

## ENERGY SYSTEMS LABORATORY

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May 27, 2011

To: Code Officials, Energy Raters, Manufactures, State Agency Officials, Stakeholders and Citizens of Texas

Subject: 15% Above 2009 IECC Code-Compliant House Energy Efficiency Measures for Residential Buildings in Texas

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

In the pages that follow, 15% above 2009 IECC code-compliant house measures for new residential buildings are presented for the three climate zones in Texas. Each page contains a description of the individual measures and combinations of these measures which achieve 15% savings above 2009 IECC code-compliant house. These measures include envelope and fenestration, HVAC systems, domestic hot water, lighting and renewable power options. Annual energy savings, estimated costs, simple payback, and NO<sub>x</sub>, SO<sub>2</sub>, and CO<sub>2</sub> emissions reduction are provided.

Sincerely,

Jeff S. Haberl, Ph.D., P.E.  
Associate Director

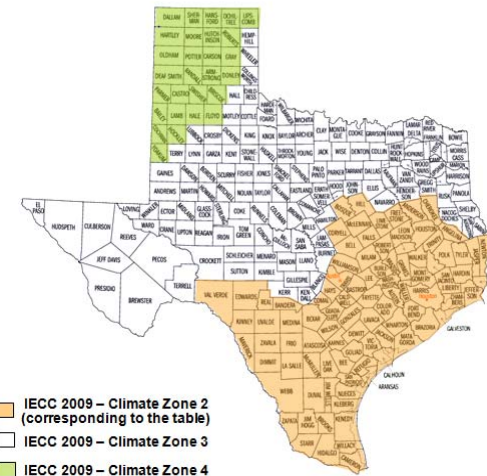
Charles C. Culp, Ph.D., P.E.  
Associate Director

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Associate Director

## Natural Gas Heating (Climate Zone 2)

### Description of Individual Measures

Individual Measures	Annual Source Energy Savings (%) <sup>1</sup>	Annual Energy Savings (\$/year) <sup>2</sup>	Estimated Cost (\$)		Simple Estimated Payback (yrs)
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>	
<b>A Envelope and Fenestration Measures</b>					
1 Radiant Barrier in Attics (w/ith Ducts in Attics) (L: <b>a</b> ;H: <b>h</b> ) <sup>7</sup>	1.6% - 2.5%	\$38 - \$57		\$300 - \$880	5.2 - 23.2
2 Sealed (Unvented) Attic (L: <b>a</b> , <b>c</b> , <b>g</b> ;H: <b>i</b> )	5.4% - 6.6%	\$116 - \$145	\$2,000 - \$3,500		13.8 - 30.2
3 Window Shading (None to 2 ft. Eaves on All Sides) (L: <b>i</b> ;H: <b>a</b> )	2.0% - 2.6%	\$52 - \$65		\$800 - \$1,000	12.3 - 19.2
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides w/ith No Shading to S=40.7%, N=22.6%, E/W = 13.6% w/ith 2ft. Eaves on All Sides) (L: <b>i</b> ;H: <b>g</b> )	2.7% - 3.0%	\$66 - \$73		\$800 - \$1,000	10.9 - 15.1
5 Decreased Window SHGC (Climate Zone 2: from 0.3 to 0.2) (L: <b>i</b> ;H: <b>a</b> )	1.7% - 3.2%	\$51 - \$81	\$200 - \$400		2.5 - 7.8
6 Decreased Window U Value (Climate Zone 2: from 0.65 to 0.3) (L: <b>a</b> ;H: <b>i</b> )	4.8% - 6.7%	\$111 - \$148	\$600 - \$900		4.0 - 8.1
7 Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L: <b>e</b> ;H: <b>d</b> )	7.9% - 8.6%	\$179 - \$201	\$900 - \$1,100		4.5 - 6.1
<b>B HVAC System Measures</b>					
8 Relocate Mechanical Systems w/ithin Conditioned Space (L: <b>a</b> ;H: <b>i</b> )	7.5% - 8.5%	\$173 - \$195	\$1,000 - \$7,000		5.1 - 40.5
9 Improved Air Conditioner SEER (from 13 to 15 SEER) (L: <b>h</b> ;H: <b>a</b> )	6.1% - 8.5%	\$146 - \$211	\$900 - \$2,500		4.3 - 17.1
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L: <b>a</b> ;H: <b>i</b> )	0.6% - 2.5%	\$12 - \$47	\$800 - \$1,300		17.0 - 110.5
<b>C Domestic Hot Water Measures</b>					
11 Tankless Gas Water Heater (w/ithout a Standing Pilot Light) (L: <b>a</b> , <b>d</b> , <b>g</b> , <b>i</b> ;H: <b>b</b> , <b>c</b> , <b>e</b> , <b>f</b> , <b>h</b> )	1.6% - 1.7%	\$29 - \$30	\$900 - \$1,400		29.8 - 47.6
12 Removal of Pilot Light from Tank-Type Hot Water System (L=H: <b>a</b> , <b>b</b> , <b>c</b> , <b>d</b> , <b>e</b> , <b>f</b> , <b>g</b> , <b>h</b> , <b>i</b> )	0.8% - 0.8%	\$14 - \$15	\$100 - \$500		6.6 - 35.0
13 Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L: <b>e</b> ;H: <b>d</b> )	2.9% - 3.6%	\$40 - \$55		\$2,200 - \$3,000	40.3 - 75.0
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L: <b>a</b> ;H: <b>h</b> )	4.3% - 5.0%	\$68 - \$79		\$3,200 - \$4,000	40.3 - 58.4
<b>D Lighting Measures</b>					
15 75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L: <b>i</b> ;H: <b>a</b> , <b>c</b> )	4.3% - 5.1%	\$111 - \$130	\$25 - \$110		0.2 - 1.0
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L: <b>i</b> ;H: <b>a</b> )	8.5% - 10.3%	\$222 - \$259	\$50 - \$215		0.2 - 1.0
<b>E Renewable Power Measures</b>					
17 4 kW Photovoltaic Array (L: <b>b</b> ;H: <b>d</b> )	25.3% - 28.0%	\$610 - \$686		\$20,000 - \$30,000	29.2 - 49.2



■ IECC 2009 – Climate Zone 2 (corresponding to the table)  
■ IECC 2009 – Climate Zone 3  
■ IECC 2009 – Climate Zone 4

### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Annual (lbs/yr)	SO <sub>2</sub> Emissions Annual (lbs/yr)	CO <sub>2</sub> Emissions Annual (tons/yr) <sup>6</sup>
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>				
<b>Combination 1 (L:<b>i</b>;H:<b>a</b>)<sup>7</sup></b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L: <b>i</b> ;H: <b>a</b> )	16.9% - 18.6%	\$406 - \$461	\$50 - \$215		2.1 - 3.2	5.8 - 6.6	3.6 - 4.1	2.5 - 2.8
7 Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L: <b>e</b> ;H: <b>d</b> )			\$900 - \$1,100					
<b>Combination 2 (L:<b>f</b>;H:<b>a</b>)</b>								
7 Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L: <b>e</b> ;H: <b>d</b> )	15.0% - 16.6%	\$333 - \$406	\$900 - \$1,100		5.2 - 13.5	4.7 - 5.8	2.8 - 3.5	2.0 - 2.5
9 Improved Air Conditioner SEER (from 13 to 15 SEER) (L: <b>h</b> ;H: <b>a</b> )			\$900 - \$2,500					
1 Radiant Barrier in Attics (w/ith Ducts in Attics) (L: <b>a</b> , <b>b</b> ;H: <b>h</b> )				\$300 - \$880				
<b>Combination 3 (L:<b>f</b>;H:<b>a</b>)</b>								
8 Relocate Mechanical Systems w/ithin Conditioned Space (L: <b>a</b> ;H: <b>i</b> )	15.0% - 16.4%	\$338 - \$405	\$1,000 - \$7,000		6.7 - 31.1	4.8 - 5.8	2.8 - 3.6	2.1 - 2.5
9 Improved Air Conditioner SEER (from 13 to 15 SEER) (L: <b>h</b> ;H: <b>a</b> )			\$900 - \$2,500					
3 Window Shading (None to 2 ft. Eaves on All Sides) (L: <b>i</b> ;H: <b>a</b> )			\$800 - \$1,000					

**Note:**

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

[2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window-to-floor ratio: 15% (Window-to-w all ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 0.78 AFUE furnace
- \* DHW: 0.59 EF NG heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

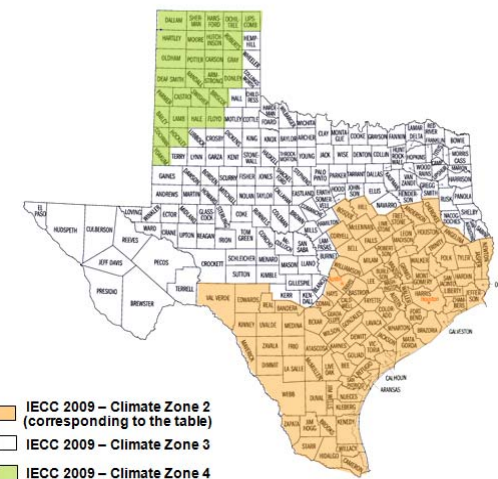


**Table 1a: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Natural Gas Heating) for Climate Zone 2**

## Heat Pump Heating (Climate Zone 2)

### Description of Individual Measures

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



### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions	SO <sub>2</sub> Emissions	CO <sub>2</sub> Emissions
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons/yr) <sup>6</sup>
<b>Combination 1 (L:<b>i</b>;H:<b>a</b>)<sup>7</sup></b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L: <b>i</b> ;H: <b>a</b> )	16.2% - 17.7%	\$409 - \$458	\$50 - \$215		2.1 - 3.2	5.9 - 6.6	3.7 - 4.1	2.5 - 2.8
7 Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L: <b>e</b> ;H: <b>d</b> )			\$900 - \$1,100					
<b>Combination 2 (L:<b>h</b>;H:<b>a</b>)</b>								
15 75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L: <b>i</b> ;H: <b>c</b> )	17.3% - 19.4%	\$429 - \$503	\$25 - \$110		4.2 - 8.7	6.2 - 7.2	3.9 - 4.5	2.6 - 3.1
7 Decreased Window SHGC & U Value (Climate Zone 2: from 0.3 to 0.2 SHGC & from 0.65 to 0.3 U-Value) (L: <b>e</b> ;H: <b>d</b> )			\$900 - \$1,100					
9 Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L: <b>h</b> ;H: <b>a</b> )			\$1,200 - \$2,500					
<b>Combination 3 (L:<b>a</b>;H:<b>h</b>)</b>								
8 Relocate Mechanical Systems within Conditioned Space (L: <b>e</b> ;H: <b>d</b> )	15.0% - 16.3%	\$384 - \$415	\$1,000 - \$7,000		10.1 - 28.6	5.5 - 6.0	3.5 - 3.7	2.3 - 2.5
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L: <b>a</b> ;H: <b>h</b> )			\$3,200 - \$4,000					

**Note:**

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

[2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 7.7 HSPF heat pump
- \* DHW: 0.90 EF Electric heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

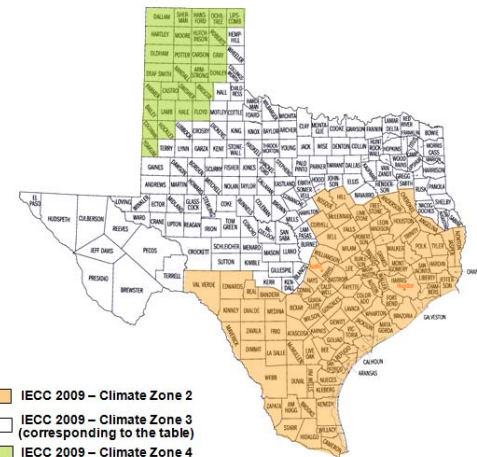


**Table 1b: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Heat Pump Heating) for Climate Zone 2**

### Natural Gas Heating (Climate Zone 3)

#### Description of Individual Measures

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



#### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Annual (lbs/yr)	SO <sub>2</sub> Emissions Annual (lbs/yr)	CO <sub>2</sub> Emissions Annual (tons/yr) <sup>6</sup>
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>				
<b>Combination 1 (L;j,k;H/I)<sup>7,8</sup></b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L;p;H/I)	15.3% - 17.5%	\$391 - \$434	\$50 - \$215		2.9 - 5.6	5.6 - 6.2	3.8 - 4.2	2.3 - 2.6
7 Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L;o;H/I)			\$900 - \$1,100					
1 Radiant Barrier in Attics (with Ducts in Attics) (L;p;H/I)				\$300 - \$880				
<b>Combination 2 (L;o;H/I)</b>								
15 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L;p;H/I)	16.0% - 17.1%	\$383 - \$422	\$50 - \$215		4.1 - 10.5	5.5 - 6.1	3.2 - 3.6	2.4 - 2.6
9 Improved Air Conditioner SEER (from 13 to 15 SEER) (L;o;H/I)			\$900 - \$2,500					
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L/I;H;o)			\$800 - \$1,300					
<b>Combination 3 (L;n;H;p)</b>								
8 Relocate Mechanical Systems within Conditioned Space (L/I;H;p)	15.0% - 16.2%	\$315 - \$358	\$1,000 - \$7,000		7.5 - 29.9	4.5 - 5.1	1.9 - 2.4	2.1 - 2.5
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE) (L/I;H;o)			\$800 - \$1,300					
7 Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L;o;H/I)			\$900 - \$1,100					

Note:

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

[2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window-to-floor ratio: 15% (Window-to-wall all ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 0.78 AFUE furnace
- \* DHW: 0.59 EF NG heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

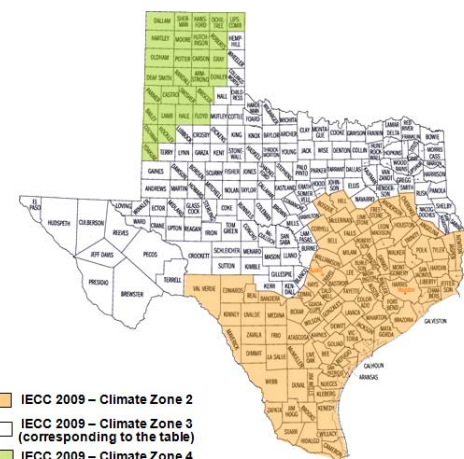


**Table 2a: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Natural Gas Heating) for Climate Zone 3**

## Heat Pump Heating (Climate Zone 3)

### Description of Individual Measures

Individual Measures	Annual Source Energy Savings (%) <sup>1</sup>	Annual Energy Savings (\$/year) <sup>2</sup>	Estimated Cost (\$)		Simple Estimated Payback (yrs)
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>	
<b>A Envelope and Fenestration Measures</b>					
1 Radiant Barrier in Attics (with Ducts in Attics) (L:p;H:I) <sup>7</sup>	1.6% - 2.7%	\$45 - \$68		\$300 - \$880	4.4 - 19.5
2 Sealed (Unvented) Attic (L:n;H:p)	4.0% - 5.6%	\$103 - \$158	\$2,000 - \$3,500		12.7 - 33.9
3 Window Shading (None to 2 ft. Eaves on All Sides) (L:o;H:I)	1.8% - 3.1%	\$48 - \$77		\$800 - \$1,000	10.3 - 20.7
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides w with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides) (L:m,o,p;H:I)	2.7% - 3.6%	\$71 - \$90		\$800 - \$1,000	8.9 - 14.1
5 Decreased Window SHGC (Climate Zone 3: from 0.3 to 0.2) (L:o;H:I)	1.1% - 2.8%	\$29 - \$71	\$200 - \$400		2.8 - 13.8
6 Decreased Window U Value (Climate Zone 3: from 0.5 to 0.3) (L:j,m;H:I)	3.7% - 4.1%	\$97 - \$110	\$600 - \$900		5.5 - 9.3
7 Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:o;H:I)	4.7% - 6.5%	\$126 - \$164	\$900 - \$1,100		5.5 - 8.7
<b>B HVAC System Measures</b>					
8 Relocate Mechanical Systems within Conditioned Space (L:I;H:p)	5.9% - 7.3%	\$148 - \$206	\$1,000 - \$7,000		4.8 - 47.2
9 Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:o;H:p)	5.7% - 6.8%	\$155 - \$193	\$1,200 - \$2,500		6.2 - 16.2
<b>C Domestic Hot Water Measures</b>					
13 Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank) (L:p;H:I)	7.0% - 9.3%	\$193 - \$233		\$2,200 - \$3,000	9.4 - 15.6
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:p;H:I)	9.0% - 10.9%	\$246 - \$284		\$3,200 - \$4,000	11.3 - 16.3
<b>D Lighting Measures</b>					
15 75% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:o,p;H:I)	3.8% - 4.5%	\$103 - \$113	\$25 - \$110		0.2 - 1.1
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:o,p;H:I)	7.5% - 9.0%	\$203 - \$226	\$50 - \$215		0.2 - 1.1
<b>E Renewable Power Measures</b>					
17 4 kW Photovoltaic Array (L:p;H:I)	24.8% - 32.8%	\$692 - \$824		\$20,000 - \$30,000	24.3 - 43.3



■ IECC 2009 - Climate Zone 2  
■ IECC 2009 - Climate Zone 3 (corresponding to the table)  
■ IECC 2009 - Climate Zone 4

### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Annual (lbs/yr)	SO <sub>2</sub> Emissions Annual (lbs/yr)	CO <sub>2</sub> Emissions Annual (tons/yr) <sup>6</sup>
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>				
<b>Combination 1 (L:j;H:I)<sup>7,8</sup></b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:o,p;H:I)	15.2% - 17.5%	\$397 - \$438	\$50 - \$215		2.9 - 5.5	5.7 - 6.3	3.6 - 4.0	2.4 - 2.7
7 Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:o;H:I)			\$900 - \$1,100					
1 Radiant Barrier in Attics (with Ducts in Attics) (L:p;H:I)				\$300 - \$880				
<b>Combination 2 (L:o;H:I)</b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps (L:o,p;H:I)	16.7% - 20.3%	\$451 - \$516	\$50 - \$215		4.2 - 8.5	6.5 - 7.4	4.1 - 4.7	2.7 - 3.1
7 Decreased Window SHGC & U Value (Climate Zone 3: from 0.3 to 0.2 SHGC & from 0.5 to 0.3 U-Value) (L:o;H:I)			\$900 - \$1,100					
9 Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF) (L:o;H:p)			\$1,200 - \$2,500					
<b>Combination 3 (L:n;H:I)</b>								
8 Relocate Mechanical Systems within Conditioned Space (L:I;H:p)	16.0% - 16.9%	\$407 - \$461	\$1,000 - \$7,000		9.1 - 27.0	5.9 - 6.6	3.7 - 4.2	2.5 - 2.8
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank) (L:p;H:I)				\$3,200 - \$4,000				

#### Note:

- Total source energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
- Energy Cost: Electricity = \$0.11/kWh
- Marginal cost = new system cost - original system cost
- New system cost = new system cost only
- See individual measures above for specific savings
- Conversion factor: 1 ton = 2,000 lbs
- L = County with the low est annual source energy savings; H = County with the highest annual source energy savings  
County code: j = Tom Green; k = Midland; l = El Paso; m = Taylor; n = Tarrant; o = Lubbock; p = Wichita
- Lubbock and Wichita counties were excluded in the savings analysis for Combination 1.

#### [2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window-to-floor ratio: 15% (Window-to-w all ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 7.7 HSPF heat pump
- \* DHW: 0.90 EF Electric heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

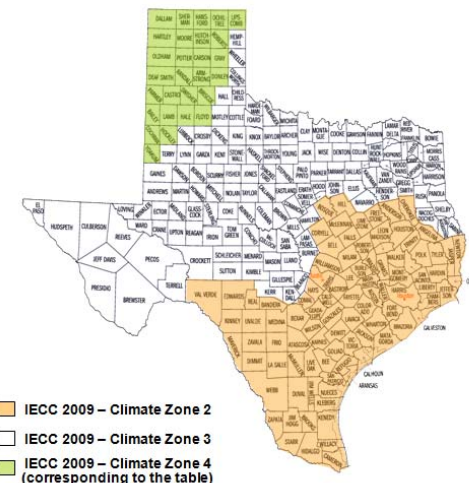


**Table 2b: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Heat Pump Heating) for Climate Zone 3**

## Natural Gas Heating (Climate Zone 4)

### Description of Individual Measures

Individual Measures	Annual Source Energy Savings (%) <sup>1</sup>	Annual Energy Savings (\$/year) <sup>2</sup>	Estimated Cost (\$)		Simple Estimated Payback (yrs)
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>	
<b>A Envelope and Fenestration Measures</b>					
1 Radiant Barrier in Attics (w ith Ducts in Attics)	1.6%	\$37		\$300 - \$880	8.0 - 23.6
2 Sealed (Unvented) Attic	7.7%	\$143	\$2,000 - \$3,500		14.0 - 24.4
3 Window Shading (None to 2 ft. Eaves on All Sides)	1.4%	\$48		\$800 - \$1,000	16.5 - 20.6
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides w ith No Shading to S=40.7%, N=22.6%, E/W = 13.6% w ith 2ft. Eaves on All Sides)	2.8%	\$77		\$800 - \$1,000	10.4 - 13.0
6 Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)	1.4%	\$22	\$350 - \$900		15.6 - 40.1
<b>B HVAC System Measures</b>					
8 Relocate Mechanical Systems w ithin Conditioned Space	9.4%	\$183	\$1,000 - \$7,000		5.5 - 38.2
9 Improved Air Conditioner SEER (from 13 to 15 SEER)	4.1%	\$114	\$900 - \$2,500		7.9 - 22.0
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)	4.3%	\$63	\$800 - \$1,300		12.6 - 20.5
<b>C Domestic Hot Water Measures</b>					
11 Tankless Gas Water Heater (w ithout a Standing Pilot Light)	1.5%	\$22	\$900 - \$1,400		40.2 - 62.5
12 Removal of Pilot Light from Tank-Type Hot Water System	0.7%	\$11	\$100 - \$500		9.2 - 46.0
13 Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	3.8%	\$38		\$2,200 - \$3,000	58.2 - 79.4
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	5.7%	\$65		\$3,200 - \$4,000	49.0 - 61.2
<b>D Lighting Measures</b>					
15 75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	3.6%	\$105	\$25 - \$110		0.2 - 1.0
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	7.1%	\$207	\$50 - \$215		0.2 - 1.0
<b>E Renewable Power Measures</b>					
17 4 kW Photovoltaic Array	29.0%	\$756		\$20,000 - \$30,000	26.5 - 39.7



### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Annual (lbs/yr)	SO <sub>2</sub> Emissions Annual (lbs/yr)	CO <sub>2</sub> Emissions Annual (tons/yr) <sup>6</sup>
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>				
<b>Combination 1</b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.0%	\$346	\$50 - \$215	\$800 - \$1,300	4.8 - 7.3	5.0	2.8	2.2
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)								
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides w ith No Shading to S=40.7%, N=22.6%, E/W = 13.6% w ith 2ft. Eaves on All Sides)			\$800 - \$1,000					
<b>Combination 2</b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.6%	\$381	\$50 - \$215	\$800 - \$1,300	4.6 - 10.5	5.5	3.1	2.4
10 Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)								
9 Improved Air Conditioner SEER (from 13 to 15 SEER)			\$900 - \$2,500					
<b>Combination 3</b>								
8 Relocate Mechanical Systems w ithin Conditioned Space	15.0%	\$307	\$1,000 - \$7,000	\$300 - \$880	8.3 - 36.8	4.4	1.9	2.2
9 Improved Air Conditioner SEER (from 13 to 15 SEER)								
1 Radiant Barrier in Attics (w ith Ducts in Attics)								
6 Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)			\$350 - \$900					

#### Note:

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

#### [2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window -to-floor ratio: 15% (Window -to-w all ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 0.78 AFUE furnace
- \* DHW: 0.59 EF NG heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA



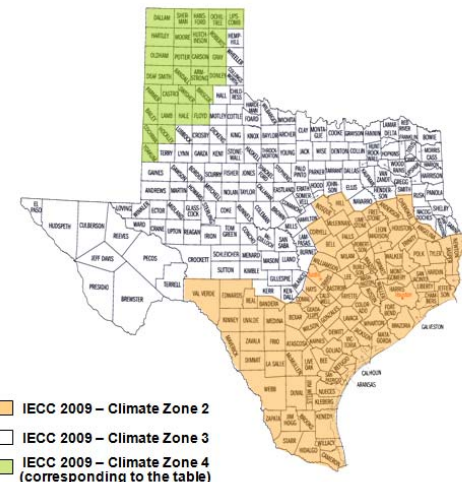
**Table 3a: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Natural Gas Heating) for Climate Zone 4<sup>7</sup>**



## Heat Pump Heating (Climate Zone 4)

### Description of Individual Measures

Individual Measures	Annual Source Energy Savings (%) <sup>1</sup>	Annual Energy Savings (\$/year) <sup>2</sup>	Estimated Cost (\$)		Simple Estimated Payback (yrs)
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>	
<b>A Envelope and Fenestration Measures</b>					
1 Radiant Barrier in Attics (with Ducts in Attics)	1.5%	\$42		\$300 - \$880	7.2 - 21.0
2 Sealed (Unvented) Attic	5.6%	\$161	\$2,000 - \$3,500		12.4 - 21.7
3 Window Shading (None to 2 ft. Eaves on All Sides)	1.6%	\$45		\$800 - \$1,000	17.7 - 22.2
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)	2.8%	\$81		\$800 - \$1,000	9.9 - 12.4
6 Decreased Window U Value (Climate Zone 4: from 0.35 to 0.3)	1.1%	\$32	\$350 - \$900		10.9 - 27.9
<b>B HVAC System Measures</b>					
8 Relocate Mechanical Systems within Conditioned Space	6.7%	\$193	\$1,000 - \$7,000		5.2 - 36.2
9 Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF)	5.6%	\$161	\$1,200 - \$2,500		7.4 - 15.5
<b>C Domestic Hot Water Measures</b>					
13 Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	7.5%	\$217		\$2,200 - \$3,000	10.1 - 13.8
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	10.3%	\$297		\$3,200 - \$4,000	10.8 - 13.5
<b>D Lighting Measures</b>					
15 75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	3.6%	\$103	\$25 - \$110		0.2 - 1.1
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	6.9%	\$200	\$50 - \$215		0.3 - 1.1
<b>E Renewable Power Measures</b>					
17 4 kW Photovoltaic Array	26.2%	\$756		\$20,000 - \$30,000	26.5 - 39.7



■ IECC 2009 – Climate Zone 2  
■ IECC 2009 – Climate Zone 3  
■ IECC 2009 – Climate Zone 4 (corresponding to the table)

### Description of Combined Measures to Achieve 15% Savings Above 2009 IECC Code-Compliant House

Combination of Measures <sup>5</sup>	Combined Source Energy Savings	Combined Energy Savings (\$/year) <sup>2</sup>	Combined Estimated Cost (\$)		Simple Estimated Payback (yrs)	NO <sub>x</sub> Emissions Annual (lbs/yr)	SO <sub>2</sub> Emissions Annual (lbs/yr)	CO <sub>2</sub> Emissions Annual (tons/yr) <sup>6</sup>
			Marginal Cost <sup>3</sup>	New System Cost <sup>4</sup>				
<b>Combination 1</b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.0%	\$413	\$50 - \$215		5.0 - 9.0	5.9	3.7	2.5
9 Improved Heat Pump Efficiency (from 13 to 15 SEER and from 7.70 to 8.50 HSPF)			\$1,200 - \$2,500					
4 Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)				\$800 - \$1,000				
<b>Combination 2</b>								
16 100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	15.7%	\$453	\$50 - \$215		5.6 - 9.0	6.5	4.1	2.7
13 Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)				\$2,200 - \$3,000				
1 Radiant Barrier in Attics (with Ducts in Attics)				\$300 - \$880				
<b>Combination 3</b>								
8 Relocate Mechanical Systems within Conditioned Space	17.0%	\$491	\$1,000 - \$7,000		8.6 - 22.4	7.1	4.4	3.0
14 Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)				\$3,200 - \$4,000				

#### Note:

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

#### [2009 IECC Code-Compliant House Description]

- \* Building type: Residential
- \* Gross area: 2,325 sq-ft
- \* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
- \* Number of floors: 1
- \* Floor-to-floor height: 8ft
- \* Window -to-floor ratio: 15% (Window -to-w all ratio: 22.6%)
- \* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
- \* HVAC system: SEER 13 AC and 7.7 HSPF heat pump
- \* DHW: 0.90 EF Electric heater
- \* Duct Location: Unconditioned, vented attic
- \* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA



**Table 3b: 15% Total Source Energy Savings Above 2009 IECC Code-Compliant House (Residential - Heat Pump Heating) for Climate Zone 4<sup>7</sup>**

