

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

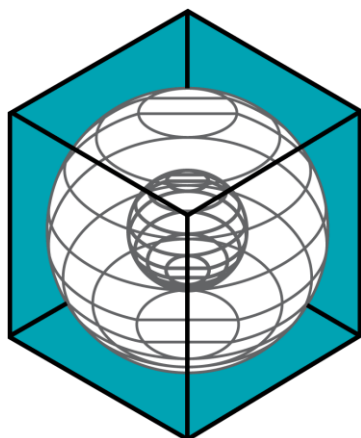
## **VOLUME I—SUMMARY REPORT**

**Annual Report to the  
Texas Commission on Environmental Quality  
January 2008-December 2008**



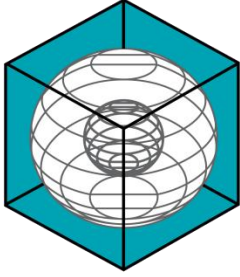
Jeff Haberl, Ph.D., P.E.; Charles Culp, Ph.D., P.E.  
Bahman Yazdani, P.E.; Don Gilman, P.E.  
Shirley Muns, C.B.O  
Zi Liu, Ph.D., Juan-Carlos Baltazar-Cervantes, Ph.D.,  
Jaya Mukhopadhyay, Larry Degelman, P.E., David Claridge, Ph.D., P.E.

December 2009



## **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 18, 2009

Chairman Bryan W. Shaw  
Texas Council on Environmental Quality  
P. O. Box 13087  
Austin, TX 78711-3087

Dear Chairman Shaw:

The Energy Systems Laboratory (Laboratory) at the Texas Engineering Experiment Station of the Texas A&M University System is pleased to provide its seventh 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) 845-1280 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.

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

Enclosure

cc: Commissioner Carlos Rubinstein  
Commissioner Buddy Garcia  
Executive Director Mark Vickery

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

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

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

#### 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 and 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.

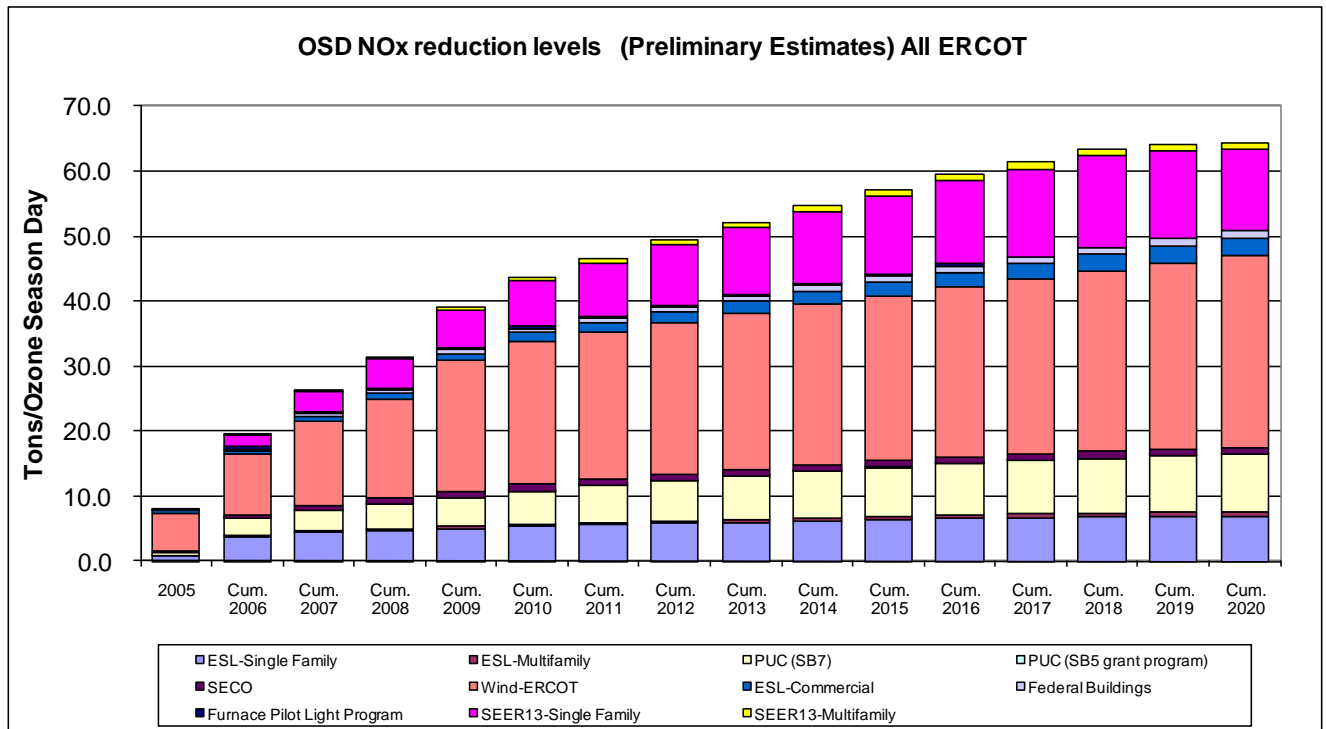


Figure 1: OSD NOx Emissions Reduction Projections through 2020

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 seventh 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 code-compliant energy simulations for all ERCOT counties in Texas included in the analysis.

#### Legislative Background

The TERP was established in 2001 by the 77<sup>th</sup> 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 2008; 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 78<sup>th</sup> 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 79<sup>th</sup> 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 80<sup>th</sup> 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, FY 2006, FY 2007 and FY 2008. 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 2008

Since January of 2008, the Laboratory accomplished the following:

- Calculated energy and resultant NO<sub>x</sub> 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;
- Developed the IC3 calculator, which is energy code compliance software based on the Texas Building Energy Performance Standards;
- Continued development and testing of key procedures for validating simulations of building energy performance;
- Maintained and updated the Laboratory’s Texas Emissions Reduction Plan (TERP) website;
- Maintained a builder’s residential energy code Self-Certification Form (Ver.1.3) for use by builders outside municipalities;
- Responded to thousands 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;
- Hosted the Clean Air Through Energy Efficiency (CATEE) Conference in December 2008, in Dallas, 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 NO<sub>x</sub> emissions reduction reporting procedures<sup>1</sup> to the TCEQ for ESL, PUCT, SECO and ERCOT EE/RE projects;
  - Enhancement of the procedures for weather normalizing NO<sub>x</sub> emissions reduction from power provided by wind energy providers to base-year calculations;
- Enhanced the web-based emissions reduction calculator, including:
  - 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;
- Developed 15% above code recommendations for residential buildings for Houston, Texas;
- Continued the development of verification procedures, including:
  - Completed 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 TERP program, the Laboratory:

---

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

- Continued development of 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.
- Updated previously developed degradation analysis to determine if degradation could be observed in the measured power from Texas wind farms.
- Updated previously developed empirical curtailment analysis of the measured power production from a wind farm and applied to the Indian Mesa wind farm.
- Updated previously developed database of other renewable projects in Texas, including: solar photovoltaic, geothermal, hydroelectric, and Landfill Gas-fired Power Plants.
- Applied previously 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.
- Continued the 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 TERP related work, including:

- Presentation to the TCEQ, Austin, Texas, March 2008.
- Presentation to the Texas Clean Air Working Group, Austin, Texas, May 2008.
- Presentation to the EPA Technical Forum, May 2008 (by phone).
- Presentation to the University of Texas Department of Architecture, Austin, Texas, September 2008.
- Presentation to the EPA Blue Skyways conference, Kansas City, Missouri, September 2008.
- Presentation to the Texas Senate Natural Resources Committee, Austin, Texas, September 2008.

Presentation of fifteen papers at the 16<sup>th</sup> Symposium on Improving Building Systems in Hot and Humid Climates, in Dallas, Texas, December 2008, including:

- Liu, Z.; Mukhopadhyay, J.; Malhotra, M.; Haberl, J.; Gilman, D.; Montgomery, C.; McKelvey, K.; Culp, C.; Yazdani, B. 2008. "Methodology for Residential Building Energy Simulations Implemented in the International Code Compliance Calculator (IC3)", *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas.
- Gilman, D.; Marshall, K.; Liu, Z.; Mukhopadhyay, J.; Stackhouse, R.; Cordes, J.; Montgomery, C.; McKelvey, K.; O'Neal, S.; Culp, C.; Haberl, J.; Yazdani, B. 2008. "Development of a Residential Code-compliant Web-based Calculator for Texas", *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Mukhopadhyay, J.; Liu, Z.; Malhotra, M.; Haberl, J.; Gilman, D.; Montgomery, C.; Culp, C.; Yazdani, B.. 2008. "An Analysis of the Residential Energy Savings from the Implementation of the 2001 IECC and 2006 NAECA Appliance Standards in the State of Texas", *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Martinez, J. T.; Verdict, M.; Baltazar-Cervantes, J. C.; Strybos, J. 2008. "Continuous Commissioning® and Energy Management Control Strategies at Alamo Community College District", *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Kim, S.; Haberl, J. 2008. "Development of an ASHRAE 152-2004 Duct Model for the Single-Family Residential House", *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas

- Nelson, I. C.; Culp, C.; Graves, R. D. 2008. “Semi-Empirical Screw Compressor Chiller Model”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Ugursal, A.; Culp, C. 2008. “The Effects of Geometry on Flexible Duct CFD Simulations”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Liu, Z.; Haberl, J. S.; Baltazar, J. C.; Culp, C.; Yazdani, B.; Chandrasekaran, V. 2008. “Calculating Emissions Reductions from Renewable Energy Programs and Its Application to the Wind Farms in the Texas ERCOT Region”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Malhotra, M.; Haberl, J. 2008. “Analysis of Off-Grid, Off-Pipe Housing for Hot-Humid and Hot-Arid Climates”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Im, P.; Haberl, J. S. 2008. “Detailed Analysis of Thermal Mass Credits in a Code-Traceable DOE-2 Simulation of the 2001 IECC for a Single-Family Residence in Texas”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Cho, S.; Haberl, J. S. 2008. “Validation of the eCALC Commercial Code-Compliant Simulation Versus Measured Data from an Office Building in a Hot and Humid Climate”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Andolsun, S.; Culp, C. 2008. “A Comparison of EnergyPlus to DOE-2.1E: Multiple Cases Ranging from a Sealed Box to a Residential Building”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Masuda, H.; Baltazar, J. C.; Ji, J.; Claridge, D. E. 2008. “Development of Data Quality Control Limits for Data Screening Through the 'Energy Balance' Method”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Malhotra, M.; Im, P.; Haberl, J.; Ramirez, E.; Cho, S.; Canez, J.; Schaidler, N.; Fisk, P.; Feigenbaum, L. 2008. “Design, Construction, Transportation, Operation and Post-Occupancy Analysis for the Texas A&M Solar Decathlon House”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas
- Ji, J.; Baltazar, J. C.; Claridge, D. E. 2008. “Study of the Outside Air Enthalpy Effects in the Screening of Metered Building Energy Data”, *Proceedings of the 16 Symposium on Improving Building Systems in Hot and Humid Climates*, Texas A&M University, Dallas, Texas

Presentation of two papers at the International Conference for Enhanced Building Operation, Berlin, Germany, October 2008, including:

- Haberl, J. S.; Davies, H.; Owens, B.; Hunn, B. 2008. “ASHRAE’s New Performance Measurement Protocols for Commercial Buildings”, *Proceedings of the 8<sup>th</sup> International Conference for Enhanced Building Operation*, Berlin, Germany.
- Dennis, J. R.; Hodapp, R. T.; Kramer, L.; Deng, S.; Wei, G.; Turner, W. D.; Yazdani, B.; Baltazar, J. C.; Henson, R.; Schroeder, F. 2008. “Continuous Commissioning<sup>®</sup> of Dallas/Fort Worth International Airport”, *Proceedings of the 8<sup>th</sup> International Conference for Enhanced Building Operation*, Berlin, Germany.

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<sub>x</sub> 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, including furnace pilot light savings and residential air conditioner retrofits**

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, 78<sup>th</sup> 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, high efficiency air conditioners and heat pumps, 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 2008, the annual electricity savings<sup>2</sup> from code-compliant residential and commercial construction is calculated to be 1,551,569 MWh/year (6.8% of the total electricity savings), savings from furnace pilot light retrofits is 2,548,904 MBtu/year, and savings from residential air conditioner retrofits<sup>3</sup> is 989,385 MWh/year (4.3%). In 2008, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 6,904 MWh/day (14.2%), savings from furnace pilot light retrofits is 6,983 MBtu/day, and savings from residential air conditioner retrofits are 7,017 MWh/day (14.5%).

By 2013, the annual electricity savings from code-compliant residential and commercial construction is calculated to be 2,045,171 MWh/year (5.8% of the total electricity savings), savings from furnace pilot light retrofits will remain at 2,548,904 MBtu/year, and savings from residential air conditioner retrofits<sup>4</sup> will be 2,286,233 MWh/year (6.5%). By 2013, the OSD electricity savings from code-compliant residential and commercial construction is calculated to be 12,110 MWh/day (15%), savings from furnace pilot light retrofits will remain at 6,893 MBtu/day, and savings from residential air conditioner retrofits will be 16,216 MWh/day (20%).

In 2008, the annual NOx emissions reduction<sup>5</sup> from code-compliant residential and commercial construction is calculated to be 1,091 tons-NOx/year (8.6% of the total NOx savings), savings from furnace pilot light retrofits is 117 tons-NOx/year (0.9%), and savings from residential air conditioner retrofits is 682 tons-NOx/year (5.3%). In 2008, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 6.0 tons-NOx/day (19.2%), savings from furnace pilot light retrofits is 0.32 tons-NOx/day (1.0%), and savings from residential air conditioner retrofits are 4.77 tons-NOx/day (15.2%).

By 2013, the NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,435 tons-NOx/year (7% of the total NOx savings), savings from furnace pilot light retrofits will be 117 tons-NOx/year (0.6%), and savings from residential air conditioner retrofits will be 1,574 tons-NOx/year (7.7%). By 2013, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 8.32 tons-NOx/day (15.9%), savings from furnace pilot light retrofits will be 0.32 tons-NOx/day (0.6%), and savings from residential air conditioner retrofits will be 11.03 tons-NOx/day (21.2%).

### **Integrated NOx Emissions Reductions Reporting Across State Agencies**

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

<sup>2</sup> This includes the savings from 2001 through 2008.

<sup>3</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

<sup>4</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

<sup>5</sup> These NOx emissions reduction were calculated with the US EPA’s 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

SB5; and from the State Energy Conservation Office (SECO) on the impacts of energy conservation in state agencies and political subdivisions.

The total annual and OSD electricity savings for all the different programs in the integrated format was calculated using the adjustment factors for 2001 through 2020. NOx emissions reduction from the electricity and natural gas savings for the annual and OSD for all the programs in the integrated format were calculated.

In 2008, the annual electricity savings from code-compliant residential and commercial construction is calculated to be 1,551,569 MWh/year (6.8% of the total electricity savings), savings from retrofits to Federal buildings is 206,960 MWh/year (0.9%), savings from furnace pilot light retrofits is 2,548,904 MBtu/year, savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 2,015,453 MWh/year (8.8%), savings from SECO's Senate Bill 5 program is 445,357 MWh/year (1.9%), electricity savings from green power purchases (wind) is 15,171,518 MWh/year (66.2%), and savings from residential air conditioner retrofits<sup>6</sup> is 989,385 MWh/year (4.3%). The total savings from all programs is 22,929,144 MWh/year.

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

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

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

In 2008, the annual NOx emissions reduction<sup>8</sup> from code-compliant residential and commercial construction is calculated to be 1,091 tons-NOx/year (8.6% of the total NOx savings), savings from retrofits to Federal buildings is 158 tons-NOx/year (1.2%), savings from furnace pilot light retrofits is 117 tons-NOx/year (0.9%), savings from the PUC's Senate Bill 5 and Senate Bill 7 programs is 1,426 tons-NOx/year (11.2%), savings from SECO's Senate Bill 5 program is 340 tons-NOx/year (2.7%), electricity savings from green power purchases (wind) is 8,914 tons-NOx/year (70.0%), and savings from residential air conditioner retrofits is 682 tons-NOx/year (5.3%). The total NOx emissions reduction from all programs is 12,727 tons-NOx/year.

In 2008, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 6 tons-NOx/day (19.2%), savings from retrofits to Federal buildings is 0.42 tons-NOx/day (1.3%), savings from furnace pilot light retrofits is 0.32 tons-NOx/day (1.0%), savings from the PUC's Senate Bill 5 and

<sup>6</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

<sup>7</sup> This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

<sup>8</sup> These NOx emissions reduction were calculated with the US EPA's 2007 eGRID for annual (25% capacity factor) and Ozone Season Day OSD.

Senate Bill 7 programs is 3.82 tons-NOx/day (12.1%), savings from SECO's Senate Bill 5 program is 0.92 tons-NOx/day (2.9%), electricity savings from green power purchases (wind) are 15.13 tons-NOx/day (48.2%), and savings from residential air conditioner retrofits are 4.77 tons-NOx/day (15.2%). The total NOx emissions reduction from all programs is 31.38 tons-NOx/day.

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

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

Figure 2: OSD NOx Emissions Reduction Projected through 2020 shows the NOx emissions reduction through 2020 for the electricity and natural gas savings from all TERP programs reporting to the TCEQ. Table 1: Adjustment Factors used for the Calculation of the Annual and OSD NOx Savings for the Different Programs provides the details regarding the annual degradation, transmission and distribution losses, discount factors and growth factors that were used in the analysis<sup>9</sup>. Additional details of the analysis are reported in Volume III of this report.

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

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

<sup>9</sup> These factors were determined by TCEQ.

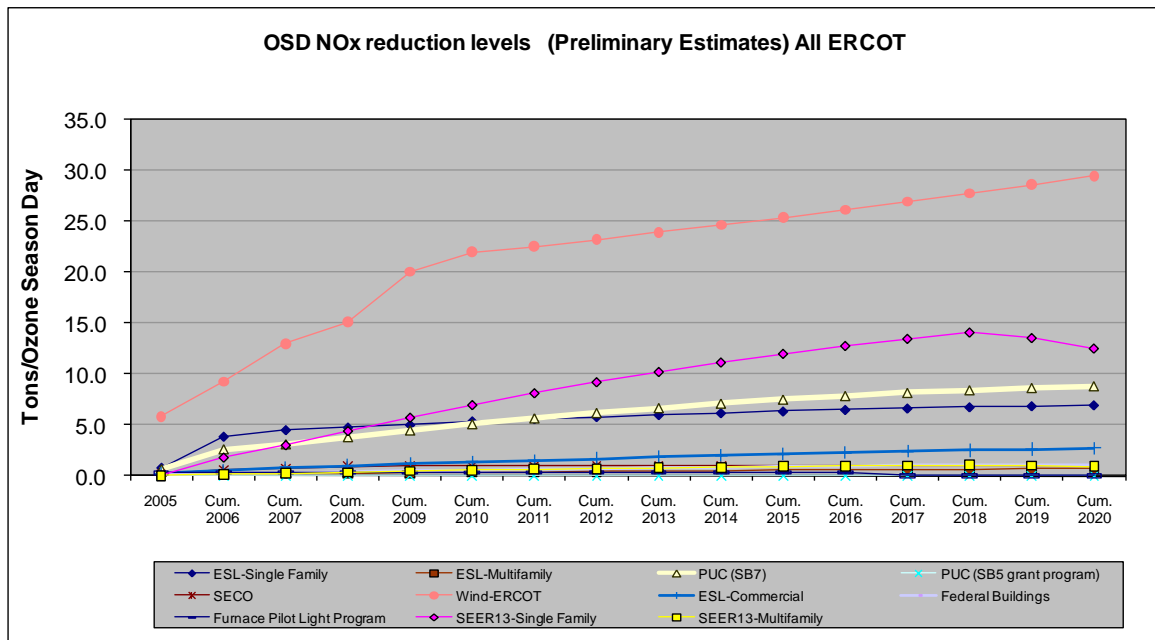


Figure 2: OSD NOx Emissions Reduction Projected through 2020

### 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 NO<sub>x</sub> emissions reduction from power plants that generate the electricity for the user<sup>10</sup>. 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 2007, the Laboratory enhanced the calculator to provide additional functions and usability, including:

- Renaming the product IC3 v2.0
- 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 calculator, including:
  - Use of the calculator to determine 15% above code residential and commercial options.
  - Gathered, cleaned and posted weather data archive for 17 NOAA stations;
  - Performed comparative testing of the calculator vs. other, non-web-based simulation programs;
  - Developed and tested radiant barrier simulation;
  - Using the web-based emissions calculator, started development of the derivative version Texas Climate Vision calculator for the City of Austin;
- Continued the development of verification procedures, including:
  - Completed the calibrated simulation of a high-efficiency office building in Austin, Texas;
  - Continued work to develop a calibrated simulation of an office building in College Station; and
  - Continued work to develop a calibrated simulation of a K-12 school in College Station;

In 2008, work on both web based calculators continued;

- Deployed IC3 v3.2 to handle a wider selection of single family building configurations (<http://ic3.tamu.edu>);
- Delivered TCV v1.0 to the City of Austin for their testing;
- Continued to operate the original *eCalc*;

<sup>10</sup> *eCalc* reports NO<sub>x</sub>, SO<sub>x</sub> and CO<sub>2</sub> emissions reduction from the US EPA eGRID database for power providers in the ERCOT region.

- Supported modeling efforts by building enhanced tools for batch simulation;
- Provided training on both IC3 and TCV.

Below are tables with the traffic details of eCalc and IC3. A 'Visit' is a metric counting the complete sets of requests from individual web client sessions with the web site. A session is considered complete and unique after thirty minutes of inactivity from the web clients IP address. A 'Page' is a metric that shows that our web server sent a complete webpage with all its files to a web client. A 'File' is when the ESL web server sends a completed request to a web client. A 'hit' is any time a web client sends any request to a web server.

<b>Summary by Month</b>				
<b>Month</b>				
	<b>Visits</b>	<b>Pages</b>	<b>Files</b>	<b>Hits</b>
<u>Dec-08</u>	1,660	1,067	17,650	29,452
<u>Nov-08</u>	1,625	686	23,188	32,868
<u>Oct-08</u>	1,982	1,612	35,210	73,988
<u>Sep-08</u>	1,503	596	18,019	29,005
<u>Aug-08</u>	2,300	752	25,109	42,571
<u>Jul-08</u>	2,246	913	23,597	36,932
<u>Jun-08</u>	2,337	816	23,206	35,867
<u>May-08</u>	2,326	844	22,212	31,864
<u>Apr-08</u>	2,348	797	460,670	1,955,840
<u>Mar-08</u>	2,114	835	440,248	1,381,368
<u>Feb-08</u>	2,061	1,302	28,297	45,772
<u>Jan-08</u>	2,377	2,294	18,245	29,201
<b>Totals</b>	<b>24,879</b>	<b>12,514</b>	<b>1,135,651</b>	<b>2,345,109</b>

Figure 3: eCalc Traffic Details January 2008-December 2008

<b>Summary by Month</b>				
<b>Month</b>				
	<b>Visits</b>	<b>Pages</b>	<b>Files</b>	<b>Hits</b>
Dec-08	756	8,280	30,195	30,804
Nov-08	683	8,421	30,832	31,541
Oct-08	1,020	9,720	36,213	37,164
Sep-08	709	11,440	42,472	43,615
Aug-08	518	7,619	28,996	29,889
<b>Totals</b>	<b>3,686</b>	<b>45,480</b>	<b>168,708</b>	<b>173,013</b>

Figure 4: IC3 Details August 2008-December 2008

### **Planned Focus for 2008/2009**

In FY 2009, 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 2009 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 – ICCO for Texas);
- Continue to develop credible 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 TERP initiatives;
- Complete the analysis of the stringency of several residential and commercial energy codes, including ASHRAE Standard 90.1-2004; and 90.1-2007, 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 for eGRID;
- Continue its role as the National Center of Excellence on Displaced Emissions Reduction (CEDER) as designated by the US EPA; and
- Host the 2009 Clean Air Through Energy Efficiency (CATEE) conference to be held in Houston, 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 979-458-0675, or by email at [terpinfo@tees.tamus.edu](mailto:terpinfo@tees.tamus.edu).