

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

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ABSTRACT

This paper provides an update of the integrated NO_x emissions reductions calculation procedures developed by the Energy Systems Laboratory (ESL) for the State of Texas. to satisfy the reporting requirements for Senate Bill 5 of the Texas State Legislature.¹ These procedures are used to report annual NO_x emissions reductions to the Texas Commission on Environmental Quality (TCEQ) from the state-wide energy efficiency and renewable energy programs. These programs include: the impact of code-complaint construction, Federal buildings, furnace pilot light upgrades, the Texas Public Utility Commission (PUC), the energy efficiency programs managed by the Texas State Energy Conservation Office (SECO), electricity generated from wind power in the state, and several additional statewide measures, including SEER 13 air conditioner and pilot lights.

BACKGROUND

In 1970, the Federal Clean Air Act directed the United States Environmental Protection Agency to establish the maximum allowable concentrations of pollutants that are known to endanger human health, harm the environment or cause property damage. In response to this act, the EPA established NAAQS,² which describe the allowable maximum limits of six primary air pollutants.³ In 2001, the Texas State Legislature

formulated and passed Senate Bill 5 to further reduce ozone levels by encouraging the reduction of emissions of NO_x by sources that are currently not regulated by the state, including area sources (e.g., residential emissions), on-road mobile sources (e.g., all types of motor vehicles), and non-road mobile sources (e.g., aircraft, locomotives, etc.).⁴ An important part of this legislation is the evaluation of the State's new energy efficiency programs, which includes reductions in energy use and demand that are associated with specific utility-based energy conservation measures, renewable energy programs, and mandatory implementation of the International Energy Conservation Code (IECC 2000; 2001). In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NO_x emissions savings 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

53 ppb annual average), Ozone (O₃ -- 120 ppb, 1 hour average.), particulate matter (PM₁₀-- 50 micrograms/m³ annual average), and sulfur dioxide (SO₂ -- 30 ppb annual average).

⁴ In 2003, the 78th Legislature modified the Texas Emissions Reduction Plan (TERP) with House bill 3235 and House bill 1365. This new legislation strengthened the previous legislation, but did not reduce the stringency of the building code or the reporting of the emissions reduction. In the 2005 79th Legislature, the TERP was further modified to include the development of creditable emissions calculations from wind and renewable sources, and to investigate emissions reduction from area sources such as natural gas-fired, domestic water heaters.

¹ The summary was presented on the Hot and Humid 15.5 Conference in 2007.

² National Ambient Air Quality Standards (NAAQS).

³ These pollutants currently are: carbon monoxide (CO -- 9 ppm, 8 hour average.), lead (Pb -- 1.5 ppm, maximumquarterly average), oxides of nitrogen (NO_x --

cumulative savings estimates from all projects projected through 2020 for both the annual and Ozone Season Day⁵ (OSD) NOx reductions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2007 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose. The different programs included in the 2008 cumulative analysis are:

- ESL Single-family new construction
- ESL Multi-family new construction
- ESL Commercial new construction
- Federal Buildings
- Furnace Pilot Light Program
- PUC Senate Bill 7 and Senate Bill 5 Program
- SECO Senate Bill 5 Program
- Electricity generated by wind farms in Texas (ERCOT⁶)
- SEER13 upgrades to Single Family and Multifamily residences

The Laboratory's single- and multi-family programs include the energy savings attained by constructing new residences in Texas according to the IECC 2000/2001 building code (IECC 2000). The baseline for comparison for the code programs is the published data on residential construction characteristics by the National Association of Home Builders (NAHB) for 1999 (NAHB 1999). Annual electricity (MWh) and natural gas (MMBtu) savings are from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002, 2003, 2004, 2006, 2007, and 2008).

The Texas Public Utility Commission's (PUC) Senate Bill and Senate Bill 7 programs include their incentive and rebates programs managed by the different Utilities for Texas (PUC 2007). These include the Residential Energy Efficiency Programs (REEP) as well as the Commercial & Industrial Standard Offer Programs (C&I SOP). 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 according to the utilities (or Power Control Authorities –PCAs) were reported for the different programs

⁵ An ozone season day (OSD) represents the daily average emissions during the period that runs from mid-July to mid-September.

⁶ ERCOT is the Electric Reliability Council of Texas.

completed in the years 2001 through 2008. The PUC also reported the savings from the Senate Bill 5 grant program which was conducted in 2002 and 2003.

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. For the 2006 reporting year SECO submitted annual energy savings values for 149 projects which included projects funded by SECO and by Energy Service projects.

Finally, the integrated savings include MWh and NOx emissions savings from the currently installed green power generation (wind) capacity in west Texas, as reported to the Electric Reliability council of Texas (ERCOT). For projections through 2020, annual growth factors were chosen to comply with the Legislative requirements: 3,700 MW in 2009, and 7,000 MW in 2015. Actual measured electricity production for 2001 through 2008 were also included.

DESCRIPTION OF ANALYSIS

Annual and Ozone Season Day (OSD) NOx emissions reductions were calculated for 2005 and cumulatively from 2006 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. An annual degradation factor of 5% was used for all the programs⁷. This value 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

⁷ 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. Improvements in this assumption will be made annually as measured data confirm a reduced degradation rate.

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- and multi-family program, the discount factor was assumed to be 20%. For PUC's Senate Bill 5 and Senate Bill 2007 programs and electricity from wind, the discount factor was taken as 25%. For the savings in the SECO program, the discount factor was 60%.

Growth factor: The growth factors shown in Table 1 were used to account for several different factors. First, in the case of wind energy, the factor accounted for the increased number of wind turbines which are being installed every year in the western portion of the state. Three different scenarios were possible for wind energy projections:

- No annual growth;
- 17% growth factor, on the basis that the installed wind power generation capacity will grow to 3,700 MW until 2009 from current installed level of 2000 MW. For this growth scenario, the 17% growth will achieve 3,700 MW by 2009; after that, the wind power generation will be fixed at the production level achieved in 2009.
- 22.7% growth factor, on the basis that the installed wind power generation capacity will grow to 7,000 MW by 2015.

In the growth factors used for 2006 and beyond a 17.0% growth factor was assumed for the wind energy portion of savings.

Also, included in Table 1 are growth factors for single-family (3.25%) and multi-family residential (1.54%) construction. These values represent the average growth rate for these housing types from recent U.S. Census data for Texas.

Figure 1 shows the overall information flow that was used to calculate the NOx emissions savings from the annual and Ozone Season Day (OSD) electricity savings (MWh) from all programs. For the Laboratory's single-family and multi-family code-implementation programs, the annual and ozone season savings were calculated from DOE-2 hourly simulation models⁸. 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 1999 (NAHB 1999). The OSD consumption is the average daily consumption for the period between July 15 and September 15, 1999. The annual electricity savings from PUC programs were calculated using deemed savings tables and spreadsheets created for the utilities incentive programs by Frontier Associates in Austin, Texas. (PUC 2007)

The SECO electricity savings were submitted as annual savings by project⁹. A description of the measures completed for the project was also submitted for information purposes (SECO 2007). The electricity production from wind farms in Texas was from the actual on-site metered data measured at 15-minute intervals.

Integration of the programs into a uniform format allowed for NOx emissions to be evaluated using different criteria as shown in the bottom row of Figure 1. These include evaluation by program across, evaluation across an individual county by program or for the total programs, 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

ESL Single-family and Multi-family. The calculation of the annual and OSD electricity savings reported for the years 2002 through 2004 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).

⁸ These values are based on a performance analysis as defined by Chapter 4 of IECC 2000/2001. This analysis is discussed in the Laboratory's annual reports to the TCEQ.

⁹ 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. Therefore annual total usage was used.

The savings for 2001 were also incorporated since some of the programs were reporting savings from September to December 2001. In 2005 and 2006 the annual and OSD 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 for 2002 through 2006, 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 2006 through 2020¹⁰. The projected energy savings through 2020, according to county, were then divided into the different Power Control Authorities (PCA) in eGRID. To determine which PCA was to be used, or in counties with multiple PCA, the allocation to each PCA by county was obtained from PUC's listing published in the Laboratory's 2005 annual report¹¹.

For the 2006 annual and OSD NOx emissions calculations the US EPA's 2007 eGRID were used¹². An example of the eGRID spreadsheet¹³ is given in Table 2. The total electricity savings for each PCA were used to calculate the NOx emissions reduction for each of the different counties using the emissions factors contained in eGRID. Similar calculations were performed for each year for which the analysis was required. The cumulative NOx emissions reductions for the electricity savings from residential new construction for 2006 through 2020 is provided in Table 3. NOx emissions reductions are provided in Table 4.

¹⁰ This would include the appropriate discount and degradation factors for each year.

¹¹ Haberl et al., 2005, pp. 197.

¹² This required two separate versions of the 2007 eGRID, which were specially prepared for Texas by Mr. Art Diem at the US EPA. One of the versions contains estimates of annual SOx, NOx and CO2 data for 2007, using a 25% capacity factor. The second version contains estimates of SOx, NOx and CO2 data for 2007 for an average day in the ozone season period, which runs from Mid July to Mid September.

¹³ To use this spreadsheet electricity savings for each PCA 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 PCA owned and operated a power plant. Totals for all PCAs are then listed on the far right columns (white columns). Similar spreadsheets for the 2007 eGRID exist for SOx and CO2.

ESL-Commercial Buildings. The annual and OSD electricity savings for 2002 through 2006 for commercial buildings were obtained from the annual reports for 2005 and 2006 submitted by the Laboratory to TCEQ¹⁴. These savings were also tabulated by county and program. Using the calculated values for 2002 through 2006, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above¹⁵.

In the projected 2006 cumulative electricity savings was assumed that the same amount of electricity savings from 2006 would be achieved for each year after 2006 through 2020. Similarly to the single family calculations, the projected energy saving numbers through 2020, by county, were allocated into the appropriate Power Control Authorities (PCA).

shows the geographical distribution of the OSD electricity savings which corresponds to the most populated areas of the state (i.e., Harris, Tarrant, Collin and Dallas counties). shows the geographical distribution of the corresponding NOx reductions calculated by eGRID for the electricity generation facilities expected to be in the state in 2007. Comparison of the location of the electricity savings (Figure 1) to the location of the pollution savings (Figure 2) emphasizes the importance of the use of county-wide NOx distributions available in eGRID.

Federal Buildings. Energy savings achieved from Energy Savings Performance Contracts (ESPCs) were also reported in 2006. This includes savings (estimated) from energy conservation measures implemented in Federal Buildings in Texas. The 2006 savings include projects implemented in 14 Federal buildings reported by the regional office of the Department of Energy. Annual kWh savings reported for each of the projects were divided by 365 to obtain the average Ozone Season Day savings¹⁶.

¹⁴ These savings include new construction in office, assembly, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 1995, 1999, 2003), using energy savings from the Pacific Northwest National Laboratory (USDOE 2005), and data from CBECs (2005).

¹⁵ This also includes the appropriate discount and degradation factors for each year.

¹⁶ This method yields suitable OSD values for lighting retrofits and/or retrofits that are not weather dependent. In the case of retrofits to cooling systems, weather normalization would increase the OSD savings substantially. Retrofits to heating systems would be reduced by weather normalization.

In the calculation for 2006, it was assumed that the electricity savings from 2005 would also be achieved for each year from 2006 through 2020 after the appropriate degradation factors were applied. Similarly to the single family calculations, the projected energy saving numbers through 2020, by county, were proportioned into the PUC's Power Control Authorities (PCA) and the cumulative NOx emission reduction values calculated.

Furnace Pilot Lights Program. For the furnace pilot light program savings, the N.G. energy savings achieved by retrofitting existing furnaces in single-family and multi-family residences for the entire residential stock for Texas have been projected until 2020. Pilot light removal saves at least 500 Btu/hr of natural gas for each hour of operation for the entire life of the furnace when the furnace is replaced with a code-compliant replacement. The energy savings for the Ozone season day are calculated by dividing the annual number by 365. It is also being assumed that of the total furnaces that were retrofitted, 75% are operational during the Ozone Season Period. Cumulative NOx emissions reductions for the N.G. savings from the removal of furnace pilot lights were also calculated by county for 2006 through 2020 by SIP area¹⁷.

PUC-Senate Bill 7. For the PUC Senate Bill 7 program savings, the annual electricity savings for 2001 through 2006 were obtained from the Public Utilities Commission¹⁸. Using these values savings were projected through 2020 by incorporating the different adjustment factors mentioned above. Similar savings were assumed for each year after 2007 until 2020. The 2007 annual and OSD eGRID was also used to calculate the NOx emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each PCA were used to calculate the NOx emissions reductions for each county using the emissions factors contained in the US EPA's eGRID spreadsheet. The cumulative NOx emissions reduction for each county by SIP area for the different programs was then calculated.

PUC-Senate Bill 5 Grants Program. To calculate the annual electricity savings from the PUC's Senate Bill 5 program, electricity savings

were also obtained from the Public Utilities Commission¹⁹. The annual and average day electricity savings were then proportioned according to the PCA and program. Using the actual reported numbers for 2002 and 2003, savings through 2020 were projected incorporating the different adjustment factors mentioned above²⁰. The 2007 annual and OSD eGRID were used to calculate the NOx emissions savings for PUC-Senate Bill 5 Grants Program. The total electricity savings for each PCA were used to calculate the NOx emissions reduction for each of the different counties.

SECO Savings. The annual electricity savings from energy conservation projects reported by political subdivisions for 35 counties through 2006 were obtained from the State Energy Conservation Office²¹. These submittals included information gathered from SECO's website²² and paper submittals²³. The annual and average day electricity values were then summarized according to county and program. Using the actual reported numbers for 2004, savings through 2020 were projected using the different adjustment factors mentioned above. In a similar fashion as the previous programs it was assumed that the same amount of electricity savings will be achieved for each year after 2007 until 2020. The 2007 annual and OSD eGRID were then

¹⁹ In a similar fashion as the PUC's Senate Bill 7 program, the annual electricity savings numbers were then divided by 365 to get average electricity savings per day for OSD calculations. The preferred approach would be to weather-normalize the savings and then calculate savings for the OSD period. However, only annual values were obtained for the 2005 report to the TCEQ. Dividing the annual values by 365 is probably a reasonable approach for lighting projects. However, this undercounts potential savings from electric loads associated with the cooling season.

²⁰ Since the savings for the PUC's Senate Bill 5 were only reported for two years these savings actually reduced due to the imposed degradation factor.

²¹ In a similar fashions as the PUC's Senate Bill 5 and 7 programs, these annual electricity savings numbers were divided by 365 to get average electricity savings per day for the OSD calculations.

²² This web site was developed for SECO by the Laboratory, at the request of the TCEQ.

²³ In these submittals, there were several municipalities whose electricity or natural consumption increased in 2004 as compared to 2001, which caused the reported savings from these municipalities to be negative. Since no additional information was reported from these projects that might have indicated what the cause of this was, it was assumed that the energy conservation projects were working as designed, but that other factors had changed the energy consumption. Therefore, in the final values of electricity savings from the political subdivisions that reported to SECO for the calculation of annual and OSD NOx reductions, the negative savings were omitted.

¹⁷ These use the NOx/MBtu values provided in the US EPA AP 42 guideline.

¹⁸ In a similar fashion to the previous programs, to obtain the Ozone Season Day (OSD) savings, the annual electricity savings were divided by 365.

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 2006 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, while for the OSD period the data were converted to average daily electricity production during the months of July, August and September. Using the reported numbers for 2006, savings through 2020 were projected incorporating the different adjustment factors mentioned above. The 2007 annual and OSD eGRID were then used to calculate the NOx emissions reductions for the electricity generated by Texas' wind farms²⁴. The total electricity savings for each PCA were used to calculate the NOx emissions reduction for each of the different counties

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 2006 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 was calculated for the retrofit. Using the numbers for 2006, the savings through 2020 were projected by incorporating the appropriate adjustment factors²⁵. 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 PCA were used to calculate the NOx

emissions reductions for each of the different county using the emissions factors contained in the 2007 eGRID. Cumulative NOx emissions reductions for each county, by SIP area were also calculated.

RESULTS

The total cumulative annual and OSD electricity savings for all the different programs in the integrated format was calculated using the adjustment factors shown in Table 1 for 2001 through 2020 as shown in Table 3. NOx emissions reductions from the electricity and natural gas savings for the annual and OSD for all the programs in the integrated format are shown in Table 4. In Table 3 and Table 4 annual values are shown for 2005, and cumulative annual values are shown 2006 through 2020. The OSD NOx emissions reductions are also shown in Figure 2 as stacked bar charts and in Figure 3 for the individual components.

In 2008, the cumulative annual electricity savings from code-compliant residential and commercial construction is calculated to be 1,551,569 MWh/year (6.8% of the total electricity savings), savings from retrofits to Federal buildings is 206,960 MWh/year (0.9%), savings from furnace pilot light retrofits is 2,548,904 MBtu/year, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 2,015,453 MWh/year (8.8%), savings from SECO's Senate Bill 5 program is 445,357 MWh/year (1.9%), electricity savings from green power purchases (wind) is 15,171,518 MWh/year (66.2%), and savings from residential air conditioner retrofits is 989,385 MWh/year (4.3%). The total savings from all programs is 22,929,144 MWh/year.

In 2008, the cumulative OSD electricity savings from code-compliant residential and commercial construction is calculated to be 6,904 MWh/day (14.2%), savings from retrofits to Federal buildings is 567 MWh/day (1.2%), savings from furnace pilot light retrofits is 6,983 MBtu/day, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 5,522 MWh/day (11.4%), savings from SECO's Senate Bill 5 program is 1,220 MWh/day (2.5%), electricity savings from green power purchases (wind) are 25,575 MWh/day (52.6%), and savings from residential air conditioner retrofits are 7,017 MWh/day (14.5%). The total savings from all programs is 48,602 MWh/day, which would be a 2,025 MW

²⁴ 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.

²⁵ Additional details about this calculation is contained in the Laboratory's 2006 Annual Report to the TCEQ, available at the Senate Bill 5 web site "eslsb5.tamu.edu".

average hourly load reduction during the OSD period.

By 2013, the cumulative annual electricity savings from code-compliant residential and commercial construction is calculated to be 2,045,171 MWh/year (5.8% of the total electricity savings), savings from retrofits to Federal buildings will be 402,732 MWh/year (1.1%), savings from furnace pilot light retrofits will remain at 2,548,904 MBtu/year, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 3,527,334 MWh/year (10.0%), savings from SECO's Senate Bill 5 program will be 489,440 MWh/year (1.4%), electricity savings from green power purchases (wind) will be 23,985,240 MWh/year (68.0%), and savings from residential air conditioner retrofits will be 2,286,233 MWh/year (6.5%). The total savings from all programs will be 35,285,055 MWh/year.

By 2013, the cumulative OSD electricity savings from code-compliant residential and commercial construction is calculated to be 12,110 MWh/day (15%), savings from retrofits to Federal buildings will be 1,103 MWh/day (1.4%), savings from furnace pilot light retrofits will remain at 6,983 MBtu/day, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 9,664 MWh/day (11.9%), savings from SECO's Senate Bill 5 program will be 1,341 MWh/day (1.7%), electricity savings from green power purchases (wind) will be 40,432 MWh/day (50.0%), and savings from residential air conditioner retrofits will be 16,216 MWh/day (20%). The total savings from all programs will be 80,866 MWh/day, which would be a 3,369 MW average hourly load reduction during the OSD period.

In 2008, the cumulative annual NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,091 tons-NOx/year (8.6% of the total NOx savings), savings from retrofits to Federal buildings is 158 tons-NOx/year (1.2%), savings from furnace pilot light retrofits is 117 tons-NOx/year (0.9%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 1,426 tons-NOx/year (11.2%), savings from SECO's Senate Bill 5 program is 340 tons-NOx/year (2.7%), electricity savings from green power purchases (wind) is 8,914 tons-NOx/year (70.0%), and savings from residential air conditioner retrofits is 682 tons-NOx/year

(5.3%). The total NOx emissions reduction from all programs is 12,727 tons-NOx/year.

In 2008, the cumulative OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 6 tons-NOx/day (19.2%), savings from retrofits to Federal buildings is 0.42 tons-NOx/day (1.3%), savings from furnace pilot light retrofits is 0.32 tons-NOx/day (1.0%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 3.82 tons-NOx/day (12.1%), savings from SECO's Senate Bill 5 program is 0.92 tons-NOx/day (2.9%), electricity savings from green power purchases (wind) are 15.13 tons-NOx/day (48.2%), and savings from residential air conditioner retrofits are 4.77 tons-NOx/day (15.2%). The total NOx emissions reduction from all programs is 31.38 tons-NOx/day.

By 2013, the cumulative NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,435 tons-NOx/year (7% of the total NOx savings), savings from retrofits to Federal buildings will be 308 tons-NOx/year (1.5%), savings from furnace pilot light retrofits will be 117 tons-NOx/year (0.6%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 2,495 tons-NOx/year (12.2%), savings from SECO's Senate Bill 5 program will be 373 tons-NOx/year (1.8%), electricity savings from green power purchases (wind) will be 14,092 tons-NOx/year (69.1%), and savings from residential air conditioner retrofits will be 1,574 tons-NOx/year (7.7%). The total NOx emissions reduction from all programs will be 20,395 tons-NOx/year.

By 2013, the cumulative OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 8.32 tons-NOx/day (15.9%), savings from retrofits to Federal buildings will be 0.81 tons-NOx/day (1.6%), savings from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.6%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 6.69 tons-NOx/day (12.8%), savings from SECO's Senate Bill 5 program will be 1.01 tons-NOx/day (1.9%), electricity savings from green power purchases (wind) will be 23.92 tons-NOx/day (45.9%), and savings from residential air conditioner retrofits will be 11.03 tons-NOx/day (21.2%). The total NOx emissions reduction from all programs will be 52.10 tons-NOx/day.

SUMMARY

This paper has presented the detailed results at the Laboratory's integrated NOx emissions reductions calculations, which were developed to satisfy the legislative requirements of Senate Bill 5. Additional information about these procedures can be found in the laboratory's annual Report to the TCEQ.

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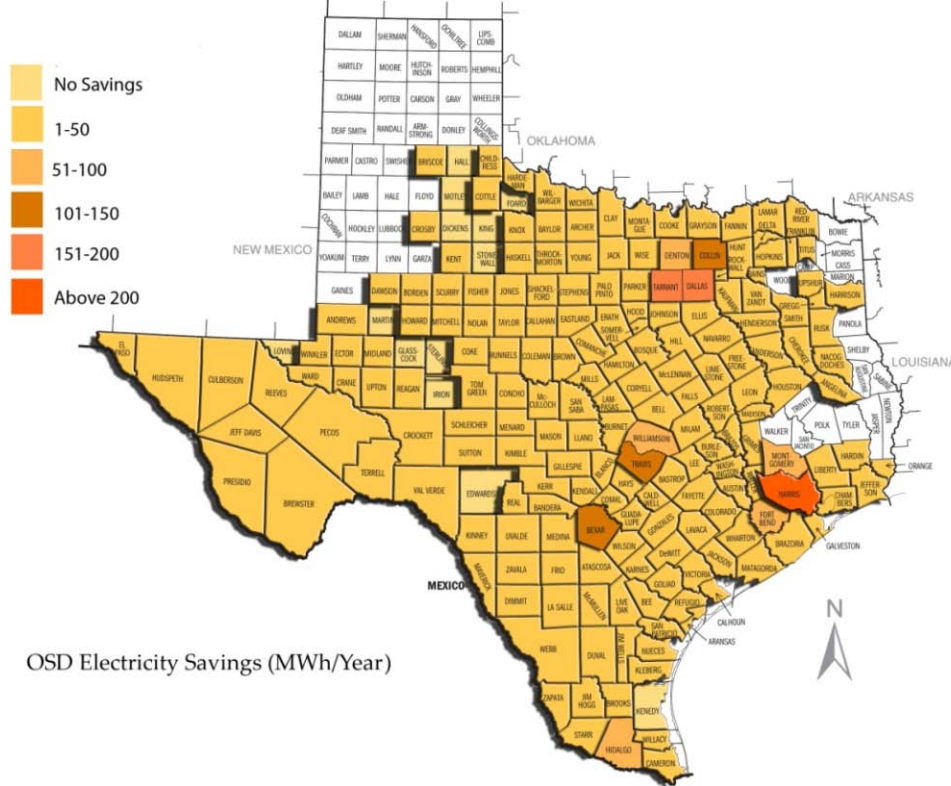
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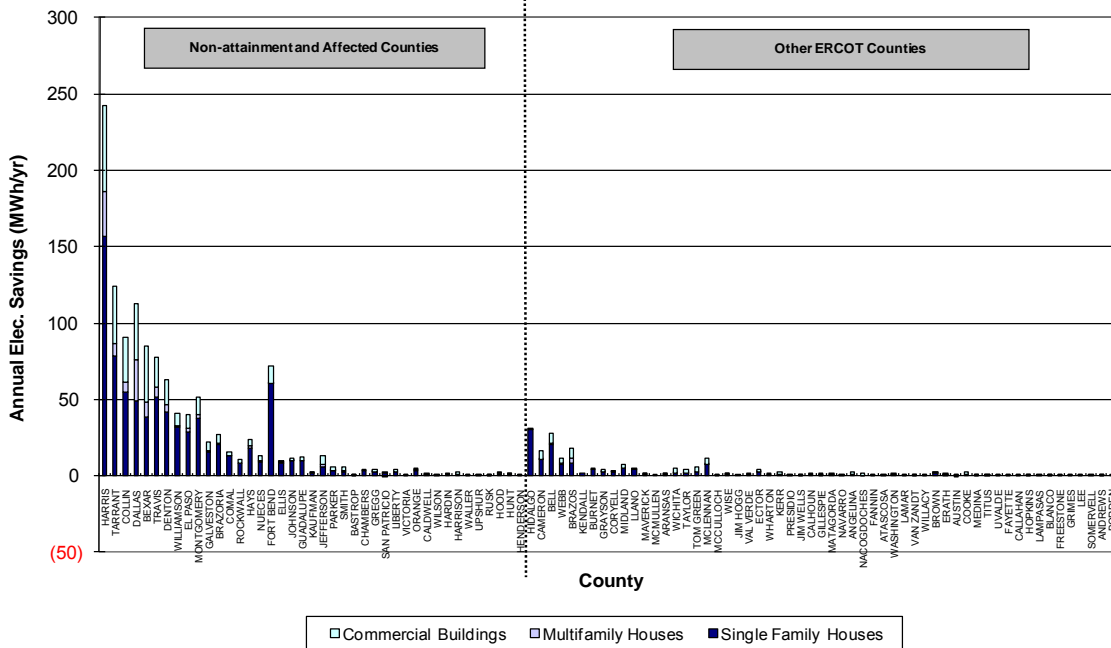
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Figure 1. 2008 OSD Electricity Reductions from IECC / IRC by PCA for Single-Family, Multi-Family Residences, and Commercial Buildings by County



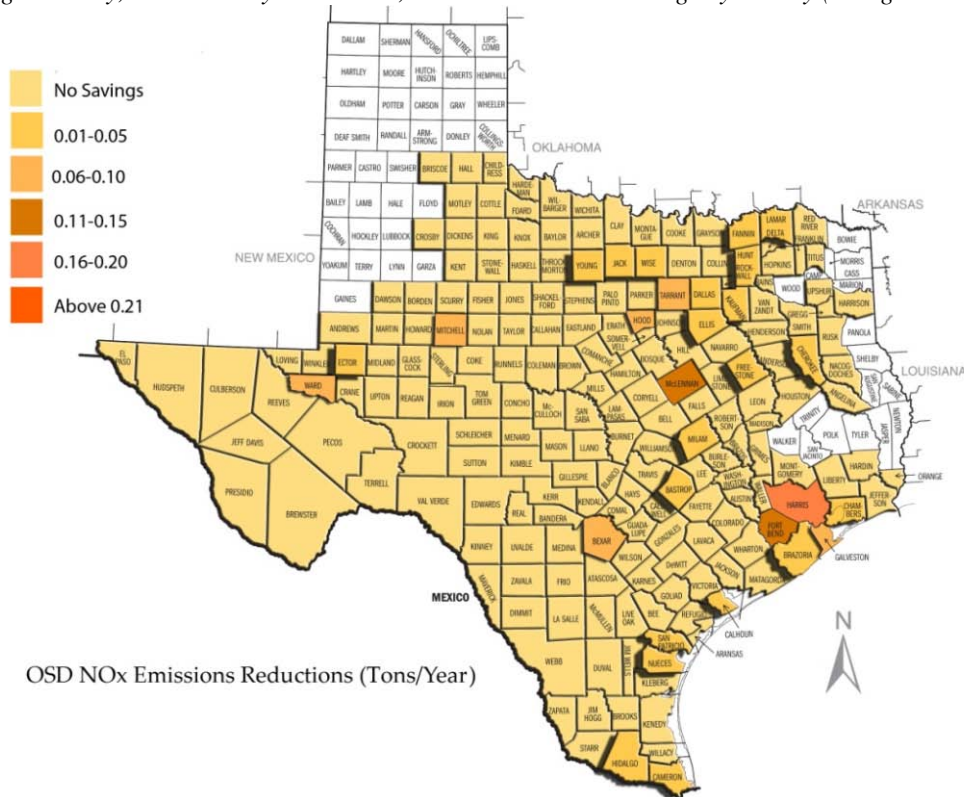
OSD Electricity Savings (MWh/Year)

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



(50)

Figure 2. 2008 OSD NOx Reductions from Electricity and Natural Gas Savings Due to the IECC/IRC for Single-Family, Multi-Family Residences, and Commercial Buildings by County (Using 2007 eGRID)



OSD NOx Emissions Reductions (Tons/Year)

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

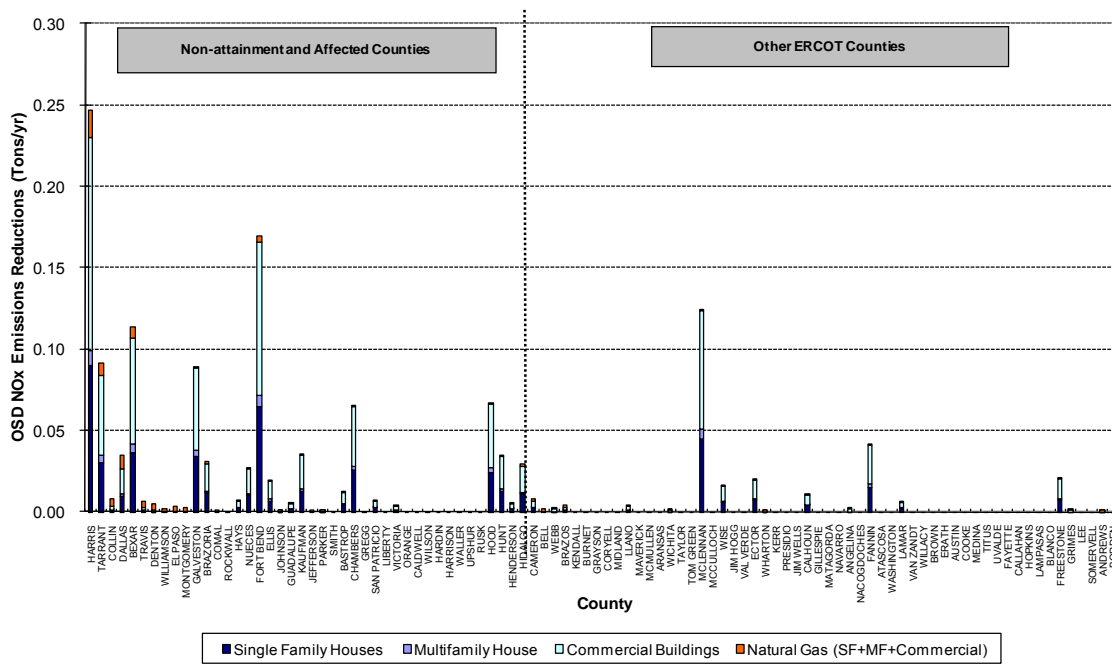


Table 1: Final Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs.

	ESL-Single Family ¹⁶	ESL-Multifamily ¹⁶	ESL-Commercial ¹⁶	Federal Buildings ¹⁵	Furnace Pilot Light Program ¹⁵	PUC (SB7) ¹⁵	PUC (SB5 Grant Program) ¹⁵	SECO ¹⁵	Wind-ERCOT ⁸	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor ¹¹	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	0.00%	5.00%	5.00%
T&D Loss ⁹	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%
Initial Discount Factor ¹²	20.00%	20.00%	20.00%	20.00%	20.00%	25.00%	25.00%	60.00%	25.00%	20.00%	20.00%
Growth Factor	3.25%	1.54%	3.25%	0.00%	0.00%	0.00%	0.00%	0.00%	Actual Rates	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes

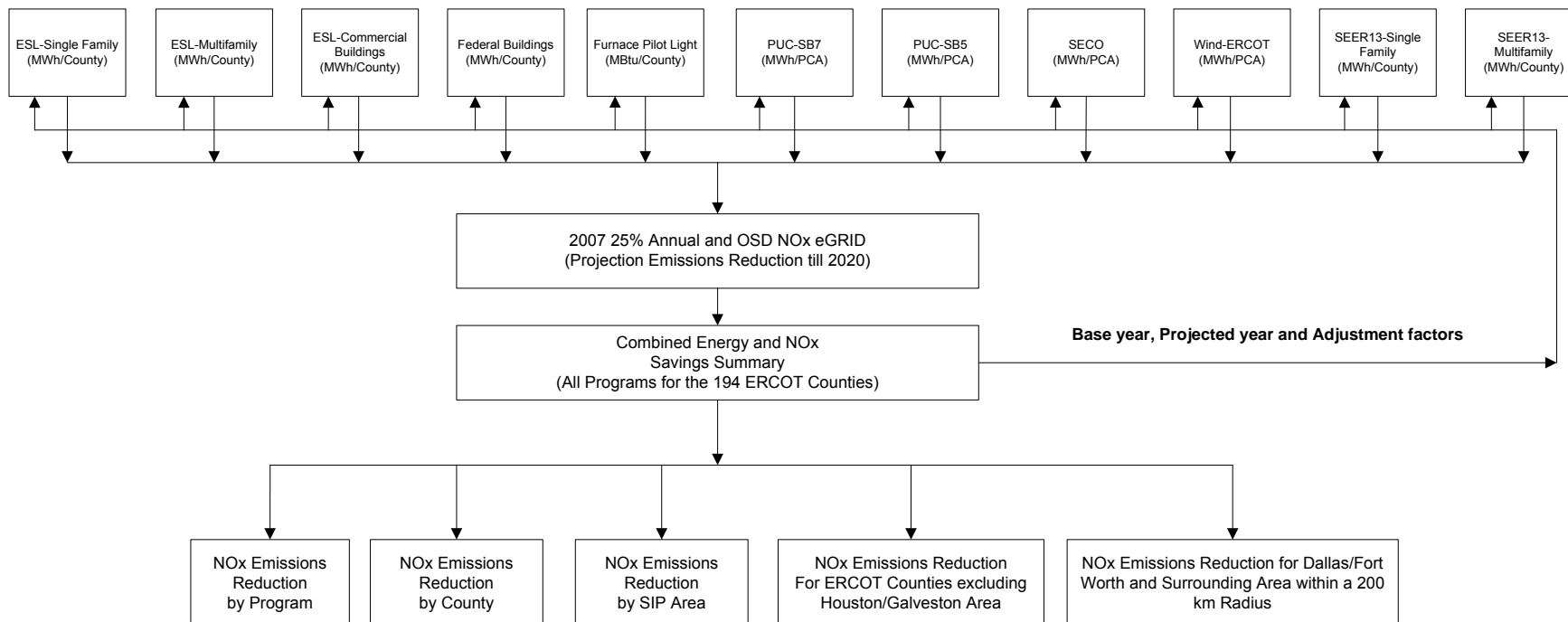


Figure 3: Process Flow Diagram of the NOx Emissions Reduction Calculations.

Table 3: Annual and OSD Electricity Savings for the Different Programs.

Program	Annual															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	225,389	1,001,051	1,197,537	1,256,764	1,313,777	1,368,371	1,420,340	1,469,480	1,515,583	1,558,446	1,597,862	1,633,626	1,665,533	1,693,376	1,716,950	1,736,050
ESL-Multifamily (MWh)	9,228	37,821	51,312	63,156	74,493	85,311	95,599	105,346	114,541	123,171	131,227	138,696	145,568	151,830	157,472	162,483
ESL-Commercial (MWh)	63,456	129,063	192,036	231,649	270,392	308,184	344,944	380,592	415,047	448,228	480,055	510,445	539,320	566,597	592,196	616,037
Federal Buildings (MWh)	52,276	109,073	159,415	206,960	251,708	293,659	332,813	369,171	402,732	433,496	461,464	486,635	509,009	528,586	545,366	559,350
Furnace Pilot Light Prog. (MMBtu)	2,209,050	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904
PUC (SB7) (MWh)	302,192	1,362,701	1,630,383	2,003,432	2,353,192	2,679,663	2,982,846	3,262,739	3,519,343	3,752,658	3,962,684	4,149,421	4,312,869	4,453,028	4,569,898	4,663,479
PUC (SB5 grant program) (MWh)	0	13,633	12,827	12,021	11,215	10,409	9,603	8,797	7,991	7,186	6,380	5,574	4,768	3,962	3,156	2,350
SECO (MWh)	115,360	293,764	353,701	445,357	457,921	468,611	477,428	484,371	489,440	492,636	493,959	493,408	490,983	486,685	480,513	472,468
Wind-ERCOT (MWh)	2,867,049	6,699,696	9,193,504	15,171,518	20,115,442	22,082,748	22,595,958	23,280,238	23,985,240	24,711,593	25,459,941	26,230,952	27,025,312	27,843,728	28,686,928	29,555,662
SEER13-Single Family (MWh)	0	374,246	624,639	913,010	1,185,311	1,441,594	1,681,860	1,906,108	2,114,339	2,306,551	2,482,746	2,642,923	2,787,083	2,915,224	2,803,568	2,590,509
SEER13-Multifamily (MWh)	0	31,634	52,532	76,375	98,620	119,281	138,371	155,904	171,894	186,354	199,298	210,738	220,690	229,165	219,722	202,900
Total Annual (MWh)	3,634,949	10,052,682	13,467,885	20,380,240	26,132,070	28,857,830	30,079,762	31,422,747	32,736,151	34,020,320	35,275,615	36,502,419	37,701,133	38,872,181	39,775,770	40,561,288
Total Annual (MMBtu)	2,209,050	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904	2,548,904

Program	Ozone Season Day - OSD															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family (MWh)	776	5,537	6,519	6,904	7,275	7,809	8,138	8,450	8,744	9,019	9,274	9,507	9,717	9,904	10,065	10,199
ESL-Multifamily (MWh)	36	192	271	351	428	508	577	643	706	765	820	871	919	962	1,002	1,037
ESL-Commercial (MWh)	0	800	1,189	1,447	1,700	1,966	2,205	2,436	2,660	2,876	3,082	3,280	3,467	3,645	3,811	3,967
Federal Buildings (MWh)	0	299	437	567	690	805	912	1,011	1,103	1,188	1,264	1,333	1,395	1,448	1,494	1,532
Furnace Pilot Light Prog. (MMBtu)	5,819	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983
PUC (SB7) (MWh)	828	3,733	4,467	5,489	6,447	7,342	8,172	8,939	9,642	10,281	10,857	11,368	11,816	12,200	12,520	12,777
PUC (SB5 grant program) (MWh)	0	37	35	33	31	29	26	24	22	20	17	15	13	11	9	6
SECO (MWh)	316	805	969	1,220	1,255	1,284	1,308	1,327	1,341	1,350	1,353	1,352	1,345	1,333	1,316	1,294
Wind-ERCOT (MWh)	5,836	14,936	20,763	25,575	33,908	37,225	38,090	39,243	40,432	41,656	42,918	44,217	45,556	46,936	48,357	49,822
SEER13-Single Family (MWh)	0	2,666	4,449	6,503	8,442	10,268	11,979	13,576	15,059	16,428	17,683	18,824	19,851	20,764	19,969	18,451
SEER13-Multifamily (MWh)	0	213	354	514	664	803	931	1,049	1,157	1,254	1,341	1,418	1,485	1,542	1,479	1,365
Total OSD (MWh)	7,791	29,219	39,453	48,602	60,840	68,037	72,339	76,700	80,866	84,837	88,610	92,186	95,565	98,745	100,022	100,451
Total OSD (MMBtu)	5,819	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983	6,983

Table 4: Annual and OSD NOx Emissions Reduction Values for the Different Programs.

Program	Annual (in tons NOx)															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	158	708	843	883	922	960	996	1,029	1,061	1,090	1,117	1,141	1,163	1,182	1,198	1,210
ESL-Multifamily	6	26	35	44	51	59	66	73	79	85	91	96	100	105	109	112
ESL-Commercial	44	90	136	164	192	218	245	270	295	319	341	363	384	403	421	438
Federal Buildings	40	84	122	158	193	225	255	283	308	332	353	373	390	405	418	428
Furnace Pilot Light Program	102	117	117	117	117	117	117	117	117	117	117	117	0	0	0	0
PUC (SB7)	237	1,074	1,157	1,421	1,668	1,899	2,113	2,311	2,492	2,657	2,805	2,937	3,052	3,151	3,234	3,553
PUC (SB5 grant program)	0	6	5	5	5	4	4	4	3	3	3	2	2	2	1	1
SECO	67	224	270	340	349	357	364	369	373	376	377	376	374	371	366	360
Wind-ERCOT	2,465	4,152	5,688	8,914	11,818	12,974	13,276	13,678	14,092	14,519	14,958	15,411	15,878	16,359	16,854	17,365
SEER13-Single Family	0	258	430	629	816	993	1,158	1,313	1,456	1,589	1,710	1,820	1,920	2,008	1,931	1,784
SEER13-Multifamily	0	22	36	53	68	82	95	107	118	128	137	145	152	158	151	140
Total Annual (Tons NOx)	3,119	6,760	8,839	12,727	16,200	17,889	18,689	19,554	20,395	21,214	22,009	22,782	23,415	24,143	24,683	25,392

Program	Ozone Season Day - OSD (in tons Nox/day)															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-Single Family	0.76	3.85	4.50	4.76	5.01	5.37	5.60	5.80	6.00	6.19	6.36	6.51	6.65	6.77	6.88	6.97
ESL-Multifamily	0.03	0.13	0.18	0.24	0.29	0.35	0.39	0.44	0.48	0.52	0.56	0.59	0.63	0.66	0.68	0.71
ESL-Commercial	0.26	0.55	0.82	1.00	1.17	1.36	1.52	1.68	1.84	1.98	2.13	2.26	2.39	2.52	2.63	2.74
Federal Buildings	0.11	0.22	0.32	0.42	0.51	0.59	0.67	0.74	0.81	0.87	0.93	0.98	1.02	1.06	1.10	1.12
Furnace Pilot Light Program	0.28	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.00	0.00	0.00	0.00
PUC (SB7)	0.64	2.61	3.10	3.81	4.47	5.09	5.66	6.19	6.68	7.12	7.51	7.87	8.18	8.44	8.66	8.84
PUC (SB5 grant program)	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
SECO	0.18	0.61	0.73	0.92	0.95	0.97	0.99	1.00	1.01	1.02	1.02	1.02	1.02	1.01	0.99	0.98
Wind-ERCOT	5.85	9.27	12.98	15.13	20.06	22.03	22.54	23.22	23.92	24.65	25.39	26.16	26.96	27.77	28.61	29.48
SEER13-Single Family	0.00	1.81	3.03	4.42	5.74	6.98	8.15	9.23	10.24	11.17	12.03	12.80	13.50	14.12	13.58	12.55
SEER13-Multifamily	0.00	0.15	0.24	0.35	0.45	0.55	0.63	0.71	0.79	0.85	0.91	0.97	1.01	1.05	1.01	0.93
Total OSD (Tons NOx)	8.09	19.53	26.24	31.38	38.99	43.61	46.48	49.36	52.10	54.70	57.17	59.49	61.36	63.40	64.15	64.31

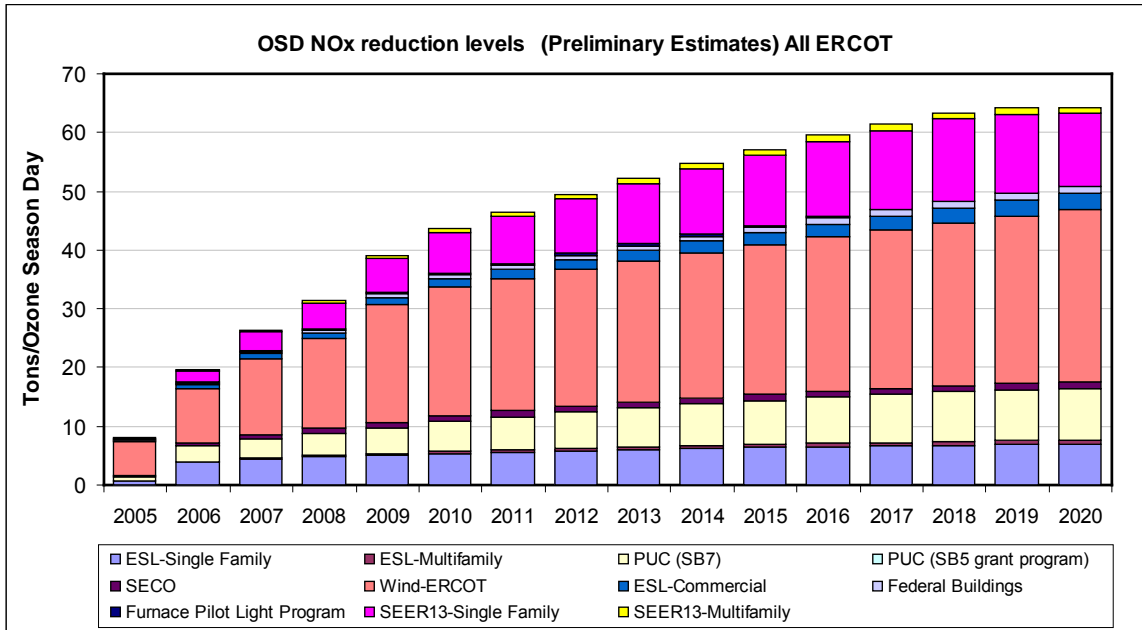


Figure 4: Cumulative OSD NOx Emissions Reduction Projections through 2020.

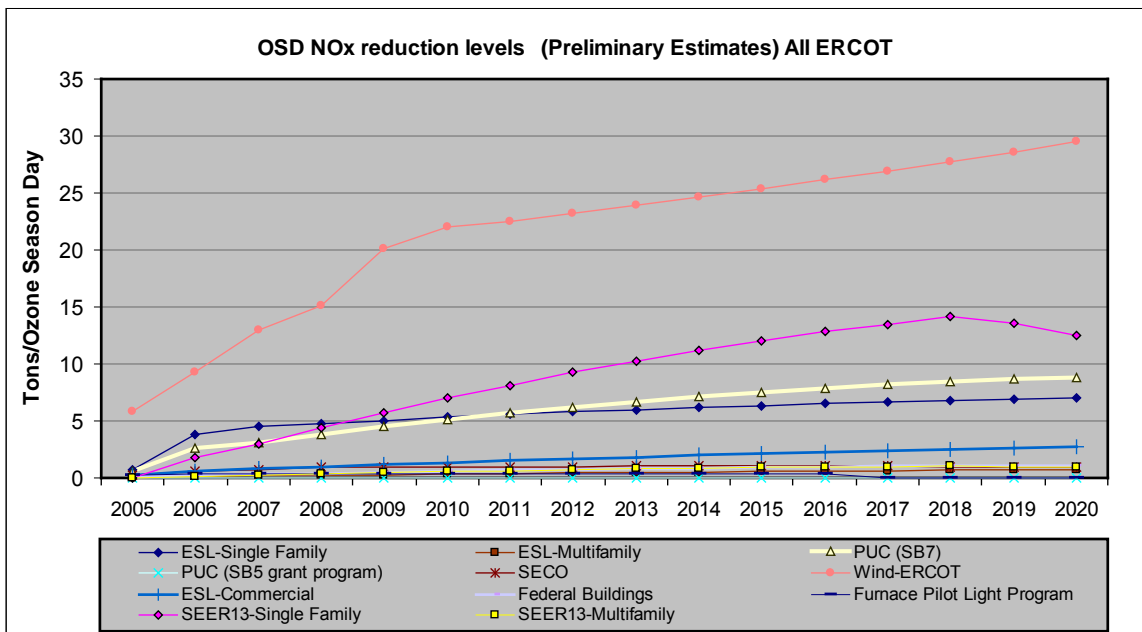


Figure 5: Cumulative OSD NOx Emissions Reduction Projections through 2020.