ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

Energy Efficiency and Renewable Energy Impacts on NOx Emission Reductions

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CATEE 2016
Clean Air Through Energy Efficiency Conference

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ACKNOWLEDGEMENTS

Faculty/Staff: Jeff Haberl, Bahman Yazdani, Juan-Carlos Baltazar, Gali Zilbershtein, Shirley Ellis, Patrick Parker, Larry Degelman, Angela Rowell, Roberto Tovar

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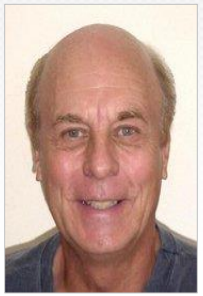






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PUCT: Katie Rich, Therese Harris
SECO: Dub Taylor, Stephen Ross
ERCOT: Paul Wattles, Kevin Hanson, Warren Lasher
USEPA: Art Diem, Julie Rosenberg

LEGISLATIVE RESPONSE

Legislation to Reduce Energy/Emissions 2001 to Present

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 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.

TERP Amended (81st Legislature, 2009)

Ch. 382. Health and Safety Code

- (HB 1796) Section 23 amends Sec. 386.252 (a) and (b) extends date of TERP to 2019 and requires Commission to contract with Laboratory for creditable EE/RE emissions reductions.

TERP Amended (82nd Legislature, 2011)

Ch. 477.004 Health and Safety Code

- HB 51 Section 2, b-2, establishes advisory committee, which including the Laboratory
- Section 3 & 4 amends review of municipal's amendments.

Ch. 388.003e & 388.007c,d Health and Safety Code

- HB 51 Section 3 & 4 amends review of municipal's amendments.

Ch. 388.006 Health and Safety Code

- SB 898 Section 2, requires the Laboratory to calculate energy savings and emissions reductions for political subdivisions reporting to SECO.

Ch. 39.9051 Utilities Code

- SB 924 Section 1g,h and Section 2c,d requires the Laboratory to calculate energy savings and emissions reductions for political subdivisions reporting to SECO.

NO new amendments were passed (83rd Legislature, 2013)

TERP Amended (84th Legislature, 2015)

Section 388.003, Health and Safety Code

- HB 1736 Section 1 Establishes the 2015 energy codes as the TBEPS effective Sept 1, 2016. The state may adopt new codes no sooner than every 6 years. The section also adds Energy Rating Index as a voluntary compliance alternative.

EPA CRITERIA FOR SIP CREDITS (2004)

Quantifiable: The emission reductions generated by measures to reduce emissions *must be quantifiable* and include procedures to evaluate and verify over time the level of emission reductions actually achieved.

Surplus: Emission reductions *are surplus* as long as they are not otherwise relied on to meet air quality attainment requirements in air quality programs related to your SIP.

Enforceability: Measures that reduce emissions from electricity generation may be: (1) *Enforceable directly* against a source; (2) *Enforceable against another party* responsible for the energy efficiency or renewable energy activity; or (3) Included under our *voluntary measures* policy.

Record Keeping: The *measure should be permanent* throughout the term for which the credit is granted unless it is replaced by another measure or the State demonstrates in a SIP revision that the emission reductions from the measure are no longer needed to meet applicable requirements.

ENERGY SAVINGS & NOx EMISSION REDUCTION

ESL Calculates NOx Emissions Reductions for:

1. Code-Compliant Construction: Energy savings from new construction

- ESL Single-family construction
- ESL Multi-family construction
- ESL Commercial construction

2. Green Power Production: Wind and other renewables

3. PUC SB7: Energy efficiency programs implemented by electric utilities under the Public Utility Regulatory Act §39.905

4. SECO: Energy-efficiency programs towards school districts, government agencies, city and county governments, private industries and residential energy consumers

5. A/C Retrofits: Installation of SEER 13/14 *replacement* air conditioners in existing residences

IC3 International CODE COMPLIANCE CALCULATOR

PUBLIC UTILITY COMMISSION OF TEXAS

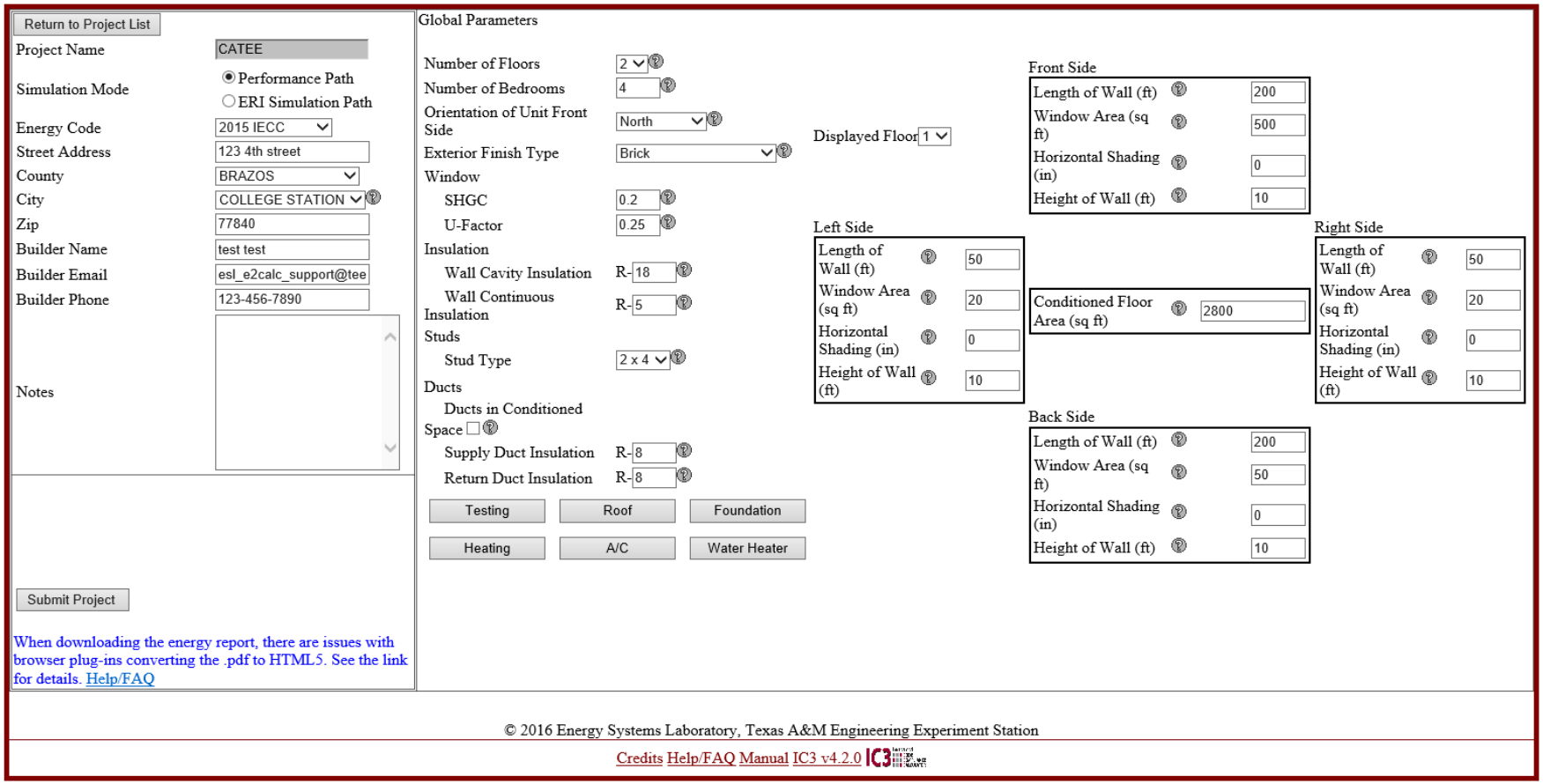
SECO State Energy Conservation Office

Current 2015 Version

Login Screen

Current 2015 Version

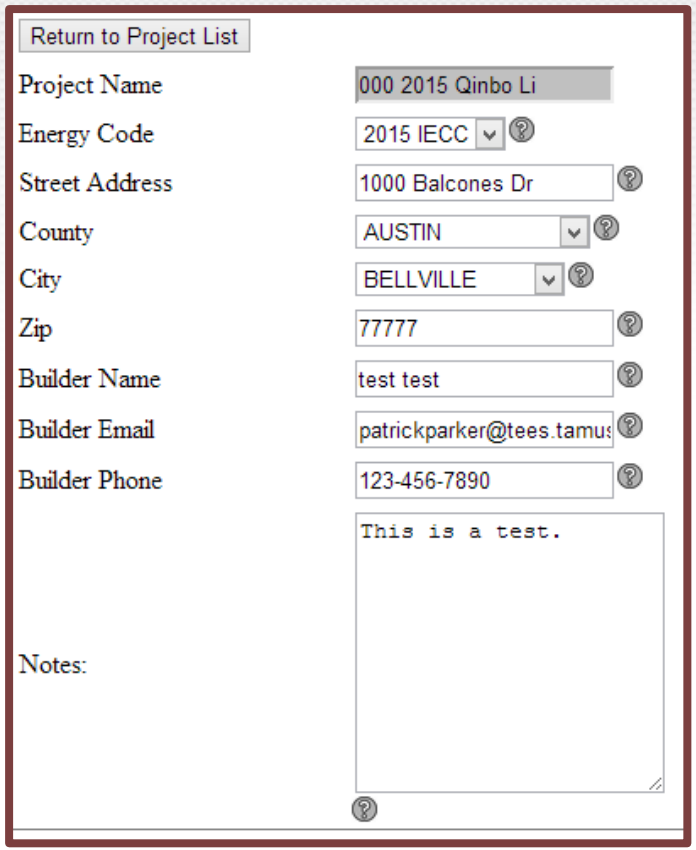
IC3 International CODE COMPLIANCE CALCULATOR



Main Page

IC3 International CODE COMPLIANCE CALCULATOR

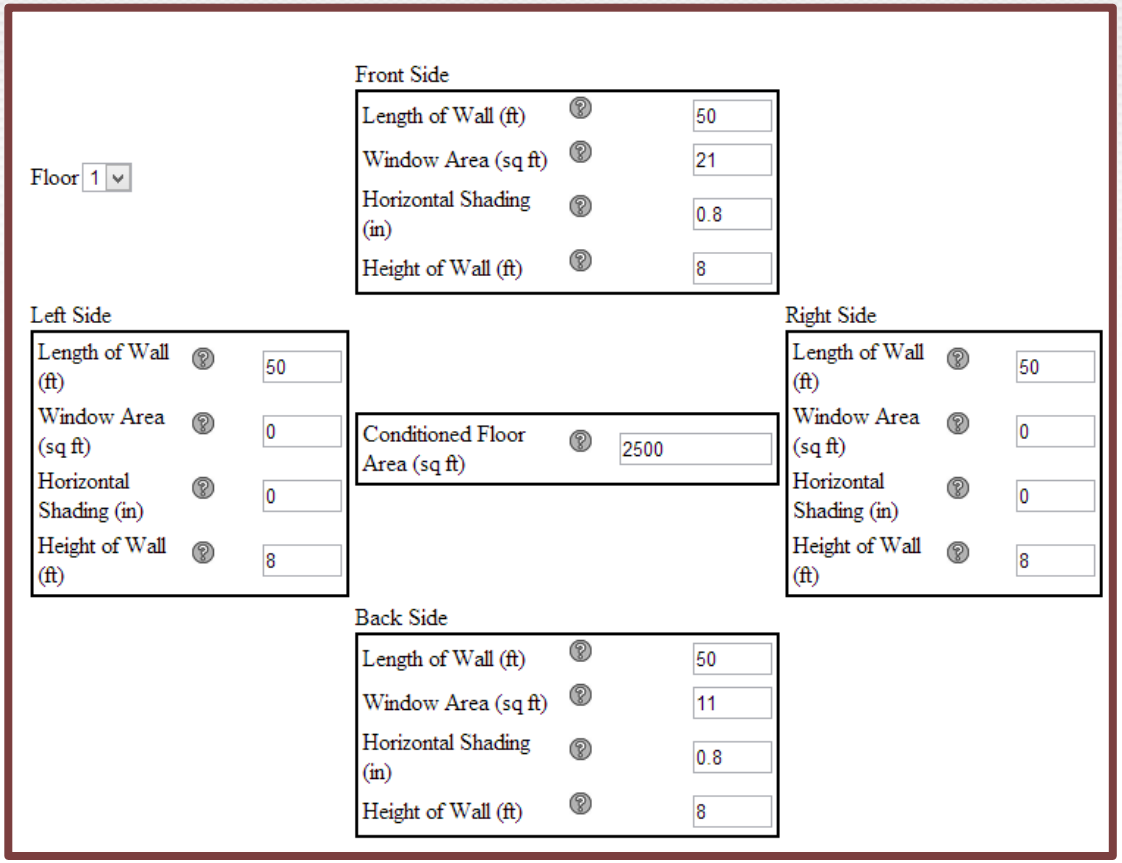
Current 2015 Version



Energy Code/Site Address/Project Details

IC3 International CODE COMPLIANCE CALCULATOR

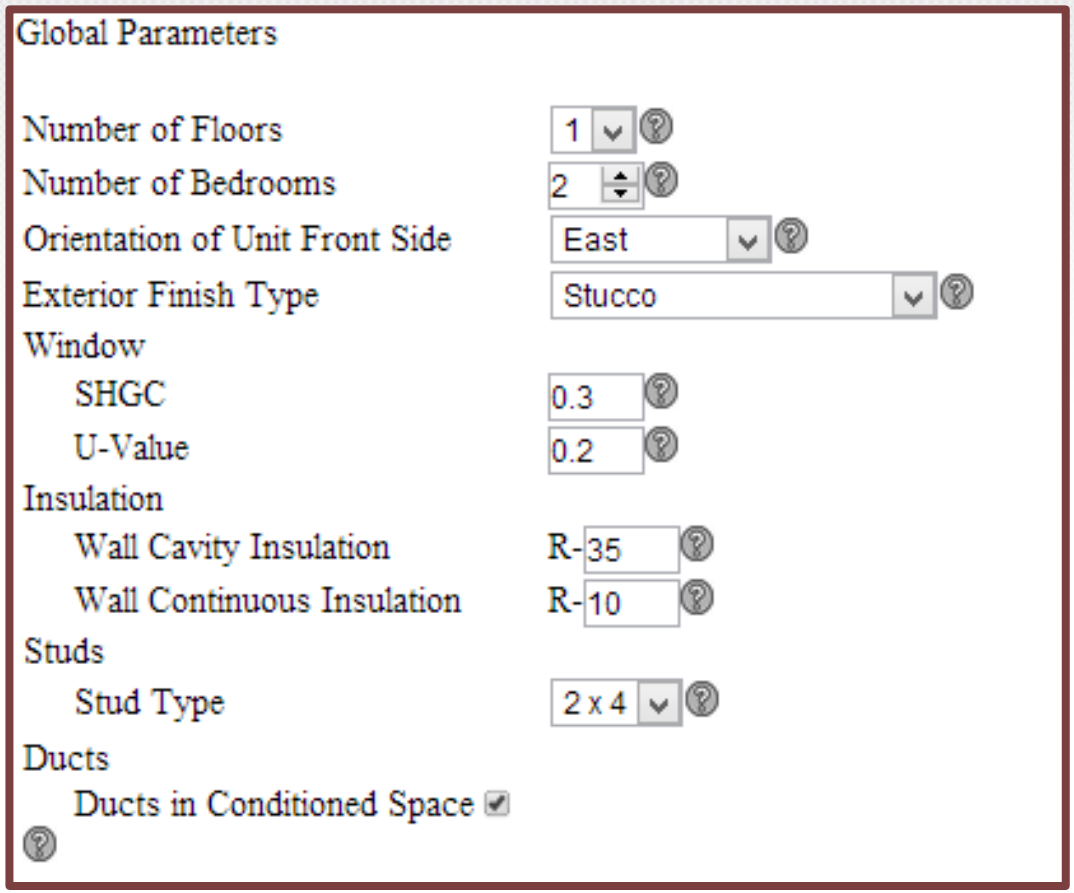
Current 2015 Version



Floors/BedRooms/Foundation

IC3 International CODE COMPLIANCE CALCULATOR

Current 2015 Version

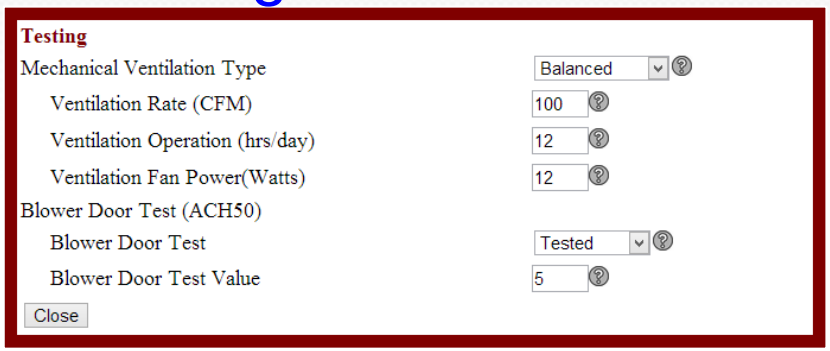


Global Parameters

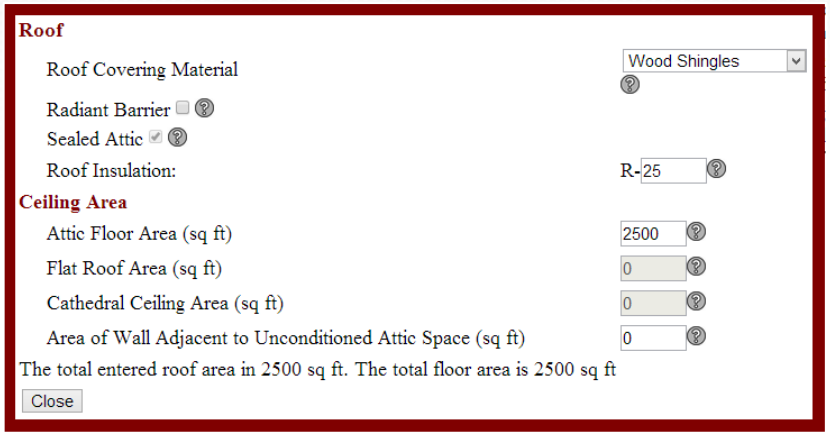
IC3 International CODE COMPLIANCE CALCULATOR

Current 2015 Version

Testing



Roof

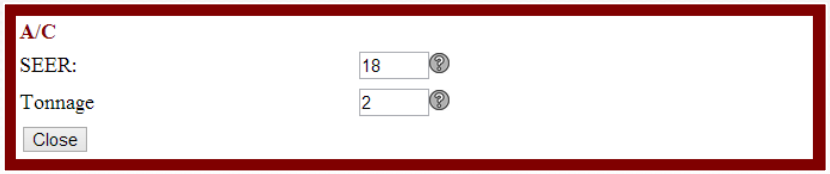


IC3 International CODE COMPLIANCE CALCULATOR

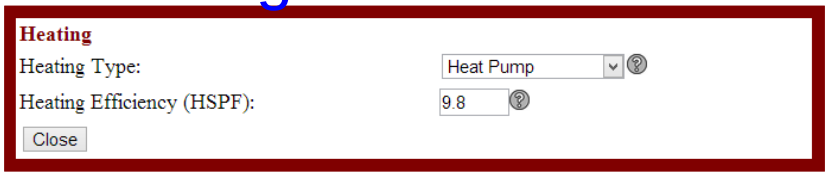
Current 2015 Version

Foundation

A/C



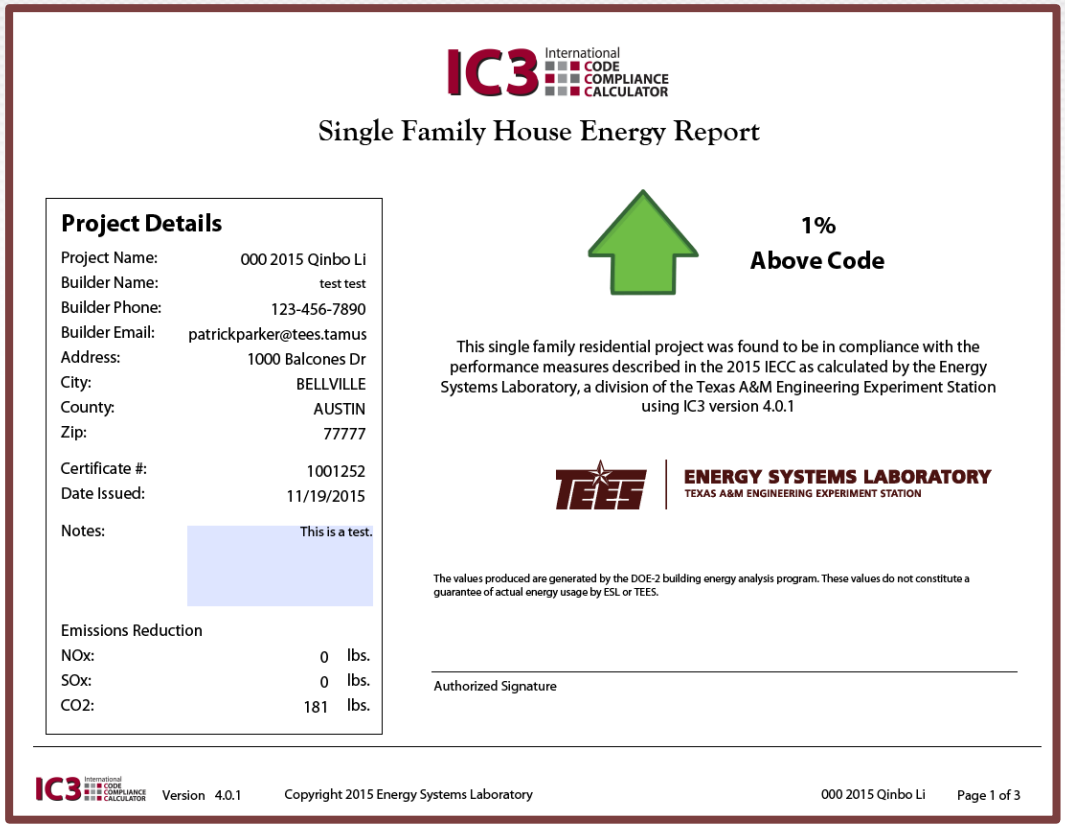
Heating



Water Heater

IC3 International CODE COMPLIANCE CALCULATOR

Current 2015 Version



IC3 International CODE COMPLIANCE CALCULATOR

Single Family House Energy Report

Project Details

Project Name:	000 2015 Qinbo Li
Builder Name:	test test
Builder Phone:	123-456-7890
Builder Email:	patrickparker@tees.tamus
Address:	1000 Balcones Dr
City:	BELLVILLE
County:	AUSTIN
Zip:	77777
Certificate #:	1001252
Date Issued:	11/19/2015
Notes:	This is a test.

Emissions Reduction

NOx:	0	lbs.
SOx:	0	lbs.
CO2:	181	lbs.

1%
Above Code

This single family residential project was found to be in compliance with the performance measures described in the 2015 IECC as calculated by the Energy Systems Laboratory, a division of the Texas A&M Engineering Experiment Station using IC3 version 4.0.1

ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

The values produced are generated by the DOE-2 building energy analysis program. These values do not constitute a guarantee of actual energy usage by ESL or TEES.

Authorized Signature

IC3 Version 4.0.1 Copyright 2015 Energy Systems Laboratory 000 2015 Qinbo Li Page 1 of 3

Certificate

Current 2015 Version

IC3 International CODE COMPLIANCE CALCULATOR

Residential Energy Efficiency Certificate

ENERGY SYSTEMS LABORATORY
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Window U-Value	U- 0.25	Duct Tightness (in CFM25)	3
Window SHGC	0.2	Cooling Efficiency	SEER 15
Wall Cavity Insulation	R - 18	Heating Efficiency	12.2 HSPF
Roof/Ceiling Insulation	R - 25	Water Heater Efficiency	Heat Pump EF 2.2
Floor/Foundation Insulation	R - 5	Builder Email	esl_e2calc_support@tees.tamus.e
Supply Duct Insulation	R - 8	Builder Phone	123-456-7890
Return Duct Insulation	R - 8	Date Issued	12/14/2016
Blower Door (in ACH50)	4	Certificate Number	1,017,977

IC3 International CODE COMPLIANCE CALCULATOR

Builder or Registered Design Professional _____

This certificate was generated by IC3 in compliance with 2015 IECC

Certificate on Electrical Panel

SAVINGS FROM CODE COMPLIANT CONSTRUCTION

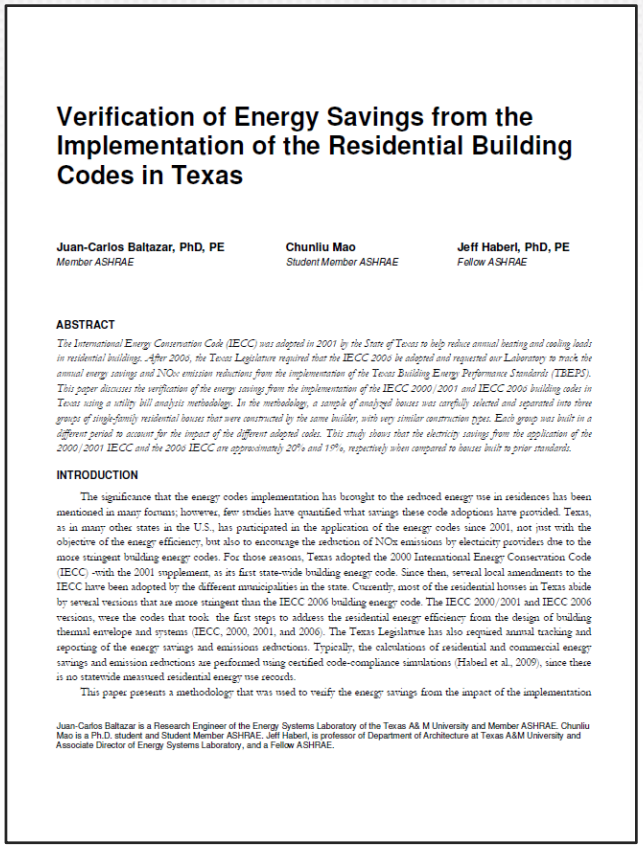
IC3 International CODE COMPLIANCE CALCULATOR

Has an analysis been performed to determine actual measured energy savings (i.e., real utility bills)?

IC3 International CODE COMPLIANCE CALCULATOR

Yes!

Calculated savings compared with utility bills



Verification of Energy Savings from the Implementation of the Residential Building Codes in Texas

Juan-Carlos Baltazar, PhD, PE
Member ASHRAE

Chunliu Mao
Student Member ASHRAE

Jeff Haberl, PhD, PE
Fellow ASHRAE

ABSTRACT

The International Energy Conservation Code (IECC) was adopted in 2001 by the State of Texas to help reduce annual heating and cooling loads in residential buildings. After 2006, the Texas Legislature required that the IECC 2006 be adopted and requested our Laboratory to track the annual energy savings and NOx emission reductions from the implementation of the Texas Building Energy Performance Standards (TBEPS). This paper discusses the verification of the energy savings from the implementation of the IECC 2000/2001 and IECC 2006 building codes in Texas using a utility bill analysis methodology. In the methodology, a sample of analyzed houses was carefully selected and separated into three groups of single-family residential houses that were constructed by the same builder, with very similar construction types. Each group was built in a different period to account for the impact of the different adopted codes. This study shows that the electricity savings from the application of the 2000/2001 IECC and the 2006 IECC are approximately 20% and 19%, respectively when compared to houses built to prior standards.

INTRODUCTION

The significance that the energy codes implementation has brought to the reduced energy use in residences has been mentioned in many forums; however, few studies have quantified what savings these code adoptions have provided. Texas, as in many other states in the U.S., has participated in the application of the energy codes since 2001, not just with the objective of the energy efficiency, but also to encourage the reduction of NOx emissions by electricity providers due to the more stringent building energy codes. For those reasons, Texas adopted the 2000 International Energy Conservation Code (IECC) -with the 2001 supplement, as its first state-wide building energy code. Since then, several local amendments to the IECC have been adopted by the different municipalities in the state. Currently, most of the residential houses in Texas abide by several versions that are more stringent than the IECC 2006 building energy code. The IECC 2000/2001 and IECC 2006 versions, were the codes that took the first steps to address the residential energy efficiency from the design of building thermal envelope and systems (IECC, 2000, 2001, and 2006). The Texas Legislature has also required annual tracking and reporting of the energy savings and emissions reductions. Typically, the calculations of residential and commercial energy savings and emission reductions are performed using certified code-compliance simulations (Habeel et al., 2009), since there is no statewide measured residential energy use records.

This paper presents a methodology that was used to verify the energy savings from the impact of the implementation

Juan-Carlos Baltazar is a Research Engineer of the Energy Systems Laboratory of the Texas A& M University and Member ASHRAE. Chunliu Mao is a Ph.D. student and Student Member ASHRAE. Jeff Haberl, is professor of Department of Architecture at Texas A&M University and Associate Director of Energy Systems Laboratory, and a Fellow ASHRAE.

*Results published in the 2014 ASHRAE Transactions.

Developed API for IC3

IC3 International CODE COMPLIANCE CALCULATOR

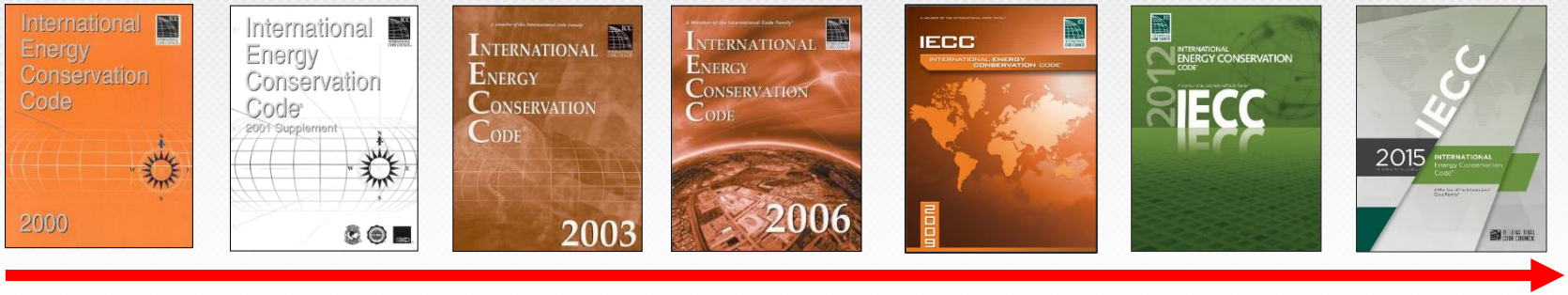
IC3 Web:
http://ic3-2015.tamu.edu

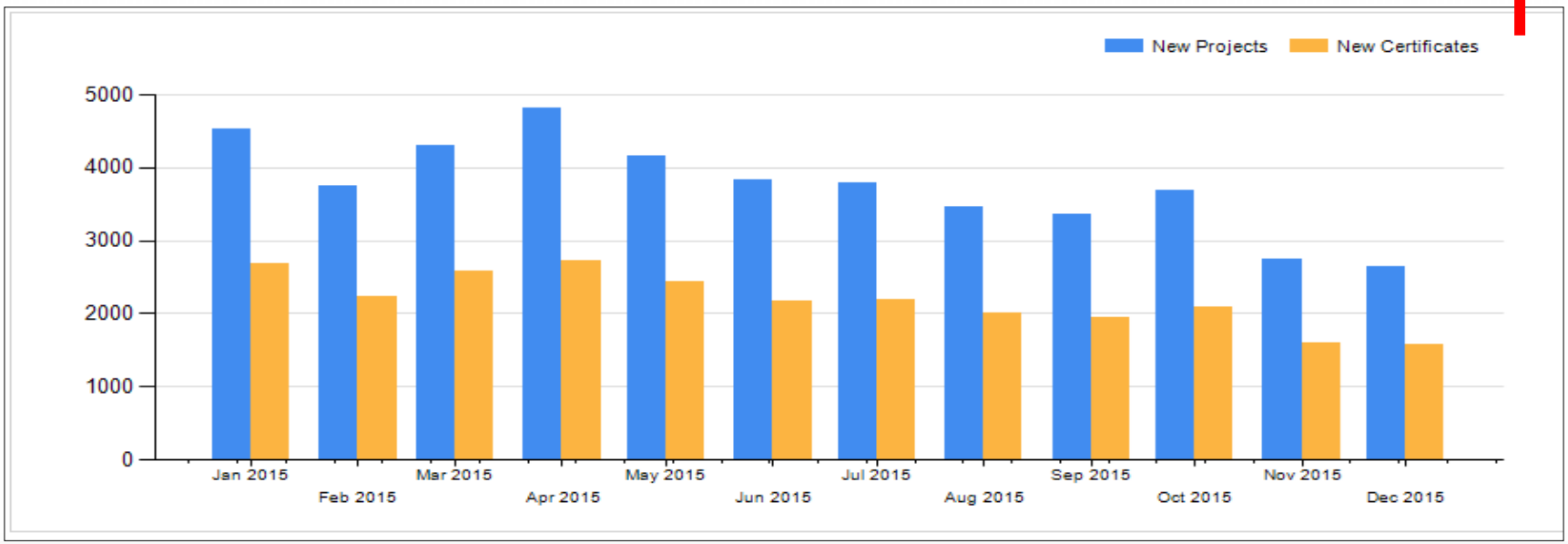
Benefits from API:

- Single screen allowing access to the same DOE-2 model used by the IC3 webpage
- Tablet/iPad/iPhone friendly
- XML input/output
- Easily integrated into existing *third party software*

STATEWIDE SAVINGS FROM CODE COMPLIANCE (2000 – 2014)

How much electricity has been saved from residential code compliance for all single-family housing 2000-2015?





STATEWIDE SAVINGS FROM CODE COMPLIANCE 2000 – 2015 (ESTIMATED)

Savings (2002 to 2015)

Electricity - $1,701 million

Demand - $1,875 million

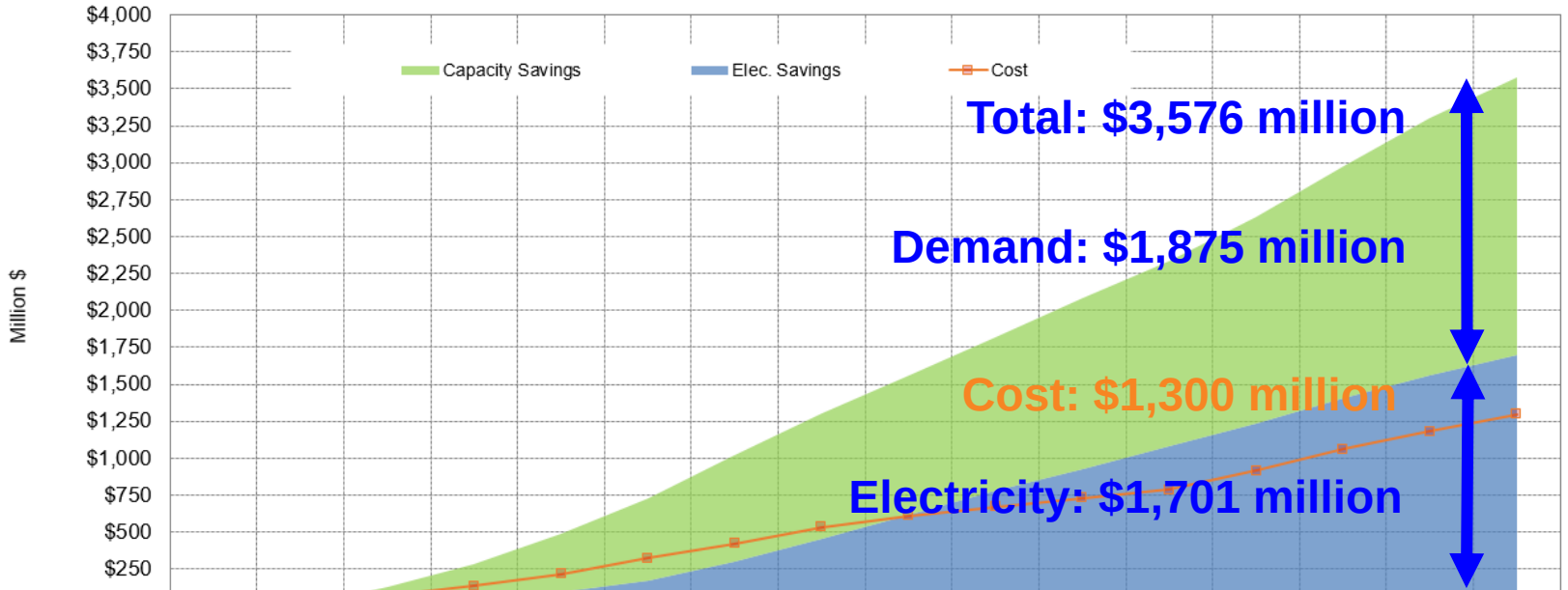
Total - $3,576 million

Increased Costs (2002 to 2015)

Costs - $ 1,300 million

Emissions Reduction in 2015

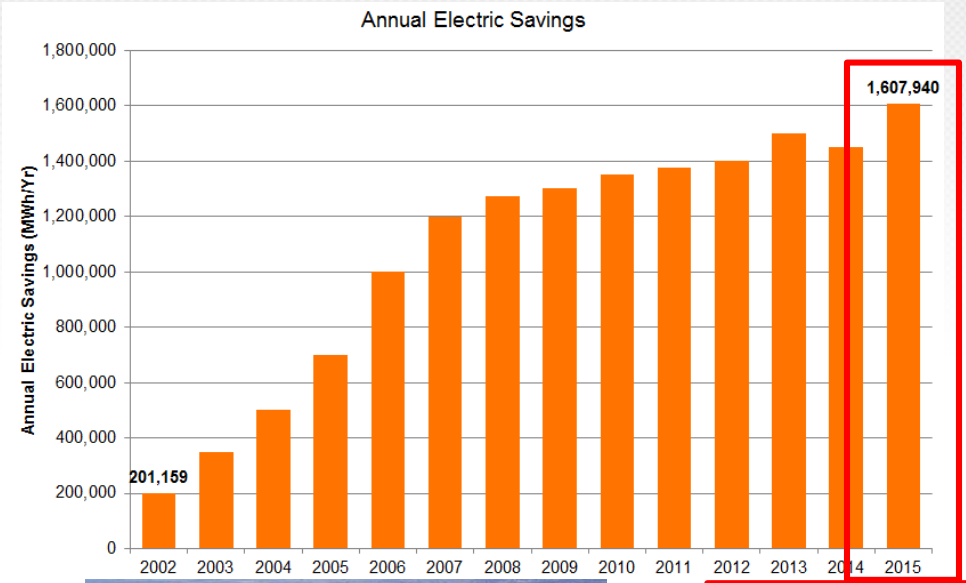
(Equivalent to about 23,000 cars)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Capacity Savings	-	-	$111	$232	$387	$558	$717	$854	$949	$1,044	$1,151	$1,248	$1,400	$1,574	$1,736	$1,875
Elec. Savings	-	-	$16	$48	$97	$175	$304	$451	$615	$776	$930	$1,082	$1,236	$1,403	$1,564	$1,701
Cost	-	-	$64	$136	$218	$321	$422	$536	$610	$669	$729	$788	$914	$1,060	$1,179	$1,299

STATEWIDE WATER SAVINGS AT POWER PLANTS 2002~2015

Electricity/Water Savings from SF (Code Compliance)

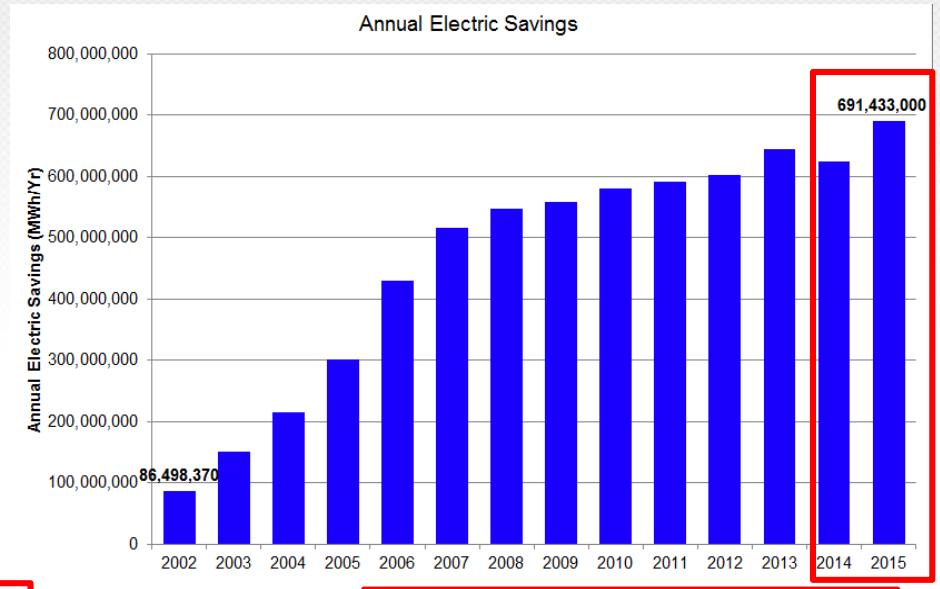


2015 Total

Electricity Savings

(MWh/Yr)

1,607,940



2015 Total

Water Savings

(gal/Yr)	(acre-ft/Yr)
691,433,000	2122

Conversion Factors: 430 *gal/MWh*
325,851 *gal/acre-ft*

SAVINGS FROM RENEWABLES

Blue Wing Solar PV Array ,San Antonio

Solar PV

Sunmaxx Solar Thermal, Fort Hood, TX

Solar Thermal

Dam at Elephant Butte, El Paso, TX

Hydro

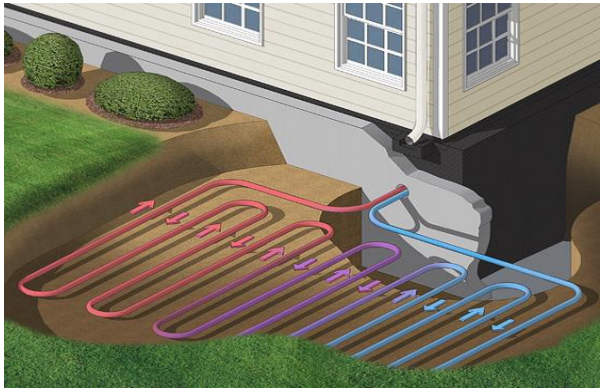
2.5 Miles Southwest of Woodville, TX

Biomass

Aspen Power plant in Lufkin, TX

Landfill Gas

Ground Source Heat Pump



Geothermal

SAVINGS FROM RENEWABLES

Blue Wing Solar PV Array ,San Antonio

Solar PV

Sunmaxx Solar Thermal, Fort Hood, TX

Dam at Elephant Butte, El Paso, TX

ydro

2.5 Miles Southwest of Woodvil

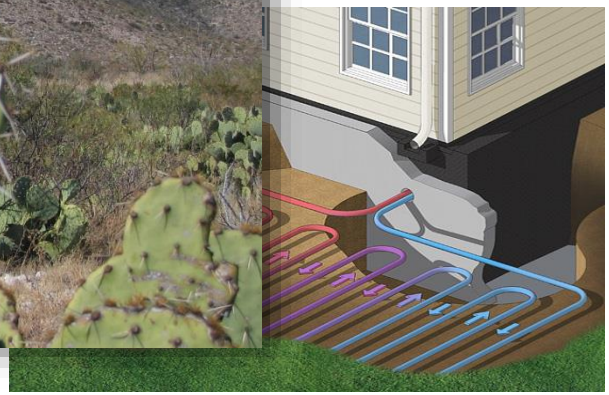
Biomass

Wind

Desert Sky Wind Farm, TX.

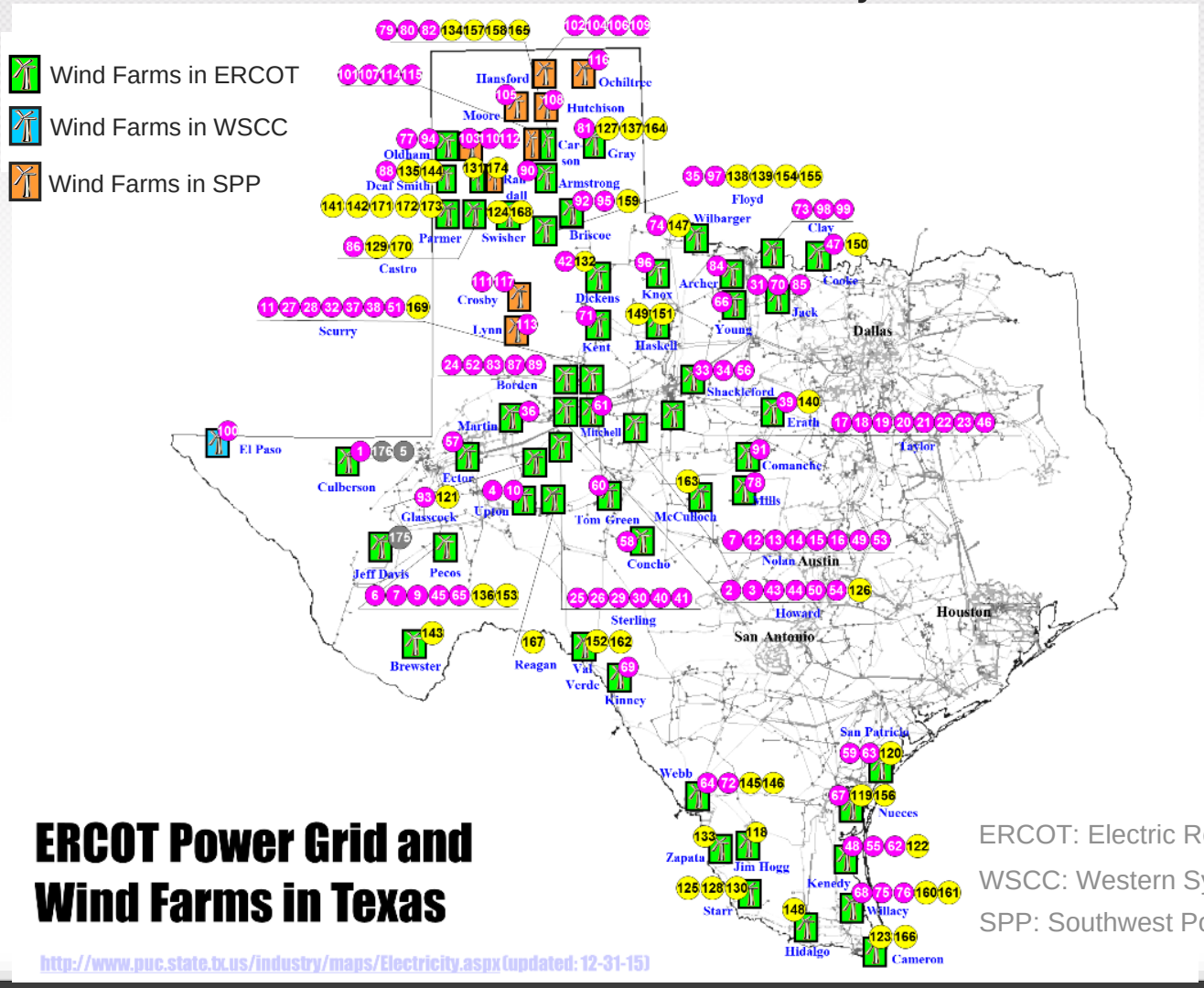
Landfill Gas

eat Pump



Geothermal

Completed, Announced, and Retired Wind Projects in Texas, as of Dec. 2015



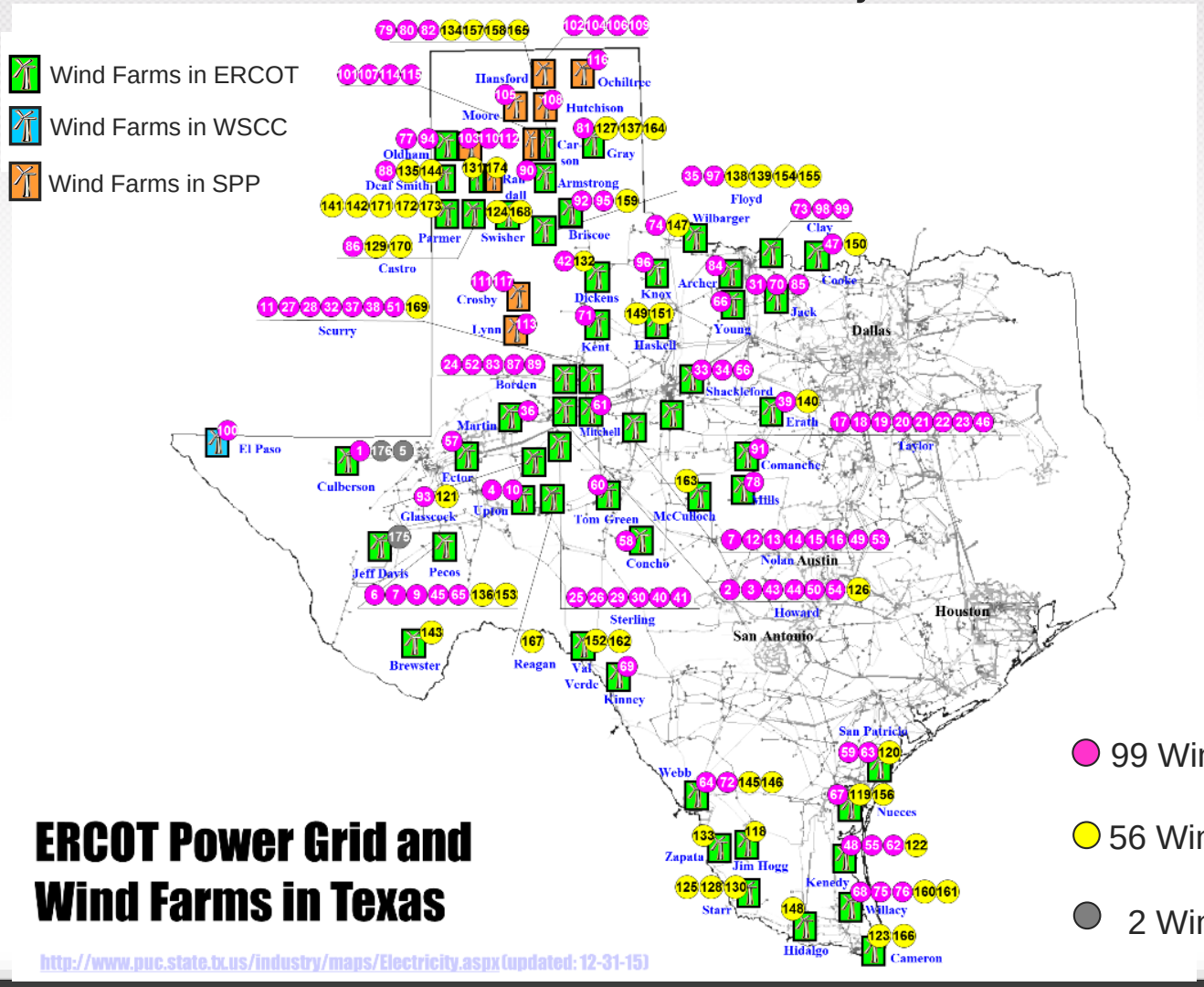
ERCOT: Electric Reliability Council of Texas

WSCC: Western Systems Coordinating Council

SPP: Southwest Power Pool

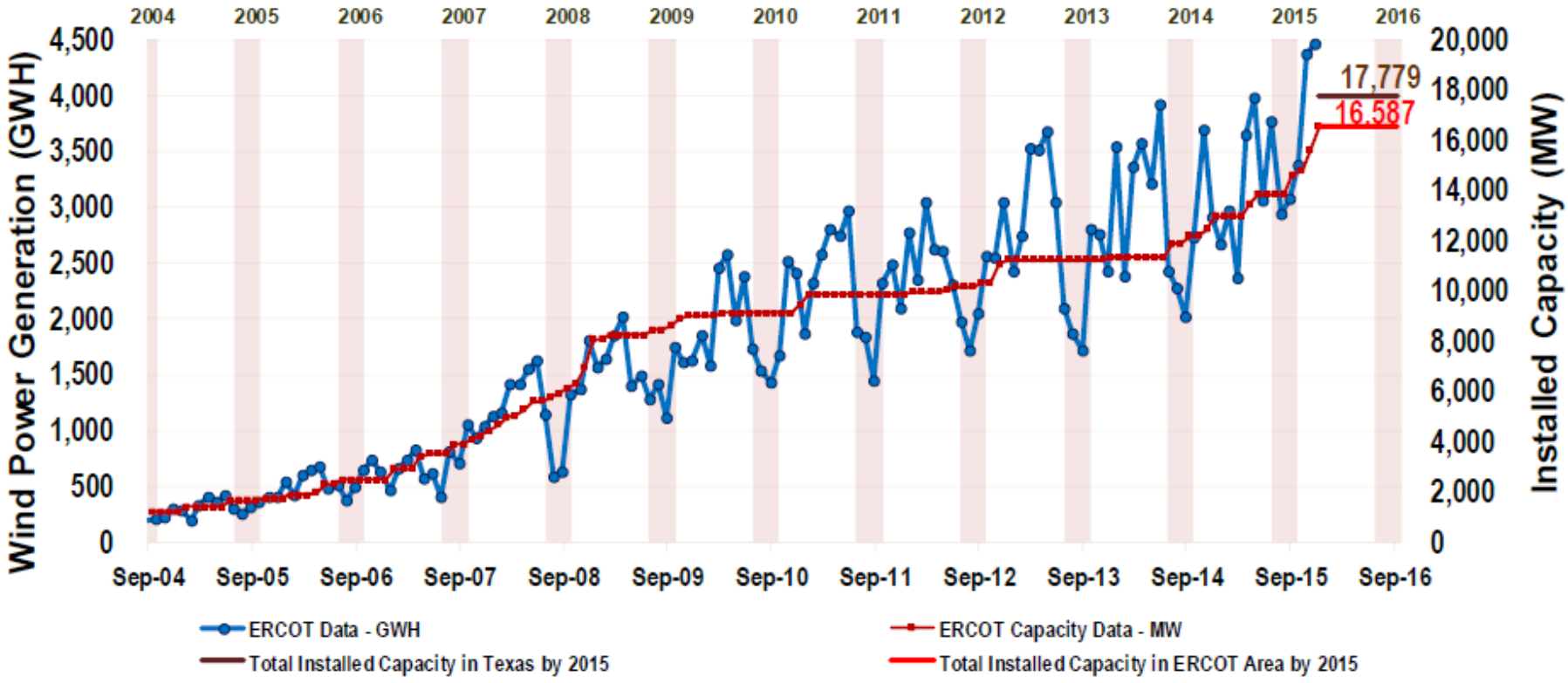
WIND PROJECTS IN TEXAS (2015)

Completed, Announced, and Retired Wind Projects in Texas, as of Dec. 2015



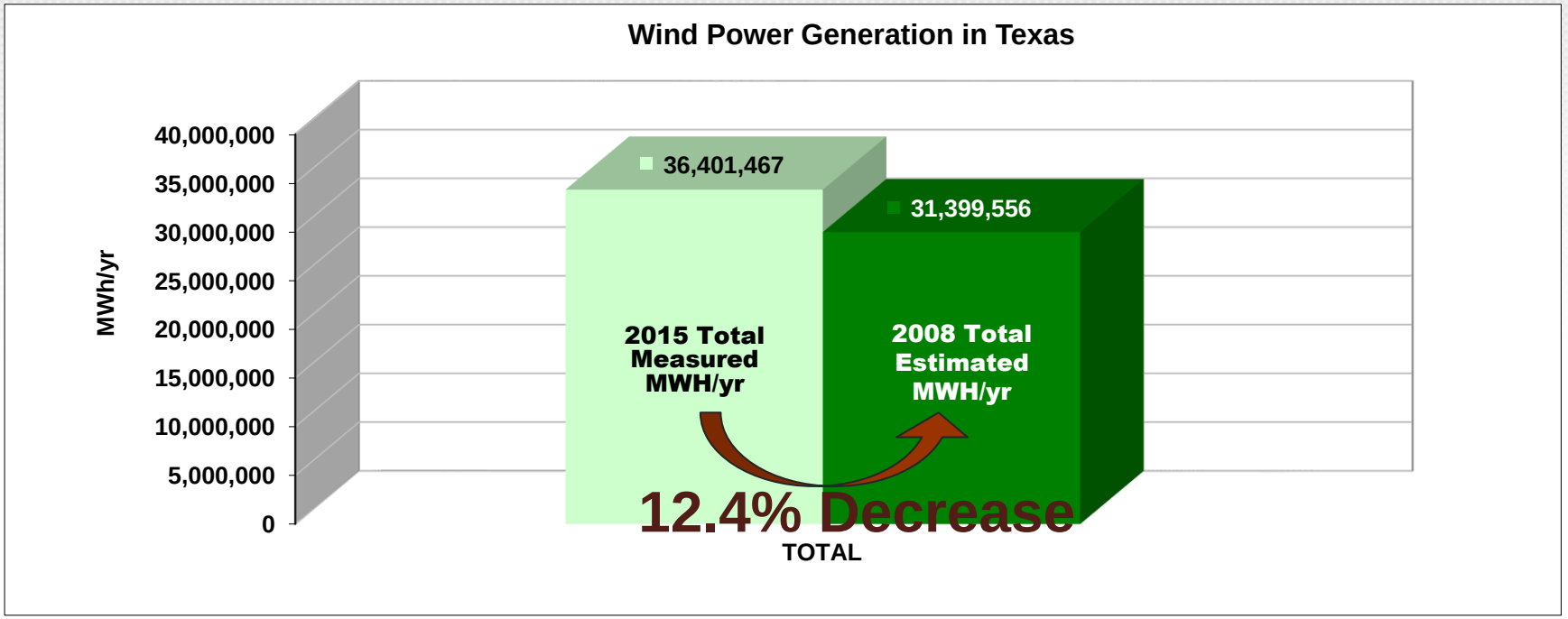
WIND PROJECTS IN TEXAS (2015)

Total Wind Power 4,500 GWh **Total Capacity 17,779** **ERCOT Capacity 16,687**



WIND FARMS CAPACITY/PRODUCTION

2008 Annual/OSP Baseline vs. 2015 Annual/OSP Measured

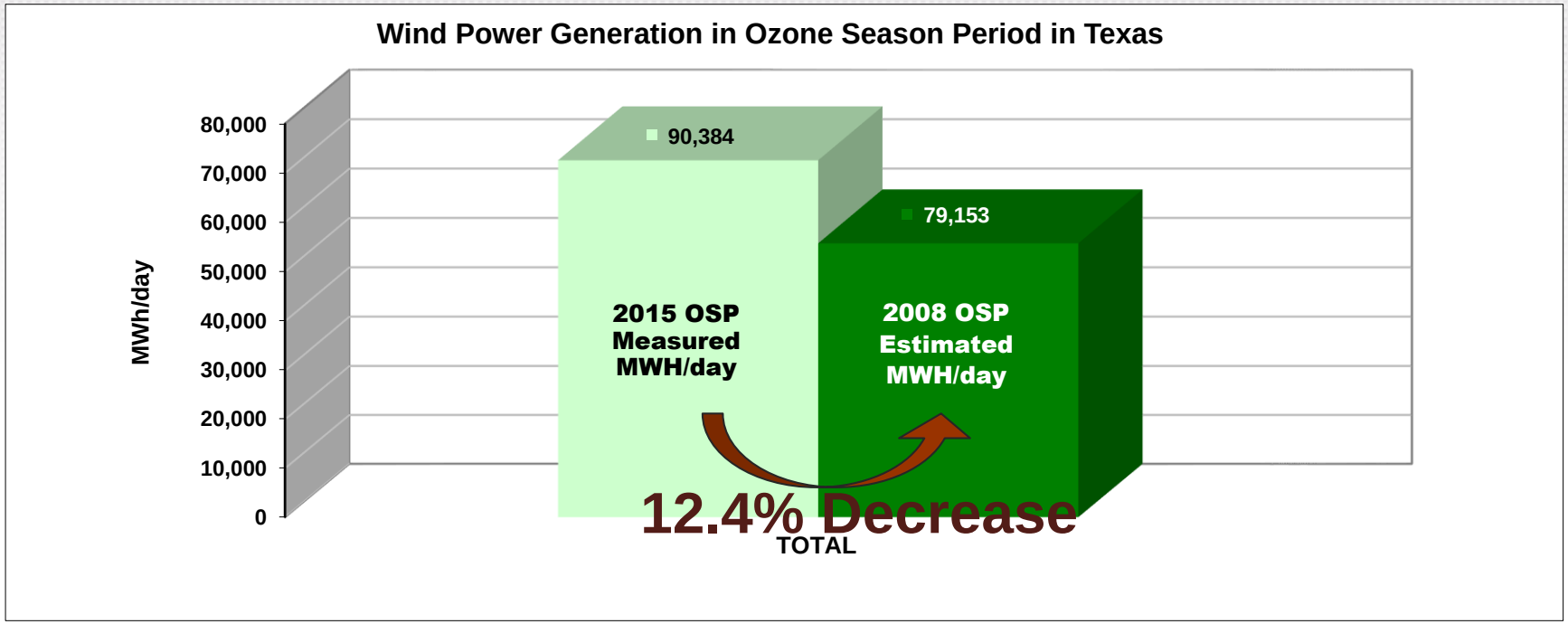


(Due to wind normalized weather condition)

2008 Calculated from 2015 Measured Annual Power Production

WIND FARMS CAPACITY/PRODUCTION

2008 Annual/OSP Baseline vs. 2015 Annual/OSP Measured



(Due to wind normalized weather condition)

2008 Calculated from 2015 Measured OSP Power Production

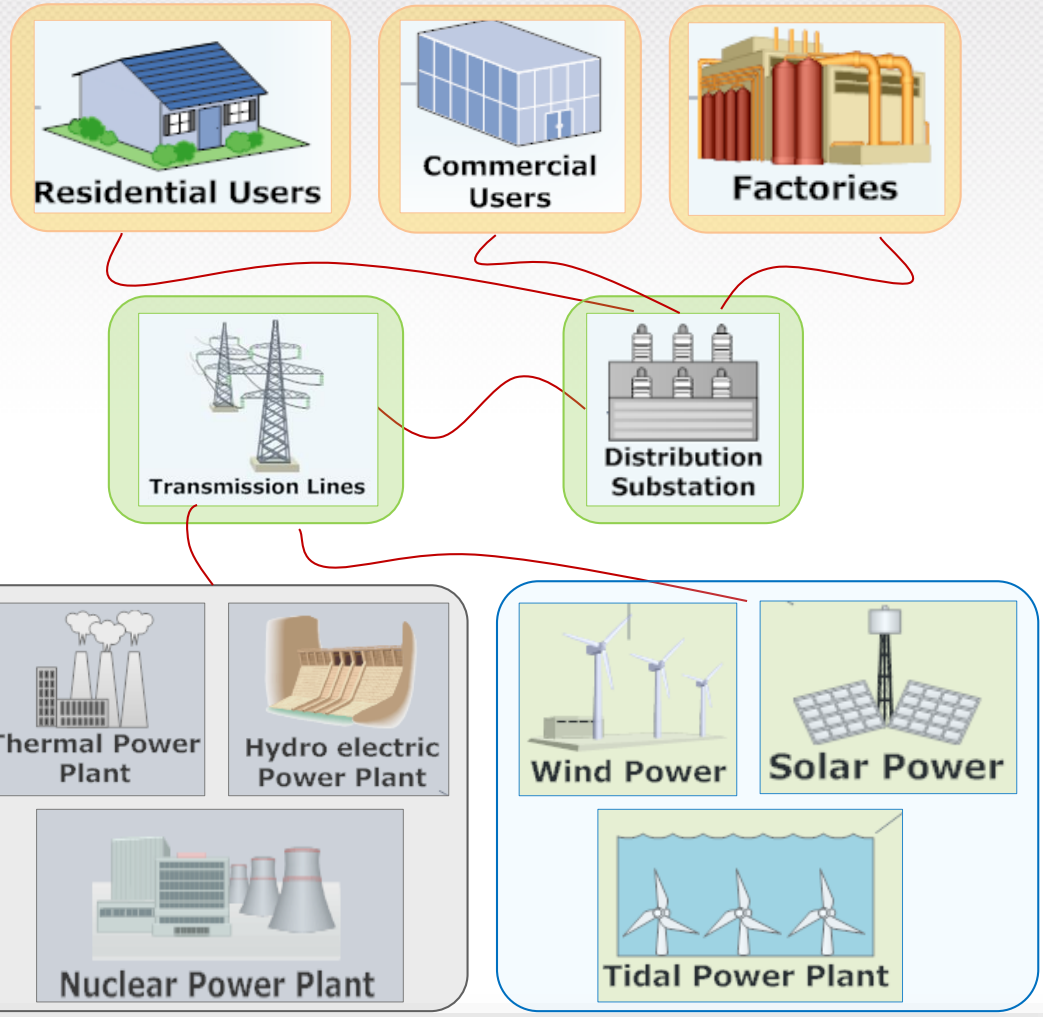
NOx REDUCTIONS USING eGRID

NOx emissions reductions calculation from electricity savings

CONSUMPTION
- Residential
- Commercial
- Industrial

TRANSMISSION & DISTRIBUTION
- Transmission Lines
- Sub-Station

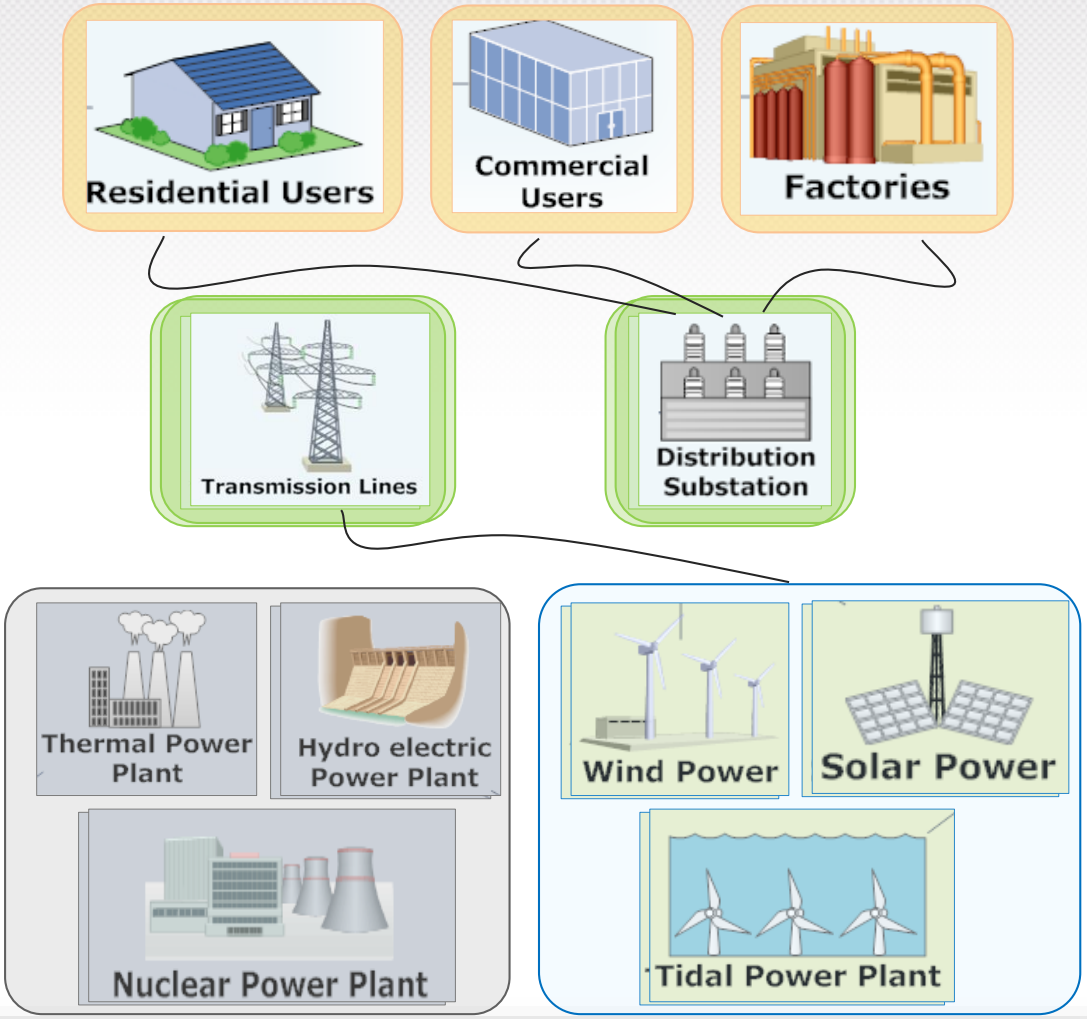
GENERATION
- Conventional
- Renewable



NOx REDUCTIONS USING eGRID

NOx emissions reductions calculation from electricity savings

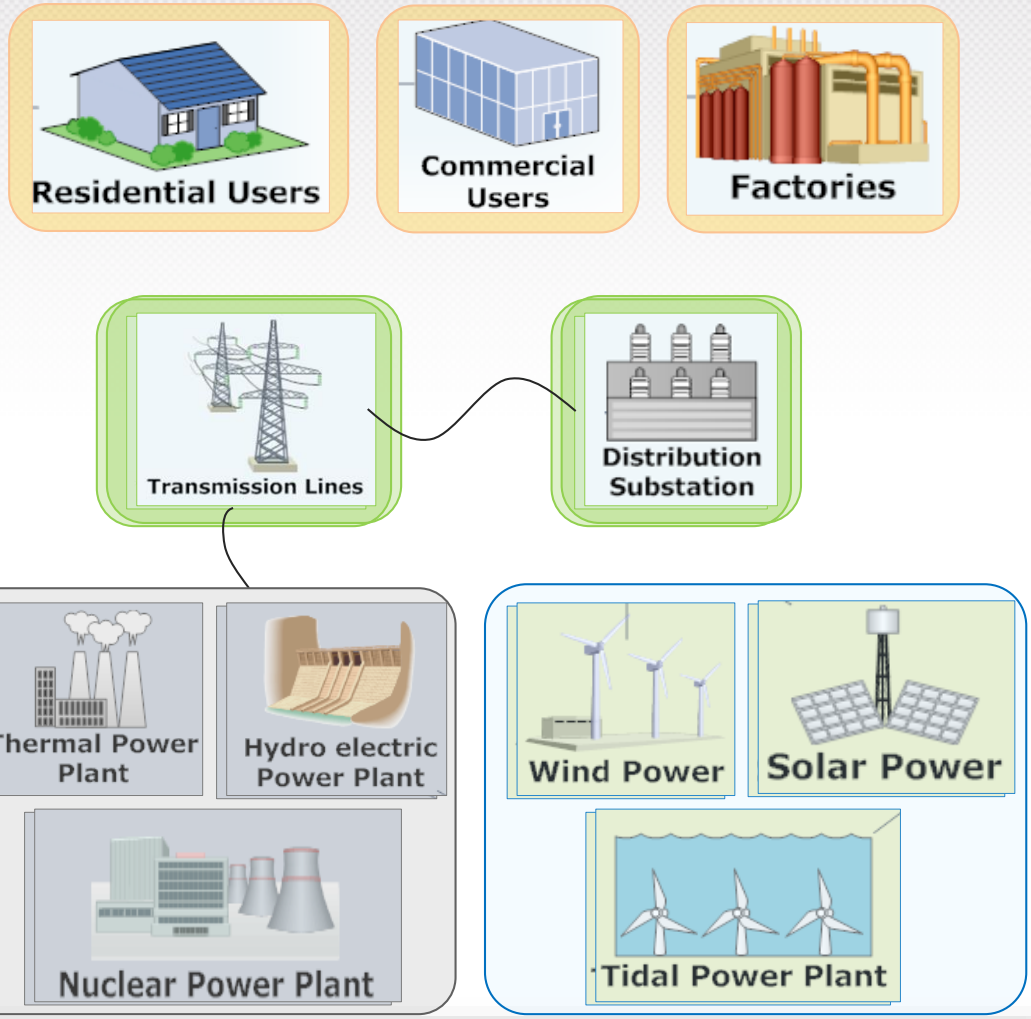
Energy Savings from EE/RE Programs



NOx REDUCTIONS USING eGRID

Energy Savings from EE/RE Programs

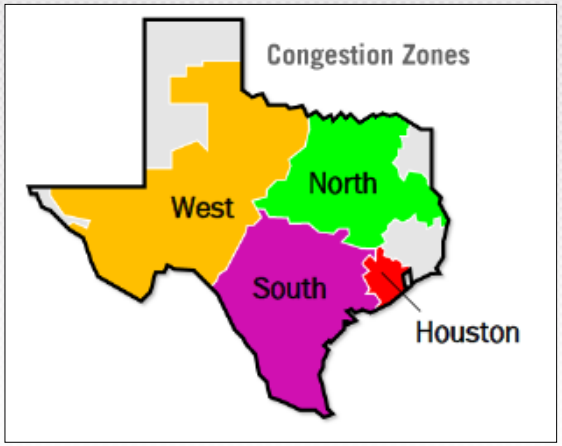
Energy Production & **Emissions Reductions**

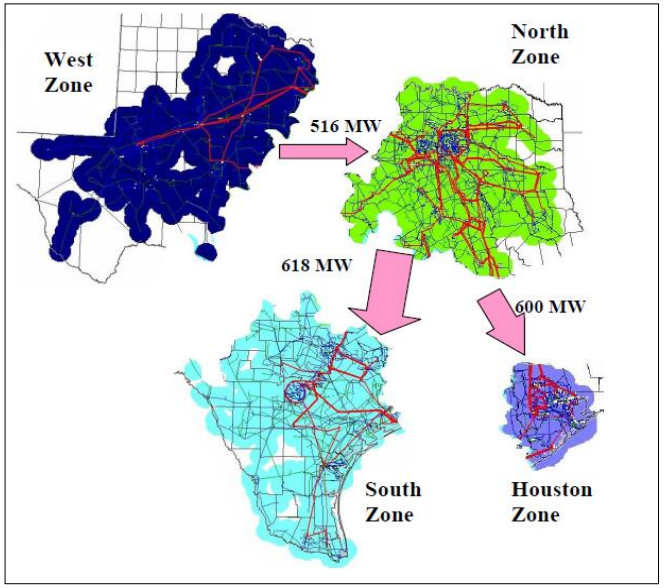


NOx REDUCTIONS USING eGRID

2010 eGrid
4 Congestion Management (CM) Zones

Area	County	CM Zones H	CM Zones N	CM Zones W	CM Zones S	Total Heat Reductions (lbs)	Total Heat Reductions (Tons)
Houston-Galveston Area	Brazoria	0.0562032	0.0000071	0.0841	0.0000001	0.0215	0.0005265	0.0488	8.55	0.004277
	Chambers	0.0264588	0.0000026	0.0398	0.0000001	0.0078	0.0001916	3.0742	3.11	0.001556
	Fort Bend	0.0313463	0.0000040	0.0469	0.0000002	0.0120	0.0002937	4.7122	4.77	0.002386
	Galveston	0.0226620	0.0000029	0.0339	0.0000001	0.0087	0.0002123	3.4067	3.45	0.001725
	Harris	0.1486911	0.0000189	0.2224	0.0000009	0.0570	0.0013930	22.3521	22.63	0.011316
	Liberty	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Montgomery	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Waller	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Jefferson	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Orange	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Dallas/ Fort Worth Area	Collin	0.0012932	0.0000002	0.0019	0.0000000	0.0005	0.0000121	0.1980	1.2987	118.79	0.059393
	Dallas	0.0024826	0.0000004	0.0036	0.0000000	0.0009	0.0000232	0.3800	2.4931	228.05	0.114023
	Denton	0.0001267	0.0000000	0.0001770	9.1602	0.0000375	2.3475	0.0000079	0.1272	11.63	0.005817
	Tarrant	0.0004742	0.0000000	0.0006889	34.2926	0.0001405	8.7883	0.0000297	0.4762	43.56	0.021779
	Ellis	0.0029920	0.0000000	0.0183544	216.3788	0.0008865	55.4526	0.0001873	3.0047	274.84	0.137418
	Johnson	0.0007256	0.0000000	0.0044512	52.4748	0.0002150	13.4480	0.0000454	0.7287	66.65	0.033326
	Kaufman	0.0043718	0.0000000	0.0268343	431.8800	0.0017695	110.6800	0.0003738	5.9972	548.56	0.274279
	Parker	0.0001812	0.0000000	0.0011	0.0000000	0.0003	0.0000000	0.0000000	0.0000	0.11	0.000055
	Rockwall	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000000	0.0000	0.00	0.000000
	Wise	0.0007262	0.0000000	0.0044	0.0000000	0.0018	0.0000000	0.0000000	1.0000	93.71	0.046855
El Paso Area	El Paso	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000000	0.0000	0.00	0.000000
San Antonio Area	Bexar	0.0138996	0.0000000	0.0000368	11.0441	0.0000452	2.8303	0.1169355	1780.0458	1793.92	0.896960
	Comal	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Guadalupe	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Wilson	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Austin Area	Bastrop	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Caldwell	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Hays	0.0008331	0.0000000	0.0012	0.6624	0.0000027	0.1698	0.0006537	0.7834	107.60	0.053798
	Travis	0.0051785	0.0000000	0.0074	4.1173	0.0000169	1.0552	0.0413577	663.6162	668.79	0.334394
	Williamson	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
North East Texas Area	Gregg	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Harrison	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Rusk	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Smith	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Upshur	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Corpus Christi Area	Nueces	0.0128578	0.0000000	0.0008672	10.2229	0.0000419	2.6199	0.1026870	1647.6917	1660.53	0.830267
	San Patricio	0.0015100	0.0000000	0.0001018	1.2005	0.0000049	0.3077	0.0120591	193.4967	195.00	0.097502
Victoria Area	Victoria	0.0021192	0.0000000	0.0001429	1.6849	0.0000069	0.4318	0.0169244	271.5644	273.68	0.136841
Other ERCOT counties	Andrews	0.0000037	0.0000000	0.0000250	0.2708	0.0039863	243.9585	0.0000062	0.0036	244.23	0.122117
	Angelina	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Bowie	0.0022284	0.0000000	0.0015012	160.5796	0.0000579	41.1526	0.0001190	2.2299	203.96	0.101981
	Brazos	0.0024089	0.0000000	0.0112305	132.3962	0.0005425	33.9299	0.0047829	76.7454	243.87	0.121935
	Calhoun	0.0009466	0.0000000	0.0000638	0.7526	0.0000031	0.1929	0.0075598	121.3022	122.25	0.061124
	Cameron	0.0063536	0.0000000	0.0004285	5.0516	0.0000207	1.2946	0.0507425	814.2016	820.55	0.410274
	Cherokee	0.0027382	0.0000000	0.0168033	198.0938	0.0008116	50.7666	0.0001714	2.7508	251.61	0.125806
	Cole	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Coleman	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Crockett	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Ector	0.0019215	0.0000000	0.0000604	7.7849	0.0911346	5700.3854	0.0146527	235.1135	5943.28	2.971642
	Fannin	0.0000041	0.0000000	0.0000249	0.2932	0.0000012	0.0752	0.0000003	0.0041	0.37	0.000186
	Fayette	0.0051867	0.0000000	0.0103217	121.6819	0.0004986	31.1841	0.0283993	455.6886	608.55	0.304277
	Freestone	0.0047643	0.0000000	0.0292268	344.5537	0.0014117	88.3007	0.0002982	4.7846	437.64	0.218820
	Frio	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Grimes	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Hardeman	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Haskell	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Henderson	0.0006908	0.0000000	0.0042376	49.9565	0.0002047	12.8026	0.0000432	0.6937	63.45	0.031726
	Hidalgo	0.0053716	0.0000000	0.0003623	4.2708	0.0000175	1.0945	0.0428994	688.3538	693.72	0.346860
	Hood	0.0050771	0.0000000	0.0311454	367.1721	0.0015044	94.0972	0.0003178	5.0987	466.37	0.233184
	Howard	0.0002411	0.0000000	0.0007641	9.0076	0.1283942	8030.9334	0.0009490	15.2273	8055.17	4.027584
	Hunt	0.0008463	0.0000000	0.0047705	55.4864	0.0002273	14.2198	0.0052823	1047.5045	1117.21	0.558605
	Jack	0.0036783	0.0000000	0.0188839	222.6215	0.0009121	57.0525	0.0001927	3.0914	282.77	0.141383
	Jones	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Lamar	0.0040001	0.0000000	0.0245388	289.2875	0.0011853	74.1373	0.0002584	4.0171	367.44	0.183721
	Limestone	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Llano	0.0040314	0.0000000	0.0002719	3.2053	0.0000131	0.8214	0.0321966	516.6198	520.65	0.260323
	McLennan	0.0056576	0.0000000	0.0347866	409.1554	0.0016764	104.8565	0.0003541	5.6816	519.69	0.259847
	Milam	0.0012586	0.0000000	0.0000706	1.0086	0.0000041	0.2585	0.0102136	162.5687	163.84	0.081918
	Mitchell	0.0000311	0.0000000	0.0001910	2.2512	0.0324268	2028.2136	0.0000019	0.0313	2030.50	1.015248
	Nolan	0.0000293	0.0000000	0.0001795	2.1157	0.0304745	1906.1498	0.0000018	0.0294	1908.29	0.954147
	Palo Pinto	0.0036129	0.0000000	0.0221635	261.2853	0.0010705	66.9610	0.0002261	3.6283	331.87	0.165937
	Pecos	0.0000020	0.0000000	0.0000121	0.1425	0.0020520	128.3525	0.0000001	0.0020	128.50	0.064248
	Presidio	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Red River	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Robertson	0.0019586	0.0000000	0.0010755	65.7291	0.0002693	16.8448	0.0246170	394.9980	477.57	0.238786
	Taylor	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Titus	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Tom Green	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Upton	0.0000025	0.0000000	0.0000156	0.1839	0.0026494	165.7193	0.0000002	0.0026	165.91	0.082953
	Ward	0.0001995	0.0000000	0.0012239	14.4291	0.2078335	12999.7905	0.0000125	0.2004	13014.42	6.507210
	Webb	0.0042817	0.0000000	0.0002634	3.3407	0.0000137	0.8561	0.0335565	538.4405	542.64	0.271319
	Wharton	0.0021695	0.0000000	0.0001423	1.6772	0.0000069	0.4298	0.0168474	270.3288	272.44	0.136218
	Wichita	0.0000121	0.0000000	0.0000743	0.8761	0.0126190	789.3057	0.0000008	0.0122	790.19	0.395097
	Wilbarger	0.0179710	0.0000000	0.1102430	1299.6511	0.0053249	333.0688	0.0011247	18.0473	1650.77	0.825384
	Young	0.0071054	0.0000000	0.0435880	513.8578	0.0021054	131.6892	0.0004447	7.1356	652.68	0.326341
	Total	0.4414591	0.0000	0.4912863	5673.8648	0.5345786	33437.3845	0.6629349	10358.2137	50069.47	25.03
Energy Savings (MWh)		0		11,789		62,549		16,046			



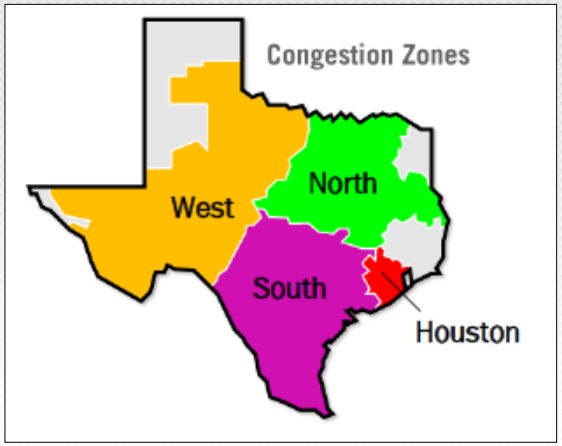


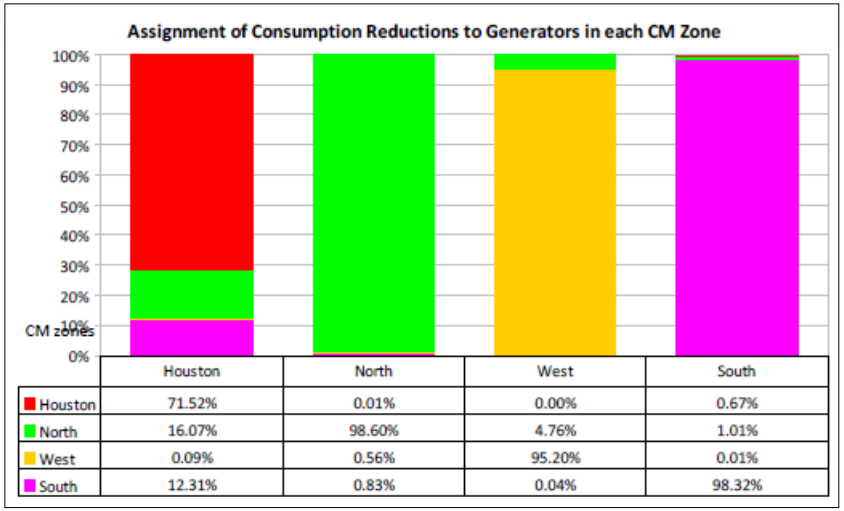
Electricity Flows between CM Zones in ERCOT

NOx REDUCTIONS USING eGRID

2010 eGrid 4 Congestion Management (CM) Zones

Area	County	CM Zones H	CM Zones N	CM Zones W	CM Zones S	Total Heat Reductions (lbs)	Total Heat Reductions (Tons)
Houston-Galveston Area	Brazoria	0.0562032	0.0000071	0.0841	0.0000001	0.0215	0.0005265	0.1488	8.55	0.004277
	Chambers	0.0264588	0.0000026	0.0398	0.0000001	0.0078	0.0001916	3.0742	3.11	0.001556
	Fort Bend	0.0313463	0.0000040	0.0469	0.0000002	0.0120	0.0002937	4.7122	4.77	0.002386
	Galveston	0.0226520	0.0000029	0.0339	0.0000001	0.0087	0.0002123	3.4067	3.45	0.001725
	Harris	0.1486911	0.0000189	0.2224	0.0000009	0.0570	0.0013930	22.3521	22.63	0.011316
	Liberty	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Montgomery	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Waller	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Jefferson	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Orange	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Dallas/ Fort Worth Area	Collin	0.0012932	0.0000002	0.0019	0.0000000	0.5210	0.0000123	1.2987	118.79	0.059393
	Dallas	0.0024826	0.0000038	0.0036	0.0000001	0.9999	0.0000236	2.4931	228.05	0.114023
	Denton	0.0001267	0.0000019	0.0007770	0.0000000	9.1602	0.0000375	2.3475	11.63	0.005817
	Tarrant	0.0004742	0.0000072	0.0029089	0.0000001	34.2926	0.0001405	8.7883	43.56	0.021779
	Ellis	0.0029920	0.0000454	0.0183544	0.0000007	216.3768	0.0008865	55.4526	274.84	0.137418
	Johnson	0.0001256	0.0000019	0.0044512	0.0000001	52.4748	0.0002150	13.4480	66.65	0.033326
	Kaufman	0.0000718	0.0000011	0.0026343	0.0000000	431.8800	0.0017695	110.6800	548.56	0.274279
	Parker	0.0000212	0.0000003	0.0007779	0.0000000	127.6800	0.0005230	32.7277	0.11	0.000055
	Rockwall	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Wise	0.0001702	0.0000026	0.0010468	0.0000000	17.2080	0.0000705	1.0800	93.71	0.046855
El Paso Area	El Paso	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
San Antonio Area	Bexar	0.0138996	0.0000212	0.0009368	0.0000000	11.0441	0.0000452	2.8303	0.1189355	1780.0458	1783.92	0.891960
	Comal	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Guadalupe	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Wilson	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Austin Area	Bastrop	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Caldwell	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Hays	0.0008331	0.0000012	0.0005779	0.0000000	0.6824	0.0000027	0.1698	0.0006537	0.7834	107.60	0.053798
	Travis	0.0051785	0.0000783	0.0036493	0.0000001	4.1173	0.0000169	1.0552	0.0413577	663.6162	668.79	0.334394
	Williamson	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
North East Texas Area	Gregg	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Harrison	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Rusk	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Smith	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Upshur	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
Corpus Christi Area	Nueces	0.0128578	0.0000196	0.0008672	0.0000000	10.2229	0.0000419	2.6199	0.1026870	1647.6917	1660.53	0.830267
	San Patricio	0.0015100	0.0000231	0.0001018	0.0000000	1.2005	0.0000049	0.3077	0.0120591	193.4967	195.00	0.097502
Victoria Area	Victoria	0.0021192	0.0000324	0.0001429	0.0000000	1.6849	0.0000069	0.4318	0.0169244	271.5644	273.68	0.136841
Other ERCOT counties	Andrews	0.0000037	0.0000001	0.0000230	0.0000000	0.2708	0.0039863	243.9585	0.0000002	0.0036	244.23	0.122117
	Angelina	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Bowie	0.0022284	0.0000034	0.0012112	0.0000000	160.5796	0.0000679	41.1526	0.0001390	2.2299	203.96	0.101981
	Brazos	0.0024089	0.0000037	0.0012305	0.0000000	132.3962	0.0000545	33.9299	0.0047829	76.7454	243.87	0.121935
	Calhoun	0.0009466	0.0000145	0.0000638	0.0000000	0.7526	0.0000031	0.1929	0.0075598	121.3022	122.25	0.061124
	Cameron	0.0063536	0.0000973	0.0004285	0.0000000	5.0516	0.0000207	1.2946	0.0507425	814.2016	820.55	0.410274
	Cherokee	0.0027382	0.0000419	0.0016833	0.0000000	198.0938	0.0008116	50.7666	0.0001714	2.7508	251.61	0.125806
	Cole	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Coleman	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Crockett	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Ector	0.0019215	0.0000294	0.0000684	0.0000000	7.7849	0.0911346	5700.3854	0.0146527	235.1135	5943.28	2.971642
	Fannin	0.0000041	0.0000001	0.0000249	0.0000000	0.2932	0.0000012	0.0752	0.0000083	0.0041	0.37	0.000186
	Fayette	0.0051867	0.0000794	0.0103217	0.0000000	121.6819	0.0004986	31.1841	0.0283993	455.6886	608.55	0.304277
	Freestone	0.0047643	0.0000729	0.0292268	0.0000000	344.5537	0.0014117	88.3007	0.0002982	4.7846	437.64	0.218820
	Frio	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Grimes	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Hardeman	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Haskell	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Henderson	0.0006908	0.0000106	0.0042376	0.0000001	49.9565	0.0002047	12.8026	0.0000432	0.6937	63.45	0.031726
	Hidalgo	0.0053716	0.0000822	0.0003623	0.0000000	4.2708	0.0000175	1.0945	0.0428994	688.3538	693.72	0.346860
	Hood	0.0050771	0.0000777	0.0311454	0.0000012	367.1721	0.0015044	94.0972	0.0003178	5.0987	466.37	0.233184
	Howard	0.0002411	0.0000037	0.0007641	0.0000000	9.0076	0.1283942	8030.9334	0.0009490	15.2273	8055.17	4.027584
	Hunt	0.0008463	0.0000129	0.0047896	0.0000002	55.4864	0.0002273	14.2198	0.0002823	1047.5045	1117.21	0.558610
	Jack	0.0036783	0.0000563	0.0188839	0.0000008	222.6215	0.0009121	57.0525	0.0001927	3.0914	282.77	0.141383
	Jones	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Lamar	0.0040001	0.0000612	0.0245388	0.0000010	289.2875	0.0011853	74.1373	0.0002584	4.0171	367.44	0.183721
	Limestone	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Llano	0.0040314	0.0000617	0.0002719	0.0000000	3.2053	0.0000131	0.8214	0.0321966	516.6198	520.65	0.260323
	McLennan	0.0056576	0.0000866	0.0347866	0.0000014	409.1554	0.0016764	104.8565	0.0003541	5.6816	519.69	0.259847
	Milam	0.0012586	0.0000193	0.0000856	0.0000000	1.0086	0.0000041	0.2585	0.0101316	162.5687	163.84	0.081918
	Mitchell	0.0000311	0.0000005	0.0001910	0.0000000	2.2512	0.0324268	2028.2136	0.0000019	0.0313	2030.58	1.015248
	Nolan	0.0000293	0.0000004	0.0001795	0.0000000	2.1157	0.0304745	1906.1498	0.0000018	0.0294	1908.29	0.954147
	Palo Pinto	0.0036129	0.0000553	0.0221635	0.0000009	261.2853	0.0010705	66.9610	0.0002261	3.6283	331.87	0.165937
	Pecos	0.0000020	0.0000000	0.0000121	0.0000000	0.1425	0.0020520	128.3525	0.0000001	0.0020	128.50	0.064248
	Presidio	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Red River	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Robertson	0.0021996	0.0000337	0.0010755	0.0000004	65.7291	0.0002693	16.8448	0.0246170	394.9980	477.57	0.238786
	Taylor	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Titus	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Tom Green	0.0000000	0.0000000	0.0000000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.000000
	Upton	0.0000025	0.0000000	0.0000156	0.0000000	0.1839	0.0026494	165.7193	0.0000002	0.0026	165.91	0.082953
	Ward	0.0001995	0.0000031	0.0012239	0.0000001	14.4291	0.2078335	12999.7905	0.0000125	0.2004	13014.42	6.507210
	Webb	0.0042817	0.0000656	0.0002834	0.0000000	3.3407	0.0000137	0.8561	0.0335565	536.4405	542.64	0.271319
	Wharton	0.0021695	0.0000333	0.0001423	0.0000000	1.6772	0.0000069	0.4298	0.0168474	270.3288	272.44	0.136218
	Wichita	0.0000121	0.0000002	0.0000743	0.0000000	0.8761	0.0126190	789.3057	0.0000008	0.0122	790.19	0.395097
	Wilbarger	0.0179710	0.0002753	0.1102430	0.0000044	1299.6511	0.0053249	333.0688	0.0011247	18.0473	1650.77	0.825384
	Young	0.0071054	0.0001089	0.0435880	0.0000017	513.8578	0.0021054	131.6892	0.0004447	7.1356	652.68	0.326341
	Total	0.4414501	0.0068	0.481263	0.0000	5673.8648	0.5346786	33437.3845	0.6829349	10958.2137	50609.47	25.83
Energy Savings (MWh)		0		11,789		62,549		16,046				





CM zones	Houston	North	West	South
Houston	71.52%	0.01%	0.00%	0.67%
North	16.07%	98.60%	4.76%	1.01%
West	0.09%	0.56%	95.20%	0.01%
South	12.31%	0.83%	0.04%	98.32%

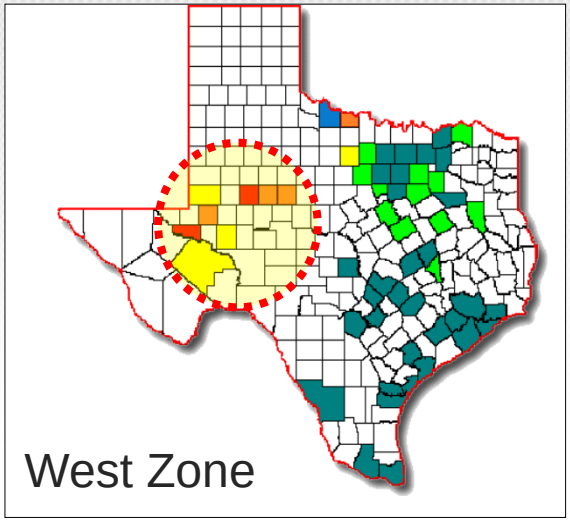
Assignment of Consumption Reductions to Generators in Each CM Zone

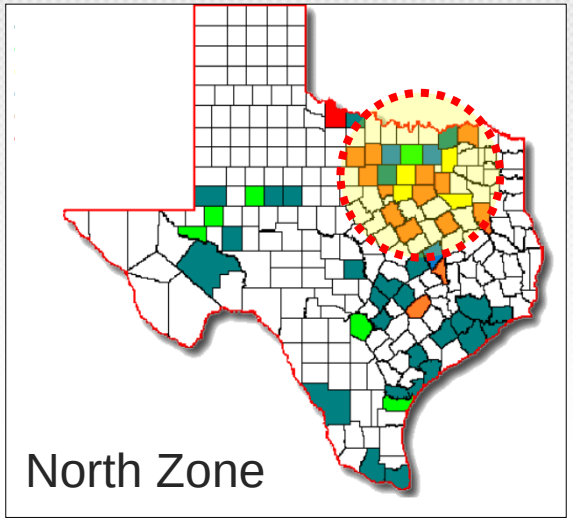
NOx REDUCTIONS USING eGRID

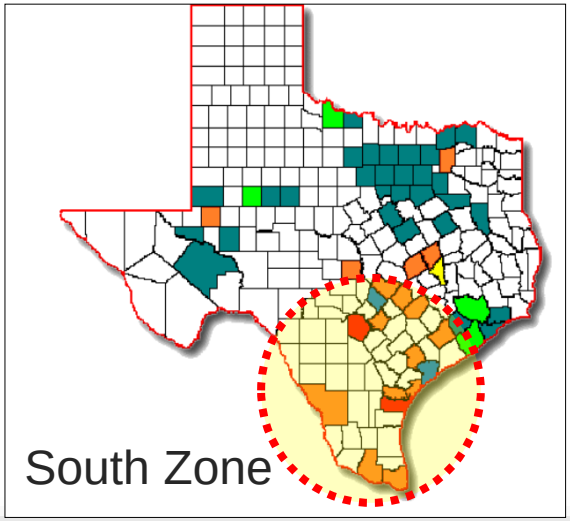
2010 **Annual** eGrid for NOx Emissions

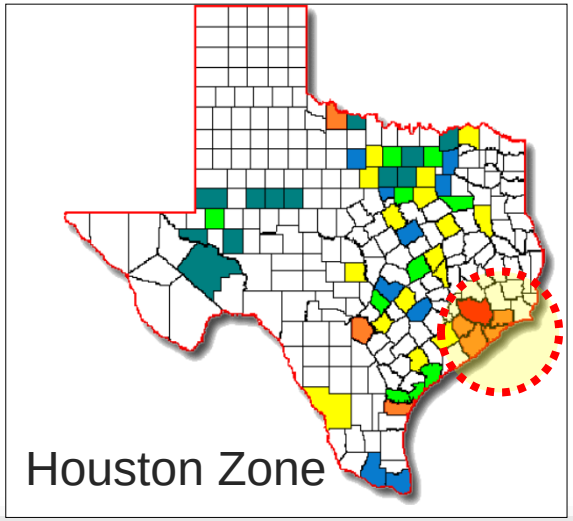
- < 0.0005
- 0.0005 - 0.002
- 0.002 - 0.005
- 0.005 - 0.01
- 0.01 - 0.1
- > 0.1

Unit: lbs of NOx/MWh



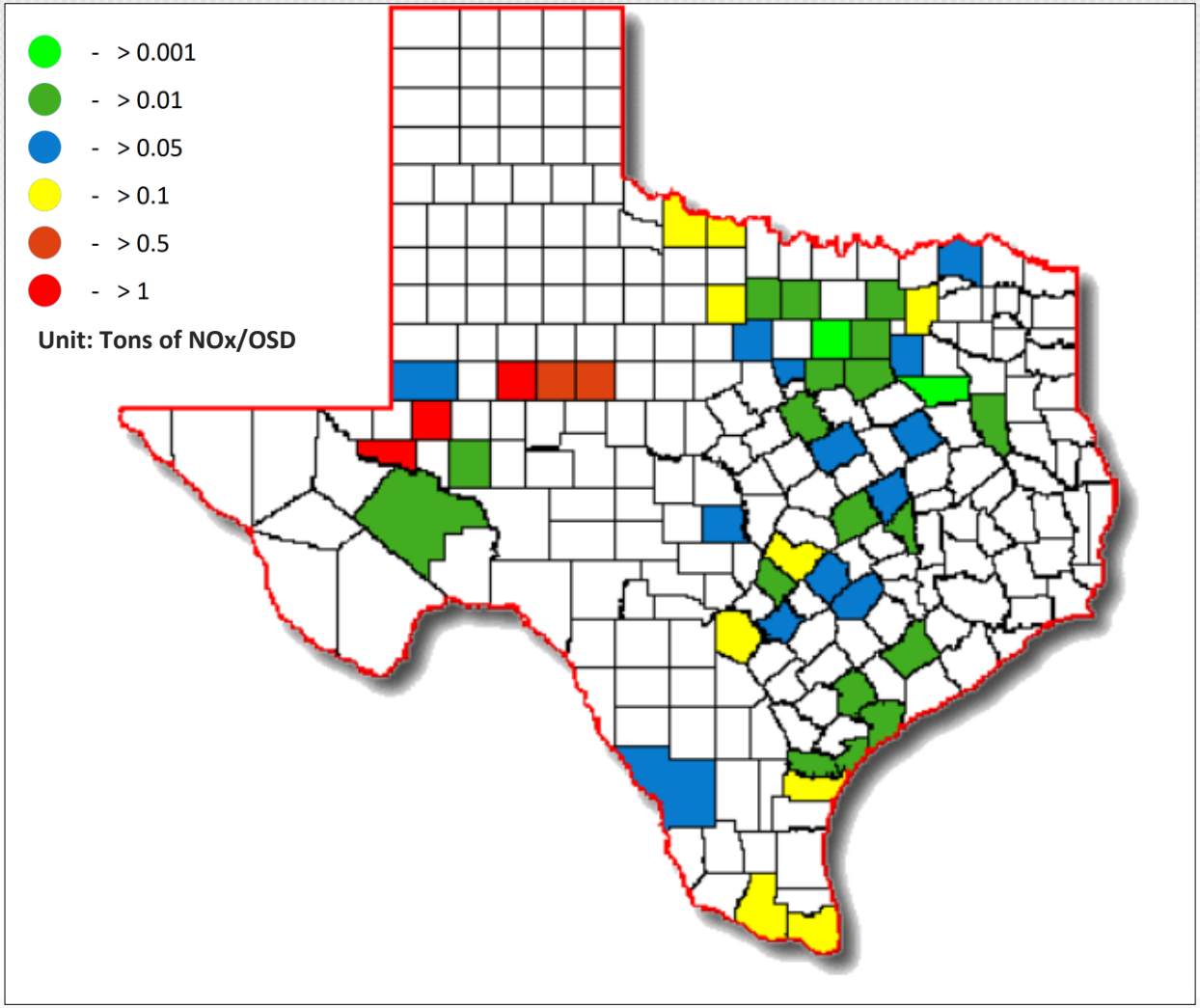






NOx REDUCTIONS USING eGRID

2010 OSD eGrid for NOx Emissions

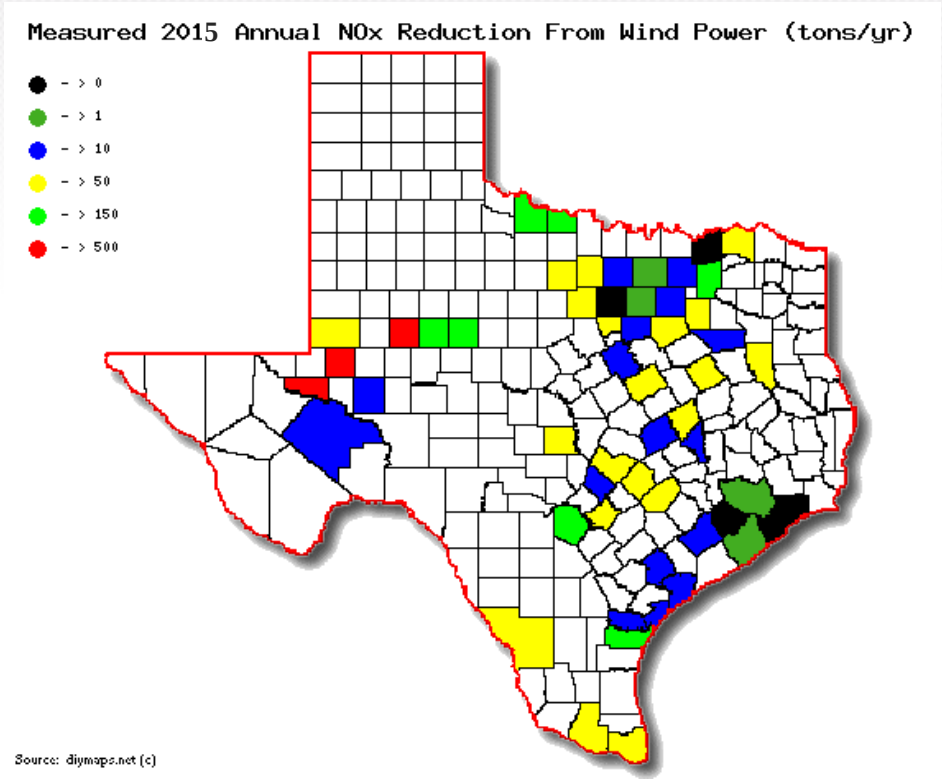


NOx REDUCTIONS USING eGRID

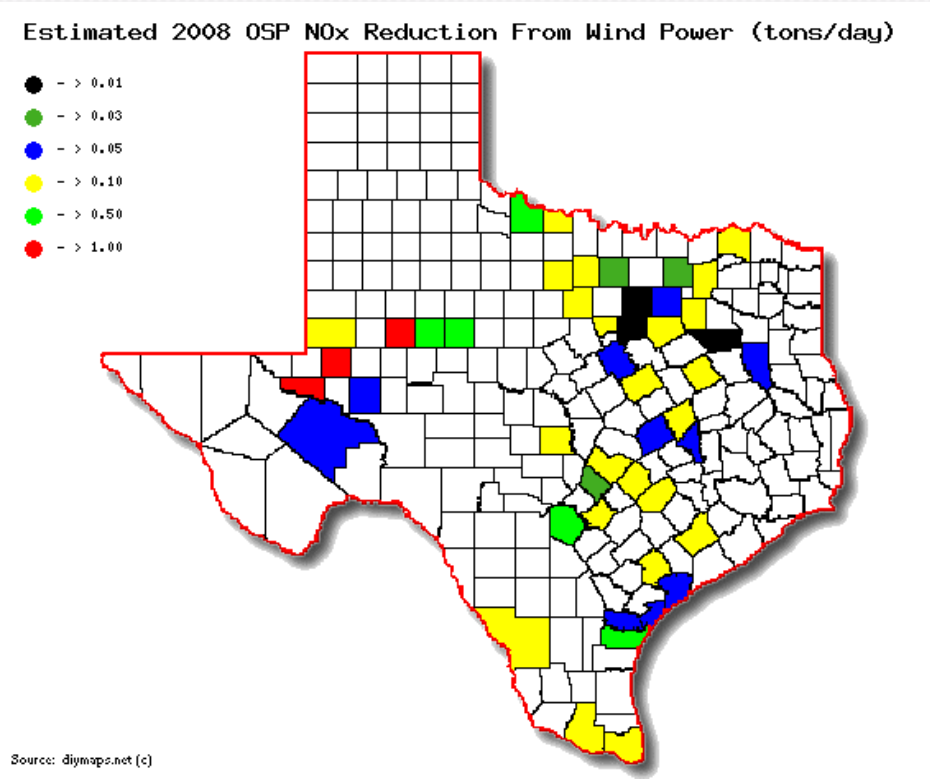
Calculation of NOx Emissions from **Wind Power** Using 2010 eGRID

Annual NOx Reductions

2015 Measured (Wind Power only)



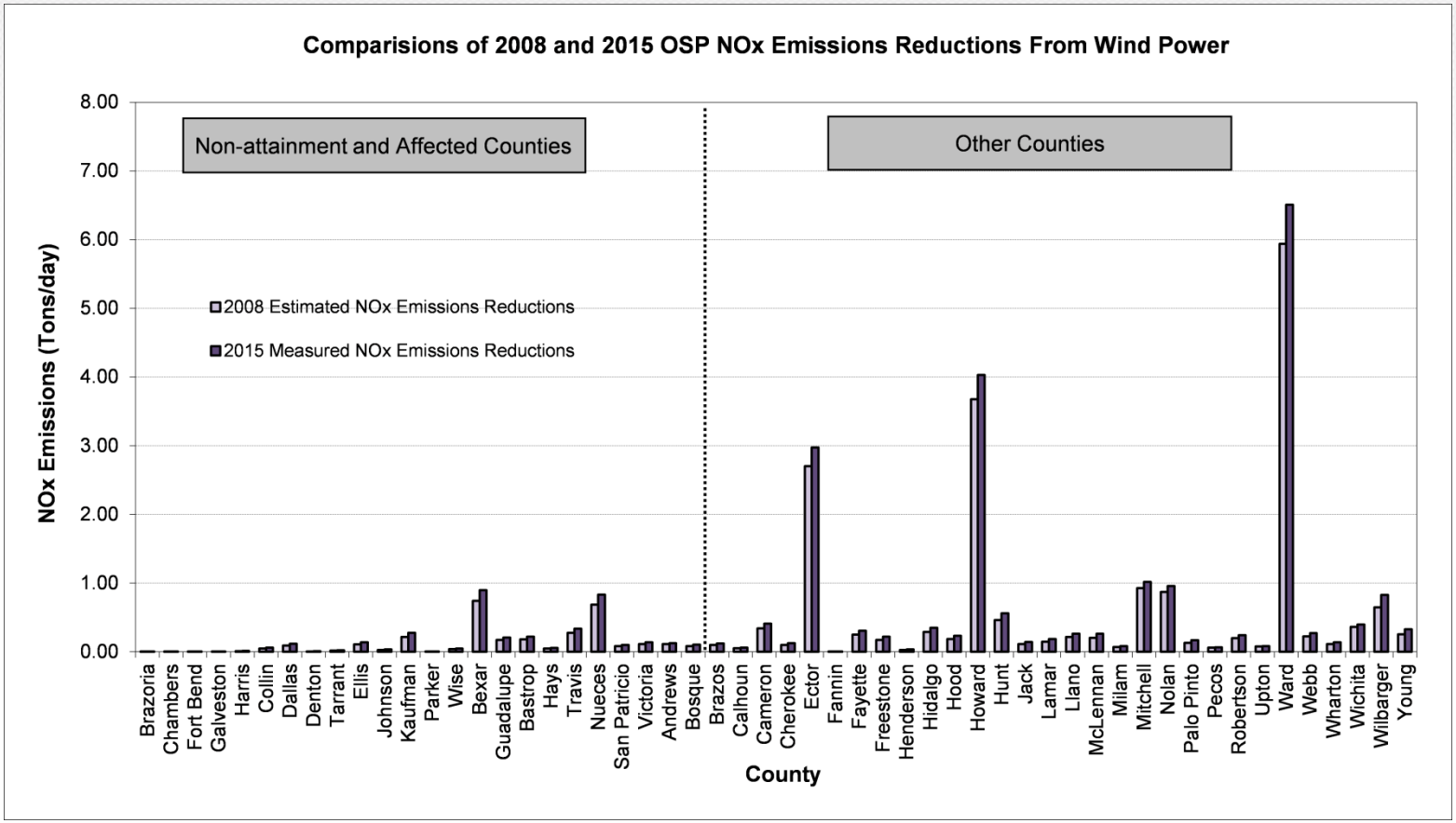
2008 Baseline (Wind Power only)



NOx REDUCTIONS USING eGRID

Calculation of NOx Emissions from **Wind Power** Using 2010 eGRID

Annual NOx Reductions
Comparisons of 2008 and 2015 Annual NOx Emissions

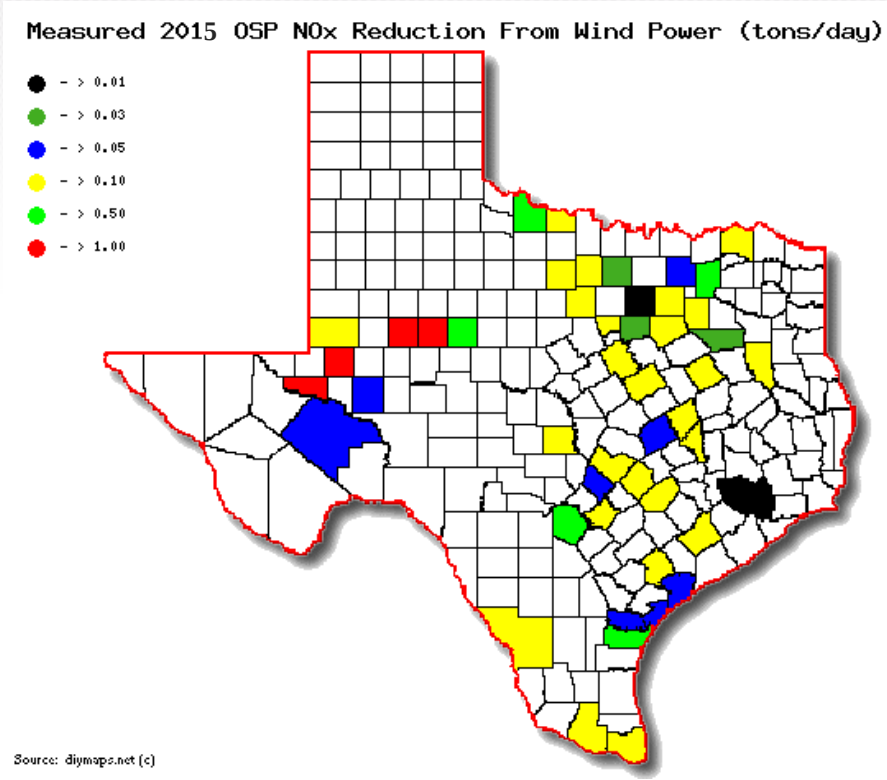


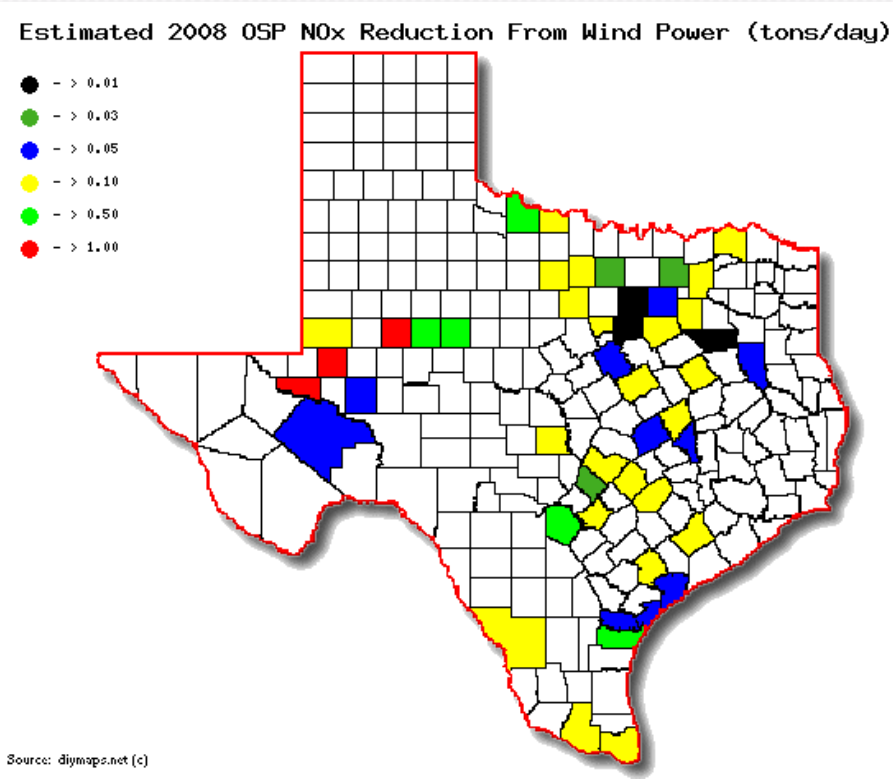
NOx REDUCTIONS USING eGRID

Calculation of NOx Emissions from **Wind Power** Using 2010 eGRID

OSP NOx Reductions

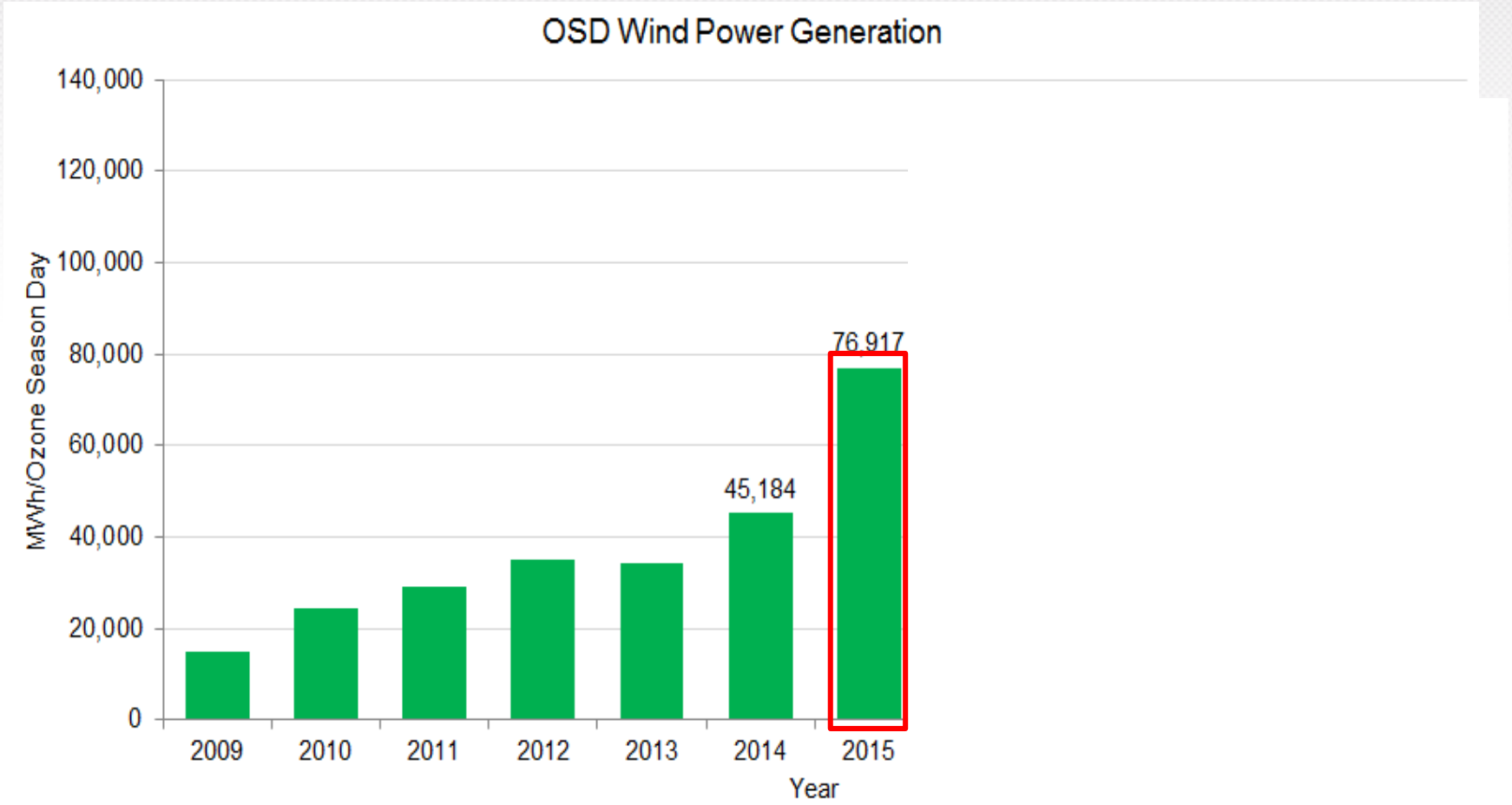
2015 Measured (Wind Power only) 2008 Baseline (Wind Power only)





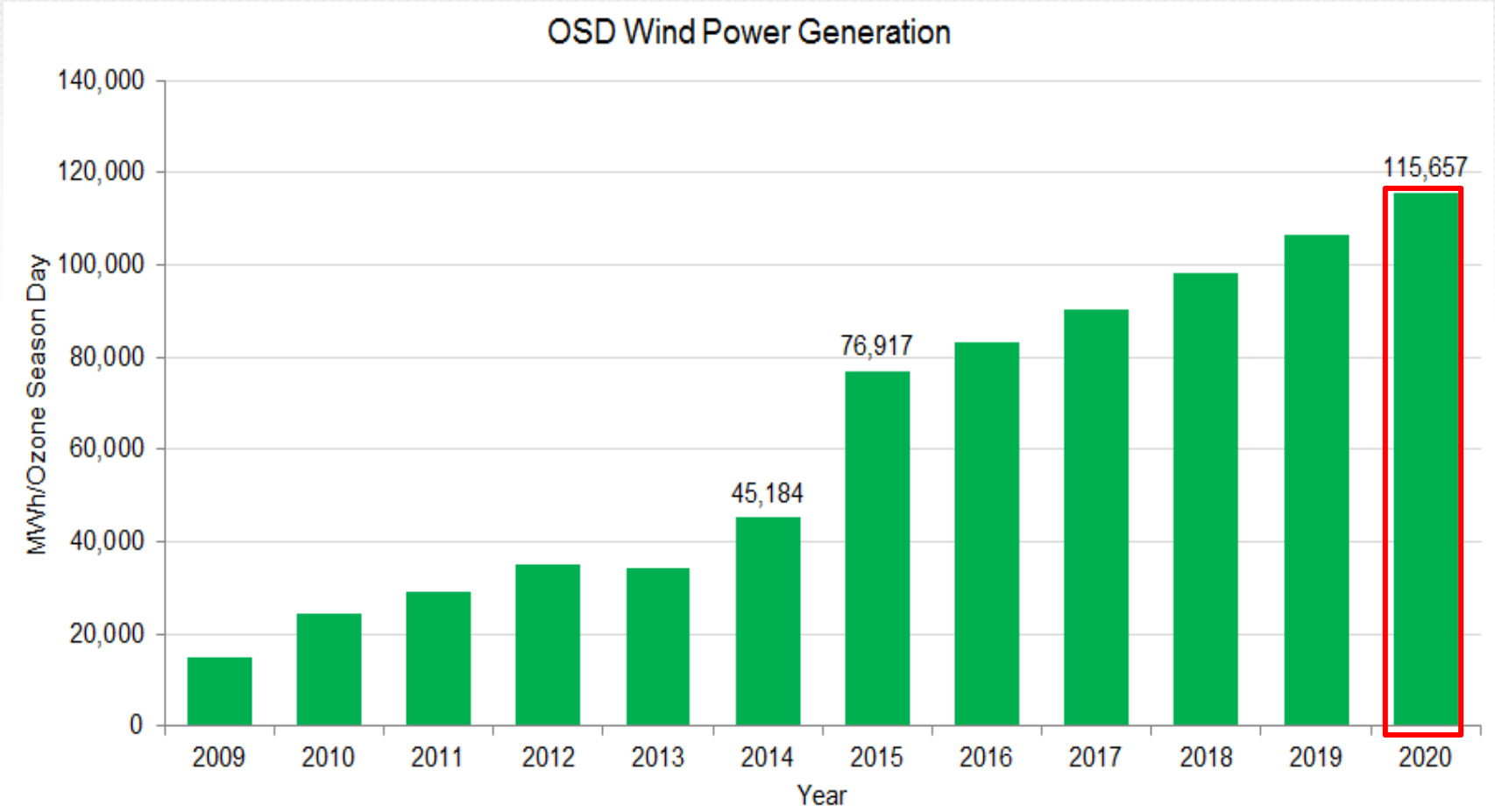
NOx REDUCTIONS FROM WIND POWER

OSD Power Generation and NOx Emissions Reductions (2008 base year)



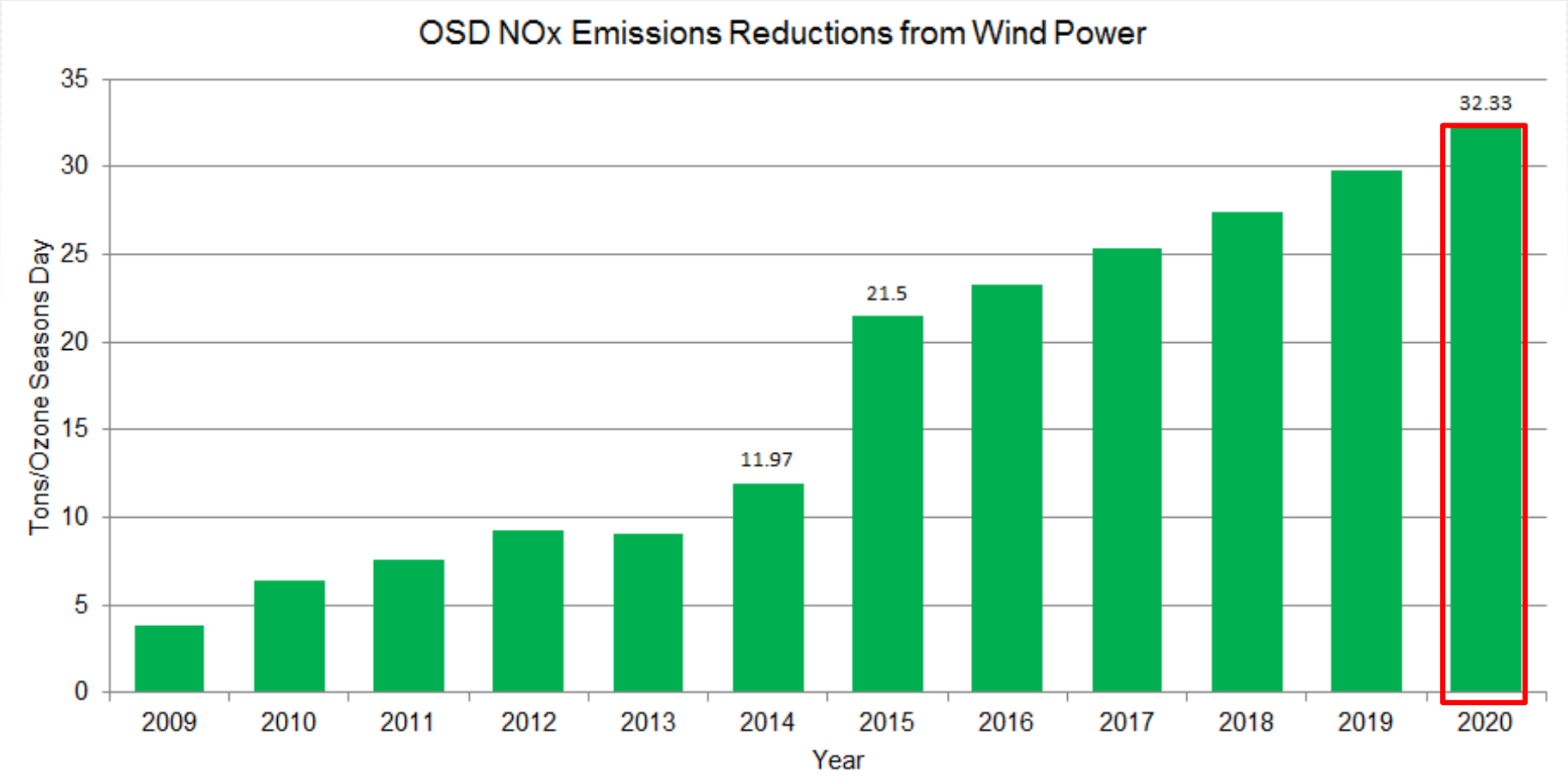
NOx REDUCTIONS FROM WIND POWER

OSD Power Generation and NOx Emissions Reductions (2008 base year)



NOx REDUCTIONS FROM WIND POWER

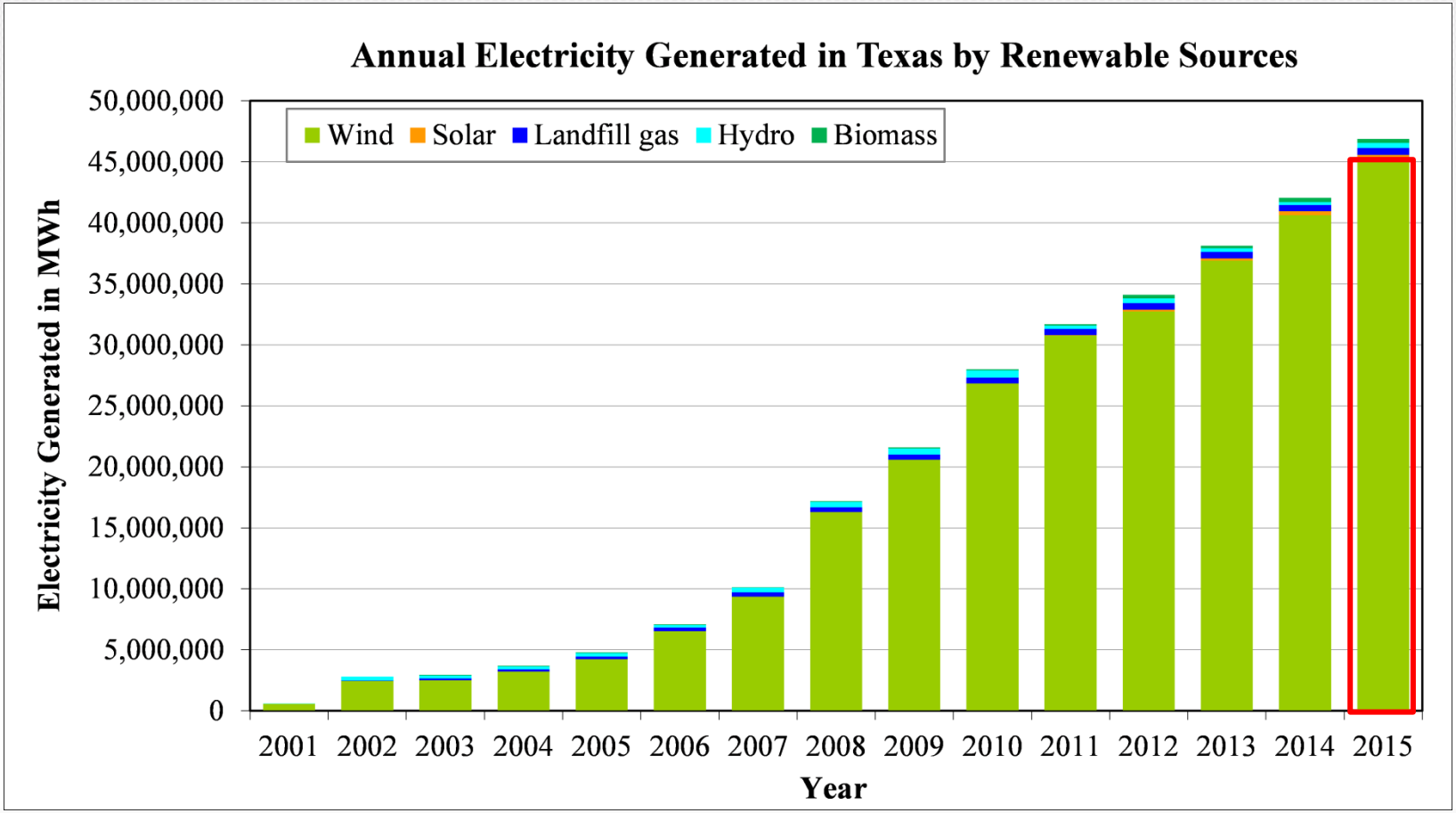
OSD Power Generation and NOx Emissions Reductions (2008 base year)



SAVINGS FROM OTHER RENEWABLES (2001-2015)

Renewables: Biomass, Hydro, Landfill Gas, Solar, Wind

✓ Wind energy is the largest portion



SAVINGS FROM OTHER RENEWABLES (2001-2015)

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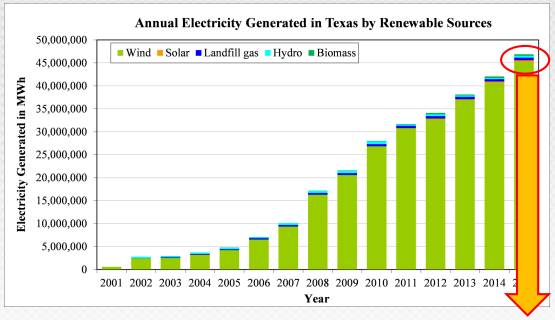
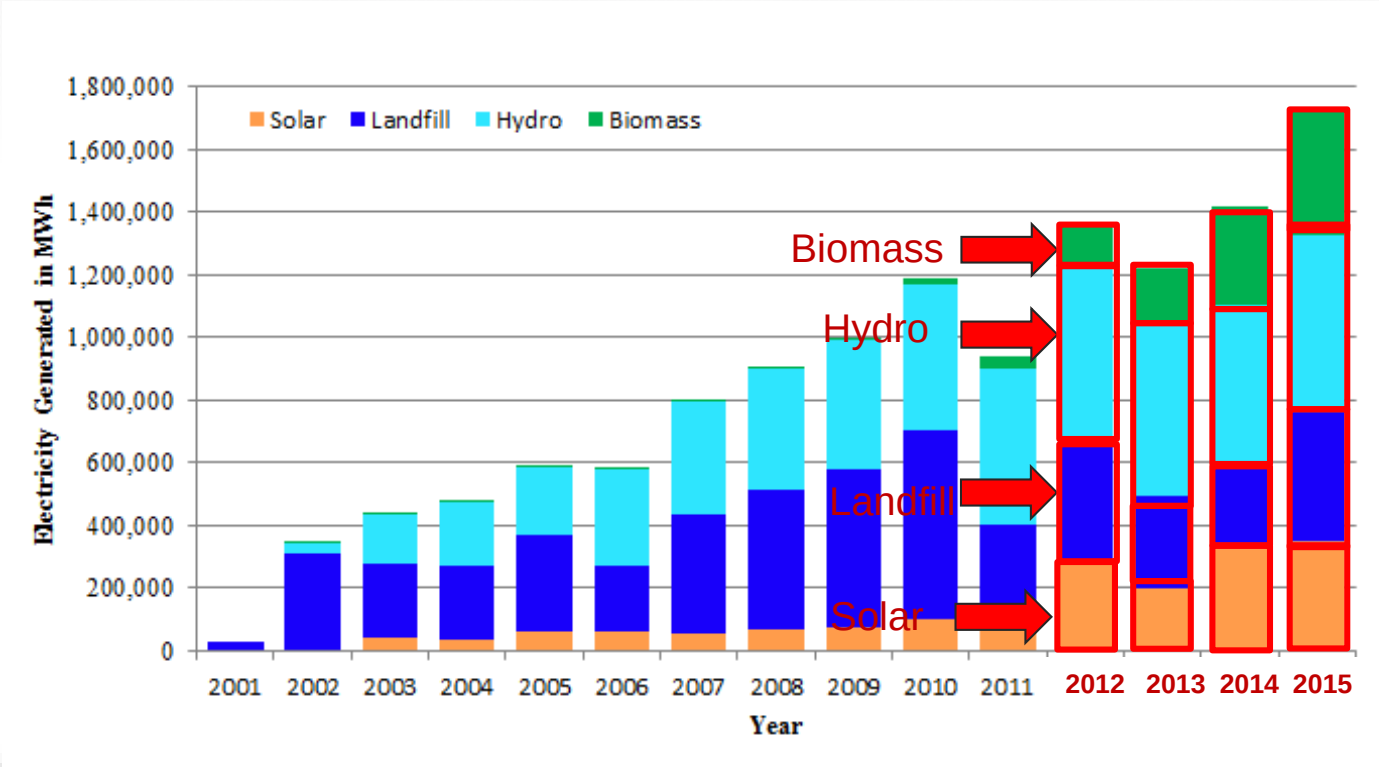
- ✓ Wind energy is the largest portion

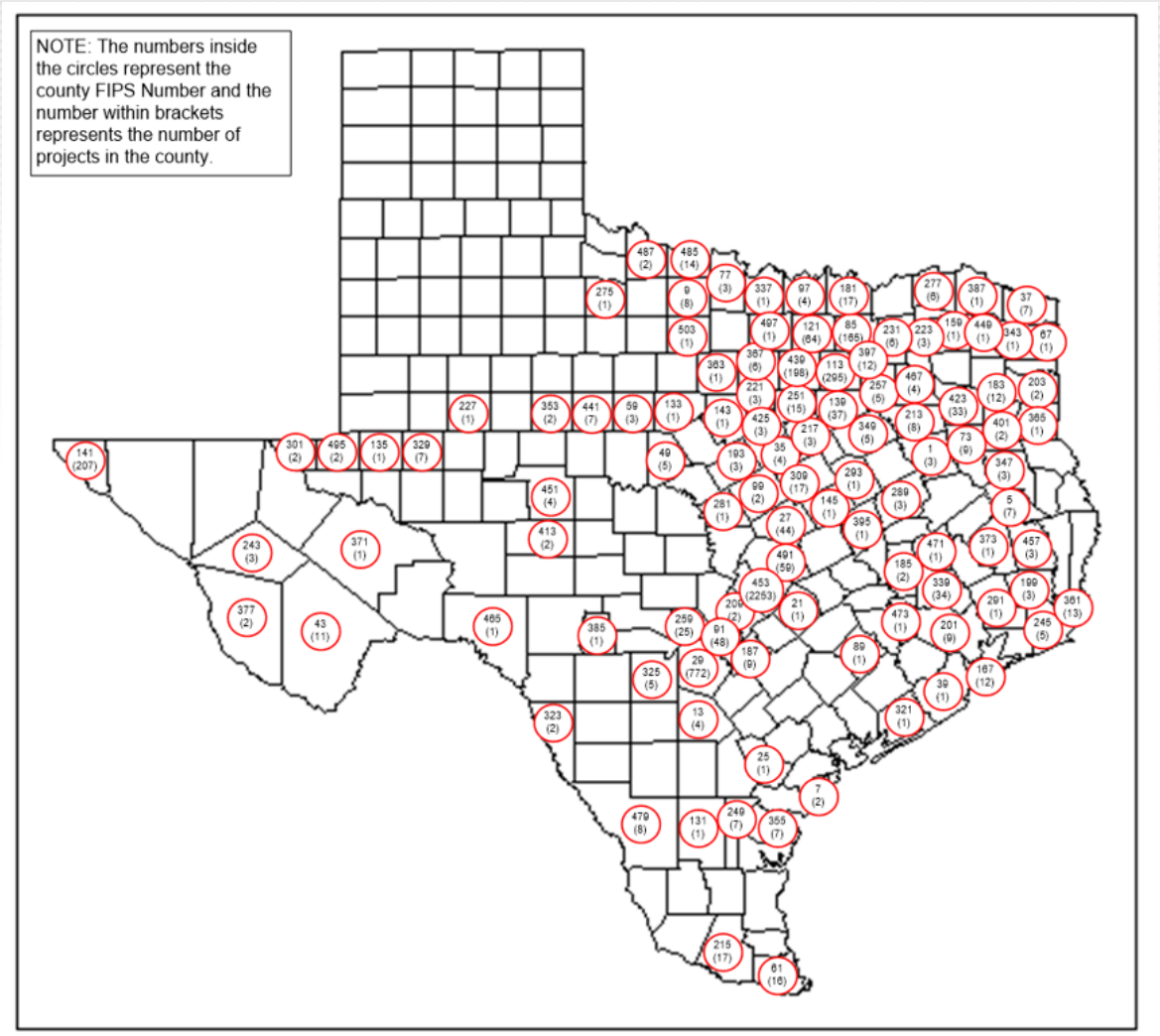


Excluding Wind



RENEWABLE PROJECTS IN TEXAS (2015)

Solar PV

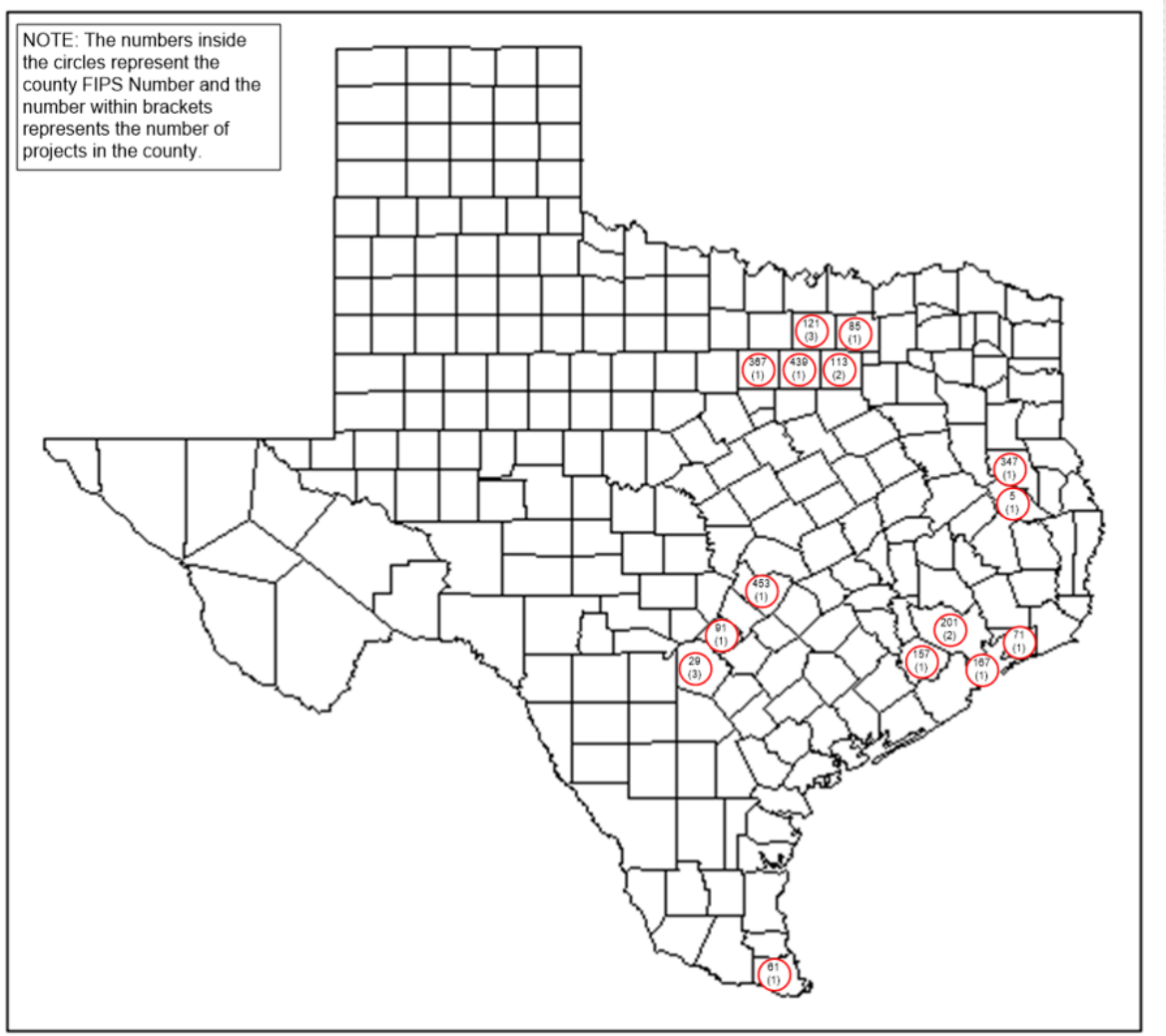


Renewables*:

Solar PV (4,684 projects)

RENEWABLE PROJECTS IN TEXAS (2015)

Biomass



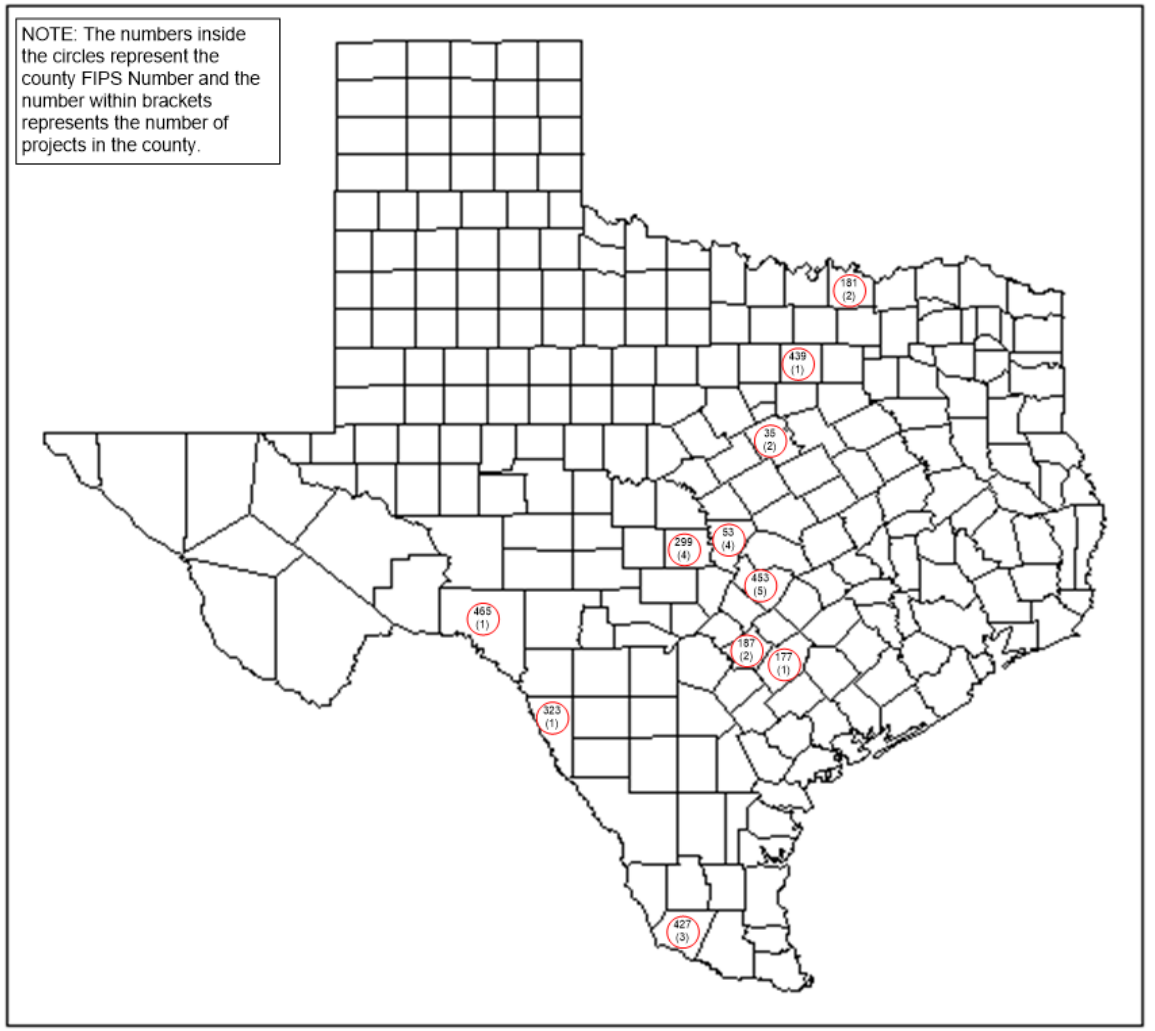
Renewables*:

Solar PV (4,684 projects)

Biomass (21 projects)

RENEWABLE PROJECTS IN TEXAS (2015)

Hydro

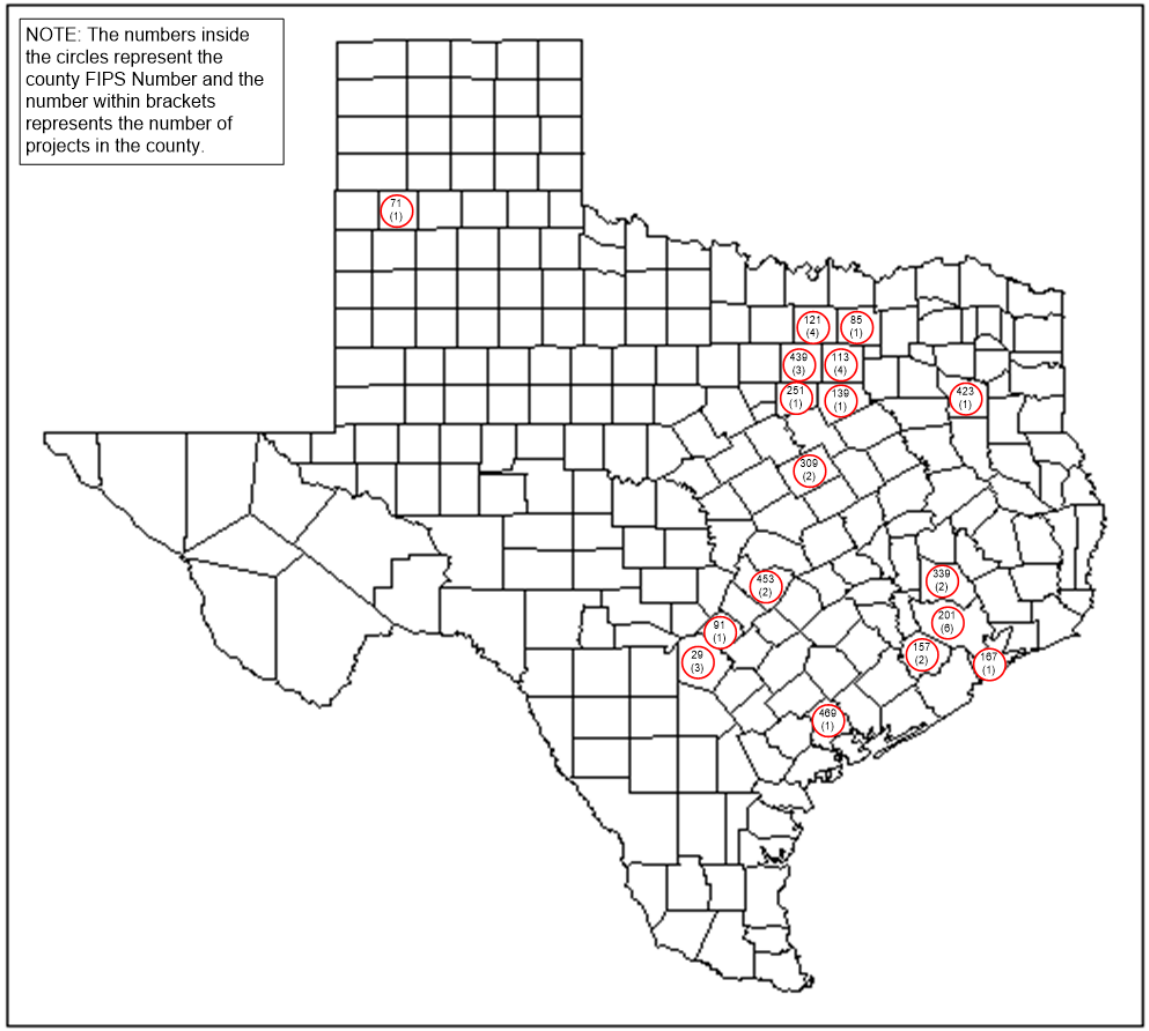


Renewables*:

- Solar PV (4,684 projects)
- Biomass (21 projects)
- Hydro (29 projects)

RENEWABLE PROJECTS IN TEXAS (2015)

Landfill Gas

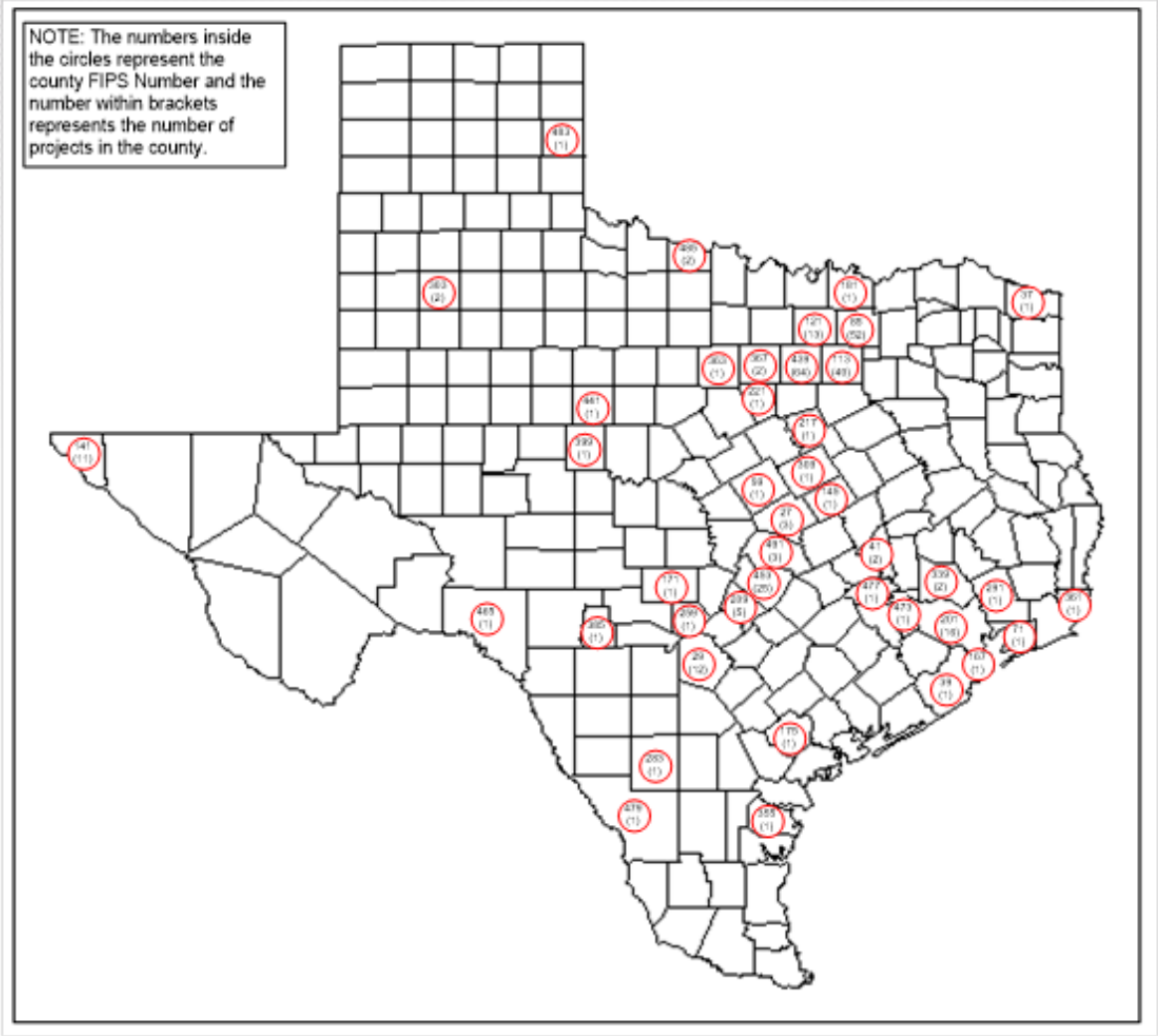


Renewables*:

- Solar PV (4,684 projects)
- Biomass (21 projects)
- Hydro (29 projects)
- Landfill Gas (36 projects)

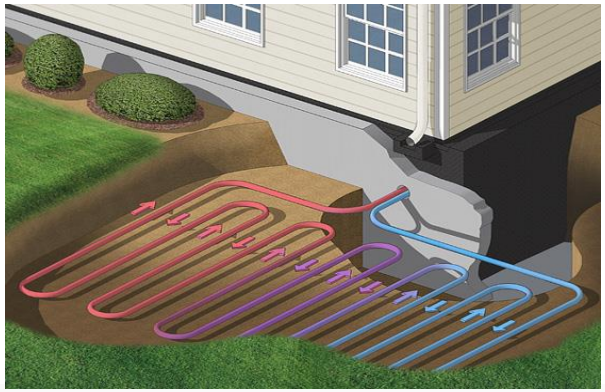
RENEWABLE PROJECTS IN TEXAS (2015)

Geothermal



Renewables*:

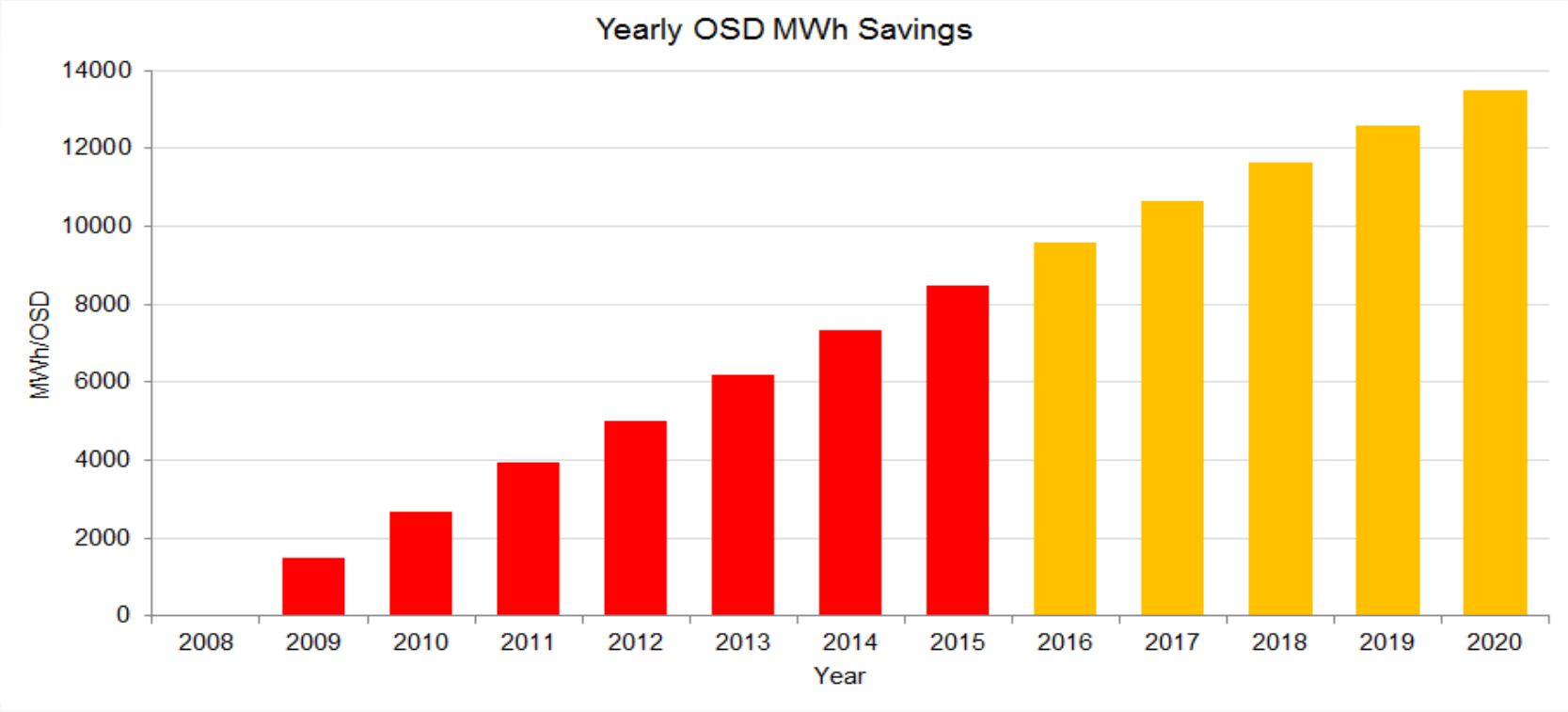
- Solar PV (4,684 projects)
- Biomass (21 projects)
- Hydro (29 projects)
- Landfill Gas (36 projects)
- Geothermal (286 projects)



ENERGY SAVINGS FROM PUC SB7

PUC SB7 Savings and Projections

- The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes their 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.

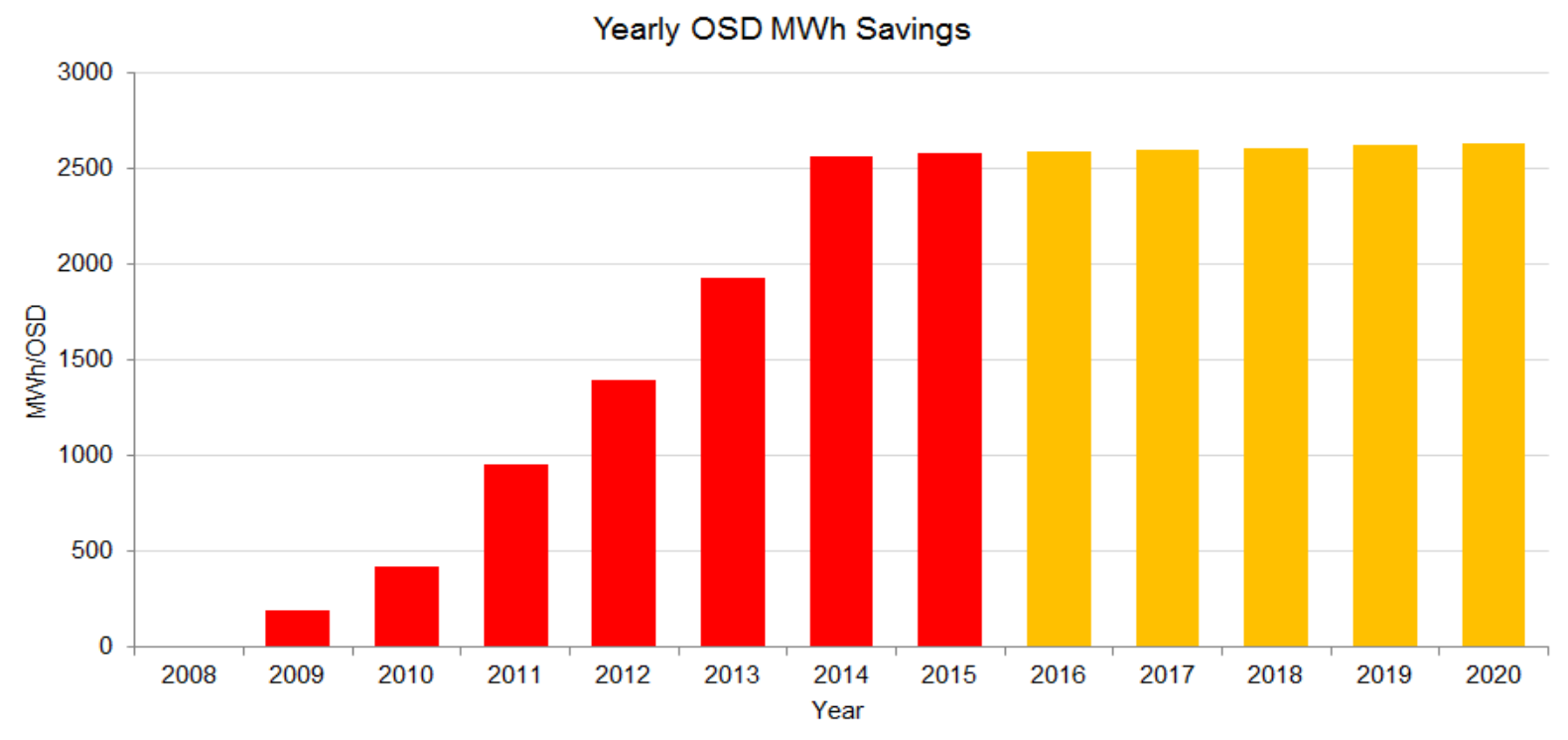


ENERGY SAVINGS FROM SECO

SECO Savings and Projections

SECO
State Energy Conservation Office

- The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers.
- The annual electricity savings are obtained from SECO's energy conservation projects reported by political subdivisions for 47 counties.



INTEGRATED NOx EMISSIONS REDUCTION

Integrated Emissions Savings Across Agencies To Report Savings To TCEQ and EPA

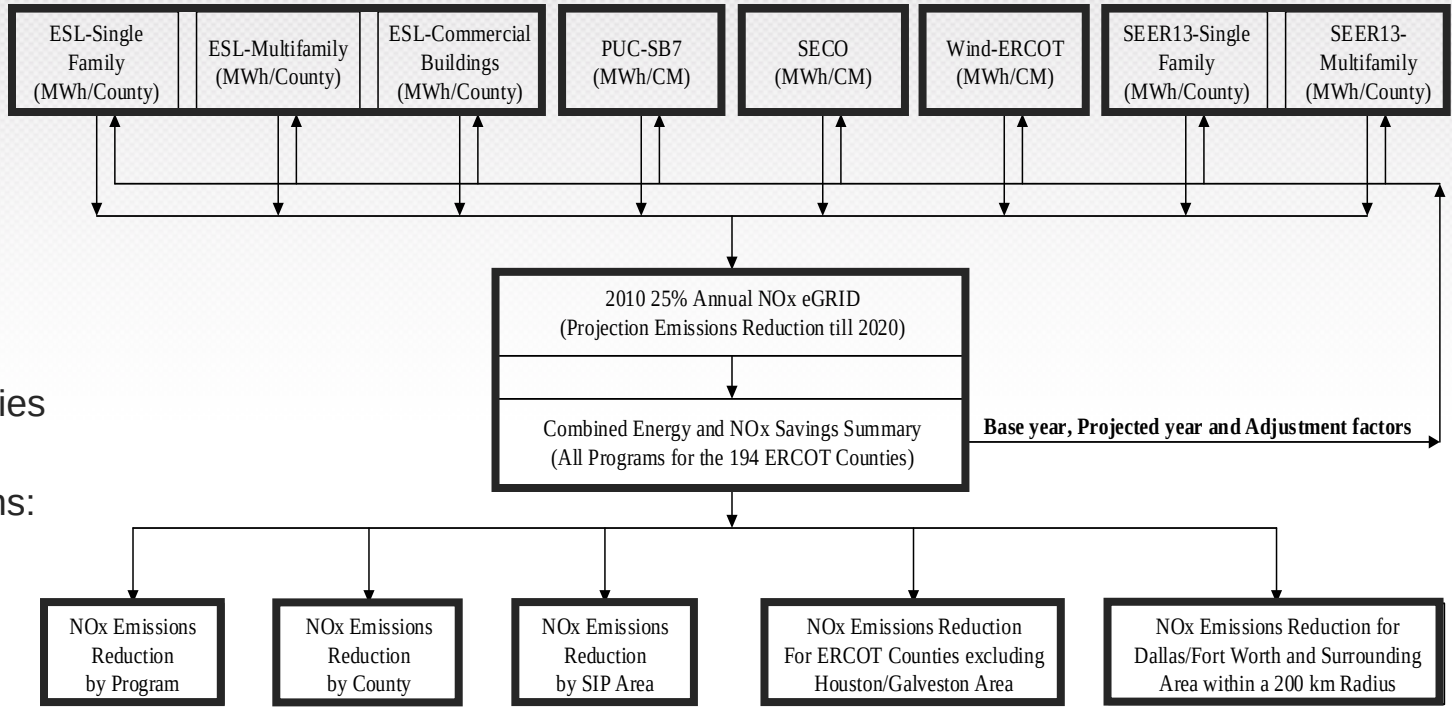
State agencies included:

- **TEES/ESL**
- **PUC**
- **SECO**
- **ERCOT/Wind**
- **SEER 13/14 Single/Multifamily**

Total savings across agencies

Annual emissions reductions:

- **By program**
- **By county**
- **By SIP area**
- **By ERCOT counties**
- **By City and Surrounding Area within a 200km Radius**



TCEQ

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

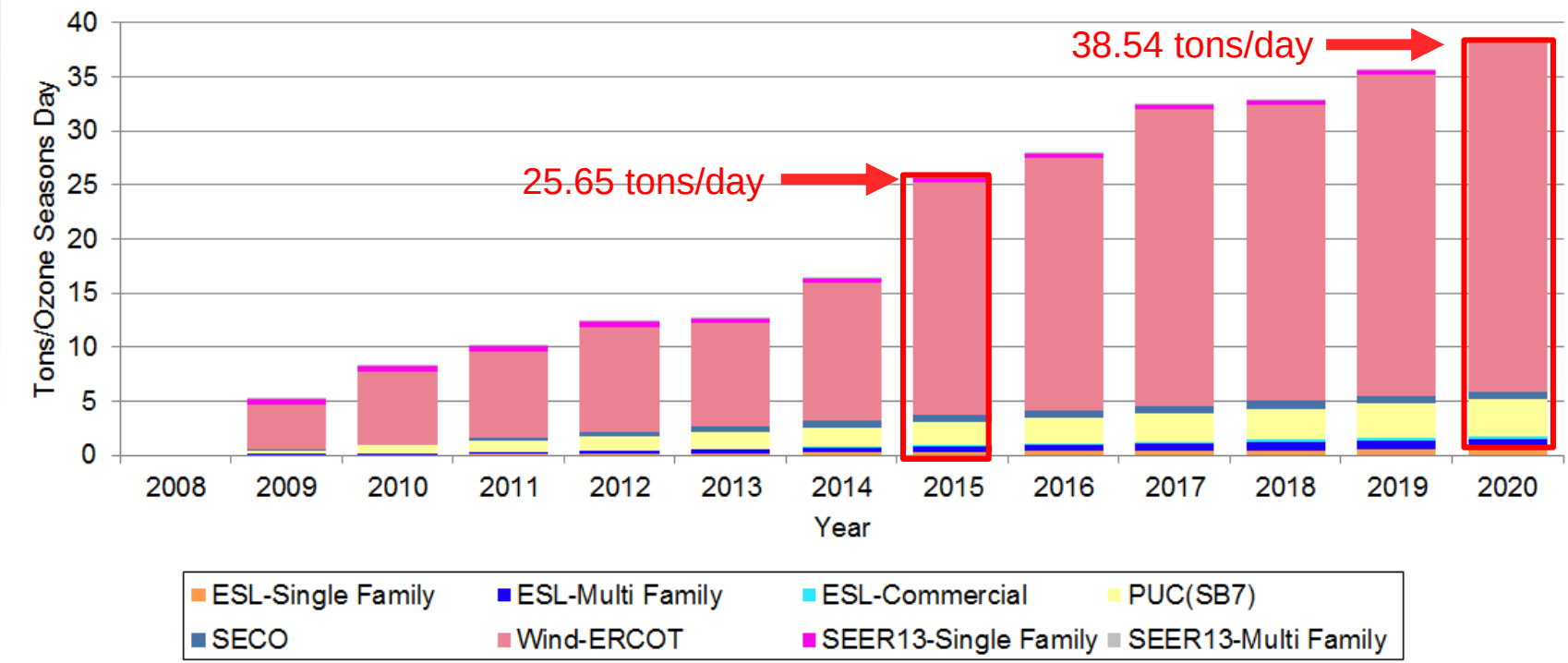
PUBLIC UTILITY COMMISSION OF TEXAS

SECO State Energy Conservation Office

ERCOT

INTEGRATED NOx EMISSIONS REDUTION (2008 Baseyear)

2015 Integrated OSD NOx Emissions Reduction Using new 2010 eGrid



2015 integrated OSD NOx Emissions Reduction

- ESL Code Compliance (0.92 tons/day)
- PUC SB7 programs (2.12 tons/day)
- SECO Political Sub. (0.67 tons/day)
- Green Power (Wind) (21.50 tons/day)
- Residential AC Retrofits (0.45 tons/day)

➢ **Total (2015) (25.65 tons/day)**

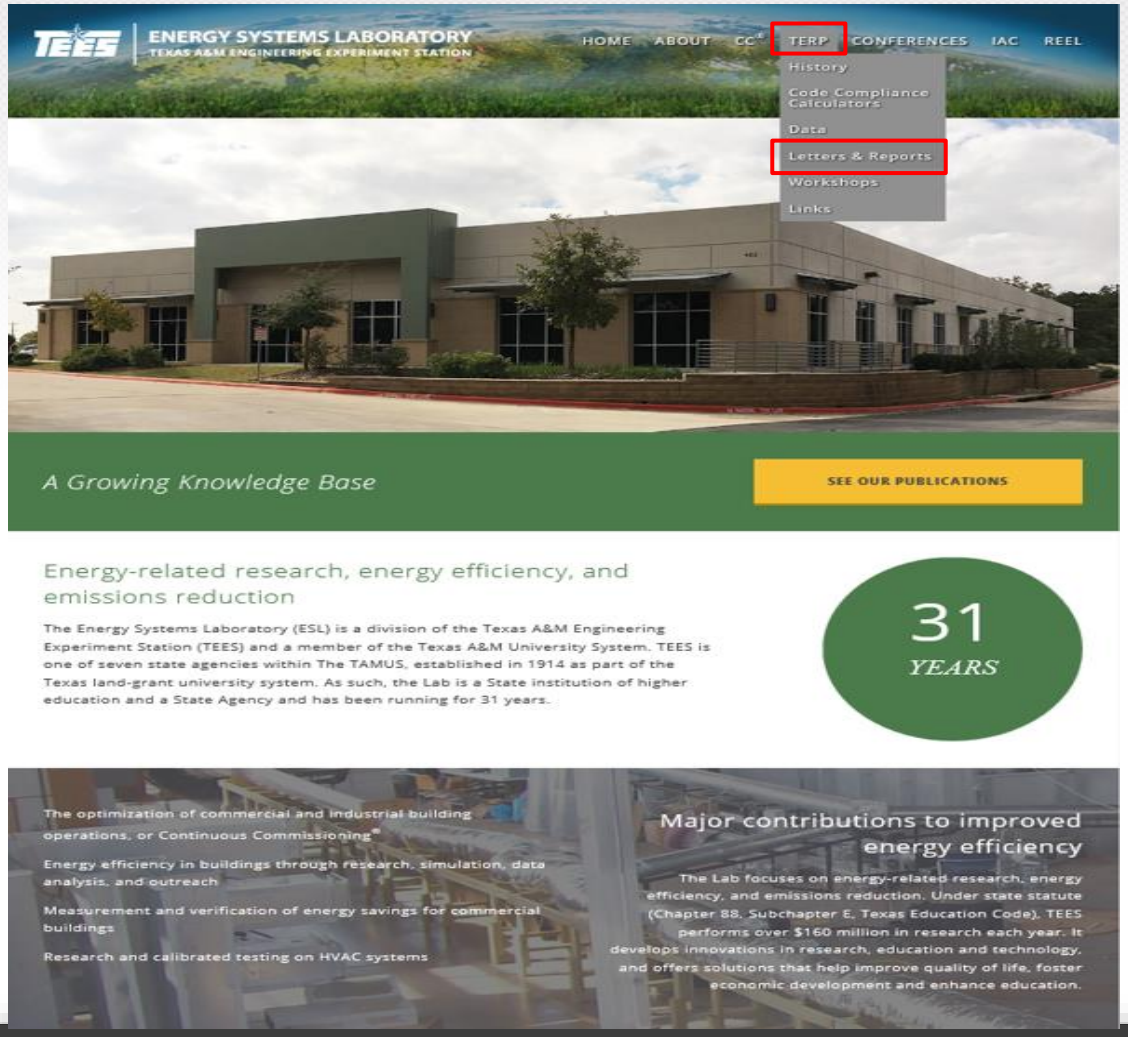
2020 integrated OSD NOx emissions reduction

- ESL Code Compliance (1.80 tons/day)
- PUC SB7 programs (3.37 tons/day)
- SECO Political Sub. (0.69 tons/day)
- Green Power (Wind) (32.33 tons/day)
- Residential AC Retrofits (0.35 tons/day)

➢ **Total (2020) (38.54 tons/day)**

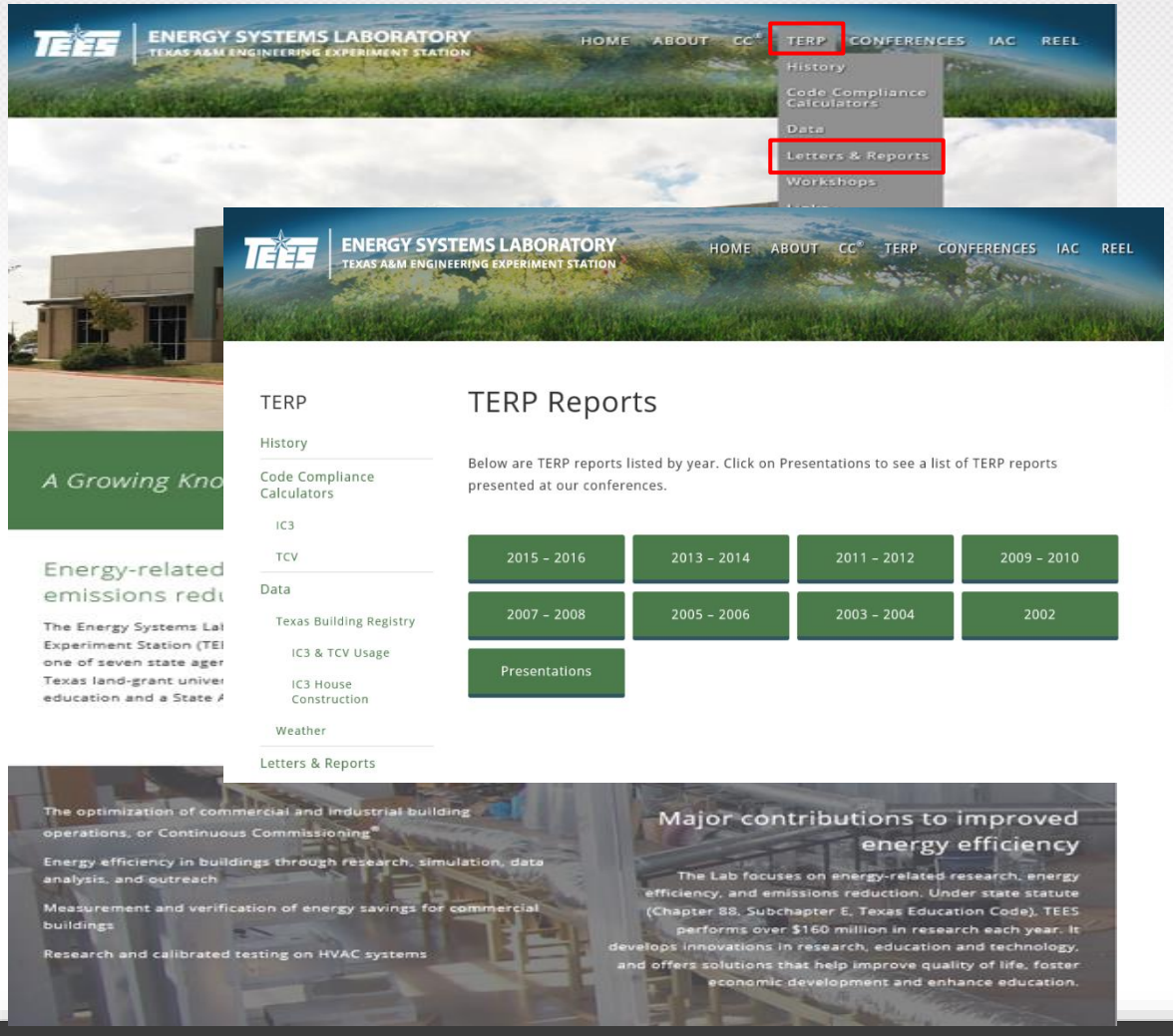
REPORTS AND PAPERS: TERP

ESL Homepage:
http://esl.tamu.edu/terp/documents/terp-reports/



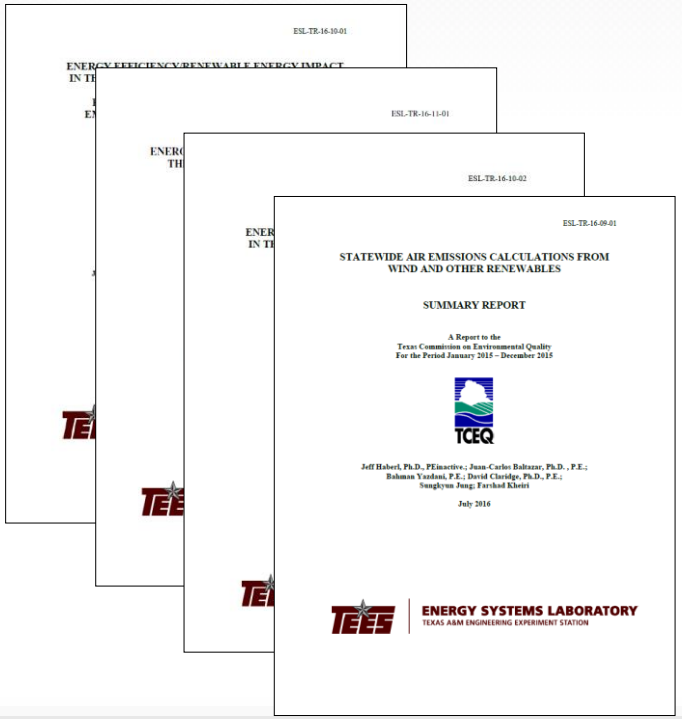
REPORTS AND PAPERS: TERP

Reports: 2002 through 2016



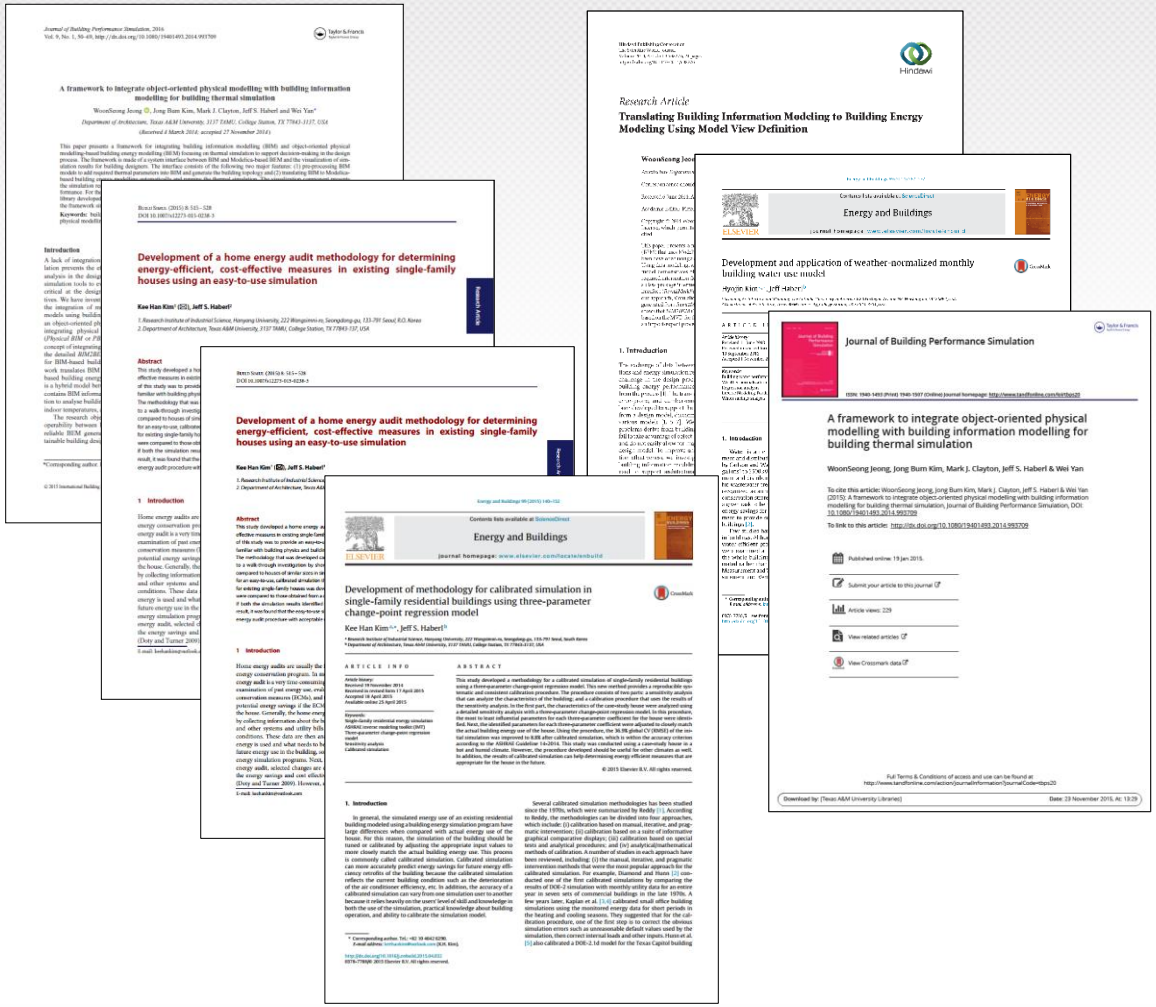
2015 Reports:

- TCEQ 2015Annual Preliminary Report: Integrated NOx Emissions Savings from EE/RE Programs Statewide
- TCEQ 2015Annual Report Volume I: Technical Report
- TCEQ 2015 Annual Report Volume II: Technical Appendix
- Statewide 2015 Air Emission Calculations from Wind and Other Renewables



REPORTS AND PAPERS: TERP

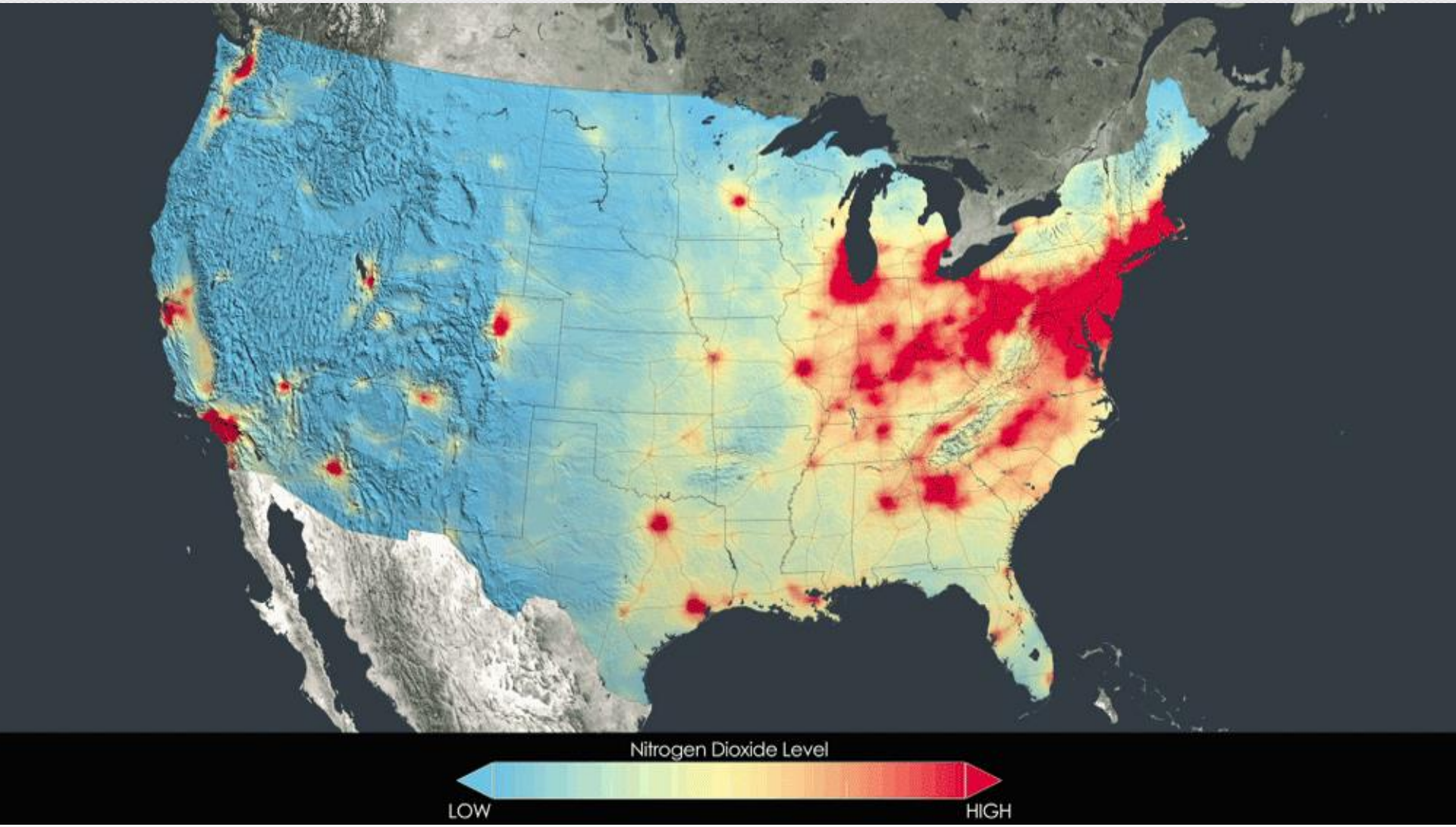
Papers: 2015



Papers 2015:

- A Framework to Integrate Object-Oriented Physical Modelling with Building Information Modelling for Building Thermal Simulation.
- Development of Methodology for Calibrated Simulation in Single-family Residential Buildings using Three-parameter Change-point Regression Model
- Development of a Home Energy Audit Methodology for Determining Energy-Efficient, Cost-Efficient Measures in Existing Single-Family Homes Using an Easy-to-use Simulation
- Enhanced Opportunities for Energy Savings in Industrial Facilities through Long-Term Monitoring
- Qualifying Efficiency Gains of Refrigeration Systems Using Advanced Expansion Valve Technology
- Improving Monthly Weather-Normalized Energy Use Model: Building Energy Use Classification Based on Occupancy
- Development of Methodology for Calibrated Simulation in Single-family Residential Buildings
- Development of a Home Energy Audit Methodology for Determining Energy-Efficient

U.S. AIR QUALITY IMPROVEMENT FROM 2005 - 2015



Source from NASA: http://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/#.U_-CNxzKbxQ

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http://esl.tamu.edu/terp