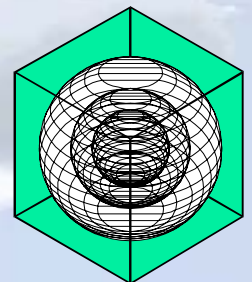


A METHODOLOGY FOR CALCULATING INTEGRATED NO_x EMISSIONS REDUCTION FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY (EE/RE) PROGRAMS ACROSS STATE AGENCIES IN TEXAS

**Juan-Carlos Baltazar, Ph.D., Piljae Im
Jeff S. Haberl, Ph.D., P.E., Betty Liu Ph.D.
Jaya Mukhopadhyay, Seongchan Kim Ph.D.
Don Gilman, P.E., Charles Culp, Ph.D., P.E.
Bahman Yazdani, P.E.**

**Energy Systems Laboratory
Texas Engineering Experiment Station
Texas A&M University System**



Acknowledgements

- **Faculty/Staff:** David Claridge, Dan Turner, Malcolm Verdict, Larry Degelman, Sherry Hughes, Angie Shafer, Stephen O'Neal
- **Students:** Mini Maholtra, Soolyeon Cho, Eduardo Ramirez
- **Jay Zarnekau (Frontier and Associates), Theresa Gross (PUC), Jess Totten (PUC), Glenn Jennings (SECO), Steve Anderson (TCEQ), Alfred Reyes (TCEQ), Akin Olubiyi (TCEQ), Warren Lasher (ERCOT), Dan Woodfin (ERCOT), and David Hitchcock (HARC), Art Diem (USEPA) , and Julie Rosenberg (USEPA).**



Legislative Initiatives

41 Counties in Texas designated non-attainment or affected.

Senate Bill 5 (77th Legislature, 2001)

Ch. 386. Texas Emissions Reduction Plan

Sec. 386.205. Evaluation Of State Energy Efficiency Programs (with PUC)

Ch. 388. Texas Building Energy Performance Standards

Sec. 388.003. Adoption Of Building Energy Efficiency Performance Standards.

Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.

Sec. 388.007. Distribution Of Information And Technical Assistance.

Sec. 388.008. Development Of Home Energy Ratings.

TERP Amended (78th Legislature, 2003)

Ch. 388. Texas Building Energy Performance Standards

(HB 1365) Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.

(HB 1365) Sec. 388.009. Energy-Efficient Building Program.

Ch. 388. Texas Building Energy Performance Standards

(HB 3235) Sec. 388.009. Certification of Municipal Inspectors.

TERP Amended (79th Legislature, 2005)

Ch. 382. Health and Safety Code

(HB 2129) Sec. 386.056 Development of Creditable Statewide emissions from wind and other renewables.

(HB 965) Sec. 382.0275 Commission Action Relating to Water Heaters

TERP Amended (80th Legislature, 2007)

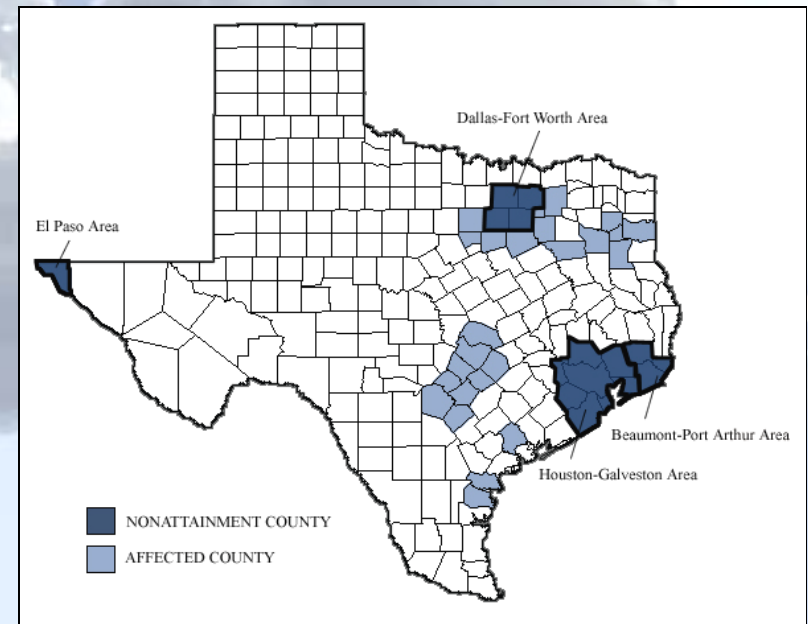
Ch. 382. Health and Safety Code

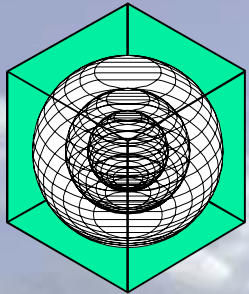
(HB 3693) Sec. 388.003 added subsection (b-1), (b-2), (b-3) that allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.

(HB 3693) Sec. 388.008 Development of Standardized report formats for newly constructed residences.

Ch. 386.252 Health and Safety Code

(SB 12) Section 388.03 added subsection (b-1), (b-2) allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.





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INTEGRATED NO_x SAVINGS

In 2005 TCEQ Initiated a program to determine integrated NO_x emissions savings (2009 & BEYOND) to allow for standardized reporting to the US EPA



State Agencies included:

- TEES/ESL
- PUC
- SECO
- ERCOT

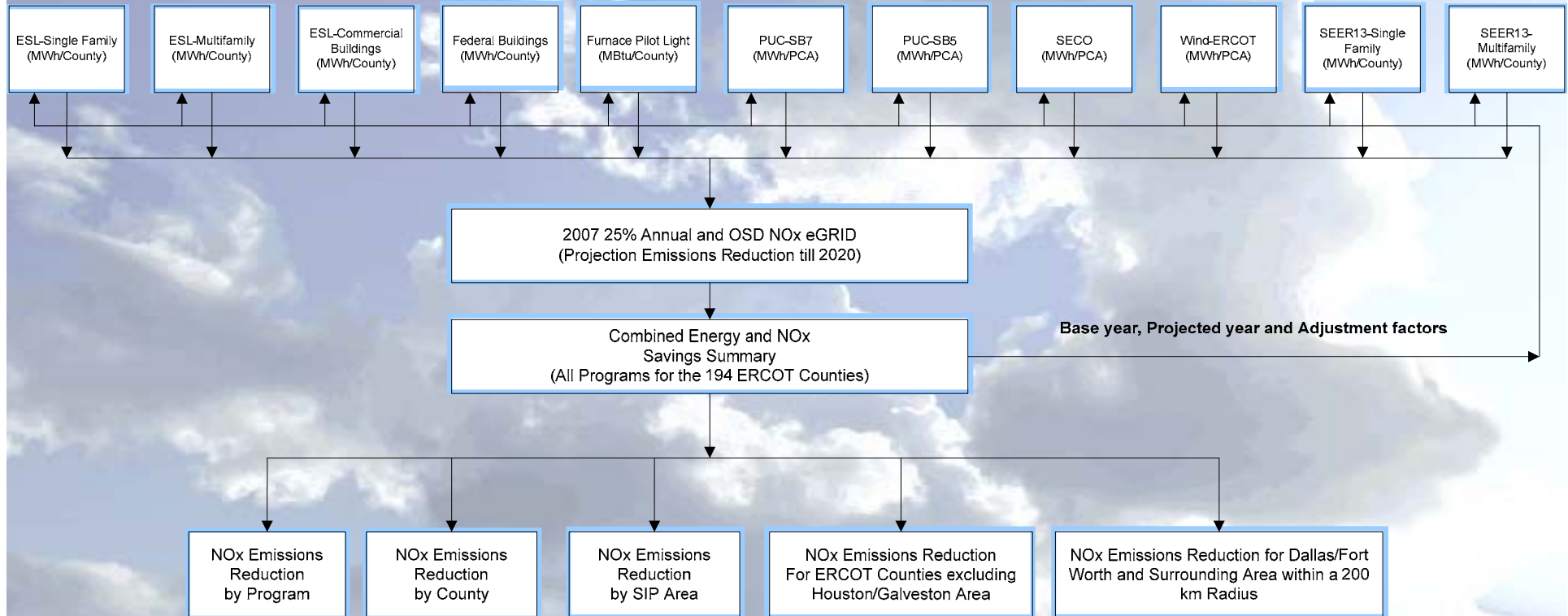
Savings Integration allows:

- Annual, OSD savings
- By County
- By SIP
- By Program
- Integration tool = Adjustable Discount, Degradation, T&D losses

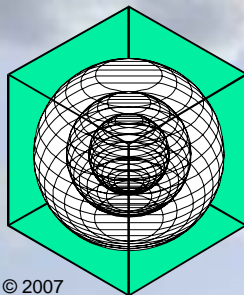


INTEGRATED NOx SAVINGS

Process Flow Diagram of the NOx Emissions Reduction Calculations



Energy Systems Laboratory © 2007



INTEGRATED NOx SAVINGS

Singlefamily savings and projection.xls
 Multifamily savings and projection.xls
 Commercial savings and projection.xls
 Federal Building savings and projection.xls
 Furnace pilot savings and projection.xls
 PUC SB7 savings and projection.xls
 PUC SB5 savings and projection.xls
 SECO savings and projection.xls
 Wind savings and projection.xls
 SEER13 SF savings and projection.xls
 SEER13 MF savings and projection.xls

Integrated Savings Summary (2007_Aug_07).xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Energy Savings Summary													
2														
3	Base year	1999												
4	Projection year	2020												
7	ADJUSTMENT FACTORS													
8		ESL- Single Family ¹⁵	ESL- Multifamily ¹⁵	ESL- Commercial ¹⁵	Federal Buildings ¹⁵	Light Program ¹⁵	PUC (SB7) ¹⁵	Grant Program ¹⁵	SECO ¹⁵	Wind-ERCOT ¹⁴	SEER13 Single Family	SEER13 Multifamily		
9	Annual Degradation Factor ¹¹	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%		
10	T&D Loss ⁹	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%		
11	Initial Discount Factor ¹²	20.00%	20.00%	20.00%	20.00%	20.00%	25.00%	25.00%	60.00%	25.00%	20.00%	20.00%		
12	Growth Factor	3.25%	1.54%	3.25%	0.00%	0.00%	0.00%	0.00%	0.00%	According to	N.A.	N.A.		
13	Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes		
15	Energy Savings Summary													
17		Total Energy Savings												
18	Program	1999		2000		2001		2002		2003		2004		20
19		Electricity		Electricity		Electricity		Electricity		Electricity		Electricity		Elect
20		Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)	Ozone Seaman Day (MWh/day)	Annual (MWh)
21	ESL-Single Family							155,000	929	145,255	915	159,265	775	169,319
22	ESL-Multifamily							76,850	464	10,055	49	5,556	35	4,222
23	ESL-Commercial	44,733	385	63,554	484	66,972	474	69,912	493	77,641	448	67,590	412	56,084
24	Federal Building													52,276
25	Furnace Pilot Light Program (MBtu)	0	0	0	0	212,469	512	949,635	1,320	1,434,841	4,074	2,124,087	5,819	2,209,050
26	PUC (SB7)	0	0	0	0	70,454	114	177,377	486	250,460	700	302,192	820	336,356
27	PUC (SB5 grant program)	0	0	0	0	0	0	1,271	3	12,793	38	0	0	0
28	SECO	0	0	0	0	0	0	0	0	0	0	115,260	316	87,550
29	Wind-ERCOT	0	0	0	0	461,407	1,674	1,606,075	4,424	1,626,532	4,305	2,150,206	4,377	2,912,693
30	SEER13-Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
31	SEER13-Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes \Energy & NOx Savings Summary \ NOx reduction 1 \ NOx reduction 2 \ NOx reduction 3

Delivered Tool: MS Workbook with multiple spreadsheets.



INTEGRATED NO_x SAVINGS ADJUSTMENT FACTORS

	ESL- Single Family ¹⁶	ESL- Multifamily ¹⁶	ESL- Commercial ¹⁶	Federal Buildings ¹⁵	Furnace Pilot Light Program ¹⁵	PUC (SB7) ¹⁵	PUC (SB5 Grant Program) ¹⁵	SECO ¹⁵	Wind- ERCOT ⁸	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor ¹¹	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
T&D Loss ⁹	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor ¹²	20%	20%	20%	20%	20%	25%	25%	60%	25%	20%	20%
Growth Factor	3.25%	1.54%	3.25%	0.0%	0.0%	0.0%	0.0%	0.0%	According to SB 20, section 39.904	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes

(11) The 5% annual degradation factor for all programs has been taken from Kats, G.H. et al. (1996) "Energy Efficiency as a Commodity," ACEEE.

(9) T&D losses are 7% except for Wind-ERCOT are 0.00% or negative since Wind is displacing the power produced by conventional plants which already have a T&D Loss associated with them.

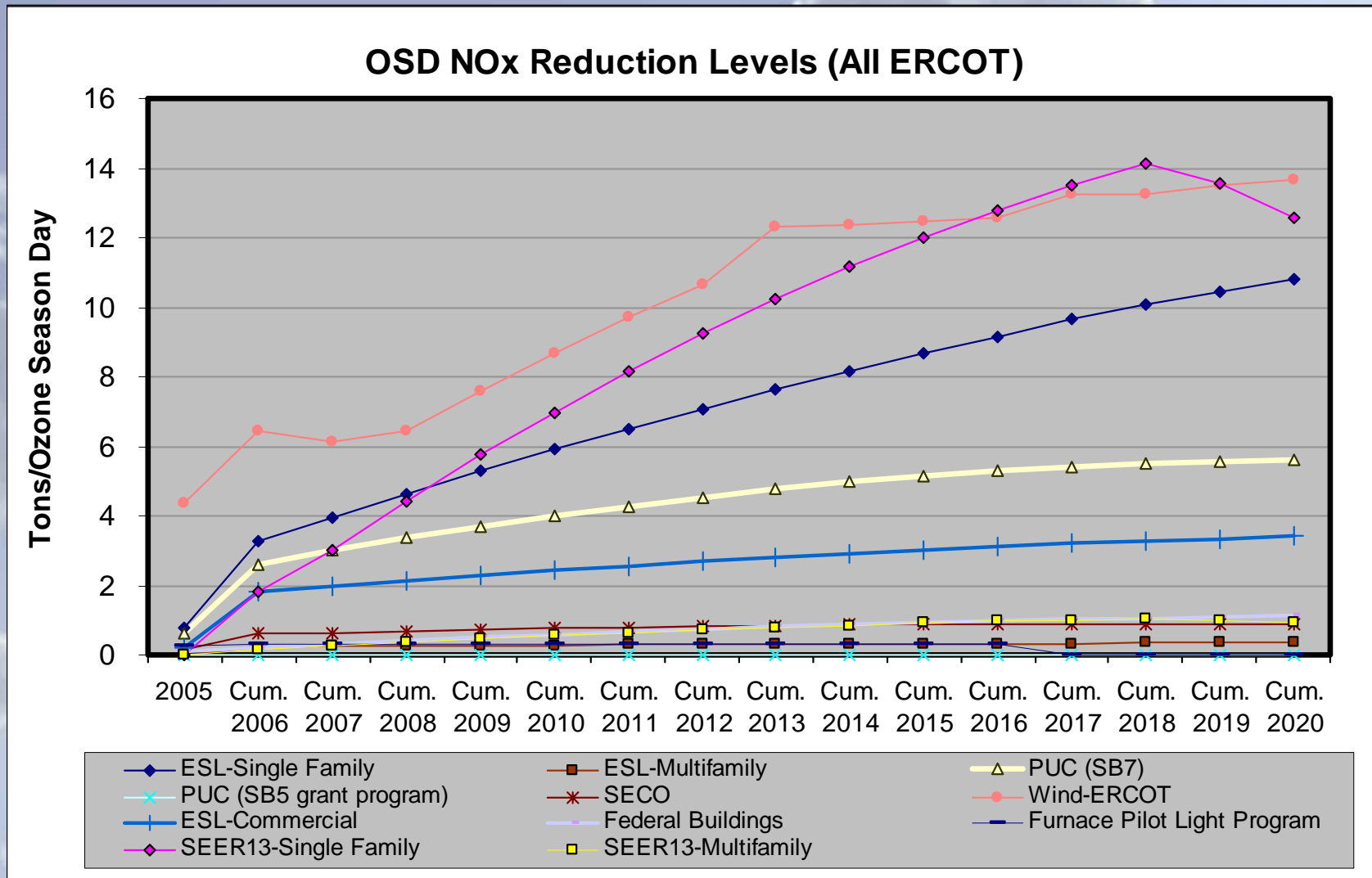
(12) The initial discount factor for each program should be chosen to reflect the accuracy of the reported numbers.

(16) Growth factors for single-family (3.25%) and multi-family residential (1.54%) construction values represent the average growth rate for these housing types from the U.S. Census data for Texas

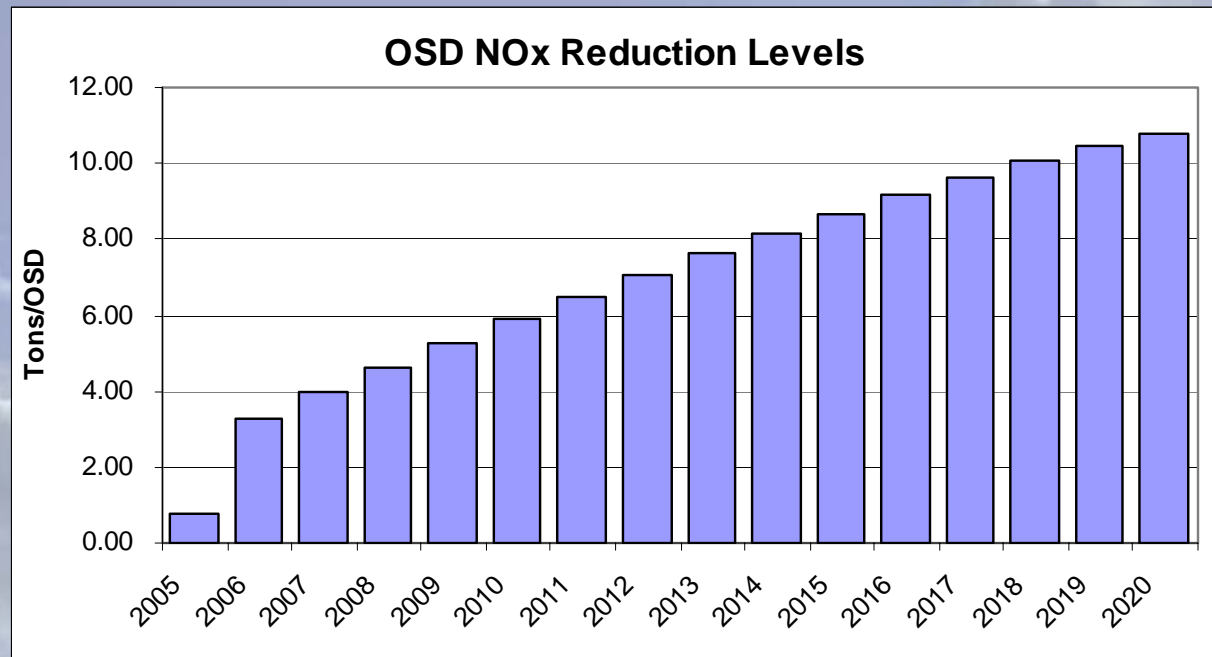
(15) The growth factor for Federal Buildings, Furnace pilot lights, PUC(SB7), PUC(SB5) and SECO is 0%, since it is being assumed that the future year savings will be at the same level as 2005.



INTEGRATED NOx SAVINGS



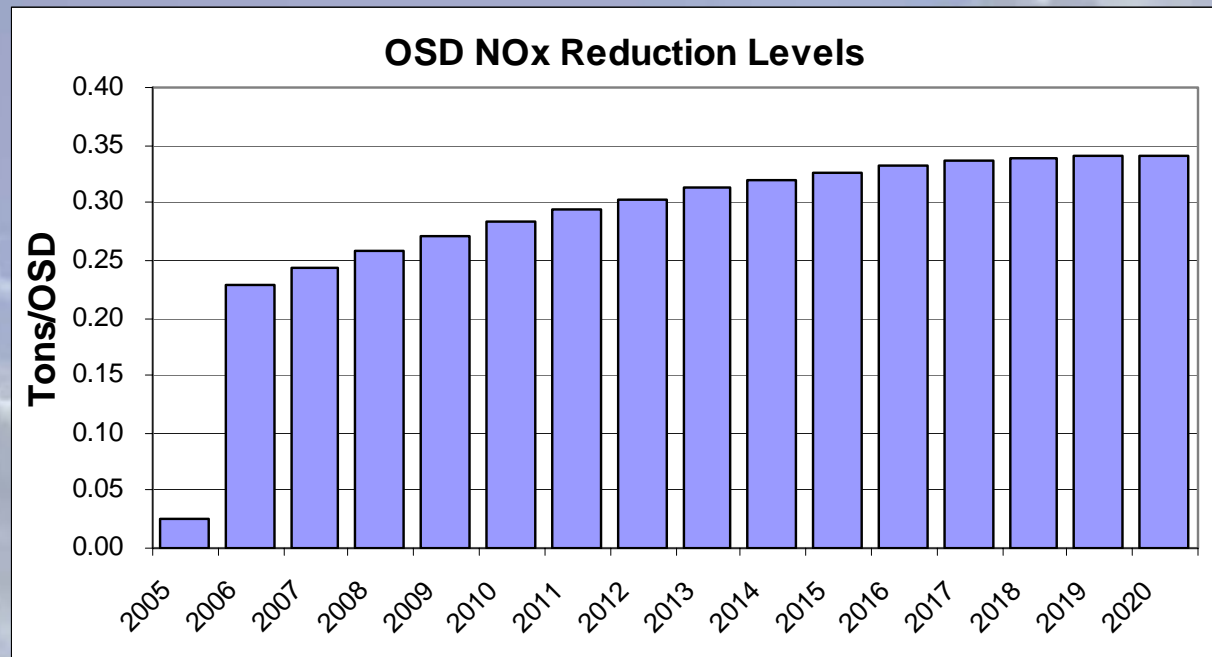
INTEGRATED NO_x SAVINGS: Single Family Savings and Projections



- **Single-family**: energy savings attained by constructing new residences in Texas according to the IECC 2000/2001 building code (IECC 2000).
- **Single-family**: calculated using DOE-2.1 simulation program. Pre-code houses : average new house built in 1999 in Texas.
- **Assumption**: same amount of electricity savings from the code-complaint construction would be achieved for each year after 2006 through 2020. Includes the appropriate discount and degradation factors for each year



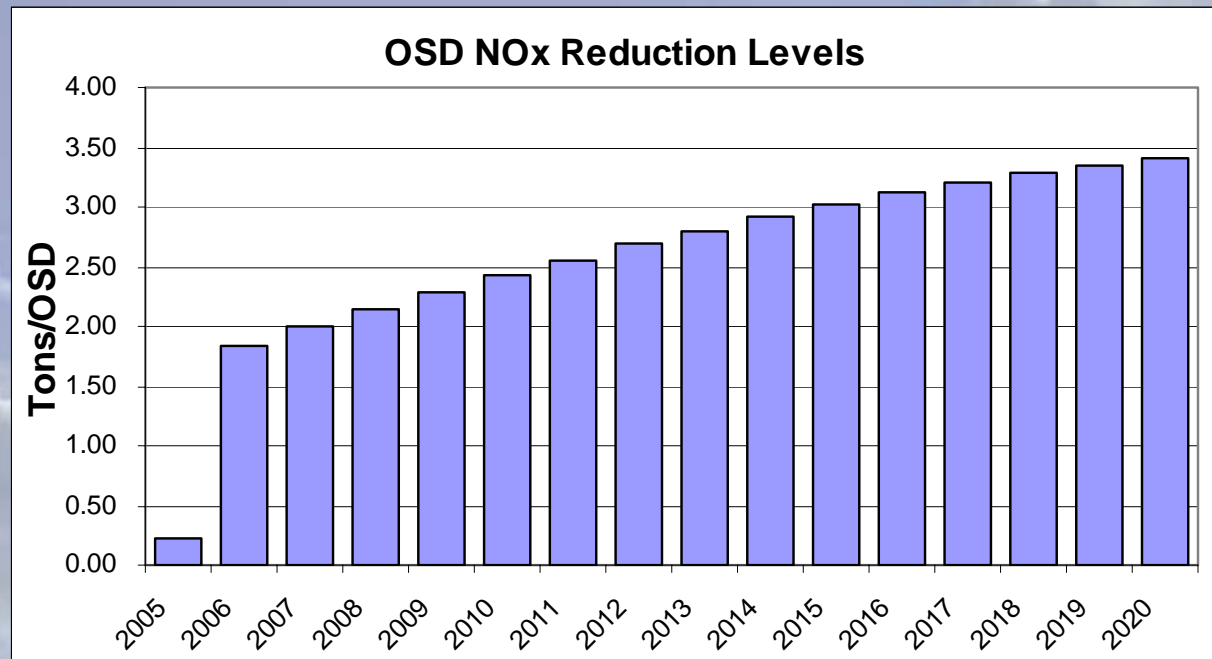
INTEGRATED NO_x SAVINGS: Multi-Family Savings and Projections



- **Multi-family:** energy savings attained by constructing new residences in Texas according to the IECC 2000/2001 building code (IECC 2000).
- **Multi-family:** calculated using DOE-2.1 simulation program. Pre-code houses assume average new house built in 1999 in Texas.
- **Assumption:** same amount of electricity savings from the code-complaint construction would be achieved for each year after 2006 through 2020. Includes the appropriate discount and degradation factors for each year



INTEGRATED NO_x SAVINGS: Commercial Savings and Projections

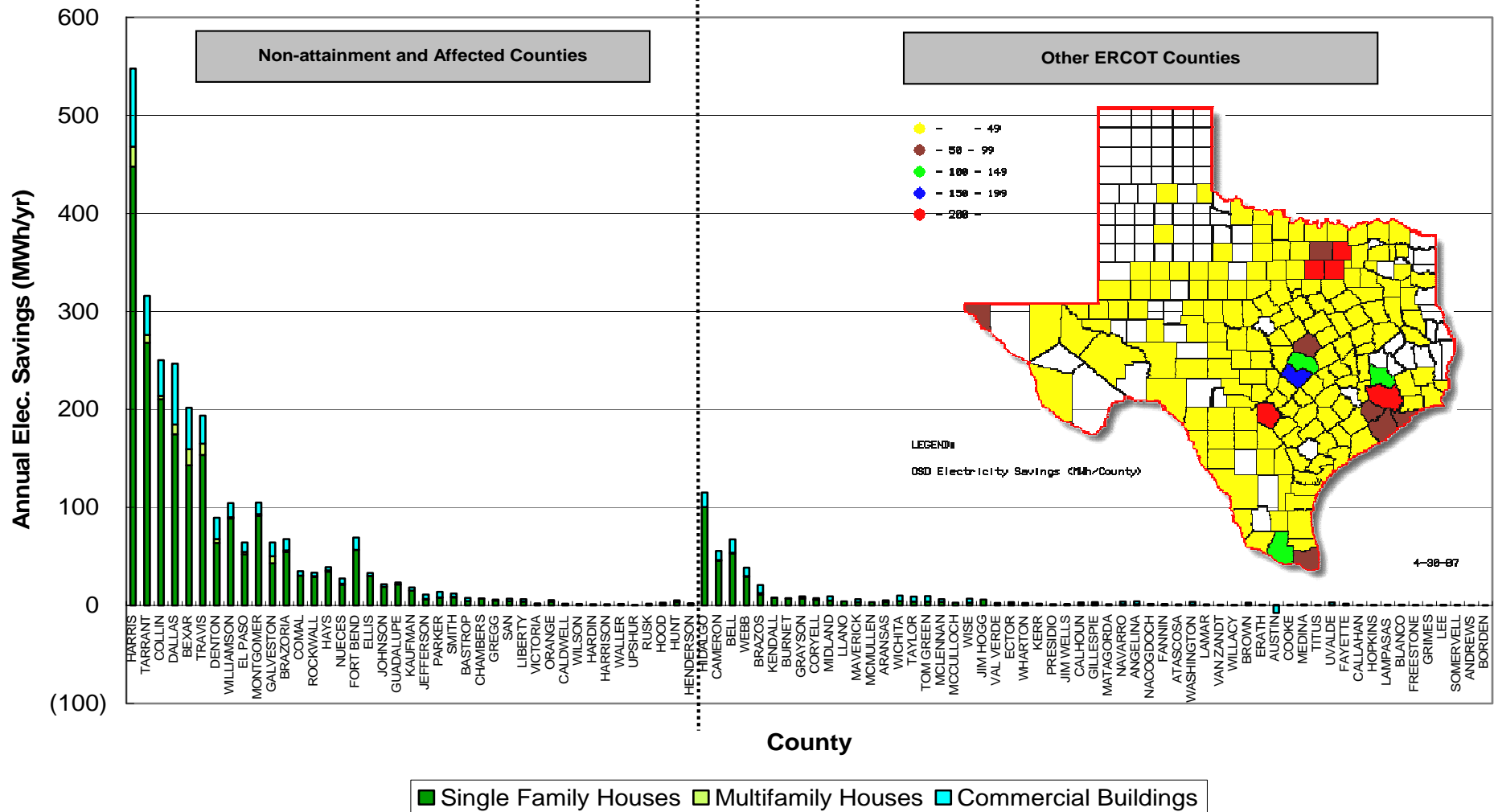


- **Commercial:** new construction in office, assembly, education, retail, food, lodging and warehouse construction as defined by Dodge building type, using energy savings from the PNNL, and data from CBECS.
- **Commercial:** savings due to the code adoption for new commercial buildings were estimated using DOE-2.1 simulation program.
- **Pre-code buildings:** the ASHRAE Standard 90.1-1989 compliant building.
- **Code compliant buildings:** the ASHRAE Standard 90.1-1999 compliant building.



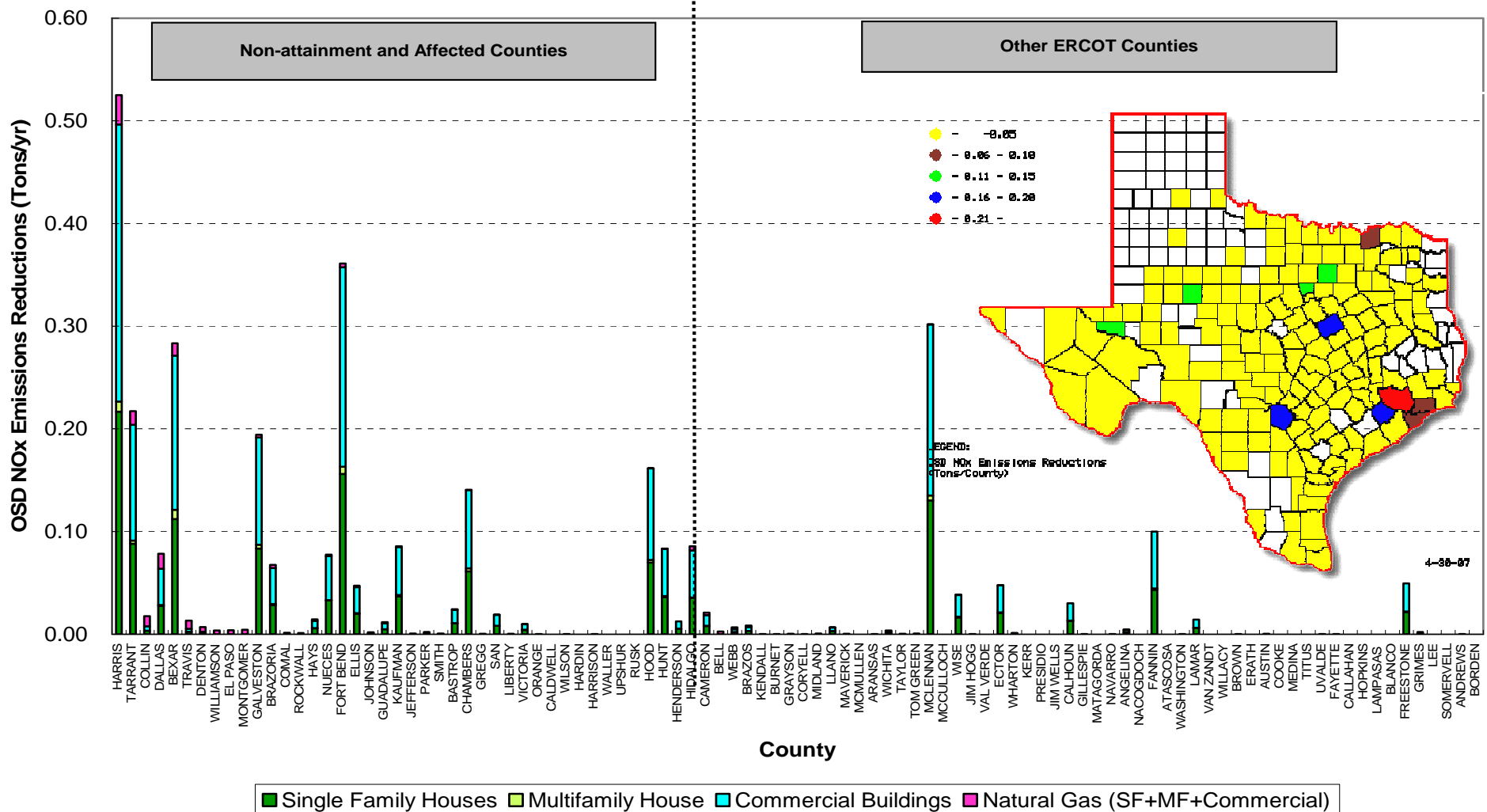
INTEGRATED NOx SAVINGS: Single-Family, Multi-Family & Commercial

**Total OSD Savings w/ 7% T&D Loss
(SF, MF and Commercial Buildings)**



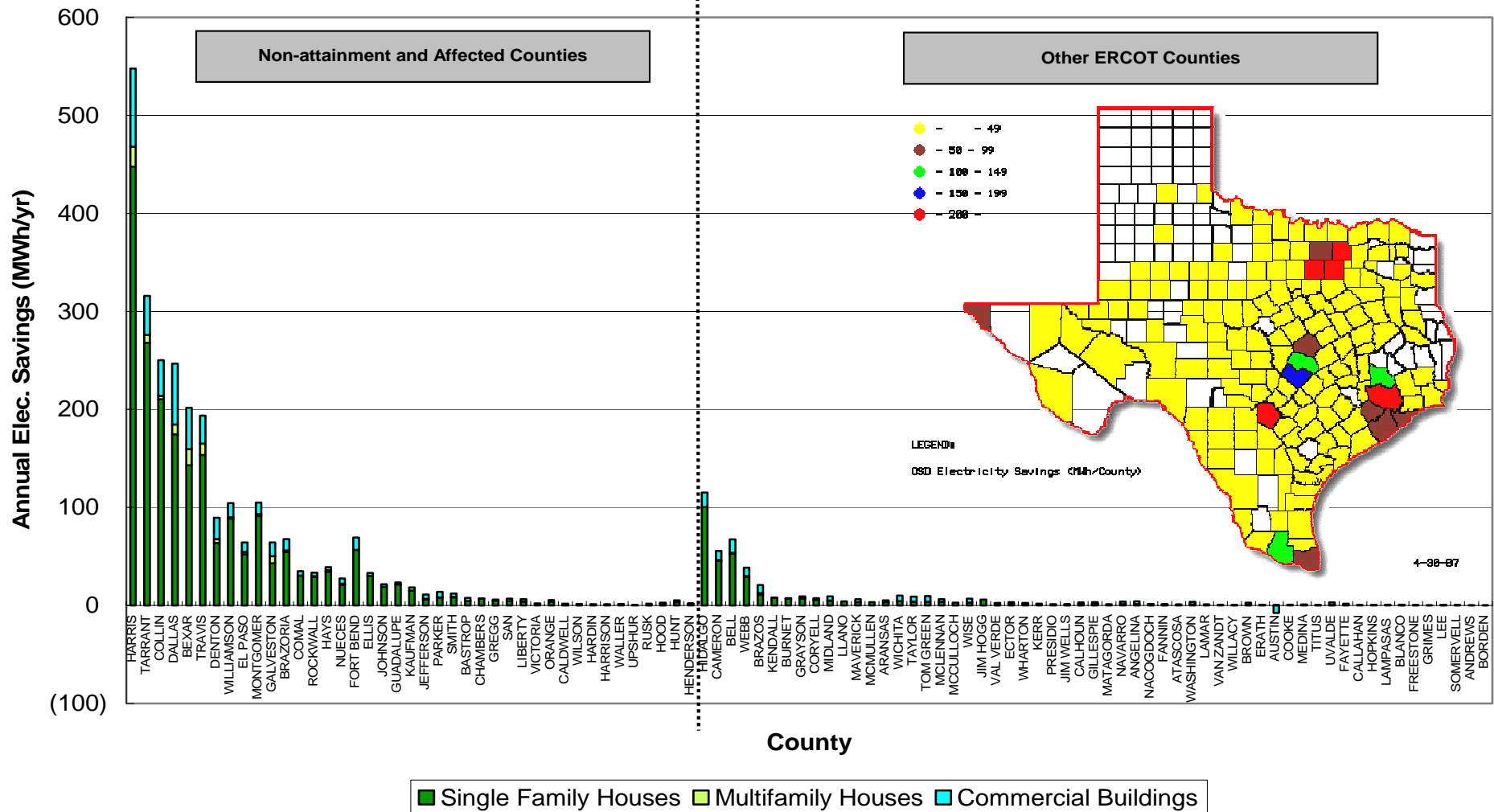
INTEGRATED NOx SAVINGS: Single-Family, Multi-Family & Commercial

Total OSD NOx Emissions Reductions
(SF, MF and Commercial Buildings)



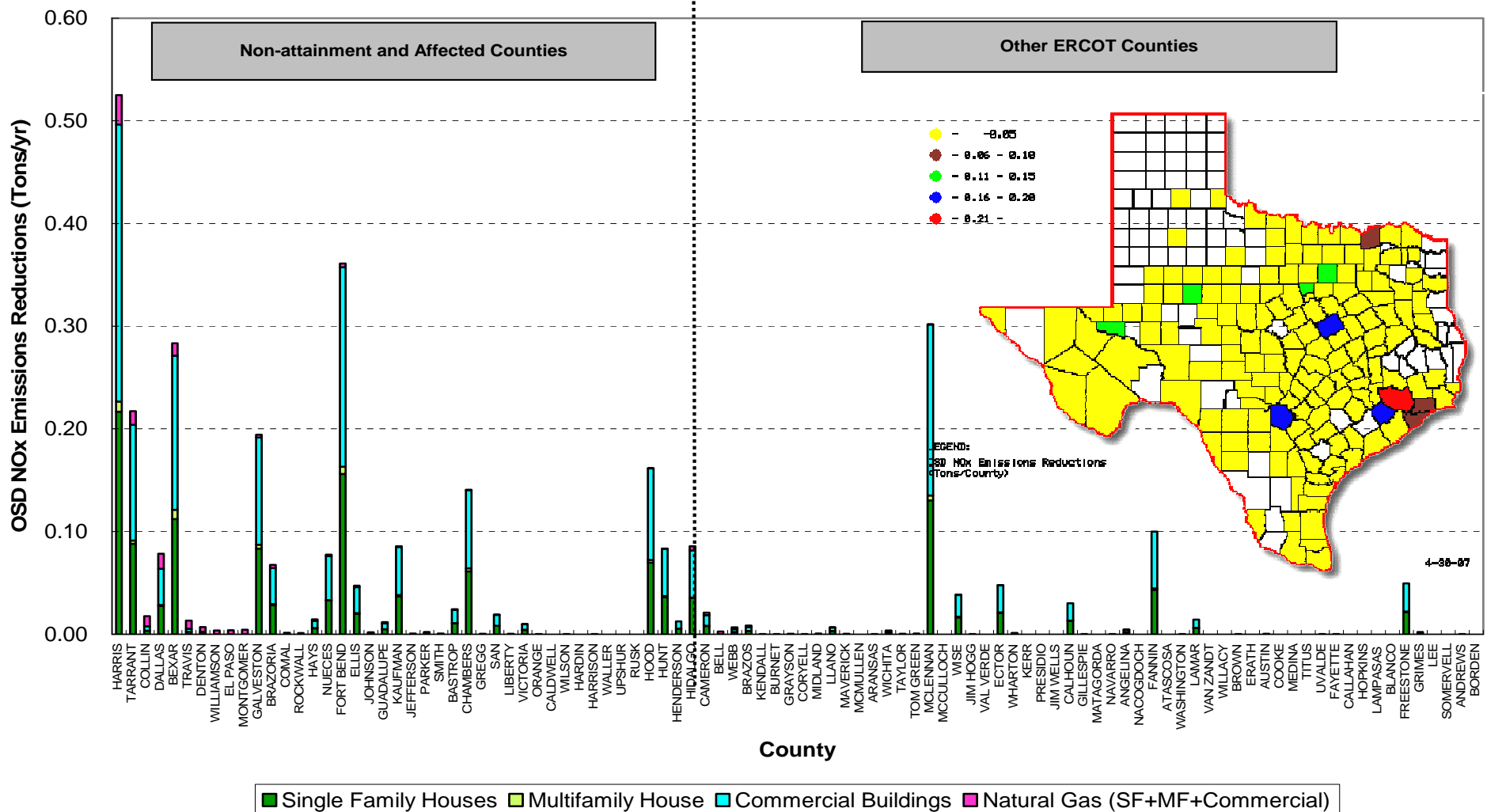
INTEGRATED NOx SAVINGS: Single-Family, Multi-Family & Commercial

**Total OSD Savings w/ 7% T&D Loss
(SF, MF and Commercial Buildings)**

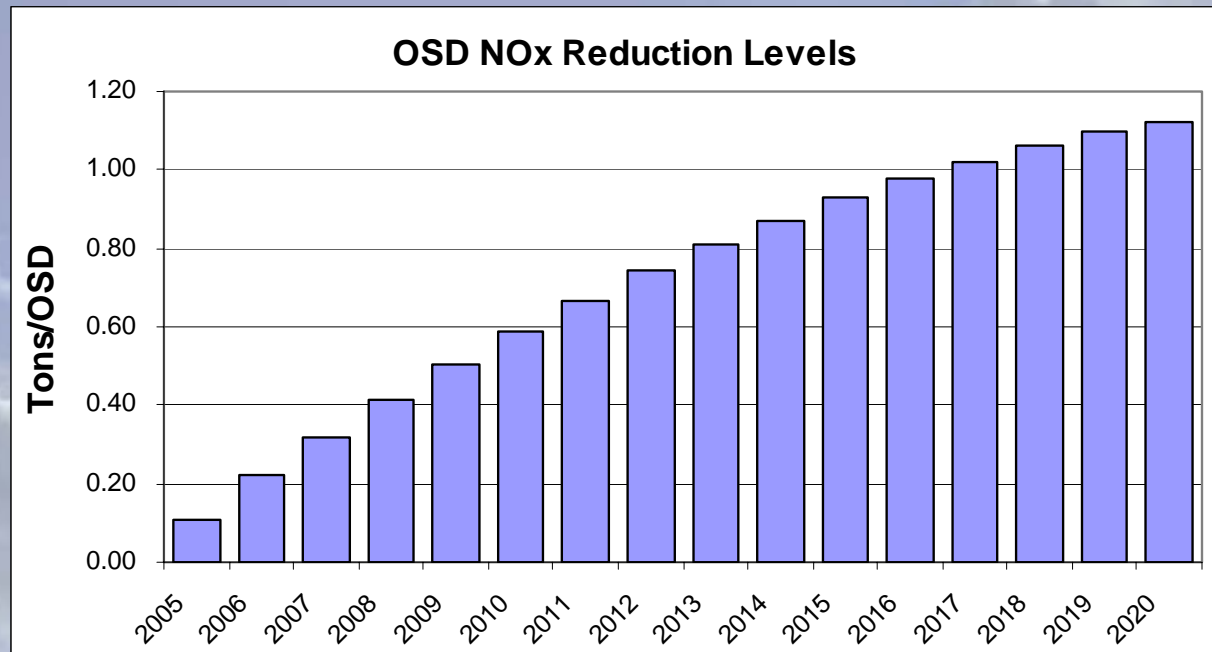


INTEGRATED NOx SAVINGS: Single-Family, Multi-Family & Commercial

Total OSD NOx Emissions Reductions
(SF, MF and Commercial Buildings)



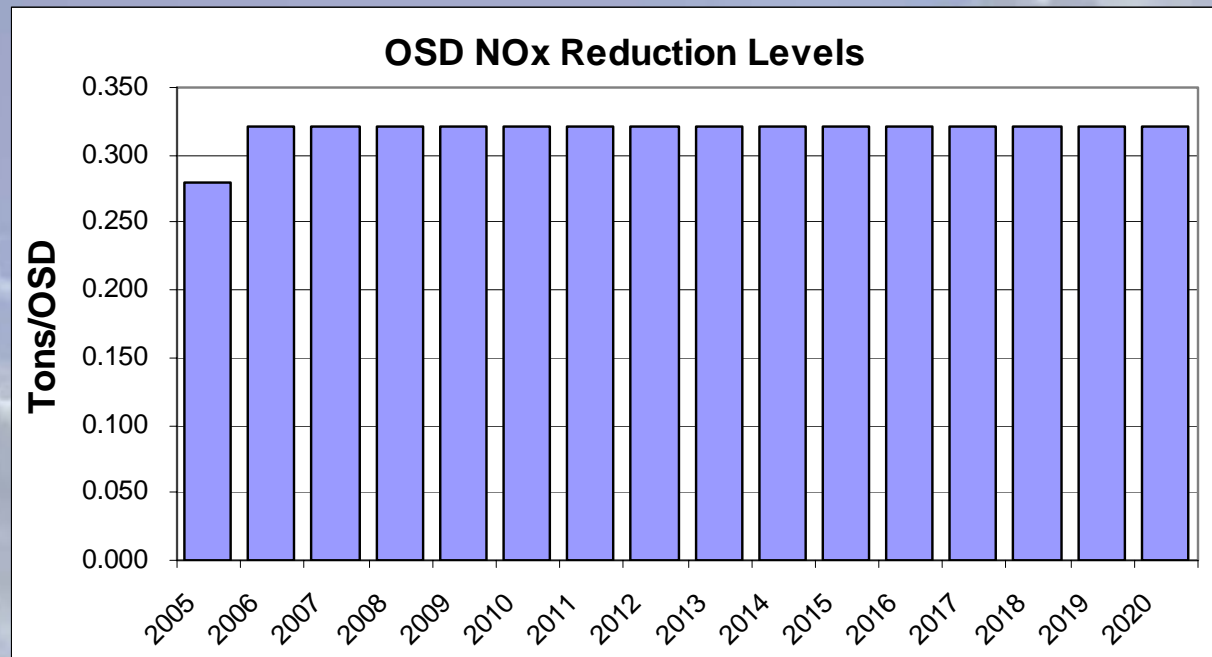
INTEGRATED NO_x SAVINGS: Federal Savings and Projections



- **2006 savings:** include 14 projects implemented in Federal buildings reported by the regional office of the Department of Energy.
- **Assumption:** electricity savings from 2005 would also be achieved for each year from 2006 through 2020 after the appropriate degradation factors were applied



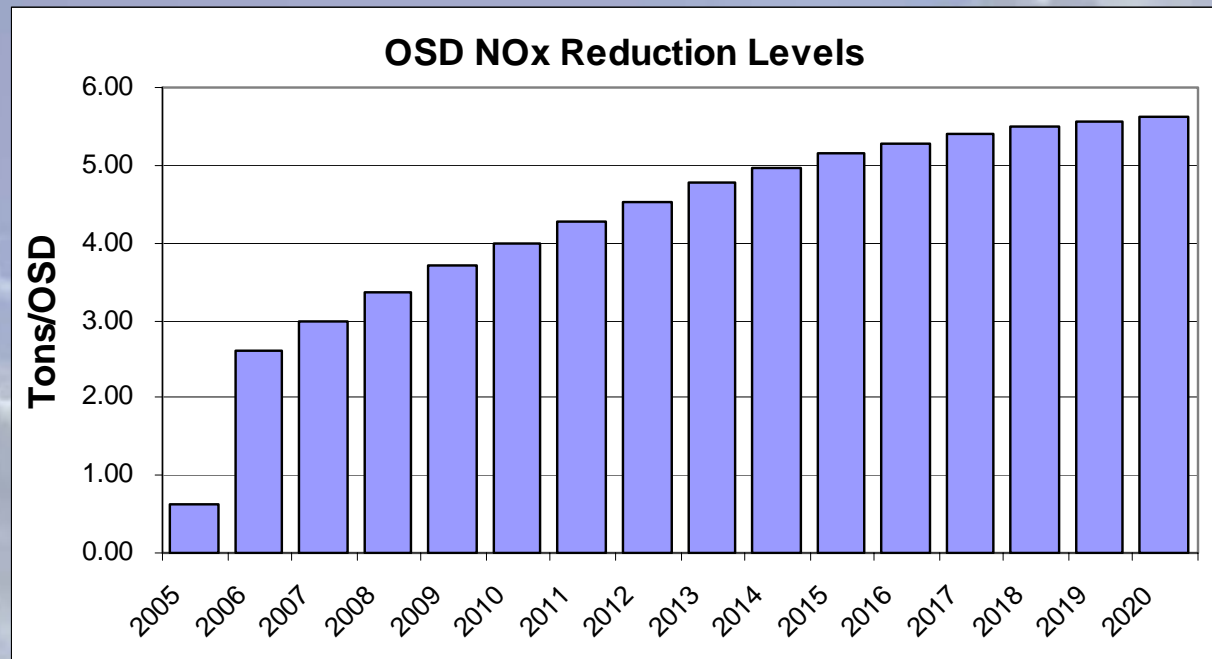
INTEGRATED NO_x SAVINGS: Furnace Pilot Savings and Projections



- **Assumption:** N.G. energy savings achieved by retrofitting existing furnaces in single-family and multi-family residences until the entire residential stock in Texas has been retrofitted (i.e., 1995 – 2005).
- **Assumption:** Pilot light removal saves 500 Btu/hr of natural gas (Emission rate per pilot light: 0.092 lb-NO_x/MMBtu) when the furnace is replaced with a code-compliant replacement.
- **Assumption:** It is also being assumed that of the total furnaces that were retrofitted, 75% are operational during the Ozone Season Period.



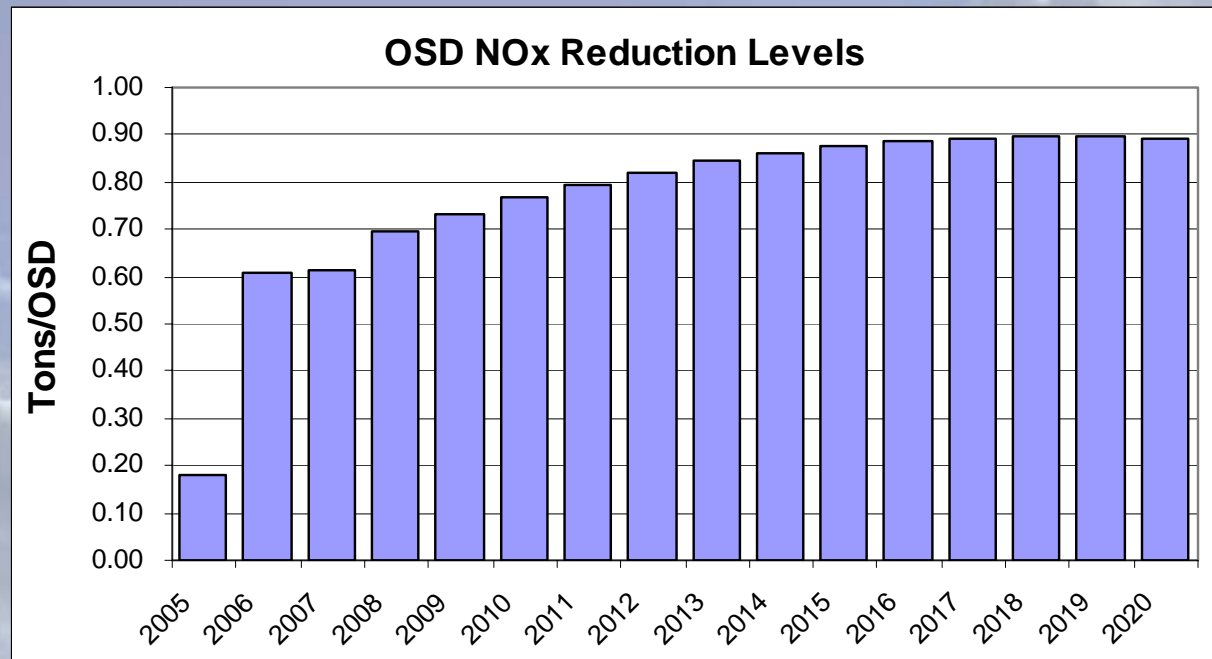
INTEGRATED NO_x SAVINGS: PUC SB7 Savings and Projections



- **The Texas Public Utility Commission's (PUC) Senate Bill 5 and Senate Bill 7 programs include the incentive and rebates programs managed by the different Utilities for Texas.**
- **These include the Residential Energy Efficiency Programs (REEP) as well as the Commercial & Industrial Standard Offer Programs (C&I SOP).**
- **Values reported to TCEQ are provided by PUC to the ESL.**



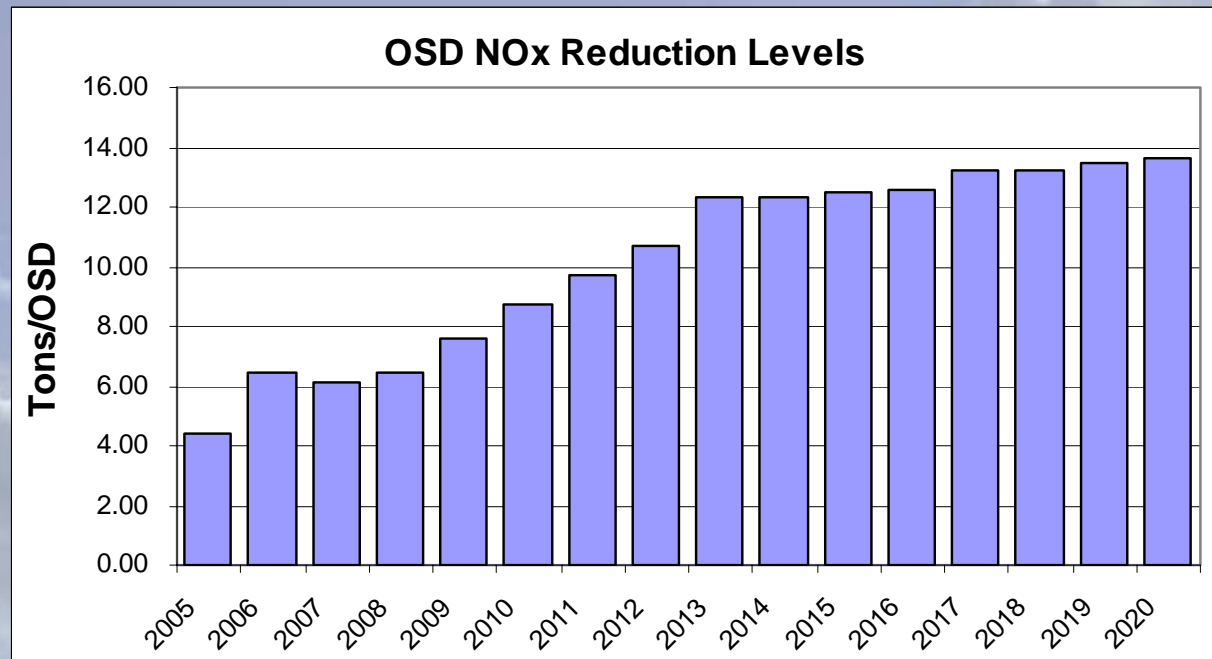
INTEGRATED NO_x SAVINGS: SECO Savings and Projections



- **The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs directed towards school districts, government agencies, city and county governments.**
- **The annual electricity savings from the political subdivision projects for 35 counties through 2006 were provided by SECO.**
- **Values reported to TCEQ are provided by SECO to the ESL.**



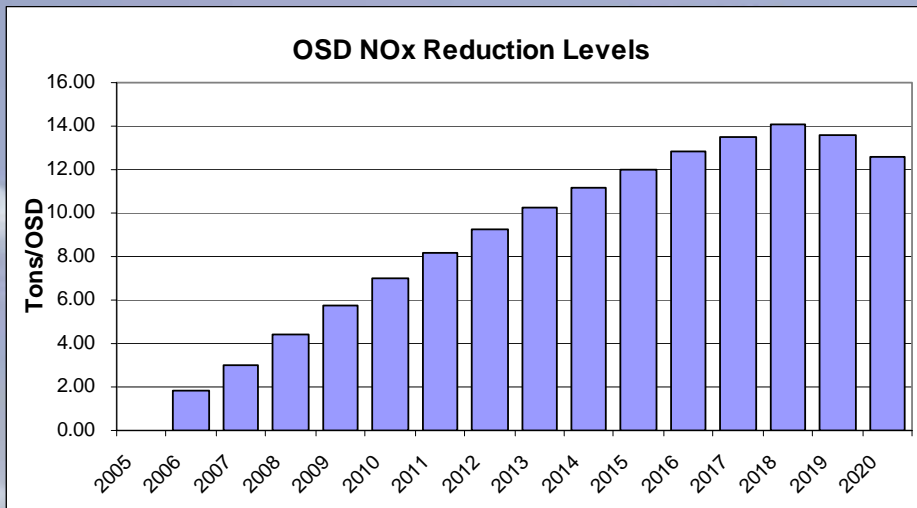
INTEGRATED NO_x SAVINGS: Wind Savings and Projections



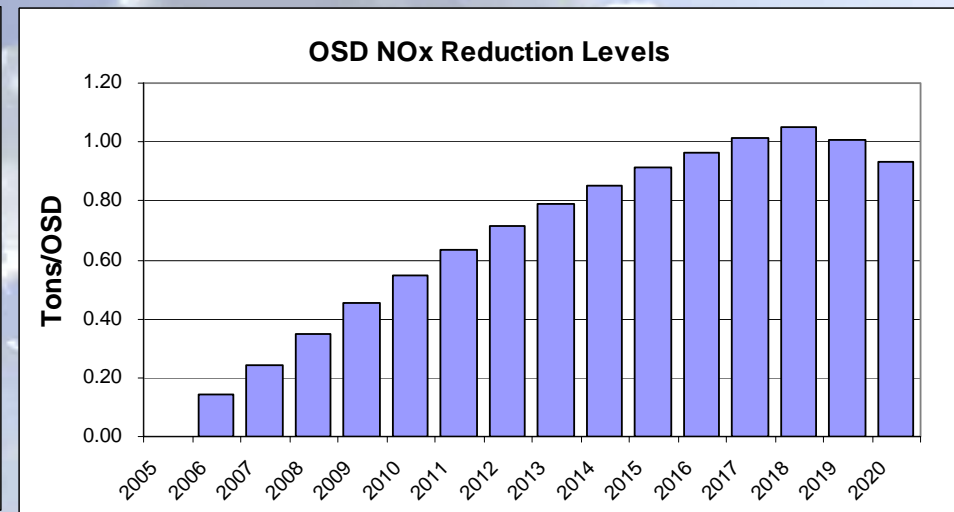
- **Actual measured electricity production for 2001 through 2006 were used.**
- **Assumptions: For saving projections, annual growth factors were chosen to comply with the yearly goals set forth by the Senate Bill 20, Section 39.904, Utilities Code: 3,700 MW in 2009, and 7,000 MW in 2015.**



INTEGRATED NO_x SAVINGS: SEER13 Single Family Savings and Projections



Single-family Residential

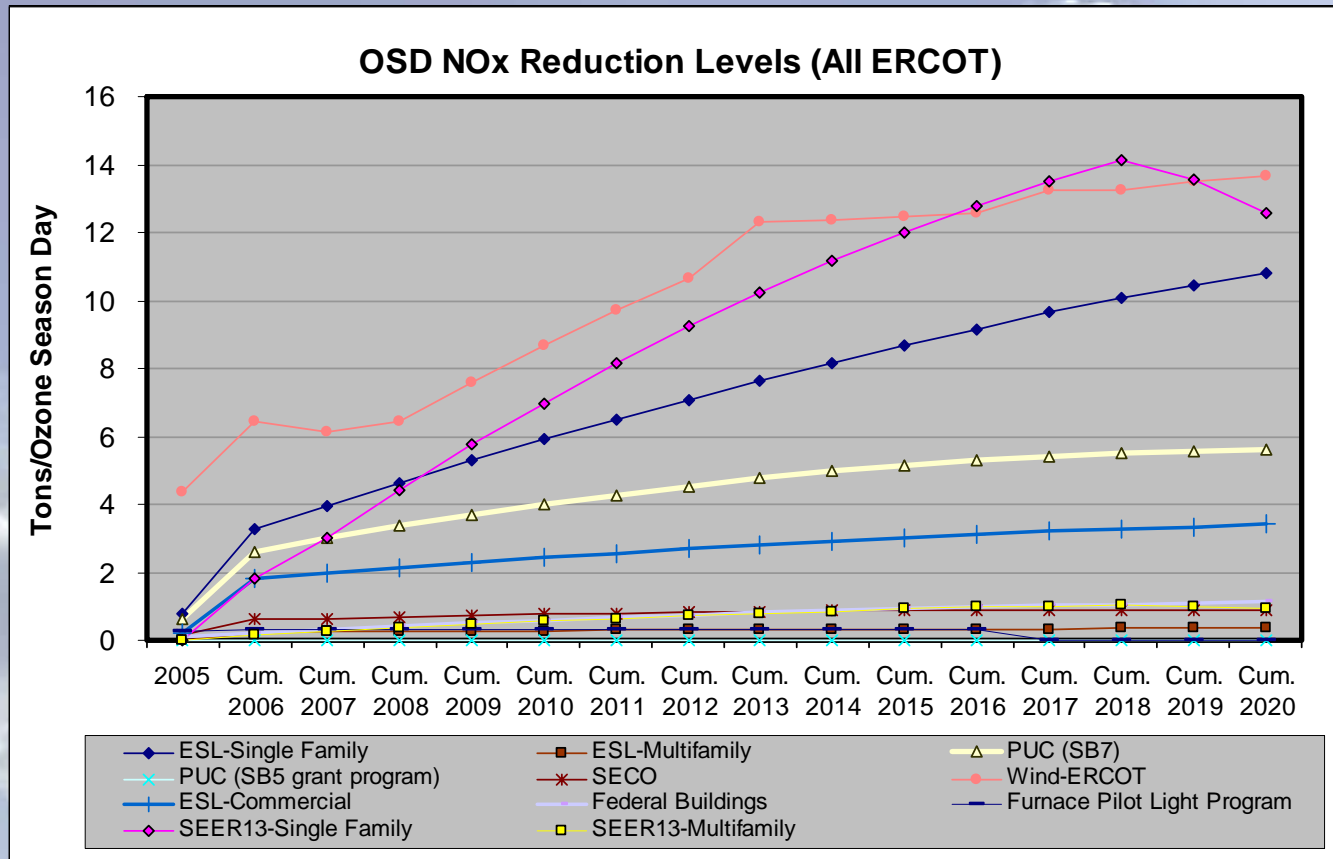


Multi-family Residential

- In January 2006 residential AC efficiency was raised to SEER 13 from SEER 10.
- The annual and OSD electricity savings due to replacement of SEER 13 AC units in existing residences were calculated using DOE-2.1 simulation.
- The number of units installed since January 2006 used Texas ARI data.
- This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners.
- New units installed in 2006 were assumed to use SEER 13 (100% but June).



RESULTS: INTEGRATED NOx SAVINGS



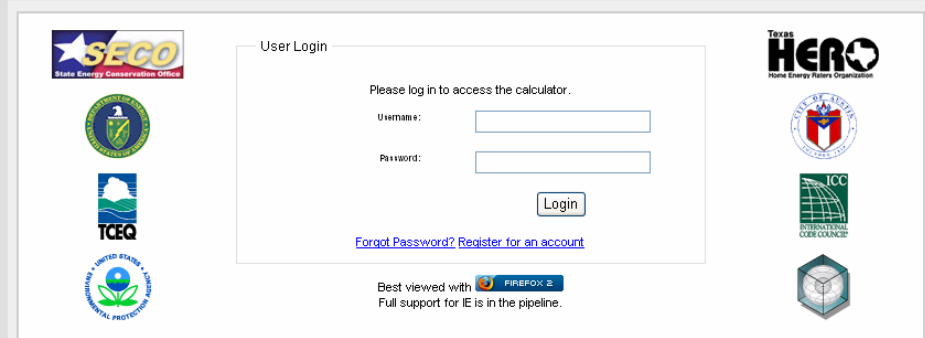
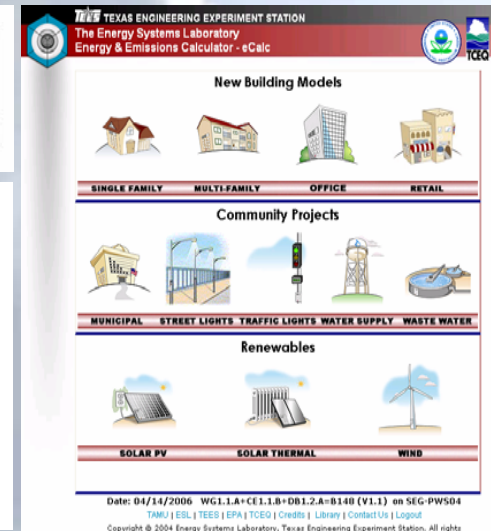
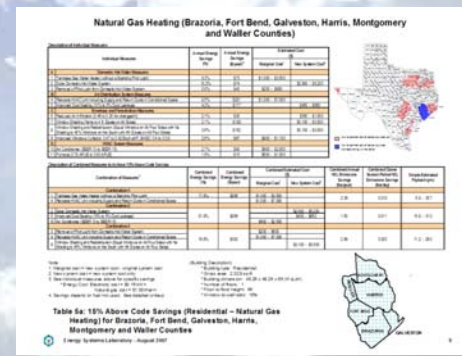
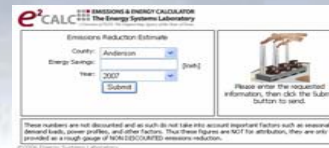
CUMULATIVE NOx EMISSIONS SAVINGS (2013)

- ESL Code Compliance	(10.75 tons/day)	(26.3%)
- PUCs SB7,SB5 programs	(4.78 tons/day)	(11.7%)
- Green Power (Wind)	(12.32 tons/day)	(30.1%)
- SEER 13 Retrofits	(11.03 tons/day)	(26.9%)
- Federal Buildings	(0.81 tons/day)	(1.9%)
- Furnace Pilot Lights	(0.32 tons/day)	(0.8%)
- SECO Political Sub.	(0.84 tons/day)	(2.0%)
Total	(40.86 tons/day)	(100.0%)



NEW TOOLS TO HELP REDUCE ENERGY AND NOx EMISSIONS

- eCalc Energy & Emissions Calculator
 - Residential, Commercial
 - Municipal buildings, traffic lights, street lights, water
 - Solar thermal, PV, wind
- Synchronous NOx Emissions Calculator
 - Quick results for MWh savings in any county
- 15% above-code measures (41 Cos.)
 - Residential – 11 measures
 - Commercial – 10 measures
- International Code Compliance Calculator (ICCC)
 - Calculates code compliance for 2001 IECC + SEER 13
 - Allows for 15% above code compliance calculations



INTEGRATED NOx SAVINGS

Annual Reporting to the TCEQ, papers, etc.

DEVELOPMENT OF A WEB-BASED EMISSIONS REDUCTION CALCULATOR FOR CODE-COMPLIANT COMMERCIAL CONSTRUCTION

Mohitve Ahluwalia, Research Engineer, Dae Gilman, P.E., Senior Software Engineer, Sangeeta Eas, Graduate Research Assistant, Clayton J. Gribben, J., Graduate Research Assistant, Jeff Robert, Ph.D., P.E., Professor, Associate Director, Energy Systems Laboratory, Texas A&M University

ABSTRACT
The Texas Energy Code (TEC) has been updated by the Texas Department of Transportation (TxDOT) to include energy efficiency requirements for the design and construction of commercial buildings. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC.

BACKGROUND
The Texas Energy Code (TEC) has been updated by the Texas Department of Transportation (TxDOT) to include energy efficiency requirements for the design and construction of commercial buildings. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC.

CONCLUSIONS
The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new commercial buildings be designed to meet the energy efficiency requirements of the TEC.

Report from the Proceedings of the 14th International Conference on Building Performance, October 2003

DEVELOPMENT OF A WEB-BASED EMISSIONS REDUCTION CALCULATOR FOR CODE-COMPLIANT SINGLE-FAMILY AND MULTI-FAMILY CONSTRUCTION

Mohitve Ahluwalia, Research Engineer, Dae Gilman, P.E., Senior Software Engineer, Clayton J. Gribben, J., Associate Professor, Jeff Robert, Ph.D., P.E., Professor, Associate Director, Energy Systems Laboratory, Texas A&M University System

ABSTRACT
The Texas Energy Code (TEC) has been updated by the Texas Department of Transportation (TxDOT) to include energy efficiency requirements for the design and construction of single-family and multi-family residential buildings. The TEC requires that new single-family and multi-family residential buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new single-family and multi-family residential buildings be designed to meet the energy efficiency requirements of the TEC.

BACKGROUND
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CONCLUSIONS
The TEC requires that new single-family and multi-family residential buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new single-family and multi-family residential buildings be designed to meet the energy efficiency requirements of the TEC. The TEC requires that new single-family and multi-family residential buildings be designed to meet the energy efficiency requirements of the TEC.

Report to the Texas Commission on Environmental Quality

LITERATURE REVIEW OF UNCERTAINTY OF ANALYSIS METHODS (F-Chart Program)

Report to the Texas Commission on Environmental Quality

ESL-TR-04-08-01

ESL-TR-04-11-01

LITERATURE REVIEW OF UNCERTAINTY OF ANALYSIS METHODS (DOE-2 Program)

Report to the Texas Commission on Environmental Quality

ESL-TR-04-11-04

ENERGY EFFICIENCY / RENEWABLE ENERGY IMPACT IN THE TEXAS EMISSIONS REDUCTION PLAN (TERP)

VOLUME II - TECHNICAL REPORT

Annual Report to the Texas Commission on Environmental Quality September 2003 - August 2004

November 2004

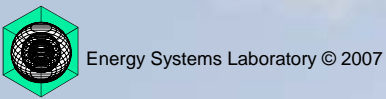
ESL-TR-04-11-04

Jeff Robert, Ph.D., P.E., Professor, Associate Director, Energy Systems Laboratory, Texas A&M University System

November 2004

Energy Systems Laboratory, Texas A&M University System

Texas Engineering Experiment Station, Texas A&M University System



ESL CONTACT INFORMATION

Juan-Carlos Baltazar: juan-carlosbaltazar@tees.tamus.edu

Jeff Haberl: jeffhaberl@tees.tamus.edu

Bahman Yazdani: bahmanyazdani@tees.tamus.edu

Charles Culp: charlesculp@tees.tamus.edu

<http://eslsb5.tamu.edu>



INTEGRATED NOx SAVINGS

Microsoft Excel

File Edit View Insert Format Tools Data Window Help Adobe PDF

Type a question for help

C1

Singlefamily savings and projection.xls

Multifamily savings and projection.xls

Commercial savings and projection.xls

Federal Building savings and projection.xls

Furnace pilot savings and projection.xls

PUC SB7 savings and projection.xls

PUC SB5 savings and projection.xls

SECO savings and projection.xls

Wind savings and projection.xls

SEER13 SF savings and projection.xls

SEER13 MF savings and projection.xls

Integrated Savings Summary (2007_Aug_07).xls

Energy Savings Summary														
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4	ADJUSTMENT FACTORS													
5		ESL- Single Family ¹⁵	ESL- Multifamily ¹⁵	ESL- Commercial ¹⁵	Federal Buildings ¹⁵	Light Program ¹⁵	PUC (SB7) ¹⁵	Grant Program ¹⁵	SECO ¹⁵	Wind-ERCOT ¹	SEER13 Single Family	SEER13 Multifamily		
6	Annual Degradation Factor ¹¹	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%		
7	T&D Loss ¹	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%		
8	Initial Discount Factor ¹¹	20.00%	20.00%	20.00%	20.00%	20.00%	25.00%	60.00%	25.00%	25.00%	20.00%	20.00%		
9	Growth Factor ¹¹	3.25%	1.54%	3.25%	0.00%	0.00%	0.00%	0.00%	0.00%	According to	N.A.	N.A.		
10	Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes		
11	Energy Savings Summary													
12		Total Energy Savings												
13		1999		2000		2001		2002		2003		2004		20
14	Program	Electricity		Electricity		Electricity		Electricity		Electricity		Electricity		Electricity
15		Annual (MWh)		Annual (MWh)		Annual (MWh)		Annual (MWh)		Annual (MWh)		Annual (MWh)		Annual (MWh)
16		Days (MWh/Day)		Days (MWh/Day)		Days (MWh/Day)		Days (MWh/Day)		Days (MWh/Day)		Days (MWh/Day)		Days (MWh/Day)
17	ESL- Single Family	189,000	925	149,256	916	155,248	776	225,259						
18	ESL- Multifamily	39,480	199	10,955	49	9,586	36	9,220						
19	ESL- Commercial	44,722	295	62,856	404	55,972	474	59,992	493	75,591	446	67,999	412	55,054
20	Federal Buildings													52,216
21	Furnace Pilot Lights Program (PBL)	0	0	0	0	212,409	592	149,635	2,328	1,456,851	4,074	2,124,087	5,819	22,950
22	PUC (SB7)	0	0	0	0	79,654	194	177,277	495	259,468	706	302,192	828	236,289
23	PUC (SB5 grant program)	0	0	0	0	0	0	1,271	3	15,742	35	0	0	0
24	SECO	0	0	0	0	0	0	0	0	0	0	195,349	316	17,850
25	Wind-ERCOT	0	0	0	0	461,407	1,674	1,409,875	4,424	1,424,532	4,235	2,190,296	4,377	2,912,453
26	SEER13- Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
27	SEER13- Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: Energy & NOx Savings Summary / NOx reduction 1 / NOx reduction 2 / NOx reduction 3

