

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

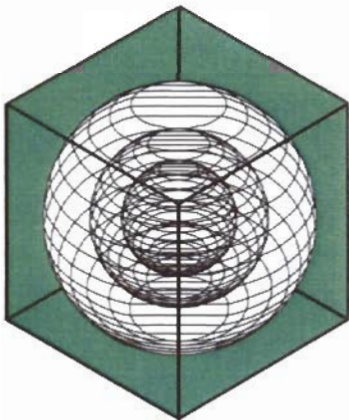
VOLUME I – SUMMARY REPORT

Annual Report to the
Texas Commission on Environmental Quality
January 2006 – June 2007



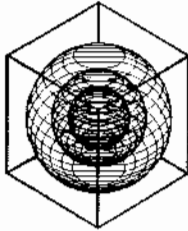
Jeff Haberl, Ph.D., P.E.; Charles Culp, Ph.D., P.E.
Bahman Yazdani, P.E.; Don Gilman, P.E.
Tom Fitzpatrick; Shirley Muns, C.B.O.
Malcolm Verdict; C.E.M.; Mushtaq Ahmed
Zi Liu, Ph.D.; Juan Carlos Baltazar-Cervantes, Ph.D.
Cynthia Montgomery; Kathy McKelvey
Jaya Mukhopadhyay; Larry Degelman, P.E.

August 2007
Revised December 2007



ENERGY SYSTEMS LABORATORY

Texas Engineering Experiment Station
Texas A&M University System



ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System
3581 TAMU
College Station, Texas 77843-3581

December 10, 2007

Chairman H. S. Buddy Garcia
Texas Council on Environmental Quality
P. O. Box 13087
Austin, TX 78711-3087

Dear Chairman Garcia:

The Energy Systems Laboratory (Laboratory) at the Texas Engineering Experiment Station of the Texas A&M University System is pleased to provide its fifth annual report, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)," as required under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002 (Senate Bill 5, 77R as amended 78 R & 78S).

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

Please contact me at (979) 862-1280 should you or any of the TCEQ staff have any questions concerning this report or any of the work presently being done to quantify emissions reduction from energy efficiency and renewable energy measures as a result of the TERP implementation.

Sincerely,

A handwritten signature in black ink that reads "David E. Claridge". The signature is fluid and cursive, with a large, stylized initial "D".

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

Enclosure

cc: Commissioner Larry R. Soward
Commissioner Bryan Shaw
Executive Director Glenn Shankle

Disclaimer

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

VOLUME I – SUMMARY REPORT

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

EXECUTIVE SUMMARY

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of the Texas A&M University System, in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002, submits its fifth annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan to the Texas Commission on Environmental Quality.

The report is organized in three volumes.

Volume I – Summary Report – provides an executive summary and overview;

Volume II – Technical Report – provides a detailed report of activities, methodologies and findings;

Volume III – Technical Appendix – contains detailed data from simulations for each of the counties included in the analysis.

Accomplishments:

1. Energy Code Amendments

The Laboratory was requested by several municipalities to analyze the stringency of several proposed residential and commercial energy code amendments, including: the 2003 and 2006 IECC and the ASHRAE Standards 90.1-2001 and 90.1-2004. Results of the analysis are included in the Vol II Technical Report.

2. Technical Assistance

The Laboratory provided technical assistance to the TCEQ, PUCT, SECO, ERCOT, and several political subdivisions, as well as Stakeholders participating in improving the compliance of the Texas Building Energy Performance Standards (TBEPS). The Laboratory also worked closely with the TCEQ to refine the integrated NOx emissions reduction calculation procedures that provide the TCEQ with a standardized, creditable NOx emissions reduction from energy efficiency and renewable energy (EE/RE) programs, which are acceptable to the US EPA. These activities have improved the accuracy of the creditable NOx emissions reduction from EE/RE initiatives contained in the TERP and have assisted the TCEQ, local governments, and the building industry with effective, standardized implementation and reporting.

3. NOx Emissions Reduction

Under the TERP legislation, the Laboratory must determine the energy savings from energy code adoption and, when applicable, from more stringent local codes or above-code performance ratings, and must report these reductions annually to the TCEQ.

Figure 1 shows the cumulative NOx emissions reduction through 2020 for the electricity and natural gas savings from the various EE/RE programs. In 2006, the cumulative NOx emissions reduction were calculated to be 17.52 tons/Ozone-Season-Day. By 2013, the cumulative NOx emissions reduction are projected to be 40.86 tons/Ozone-Season-Day.

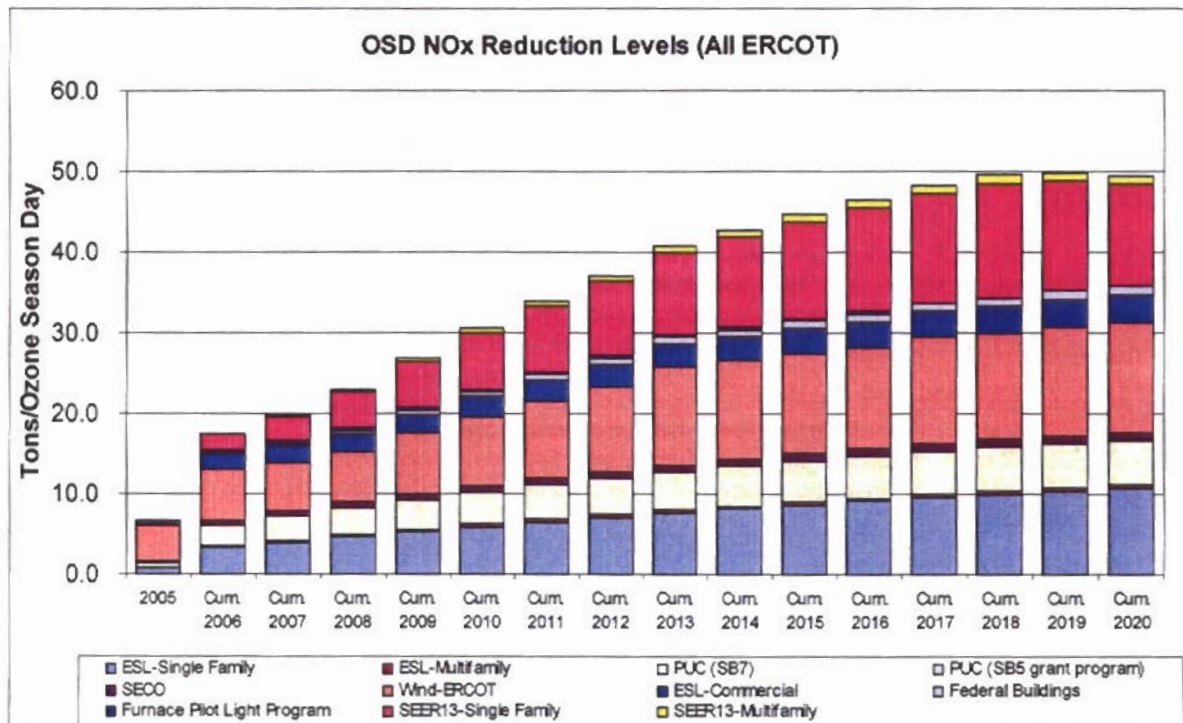


Figure 1: Cumulative OSD NOx Emissions Reduction Projected through 2020.

4. Technology Transfer

The Laboratory, along with the TCEQ, is host to the annual Clean Air Through Energy Efficiency (CATEE) conference, which is attended by top experts and policy makers in Texas and from around the country. At the conference the latest educational programs and technology is presented discussed, including efforts by the Laboratory, and others to reduce air pollution in Texas through energy efficiency and renewable energy. These efforts have produced significant success in bringing EE/RE closer to US EPA acceptance in the Texas SIP. The Laboratory will continue to provide superior technology to the State of Texas through such efforts with the TCEQ and the US EPA.

To accelerate the transfer of technology developed as part of the TERP, the Laboratory has also made presentations at national, state and local meetings and conferences, which includes the publication of peer-reviewed papers. The Laboratory will continue to provide technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans.

These efforts have been recognized nationally by the US EPA. In 2007, the Laboratory was awarded a National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA so that these accomplishments could be rapidly disseminated to other states for their use. The benefits of CEDER include: reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures; continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states; helping other states better identify and prioritize cost-effective clean air strategies from EE/RE, and communicating the results of quantification efforts through case-studies and a clearinghouse of information.

VOLUME I – SUMMARY REPORT

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

OVERVIEW

The Energy Systems Laboratory (Laboratory), at the Texas Engineering Experiment Station of the Texas A&M University System, is pleased to provide our fifth annual report, Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP), to the Texas Commission on Environmental Quality (TCEQ) in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), Vernon Supp. 2002. This annual report:

- Provides an estimate of the energy savings and NOx reductions from energy code compliance in new residential construction in all ERCOT counties;
- Provides an estimate of the standardized, cumulative, integrated energy savings and NOx reductions from the TERP programs implemented by the Laboratory, SECO, the PUC and ERCOT in all ERCOT Texas;
- Describes the technology developed to enable the TCEQ to substantiate energy and emissions reduction credits from energy efficiency and renewable energy initiatives (EE/RE) to the U.S. Environmental Protection Agency (US EPA), including the development of a web-based emissions reduction calculator; and
- Outlines progress in advancing EE/RE strategies for credit in the Texas State Implementation Plan (SIP).

The report is organized in three volumes.

Volume I – Summary Report – provides an executive summary and overview;

Volume II – Technical Report – provides a detailed report of activities, methodologies and findings;

Volume III – Technical Appendix – contains detailed data from simulations for all ERCOT counties in Texas included in the analysis.

Legislative Background

The TERP was established in 2001 by the 77th Legislature through the enactment of Senate Bill 5 to:

- Ensure that Texas air meets the Federal Clean Air Act requirements (Section 707, Title 42, United States Code); and
- Reduce NOx emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE).

To achieve the clean air and emissions reduction goals of the TERP, Senate Bill 5 created a number of EE/RE programs for credit in the SIP:

- Adopts statewide Texas Building Energy Performance Standards (TBEPS) as the building energy code for all residential and commercial buildings;
- Provides that a municipality or county may request the Laboratory to determine the energy impact of proposed energy code changes;
- Provides for an annual evaluation by the Public Utility Commission of Texas (PUCT), in cooperation with the Laboratory, of the emissions reduction of energy demand, peak electric loads and the associated air contaminant reductions from utility-sponsored programs established under Senate Bill 5 and utility-sponsored programs established under the electric utility restructuring act (Section 39.905 Utilities Code);
- Establishes a 5% per year electricity reduction goal each year for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2007; and
- Requires the Laboratory to report annually to the TCEQ the energy savings (and resultant emissions reduction) from implementation of building energy codes and to identify the municipalities and counties whose codes are more or less stringent than the unamended code.

The 78th Legislature (2003), through HB 1365 and HB 3235, amended TERP to enhance its effectiveness with additional energy efficiency initiatives, and includes:

- Requires the TCEQ to conduct outreach to non-attainment and near-non-attainment counties on the benefits of implementing energy efficiency measures as a way to meet the air quality goals under the federal Clean Air Act;
- Requires the TCEQ develop a methodology for computing emissions reduction from energy efficiency initiatives;
- Authorized a voluntary Energy-Efficient Building Program at the General Land Office (GLO), in consultation with the Laboratory, for the accreditation of buildings that exceed the state energy code requirements by 15% or more;
- Authorizes municipalities to adopt an optional, alternate energy code compliance mechanism through the use of accredited energy efficiency programs determined to be code-compliant by the Laboratory, as well as the US EPA's Energy Star New Homes program; and
- Requires the Laboratory to develop and administer a statewide training program for municipal building inspectors seeking to become code-certified inspectors for enforcement of energy codes.

The 79th Legislature (2005), through SB 20, HB 2481 and HB 2129, amended Senate Bill 5 to enhance its effectiveness by adding the following additional energy efficiency initiatives:

- Requires 5,880 MW of generating capacity from renewable energy technologies by 2015;
- Includes 500 MW from non-wind renewables;
- Requires the PUCT to establish a target of 10,000 megawatts of installed renewable capacity by 2025;
- Requires the TCEQ to develop methodology for computing emissions reduction from renewable energy initiatives and the associated credits;
- Requires the Laboratory to assist the TCEQ in quantifying emissions reduction credits from energy efficiency and renewable energy programs;
- Requires the Texas Environmental Research Consortium (TERC) to contract with the Laboratory to develop and annually calculate creditable emissions reduction from wind and other renewable energy resources for the state's SIP; and
- Requires the Laboratory to develop at least three alternative methods for achieving a 15 % greater potential energy savings in residential, commercial and industrial construction.

The 80th Legislature (2007), through SB 12, and HB 3693 amended Senate Bill 5 to enhance its effectiveness by adding the following additional energy efficiency initiatives:

- Requires 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. The Laboratory shall make its recommendations no later than six months after publication of new editions at the end of each three-year code development cycle of the International Residential Code and the International Energy Conservation Code.
- Requires the Laboratory to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- Requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings, including different report formats for rating newly constructed residences from those for existing residences. The form must be designed to give potential buyers information on a structure's energy performance, including: insulation; types of windows; heating and cooling equipment; water heating equipment; additional energy conserving features, if any; results of performance measurements of building tightness and forced air distribution; and an overall rating of probable energy efficiency relative to the minimum requirements of the International Energy Conservation Code or the energy efficiency chapter of the International Residential Code, as appropriate.
- Encourages the Laboratory to cooperate with an industry organization or trade association to: develop guidelines for home energy ratings; provide training for individuals performing home energy ratings and providers of home energy ratings; and provide a registry of completed ratings for newly constructed residences and residential improvement projects for the purpose of computing the energy savings and emissions reduction benefits of the home energy ratings program.

- Requires the Laboratory to include information on the benefits attained from this program in an annual report to the commission.

Laboratory Funding for the TERP

The Laboratory received \$182,000 in FY 2002; \$285,000 in FY 2003; \$950,421 in FY 2004; \$952,019 in FY 2005; and \$952,019 in FY 2006. The Laboratory has also supplemented these funds with competitively awarded Federal grants to provide the needed statewide training for the new mandatory energy codes and to provide technical assistance to cities and counties in helping them implement adoption of the legislated energy efficiency codes, and an award from the US EPA in the Spring of 2007 to establish a Center of Excellence for the Determination of Emissions Reduction (CEDER) which will help to enhance the EE/RE emissions calculations.

Accomplishments Since January 2006

Since January of 2006, the Laboratory accomplished the following:

- Calculated energy and resultant NOx reductions from implementation of the Texas Building Energy Performance Standards (IECC/IRC codes) to new residential and commercial construction for all non-attainment and near-non-attainment counties;
- Enhanced the web-based "Emissions Reduction Calculator - eCalc" for determining emissions reduction from energy efficiency improvements in residential and commercial construction, municipal projects and renewable energy projects;
- Enhanced the Laboratory's IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Continued development and testing of key procedures for validating simulations of building energy performance;
- Provided energy code training workshops, including: 12 residential, 4 commercial IECC/IRC energy code training sessions, 13 code-compliant software sessions, 3 ASHRAE Standard 62.1 sessions, and 9 ASHRAE Standard 90.1 workshops throughout the State of Texas;
- Maintained and updated the Laboratory's Senate Bill 5 website;
- Maintained a builder's residential energy code Self-Certification Form (Ver.1.3) for use by builders outside municipalities;
- Responded to hundreds of phone and email inquiries on code implementation and verification issues;
- Analyzed the stringency of several residential and commercial energy codes, including the 2006 IECC and ASHRAE Standard 90.1-2001 and Standard 90.1-2004;
- Presented an invited presentation about Texas' NOx emissions reduction calculations at the US EPA's Air Innovations Conference in September 2006, in Denver, Colorado;
- Hosted the Energy Leadership and Emissions Reduction Conference in November 2006, in Houston, Texas. Conference sessions included key talks by the TCEQ, EPA, DOE and the Laboratory about quantifying emissions reduction from EE/RE opportunities and guidance on key energy efficiency and renewable energy topics;
- Provided technical assistance to the TCEQ regarding specific issues, including:
 - Enhancement of the standardized, integrated NOx emissions reduction reporting procedures¹ to the TCEQ for ESL, PUCT, SECO and ERCOT EE/RE projects;
 - Enhancement of the procedures for weather normalizing NOx emissions reduction from power provided by wind energy providers to base-year calculations;
 - Quantified emissions reduction from the new, Federally-mandated SEER 13 air conditioner standard (starting in January 2006).
- Enhanced the web-based emissions reduction calculator, including:
 - Expanded the emissions reduction calculator to include all counties in ERCOT;
 - Gathered, cleaned and posted weather data archive for 17 NOAA stations in Texas;
 - Expanded emissions reduction to include SEER 13 air conditioners;
 - Continued the enhancement of the new computer architecture to allow for synchronous calculations, user accounts, and code-compliance;

¹ These procedures are currently under review by the USDOE, through the National Renewable Energy Laboratory (NREL).

- Developed 15% above code recommendations for residential buildings;
- Developed 15% above code recommendations for commercial and industrial buildings; and
- Continued the development of verification procedures, including:
 - Completion of calibrated simulation of a high-efficiency office building in Austin, TX;
 - Worked towards a calibrated simulation of an office building;
 - Worked towards a calibrated simulation of a K-12 school; and
 - Completed the calibrated simulation of a Habitat for Humanities residence.

Technology Transfer

To accelerate the transfer of technology developed as part of the Senate Bill 5 program, the Laboratory:

- Delivered "Statewide Air Emissions Calculations from Wind and Other Renewables," to the Texas Commission on Environmental Quality in August 2006, including Stakeholder's meetings to gather input from the industry and the review incorporation of information from ERCOT's Renewable Energy Credit Program site www.texasrenewables.com.
- Developed a method to predict on-site wind speeds using Artificial Neural Networks (ANN) and developed improvements to the daily modeling procedures using ANN-derived hourly wind speeds.
- Developed degradation analysis to determine if degradation could be observed in the measured power from Texas wind farms.
- Developed empirical curtailment analysis of the measured power production from a wind farm and applied to the Indian Mesa wind farm.
- Developed a database of other renewable projects in Texas, including: solar photovoltaic, geothermal, hydroelectric, and Landfill Gas-fired Power Plants.
- Developed estimation techniques for hourly solar radiation from limited data sets.
- Along with the TCEQ and the US EPA, is host to the annual Clean Air Through Energy Efficiency (CATEE) Conference attended by top Texas experts and policy makers and national experts.
- Was granted a National Center of Excellence on Displaced Emissions Reduction (CEDER) by the US EPA. The benefits of CEDER include:
 - reducing the financial, technical, and administrative costs of determining the emissions reduction from EE/RE measures;
 - continuing to accelerate implementation of EE/RE strategies as a viable clean air effort in Texas and other states;
 - helping other states identify and prioritize cost-effective clean air strategies from EE/RE; and;
 - communicating the results of quantification efforts through case-studies and a clearinghouse of information.

In addition to the tasks listed above, the Laboratory delivered presentations regarding the Senate Bill 5 related work, including:

- Presentation at the US EPA Air Innovations Conference, Denver, Colorado, September 2006.
- Presentation at Rice University, Civil Engineering Department, September 2006.
- Presentation at Clean Air Conference, University of Houston, October 11-12.
- Presentation at the American Waste Management Association Meeting, Austin, February 2007.
- Presentation at Baylor University, Mechanical Engineering Department, February 2007.
- Presentation at U.S. Congress about Texas NOx emissions reduction for ASHRAE Tech Briefing, March 2007.
- Presentation at ASHRAE Carbon Toolkit Workshop, March, 2007 (by phone).
- Presentation at EPRI Conference, April 2007 (by phone).
- Presentation of seven papers at the 15th Symposium on Improving Building Systems in Hot and Humid Climates, in Orlando, Florida, July 2006, including:
 - *Malhotra, M., Haberl, J. 2006. "An Analysis of Maximum Residential Energy Efficiency in Hot and Humid Climates," Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, Orlando, Florida, published on CD ROM (July).*

- Cho, S., Haberl, J. 2006. "A Survey of High-performance Office Buildings for Hot and Humid Climates," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Im, P., Haberl, J. 2006. "A Survey of High-performance Schools for Hot and Humid Climates," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Ahmed, M., Im, P., Mukhopadhyay, J., Malhotra, M., Haberl, J., Culp, C., Yazdani, B. 2006. "Impact of the Implementation of the 2000/2001 IECC on Residential Energy use in Texas: Analysis of Residential Savings," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Ahmed, M., Kim, S., Im, P., Chongcharoensuk, C., Haberl, J., Culp, C., Yazdani, B. 2006. "Impact of the Implementation of the 2000/2001 IECC on Commercial Energy use in Texas: Analysis of Commercial Savings," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Mukhopadhyay, J., Haberl, J. 2006. "Comparison of Simulation Methods for Evaluating Improved Fenestration Using the DOE-2.1e Building Energy Simulation Program," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Baltazar-Cervantes, J.C., Haberl, J., Culp, C., Yazdani, B. 2006. "Impact of the Implementation of the 2000/2001 on Residential Energy use in Texas: Verification of Residential Energy Savings," *Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Orlando, Florida, published on CD ROM (July).
- Presented two papers at the 2nd SimBuild Conference, Boston, MA, August 2006:
 - Mukhopadhyay, J., Haberl, J. 2006. "Comparing the Performance of High-performance Glazing in IECC Compliant Building Simulation Model," *Proceedings of the 2nd SimBuild Conference*, Boston, MA, published on CD ROM (August).
 - Malhotra, M., Haberl, J. 2006. "An Analysis of Building Envelope Upgrades for Residential Energy Efficiency in Hot and Humid Climates," *Proceedings of the 2nd SimBuild Conference*, Boston, MA, published on CD ROM (August).
- Presented one Paper at the ACEEE Summer Study on Energy Efficiency, Asilomar, California, August 2006:
 - Verdict, M., Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, T., Gilman, D., Ahmed, M., Liu, B., Baltazar, J. C., Muns, S., and Turner, D. 2006. "Quantification of NO_x Emissions Reduction for SIP Credits from Energy Efficiency and Renewable Energy Projects in Texas," *2006 ACEEE Summer Study on Energy Efficiency in Buildings*, American Council for an Energy Efficient Economy, Washington, D.C., published on CD ROM (August).
- Presented one Paper at the 6th International Conference for Enhanced Building Operations, Shenzhen, China, October 2006:
 - Liu, Z., Haberl, J., Gilman, D., Culp, C., Yazdani, B. 2006. "Development of a Web-based Emissions Reduction Calculator for Storm Water/Infiltration Sanitary Sewage Separation," *Proceedings of the 6th International Conference for Enhanced Building Operations*, Shenzhen, China, published on CD ROM (October).

The Laboratory has and will continue to provide leading-edge technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP. These activities were designed to more accurately calculate the creditable NO_x emissions reduction from EE/RE initiatives contained in the TERP and to assist the TCEQ, local governments, and the building industry with standardized, effective implementation and reporting.

Energy and NOx Reductions From New Residential and Commercial Construction

State adoption of the energy efficiency provisions of the International Residential Code (IRC) and International Energy Conservation Code (IECC) became effective September 1, 2001. The Laboratory has developed and delivered training to assist municipal inspectors to become certified energy inspectors. The Laboratory also supported code officials with guidance on interpretations as needed. This effort, based on a requirement of HB 3235, 78th Texas Legislature, supports a more uniform interpretation and application of energy codes throughout the state. In general, the State is experiencing a true market transformation from low energy efficiency products to high energy efficiency products. These include: Low Solar Heat Gain windows, higher efficiency appliances, increased insulation, lower thermal loss ducts and in builder participation in "above-code" code programs such as Energy Star New Homes, which previously had no state baseline and almost no participation.

In the counties served by ERCOT, the resultant *annual* NOx reductions in 2006 were calculated to be 361 tons NOx/year², which include:

- 274 tons NOx/year from single-family and multi-family residential (409,025 MWh/year saved);
- 61 tons NOx/year from commercial construction (89,557 MWh/year saved); and
- 26 tons NOx/year from natural gas savings from single-family, multi-family residential and commercial construction (576,680 MBtu/year saved).

For the *peak ozone season day (OSD)*, the NOx emissions reduction in 2006 are calculated to be 2.23 tons of NOx/peak-OSD, which represents:

- 1.70 tons NOx/day from single-family and multi-family residential (2,564 MWh/day saved);
- 0.38 tons NOx/day from commercial (568 MWh/day saved); and
- 0.15 tons NOx/day from natural gas savings from single-family, multi-family and commercial construction (3,266 MBtu/day saved).

Beginning in 2005, the Laboratory worked with the TCEQ to develop a standardized, integrated NOx emissions reduction across state agencies implementing EE/RE programs so that the results can be evaluated consistently. As required by the legislation, the TCEQ receives reports: from the Laboratory on savings from code compliance and renewables; from the Laboratory, in cooperation with the Electric Reliability Council of Texas (ERCOT), on the savings from electricity generated from wind power; from the Public Utilities Commission of Texas (PUCT) on the impacts of the utility-administered programs designed to meet the mandated energy efficiency goals of SB7 and SB5; and from the State Energy Conservation Office (SECO) on the impacts of energy conservation in state agencies and political subdivisions.

- In 2006, *total cumulative annual energy savings*³ 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 retrofits⁴ is 405,879 MWh/year (4.8%). The total savings from all programs is 8,396,023 MWh/year. The *total cumulative OSD energy 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.

² These NOx emissions reduction were calculated with the US EPA's 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

³ This includes the savings from 2001 through 2006.

⁴ 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.

- The **total cumulative annual NOx emissions reduction** 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 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. The **total 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.
- In 2013, the **total cumulative annual energy 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 will be 2,286,232 MWh/year (12.7%). The total savings from all programs will be 17,939,336 MWh/year. The **total cumulative OSD energy 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.
- The **total cumulative annual 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 reductions from all programs will be 11,868 tons-NOx/year. The **total 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.

Figure 2 shows the cumulative NOx emissions reduction through 2020 for the electricity and natural gas savings from all TERP programs reporting to the TCEQ. Table 1 provides the details regarding the annual degradation, transmission and distribution losses, discount factors and growth factors that were used in the analysis³. Additional details of the analysis are reported in Volume II of this report.

³ These factors were determined by TCEQ.

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

	ESL-Single Family ¹⁰	ESL-Multifamily ¹⁰	ESL-Commercial ¹⁰	Federal Buildings ¹⁰	Furnace Pilot Light Program ¹⁰	PUC (SB7) ¹⁰	PUC (SB5 Grant Program) ¹⁰	SECO ¹⁰	Wind-ERCOT ¹⁰	SEER13 Single Family
Annual Degradation Factor ¹⁰	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%		5.00%
T&D Loss ⁶	7.00%	7.00%	7.00%	7.00%	0.00%	7.00%	7.00%	7.00%		0.00%
Initial Discount Factor ¹⁰	20.00%	20.00%	20.00%	20.00%	20.00%	25.00%	25.00%	60.00%		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 28.004	N.A.

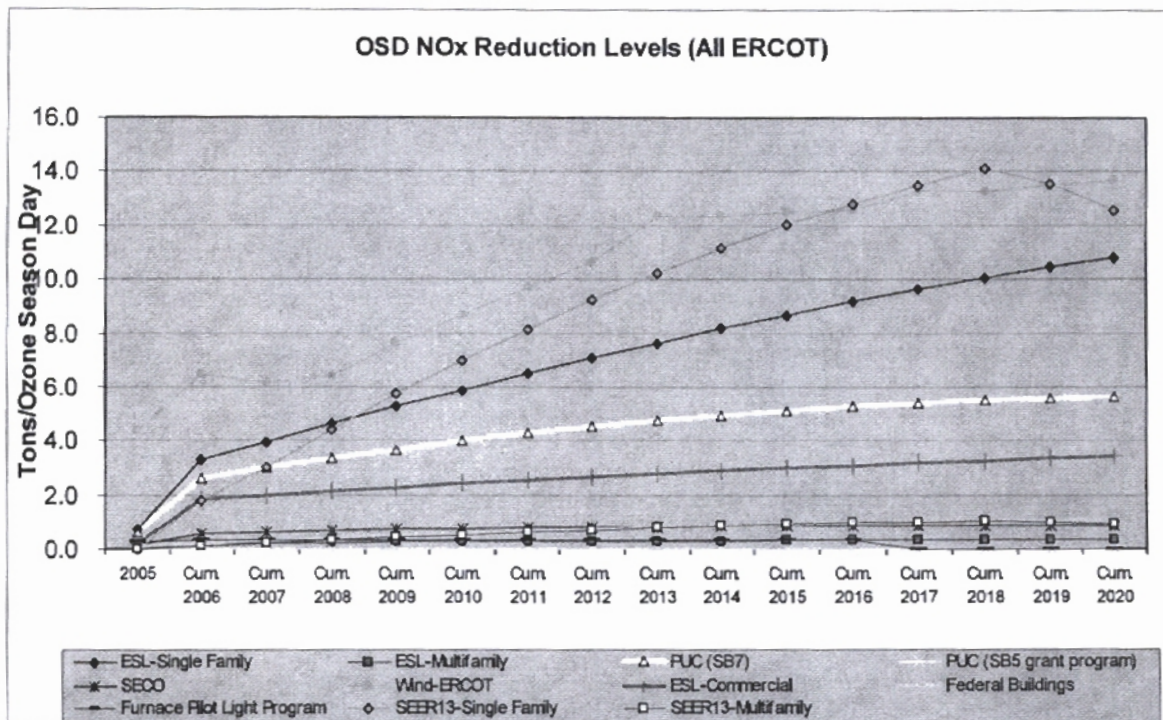


Figure 2: Cumulative OSD NOx Emissions Reduction Projected through 2020.

Technology for Calculating and Verifying Emissions Reduction from Energy Used in Buildings

In 2004 and 2005, the Laboratory developed a web-based Emissions Reduction Calculator, known as “eCalc,” which contains the underlying technology for determining NOx emissions reduction from power plants that generate the electricity for the user⁶. The emissions reduction calculator is being used to calculate emissions reduction for consideration for SIP credits from energy efficiency and renewable energy programs in the TERP.

In 2006, the Laboratory enhanced the calculator to provide additional functions and usability, including:

- Enhanced the web-based “Emissions Reduction Calculator” for determining emissions reduction from energy efficiency improvements in residential and commercial construction, municipal projects and renewable energy projects;
- Enhanced the Laboratory’s IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Enhanced web-based emissions reduction calculator, including:
 - Expanded emissions reduction calculator to include all counties in ERCOT;
 - Gathered, cleaned and posted weather data archive for 17 NOAA stations;

⁶ eCalc reports NOx, SOx and CO2 emissions reduction from the US EPA eGRID database for power providers in the ERCOT region.

- Expanded emissions reduction to include SEER 13 air conditioners for new and existing homes;
- Continued the enhancement of the new computer architecture to allow for synchronous calculations, user accounts, and code-compliance;
- Continued the development of verification procedures, including:
 - Completion of calibrated simulation of a high-efficiency office building in Austin, Texas;
 - Worked towards a calibrated simulation of an office building;
 - Worked towards a calibrated simulation of a K-12 school; and
 - Completed the calibrated simulation of a Habitat for Humanities residence.
- Expanding the calculator to be able to analyze energy efficiency improvement to K-12 schools;
- Completing the new modules for municipal water and waste-water calculations; and
- Developing verification procedures for the savings including a utility bill analysis of representative residences built before and after the implementation of the State-wide building code.

Planned Focus for 2007/2008

In FY 2007, the Energy Systems Laboratory is continuing its cooperative efforts with the TCEQ, PUCT, SECO, US EPA and others to ensure EE/RE measures remain a cost-effective solution to clean air, and continue to support the energy efficiency and renewable energy opportunities of the TERP. In FY 2007 the Laboratory team will:

- Continue to assist the TCEQ to obtain SIP credits from energy efficiency and renewable energy using the Laboratory's Emissions Reduction Calculator technology;
- Verify, document and report energy efficiency and renewable energy savings in all TERP EE/RE programs for the SIP in each non-attainment and near-non-attainment county using the TCEQ/US EPA approved technology;
- Assist the PUCT with determining emissions reduction credits from energy efficiency programs funded by SB 7 and SB 5;
- Assist political subdivisions and Councils of Governments with calculating emissions reduction from local code changes and voluntary EE/RE programs reported to SECO for SIP inclusion;
- Continue to develop additional low-cost methods and techniques to implement 15% above code energy efficiency in low-priced and moderately-priced residential housing and commercial construction;
- With support from the US DOE and SECO, continue the development of a web-based code-compliance calculator in Austin, Texas (TCV project), and expand the use of such a calculator in other areas of Texas (i.e., the International Code Compliance Calculator – ICCC for Texas);
- Continue to develop creditable procedures for calculating NOx emissions reduction from green renewable technologies, including wind power, solar energy and geothermal energy systems;
- Continue development of the standardized, integrated NOx emissions reduction methodologies for calculating and reporting NOx reductions, including a unified database framework for required reporting to the TCEQ of potentially creditable measures from the ESL, PUCT, and SECO Senate Bill 5 initiatives;
- Complete the analysis of the stringency of several residential and commercial energy codes, including ASHRAE Standard 90.1-2004, and the 2006 IECC; and
- With the assistance of the TCEQ and EPA, expand all analysis to include all counties in Texas;
- With the assistance of the US EPA, expand the analysis to include new base year calculations;
- Continue its role as the National Center of Excellence on Displaced Emissions Reduction (CEDER) as designated by the US EPA; and
- Host the 2008 Clean Air Through Energy Efficiency (CATEE) conference to be held in Dallas, Texas.

The Laboratory will continue to provide technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans.

If any questions arise, please contact us by phone at 979-862-2804 or by email at SB5info@esl.tamu.edu.