

**A METHODOLOGY FOR CALCULATING INTEGRATED NO<sub>x</sub> EMISSIONS REDUCTION FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY (EE/RE) PROGRAMS ACROSS STATE AGENCIES IN TEXAS**

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## ABSTRACT

This paper presents a summary of the integrated NO<sub>x</sub> emissions reduction calculation procedures developed by the Energy Systems Laboratory (ESL) to satisfy the reporting requirements for Senate Bill 5. These procedures are used to report annual NO<sub>x</sub> emissions reduction to the Texas Commission on Environmental Quality (TCEQ) from the state-wide energy efficiency and renewable energy programs of the Laboratory, Federal buildings, furnace pilot light upgrades, the Texas Public Utility Commission (PUC), the Texas State Energy Conservation Office (SECO) and electricity generated from wind power.

## BACKGROUND

In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NO<sub>x</sub> 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 cumulative savings estimates from all projects projected through 2020 for both the annual and Ozone Season Day<sup>1</sup> (OSD) NO<sub>x</sub> reductions. The NO<sub>x</sub> emissions reduction 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 2006 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 (ERCOT<sup>2</sup>)
- 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 (MBtu) savings are from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002, 2003, 2004, 2006).

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).

<sup>1</sup> An ozone season day (OSD) represents the daily average emissions during the period that runs from mid-July to mid-September.

<sup>2</sup> ERCOT is the Electric Reliability Council of Texas.

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 completed in the years 2001 through 2006. 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 2013, 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 2006 were also included.

## DESCRIPTION OF ANALYSIS METHOD

Annual and Ozone Season Day (OSD) NOx emissions reduction 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

programs<sup>3</sup>. 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 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; and
- 22.7% growth factor, on the basis that the installed wind power generation capacity will grow to 7,000 MW by 2015.

<sup>3</sup> 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.

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 models<sup>4</sup>. 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 project<sup>5</sup>. 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). 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 2020<sup>6</sup>. 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 report<sup>7</sup>.

For the 2006 annual and OSD NOx emissions calculations the US EPA's 2007 eGRID were used<sup>8</sup>. An example of the eGRID spreadsheet<sup>9</sup> is

<sup>6</sup> This would include the appropriate discount and degradation factors for each year.

<sup>7</sup> Haberl et al., 2005, pp. 197.

<sup>8</sup> 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.

<sup>9</sup> 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

<sup>4</sup> 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.

<sup>5</sup> 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.

given in Table 2. The total electricity savings for each PCA were used to calculate the NO<sub>x</sub> 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 NO<sub>x</sub> emissions reduction for the electricity savings from residential new construction for 2006 through 2020 is provided in Table 3. NO<sub>x</sub> emissions reduction is provided in Table 4.

**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 TCEQ<sup>10</sup>. 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 above<sup>11</sup>.

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).

**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 savings<sup>12</sup>.

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then listed on the far right columns (white columns). Similar spreadsheets for the 2007 eGRID exist for SO<sub>x</sub> and CO<sub>2</sub>.

<sup>10</sup> 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).

<sup>11</sup> This also includes the appropriate discount and degradation factors for each year.

<sup>12</sup> 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 NO<sub>x</sub> emission reduction values calculated.

**Furnace Pilot Light 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 NO<sub>x</sub> emissions reduction for the N.G. savings from the removal of furnace pilot lights were also calculated by county for 2006 through 2020 by SIP area<sup>13</sup>.

**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 Commission<sup>14</sup>. 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 NO<sub>x</sub> emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each PCA were used to calculate the NO<sub>x</sub> emissions reduction for each county using the emissions factors contained in the US EPA's eGRID spreadsheet. The cumulative NO<sub>x</sub> 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

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<sup>13</sup> These use the NO<sub>x</sub>/MBtu values provided in the US EPA AP 42 guideline.

<sup>14</sup> In a similar fashion to the previous programs, to obtain the Ozone Season Day (OSD) savings, the annual electricity savings were divided by 365.

were also obtained from the Public Utilities Commission<sup>15</sup>. 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 above<sup>16</sup>. 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 Office<sup>17</sup>. These submittals included information gathered from SECO's website<sup>18</sup> and paper submittals<sup>19</sup>. 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

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 reduction for the electricity generated by Texas' wind farms<sup>20</sup>. 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 factors<sup>21</sup>. 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

<sup>15</sup> 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.

<sup>16</sup> 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.

<sup>17</sup> In a similar fashion 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.

<sup>18</sup> This web site was developed for SECO by the Laboratory, at the request of the TCEQ.

<sup>19</sup> 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.

<sup>20</sup> 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.

<sup>21</sup> 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 "eslsb5.tamu.edu".

emissions reduction for each of the different county using the emissions factors contained in the 2007 eGRID. Cumulative NOx emissions reduction for each county by SIP area was 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 reduction from the electricity and natural gas savings for the annual and OSD for all the programs in the integrated format is 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 reduction is also shown in Figure 2 as stacked bar charts and in Figure 3 for the individual components.

In 2006 (Table 3) the cumulative annual electricity savings<sup>22</sup> from code-compliant residential and commercial construction is calculated to be 1,428,464 MWh/year (17.0% of the total electricity savings), savings from retrofits to Federal buildings is 109,073 MWh/year (1.3%), 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 1,376,334 MWh/year (16.3%), savings from SECO's Senate Bill 5 program is 293,763 MWh/year (3.5%), electricity savings from green power purchases (wind) is 4,782,508 MWh/year (56.9%), and savings from residential air conditioner retrofits<sup>23</sup> is 405,879 MWh/year (4.8%). The total savings from all programs is 8,396,023 MWh/year.

In 2006 the cumulative OSD electricity savings from code-compliant residential and commercial construction is calculated to be 7,703 MWh/day (29.9%), savings from retrofits to Federal buildings is 299 MWh/day (1.2%), savings from furnace pilot light retrofits is 5,819 MBtu/day, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 3,770 MWh/day (14.6%), savings from SECO's Senate Bill 5 program is 804 MWh/day (3.1%), electricity savings from

green power purchases (wind) are 10,305 MWh/day (40.0%), and savings from residential air conditioner retrofits are 2,879 MWh/day (11.1%). The total savings from all programs is 25,760 MWh/day, which would be a 1,073 MW 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 3,024,261 MWh/year (16.8% of the total electricity savings), savings from retrofits to Federal buildings will be 402,732 MWh/year (2.2%), 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 2,544,432 MWh/year (14.2%), savings from SECO's Senate Bill 5 program will be 407,940 MWh/year (2.3%), electricity savings from green power purchases (wind) will be 9,273,739 MWh/year (51.7%), and savings from residential air conditioner retrofits<sup>24</sup> will be 2,286,232 MWh/year (12.7%). The total savings from all programs will be 17,939,336 MWh/year.

By 2013 the cumulative OSD electricity savings from code-compliant residential and commercial construction is calculated to be 15,544 MWh/day (25.5%), savings from retrofits to Federal buildings will be 1103 MWh/day (1.8%), savings from furnace pilot light retrofits will remain at 5,819 MBtu/day, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 6,971 MWh/day (11.4%), savings from SECO's Senate Bill 5 program will be 1,117 MWh/day (1.8%), electricity savings from green power purchases (wind) will be 20,088 MWh/day (32.9%), and savings from residential air conditioner retrofits will be 16,216 MWh/day (26.6%). The total savings from all programs will be 61,039 MWh/day, which would be a 2,543 MW average hourly load reduction during the OSD period.

In 2006 (Table 4) the cumulative NOx emissions reduction<sup>25</sup> from code-compliant residential and commercial construction is calculated to be 1,010 tons-NOx/year (17.0% of the total NOx savings), savings from retrofits to Federal

<sup>22</sup> This includes the savings from 2001 through 2006.

<sup>23</sup> 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.

<sup>24</sup> 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.

<sup>25</sup> These NOx emissions reduction were calculated with the US EPA's 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

buildings is 84 tons-NOx/year (1.5%), savings from furnace pilot light retrofits is 117 tons-NOx/year (2.0%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 1,045 tons-NOx/year (18.2%), savings from SECO's Senate Bill 5 program is 224 tons-NOx/year (3.9%), electricity savings from green power purchases (wind) is 2,978 tons-NOx/year (51.9%), and savings from residential air conditioner retrofits is 280 tons-NOx/year (4.9%). The total NOx emissions reduction from all programs is 5,738 tons-NOx/year.

In 2006 the cumulative OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 5.35 tons-NOx/day (30.5%), savings from retrofits to Federal buildings is 0.22 tons-NOx/day (1.3%), savings from furnace pilot light retrofits is 0.32 tons-NOx/day (1.8%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 2.63 tons-NOx/day (15.0%), savings from SECO's Senate Bill 5 program is 0.62 tons-NOx/day (3.4%), electricity savings from green power purchases (wind) are 6.44 tons-NOx/day (36.7%), and savings from residential air conditioner retrofits are 1.96 tons-NOx/day (11.2%). The total NOx emissions reduction from all programs is 17.52 tons-NOx/day.

By 2013 the cumulative NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 2,121 tons-NOx/year (17.8% of the total NOx savings), savings from retrofits to Federal buildings will be 308 tons-NOx/year (2.6%), savings from furnace pilot light retrofits will be 117 tons-NOx/year (0.9%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 1,784 tons-NOx/year (15.0%), savings from SECO's Senate Bill 5 program will be 311 tons-NOx/year (2.6%), electricity savings from green power purchases (wind) will be 5,652 tons-NOx/year (47.6%), and savings from residential air conditioner retrofits will be 1,574 tons-NOx/year (13.3%). The total NOx emissions reduction from all programs will be 11,868 tons-NOx/year.

By 2013 the cumulative OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 10.75 tons-NOx/day (26.3%), savings from retrofits to Federal buildings will be 0.81 tons-NOx/day (1.9%), savings from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.8%),

savings from the PUC's Senate Bill 5 and Senate Bill 7 programs will be 4.78 tons-NOx/day (11.7%), savings from SECO's Senate Bill 5 program will be 0.84 tons-NOx/day (2.0%), electricity savings from green power purchases (wind) will be 12.32 tons-NOx/day (30.1%), and savings from residential air conditioner retrofits will be 11.03 tons-NOx/day (26.9%). The total NOx emissions reduction from all programs will be 40.86 tons-NOx/day.

## SUMMARY

This paper has presented the detailed results at the Laboratory's integrated NOx emissions reduction 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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Table 1: Final Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs.

	ESL-Single Family <sup>16</sup>	ESL-Multifamily <sup>16</sup>	ESL-Commercial <sup>16</sup>	Federal Buildings <sup>15</sup>	Furnace Pilot Light Program <sup>15</sup>	PUC (SB7) <sup>15</sup>	PUC (SB5 Grant Program) <sup>15</sup>	SECO <sup>15</sup>	Wind-ERCOT <sup>8</sup>	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor <sup>11</sup>	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
T&D Loss <sup>9</sup>	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 <sup>12</sup>	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%	According to SB 20, section 39.904	N.A.	N.A.

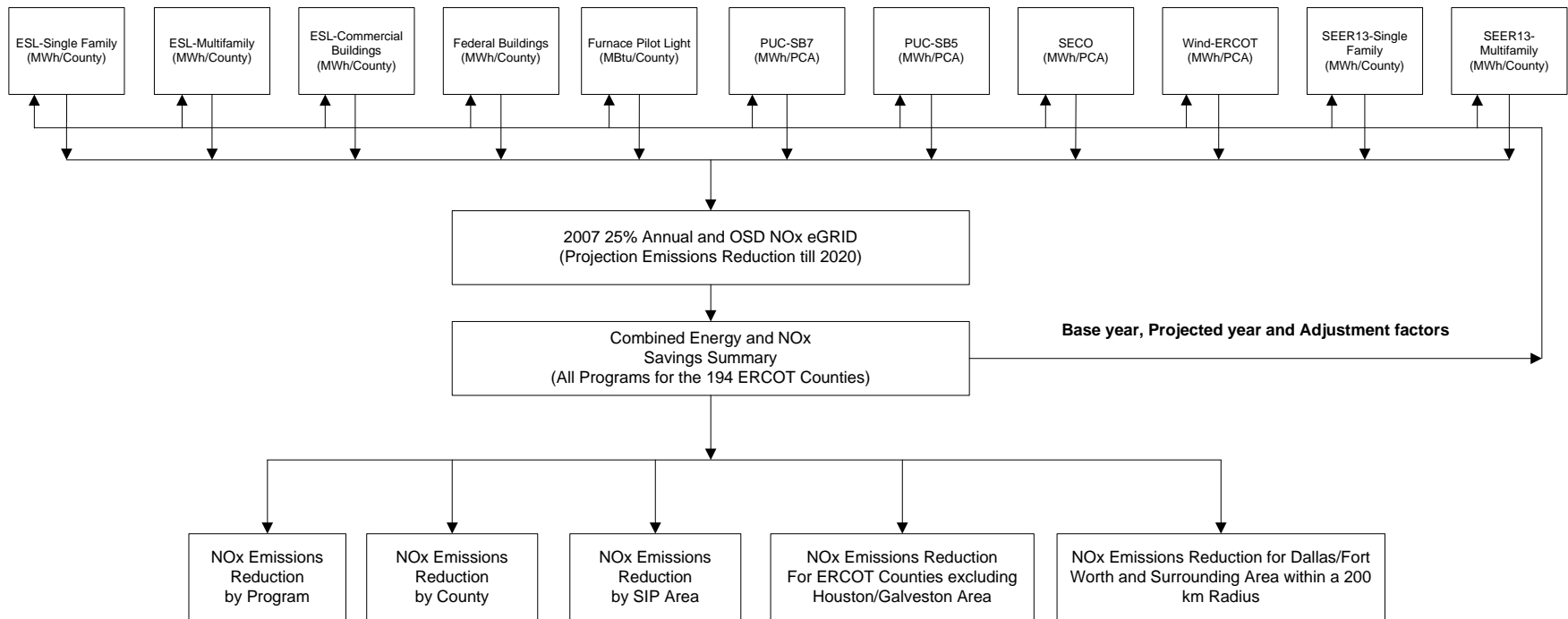


Figure 1: Process Flow Diagram of the NOx Emissions Reduction Calculations.

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

Table with columns for Area, County, American Electric Power - West (ERCOT), NOx Reductions (lbs), Austin Energy/PCA, NOx Reductions (lbs), Brownsville Public Utility Service (lbs), NOx Reductions (lbs), Lower Colorado River Authority /PCA, NOx Reductions (lbs), Reliant Energy H&LP/PCA, NOx Reductions (lbs), San Antonio Public Bid/PCA, NOx Reductions (lbs), South Texas Electric Coop N/C/PCA, NOx Reductions (lbs), Texas Municipal Power Pool/PCA, NOx Reductions (lbs), Texas New Mexico Power, NOx Reductions (lbs), TXU Electric/PCA, NOx Reductions (lbs), Total NOx Reductions (lbs), Total NOx Reductions (Tons).

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

Program	2005	Cumulative 2006	Cumulative 2007	Cumulative 2008	Cumulative 2009	Cumulative 2010	Cumulative 2011	Cumulative 2012	Cumulative 2013	Cumulative 2014	Cumulative 2015	Cumulative 2016	Cumulative 2017	Cumulative 2018	Cumulative 2019	Cumulative 2020
	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)	Annual (MWh)
ESL-Single Family	225,389	924,435	1,130,412	1,331,385	1,526,961	1,716,750	1,900,358	2,077,955	2,247,468	2,410,186	2,565,156	2,711,987	2,855,381	2,984,366	3,104,035	3,213,997
ESL-Multifamily	9,228	70,641	76,713	82,429	87,780	92,759	97,358	101,570	105,387	108,801	111,806	114,393	116,653	118,374	119,655	120,487
ESL-Commercial	56,084	433,388	471,614	508,595	544,233	578,430	611,990	642,115	671,406	698,868	724,402	747,910	770,563	789,631	806,381	820,315
Federal Buildings	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 Program (Mbtu)	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)	336,358	1,362,701	1,573,304	1,769,598	1,951,584	2,119,261	2,272,629	2,411,680	2,536,441	2,646,884	2,743,018	2,824,843	2,892,360	2,945,569	2,984,469	3,009,060
PUC (SB5 grant program)	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	87,550	293,764	297,494	335,753	353,938	370,249	384,686	397,250	407,941	416,757	423,700	428,770	431,966	433,289	432,738	430,313
Wind-ERCOT	2,912,683	4,782,508	5,023,145	4,820,640	5,705,725	6,533,348	7,303,511	8,016,212	9,273,739	9,269,232	9,383,227	9,461,078	9,954,593	9,960,154	10,138,098	10,268,312
SEER13-Single Family	0	374,246	624,639	913,010	1,183,311	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	2,893,588	2,580,509
SEER13-Multifamily	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
OSD (MWh)		OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)	OSD (MWh)
ESL-Single Family	776	4,693	5,676	6,634	7,566	8,469	9,344	10,186	10,994	11,768	12,503	13,200	13,879	14,489	15,054	15,573
ESL-Multifamily	36	329	352	374	393	412	428	444	457	469	479	487	494	499	502	503
ESL-Commercial	412	2,681	2,909	3,128	3,340	3,543	3,736	3,920	4,093	4,255	4,406	4,544	4,677	4,788	4,885	4,968
Federal Buildings	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 Program (Mbtu)	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)	828	3,733	4,310	4,848	5,347	5,806	6,226	6,607	6,949	7,252	7,515	7,739	7,924	8,070	8,177	8,244
PUC (SB5 grant program)	0	37	35	33	31	29	26	24	22	20	17	15	13	11	9	6
SECO	316	805	815	920	970	1,014	1,054	1,088	1,118	1,142	1,161	1,176	1,187	1,191	1,186	1,179
Wind-ERCOT	4,377	10,305	10,003	10,425	12,651	14,142	15,809	17,352	20,089	20,084	20,111	20,479	21,548	21,549	21,967	22,227
SEER13-Single Family	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	0	213	354	514	644	803	931	1,049	1,157	1,254	1,341	1,418	1,485	1,542	1,479	1,365
Total Ann (MWh)	3,679,568	8,396,023	9,422,095	10,056,765	11,177,073	12,275,739	14,732,280	16,086,212	17,939,338	18,484,315	19,101,196	19,634,850	20,543,066	20,908,319	21,157,187	21,217,993
Total OSD (MWh)	6,744	25,762	29,340	33,955	39,792	45,290	50,446	55,258	61,042	63,839	66,681	69,215	72,450	74,359	74,699	74,049
Total OSD (Mbtu)	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	2005	Cum. 2006	Cum. 2007	Cum. 2008	Cum. 2009	Cum. 2010	Cum. 2011	Cum. 2012	Cum. 2013	Cum. 2014	Cum. 2015	Cum. 2016	Cum. 2017	Cum. 2018	Cum. 2019	Cum. 2020
	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)	Annual (Tons)
ESL-Single Family	158	656	800	940	1,076	1,208	1,336	1,459	1,578	1,691	1,799	1,901	2,000	2,090	2,173	2,250
ESL-Multifamily	41	50	54	59	62	65	69	71	73	75	77	79	81	82	83	83
ESL-Commercial	39	394	331	357	381	405	428	450	470	490	508	524	540	553	565	576
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	117	117	117	117
PUC (SB7)	237	1,039	1,118	1,253	1,378	1,494	1,599	1,695	1,781	1,856	1,922	1,978	2,023	2,059	2,085	2,238
PUC (SB5 grant program)	0	6	5	5	5	4	4	4	3	3	3	2	2	2	1	1
SECO	67	224	227	256	270	282	293	303	311	318	323	327	330	330	330	328
Wind-ERCOT	1,848	2,978	3,128	2,947	3,488	3,994	4,464	4,900	5,652	5,666	5,736	5,783	6,085	6,088	6,197	6,277
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	69	82	95	107	118	123	137	145	152	158	151	140
OSD (Tons)		OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)	OSD (Tons)
ESL-Single Family	0.76	3.29	3.97	4.63	5.27	5.90	6.50	7.09	7.64	8.18	8.69	9.17	9.64	10.06	10.45	10.81
ESL-Multifamily	0.03	0.23	0.24	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.33	0.34	0.34	0.34	0.34
ESL-Commercial	0.23	1.83	1.99	2.14	2.29	2.43	2.56	2.68	2.80	2.91	3.02	3.11	3.20	3.28	3.35	3.40
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	0.32	0.32	0.32	0.32
PUC (SB7)	0.64	2.61	3.00	3.36	3.69	4.00	4.28	4.54	4.77	4.97	5.14	5.29	5.41	5.51	5.57	5.62
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	0.62	0.69	0.73	0.77	0.80	0.82	0.84	0.86	0.88	0.89	0.90	0.89	0.89	0.89
Wind-ERCOT	4.38	6.44	6.15	6.42	7.60	8.70	9.72	10.67	12.32	12.34	12.49	12.60	13.25	13.26	13.50	13.67
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 Annual	2,498	5,738	6,368	6,772	7,854	8,870	9,819	10,702	11,668	12,265	12,684	13,049	13,521	13,774	13,933	14,163
Total OSD	6.60	17.52	19.89	23.02	26.89	30.52	33.94	37.12	40.86	42.81	44.74	46.46	48.27	49.58	49.79	49.33

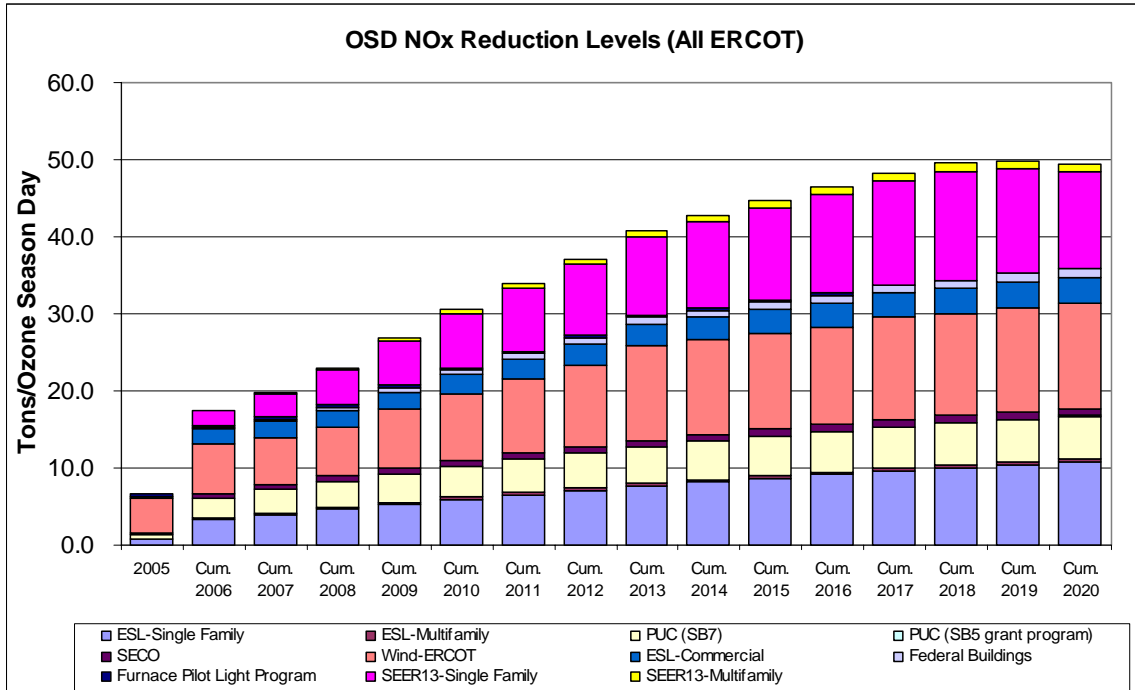


Figure 2: Cumulative OSD NOx Emissions Reduction Projections through 2020.

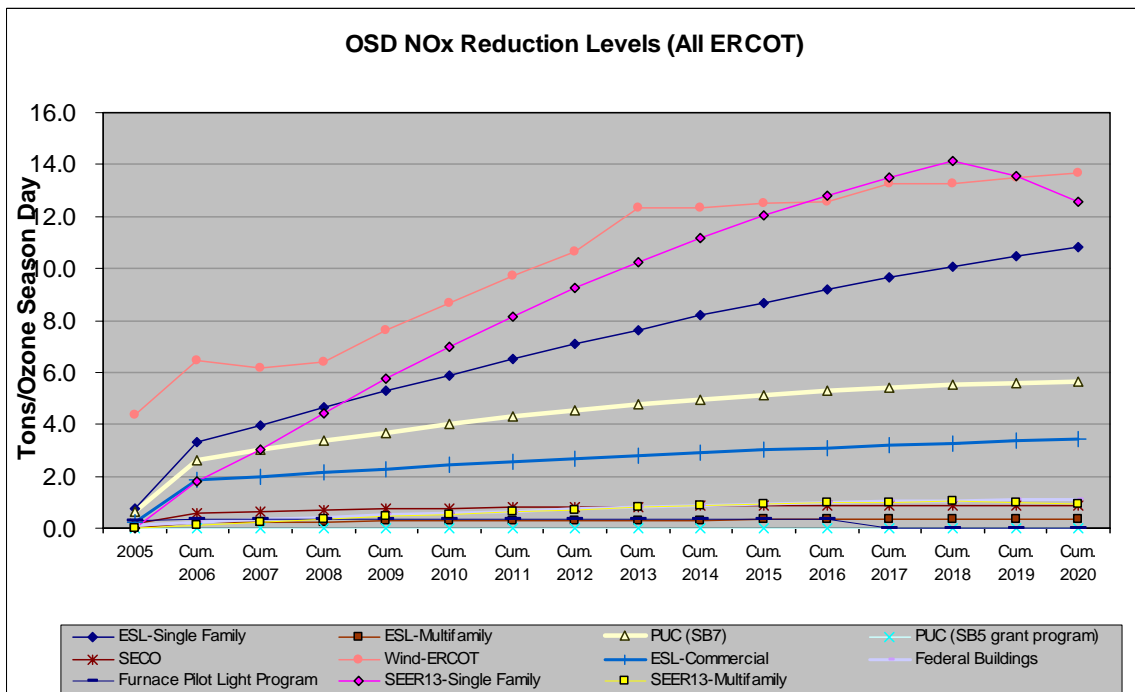


Figure 3: Cumulative OSD NOx Emissions Reduction Projections through 2020.