

## Calculation of Integrated NO<sub>x</sub> Emissions Reductions from Energy Efficiency and Renewable Energy (EE/RE) Programs across State Agencies in Texas

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### ABSTRACT

This paper presents an update of the integrated NO<sub>x</sub> emissions reductions calculations 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. These procedures are used to report annual and Ozone Season Day (OSD) NO<sub>x</sub> 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, 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 conditioners.

### BACKGROUND

In 1970, the Federal Clean Air Act directed the United States Environmental Protection Agency (US EPA) 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 National Ambient Air Quality Standards (NAAQS) which describe the allowable maximum limits of six primary air pollutants.<sup>2</sup> 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<sub>x</sub> 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.).<sup>3</sup> 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 (ICC 2000; 2001; 2009a; 2009b). In January 2005, the Laboratory was asked by the

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<sup>2</sup> The limits for these pollutants currently are: carbon monoxide (CO – 9 ppm, 8-hour average; 35 ppm, 1-hour average), lead (Pb – 0.15 µg/m<sup>3</sup>, quarterly average), nitrogen dioxide (NO<sub>2</sub> – 100 ppb, 1-hour average; 53 ppb annual average), Ozone (O<sub>3</sub> – 0.075 ppm, 8-hour average), particle pollution (PM<sub>2.5</sub>–12 µg /m<sup>3</sup>, annual average; 35 µg /m<sup>3</sup>, 24-hour average; PM<sub>10</sub> – 150 µg /m<sup>3</sup>, 24-hour average), and sulfur dioxide (SO<sub>2</sub> – 75 ppb, 1-hour average) (EPA 2013).

<sup>3</sup> In 2003, the 78<sup>th</sup> 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 79<sup>th</sup> 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. In the 2007 80<sup>th</sup> 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. In 2009, the 81<sup>st</sup> Legislature extended the date 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. In the 2011 82<sup>nd</sup> Legislature, the Laboratory's responsibilities under TERP increased, as new energy efficiency initiatives were introduced, including: requiring the Laboratory to calculate energy savings and emissions reduction for each political subdivision, institution of higher education or state agency; and requiring the Laboratory to calculate energy savings and emissions reduction for municipally owned utilities and for electric cooperatives, based on the information collected by SECO.

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 (OSD)<sup>4</sup> NO<sub>x</sub> reductions. Baltazar et al. (2010) presents the developed calculation method, which was based on the 2008 cumulative analysis. This paper is an update of the previous calculations reported by Baltazar et al. based on the 2011 cumulative analysis.

Several changes have been made for the calculation in the 2011 analysis. First, the NO<sub>x</sub> emissions reductions from all these programs were calculated for each year based on year 2008 savings using estimated emissions factors for 2010 from the US EPA's Emissions and Generation Resource Integrated Database (eGrid) database, which had been specially prepared for this purpose (EPA and ESL 2008)<sup>5</sup>. Several programs (i.e., federal buildings program, furnace pilot light program, and PUC Senate Bill 5 grant program) which were discontinued before year 2008 were not considered in the 2011 analysis<sup>6</sup>. The current programs included in the 2011 cumulative analysis are:

- ESL Single-family new construction,
- Multi-family new construction,
- Commercial new construction
- PUC Senate Bill 7 Program
- SECO Senate Bill 5 Program
- Electricity generated by wind farms in Texas (ERCOT)
- 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 IRC 2009 building code (ICC 2009b). 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).

The Laboratory's commercial programs include the energy savings attained by new construction in

office, assembly, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 2011). The calculations used energy savings from the Pacific Northwest National Laboratory (DOE 2011).

The Texas Public Utility Commission's (PUC) Senate Bill 7 programs include their incentive and rebates programs managed by the different Utilities for Texas (PUC 2012). 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.

The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers. The annual electricity savings from energy conservation projects reported by political subdivisions for 39 counties through 2011 were obtained from the SECO.

The integrated savings also include MWh and NO<sub>x</sub> emissions savings from the currently installed green power generation (wind) capacity in west Texas for 2001 through 2011. Projections through 2012 include planned projects by ERCOT with annual growth factors from the PUC.

Finally, NO<sub>x</sub> emissions reductions from the installation of SEER 13 air conditioners in existing residences are also reported. 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.

## DESCRIPTION OF ANALYSIS

The annual and OSD NO<sub>x</sub> emissions reductions were calculated for 2011 and cumulatively 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

<sup>4</sup> An ozone season day (OSD) represents the daily average emissions during the period that runs from mid-July to mid-September.

<sup>5</sup> The previous analysis estimated the NO<sub>x</sub> emissions reductions for each year based on year 1999 savings using the 2007 eGrid. The 2007 eGrid uses the ten different Power Control Authorities

(PCAs), but the 2010 eGrid uses the four different Congestion Management (CM) zones.

<sup>6</sup> The SEER 13 single-family and multi-family programs are included in this analysis since the programs are still on-going even if their recent data update is not included in this analysis.

annual degradation factor of 2% was used for ESL single-family, multi-family, and commercial programs<sup>7</sup> and an annual degradation factor of 5% was used for all other programs<sup>8</sup>. The value of the 5% degradation factor was taken from a study by Kats et al. (1996).

**Transmission and distribution loss (T&D 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-family, multi-family, commercial, and SEER 13 retrofit programs, the discount factor was assumed to be 20%. For PUC's Senate Bill 7 programs, the discount factor was taken as 25%. For the savings in the SECO program, the discount factor was 60%. Lastly, a 10% initial discount factor was used for electricity from wind.

**Growth factor:** The growth factors shown were used to account for several different factors. Growth factors for single-family (3.25%) and multi-family residential (1.54%) construction are projections based on the average growth rate for these housing types from recent U.S. Census data for Texas. Growth factors for wind energy are from the Texas PUC<sup>9</sup>. 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 NOx savings were calculated from DOE-2.1e hourly simulation models<sup>10</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 2012). The SECO electricity savings were submitted as annual savings by project<sup>11</sup>. 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 the bottom row of Figure 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

**ESL Single-family and Multi-family.** The calculation of the annual and OSD electricity savings reported for the years 2002 through 2011 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 TCEQ (Haberl et al., 2002-2012). From 2009 to 2011, 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 2011, savings were then projected to 2020 by

<sup>7</sup> TCEQ suggested using a 2% degradation factor instead of 5% for the Laboratory's residential and commercial programs after public comments.

<sup>8</sup> A degradation of 5% per year would accumulate as a 5%, 10%, 15%...etc., degradation in performance for each year. 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 years 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.

<sup>9</sup> The growth factors for wind energy through 2012 are based on permitted wind farms registered with the Texas PUC, [http://www.puc.state.tx.us/electric/maps/gen\\_tables.xls](http://www.puc.state.tx.us/electric/maps/gen_tables.xls). Growth factors for 2013 through 2020 assume a linear projection based on the permits for 2011 and 2012.

<sup>10</sup> These values are based on a performance analysis as defined by Chapter 4 of IECC 2009. This analysis is discussed in the Laboratory's annual reports to the TCEQ.

<sup>11</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.

incorporating the different adjustment factors mentioned above.

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

	ESL-Single Family	ESL-Multi Family	ESL-Commercial	PUC (SB7)	SECO	Wind-ERCOT	SEER13 Single Family	SEER13 Multi Family
<b>Annual Degradation Factor</b>	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%
<b>T&amp;D Loss</b>	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
<b>Initial Discount Factor</b>	20.0%	20.0%	20.0%	25.0%	60.0%	10.0%	20.0%	20.0%
<b>Growth Factor</b>	3.25%	1.54%	3.25%	0.0%	0.0%	Actual Rates	N.A.	N.A.
<b>Weather Normalized</b>	Yes	Yes	Yes	No	No	(Note 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 of the year.

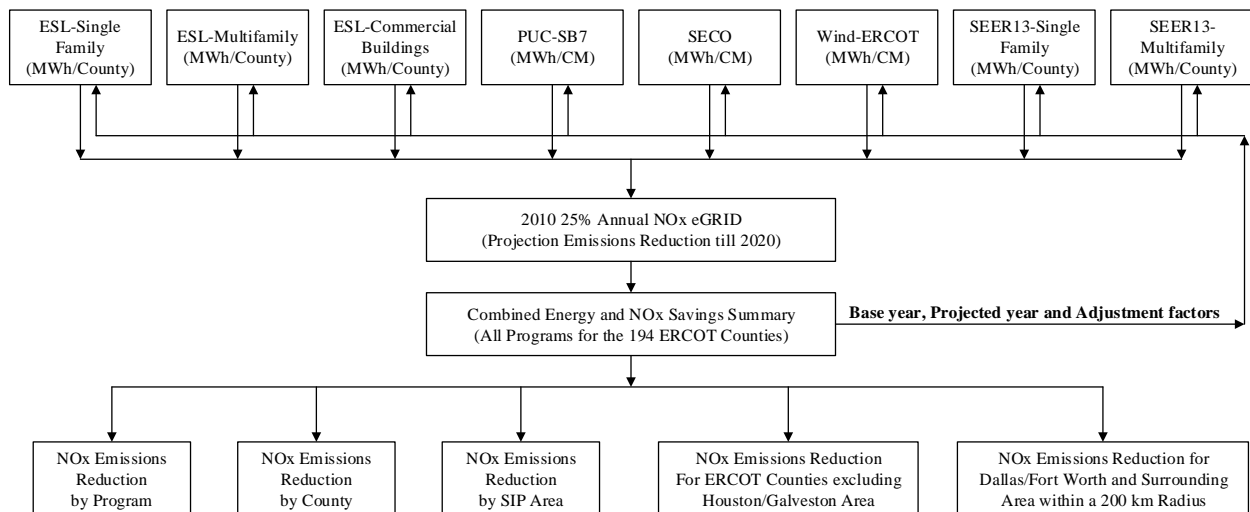


Figure 1: Process Flow Diagram of the Annual and OSD NOx Emissions Reduction Calculations

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 2011 through 2020<sup>12</sup>. The projected energy savings through 2020, according to county, were then divided into the Congestion Management (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 annual report (Haberl et al., 2012)<sup>13</sup>.

For the 2011 annual NOx emissions calculations, the US EPA’s 2010 eGRID were used<sup>14</sup>. The total electricity savings for each CM zone 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. For the OSD NOx emissions calculations, the 2010 eGrid was also applied since the 2010 eGrid

<sup>12</sup> This would include the appropriate discount and degradation factors for each year.

<sup>13</sup> Table 42, pp. 268.

<sup>14</sup> An example of the eGRID spreadsheet can be found in the Laboratory’s annual report (Haberl et al., 2012): Table 37, pp.259. 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 where the CM zone owned and operated a power plant. Totals for all CM zones are then listed on the far right columns. Similar spreadsheets for the 2010 eGRID exist for SOx and CO2.

has only one version of the eGrid, which contains estimates of annual SO<sub>x</sub>, NO<sub>x</sub>, and CO<sub>2</sub> data<sup>15</sup>.

**ESL Commercial.** The annual electricity savings for 2004 through 2010 for commercial buildings were obtained from the annual reports for 2004 through 2010 submitted by the Laboratory to TCEQ. From 2009 to 2011, based on year 2008, the annual and OSD electricity savings were also calculated for new commercial construction by county<sup>16</sup>. Using the calculated values through 2011, savings were then projected to 2020 by incorporating the different adjustment factors mentioned above<sup>17</sup>. In the projected annual electricity savings, it was assumed that the same 2011 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 2011 were obtained from the Public Utilities Commission. Using these values, the annual and OSD electricity savings were projected through 2020 by incorporating the different adjustment factors mentioned above<sup>18</sup>. Similar savings were assumed for each year after 2011 until 2020. The 2010 annual 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 CM zone was 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 integrated NO<sub>x</sub> emissions reduction for each county was then calculated.

**SECO Savings.** The annual electricity savings from energy conservation projects reported by political subdivisions for 39 counties through 2011 were obtained from the State Energy Conservation Office. These submittals included information

gathered from SECO's website<sup>19</sup> and paper submittals<sup>20</sup>. The annual and average day electricity values were then summarized according to county and program. Using the actual reported numbers for 2007 through 2011, the annual and OSD electricity savings through 2020 were projected using the different adjustment factors mentioned above<sup>21</sup>. 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 eGRID were then used to calculate the NO<sub>x</sub> 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 2011 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 2011, savings through 2020 were projected incorporating the different adjustment factors mentioned above. The 2010 eGRID were then used to calculate the NO<sub>x</sub> emissions reduction for the electricity generated by Texas' wind farms<sup>22</sup>. The annual and OSD electricity savings for each CM zone was used to calculate the NO<sub>x</sub> 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 was

<sup>15</sup> The 2010 eGrid has only one version of the eGrid, which contains estimates of annual SO<sub>x</sub>, NO<sub>x</sub>, and CO<sub>2</sub> data. As a result, the 2010 eGrid is also applied to the OSD emissions reductions calculations in this report. On the other hand, the 2007 eGrid used in the previous reports has two separate versions of the eGRID. One of the versions contains estimates of annual SO<sub>x</sub>, NO<sub>x</sub>, and CO<sub>2</sub> data, using a 25% capacity factor. The second version contains estimates of SO<sub>x</sub>, NO<sub>x</sub>, and CO<sub>2</sub> data for 2007 for an average day in the ozone season period, which runs from mid-July to mid-September.

<sup>16</sup> To estimate the OSD electricity savings, annual electricity savings were simply divided by 365 days for commercial programs since the savings for the OSD period is not available separately. The preferred approach would be to weather-normalize the savings and then calculate savings for the OSD period.

<sup>17</sup> This also includes the appropriate discount and degradation factors for each year.

<sup>18</sup> In a similar fashion as the commercial program, annual electricity savings were simply divided by 365 days to obtain the OSD electricity savings.

<sup>19</sup> This web site was developed for SECO by the Laboratory, at the request of the TCEQ.

<sup>20</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 NO<sub>x</sub> reductions, the negative savings were omitted.

<sup>21</sup> In a similar fashion as the commercial program, annual electricity savings were simply divided by 365 days to obtain the OSD electricity savings.

<sup>22</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.

calculated. 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 and OSD savings for each CM were used to calculate the NOx emissions reductions for each of the different county using the emissions factors contained in the 2010 eGRID.

## RESULTS

The total integrated 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 2009 through 2020 as shown in Table 2. The integrated annual and OSD NOx emissions reduction from the electricity savings is provided in Table 3 for all the programs in the integrated format. The OSD NOx emissions reduction is also shown in Figure 2 as stacked bar charts and in Figure 3 for the individual components.

In 2011, the total integrated annual electricity savings from all programs is calculated to be 13,354,918 MWh/year. The integrated annual electricity savings from all the different programs is: 315,876 MWh/year (2.4% of the total electricity savings) from code-compliant residential and commercial construction; 1,197,953 MWh/year (9.0%) from the PUC's Senate Bill 7 program; 509,616 MWh/year (3.8%) from the SECO's Senate

Bill 5 program; 10,995,427 MWh/year (82.3%) from green power purchases (wind); and 336,046 MWh/year (2.5%) from residential SEER 13 air conditioner retrofits.

In 2011, the total integrated OSD electricity savings from all programs is calculated to be 36,076 MWh/day, which would be a 1,503 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is: 1,361 MWh/day (3.8%) from code-compliant residential and commercial construction; 3,282 MWh/day (9.1%) from the PUC's Senate Bill 7 programs; 1,396 MWh/day (3.9%) from the SECO's Senate Bill 5 program; 27,654 MWh/day (76.7%) from green power purchases (wind); and 2,383 MWh/day (6.6%) from residential SEER 13 air conditioner retrofits

By 2016, the total integrated annual electricity savings from all programs is calculated to be 8,336,472 MWh/year. The integrated annual electricity savings from all the different programs is: 1,026,244 MWh/year (5.6% of the total electricity savings) from code-compliant residential and commercial construction; 2,847,590 MWh/year (15.5%) from the PUC's Senate Bill 7 program; 1,438,359 MWh/year (7.8%) from the SECO's Senate Bill 5 program; 12,764,253 MWh/year (69.6%) from green power purchases (wind); and 260,026 MWh/year (1.4%) from residential SEER 13 air conditioner retrofits.

Table 2: Annual and OSD Electricity Savings for the Different Programs (Base Year 2008)<sup>1</sup>

Program	ANNUAL (MWh/year)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-SF	0	21,748	55,268	93,760	132,768	172,325	212,462	253,214	294,613	336,694	379,492	423,044	467,388
ESL-MF	0	50,218	94,867	167,566	239,960	312,072	383,927	455,547	526,957	598,177	669,233	740,146	810,939
ESL-Commercial	0	11,379	25,750	54,550	83,726	113,302	143,303	173,752	204,674	236,097	268,045	300,545	333,627
PUC (SB7)	0	449,034	814,153	1,197,953	1,562,564	1,908,944	2,238,004	2,550,612	2,847,590	3,129,718	3,397,740	3,652,361	3,894,251
SECO	0	235,216	293,537	509,616	714,891	909,903	1,095,163	1,271,161	1,438,359	1,597,197	1,748,093	1,891,444	2,027,628
Wind-ERCOT	0	3,273,150	8,135,429	10,995,427	11,328,405	11,671,466	12,024,917	12,389,071	12,764,253	13,150,797	13,549,046	13,959,356	14,382,092
SEER13-SF	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-MF	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
<b>Total Annual (MWh/year)</b>	0	4,413,096	9,772,736	13,354,918	14,381,557	15,391,293	16,385,894	17,367,069	18,336,472	19,295,705	20,246,322	21,189,836	22,127,718
Program	OZONE SEASON DAY - OSD (MWh/day)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-SF	0	124	283	468	655	844	1,037	1,232	1,431	1,633	1,838	2,047	2,259
ESL-MF	0	233	460	744	1,027	1,308	1,589	1,869	2,148	2,426	2,704	2,981	3,258
ESL-Commercial	0	31	71	149	229	310	393	476	561	647	734	823	914
PUC (SB7)	0	1,230	2,231	3,282	4,281	5,230	6,132	6,988	7,802	8,575	9,309	10,006	10,669
SECO	0	644	804	1,396	1,959	2,493	3,000	3,483	3,941	4,376	4,789	5,182	5,555
Wind-ERCOT	0	14,246	23,054	27,654	28,492	29,355	30,244	31,160	32,103	33,075	34,077	35,109	36,172
SEER13-SF	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-MF	0	195	186	176	167	159	151	144	136	130	123	117	111
<b>Total OSD (MWh/day)</b>	0	19,148	29,412	36,076	38,907	41,691	44,438	47,150	49,830	52,484	55,115	57,729	60,329

NOTE:

1) The annual and OSD electricity savings from ESL commercial programs in 2009 was estimated based on the savings that were calculated for 2010 using the methodology described in this paper because some of the data needed for the calculation were not available at the time of reporting.

Table 3: Annual and OSD NOx Emissions Reduction Values for the Different Programs (Base Year 2008)<sup>1</sup>

Program	ANNUAL (tons NOx/year)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-SF	0	5	14	23	33	42	52	62	72	83	93	104	115
ESL-MF	0	13	24	43	61	80	98	117	135	153	171	190	208
ESL-Commercial	0	3	6	14	21	28	36	43	51	59	67	75	83
PUC (SB7)	0	126	229	340	447	547	643	734	821	903	981	1,055	1,125
SECO	0	67	99	162	221	277	330	381	429	475	518	559	599
Wind-ERCOT	0	893	2,268	3,062	3,154	3,250	3,348	3,450	3,554	3,662	3,773	3,887	4,005
SEER13-SF	0	81	77	73	69	66	62	59	56	53	51	48	46
SEER13-MF	0	7	6	6	6	6	5	5	5	5	4	4	4
<b>Total Annual (tons NOx/year)</b>	<b>0</b>	<b>1,195</b>	<b>2,723</b>	<b>3,723</b>	<b>4,012</b>	<b>4,296</b>	<b>4,574</b>	<b>4,851</b>	<b>5,123</b>	<b>5,393</b>	<b>5,658</b>	<b>5,922</b>	<b>6,185</b>
Program	OZONE SEASON DAY - OSD (tons NOx/day)												
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ESL-SF	0.00	0.03	0.07	0.11	0.16	0.21	0.25	0.30	0.35	0.40	0.45	0.50	0.55
ESL-MF	0.00	0.06	0.12	0.19	0.26	0.33	0.41	0.48	0.55	0.62	0.69	0.76	0.83
ESL-Commercial	0.00	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.23
PUC (SB7)	0.00	0.35	0.63	0.93	1.22	1.50	1.76	2.01	2.25	2.47	2.69	2.89	3.08
SECO	0.00	0.18	0.27	0.44	0.60	0.76	0.90	1.04	1.18	1.30	1.42	1.53	1.64
Wind-ERCOT	0.00	3.94	6.42	7.63	7.87	8.10	8.35	8.60	8.86	9.13	9.41	9.69	9.99
SEER13-SF	0.00	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-MF	0.00	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
<b>Total OSD (tons NOx/day)</b>	<b>0.00</b>	<b>5.19</b>	<b>8.11</b>	<b>9.89</b>	<b>10.70</b>	<b>11.48</b>	<b>12.25</b>	<b>13.00</b>	<b>13.76</b>	<b>14.49</b>	<b>15.23</b>	<b>15.94</b>	<b>16.67</b>

NOTE:

1) The annual and OSD NOx reduction from ESL commercial programs in 2009 was estimated based on the NOx reduction that were calculated for 2010 using the methodology described in this paper because some of the data needed for the calculation were not available at the time of reporting.

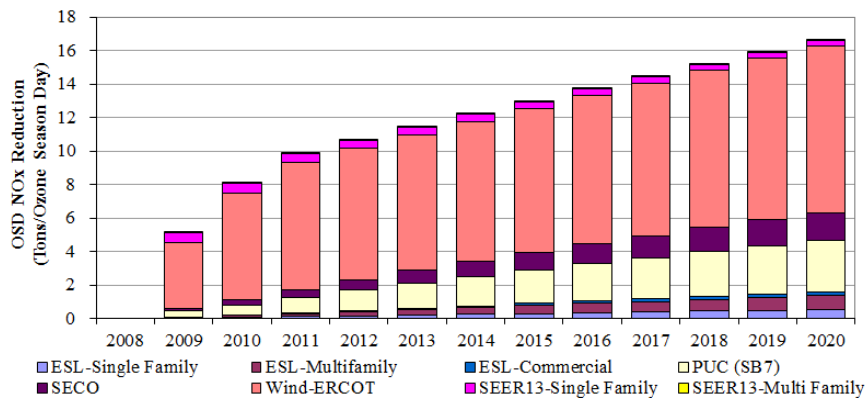


Figure 2: Integrated OSD NOx Emissions Reduction Projections through 2020

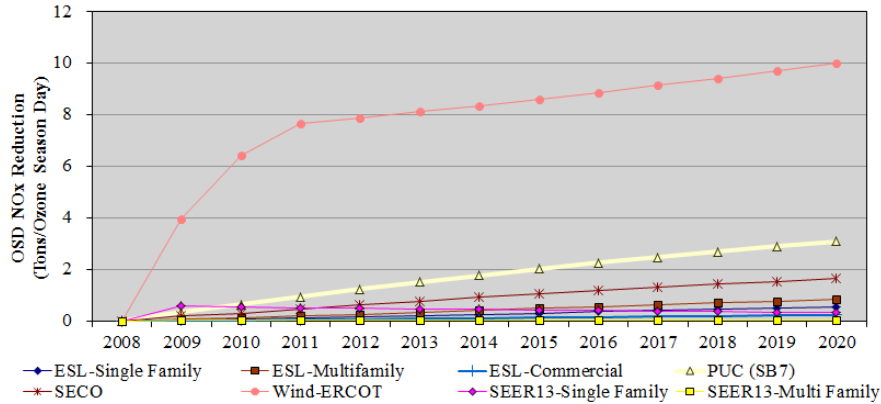


Figure 3: Integrated OSD NOx Emissions Reduction Projections through 2020

By 2016, the total integrated OSD electricity savings from all programs is calculated to be 49,830 MWh/day, which would be a 2,076 MW average hourly load reduction during the OSD period. The integrated OSD electricity savings from all the different programs is: 4,140 MWh/day (8.3%) from code-compliant residential and commercial construction; 7,802 MWh/day (15.7%) from the PUC's Senate Bill 7 programs; 3,941 MWh/day (7.9%) from the SECO's Senate Bill 5 program; 32,103 MWh/day (64.4%) from green power purchases (wind); and 1,844 MWh/day (3.7%) from residential SEER 13 air conditioner retrofits.

In 2011, the total integrated annual NOx emissions reduction from all programs is 3,723 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is: 80 tons-NOx/year (2.1% of the total NOx savings) from code-compliant residential and commercial construction; 340 tons-NOx/year (9.1%) from the PUC's Senate Bill 7 programs; 162 tons-NOx/year (4.4%) from SECO's Senate Bill 5 program; 3,062 tons-NOx/year (82.2%) from green power purchases (wind); and 79 tons-NOx/year (2.1%) from residential SEER 13 air conditioner retrofits.

In 2011, the total integrated OSD NOx emissions reduction from all programs is 9.89 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is: 0.34 tons-NOx/day (3.4%) from code-compliant residential and commercial construction; 0.93 tons-NOx/day (9.4%) from the PUC's Senate Bill 7 programs; 0.44 tons-NOx/day (4.4%) from SECO's Senate Bill 5 program; 7.63 tons-NOx/day (77.1%) from green power purchases (wind); and 0.55 tons-NOx/day (5.6%) from residential SEER 13 air conditioner retrofits.

By 2016, the total integrated annual NOx emissions reduction from all programs is 5,123 tons-NOx/year. The integrated annual NOx emissions reduction from all the different programs is: 258 tons-NOx/year (5.0% of the total NOx savings) from

code-compliant residential and commercial construction; 821 tons-NOx/year (16.0%) from the PUC's Senate Bill 7 programs; 429 tons-NOx/year (8.4%) from SECO's Senate Bill 5 program; 3,554 tons-NOx/year (69.4%) from green power purchases (wind); and 61 tons-NOx/year (1.2%) from residential SEER 13 air conditioner retrofits.

By 2016, the total integrated OSD NOx emissions reduction from all programs is 13.76 tons-NOx/day. The integrated OSD NOx emissions reduction from all the different programs is: 1.04 tons-NOx/day (7.6%) from code-compliant residential and commercial construction; 2.25 tons-NOx/day (16.4%) from the PUC's Senate Bill 7 programs; 1.18 tons-NOx/day (8.6%) from SECO's Senate Bill 5 program; 8.86 tons-NOx/day (64.4%) from green power purchases (wind); and 0.43 tons-NOx/day (3.1%) from residential SEER 13 air conditioner retrofits.

## 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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