STATEWIDE ELECTRICITY AND DEMAND CAPACITY SAVINGS FROM THE IMPLEMENTATION OF IECC CODE IN TEXAS: ANALYSIS FOR SINGLE-FAMILY RESIDENCES

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Outline

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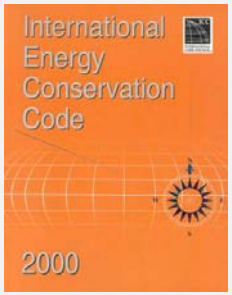
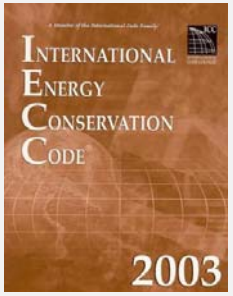
Summary

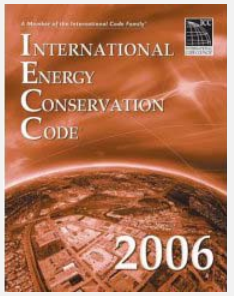
Introduction (1/2)

In September 2001, Texas adopted the 2000 International Energy Conservation Code (IECC), including the 2001 Supplement as the first statewide energy code.



Improved versions of IECC have been published and adopted by individual jurisdictions.

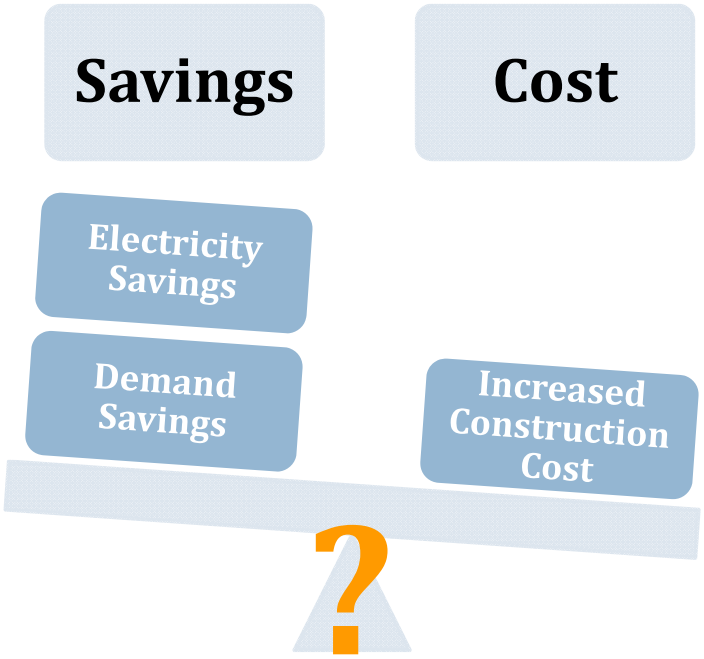




Has energy code improved the energy efficiency of housing in TX?
How much savings has been achieved from the code adoption?

Introduction (2/2)

Hence, this paper 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 eight-year period from 2002 through 2009.

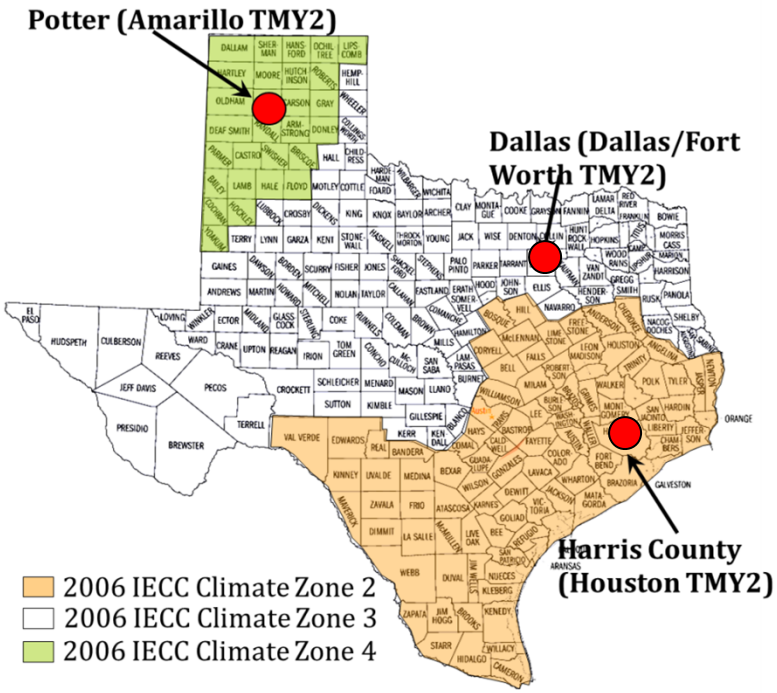


Methodology (1/4)

Building-Level Analysis

- Calculated "**per-house**" energy savings and peak demand reductions
- ESL simulation model based on the DOE-2.1e of a single-family residence
- Two options by the type of heating fuel
  - **Electric/gas** house:
    Electric cooling, Natural gas heating
  - **Heat pump** house:
    Electric cooling, Heat pump heating
- Three representative counties in Texas
  - **Harris** Count y(CZ 2)
  - **Tarrant** County (CZ 3)
  - **Potter** County (CZ 4)

IC3 International CODE COMPLIANCE CALCULATOR



Methodology (2/4)

State-Level Analysis

1) Statewide Electricity Savings

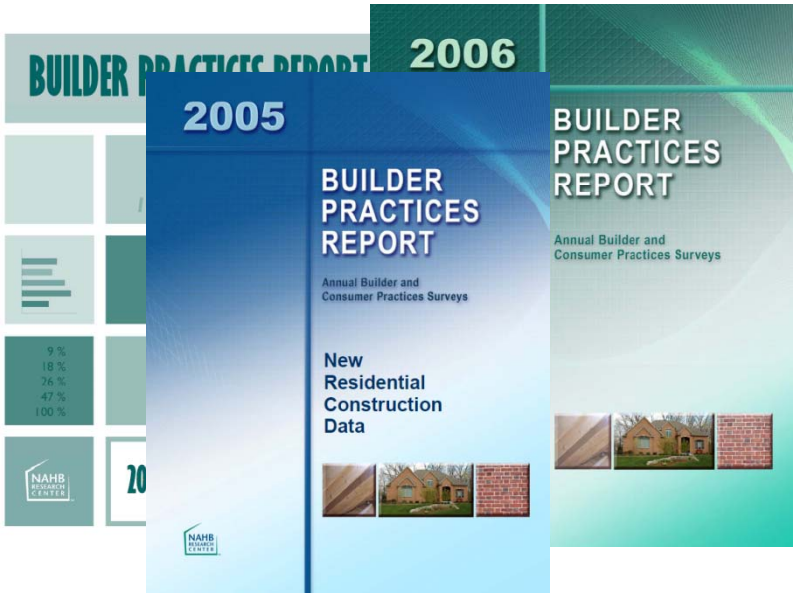
- Calculated using **annual MWh savings from code-compliant, new single-family housing in Texas** reported in the Laboratory's Annual Reports submitted to the Texas Commission on Environmental Quality (TCEQ)

Methodology (2/4)

State-Level Analysis

1) Statewide Electricity Savings

- Calculated using **annual MWh savings from code-compliant, new single-family housing in Texas** reported in the Laboratory's Annual Reports submitted to the Texas Commission on Environmental Quality (TCEQ)



•Annual statewide MWh savings

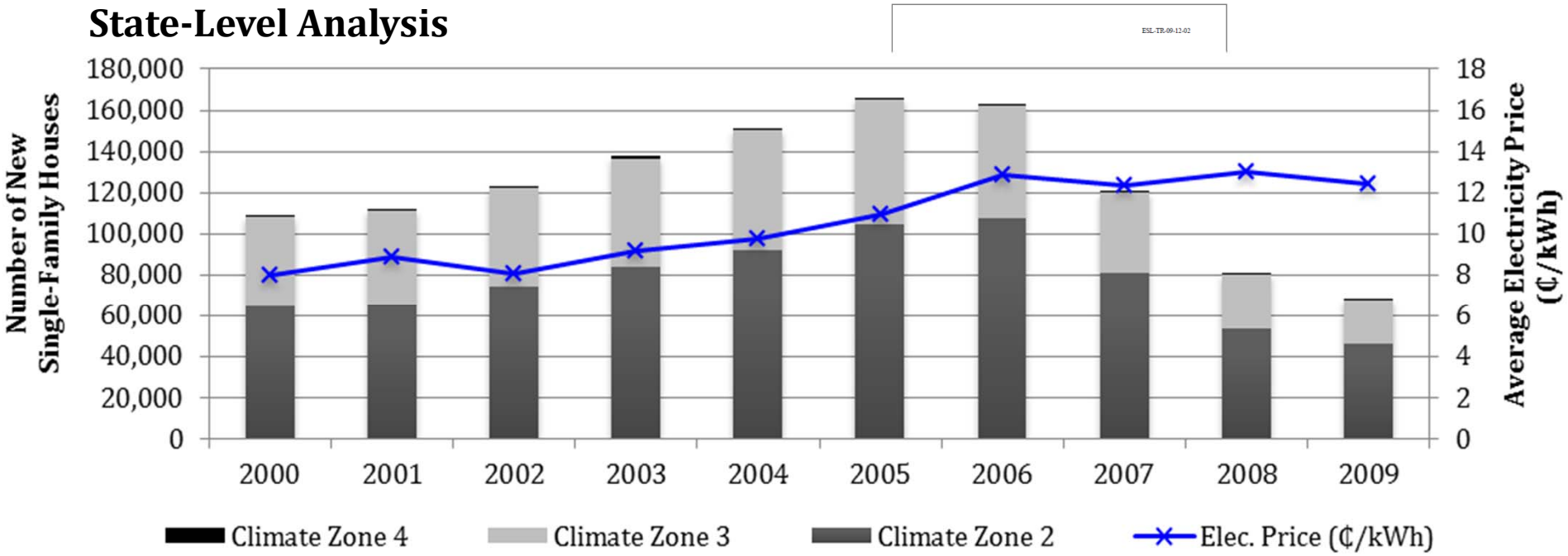
$=(E_{pre\text{-}code} - E_{year}) \times$ Number of new single-family houses

•$E_{pre\text{-}code}$: annual electricity consumption of a house that has the average characteristics of single-family residences for Texas published by the National Association of Home Builders (NAHB) of **1999**

•E_{year}: annual electricity consumption of a house that has the average characteristics of single-family residences for Texas published by the National Association of Home Builders (NAHB) of the **corresponding year**

Methodology (2/4)

State-Level Analysis



- Annual statewide electricity savings ($/yr)
  = MWh savings/yr
  x annual average electricity price ($/kWh)[1]

[1]U.S. DOE EIA (2011)

Methodology (3/4)

State-Level Analysis

2) Statewide Demand Savings (Avoided construction cost of a peaking plant)

- Calculated using **"Per-house" peak demand reduction** (kW) calculated at the building-level analysis

- Three adjustment factors
  - 10% initial discount factor
  - 7% transmission and distribution loss factor
  - 5% annual degradation factor

- Annual statewide electric demand savings ($/yr)
  = "Per-house" demand reduction (kW)
  x Number of new single-family houses[1]
  x average capital cost of a NG combined cycle power plant (= $1,165 /kW)[2]
  x 15% reserve margin[3]

[1]RECenter 2011
[2]Kaplan 2008
[3]Faruqui et al. 2007

- 2006 IECC was assumed to be adopted across Texas in 2007

Methodology (4/4)

Incremental Cost Analysis

- Increased costs for upgrading major residential building components and systems to comply with the 2001 IECC and the 2006 IECC

- Sources
  - R.S. Means Residential Cost Data
  - Building Codes Assistance Project (BCAP) Incremental Construction Cost Analysis for New Homes
  - American Council for an Energy-Efficient Economy (ACEEE) Consumer Guide to Home Energy Savings
  - Other individual studies conducted by the Laboratory (Malhotra et al. 2008; Kim et al. 2010)

- Annual increased construction costs ($/yr)
  = "Per-house" increased costs
  x Number of new single-family houses[1]

[1]RECenter 2011

Base-Case Building (1/3)

Building Envelope

- 2,325 ft^2, square-shape, one story, single-family detached house
- Vented, unconditioned attic
- Light weight wood frame construction
- 18% window-to-floor ratio (27.1% window-to-wall ratio)

- Other envelope characteristics: climate-specific characteristics as specified in
  - NAHB survey for 1999 construction in TX for pre-code
  - 2001 IECC Chapter 4
  - 2006 IECC Chapter 4

Characteristics	Pre-Code 1999			2001 IECC			2006 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
Construction									
Ceiling Insulation (hr-sq.ft.-°F/Btu)[1]	R-27.08	R-26.75		R-30	R-38		R-27.84		R-32.51
Wall Insulation (hr-sq.ft.-°F/Btu)[1]	R-13.99	R-14.18		R-11		R-12/3 c.i.	R-11.8		
Slab Perimeter Insulation	None		R-6	None		R-6	None		R-10
U-Factor of Glazing (Btu/hr-sq.ft.-°F)[1]	1.11	0.87		0.47		0.41	0.75	0.65	0.40
Solar Heat Gain Coefficient (SHGC)[1]	0.71	0.66		0.40		0.68	0.40		
Exterior Shading	None								
Roof Radiant Barrier	No								

Base-Case Building (2/3)

HVAC/DHW System

- HVAC/DHW characteristics: characteristics as specified in
  - NAHB survey for 1999 construction in TX for pre-code
  - 2001 IECC Chapter 4
  - 2006 IECC Chapter 4

Characteristics	Pre-Code 1999			2001 IECC			2006 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
Mechanical Systems									
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 furnace			(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: 0.364						(b) Heat Pump House: 0.904		
Duct Distribution System Efficiency	0.80								
Supply Air Flow (CFM/ton)	360								
Infiltration Rate (SG)	SLA= 0.00057						SLA= 0.00036		

Base-Case Building (3/3)

Space Conditions (Modified)

- Thermostat per IECC 2009 Table 405.5.2(1)
  - 72 F for heating
  - 75 F for cooling
  - No set-back/set-up
- Internal gains per IECC 2006 Table 405.5.2(1)
  - 1.095 kW for lighting and equipment

Results

1. Per-House Analysis

2. Incremental Cost Analysis

3. Statewide Cost Savings

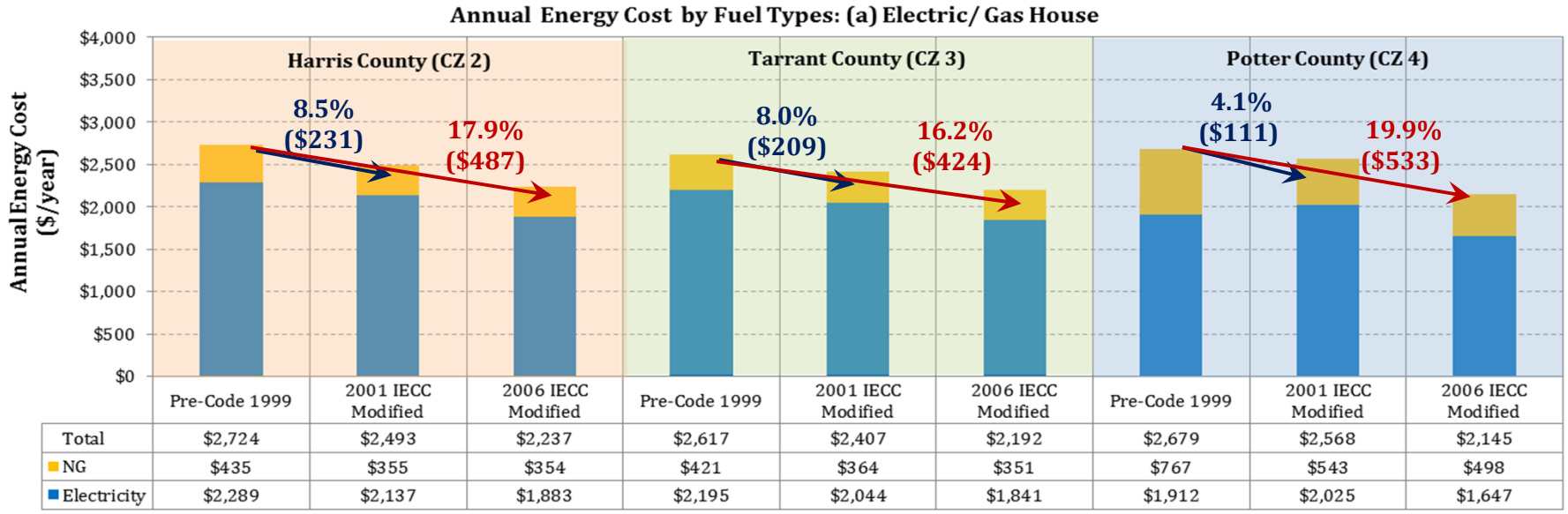
Results

1. Per-House Analysis

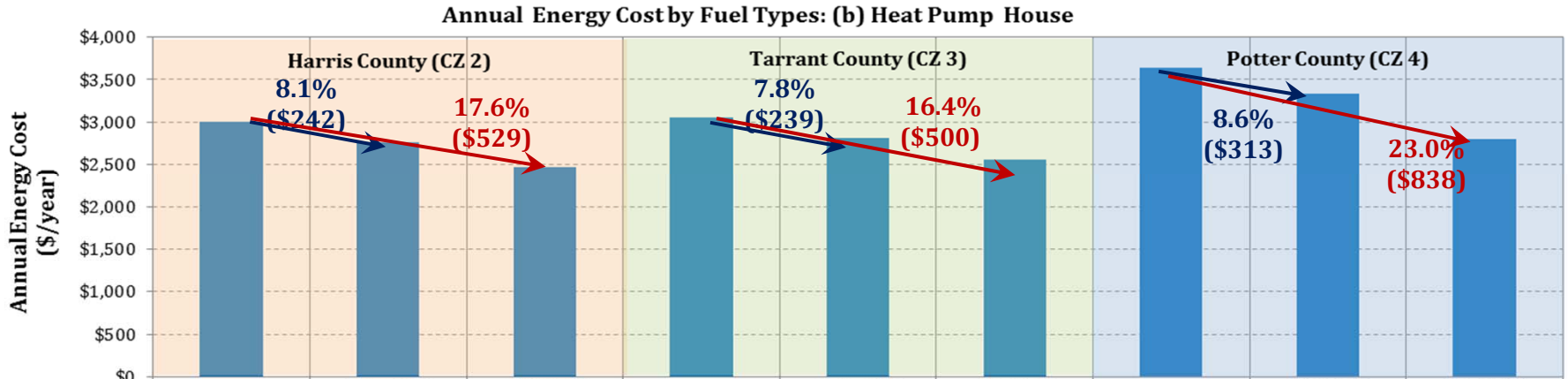
2. Incremental Cost Analysis

3. Statewide Cost Savings

Results: Per-House Analysis (1/2)



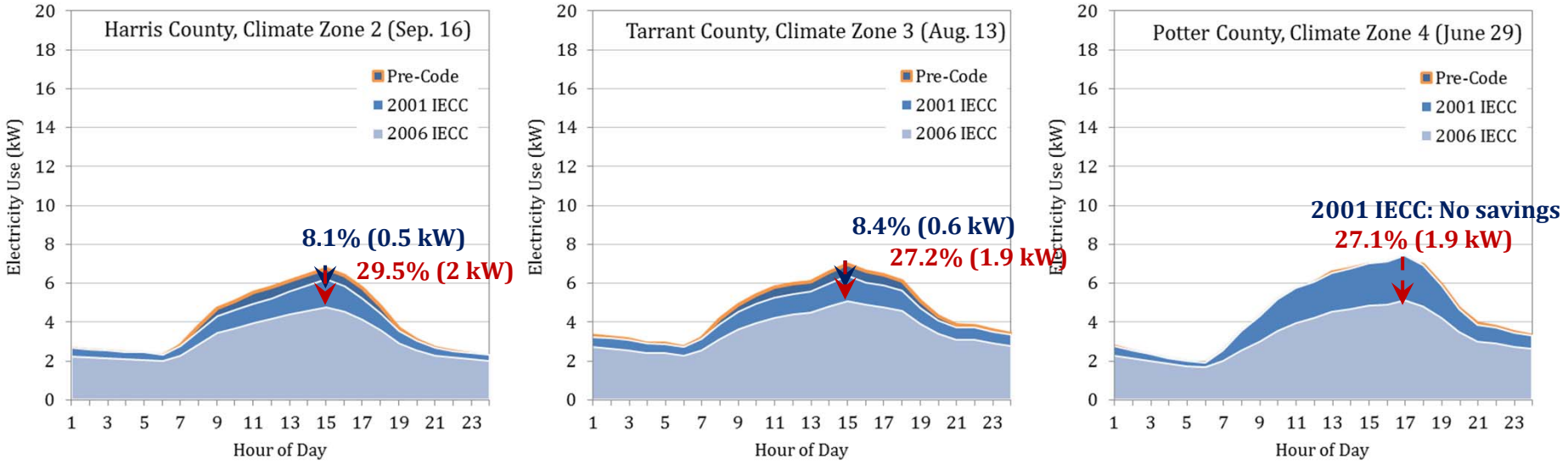
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified
Total	$2,724	$2,493	$2,237	$2,617	$2,407	$2,192	$2,679	$2,568	$2,145
NG	$435	$355	$354	$421	$364	$351	$767	$543	$498
Electricity	$2,289	$2,137	$1,883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



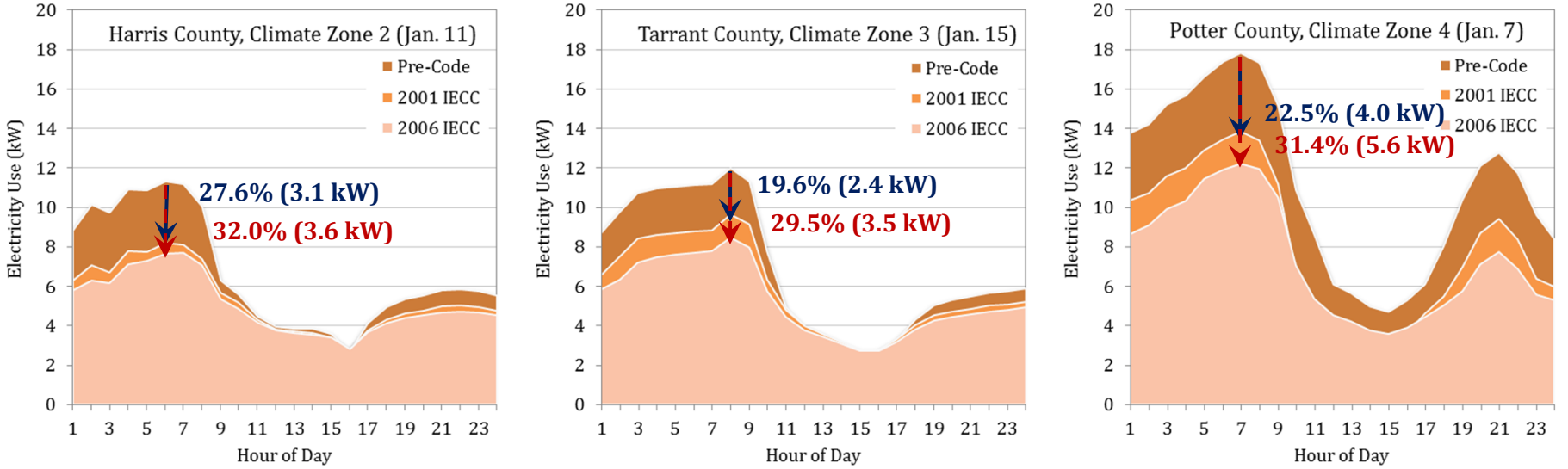
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified
Total	$3,001	$2,760	$2,473	$3,053	$2,814	$2,553	$3,643	$3,330	$2,805
NG	-	-	-	-	-	-	-	-	-
Electricity	$3,001	$2,760	$2,473	$3,053	$2,814	$2,553	$3,643	$3,330	$2,805

Results: Per-House Analysis (2/2)

(a) Peak Summer Day Hourly Electricity Use for both Electric/Gas and Heat Pump House



(b) Peak Winter Day Hourly Electricity Use for a Heat Pump House



Results

1. Per-House Analysis

2. Incremental Cost Analysis

3. Statewide Cost Savings

Results: Incremental Cost Analysis

Climate Zone 2

Components	Pre-Code	2001 IECC	2006 IECC	Change Per Sq. Ft.		Sq. Ft /Linear Ft	Total Change		Reference
				2001 IECC	2006 IECC		2001 IECC	2006 IECC	
Ceiling Insulation	**R-27**	R-30	R-30	$ 0.09	$ 0.11	2,548	$ 229	$ 280	RSMeans 2002 and 2007
Window U/SHGC	**1.11/0.71**	0.52/0.40	0.75/0.40	$ 1.50	$ 1.00	247	$ 371	$ 247	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	**R-14**	R-11	R-13	$ -	$ -	1,778	$ -	$ -	
Slab Insulation	**NR**	NR	NR	$ -	$ -	202	$ -	$ -	
AC SEER	**11**	10	13	$ -	$ -		$ -	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	**0.54**	0.54	0.59	$ -	$ -		$ -	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	**0.86**	0.86	0.90	$ -	$ -		$ -	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)

Climate Zone 3

Components	Pre-Code	2001 IECC	2006 IECC	Change Per Sq. Ft.		Sq. Ft /Linear Ft	Total Change		Reference
				2001 IECC	2006 IECC		2001 IECC	2006 IECC	
Ceiling Insulation	**R-27**	R-30	R-30	$ 0.09	$ 0.11	2,426	$ 218	$ 267	RSMeans 2002 and 2007
Window U/SHGC	**0.87/0.66**	0.50/0.40	0.65/0.40	$ 1.50	$ 1.00	373	$ 560	$ 373	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	**R-14**	R-11	R-13	$ -	$ -	1,814	$ -	$ -	
Slab Insulation	**NR**	NR	NR	$ -	$ -	197	$ -	$ -	
AC SEER	**11**	10	13	$ -	$ -		$ -	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	**0.544**	0.544	0.594	$ -	$ -		$ -	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	**0.86**	0.86	0.90	$ -	$ -		$ -	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)

Climate Zone 4

Components	Pre-Code	2001 IECC	2006 IECC	Change Per Sq. Ft.		Sq. Ft /Linear Ft	Total Change		Reference
				2001 IECC	2006 IECC		2001 IECC	2006 IECC	
Ceiling Insulation	**R-27**	R-38	R-38	$ 0.27	$ 0.19	2,426	$ 655	$ 461	RSMeans 2002 and 2007
Window U/SHGC	**0.87/0.66**	0.37/NR	0.40/NR	$ 1.50	$ 1.50	373	$ 560	$ 560	BCAP 2010; ESL-TR-10-11-01
Wall Insulation	**R-14**	R-11	R-12/3.1 c.i.	$ -	$ -	1,814	$ -	$ -	BCAP 2010
Slab Insulation	R-6, 2ft	R-6, 2ft	R-10, 2ft	$ -	$ 1.26	197	$ -	$ 248	BCAP 2010 (R5 to R10: $1.26)
AC SEER	**11**	10	13	$ -	$ -	-	$ -	$ 300	10% of 5 ton AC cost ($2900), RSMeans 2007
Gas DHW EF	**0.544**	0.544	0.594	$ -	$ -		$ -	$ 175	ACEEE 2007 (0.60 EF to 0.65 EF)
Electric DHW EF	**0.86**	0.86	0.90	$ -	$ -		$ -	$ 75	ACEEE 2007 (0.90 EF to 0.95 EF)

Results

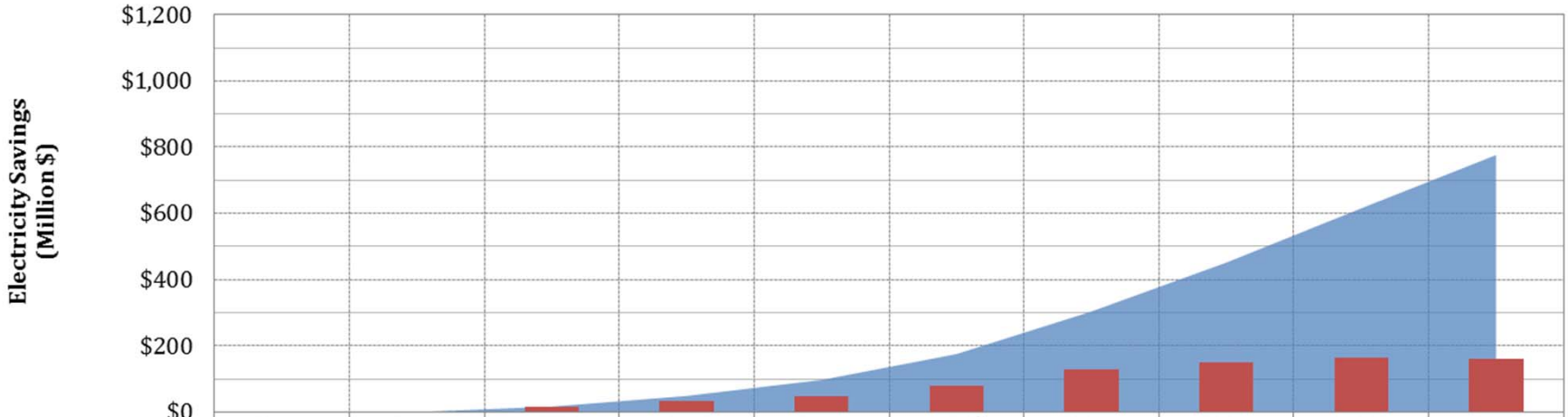
1. Per-House Analysis

2. Incremental Cost Analysis

3. Statewide Cost Savings

Results: Statewide Cost Savings (1/4)

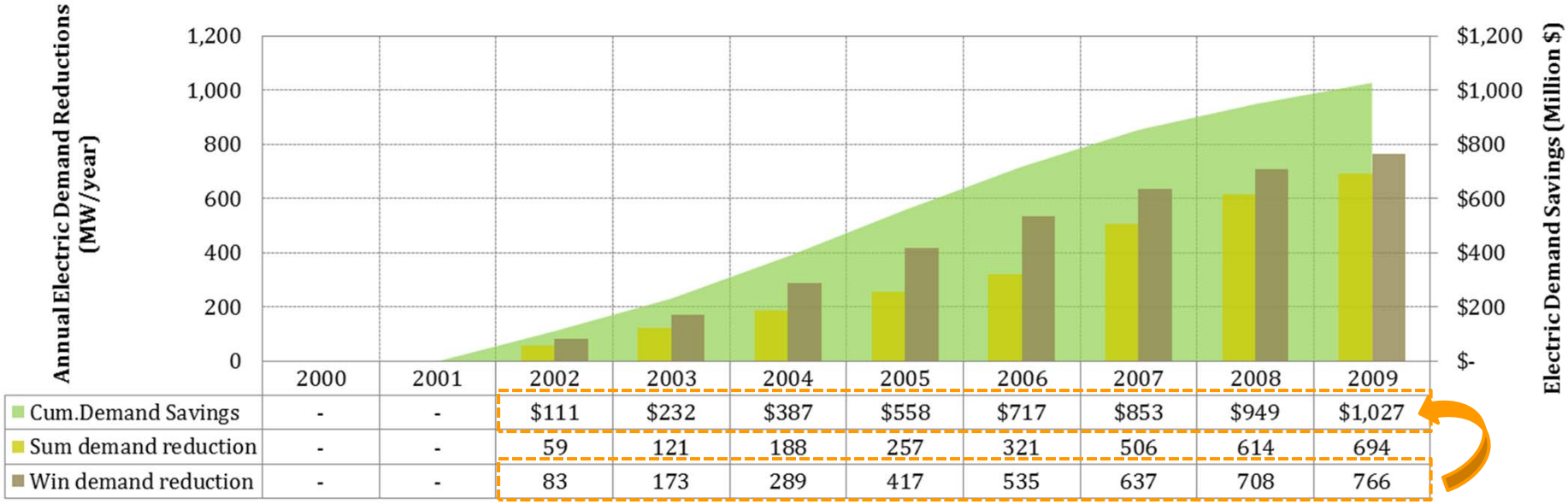
Annual and Cumulative Statewide Electricity Savings from the IECC Code Adoption for New SF Residences in Texas: 2002-2009



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cum. Elec. Savings	-	-	$16	$48	$97	$175	$304	$451	$615	$776
Annual Elec. Savings	-	-	$16	$32	$49	$78	$129	$148	$164	$161

Results: Statewide Cost Savings (2/4)

Annual Statewide Electric Demand Reductions and Electric Demand Savings from the IECC Code Adoption for New SF Residences in Texas: 2002-2009

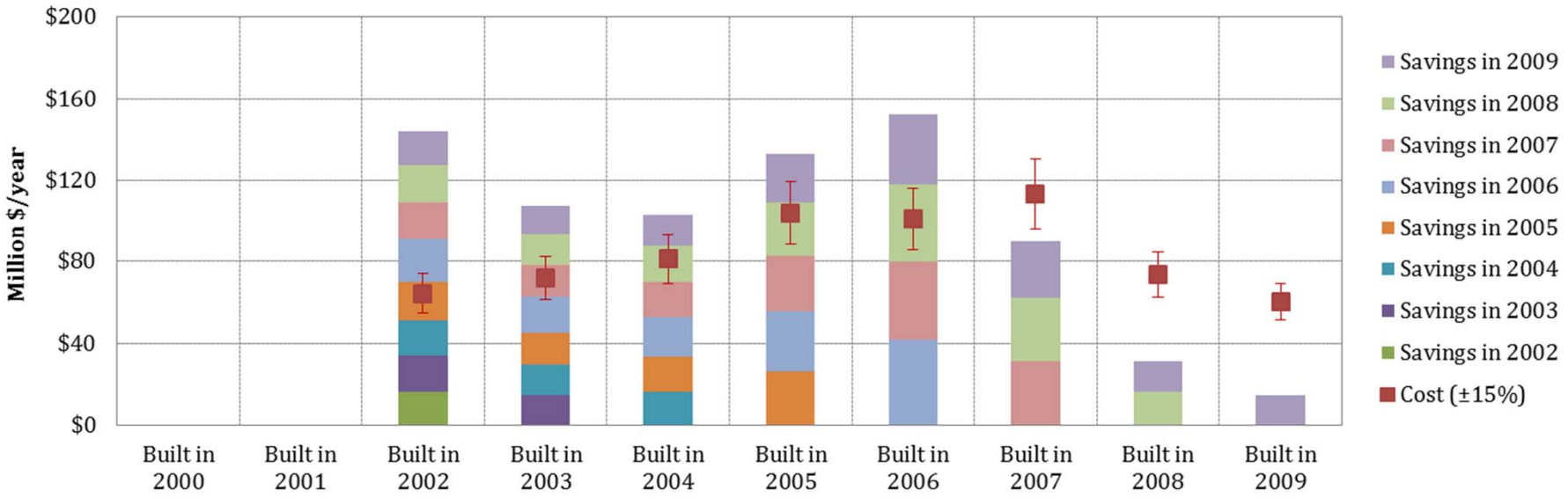


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cum.Demand Savings	-	-	$111	$232	$387	$558	$717	$853	$949	$1,027
Sum demand reduction	-	-	59	121	188	257	321	506	614	694
Win demand reduction	-	-	83	173	289	417	535	637	708	766

Demand saving calculated using summer reduction: **$ 929** million (**90%** of winter savings)

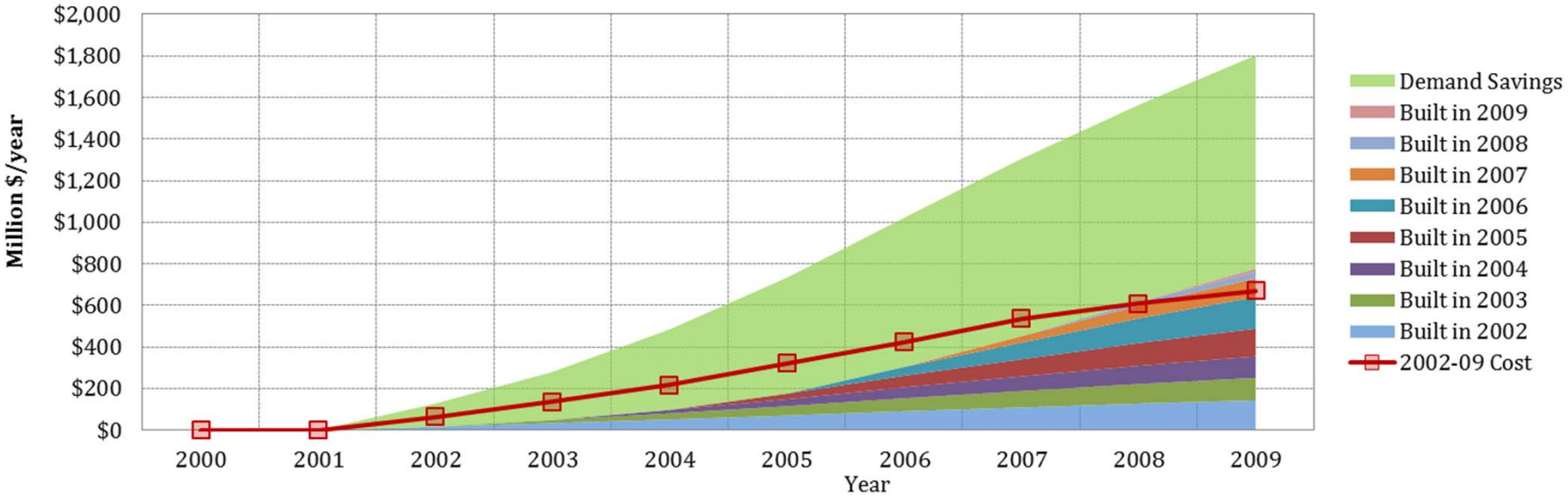
Results: Statewide Cost Savings (3/4)

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



Results: Statewide Cost Savings (4/4)

Cumulative Increased Costs, Statewide Electricity Savings, and Electric Demand Savings Associated with the IECC Code Adoption for SF Residences in Texas: 2002-2009



Summary (1/2)

Statewide electricity savings and electric demand savings from the IECC code adoption for SF residences in Texas (2002-2009)

- ESL simulation model based on the DOE-2.1e of a single-family residence

- Three adjustment factors
  - 10% initial discount factor
  - 7% transmission and distribution loss factor
  - 5% annual degradation factor

- Annual average prices of Texas residential electricity published by the U.S. DOE EIA

- Avoided construction cost of a peaking plant:
  Capital cost of a NG combined-cycle power plant with a 15% reserve margin

Summary (2/2)

Results

- Building level analysis for three representative counties

	Electricity savings	Electric demand savings	Increased construction costs
2001 IECC	$111 ~ $313	0 ~ 0.6 kW for summer 2.4 ~ 4 kW for winter	$600 ~ $1215
2006 IECC	$424 ~ $838	1.9 ~ 2.0 kW for summer 3.5 ~5.6 kW for winter	$902 ~ $1,744

- Statewide level analysis

	Electricity savings	Electric demand savings	Total Savings	Increased construction costs
Statewide (2002 -2009)	$776 million	$929 million OR (summer reductions) $1,027 million (winter reductions)	**$1,705 million OR** **$1,803 million**	**$670 million**

Acknowledgement

Acknowledgement

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Thank You!