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

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Texas Engineering Experiment Station
Texas A&M University System
Acknowledgements

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**Students:** Sung Lok Do, Kee Han Kim, Chunliu Mao, and Georgina Davis

**State & Federal Agencies:** Theresa Gross and Rebecca Reed (PUC), Stephen Ross and Dub Taylor (SECO), Vincent Meiller(TCEQ), Warren Lasher and Dan Woodfin (ERCOT), James Yarbrough and Art Diem (USEPA).
Legislative Response

41 Counties in Texas designated non-attainment or affected
Legislation passed to reduce energy/emissions
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Legislation passed to reduce energy/emissions

**Senate Bill 5 (77th Legislature, 2001)**
Ch. 386. Texas Emissions Reduction Plan  
Sec. 386.205. Evaluation Of State Energy Efficiency Programs (with PUC)
Ch. 388. Texas Building Energy Performance Standards  

**TERP Amended (78th Legislature, 2003)**
Ch. 388. Texas Building Energy Performance Standards  
(HB 1365) Sec. 388.004. Enforcement of Energy Standards outside of Municipality.
(HB 1365) Sec. 388.009. Energy-Efficient Building Program.
Ch. 388. Texas Building Energy Performance Standards  
(HB 3235) Sec. 388.009. Certification of Municipal Inspectors.

**TERP Amended (79th Legislature, 2005)**
Ch. 382. Health and Safety Code  
(HB 2129) Sec. 386.056 Development of Creditable Statewide emissions from wind and other renewables.  
(HB 965) Sec. 382.0275 Commission Action Relating to Water Heaters

**TERP Amended (80th Legislature, 2007)**
Ch. 382. Health and Safety Code  
(HB 3693) Sec. 388.003 added subsection (b-1), (b-2), (b-3) that allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.  
(HB 3693) Sec. 388.008 Development of Standardized report formats for newly constructed residences.
Ch. 386. Health and Safety Code  
(SB 12) Section 388.03 added subsection (b-1), (b-2) allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.

**TERP Amended (81st Legislature, 2009)**
Ch. 382. Health and Safety Code  
(HB 1796) Section 23 amends Sec. 386.252 (a) and (b) extends date of TERP to 2019 and requires Commission to contract with Laboratory for creditable EE/RE emissions reductions.

**TERP Amended (82nd Legislature, 2011)**
Ch. 477. Government Code  
(HB 51) Sec 477.004 added subsection (b-2), directing SECO to appoint a new advisory committee for selecting high-performance building design evaluation systems. The committee includes a representative from the Laboratory and meets at least once every two years.
Ch. 388. Health and Safety Code  
(HB 51) Sec 388.003 (e) and & Sec 388.007 (c) amend review of municipal’s amendments.  
(HB 51) Sec 388.007 (d) allows the Laboratory to conduct outreach to the real estate industry on the value of energy code compliance and above code construction.  
(SB 898) Sec 388.006 requires the Laboratory to calculate energy savings and emissions reduction for political subdivisions based on info collected by SECO, and report findings to TCEQ, EPA, and ERCOT.

**Chapter 39. Utilities Code**
(SB 924) Sec 39.9051 (g) (h) & Sec 39.9052 (c) (d) require the Laboratory to calculate energy savings and emissions reductions for municipally owned utilities and electric cooperatives reporting to SECO.
INTEGRATED NOx SAVINGS

IN 2005 TCEQ INITIATED A PROGRAM TO DETERMINE INTEGRATED EMISSIONS SAVINGS (from 2005 to 2020) TO REPORT SAVINGS TO EPA
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- Annual, OSD savings
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Savings Integration allows:
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- By County, SIP, Program
- Integration tool = Adjustable Discount, Degradation, T&D losses
INTEGRATED NOx SAVINGS:
Process Flow Diagram of the NOx Emissions Reduction Calculations
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Process Flow Diagram of the NOx Emissions Reduction Calculations

2007 25% Annual and OSD NOx eGRID (Projection Emissions Reduction till 2020)

Energy Systems Laboratory 2012
INTEGRATED NOx SAVINGS:
Process Flow Diagram of the NOx Emissions Reduction Calculations

2007 25% Annual and OSD NOx eGRID
(Projection Emissions Reduction till 2020)

Combined Energy and NOx Savings Summary
(All Programs for the 194 ERCOT Counties)
INTEGRATED NOx SAVINGS:
Data File Flow Diagram of the NOx Emissions Reduction Calculations
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Data File Flow Diagram of the NOx Emissions Reduction Calculations

1. Program

- ESL-Single Family
- ESL-Multi Family
- ESL-Commercial Buildings
- Federal Buildings
- PUC-SB7
- PUC-SB5
- SECO
- Wind-ERCOT
- SEER13-Single Family
- SEER13-Multifamily
- Furnace Pilot Light
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1. Program

2. Annual Energy Savings/ Generation Data

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"Singlefamily Data.xls"  "Multifamily Data.xls"  "Commercial savings and projection.xls"  "Federal Building Data.xls"  "PUC SB7 savings and projection.xls"  "PUC SB5 savings and projection.xls"  "SECO Data.xls"  "Wind Savings Data.xls"  "SEER13 SF Data.xls"  "SEER13 MF Data.xls"  "Furnace Pilot Data.xls"
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3. Annual Emissions Reductions
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4. Multiyear Statewide Energy & NOx Savings
   - "Single family savings and projection.xls"
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5. Integrated NOx Reductions & Projections Workbooks
   - "Integrated Savings Executable.xlw"
   - "Integrated Savings Summary.xls"

6. Final Summary of Integrated NOx Reductions & Projections

Note:
1. Energy savings data for commercial buildings are found in two excel files: Commercial Data.xls & Commercial savings and projection.xls.
2. Energy savings data for PUC SB5 and PUC SB7 are found in their savings and projection excel files.
3. The emissions factors contained in eGRID used for electricity savings only. Due to this, eGrid cannot be used for the emissions reduction in the furnace Pilot Light program achieved the N.G. savings by retrofitting existing furnaces.
## OSD 2007 eGrid for ERCOT EGUs

| Area                  | County          | Victorian Electric Power Plant (ERCOT) | NOx Reductions (ton) | Austin Electric (PCA) | NOx Reductions (ton) | Brownsville Public UTI (PCA) | NOx Reductions (ton) | Colorado Public Utilities (PCA) | NOx Reductions (ton) | Duke Energy (PCA) | NOx Reductions (ton) | Entergy Texas (PCA) | NOx Reductions (ton) | South Texas Electric Coop (PCA) | NOx Reductions (ton) | Texas Municipal Power Agency (PCA) | NOx Reductions (ton) | Texas-New Mexico Power Co (PCA) | NOx Reductions (ton) | Total NOx Reductions (ton) | Total NOx Reductions (ton) |
|-----------------------|-----------------|----------------------------------------|----------------------|-----------------------|----------------------|---------------------------|----------------------|---------------------------------|----------------------|---------------------|----------------------|---------------------|----------------------|-------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-------------------------------|
| Victoria Area         |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| El Paso Area          |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| Galveston Port Arthur Area |        |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| Dallas-Fort Worth Area |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| Austin Area           |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| North East Texas Area |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| Eagle County Area     |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
| Other ERCOT counties  |                  |                                        |                      |                       |                      |                           |                      |                                 |                      |                     |                      |                     |                      |                                |                      |                      |                     |                     |                      |                                |                      |
INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections
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<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity Annual (MWh)</th>
<th>Seasonal Day (MWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>63,410</td>
<td>385</td>
</tr>
<tr>
<td>2007</td>
<td>66,990</td>
<td>424</td>
</tr>
<tr>
<td>2008</td>
<td>48,480</td>
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<td>2009</td>
<td>50,300</td>
<td>310</td>
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<td>2010</td>
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<tr>
<td>2011</td>
<td>54,593</td>
<td>385</td>
</tr>
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</tr>
</tbody>
</table>

Integrated Annual MWh Savings

### ESL-Single Family / ESL-Multi Family / ESL-Commercial Buildings
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#### Final Summary Tables For Integrated NOx Reductions & Projections

#### Federal Buildings

**Annual MWh Savings (Preliminary Estimates)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Energy Savings</th>
<th>Electricity</th>
<th>Ozone Season Day (MWh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>109.07 (2)</td>
<td>109.07</td>
<td>295.00</td>
</tr>
<tr>
<td>2006</td>
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**O3 MWh Savings (Preliminary Estimates)**

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*Figures are preliminary estimates and subject to further analysis and refinement.*
INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections

![Graph and Table]

PUC SB5 / PUC SB7
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<th>Year</th>
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Annual MWh Savings (Preliminary Estimates)
INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections

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Future Projection (year) | Total Integrated Energy Savings (MWh) | Ozone Season Day (MWh/Day) |
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SEER13 MF / SEER13 SF
## INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections

### Wind

![Wind Energy Savings Chart]

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*Note: Values are illustrative and subject to change.*
INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections

Furnace Pilot
INTEGRATED NOx SAVINGS:
Final Summary Tables For Integrated NOx Reductions & Projections

### Integrated Savings Summary

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### Energy Savings Summary

- **Base Year:** 1999
- **Projection Year:** 2000

#### Assumptions

- **Degradation:** 5.00%
- **T&D Loss:** 7.00%
- **Initial Discount Factor:** 20.00%
- **Growth Factor:** 3.25%
- **Weather Normalized:** Yes

#### Energy Savings Summary

- **1999 Energy Savings:**
  - ESL - Single Family: 0
  - ESL - Multifamily: 0
  - ESL - Commercial: 0
  - Federal Buildings: 0
  - Furnace Pilot Light Program: 0
  - PUC (SB7): 0
  - PUC (SB5 Grant Program): 0
  - SECO: 0

- **2000 Energy Savings:**
  - ESL - Single Family: 0
  - ESL - Multifamily: 0
  - ESL - Commercial: 0
  - Federal Buildings: 0
  - Furnace Pilot Light Program: 0
  - PUC (SB7): 0
  - PUC (SB5 Grant Program): 0
  - SECO: 0

- **Total Energy Savings:**
  - ESL - Single Family: 0
  - ESL - Multifamily: 0
  - ESL - Commercial: 0
  - Federal Buildings: 0
  - Furnace Pilot Light Program: 0
  - PUC (SB7): 0
  - PUC (SB5 Grant Program): 0
  - SECO: 0

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**Integrated Savings Summary**
### INTEGRATED NOx SAVINGS:
#### Adjustment Factors

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**Initial Discount Factor**

**Growth Factor**

**Weather Normalized**
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<td>5.00%</td>
<td>5.00%</td>
<td>N.A.</td>
<td>5.00%</td>
<td>5.00%</td>
<td>5.00%</td>
<td>0.00%</td>
<td>5.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td><strong>T&amp;D Loss</strong></td>
<td>7.00%</td>
<td>7.00%</td>
<td>7.00%</td>
<td>7.00%</td>
<td>0.00%</td>
<td>7.00%</td>
<td>7.00%</td>
<td>7.00%</td>
<td>0.00%</td>
<td>7.00%</td>
<td>7.00%</td>
</tr>
<tr>
<td><strong>Initial Discount Factor</strong></td>
<td>20.00%</td>
<td>20.00%</td>
<td>20.00%</td>
<td>20.00%</td>
<td>20.00%</td>
<td>25.00%</td>
<td>25.00%</td>
<td>60.00%</td>
<td>0.00%</td>
<td>20.00%</td>
<td>20.00%</td>
</tr>
<tr>
<td><strong>Growth Factor</strong></td>
<td>3.25%</td>
<td>1.54%</td>
<td>3.25%</td>
<td>N.A.</td>
<td>0.00%</td>
<td>0.00%</td>
<td>N.A.</td>
<td>0.00%</td>
<td>Actual Rates</td>
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<td>N.A.</td>
</tr>
<tr>
<td><strong>Weather Normalized</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>See note 7</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
INTEGRATED NOx SAVINGS:
Result of OSD Electricity Savings

OSD Elec. Savings (MWh/yr)
INTEGRATED NOx SAVINGS:
Result of OSD NOx Emissions Reductions

Non-attainment and Affected Counties

Other ERCOT Counties

OSD NOx Emissions Reductions (Tons/yr)

- No Savings
- 0.01-0.05
- 0.06-0.10
- 0.11-0.15
- 0.16-0.20
- Above 0.21

County

- Single Family Houses
- Multifamily Houses
- Commercial Buildings
- Natural Gas (SF+MF+Commercial)
INTEGRATED NOx SAVINGS:
Single Family Savings and Projection

CUMULATIVE NOx EMISSIONS SAVINGS (2013)

- ESL Code Compliance (9.03 tons/day) (26.3%)
- Federal Buildings (0.81 tons/day) (1.9%)
- Furnace Pilot Lights (0.32 tons/day) (0.8%)
- PUCs SB7,SB5 programs (5.78 tons/day) (11.7%)
- SECO Political Sub. (1.01 tons/day) (2.0%)
- Green Power (Wind) (32.63 tons/day) (30.1%)
- SEER 13 Retrofits (11.03 tons/day) (26.9%)
Total (60.61 tons/day) (100.0%)
INTEGRATED NOx SAVINGS:
Multi-Family Savings and Projection

CUMULATIVE NOx EMISSIONS SAVINGS (2013)

- ESL Code Compliance (9.03 tons/day) (26.3%)
- Federal Buildings (0.81 tons/day) (1.9%)
- Furnace Pilot Lights (0.32 tons/day) (0.8%)
- PUCs SB7,SB5 programs (5.78 tons/day) (11.7%)
- SECO Political Sub. (1.01 tons/day) (2.0%)
- Green Power (Wind) (32.63 tons/day) (30.1%)
- SEER 13 Retrofits (11.03 tons/day) (26.9%)
Total (60.61 tons/day) (100.0%)
INTEGRATED NOx SAVINGS:
Commercial Savings and Projection

CUMULATIVE NOx EMISSIONS SAVINGS (2013)

- ESL Code Compliance (9.03 tons/day) (26.3%)
- Federal Buildings (0.81 tons/day) (1.9%)
- Furnace Pilot Lights (0.32 tons/day) (0.8%)
- PUCs SB7,SB5 programs (5.78 tons/day) (11.7%)
- SECO Political Sub. (1.01 tons/day) (2.0%)
- Green Power (Wind) (32.63 tons/day) (30.1%)
- SEER 13 Retrofits (11.03 tons/day) (26.9%)
Total (60.61 tons/day) (100.0%)
INTEGRATED NOx SAVINGS: OSD NOx Emissions Reduction Projection through 2020

CUMULATIVE NOx EMISSIONS SAVINGS (2013)
- ESL Code Compliance: 9.03 tons/day (26.3%)
- Federal Buildings: 0.81 tons/day (1.9%)
- Furnace Pilot Lights: 0.32 tons/day (0.8%)
- PUCs SB7,SB5 programs: 5.78 tons/day (11.7%)
- SECO Political Sub.: 1.01 tons/day (2.0%)
- Green Power (Wind): 32.63 tons/day (30.1%)
- SEER 13 Retrofits: 11.03 tons/day (26.9%)
Total: 60.61 tons/day (100.0%)
INTEGRATED NOx SAVINGS:
Publications (2002~2012)
INTEGRATED NOx SAVINGS:
Publications (2002~2012)

Papers
INTEGRATED NOx SAVINGS:
Publications (2002~2012)

Papers

Annual Reports to the TCEQ
INTEGRATED NOx SAVINGS:
Single Family Savings and Projection

- 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).

- Electricity Savings due to the code adoption for new SF & MF residences were estimated using DOE-2.1 simulation program. Pre-code houses : average new house built in 1999 in Texas.

- It was assumed that the same amount of electricity savings from the code-complaint construction would be achieved for each year after 2010 through 2020. This would include the appropriate discount and degradation factors for each year.
• 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).

• Electricity Savings due to the code adoption for new SF & MF residences were estimated using DOE-2.1 simulation program. Pre-code houses: average new house built in 1999 in Texas.

• It was assumed that the same amount of electricity savings from the code-complaint construction would be achieved for each year after 2010 through 2020. This would include the appropriate discount and degradation factors for each year.
INTEGRATED NOx SAVINGS:
Commercial Savings and Projection

- 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).
- Electricity Savings due to the code adoption for new commercial buildings were estimated using DOE-2.1 simulation program.
- Pre-code buildings: the ASHRAE standard 90.1-1989 compliant building.
The 2006 savings include projects implemented in 14 Federal buildings reported by the regional office of the Department of Energy.

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.
INTEGRATED NOx SAVINGS: Furnace Pilot Savings and Projection

- 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 (Emission rate per pilot light: 0.092 lb-NOx/MMBtu) for each hour of operation for the entire life of the furnace when the furnace is replaced with a code-compliant replacement.
- It is also being assumed that of the total furnaces that were retrofitted, 75% are operational during the Ozone Season Period.
The Texas Public Utility Commission’s (PUC) Senate Bill 5 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 Texas Public Utility Commission’s (PUC) Senate Bill 5 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 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 35 counties through 2006 were obtained from the State Energy Conservation Office. These submittals included information gathered from SECO’s website and paper submittals.
For saving projections, annual growth factors were chosen to comply with the yearly goals set forth by the Senate Bill 20, Section 39.904, Utilities Code: 3,700 MW in 2009, and 7,000 MW in 2015.

Actual measured electricity production for 2001 through 2006 were also included.
The annual and OSD electricity savings due to replacement of SEER 13 air conditioning units for existing residences are estimated using DOE-2.1 simulation.

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 using the ARI data (i.e., Texas Manufacturer’s Shipments of 1 phase unitary products).

This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners.
The annual and OSD electricity savings due to replacement of SEER 13 air conditioning units for existing residences are estimated using DOE-2.1 simulation.

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 using the ARI data (i.e., Texas Manufacturer’s Shipments of 1 phase unitary products).

This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners.
INTEGRATED NOx SAVINGS: OSD NOx Emissions Reduction Projection through 2020

OSD NOx Reduction Levels (All ERCOT)

- ESL-Single Family
- ESL-Multifamily
- SECO
- Wind-ERCOT
- ESL-Commercial
- Federal Buildings
- Furnace Pilot Light Program
- SEER13-Single Family
- SEER13-Multifamily

Tons/Ozone Season Day

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