CALCULATION WORKSHEET
Savings Achieved from Application of 2009 Building Energy Code to Retrofits

Step 1. Calculate the baseline percentage of residential electricity use potentially affected by building energy codes in Texas.

Building energy codes only impact a portion of total household electricity consumption. When applying building energy codes to retrofits (additions, alterations, and renovations), typically only the systems and parts of the structure that are directly affected by the change to the structure must be brought up to code. For residential buildings, it is most common that only heating and cooling are affected. Cooking, refrigeration, hot water, household appliances, and most lighting are not affected by the code.[1]

In 2005, about 6 billion kWh were used for heating and 43 billion kWh were used for cooling out of a total of 121 billion kWh for all purposes.[2] At a maximum, (6+43)/121 = **40%** of a renovated household's electricity is for heating and cooling and thus would be exposed to savings from application of the updated building energy code. *See* Table 1.

Step 2. Calculate the impact of updated building energy code on electricity consumption in typical residences.

2a. Newer existing stock. The average difference in electricity use for heating and cooling under the 2009 IECC code as compared to the 2001 IECC code is **12.6%**.[3] *See* Table 2a.

2b. Older existing stock. The difference in electricity use for heating and cooling between a 1970s-era single family house in Houston and a similar structure meeting the 2009 IECC is **47.0%**.[4] *See* Table 2b.

Step 3. Calculate the impact of applying code updates during retrofits to the differences in electricity consumption under updated building energy codes for entire building.

As explained in Step 1, building energy codes most commonly affect heating and cooling. However, not all sources of cooling and heating loads have the same impact on heating and cooling electricity consumption; nor are they all likely to be affected by codes during a retrofit.[5] Using the Steven Winter Associates (Ex. NRC000069) 1970s baseline building data, it appears that, at most, about 51.4 % of cooling energy consumption would be impacted by application of the 2009 standard to the conditioned space as a result of a renovation.[6] *See* Table 3. It could be a larger proportion for an addition, but additions are a small proportion (8.3%) of the overall additions, alterations, and renovations.

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[1] *See* U.S. DOE. 2011. Building Energy Codes Program (Ex. NRC000067).

[2] U.S. DOE/EIA. 2005. Residential Energy Consumption Survey (Ex. NRC000068).

[3] *See* Kim et al. 2011 at Figures 2 and 3 (Ex. NRC000048).

[4] *See* Steven Winter Associates. 2010. Retrofitting America: 1970s Home Analysis (Ex. NRC000069).

[5] DOE Building Energy Codes Program 2011 (Ex. NRC000067).

[6] For example, the interior heat gains due to occupants and appliance use would not be affected, and for most updates, the 2009 IECC would not require changes to reduce space conditioning losses through slab floors or leaks in ductwork.

Recalling Step 2, to obtain the weighted average impact of the 2009 code applied to a typical residential retrofit, I assumed that 80% of retrofitted houses had 1970 baseline electricity use before the retrofit (47% of household electricity consumption for space conditioning saved) and 20% met the 2001 IECC code before the retrofit (12.6% of household electricity consumption for space conditioning saved). I multiplied this weighted average by the space-conditioning percentage of total household electricity use from Step 1 (40%), then by 51.4% (to account for code-related actions that typically would not be taken during retrofits) to obtain a maximum "save-able" percentage of household electricity consumption of **8.3%** if the code were applied to the entire house. *See* Table 3.

Step 4. Calculate electricity savings from typical retrofit.

I assumed that the average house was a three-bedroom house with 8 rooms (living room, dining room, kitchen, two baths, and 3 bedrooms) in conditioned space. I assumed that the average addition, alteration, or renovation involved one room and one-eighth of the electricity consumption in the whole house.[7] Applying 12.5% ($1/8^{th}$) to the maximum save-able electricity from Step 3 (8.3%) results in about **1%** electricity savings from the typical retrofit. *See* Table 4.

Step 5. Calculate electricity savings from typical unit of existing stock per year.

During the previous two years, 1.5 % of owner-occupied houses had an addition, and 16.5% had a room added or renovated or replaced doors or windows.[8] If those two groups of activity do not overlap, a total of 18.0%/2 =9.0% had a "major" addition or renovation per year, suggesting that about 9.0% per year of existing residential electricity use would be exposed to potential saving when building energy codes are enforced on the retrofit. When multiplied by the impact of a typical retrofit on a single building from Step 4 (1%), this yields about **0.1%** reduction of total electricity use in the residential stock in any given year. *See* Table 5.

Step 6. Calculate the effect on total residential electricity consumption in ERCOT.

In this step, I used the ACEEE 2007 report (Ex. STP000008) to obtain an estimate of total peak energy use in the existing residential stock in 2010 in Texas, multiplied by 85% to convert that figure into an estimate for ERCOT, calculated the accumulating savings contributed by each year's additions, alterations, and renovations over time as was done for new buildings in the direct testimony, and adjusted for the line loss factor discussed in the Staff DEIS-1 Direct Testimony at A48 (Ex. NRC000031). The resulting cumulative savings are 163 MW in 2015 and 324 MW in 2020. I also applied the 44% baseload-to-peak ratio to estimate the baseload demand savings at **72 MW in 2015** and **143 MW in 2020**. *See* Table 6.

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[7] While some retrofits involve more than one room, other retrofits such as door, roof, or window replacement do not involve bringing the space up to the current code. In any case, only the portions of the building affected by the retrofit must meet the new code, not the entire building.

[8] *See* U.S. Census Bureau. 2009. American Housing Survey, South Census Region data (Ex. NRC000070).

Savings Achieved from Application of 2009 Building Energy Code to Retrofits Calculations

Table 1.

Residential Electricity Use in Texas for Heating and Cooling

	Total 10^9 kWh
Heating	6
Air Conditioning	43
Total (All Uses)	121
Heating and Air Conditioning % of Total	40%
Source: U.S. DOE/EIA. 2005. Residential Energy Consumption Survey (Ex. NRC000068)	

Table 2a.

Savings in Newer Existing Single Family Housing Electricity Use (Mbtu/Yr) (IECC 2000 vs IECC 2009)

	2001 Code			2009 Code			Average %
N Gas House	Harris	Tarrant	Potter	Harris	Tarrant	Potter	**Saved**
Heat (Gas--no electrical)	0	0	0	0	0	0	
Cool	27.1	24.2	22	15.5	14	8.5	48.8%
Sum of Heat and Cool	27.1	24.2	22	15.5	14	8.5	48.8%
Total (2009 = 2001, minus H&C Savings)	108.6	120.2	147.7	97	110	134.2	9.4%
Heat Pump House							
Heat	8	12	26.2	6.6	9	21.9	19.6%
Cool	27.1	24.2	22	15.5	14	8.5	48.8%
Sum of Heat and Cool	35.1	36.2	48.2	22.1	23	30.4	36.8%
Total (2009 =2001, minus H&C Savings)	85.6	87.3	103.3	72.6	74.1	85.5	15.8%
						Average Savings from 2001 Baseline	12.6%
Source: Kim et al 2011, Figures 2 and 3(Ex. NRC000048)							

Table 2b.

Savings in Older Existing Single Family Housing Electricity Use (Houston 1970s House vs IECC 2009)

	1970s Single Family House	2009 Code	Percent Change
Mix of Electric and Natural Gas House [1]	MBtu/yr	Mbtu/yr	
Heat (Electric Portion)	2	1	45.8%
Cool	40	13	67.5%
Total (2009) = [2001 minus (Heat + Cool Savings)]	59	31	
Grand % of Household Electricity Saved [2]			**47.0%**

Source: Steven Winter Associates. 2010. Retrofitting America: 1970s Home Analysis (Ex. NRC000069).

[1] (1600 sq ft, 3-bedroom house)

[2] Houston Cooling + Heating from Retrofit Dashboard (2009 IECC vs 1970s house)

Table 3.

Cooling energy consumption sources

	MBtu/yr	Adjusted Total	Addressable in Code Retrofits
Ducts	12.5	12.0	
Windows/Skylights	9.7	9.3	9.3
Infiltration	8.2	7.9	7.9
Interior Gains	7.1	6.8	
Above Grade Walls	2.2	2.1	2.1
Ceilings/Roofs	1.3	1.3	1.3
Slab Floors	0.8	0.8	
Doors	0.1	0.1	0.1
Total	41.9	40.3	20.7
Actual Total in Source	40.3		
%of Houston Savings addressed in retrofits Calculated by dividing the Total "Addressable in Code Retrofits" into the Total "Adjusted Total"			**51.4%**
% of retrofits in 1970s vintage (assumption)			80%
Maximum % "Saveable" per house (Space Cond % x % saved)			8.3%

Details are in Steven Winter Associates. 2010. Retrofitting America: 1970s Home Analysis (Ex. NRC000069).

Table 4.

Impact of typical retrofit (assume one room typically affected - either added, altered, or renovated)

One room's worth (8 room house) of energy	12.5%
One room save-able energy per house	**1.0%**
Note: The 12.5% is an assumption by NRC staff.	

Table 5.

New additions, renovations, and alterations over two years – effect on average unit of stock

Southern Census region	*Item*	*% of Total*
Total Stock (10^3 units)	29,193	
New Inside Additions (10^3 jobs)	446	1.5%
Code-Relevant Interior Renovations (create or remodel room, replace doors, windows, or insulation (10^3 jobs)	4,819	16.5%
Total Additions, Alterations, and Renovations as % of stock over 2 years	18.0%	
Total Additions, Alterations, and Renovations as % of stock **per year**	9.0%	
Percent of Stock Electricity Affected per Year (% of Stock Affected by Additions, Alterations, Renovations (AAR) x % of Household Electricity Saved per AAR)	**0.1%**	
Source: U.S. Census Bureau. 2009. American Housing Survey, South Census Region data (Ex. NRC000070)		

Table 6.

Effect on Residential Energy Consumption

Ratio of Baseload Demand to Peak Demand	0.44

	Texas Residential Stock Electricity Use		Annual Peak Retrofit Savings within ERCOT [3]	Cumulative Peak Retrofit Savings within ERCOT	Line Loss Factor	Line Loss Annual Rate of Change	Cumulative Peak Savings within ERCOT, Adjusted for Line Loss	Cumulative Baseload Savings
	From Initial Residential Stock in Texas, 2010 [1]	Consumption Within ERCOT [2]						
	MW	MW	MW	MW			MW	MW
2010	38,520	32,742	0	0	1.067	-0.001	0	0
2011	38,520	32,742	31	31	1.066		33	14
2012	38,484	32,711	31	62	1.065		66	29
2013	38,448	32,680	31	92	1.064		98	43
2014	38,411	32,650	31	123	1.063		131	58
2015	38,375	32,619	31	154	1.062		163	72
2016	38,339	32,588	31	184	1.061		196	86
2017	38,303	32,558	31	215	1.061		228	100
2018	38,267	32,527	31	245	1.060		260	114
2019	38,231	32,497	31	276	1.059		292	129
2020	38,195	32,466	31	307	1.058		324	143
2021	38,159	32,435	30	337	1.057		356	157
2022	38,124	32,405	30	367	1.056		388	171
2023	38,088	32,375	30	398	1.055		420	185
2024	38,052	32,344	30	428	1.054		451	199
2025	38,016	32,314	30	459	1.053		483	213

[1] From ACEEE 2007, Table B.1 (Ex. STP000008)

[2] Calculated by multiplying first column by 0.85.

[3] Calculated by multiplying the Consumption within ERCOT by 0.44, savings begin in 2011.