ESL-TR-14-09-01

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

PRELIMINARY REPORT: INTEGRATED NOX EMISSIONS SAVINGS FROM EE/RE PROGRAMS STATEWIDE

Annual Report to the
Texas Commission on Environmental Quality
January 2013 – December 2013

Jeff Haberl, Ph.D., P.E., Bahman Yazdani, P.E., Juan-Carlos Baltazar, Ph.D., P.E., Patrick Parker, Shirley Ellis, Jaya Mukhopadhyay, Ph.D., Sung Lok Do, Ph.D., Gali Zilbertshtein, Ph.D., David Claridge, Ph.D., P.E.

September 2014

ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M ENGINEERING EXPERIMENT STATION

ENERGY SYSTEMS LABORATORY

September 31, 2014

Chairman Bryan W. Shaw, Ph.D.
Texas Council on Environmental Quality
P. O. Box 13087
Austin, TX 78711-3087

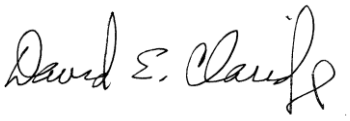
Dear Chairman Shaw:

The Energy Systems Laboratory (ESL) at the Texas Engineering Experiment Station of the Texas A&M University System is pleased to provide this preliminary report, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP): Integrated NOx Emissions Savings from EE/RE Programs Statewide," as required under Texas Health and Safety Code Ann. § 388.003 (e) (Senate Bill 5, 77R as amended 78 R & 78S).

The ESL is required to annually report the energy savings from statewide adoption of the Texas Building Energy Performance Standards in Senate Bill 5 (SB 5), as amended, and the relative impact of proposed local energy code amendments in the Texas non-attainment and near-non-attainment counties as part of the Texas Emissions Reduction Plan (TERP).

Please contact me at (979) 862-8471 should you or any of the TCEQ staff have any questions concerning this report or any of the work presently being done to quantify emissions reductions from energy efficiency and renewable energy measures as a result of the TERP implementation.

Sincerely,



David E. Claridge, Ph.D., P.E., FASHRAE
Director

Enclosure

cc: Commissioner Toby Baker
Commissioner Zak Covar
Executive Director Richard A. Hyde, P. E.

Disclaimer

This report is provided by the Texas Engineering Experiment Station (TEES) as required under Section 388.003 (e) of the Texas Health and Safety Code and is distributed for purposes of public information. The information provided in this report is intended to be the best available information at the time of publication. TEES makes no claim or warranty, express or implied, that the report or data herein is necessarily error-free. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or favoring by the Energy Systems Laboratory or any of its employees. The views and opinions of authors expressed herein do not necessarily state or reflect those of the Texas Engineering Experiment Station or the Energy Systems Laboratory.

PRELIMINARY REPORT:
INTEGRATED NOX EMISSIONS SAVINGS FROM EE/RE STATEWIDE

Energy Efficiency/Renewable Energy Impact
In The Texas Emissions Reduction Plan

Executive Summary

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of the Texas A&M University System, in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), submits this annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (Preliminary Report) to the Texas Commission on Environmental Quality.

This preliminary report shows the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2020 for both the annual and Ozone Season Day (OSD)[1] NOx reductions. The year of 2008 was used for the baseline year to estimate the emissions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2010 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose.

In 2013, the integrated total electricity savings from all programs are:

- Annual electricity savings is 19,704,209 MWh/year (5,397 tons-NOx/year) and
- OSD electricity savings is 45,262 MWh/day, which would be a 1,886 MW average hourly load reduction during the OSD period (12.22 tons-NOx/day).

By 2015, the integrated total electricity savings from all programs are:

- Annual electricity savings will be 22,508,426 MWh/year (6,133 tons-NOx/year) and
- OSD electricity savings will be 51,958 MWh/day, which would be a 2,165 MW average hourly load reduction during the OSD period (13.96 tons-NOx/day).

A summary of the savings for 2013 and 2015 is presented in the table below. (Base year 2008)

	2013	2015
Annual Electricity Savings (MWh/year)	19,704,209	22,508,426
Annual Emissions Reductions (tons NOx/year)	5,397	6,133
OSD Electricity Savings (MWh/day)	45,262	51,958
OSD Emissions Reductions (tons NOx/day)	12.22	13.96

[1] An ozone season day (OSD) represents the daily average emissions during the period that runs from mid-July to mid –September.

Legislative Background

In 2001, the Texas Emissions Reduction Plan (TERP), established by the 77th Texas Legislature with the enactment of Senate Bill 5 (SB 5), identified that Energy Efficiency and Renewable Energy (EE/RE) measures make an important contribution to a comprehensive approach for meeting the minimum federal ambient air quality standards. In 2003 through 2007, the 78th, 79th and 80th Legislatures enhanced the use of EE/RE programs for meeting the TERP. The 78th Legislature enhanced the use of EE/RE programs for meeting TERP goals by requiring the Texas Commission on Environmental Quality (TCEQ) to promote EE/RE as a means to improve air quality standards and to develop a methodology for computing emissions reduction for use in the State Implementation Plan (SIP) from EE/RE programs.

The 79th Legislature expanded the scope of the SIP-eligible credits by adding savings from the State Renewable Portfolio Standards from the generation of electricity from renewable sources; specifically requiring the TCEQ to develop methods to quantify emissions reductions from renewable energy; and required the Laboratory to develop at least 3 alternative methods for achieving a 15 percent greater potential energy savings in residential, commercial and industrial construction.

In the 80th Legislature several new energy efficiency initiatives were introduced, including: requiring the Laboratory to provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC), or the International Energy Conservation Code (IECC), are equivalent to or better than the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC; requiring the Laboratory to develop a standardized report format to be used by providers of home energy ratings; and encouraging the Laboratory to cooperate with an industry organization or trade association to develop guidelines for home energy ratings, including training.

The 81st Legislature (2009) extended the data of the TERP to 2019 and required the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

The 82nd Legislature (2011), the Laboratory's responsibilities under TERP increased as new legislatively allocated energy efficiency initiatives were introduced.

The 83rd Legislature (2013) the Laboratory's responsibilities under TERP kept the same as previous years.

Calculation of Integrated NOx Emissions Reductions from Multiple State Agencies Participating in the Texas Emissions Reduction Plan (TERP)

In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 could be reported in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2020 for both the annual and Ozone Season Day (OSD) NOx reductions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2010 from the US

Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose. The different programs included in this 2013 integrated analysis are:

- ESL Single-family new construction
- ESL Multi-family new construction
- ESL Commercial new construction
- PUC Senate Bill 7 Program
- SECO Senate Bill 5 Program
- Electricity generated by wind farms in Texas (ERCOT)[2]
- SEER 13 upgrades to Single-family and Multi-family residences

The Laboratory's single-family and multi-family programs include the energy savings attained by constructing new residences in Texas. The baseline to estimate energy savings uses the published data on residential construction characteristics by the 2008 National Association of Home Builders (NAHB 2008) based on the IECC 2006 building code (ICC 2006). Annual electricity savings (MWh) are obtained from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002 - 2013).

The Laboratory's commercial program includes the energy savings attained by constructing new commercial buildings in Texas, including office, apartment, healthcare, education, retail, food and lodging as defined by Dodge building type (Dodge 2011). Energy savings were estimated from code compliant buildings (ASHRAE Standard 90.1-2007) against pre-code buildings (ASHRAE Standard 90.1-2004) using EUI in the USDOE report and constructed square footage in Dodge data (Dodge 2014).

The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes the energy efficiency programs implemented by electric utilities under the Public Utility Regulatory Act §39.905. The PUC regulated energy efficiency program was adopted pursuant to 1999 legislation (SB 7) and subsequent legislation in 2001 (SB 5), 2007 (HB 3693), and 2011 (SB 1125). The energy efficiency measures include high efficiency HVAC equipment, variable speed drives, increased insulation levels, infiltration reduction, duct sealing, Energy Star Homes, etc. Annual electricity savings claimed by the utilities were reported for the different programs completed in the years 2001 through 2013.

The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs that are directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers. For the 2013 reporting year SECO submitted annual energy savings values for projects funded by SECO and by Energy Service projects.

The *Electric Reliability Council of Texas (ERCOT) electricity production from currently installed green power generation (wind)* in Texas is reported. Actual measured electricity productions for 2001 through 2013 were included. For projections to 2020, the annual growth factor was estimated using the last five years installed wind power capacity.

Finally, NOx emissions reductions from *the installation of SEER 13 air conditioners in existing residences* are also reported.

[2] ERCOT is the Electric Reliability Council of Texas.

Description of the Analysis Method

Annual and Ozone Season Day (OSD) NOx emissions reductions were calculated for 2013 and integrated from 2009 to 2020 using several factors to discount the potential savings. These factors include an annual degradation factor, a transmission and distribution factor, a discount factor, and growth factors as shown in Table 1 and are described as follows:

Annual degradation factor: This factor was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. With the exception of electricity generated from wind, an annual degradation factor of 2% was used for ESL Single-family, Multi-family, and Commercial programs and an annual degradation factor of 5% was used for all other programs[3]. The value of the 5% degradation factor was taken from a study by Kats et al. (1996).

Transmission and distribution loss: This factor adjusts the reported savings to account for the loss in energy resulting from the transmission and distribution of the power from the electricity producers to the electricity consumers. For this calculation, the energy savings reported at the consumer level are increased by 7% to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer. In the case of electricity generated by wind, the T&D losses were assumed to cancel out since wind energy is displacing power produced by conventional power plants; therefore, there is no net increase or decrease in T&D losses.

Initial discount factor: This factor was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures. For the Laboratory's single, multi-family and commercial program, the discount factor was assumed to be 20%. For PUC's Senate Bill 7 program and electricity from wind, the discount factor was taken as 10%. For the savings in the SECO program, the discount factor was 60%. In addition, the discount factor for SEER 13 single-family and SEER 13 multi-family program was 20%.

Growth factor: The growth factors shown in Table 1 were used to account for several different factors. Growth factors for single-family (3.3%), multi-family residential (1.5%), and commercial (3.3%) construction are projections based on the average growth rate for these housing types from recent U.S. Census data for Texas. Growth factor for wind energy (3.9%) is a linear projection based on the installed wind power capacity for 2009 through 2012 from the Public Utility Commission of Texas. No growth was assumed for PUC programs, SECO, and SEER 13 entries.

Figure 1 shows the overall information flow that was used to calculate the NOx emissions savings from the annual and OSD electricity savings (MWh) from all programs. For the Laboratory's single-family and multi-family code-implementation programs, the annual and OSD were calculated from DOE-2 hourly simulation models[4]. The base case is taken as the average characteristics of single- and multi-family residences for Texas published by the National Association of Home Builders for 2008 (NAHB 2008). The annual electricity savings from PUC's energy efficiency programs were calculated using PUC approved demand savings calculations or tables or industry accepted measurement and verification methods (PUC 2014).

[3] A degradation of 5% per year would accumulate as a 5%, 10%, 15%...etc, degradation in performance. Although the assumption of this high level of degradation may not actually occur, it was chosen as a conservative estimate. For wind energy, a degradation factor of 0% was used. The choice of a 0% degradation factor for wind is based on two year's of analysis of measured wind data from all Texas wind farms that shows no degradation, on average, for a two year period after the wind farms became operational.
[4] These values are based on a performance analysis as defined by Chapter 4 of IECC 2006. This analysis is discussed in the Laboratory's annual reports to the TCEQ.

The OSD consumption is the average daily consumption for the period between July 15 and September 15.

The SECO electricity savings were submitted as annual savings by project[5]. A description of the measures completed for the project was also submitted for information purposes. The electricity production from wind farms in Texas was from the actual on-site metered data measured at 15-minute intervals.

Integration of the savings from the different programs into a uniform format allowed for creditable NOx emissions to be evaluated using different criteria as shown in Table 1. These include evaluation across programs, evaluation across individual counties by program, evaluation by SIP area, evaluation for all ERCOT counties except Houston/Galveston, and evaluation within a 200 km radius of Dallas/Ft.Worth.

Calculation Procedure

The electricity savings in this report was estimated based on the baseline year of 2008. In addition, the emissions estimation throughout this report was based on the 2010 eGrid database which is using the four different Congestion Management (CM) zones: Houston, North, West, and South. This report calculates the OSD emissions reductions by dividing the annual emissions reductions with 365 since the 2010 eGrid estimates the annual emissions only. However, the OSD emissions reductions from the Electricity Generated by Wind Farms were estimated by actual measured data.

ESL Single-family and Multi-family. The calculation of the annual electricity savings reported for the years 2002 through 2013 included the savings from code-compliant new housing in all 41 non-attainment and affected counties as reported in the Laboratory's annual report submitted by the Laboratory to the Texas Commission of Environmental Quality (TCEQ). From 2009 to 2013, based on year 2008, the annual electricity savings were calculated for new residential construction in all the counties in ERCOT region, which includes the 41 non-attainment and affected counties. These savings were then tabulated by county and program. Using the calculated values through 2013, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above.

In these calculations, it was assumed that the same amount of electricity savings from the code-complaint construction would be achieved for each year after 2013 through 2020[6]. The projected energy savings through 2020, according to county, were then divided into the CM zones in the 2010 eGRID. To determine which CM zone was to be used, or in counties with multiple CM zone, the allocation to each CM zone by county was obtained from CM zone's listing published in the Laboratory's 2010 annual report[7].

For the 2013 annual NOx emissions calculations, the US EPA's 2010 eGRID were used. An example of the eGRID spreadsheet[8] is given in the Table 2. The total electricity savings for each CM zone were used to calculate the NOx emissions reductions for each of the different counties

[5] The reporting requirements to the SECO did not require energy savings by project type, although for selected sites, energy savings by project type was available.
[6] This would include the appropriate discount and degradation factors for each year.
[7] Haberl et al., 2010, pp. 265.
[8] To use this spreadsheet electricity savings for each eGrid zone is entered in the bottom row of the spreadsheet (MWh). The spreadsheet then allocates the MWh of electricity savings according to the counties (blue columns) where the CM zone owned and operated a power plant. Totals for all CM zones are then listed on the far right columns (white columns). Similar spreadsheets for the 2010 eGRID exist for SOx and CO2.

using the emissions factors contained in eGRID. Similar calculations were performed for each year for which the analysis was required.

ESL-Commercial Buildings. The annual electricity savings for 2004 through 2013 for commercial buildings were obtained from the annual reports for 2004 through 2013 submitted by the Laboratory to TCEQ[9]. From 2009 to 2013, based on year 2008, the annual electricity savings were also calculated for new commercial construction by county[10]. Using the calculated savings through 2013, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above[11]. In the projected annual electricity savings, it was assumed that the same 2013 amount of electricity savings would be achieved for each year through 2020. Similarly to the single family calculations, the projected energy saving numbers through 2020, by county, were allocated into the appropriate CM zones.

PUC-Senate Bill 7. For the PUC Senate Bill 7 program savings, the annual electricity savings for 2001 through 2013 were obtained from the Public Utility Commission of Texas. Using these values savings were projected through 2020 by incorporating the different adjustment factors mentioned above. Similar savings were assumed for each year after 2013 until 2020. The 2010 annual eGRID was also used to calculate the NOx emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each CM zone were used to calculate the NOx emissions reductions for each county using the emissions factors contained in the US EPA's eGRID spreadsheet. The integrated NOx emissions reductions for each county were then calculated.

SECO Savings. The annual electricity consumption reported by political subdivisions for 39 counties through 2013 were obtained from the State Energy Conservation Office (SECO). Using the reported consumption, the annual and OSD electricity savings resulted from energy conservation projects were then calculated. To achieve this, the annual energy use intensity (EUI) for each county was estimated and the county's energy savings for each year against the baseline year of 2008 were then calculated[12]. In addition, the savings through 2020 were projected using the different adjustment factors mentioned above. In a similar fashion to the previous programs, it was assumed that the same amount of electricity savings will be achieved for each year through 2020. The 2010 annual eGRID was also used to calculate the NOx emissions savings for the SECO program.

Electricity Generated by Wind Farms. The measured electricity production from all the wind farms in Texas for 2001 through 2013 was obtained from the Energy Reliability Council of Texas (ERCOT). To obtain the annual production, the 15-minute data were summed for the 12 months. Using the reported numbers for 2013, savings through 2020 were projected incorporating the different adjustment factors mentioned above. The 2010 annual eGRID was then used to calculate the NOx emissions reductions for the electricity generated by Texas' wind farms[13]. The total electricity savings for each CM zone were used to calculate the NOx emissions reductions for each of the different counties.

[9] These savings include new construction in office, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 2011), using energy savings from the US DOE's report (USDOE 2011), and data from CBECS (1995 - 2003) and Dodge (2014).
[10] The 2013 report included updated savings for the years of 2012 and 2013.
[11] This also includes the appropriate discount and degradation factors for each year.
[12] In the 2013 report, EUI values were used to calculate the electricity savings. This calculation method was also applied to savings estimation for the previous years from 2009 to 2012.
[13] This credited the electricity generated by the wind farm to the utility that either owned the wind farm or was associated with the wind farm owner.

SEER 13 Single-Family and Multi-Family. In January of 2006, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 13 from the previous SEER 10. Although the electricity savings from new construction reflected this change in values, the annual and OSD electricity savings from the replacement of the air conditioning units by air conditioners with an efficiency of SEER 13 in existing residences needed to be calculated.

In the 2013 report to the TCEQ, the annual and OSD electricity savings for all the counties in ERCOT region as well as the 41 non-attainment and affected counties were calculated. Using the numbers for 2006, the savings after 2006 until 2020 were projected by incorporating the appropriate adjustment factors[14]. In this analysis, it was assumed that an equal number of existing houses had their air conditioners replaced, as reported for 2006, by the air conditioner manufacturers. This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners. The total electricity savings for each CM zone were used to calculate the NOx emissions reductions for each of the different county using the emissions factors contained in the 2010 eGRID. Integrated NOx emissions reductions for each county by SIP area were also calculated.

Results

The total integrated annual and OSD electricity savings for all the different programs in the integrated format were calculated for 2009 through 2020 as shown in Table 3, using the adjustment factors shown in Table 1. Annual and OSD NOx emissions reductions from the electricity savings (presented in Table 3) for all the programs in the integrated format were shown in Table 4.

In 2013, the total integrated annual savings from all programs are 19,704,209 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 704,919 MWh/year (3.6% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 2,267,414 MWh/year (11.5%),
- Savings from SECO's Senate Bill 5 program are 705,060 MWh/year (3.6%),
- Electricity savings from green power purchases (wind) are 15,723,534 MWh/year (79.8%), and
- Savings from residential air conditioner retrofits[15] are 303,282 MWh/year (1.5%).

In 2013, the total integrated OSD savings from all programs are 45,262 MWh/day, which would be a 1,886 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 2,407 MWh/day (5.3%),
- Savings from the PUC's Senate Bill 7 programs are 6,212 MWh/day (13.7%),
- Savings from SECO's Senate Bill 5 program are 1,932 MWh/day (4.3%),
- Electricity savings from green power purchases (wind) are 32,560 MWh/day (71.9%), and

[14] Additional details about this calculation are contained in the Laboratory's 2006 Annual Report to the TCEQ, available at the Senate Bill 5 web site "http://esl.tamu.edu/".
[15] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- Savings from residential air conditioner retrofits are 2,151 MWh/day (4.8%).

By 2015, the total integrated annual savings from all programs will be 22,508,426 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 1,111,655 MWh/year (4.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 3,075,280 MWh/year (13.7%),
- Savings from SECO's Senate Bill 5 program will be 1,069,420 MWh/year (4.8%),
- Electricity savings from green power purchases (wind) will be 16,978,360 MWh/year (75.4%), and
- Savings from residential air conditioner retrofits will be 273,712 MWh/year (1.2%).

By 2015, the total integrated OSD savings from all programs will be 51,958 MWh/day, which would be a 2,165 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 3,503 MWh/day (6.7%),
- Savings from the PUC's Senate Bill 7 programs will be 8,425 MWh/day (16.2%),
- Savings from SECO's Senate Bill 5 program will be 2,930 MWh/day (5.6%),
- Electricity savings from green power purchases (wind) will be 35,158 MWh/day (67.7%), and
- Savings from residential air conditioner retrofits will be 1,941 MWh/day (3.7%).

In 2013 (Table 4), the total integrated annual NOx emissions reductions from all programs are 5,397 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 177 tons-NOx/year (3.3% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 567 tons-NOx/year (10.5%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 183 tons-NOx/year (3.4%),
- NOx emissions reductions from green power purchases (wind) are 4,399 tons-NOx/year (81.5%), and
- NOx emissions reductions from residential air conditioner retrofits are 71 tons-NOx/year (1.3%).

In 2013, the total integrated OSD NOx emissions reductions from all programs are 12.22 tons-NOx/day. The integrated OSD NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 0.60 tons-NOx/day (4.9%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 1.55 tons-NOx/day (12.7%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.50 tons-NOx/day (4.1%),
- NOx emissions reductions from green power purchases (wind) are 9.06 tons-NOx/day (74.1%), and
- NOx emissions reductions from residential air conditioner retrofits are 0.50 tons-NOx/day (4.1%).

By 2015, the total integrated annual NOx emissions reductions from all programs will be 6,133 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 279 tons-NOx/year (4.6% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 766 tons-NOx/year (12.5%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 274 tons-NOx/year (4.5%),
- NOx emissions reductions from green power purchases (wind) will be 4,750 tons-NOx/year (77.4%), and
- NOx emissions reductions from residential air conditioner retrofits will be 64 tons-NOx/year (1.0%).

By 2015, the total integrated OSD NOx emissions reductions from all programs will be 13.96 tons-NOx/day. The integrated OSD NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 0.88 tons-NOx/day (6.3%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 2.10 tons-NOx/day (15.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 0.75 tons-NOx/day (5.4%),
- NOx emissions reductions from green power purchases (wind) will be 9.78 tons-NOx/day (70.1%), and
- NOx emissions reductions from residential air conditioner retrofits will be 0.45 tons-NOx/day (3.2%).

Summary

This preliminary report shows the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2020 for both the annual and OSD NOx reductions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2010 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose.

In 2013, the integrated total electricity savings from all programs are:

- Annual electricity savings is 19,704,209 MWh/year (5,397 tons-NOx/year) and
- OSD electricity savings is 45,262 MWh/day, which would be a 1,886 MW average hourly load reduction during the OSD period (12.22 tons-NOx/day).

By 2015, the integrated total electricity savings from all programs are:

- Annual electricity savings will be 22,508,426 MWh/year (6,133 tons-NOx/year) and
- OSD electricity savings will be 51,958 MWh/day, which would be a 2,165 MW average hourly load reduction during the OSD period (13.96 tons-NOx/day).

The Laboratory has and will continue to provide leading-edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP.

If any questions arise, please contact us by phone at 979-845-6065 or email us at terpinfo@tees.tamus.edu.

Table 1: Final Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs

	ESL-Single Family	ESL-Multi Family	ESL-Commercial	PUC (SB7)	SECO	Wind-ERCOT	SEER13 Single Family	SEER13 Multi Family
Annual Degradation Factor	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%
T&D Loss	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor	20.0%	20.0%	20.0%	10.0%	60.0%	10.0%	20.0%	20.0%
Growth Factor	3.3%	1.5%	3.3%	0.0%	0.0%	3.9%	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No[1]	Yes	Yes

Note:

1. For Wind-ERCOT, the OSD energy consumption is the average daily consumption of the measured data in the months of July, August and September.

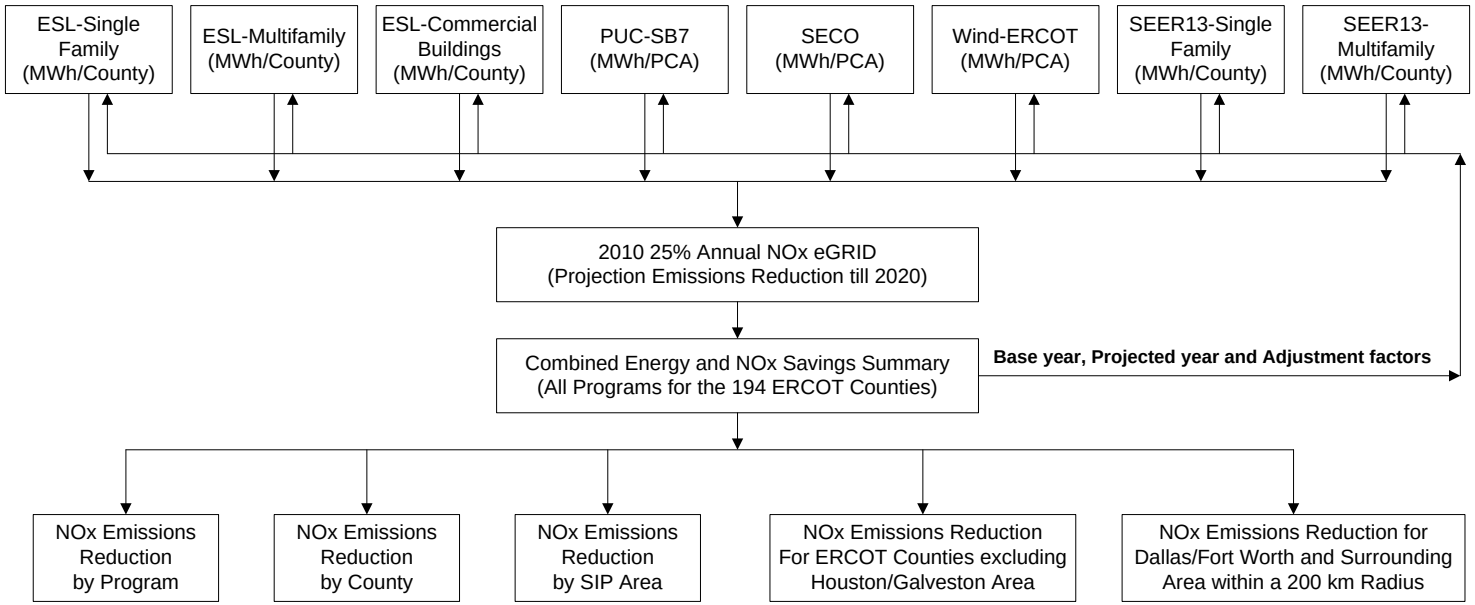


Figure 1: Process Flow Diagram of the NOx Emissions Reduction Calculations

Table 2: Example of NOx Emissions Reduction Calculations using 2010 eGRID

Area	County	CM Zones								Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
		H		N		W		S			
Houston-Galveston Area	Brazoria	0.0562032	347.6943	0.0000071	0.0710	0.0000003	0.0002	0.0005265	3.8055	351.57	0.18
	Chambers	0.0204500	126.5115	0.0000026	0.0258	0.0000001	0.0001	0.0001916	1.3847	127.92	0.06
	Fort Bend	0.0313463	193.9202	0.0000040	0.0396	0.0000002	0.0001	0.0002937	2.1224	196.08	0.10
	Galveston	0.0226620	140.1955	0.0000029	0.0286	0.0000001	0.0001	0.0002123	1.5344	141.76	0.07
	Harris	0.1486911	919.8596	0.0000189	0.1877	0.0000009	0.0006	0.0013930	10.0678	930.12	0.47
	Liberty	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Montgomery	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Waller	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Jefferson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Orange	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Dallas/ Fort Worth Area	Collin	0.0012932	8.0000	0.0079329	78.9444	0.0003832	0.2345	0.0000809	0.5849	87.76	0.04
	Dallas	0.0024826	15.3584	0.0152295	151.5565	0.0007356	0.4503	0.0001554	1.1230	168.49	0.08
	Denton	0.0001267	0.7836	0.0007770	7.7325	0.0000375	0.0230	0.0000079	0.0573	8.60	0.00
	Tarrant	0.0004742	2.9335	0.0029089	28.9476	0.0001405	0.0860	0.0000297	0.2145	32.18	0.02
	Ellis	0.0029920	18.5096	0.0183544	182.6530	0.0008865	0.5426	0.0001873	1.3534	203.06	0.10
	Johnson	0.0007256	4.4888	0.0044512	44.2958	0.0002150	0.1316	0.0000454	0.3282	49.24	0.02
	Kaufman	0.0059718	36.9441	0.0366343	364.5651	0.0017695	1.0831	0.0003738	2.7012	405.29	0.20
	Parker	0.0000012	0.0076	0.0000075	0.0751	0.0000004	0.0002	0.0000001	0.0006	0.08	0.00
	Rockwall	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Henderson	0.0006908	4.2734	0.0042376	42.1700	0.0002047	0.1253	0.0000432	0.3125	46.88	0.02
	Hood	0.0050771	31.4088	0.0311454	309.9429	0.0015044	0.9208	0.0003178	2.2965	344.57	0.17
	Hunt	0.0088463	54.7268	0.0047066	46.8380	0.0002273	0.1391	0.0652823	471.8144	573.52	0.29
El Paso Area	El Paso	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
San Antonio Area	Bexar	0.0138906	85.9325	0.0009368	9.3227	0.0000452	0.0277	0.1109355	801.7639	897.05	0.45
	Comal	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Guadalupe	0.0032029	19.8143	0.0002160	2.1496	0.0000104	0.0064	0.0255795	184.8703	206.84	0.10
	Wilson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Austin Area	Bastrop	0.0033782	20.8990	0.0002278	2.2673	0.0000110	0.0067	0.0269798	194.9906	218.16	0.11
	Caldwell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hays	0.0008331	5.1541	0.0000562	0.5592	0.0000027	0.0017	0.0066537	48.0881	53.80	0.03
	Travis	0.0051785	32.0364	0.0003493	3.4756	0.0000169	0.0103	0.0413577	298.9044	334.43	0.17
	Williamson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
North East Texas Area	Gregg	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Harrison	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Rusk	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Smith	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Upshur	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
Corpus Christi Area	Nueces	0.0128578	79.5431	0.0008672	8.6295	0.0000419	0.0256	0.1026870	742.1493	830.35	0.42
	San Patricio	0.0015100	9.3411	0.0001018	1.0134	0.0000049	0.0030	0.0120591	87.1543	97.51	0.05
Victoria Area	Victoria	0.0021192	13.1099	0.0001429	1.4223	0.0000069	0.0042	0.0169244	122.3174	136.85	0.07
Other ERCOT counties	Andrews	0.0000037	0.0232	0.0000230	0.2286	0.0039003	2.3873	0.0000002	0.0017	2.64	0.00
	Angelina	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Bosque	0.0022204	13.7364	0.0136212	135.5508	0.0006579	0.4027	0.0001390	1.0044	150.69	0.08
	Brazos	0.0024089	14.9022	0.0112305	111.7603	0.0005425	0.3320	0.0047829	34.5675	161.56	0.08
	Calhoun	0.0009466	5.8559	0.0000638	0.6353	0.0000031	0.0019	0.0075598	54.6366	61.13	0.03
	Cameron	0.0063536	39.3060	0.0004285	4.2642	0.0000207	0.0127	0.0507425	366.7307	410.31	0.21
	Cherokee	0.0027392	16.9455	0.0168033	167.2180	0.0008116	0.4968	0.0001714	1.2390	185.90	0.09
	Coke	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Coleman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Crockett	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Ector	0.0019215	11.8872	0.0006604	6.5715	0.0911346	55.7813	0.0146527	105.8993	180.14	0.09
	Fannin	0.0000041	0.0251	0.0000249	0.2475	0.0000012	0.0007	0.0000003	0.0018	0.28	0.00
	Fayette	0.0051867	32.0869	0.0103217	102.7160	0.0004986	0.3052	0.0283993	205.2502	340.36	0.17
	Freestone	0.0047643	29.4740	0.0292268	290.8499	0.0014117	0.8641	0.0002982	2.1551	323.34	0.16
	Frio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Grimes	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hardeman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Haskell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Hidalgo	0.0053716	33.2306	0.0003623	3.6051	0.0000175	0.0107	0.0428994	310.0466	346.89	0.17
	Howard	0.0002411	1.4916	0.0007641	7.6036	0.1283942	78.5870	0.0009490	6.8586	94.54	0.05
	Jack	0.0030783	19.0436	0.0188839	187.9227	0.0009121	0.5583	0.0001927	1.3924	208.92	0.10
	Jones	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Lamar	0.0040001	24.7464	0.0245388	244.1978	0.0011853	0.7255	0.0002504	1.8094	271.48	0.14
	Limestone	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Llano	0.0040314	24.9401	0.0002719	2.7057	0.0000131	0.0080	0.0321966	232.6946	260.35	0.13
	McLennan	0.0056576	35.0002	0.0347066	345.3824	0.0016764	1.0261	0.0003541	2.5591	383.97	0.19
	Milam	0.0012686	7.8481	0.0000856	0.8514	0.0000041	0.0025	0.0101316	73.2238	81.93	0.04
	Mitchell	0.0000311	0.1926	0.0001910	1.9003	0.0324260	19.8472	0.0000019	0.0141	21.95	0.01
	Nolan	0.0000293	0.1810	0.0001795	1.7860	0.0304745	18.6527	0.0000018	0.0132	20.63	0.01
	Palo Pinto	0.0036129	22.3510	0.0221635	220.5601	0.0010705	0.6552	0.0002261	1.6342	245.20	0.12
	Pecos	0.0000020	0.0122	0.0000121	0.1203	0.0020520	1.2560	0.0000001	0.0009	1.39	0.00
	Presidio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Red River	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Robertson	0.0039506	24.4397	0.0055755	55.4842	0.0002693	0.1648	0.0246170	177.9140	258.00	0.13
	Taylor	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Titus	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Tom Green	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
	Upton	0.0000025	0.0157	0.0000156	0.1553	0.0026494	1.6217	0.0000002	0.0012	1.79	0.00
	Ward	0.0001995	1.2343	0.0012239	12.1801	0.2078335	127.2099	0.0000125	0.0902	140.71	0.07
	Webb	0.0042017	25.9935	0.0002834	2.8200	0.0000137	0.0084	0.0335565	242.5231	271.34	0.14
	Wharton	0.0021095	13.0502	0.0001423	1.4158	0.0000069	0.0042	0.0168474	121.7608	136.23	0.07
	Wichita	0.0000121	0.0749	0.0000743	0.7395	0.0126190	7.7238	0.0000008	0.0055	8.54	0.00
	Wilbarger	0.0179710	111.1755	0.1102430	1097.0811	0.0053249	3.2593	0.0011247	8.1288	1219.64	0.61
	Wise	0.0010202	6.3112	0.0062583	62.2792	0.0003023	0.1850	0.0000638	0.4615	69.24	0.03
	Young	0.0071054	43.9567	0.0435880	433.7654	0.0021054	1.2886	0.0004447	3.2140	482.22	0.24
	Total	**0.4414501**	**2730.9774**	**0.4812863**	**4789.5112**	**0.5345786**	**327.2027**	**0.6829349**	**4935.7718**	12783.46	**6.39**
Energy Savings (MWh)		6,186		9,951		612		7,227			

Table 3: Annual and OSD Electricity Savings for the Different Programs (Base Year 2008) [16]

PROGRAM	ANNUAL												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	21,748	55,268	93,760	153,171	220,975	289,761	359,587	430,512	502,596	575,901	650,492	726,432
ESL-Multifamily (MWh)	0	50,218	94,867	167,566	262,939	357,717	452,100	546,119	639,803	733,182	826,287	919,146	1,011,789
ESL-Commercial (MWh)	0	0	25,750	54,550	87,230	126,228	165,790	205,950	246,741	288,199	330,358	373,255	416,928
PUC (SB7) (MWh)	0	538,841	976,984	1,437,883	1,831,318	2,267,414	2,681,704	3,075,280	3,449,177	3,804,380	4,141,822	4,462,392	4,766,933
SECO (MWh)	0	71,910	154,786	347,175	508,375	705,060	891,911	1,069,420	1,238,053	1,398,254	1,550,445	1,695,027	1,832,380
Wind-ERCOT (MWh)	0	3,273,150	8,135,429	10,995,427	13,049,580	15,723,534	16,338,905	16,978,360	17,642,840	18,333,327	19,050,837	19,796,428	20,571,199
SEER13-Single Family (MWh)	0	343,330	326,163	309,855	294,362	279,644	265,662	252,379	239,760	227,772	216,383	205,564	195,286
SEER13-Multifamily (MWh)	0	29,021	27,569	26,191	24,881	23,637	22,456	21,333	20,266	19,253	18,290	17,376	16,507
Total Annual (MWh)	0	4,328,218	9,796,817	13,432,406	16,211,857	19,704,209	21,108,289	22,508,426	23,907,152	25,306,962	26,710,324	28,119,680	29,537,454

PROGRAM	OZONE SEASON DAY - OSD												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	0	124	283	468	626	808	992	1,180	1,370	1,564	1,761	1,962	2,166
ESL-Multifamily (MWh)	0	233	460	744	999	1,253	1,507	1,759	2,010	2,261	2,511	2,760	3,009
ESL-Commercial (MWh)	0	0	71	149	239	346	454	564	676	790	905	1,023	1,142
PUC (SB7) (MWh)	0	1,476	2,677	3,939	5,017	6,212	7,347	8,425	9,450	10,423	11,347	12,226	13,060
SECO (MWh)	0	197	424	951	1,393	1,932	2,444	2,930	3,392	3,831	4,248	4,644	5,020
Wind-ERCOT (MWh)	0	14,246	23,054	27,654	33,273	32,560	33,834	35,158	36,534	37,964	39,450	40,994	42,598
SEER13-Single Family (MWh)	0	2,445	2,323	2,207	2,097	1,992	1,892	1,798	1,708	1,622	1,541	1,464	1,391
SEER13-Multifamily (MWh)	0	195	186	176	167	159	151	144	136	130	123	117	111
Total OSD (MWh)	0	18,918	29,477	36,289	43,812	45,262	48,621	51,958	55,277	58,584	61,887	65,189	68,498

[16] The 2013 report updated the energy savings and NOx reductions resulted from the commercial and SECO programs for the previous years. Changes made can be found in each of the corresponding sections.

Table 4: Annual and OSD NOx Emissions Reduction Values for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (in tons NOx)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0	5	14	23	38	54	71	89	106	124	142	160	179
ESL-Multifamily	0	13	24	43	67	91	115	139	163	187	210	234	257
ESL-Commercial	0	0	6	14	22	32	41	52	62	72	83	94	105
PUC (SB7)	0	135	246	362	460	567	669	766	858	945	1,028	1,107	1,182
SECO	0	19	43	92	133	183	230	274	317	357	395	432	466
Wind-ERCOT	0	895	2,262	3,053	3,648	4,399	4,571	4,750	4,936	5,129	5,330	5,538	5,755
SEER13-Single Family	0	81	77	73	69	66	62	59	56	53	51	48	46
SEER13-Multifamily	0	7	6	6	6	6	5	5	5	5	4	4	4
Total Annual (Tons NOx)	0	1,154	2,677	3,664	4,443	5,397	5,765	6,133	6,502	6,872	7,243	7,617	7,993

PROGRAM	OZONE SEASON DAY - OSD (in tons NOx/day)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0	0.03	0.07	0.11	0.15	0.20	0.24	0.29	0.34	0.39	0.43	0.48	0.53
ESL-Multifamily	0	0.06	0.12	0.19	0.26	0.32	0.38	0.45	0.51	0.57	0.64	0.70	0.76
ESL-Commercial	0	0.00	0.02	0.04	0.06	0.09	0.11	0.14	0.17	0.20	0.23	0.26	0.29
PUC (SB7)	0	0.37	0.67	0.99	1.26	1.55	1.83	2.10	2.35	2.59	2.82	3.03	3.24
SECO	0	0.05	0.12	0.25	0.37	0.50	0.63	0.75	0.87	0.98	1.08	1.18	1.28
Wind-ERCOT	0	3.93	6.40	7.62	9.28	9.06	9.41	9.78	10.16	10.56	10.98	11.40	11.85
SEER13-Single Family	0	0.57	0.54	0.51	0.49	0.46	0.44	0.42	0.40	0.38	0.36	0.34	0.32
SEER13-Multifamily	0	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Total OSD (Tons NOx)	0	5.05	7.97	9.76	11.90	12.22	13.09	13.96	14.83	15.69	16.56	17.43	18.30

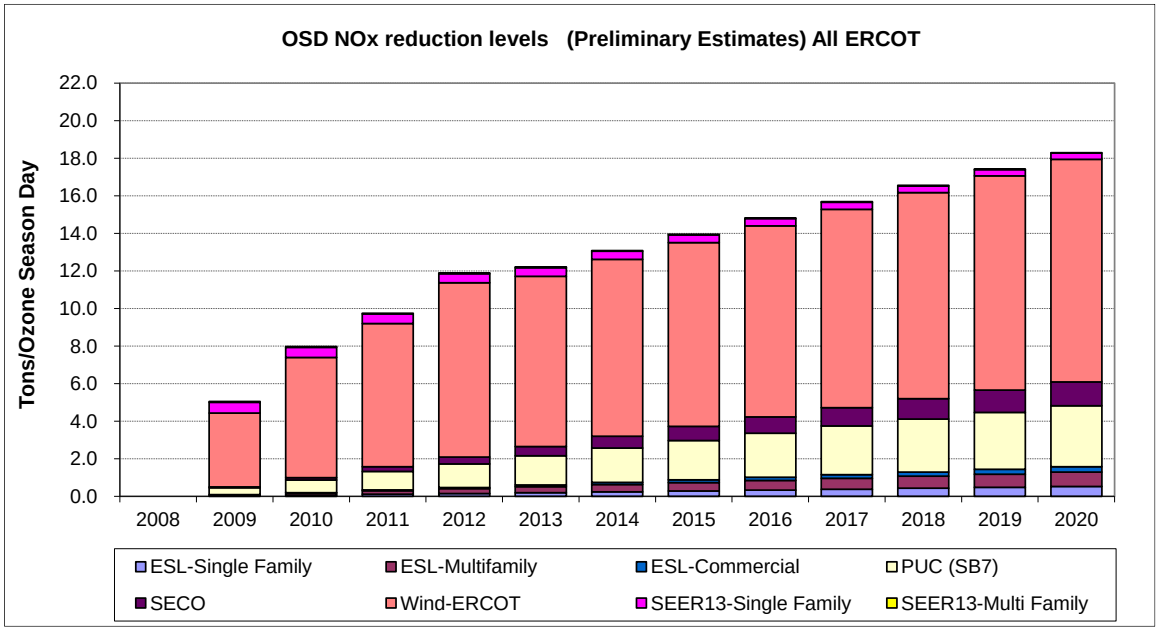


Figure 2: Integrated OSD NOx Emissions Reduction Projections through 2020 (Base Year 2008)

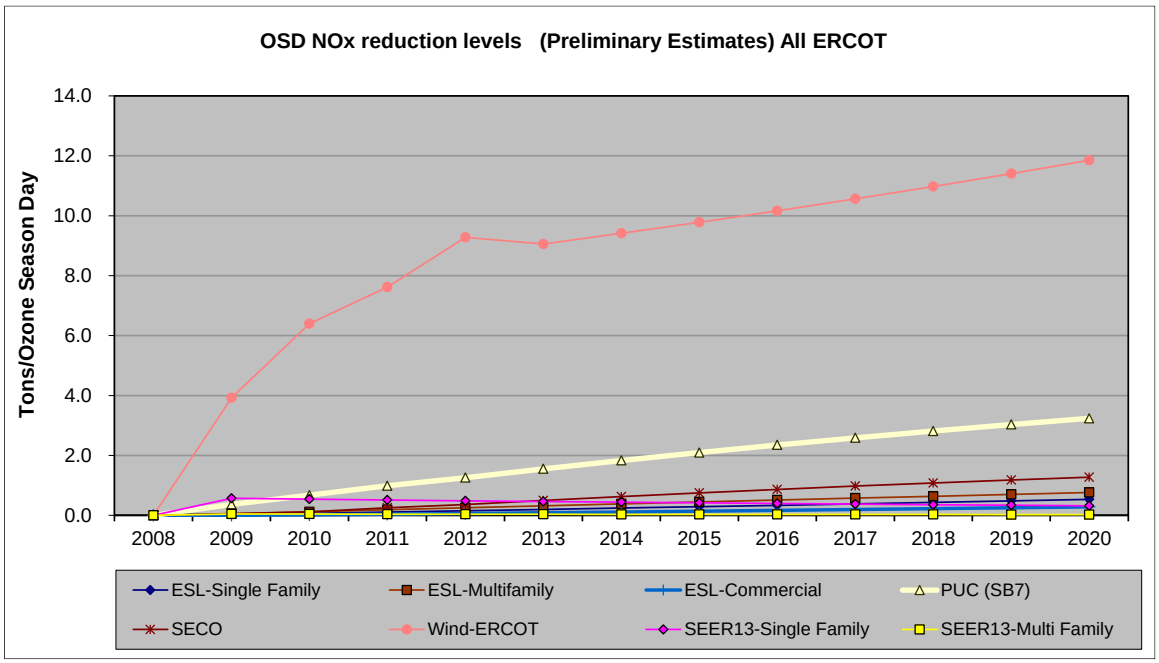


Figure 3: Integrated OSD Individual Programs NOx Emissions Reduction Projections through 2020 (Base Year 2008)

References

CBECS 1995, 1999, 2003. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report.

Dodge. 2011. MarkeTrack: McGraw-Hill Construction Analytics. McGraw-Hill Construction Information Group, 148 Princeton-Hightstown Rd., Hightstown, N.J. http://dodge.construction.com.

Dodge. 2014. McGraw Hill Construction Starts Information. McGraw-Hill Financial. Bedford, M.A.

ICC. 2006 International Energy Conservation Code. Falls Church, VA: International Code Council, Inc.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, and Turner, D., 2002, "Texas's senate Bill 5 Legislation for Reducing Pollution in Non-attainment and Affected Areas," Annual Report to the Texas Natural Resource Conservation Commission, July, Energy Systems Laboratory Report ESL-TR-02/07-01.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, T., Bryant, J., and Turner, D., 2003, "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 2002 to August 2003, Energy Systems Laboratory Report ESL-TR-03/12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, B., Baltazar-Cervantes, J.C., Bryant, J., Degelman, L., and Turner, D. 2004. "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 to August 2004, Energy Systems Laboratory Report ESL-TR-04/12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, B., Baltazar-Cervantes, J.C., Bryant, J., Degelman, L., and Turner, D. 2006. "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 2004 to December 2005, Energy Systems Laboratory, Report ESL-TR-06-06-08.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, Z., Baltazar-Cervantes, J-C, Mukhopadhyay, J., Degelman, L., and Turner, D. 2007. "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, January 2006 to June 2007, Energy Systems Laboratory, Report ESL-TR-07-12-02.

Haberl, J. S., Liu, Z., Baltazar-Cervantes, J. C., Subbarao, K., Gilman, D., Culp, C., Yazdani, B., Turner, W. D., and Chandrasekaran, V. 2008. "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, January 2007 – December 2007, Energy Systems Laboratory, Report ESL-TR-08-12-02.

Haberl, J. S., Liu, Z., Baltazar-Cervantes, J. C., Subbarao, K., Gilman, D., Culp, C., Yazdani, B., Turner, W. D., and Chandrasekaran, V. 2009. "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, January 2008 – December 2008, Energy Systems Laboratory, Report ESL-TR-09-12-02.

Haberl, J. S., Culp, C., Yazdani, B., Lewis, C., Liu, Z., Baltazar-Cervantes, J. C., Mukhopadhyay, J. Gilman, D., Degelman, L., Mckelvey, K., and Claridge, D. 2010. "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, January 2009 – December 2009, Energy Systems Laboratory, Report ESL-TR-10-12-02.

Haberl, J. S., Yazdani, B., Lewis, C., Liu, Z., Baltazar-Cervantes, Mukhopadhyay, J., Gilman, D., Degelman, L., Mckelvey, K., Zilbertshtein, G., and Claridge, D. 2011. "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, January 2010 – December 2010, Energy Systems Laboratory, Report ESL-TR-11-12-03.

Haberl, J. S., Yazdani, B., Baltazar-Cervantes, J. C., Lewis, C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbertshtein, G., Claridge, D. 2012. "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, January 2011 – December 2011, Energy Systems Laboratory, Report ESL-TR-12-12-05.

Haberl, J. S., Yazdani, B., Baltazar-Cervantes, J. C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbertshtein, G., and Claridge, D. 2013. "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, January 2012 – December 2012, Energy Systems Laboratory, Report ESL-TR-13-10-04.

NAHB 2008. Builder Practices Survey Reports, National Association of Home Builders, Research Center, Upper Marlboro, Maryland (September).

Kats, G. H., Rosenfeld, A. H., McGaraghan, S. A. 1996. "Energy Efficiency as a Commodity: The Emergence of an Efficiency Secondary Market for Savings in Commercial Buildings," ACEEE Summer Study on Energy Efficiency in Buildings.

PUC 2014. Public Utility Commission of Texas, available at: http://www.puc.texas.gov/

USDOE 2011. Building Energy Standards Program: Determination Regarding Energy Efficiency Improvements in the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ANSI/ASHRAE/IESNA Standard 90.1-2007. FR DOC# 2011-18251. Washington, D.C.