 | 11.8 | 0.65 | 0.30 | 0.021 | 0.021 |
| | 2012 IECC | 0.00049 | 0.87 | 0.87 | 33.7 | 11.8 | 0.40 | 0.25 | 0.021 | 0.021 |

Table 3. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC: Tarrant County for Climate Zone 3.

| | | INPUT PARAMETERS FOR TARRANT COUNTY (CZ 3) | | | | | | | | |
|---------|--|--|--------------------------------|--------------------------------|--------------|--------------|------------------|--------------|---------------------|---------------------|
| Run No. | Test Cases | SLA for House | Winter Interior Shade Fraction | Summer Interior Shade Fraction | Roof R-Value | Wall R-Value | Glazing U-Factor | Glazing SHGC | Supply Duct Leakage | Return Duct Leakage |
| | 2009 IECC NG House for Tarrant (CZ 3) | 0.00036 | 0.85 | 0.70 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00058 | 0.87 | 0.87 | 33.7 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 2 | Increased Wall Insulation | 0.00058 | 0.87 | 0.87 | 28.9 | 18.9 | 0.50 | 0.30 | 0.056 | 0.056 |
| 3 | Decreased Window U-Value | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.35 | 0.30 | 0.056 | 0.056 |
| 4 | Decreased Window SHGC | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.25 | 0.056 | 0.056 |
| 5 | Decreased Infiltration | 0.00037 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 6 | Decreased Duct Leakage | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.021 | 0.021 |
| | 2012 IECC | 0.00037 | 0.87 | 0.87 | 33.7 | 18.9 | 0.35 | 0.25 | 0.021 | 0.021 |
| | 2009 IECC HP House for Tarrant (CZ 3) | 0.00036 | 0.85 | 0.70 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00058 | 0.87 | 0.87 | 33.7 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 2 | Increased Wall Insulation | 0.00058 | 0.87 | 0.87 | 28.9 | 18.9 | 0.50 | 0.30 | 0.056 | 0.056 |
| 3 | Decreased Window U-Value | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.35 | 0.30 | 0.056 | 0.056 |
| 4 | Decreased Window SHGC | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.25 | 0.056 | 0.056 |
| 5 | Decreased Infiltration | 0.00037 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.056 | 0.056 |
| 6 | Decreased Duct Leakage | 0.00058 | 0.87 | 0.87 | 28.9 | 11.8 | 0.50 | 0.30 | 0.021 | 0.021 |
| | 2012 IECC | 0.00037 | 0.87 | 0.87 | 33.7 | 18.9 | 0.35 | 0.25 | 0.021 | 0.021 |

Table 4. Input Parameters for Step-by-Step Simulations of Changes Made in the 2012 IECC: Potter County in Climate Zone 4.

| | | INPUT PARAMETERS FOR POTTER COUNTY (CZ 4) | | | | | | | | |
|---------|---|---|--------------------------------|--------------------------------|--------------|--------------|------------------|--------------|---------------------|---------------------|
| Run No. | Test Cases | SLA for House | Winter Interior Shade Fraction | Summer Interior Shade Fraction | Roof R-Value | Wall R-Value | Glazing U-Factor | Glazing SHGC | Supply Duct Leakage | Return Duct Leakage |
| | 2009 IECC NG House for Potter (CZ 4) | 0.00036 | 0.85 | 0.70 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00053 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00053 | 0.84 | 0.84 | 38.8 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 2 | Increased Wall Insulation | 0.00053 | 0.84 | 0.84 | 33.7 | 18.9 | 0.35 | 0.40 | 0.056 | 0.056 |
| 3 | Decreased Infiltration | 0.00032 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 4 | Decreased Duct Leakage | 0.00053 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.021 | 0.021 |
| | 2012 IECC | 0.00032 | 0.84 | 0.84 | 38.8 | 18.9 | 0.35 | 0.40 | 0.021 | 0.021 |
| | 2009 IECC HP House for Potter (CZ 4) | 0.00036 | 0.85 | 0.70 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| | 2009 IECC Modified | 0.00053 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 1 | Increased Roof Insulation | 0.00053 | 0.84 | 0.84 | 38.8 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 2 | Increased Wall Insulation | 0.00053 | 0.84 | 0.84 | 33.7 | 18.9 | 0.35 | 0.40 | 0.056 | 0.056 |
| 3 | Decreased Infiltration | 0.00032 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.056 | 0.056 |
| 4 | Decreased Duct Leakage | 0.00053 | 0.84 | 0.84 | 33.7 | 11.8 | 0.35 | 0.40 | 0.021 | 0.021 |
| | 2012 IECC | 0.00032 | 0.84 | 0.84 | 38.8 | 18.9 | 0.35 | 0.40 | 0.021 | 0.021 |

Table 5. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Harris County for Climate Zone 2.

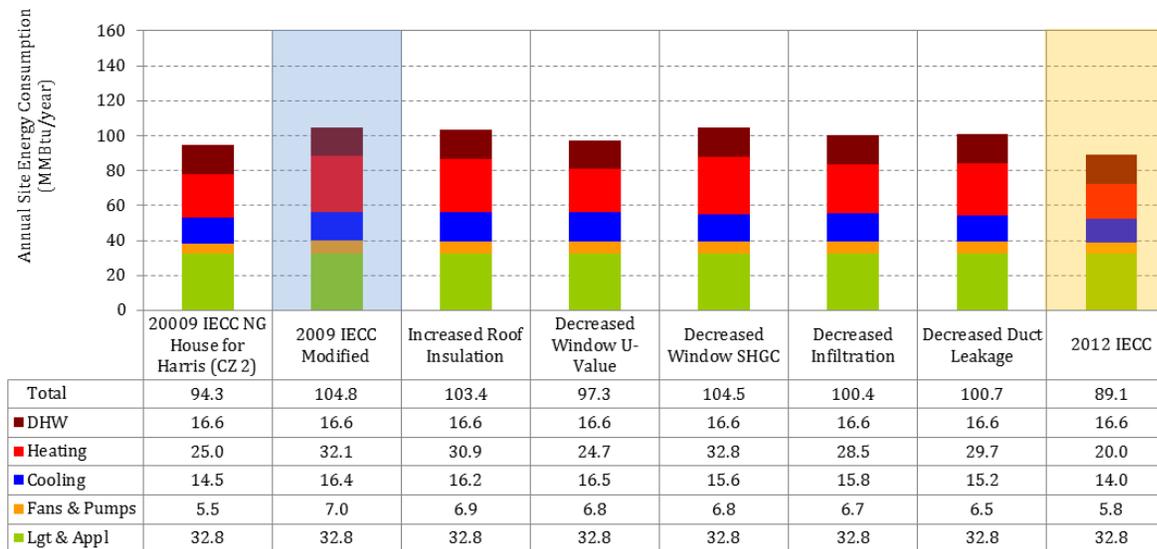
| | | RESULTS FOR HARRIS COUNTY (CZ 2) | | | | | | | | | | | | | | |
|---------|---|--|---------|------------|--------------|------|--|------|-------|--|------|-------|---|-------|-------|--------------|
| Run No. | Test Cases | Annual Site Energy Consumption by End Use (MMBtu/yr) | | | | | Annual Site Energy Consumption by Fuel Type (MMBtu/yr) | | | Annual Source Energy Consumption by Fuel Type (MMBtu/yr) | | | Savings Above 2009 IECC Modified (Source %) | | | |
| | | Cooling | Heating | Lgt & Appl | Fans & Pumps | DHW | Elec. | Gas | Total | Elec. | Gas | Total | Elec. | Gas | Total | C+H+DHW |
| | 2009 IECC NG House for Harris (CZ 2) | 14.5 | 25.0 | 32.8 | 5.5 | 16.6 | 52.7 | 41.6 | 94.3 | 166.5 | 45.8 | 212.3 | | | | |
| | 2009 IECC Modified | 16.4 | 32.1 | 32.8 | 7.0 | 16.6 | 56.1 | 48.7 | 104.8 | 177.3 | 53.6 | 230.9 | 0.0% | 0.0% | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 16.2 | 30.9 | 32.8 | 6.9 | 16.6 | 55.9 | 47.5 | 103.4 | 176.7 | 52.3 | 228.9 | 0.4% | 2.5% | 0.8% | 1.5% |
| 2 | Decreased Window U-Value | 16.5 | 24.7 | 32.8 | 6.8 | 16.6 | 56.0 | 41.3 | 97.3 | 177.0 | 45.4 | 222.4 | 0.2% | 15.2% | 3.7% | 6.6% |
| 3 | Decreased Window SHGC | 15.6 | 32.8 | 32.8 | 6.8 | 16.6 | 55.1 | 49.4 | 104.5 | 174.2 | 54.3 | 228.5 | 1.8% | -1.4% | 1.0% | 1.9% |
| 4 | Decreased Infiltration | 15.8 | 28.5 | 32.8 | 6.7 | 16.6 | 55.3 | 45.1 | 100.4 | 174.8 | 49.6 | 224.4 | 1.4% | 7.4% | 2.8% | 5.1% |
| 5 | Decreased Duct Leakage | 15.2 | 29.7 | 32.8 | 6.5 | 16.6 | 54.4 | 46.3 | 100.7 | 172.0 | 50.9 | 222.9 | 3.0% | 4.9% | 3.5% | 6.3% |
| | 2012 IECC | 14.0 | 20.0 | 32.8 | 5.8 | 16.6 | 52.5 | 36.6 | 89.1 | 166.0 | 40.3 | 206.2 | 6.4% | 24.8% | 10.7% | 19.4% |
| | 2009 IECC HP House for Harris (CZ 2) | 14.5 | 6.9 | 32.8 | 5.4 | 10.8 | 70.3 | - | 70.3 | 222.1 | - | 222.1 | | | | |
| | 2009 IECC Modified | 16.4 | 8.5 | 32.8 | 6.8 | 10.8 | 75.3 | - | 75.3 | 238.0 | - | 238.0 | 0.0% | - | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 16.2 | 8.3 | 32.8 | 6.7 | 10.8 | 74.8 | - | 74.8 | 236.4 | - | 236.4 | 0.7% | - | 0.7% | 1.2% |
| 2 | Decreased Window U-Value | 16.5 | 6.9 | 32.8 | 6.7 | 10.8 | 73.7 | - | 73.7 | 232.9 | - | 232.9 | 2.1% | - | 2.1% | 3.8% |
| 3 | Decreased Window SHGC | 15.6 | 8.7 | 32.8 | 6.6 | 10.8 | 74.5 | - | 74.5 | 235.5 | - | 235.5 | 1.1% | - | 1.1% | 1.9% |
| 4 | Decreased Infiltration | 15.8 | 7.7 | 32.8 | 6.6 | 10.8 | 73.7 | - | 73.7 | 232.9 | - | 232.9 | 2.1% | - | 2.1% | 3.8% |
| 5 | Decreased Duct Leakage | 15.2 | 7.9 | 32.8 | 6.4 | 10.8 | 73.1 | - | 73.1 | 231.1 | - | 231.1 | 2.9% | - | 2.9% | 5.2% |
| | 2012 IECC | 14.0 | 5.8 | 32.8 | 5.8 | 10.8 | 69.2 | - | 69.2 | 218.7 | - | 218.7 | 8.1% | - | 8.1% | 14.3% |

Table 6. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Tarrant County for Climate Zone 3.

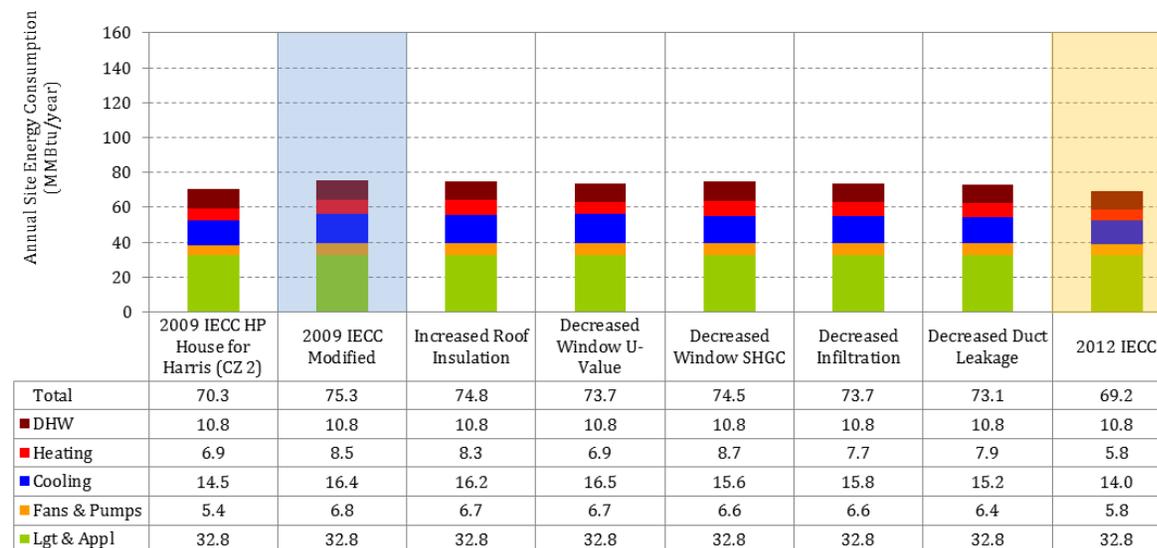
| | | RESULTS FOR TARRANT COUNTY (CZ 3) | | | | | | | | | | | | | | |
|---------|--|--|---------|------------|--------------|------|--|------|-------|--|------|-------|---|-------|-------|--------------|
| Run No. | Test Cases | Annual Site Energy Consumption by End Use (MMBtu/yr) | | | | | Annual Site Energy Consumption by Fuel Type (MMBtu/yr) | | | Annual Source Energy Consumption by Fuel Type (MMBtu/yr) | | | Savings Above 2009 IECC Modified (Source %) | | | |
| | | Cooling | Heating | Lgt & Appl | Fans & Pumps | DHW | Elec. | Gas | Total | Elec. | Gas | Total | Elec. | Gas | Total | C+H+DHW |
| | 2009 IECC NG House for Tarrant (CZ 3) | 13.1 | 35.0 | 32.8 | 5.6 | 17.4 | 51.4 | 52.4 | 103.8 | 162.4 | 57.6 | 220.1 | | | | |
| | 2009 IECC Modified | 14.7 | 44.7 | 32.8 | 7.1 | 17.4 | 54.6 | 62.1 | 116.7 | 172.6 | 68.3 | 240.9 | 0.0% | 0.0% | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 14.6 | 43.2 | 32.8 | 7.0 | 17.4 | 54.3 | 60.6 | 114.9 | 171.6 | 66.7 | 238.3 | 0.5% | 2.4% | 1.1% | 1.9% |
| 2 | Increased Wall Insulation | 14.4 | 42.7 | 32.8 | 7.0 | 17.4 | 54.0 | 60.1 | 114.1 | 170.7 | 66.1 | 236.8 | 1.1% | 3.2% | 1.7% | 3.0% |
| 3 | Decreased Window U-Value | 13.3 | 43.7 | 32.8 | 6.6 | 17.4 | 52.7 | 61.1 | 113.8 | 166.6 | 67.2 | 233.8 | 3.5% | 1.6% | 2.9% | 5.2% |
| 4 | Decreased Window SHGC | 14.0 | 45.9 | 32.8 | 6.9 | 17.4 | 53.6 | 63.3 | 116.9 | 169.4 | 69.6 | 239.1 | 1.8% | -1.9% | 0.8% | 1.3% |
| 5 | Decreased Infiltration | 13.8 | 34.9 | 32.8 | 6.6 | 17.4 | 53.1 | 52.3 | 105.4 | 167.9 | 57.5 | 225.4 | 2.7% | 15.8% | 6.4% | 11.3% |
| 6 | Decreased Duct Leakage | 13.6 | 41.4 | 32.8 | 6.6 | 17.4 | 53.0 | 58.8 | 111.8 | 167.5 | 64.7 | 232.2 | 2.9% | 5.3% | 3.6% | 6.3% |
| | 2012 IECC | 10.5 | 30.6 | 32.8 | 5.3 | 17.4 | 48.5 | 48.0 | 96.5 | 153.3 | 52.8 | 206.1 | 11.2% | 22.7% | 14.4% | 25.3% |
| | 2009 IECC HP House for Tarrant (CZ 3) | 13.1 | 9.5 | 32.8 | 5.4 | 11.5 | 72.1 | - | 72.1 | 227.8 | - | 227.8 | | | | |
| | 2009 IECC Modified | 14.7 | 11.6 | 32.8 | 6.9 | 11.5 | 77.4 | - | 77.4 | 244.6 | - | 244.6 | 0.0% | - | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 14.6 | 11.3 | 32.8 | 6.8 | 11.5 | 76.8 | - | 76.8 | 242.7 | - | 242.7 | 0.8% | - | 0.8% | 1.3% |
| 2 | Increased Wall Insulation | 14.4 | 11.2 | 32.8 | 6.7 | 11.5 | 76.5 | - | 76.5 | 241.8 | - | 241.8 | 1.2% | - | 1.2% | 2.0% |
| 3 | Decreased Window U-Value | 13.3 | 11.4 | 32.8 | 6.4 | 11.5 | 75.3 | - | 75.3 | 238.0 | - | 238.0 | 2.7% | - | 2.7% | 4.7% |
| 4 | Decreased Window SHGC | 14.0 | 11.9 | 32.8 | 6.7 | 11.5 | 76.7 | - | 76.7 | 242.4 | - | 242.4 | 0.9% | - | 0.9% | 1.6% |
| 5 | Decreased Infiltration | 13.8 | 9.5 | 32.8 | 6.4 | 11.5 | 73.9 | - | 73.9 | 233.6 | - | 233.6 | 4.5% | - | 4.5% | 7.8% |
| 6 | Decreased Duct Leakage | 13.6 | 10.9 | 32.8 | 6.5 | 11.5 | 75.2 | - | 75.2 | 237.7 | - | 237.7 | 2.8% | - | 2.8% | 4.9% |
| | 2012 IECC | 10.5 | 8.5 | 32.8 | 5.2 | 11.5 | 68.3 | - | 68.3 | 215.9 | - | 215.9 | 11.8% | - | 11.8% | 20.4% |

Table 7. Results of Step-by-Step Simulations of Changes Made in the 2012 IECC: Potter County for Climate Zone 4.

| | | RESULTS FOR POTTER COUNTY (CZ 4) | | | | | | | | | | | | | | |
|---------|---|--|---------|------------|--------------|------|--|-------|-------|--|-------|-------|---|-------|-------|--------------|
| Run No. | Test Cases | Annual Site Energy Consumption by End Use (MMBtu/yr) | | | | | Annual Site Energy Consumption by Fuel Type (MMBtu/yr) | | | Annual Source Energy Consumption by Fuel Type (MMBtu/yr) | | | Savings Above 2009 IECC Modified (Source %) | | | |
| | | Cooling | Heating | Lgt & Appl | Fans & Pumps | DHW | Elec. | Gas | Total | Elec. | Gas | Total | Elec. | Gas | Total | C+H+DHW |
| | 2009 IECC NG House for Potter (CZ 4) | 7.5 | 68.3 | 32.8 | 5.7 | 20.0 | 45.9 | 88.3 | 134.2 | 145.0 | 97.1 | 242.2 | | | | |
| | 2009 IECC Modified | 8.0 | 85.1 | 32.8 | 7.3 | 20.0 | 48.0 | 105.1 | 153.1 | 151.7 | 115.6 | 267.3 | 0.0% | 0.0% | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 7.9 | 82.9 | 32.8 | 7.2 | 20.0 | 47.8 | 102.9 | 150.7 | 151.1 | 113.2 | 264.3 | 0.4% | 2.1% | 1.1% | 1.9% |
| 2 | Increased Wall Insulation | 7.9 | 81.1 | 32.8 | 7.1 | 20.0 | 47.7 | 101.1 | 148.8 | 150.8 | 111.2 | 262.0 | 0.6% | 3.8% | 2.0% | 3.3% |
| 3 | Decreased Infiltration | 7.8 | 64.3 | 32.8 | 6.5 | 20.0 | 47.1 | 84.3 | 131.4 | 148.9 | 92.7 | 241.6 | 1.9% | 19.8% | 9.6% | 15.7% |
| 4 | Decreased Duct Leakage | 7.5 | 78.3 | 32.8 | 6.8 | 20.0 | 47.1 | 98.3 | 145.4 | 148.9 | 108.1 | 257.0 | 1.9% | 6.5% | 3.9% | 6.3% |
| | 2012 IECC | 7.2 | 54.7 | 32.8 | 5.9 | 20.0 | 45.8 | 74.7 | 120.5 | 144.8 | 82.2 | 227.0 | 4.6% | 28.9% | 15.1% | 24.7% |
| | 2009 IECC HP House for Potter (CZ 4) | 7.5 | 24.0 | 32.8 | 5.7 | 13.5 | 83.4 | - | 83.4 | 263.5 | - | 263.5 | | | | |
| | 2009 IECC Modified | 8.0 | 29.0 | 32.8 | 7.2 | 13.5 | 90.5 | - | 90.5 | 286.0 | - | 286.0 | 0.0% | - | 0.0% | 0.0% |
| 1 | Increased Roof Insulation | 7.9 | 28.3 | 32.8 | 7.1 | 13.5 | 89.6 | - | 89.6 | 283.2 | - | 283.2 | 1.0% | - | 1.0% | 1.6% |
| 2 | Increased Wall Insulation | 7.9 | 27.8 | 32.8 | 7.0 | 13.5 | 88.9 | - | 88.9 | 281.0 | - | 281.0 | 1.8% | - | 1.8% | 2.8% |
| 3 | Decreased Infiltration | 7.8 | 22.9 | 32.8 | 6.5 | 13.5 | 83.4 | - | 83.4 | 263.6 | - | 263.6 | 7.8% | - | 7.8% | 12.3% |
| 4 | Decreased Duct Leakage | 7.5 | 26.6 | 32.8 | 7.0 | 13.5 | 87.4 | - | 87.4 | 276.2 | - | 276.2 | 3.4% | - | 3.4% | 5.4% |
| | 2012 IECC | 7.2 | 20.1 | 32.8 | 6.0 | 13.5 | 79.6 | - | 79.6 | 251.6 | - | 251.6 | 12.0% | - | 12.0% | 18.9% |

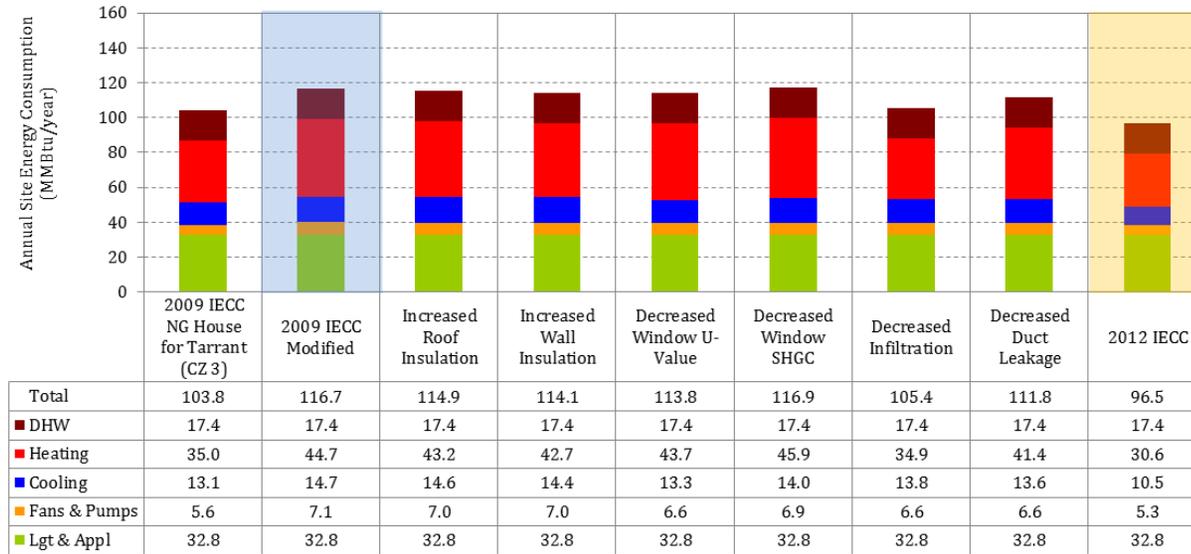


(a) Electric/Gas House

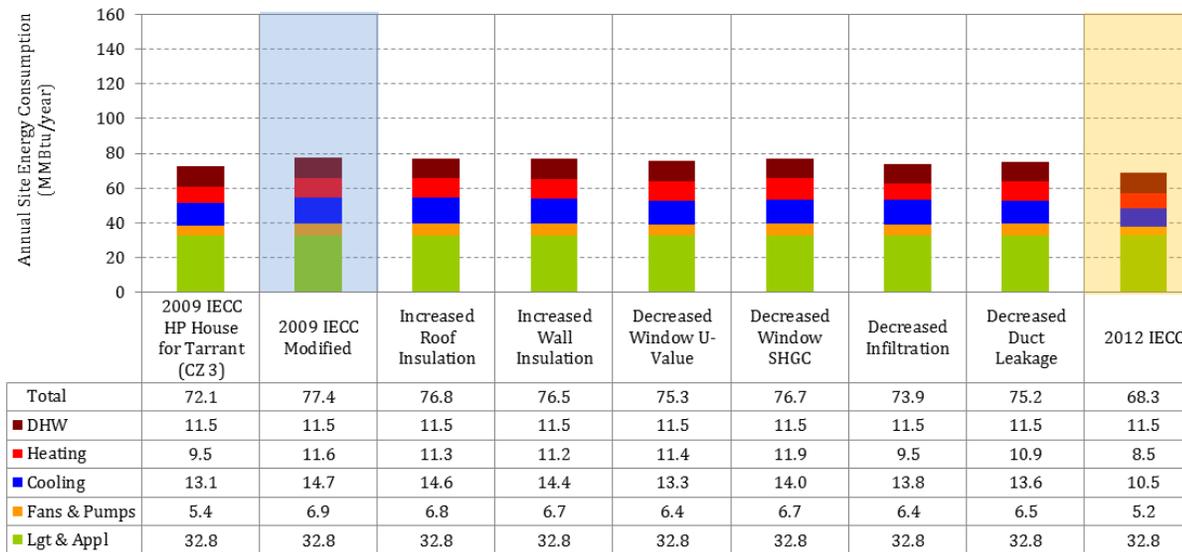


(b) All-Electric House

Figure 3. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Harris County for Climate Zone 2.

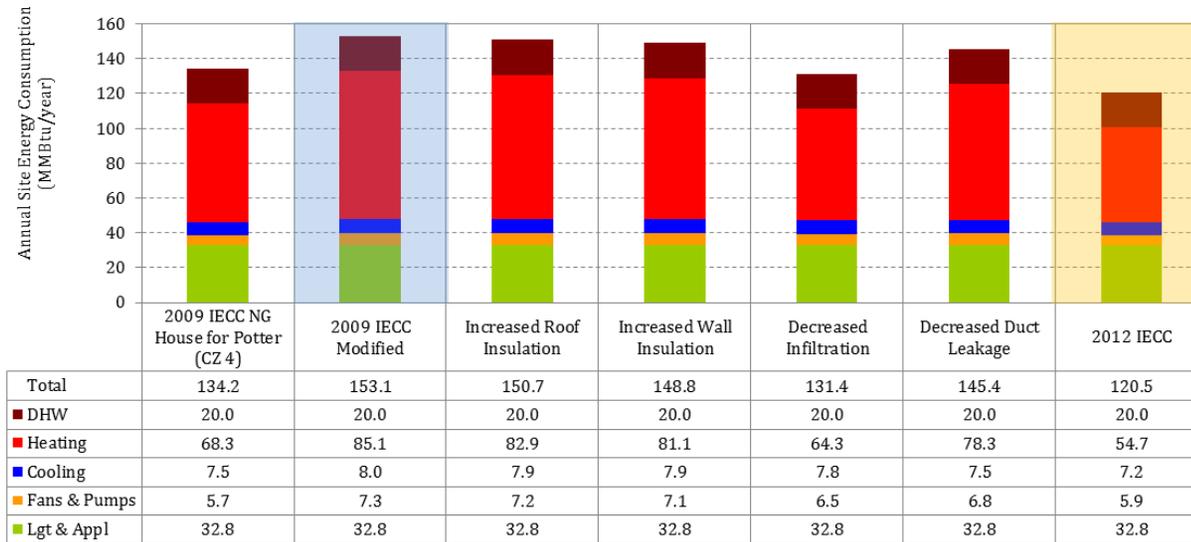


(a) Electric/Gas House

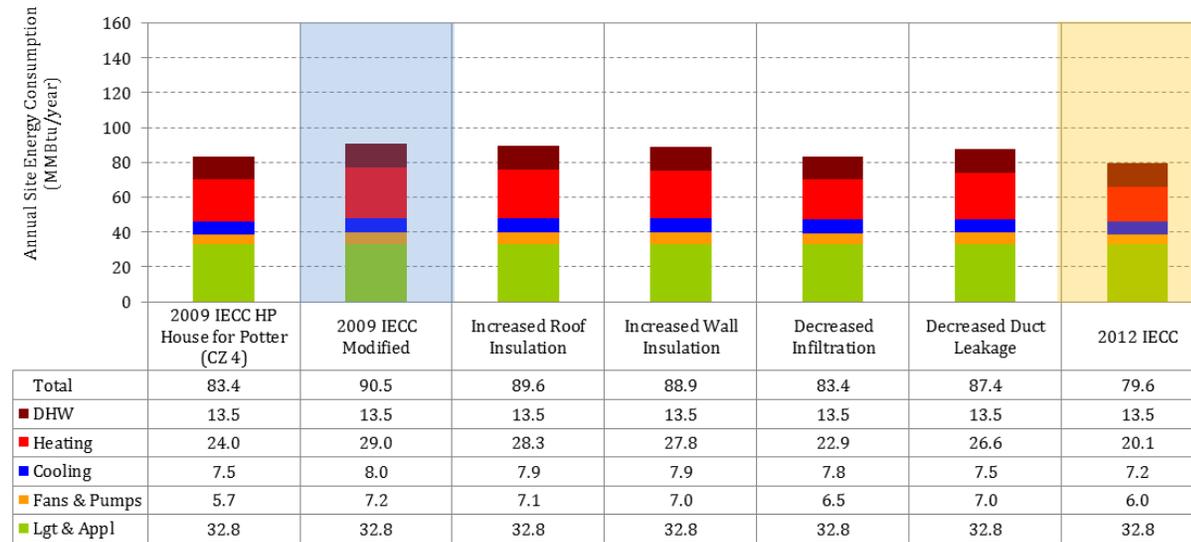


(b) All-Electric House

Figure 4. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Tarrant County for Climate Zone 3.



(a) Electric/Gas House



(b) All-Electric House

Figure 5. Annual Site Energy Consumption by Different End Uses for Step-by-Step Simulations: Potter County for Climate Zone 4.



Figure 6. Monthly Electricity and Natural Gas Use for the Modified 2009 and 2012 Code-Compliant, Electric/Gas House in Texas.

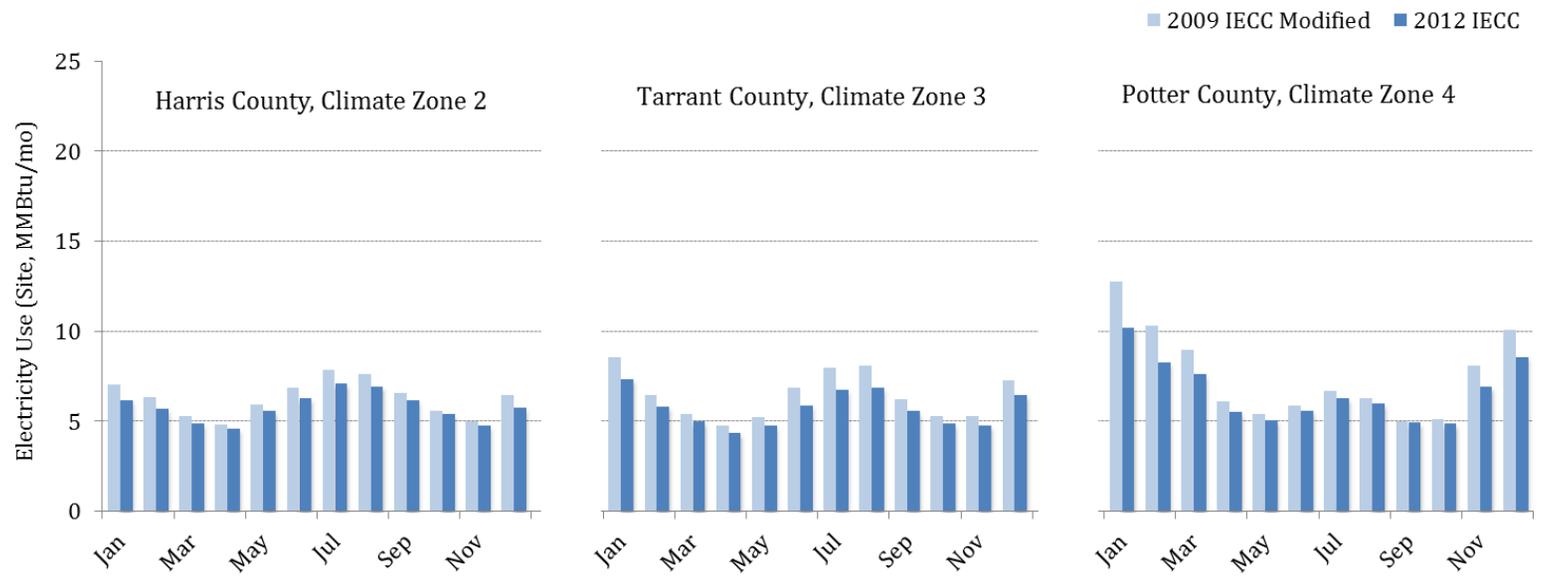


Figure 7. Monthly Electricity Use for the Modified 2009 and 2012 Code-Compliant, All-Electric House in Texas.

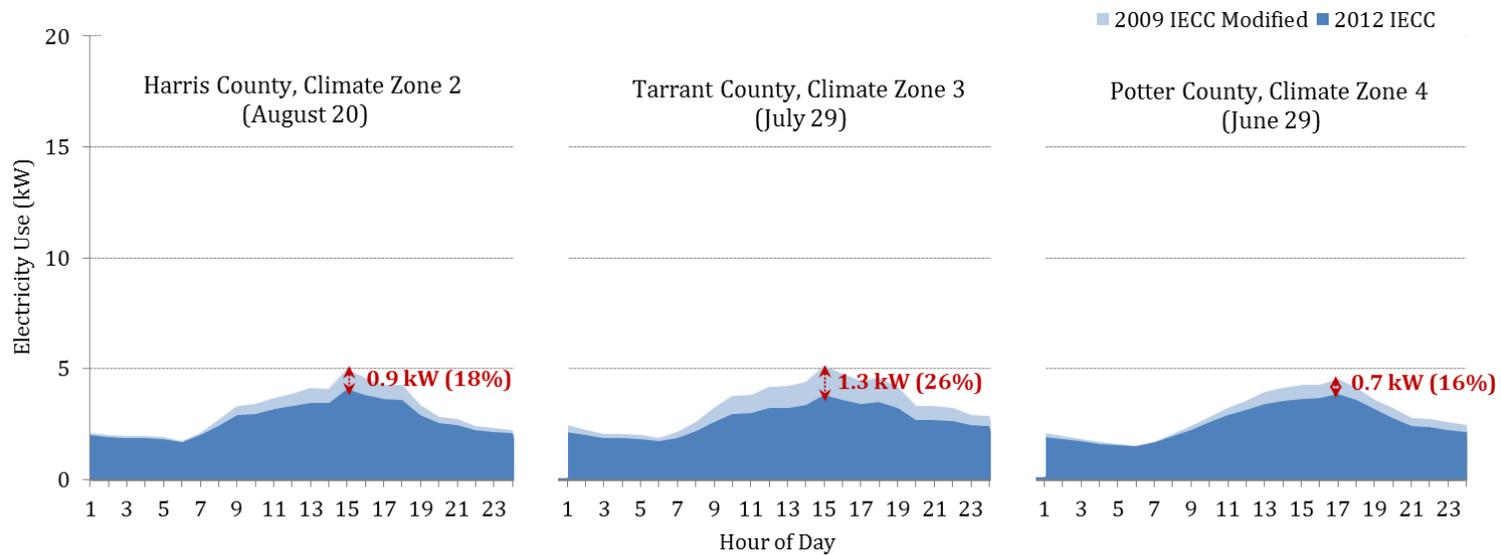


Figure 8. Peak Summer Day Hourly Electricity Use and Demand Savings for the Modified 2009 and 2012 Code-Compliant House in Texas

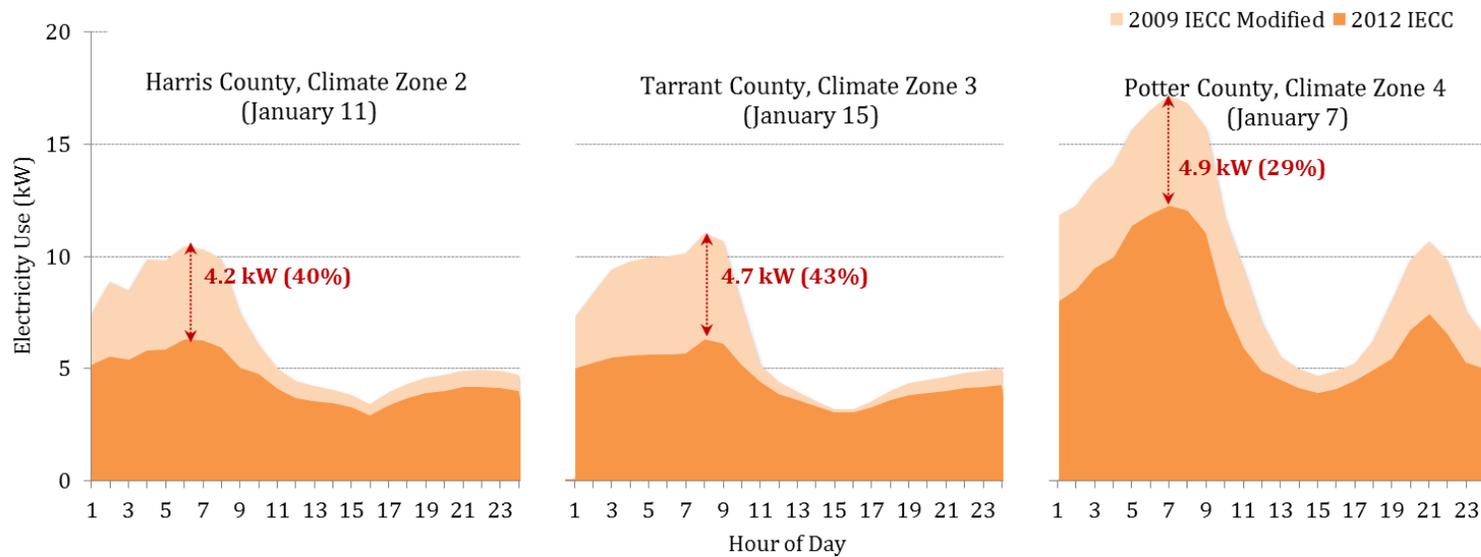
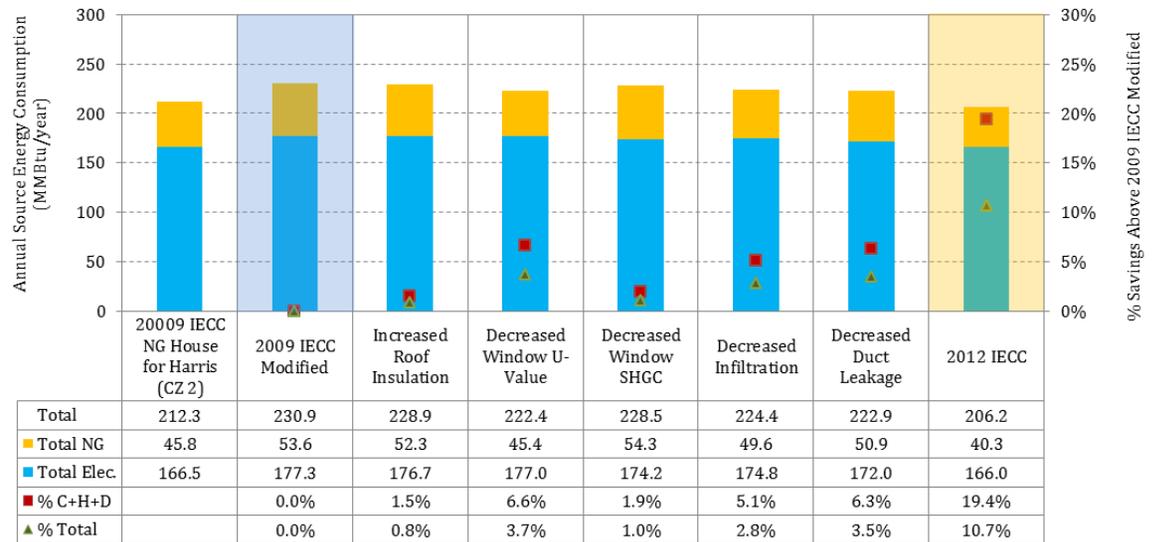
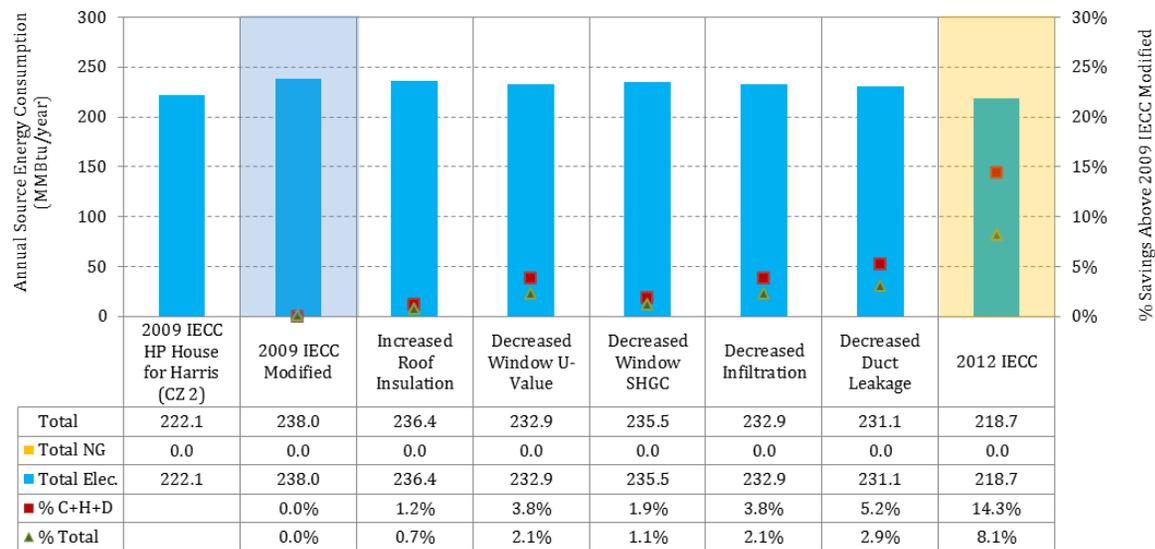


Figure 9. Peak Winter Day Hourly Electricity Use and Demand Savings for the Modified 2009 and 2012 Code-Compliant, All-Electric House in Texas

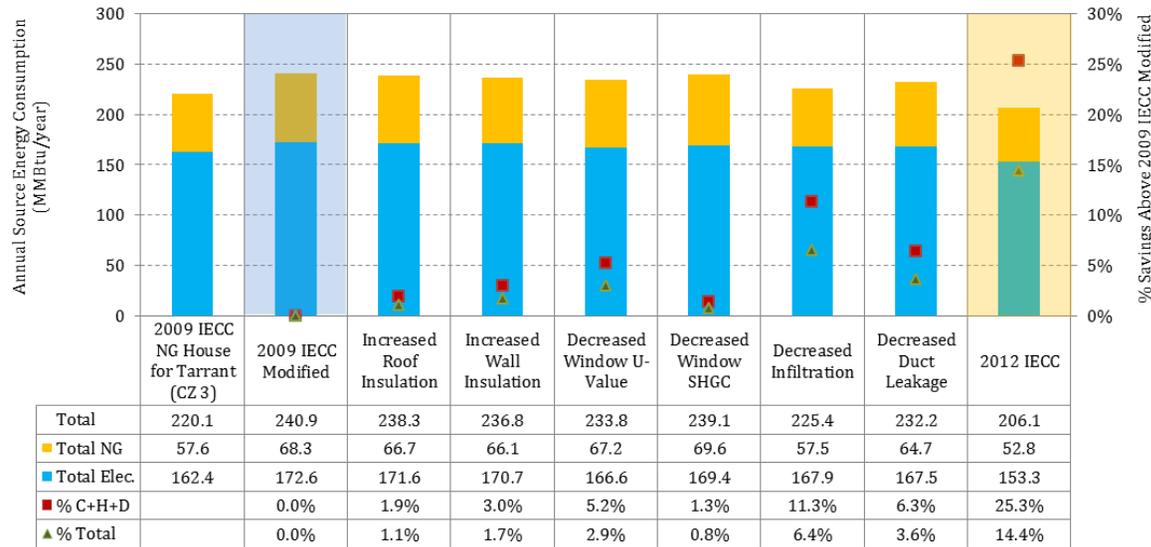


(a) Electric/Gas House

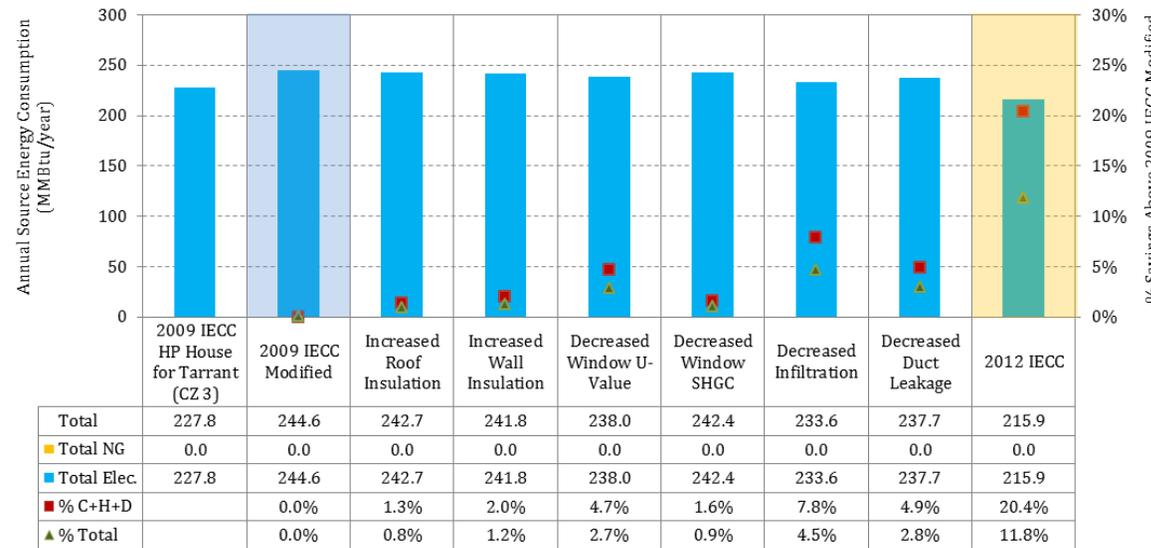


(b) All-Electric House

Figure 10. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Harris County for Climate Zone 2.

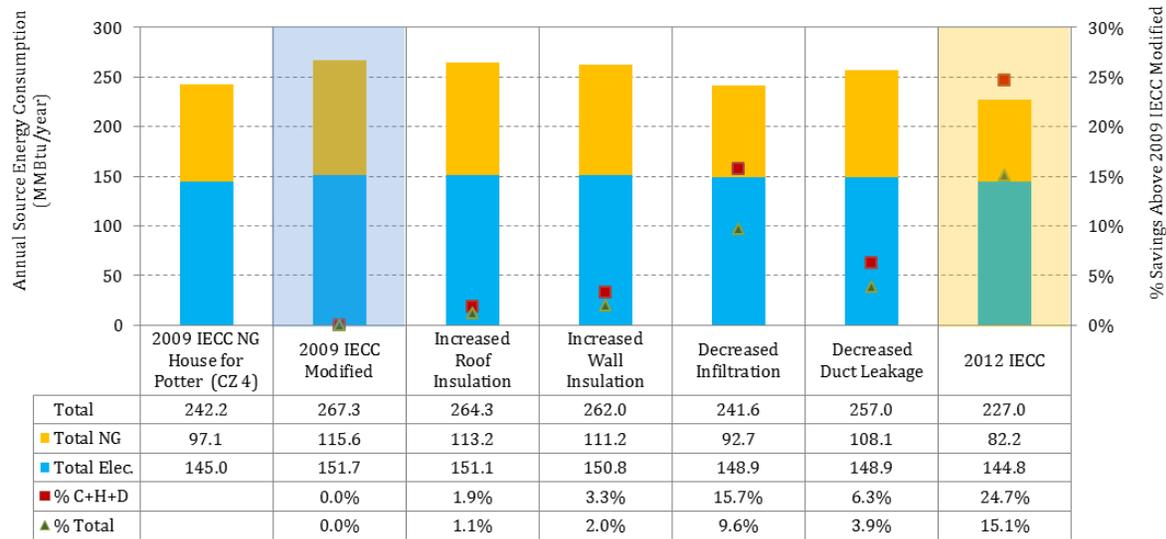


(a) Electric/Gas House

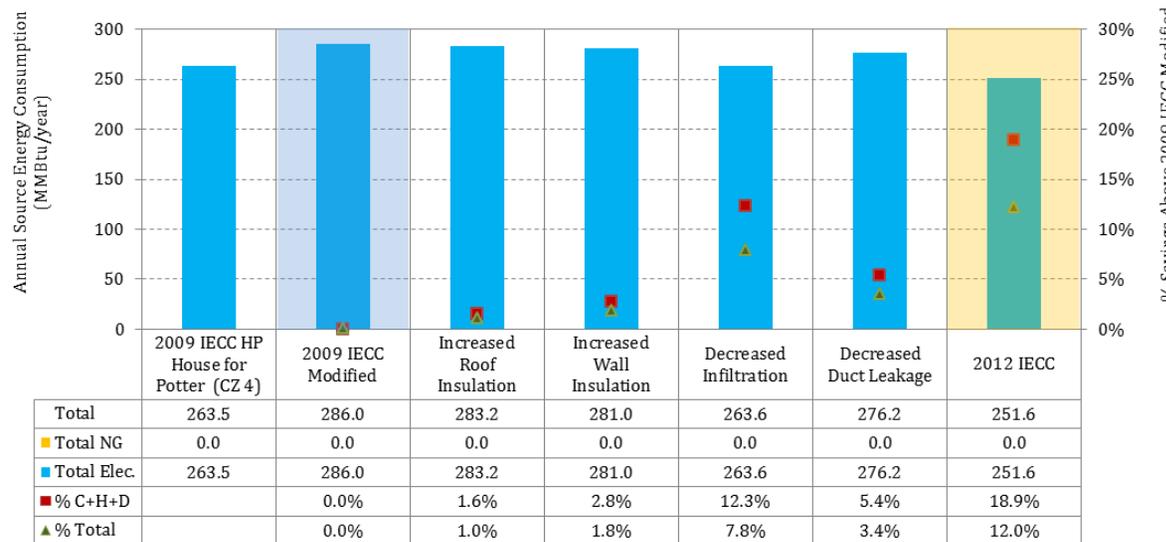


(b) All-Electric House

Figure 11. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Tarrant County for Climate Zone 3.



(a) Electric/Gas House



(b) All-Electric House

Figure 12. Annual Source Energy Consumption by Fuel Type and % Savings Above Modified 2009 IECC Code-Compliant House for Step-by-Step Simulations: Potter County for Climate Zone 4.

4 SUMMARY

A technical analysis was performed to compare the stringency of the Texas Building Energy Performance Standards for single-family residential construction, based on the 2009 International Residential Code (2009 IRC), to the 2012 International Residential Code (2012 IRC). The analysis used the relevant 2009 IECC residential (Chapters 1-4) provisions, which is one of the two paths to comply with the 2009 IRC per Section N1101.2 of the code, and the 2012 IECC provisions which are identical to the 2012 IRC. A series of simulations were performed using an ESL single-family simulation model (BDL version 4.01.08 of International Code Compliance Calculator (IC3)) based on the DOE-2.1e program and the appropriate TMY2 weather files for three counties representing three 2009 and 2012 IECC Climate Zones across Texas: Harris County for Climate Zone 2, Tarrant County for Climate Zone 3, and Potter County for Climate Zone 4.

The analysis has determined that the residential provisions of 2012 IECC are more stringent than the 2009 IECC, which is one of the compliance options of the TBEPS based on the 2009 IRC. The estimated annual source energy savings associated with the 2012 IECC compared to the modified 2009 IECC¹¹ are:

- (c) For an electric/gas house:
 - 24.7 MMBtu/yr (10.6 kBtu/ft²·yr) for Harris County,
 - 34.8 MMBtu/yr (15.0 kBtu/ft²·yr) for Tarrant County, and
 - 40.3 MMBtu/yr (17.3 kBtu/ft²·yr) for Potter County.
- (d) For a heat pump house:
 - 19.3 MMBtu/yr (8.3 kBtu/ft²·yr) for Harris County,
 - 28.7 MMBtu/yr (12.3 kBtu/ft²·yr) for Tarrant County, and
 - 34.4 MMBtu/yr (14.8 kBtu/ft²·yr) for Potter County.

The corresponding percentage savings based on cooling, heating and domestic hot water consumption of the modified 2009 IECC code-compliant house are¹²:

- (c) For an electric/gas house:
 - 19% for Harris County,
 - 25% for Tarrant County, and
 - 25% Potter County.
- (d) For a heat pump house:
 - 14% for Harris County,
 - 20% for Tarrant County, and
 - 19% for Potter County.

¹¹ The base-case building envelope and system characteristics were determined from the general characteristics and the climate-specific characteristics as specified in the 2009 and 2012 IECC performance path analysis per Section 405 of the 2009 IECC and Section R405 of the 2012 IECC. To facilitate a better comparison between two codes, the following modifications were applied to the 2009 IECC codes: 1) Interior shading fractions were modified to match the values provided in the 2012 IECC; and 2) The mechanical ventilation rate, which is the same as the 2012 IECC code-compliant house, was added in addition to the air leakage rate to determine an air exchange rate of a house.

¹² The end-uses covered by the 2009 and 2012 IECC include heating, cooling, and DHW energy only per Section 405.1 of the 2009 IECC and Section R405.1 of the 2012 IECC.

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