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

VOLUME I—TECHNICAL REPORT

Annual Report to the
Texas Commission on Environmental Quality
January 2020-December 2020

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ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

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Energy Systems Laboratory

November 08, 2021

Mr. Robert Gifford
Air Quality Division
Texas Commission on Environmental Quality
Austin, TX 78711-3087

Dear Mr. Gifford:

The Energy Systems Laboratory (ESL) at the Texas A&M Engineering Experiment Station of the Texas A&M University System is pleased to provide its annual report, “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP),” as required under Texas Health and Safety Code 386.205, 386.252, 388.006, 389.003 (e), and under Texas Utilities Code Sec. 39.9051 (g) (h), and Sec. 39.9052 (c) (d).

The ESL 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) 845-9213 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,

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

Disclaimer

VOLUME I – TECHNICAL REPORT

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

Executive Summary

The Energy Systems Laboratory (Laboratory), a division of the Texas A&M Engineering Experiment Station and a member of The Texas A&M University System, in fulfillment of its responsibilities under Sections 386.205, 386.252, 388.006, and 388.003 (e) of the Texas Health and Safety Code and Sections 39.9051 (g) (h), and 39.9052 (c) (d) of the Texas Utilities Code, submits its annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (TERP) to the Texas Commission on Environmental Quality.

The report is organized in two volumes.

- Volume I – Technical Report – provides a detailed report of activities, methodologies and findings, including an executive summary and overview;
- Volume II – Technical Appendix – contains detailed data from simulations for each of the counties included in the analysis.

The ESL worked with the EPA and TCEQ regarding a new version of eGRID for all counties in Texas. A new version of eGRID was developed and presented in this report.

Accomplishments:

a. Energy Code Amendments

The Laboratory was requested by several Councils of Governments (COGs) and municipalities to analyze the stringency of several proposed residential and commercial energy code amendments, including: the 2015 IECC and the ASHRAE Standards 90.1-2013. Results of the analysis are included in this Volume I-Technical Report.

b. 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.

c. 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 integrated NOx emissions reduction through 2025 for the electricity and natural gas savings from the various EE/RE programs.

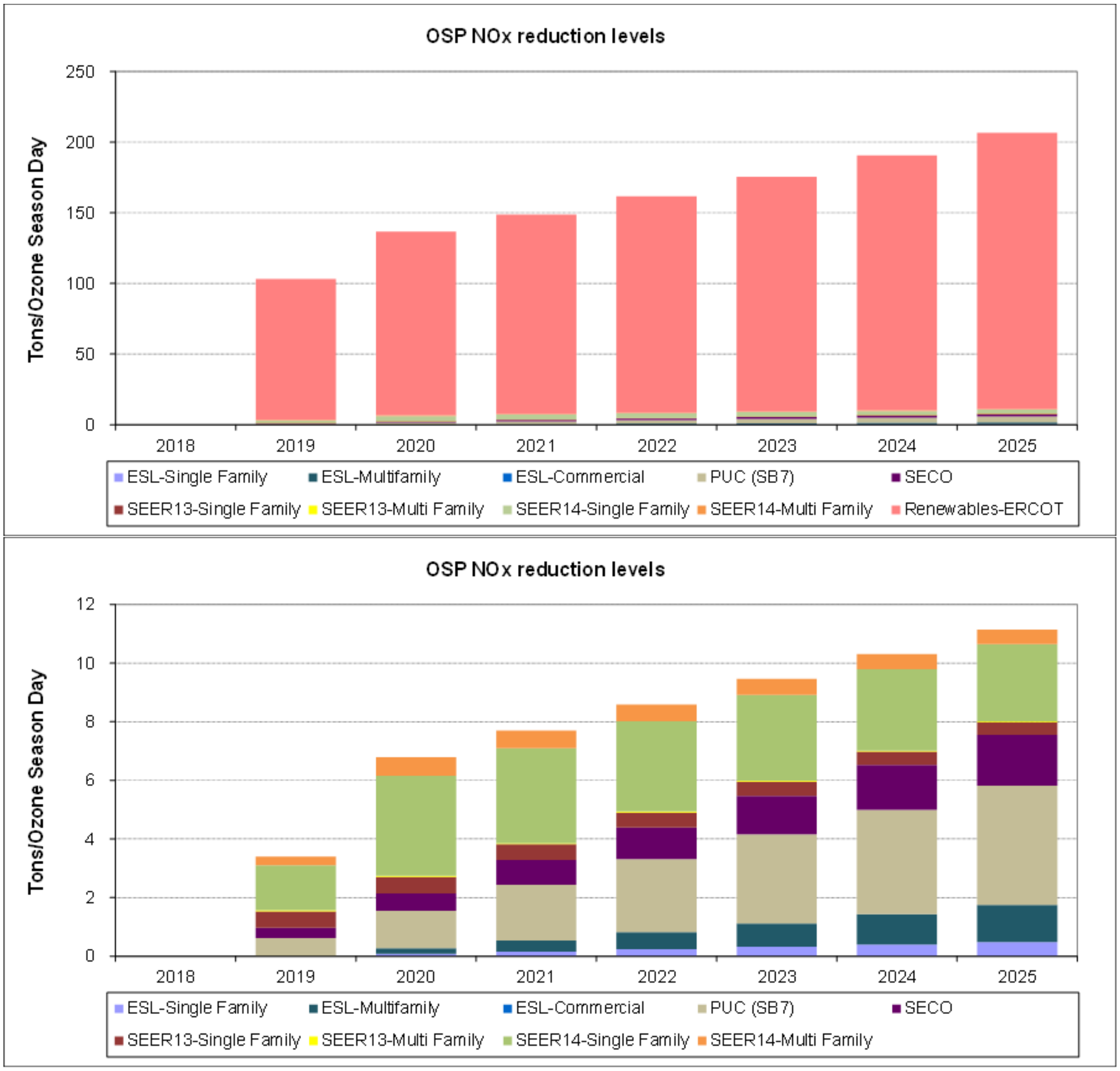

Figure 1: Integrated OSP NOx Emissions Reduction Projections through 2025 (Base Year 2018). (Upper plot) all programs, (lower plot) all programs except Renewables.

Table 1), the total integrated annual savings from all programs are 81,073,322 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from the PUC's Senate Bill 7 program are 1,263,892 MWh/year (1.6%),
- Savings from SECO's Senate Bill 5 program are 567,339 MWh/year (0.7%),
- Electricity savings from renewable power generation are 77,365,814 MWh/year (95.4%), and
- Savings from residential air conditioner retrofits[1] are 1,626,346 MWh/year (2.0%).

By 2025, the total integrated annual savings from all programs will be 124,686,284 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 1,643,386 MWh/year (1.3% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 3,990,544 MWh/year (3.2%),

[1] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13/14 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- Savings from SECO's Senate Bill 5 program will be 1,462,295 MWh/year (1.2%),
- Electricity savings from renewable power generation will be 116,331,624 MWh/year (93.3%), and
- Savings from residential air conditioner retrofits will be 1,258,435 MWh/year (1.0%).

In 2020 (Table 2), the total integrated annual NOx emissions reductions from all programs are 49,450 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 104 tons-NOx/year (0.2% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 496 tons-NOx/year (1.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 230 tons-NOx/year (0.5%),
- NOx emissions reductions from renewable power generation are 47,874 tons-NOx/year (96.8%), and
- NOx emissions reductions from residential air conditioner retrofits are 746 tons-NOx/year (1.5%).

By 2025, the total integrated annual NOx emissions reductions from all programs will be 75,496 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 686 tons-NOx/year (0.9% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1,571 tons-NOx/year (2.1%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 676 tons-NOx/year (0.9%),
- NOx emissions reductions from renewable power generation will be 71,985 tons-NOx/year (95.3%), and
- NOx emissions reductions from residential air conditioner retrofits will be 578 tons-NOx/year (0.8%).

Table 1: Annual and OSP Electricity Savings for the Different Programs (Base Year 2018)

PROGRAM	ANNUAL (MWh)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	74,850	151,273	229,361	309,214	390,931	474,618
ESL-Multifamily	0	0	175,080	357,338	547,283	745,451	952,412	1,168,768
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	629,516	1,263,892	1,866,549	2,439,074	2,982,972	3,499,676	3,990,544
SECO	0	359,121	567,339	765,147	953,064	1,131,585	1,301,180	1,462,295
Renewables-ERCOT	0	62,168,032	77,365,814	83,941,908	91,076,970	98,818,513	107,218,086	116,331,624
SEER13-Single Family	0	217,605	206,725	196,389	186,569	177,241	168,379	159,960
SEER13-Multi Family	0	18,420	17,499	16,624	15,793	15,003	14,253	13,541
SEER14-Single Family	0	567,976	1,171,988	1,113,389	1,057,719	1,004,833	954,592	906,862
SEER14-Multi Family	0	116,741	230,133	218,627	207,695	197,311	187,445	178,073
Total Annual (MWh)	**0**	**64,077,411**	**81,073,322**	**88,627,244**	**96,713,529**	**105,382,123**	**114,686,954**	**124,686,284**

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	205	414	628	847	1,071	1,300
ESL-Multifamily	0	0	480	979	1,499	2,042	2,609	3,202
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	1,725	3,463	5,114	6,682	8,173	9,588	9,588
SECO	0	984	1,553	2,093	2,606	3,094	3,557	3,557
Renewables-ERCOT	0	187,283	222,795	241,732	262,279	284,573	308,762	335,007
SEER13-Single Family	0	1,546	1,468	1,395	1,325	1,259	1,196	1,136
SEER13-Multi Family	0	124	118	112	106	101	96	91
SEER14-Single Family	0	3,712	7,660	7,277	6,913	6,568	6,239	5,927
SEER14-Multi Family	0	763	1,504	1,429	1,357	1,290	1,225	1,164
Total OSP (MWh)	**0**	**196,136**	**239,245**	**260,545**	**283,398**	**307,946**	**334,344**	**360,973**

Table 2: Annual and OSP NOx Emissions Reductions Values for the Different Programs (Base Year 2018)

PROGRAM	ANNUAL (in tons NOx)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	31	62	95	128	161	196
ESL-Multifamily	0	0	73	150	230	313	399	490
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	208	496	734	959	1,174	1,377	1,571
SECO	0	121	230	329	422	511	596	676
Renewables-ERCOT	0	27,757	47,874	51,943	56,358	61,148	66,346	71,985
SEER13-Single Family	0	73	85	80	76	72	69	65
SEER13-Multi Family	0	6	7	7	6	6	6	5
SEER14-Single Family	0	219	552	524	497	473	450	427
SEER14-Multi Family	0	44	103	98	93	88	84	80
Total Annual (Tons NOx)	**0**	**28,428**	**49,450**	**53,927**	**58,736**	**63,914**	**69,488**	**75,496**

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0.00	0.00	0.08	0.16	0.24	0.32	0.40	0.49
ESL-Multifamily	0.00	0.00	0.19	0.39	0.59	0.80	1.03	1.26
ESL-Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUC (SB7)	0.00	0.62	1.28	1.90	2.48	3.03	3.56	4.06
SECO	0.00	0.35	0.59	0.84	1.08	1.31	1.53	1.74
Renewables-ERCOT	0.00	99.65	130.00	141.05	153.04	166.05	180.16	195.47
SEER13-Single Family	0.00	0.56	0.56	0.53	0.51	0.48	0.46	0.43
SEER13-Multi Family	0.00	0.04	0.04	0.04	0.04	0.04	0.03	0.03
SEER14-Single Family	0.00	1.53	3.41	3.24	3.08	2.92	2.78	2.64
SEER14-Multi Family	0.00	0.31	0.64	0.61	0.58	0.55	0.52	0.49
Total OSP (Tons NOx)	**0.00**	**103.06**	**136.79**	**148.75**	**161.63**	**175.51**	**190.47**	**206.62**

d. Technology Transfer

In 2020, The Laboratory, hosted the 2020 Texas Energy Summit (formerly called the Clean Air Through Energy Efficiency/CATEE conference), which is attended by top experts and policy makers in Texas and from around the country. In the 2020 conference, the latest educational programs and technology were 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.

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 continuously provides 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 the 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.

The Energy Systems Laboratory provides the annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (TERP), to the Texas Commission on Environmental Quality (TCEQ) in fulfillment of its responsibilities under Sections 386.205, 386.252, 388.006, and 388.003 (e) of the Texas Health and Safety Code and Sections 39.9051 (g) (h), and 39.9052 (c) (d) of the Texas Utilities Code. If any questions arise, please contact us by phone at (979) 845-9213.

Acknowledgments

This work has been completed as a fulfillment of Sections 386.205, 386.252, 388.006, and 388.003 (e) of the Texas Health and Safety Code and Sections 39.9051 (g) (h), and 39.9052 (c) (d) of the Texas Utilities Code, which require the Laboratory to assist TCEQ in quantifying emissions reductions credits from energy efficiency and renewable energy programs.

The authors are also grateful for the timely input provided by the following individuals, and agencies: Mr. Robert Gifford, TCEQ.

Numerous additional individuals at the Laboratory contributed significantly to this report, including, Ms. Mitra Azimi, Ms. Yu Sun, and Mr. Jounghwan Ahn.

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1 Overview

The Energy Systems Laboratory (Laboratory), at the Texas A&M Engineering Experiment Station (TEES) of the Texas A&M University System, is pleased to provide our 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 Sections 386.205, 386.252, 388.006, and 388.003 (e) of the Texas Health and Safety Code and Sections 39.9051 (g) (h), and 39.9052 (c) (d) of the Texas Utilities Code. This annual report:

- Provides an estimate of the energy savings and NOx reductions from energy code compliance in new residential construction in all Electric Reliability Council of Texas (ERCOT) counties;
- Provides an estimate of the standardized, cumulative, integrated energy savings and NOx reductions from the TERP programs implemented by the Laboratory, the State Energy Conservation Office (SECO), the Public Utility Commission (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 two volumes.

Volume I – Technical Report – provides a detailed report of activities, methodologies and findings, including an executive summary and overview;

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

1.1 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:

- The Texas Building Energy Performance Standards (TBEPS) as the building energy code for all new residential and commercial buildings;
- A municipality or county may request the Laboratory to determine the energy impact of proposed energy code changes;
- 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);
- A 5% electricity reduction goal each year for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2009; and
- Annual report to TCEQ to be provided by the Laboratory on the energy savings and resultant emissions reduction from the implementation of building energy codes and which identifies the municipalities and counties whose codes are more or less stringent than the un-amended code.

Passed during the 78th Legislature (2003), HB 1365 and HB 3235 amended TERP to enhance its effectiveness with these additional energy efficiency initiatives:

- TCEQ is required 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;
- TCEQ is required to develop a methodology for computing emissions reduction from energy efficiency initiatives;
- 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;
- Municipalities are allowed 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
- The Laboratory is required to develop and administer a statewide training program for municipal building inspectors seeking to become code-certified inspectors for the enforcement of energy codes.

Senate Bill 5 was again amended during the 79th Legislature (2005) through SB 20, HB 2481 and HB 2129. These enhanced the effectiveness of Senate Bill 5 by adding the following energy efficiency initiatives:

- 5,880 MW of generating capacity is required from renewable energy technologies by 2015;
- 500 MW from non-wind renewables;
- The PUCT is required to establish a target of 10,000 megawatts of installed renewable capacity by 2025;
- The TCEQ is required to develop a methodology for computing emissions reduction from renewable energy initiatives and the associated credits;
- The Laboratory is required to assist the TCEQ in quantifying emissions reduction credits from energy efficiency and renewable energy programs;
- The Texas Environmental Research Consortium (TERC) is required 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
- The Laboratory is required 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 further amended Senate Bill 5 to enhance its effectiveness by adding the following energy efficiency initiatives:

- The Laboratory is required 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.
- The Laboratory is required to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- The Laboratory is required 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.
- The Laboratory is encouraged 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.
- The Laboratory is required to include information on the benefits attained from this program in an annual report to the commission.

The 81st Legislature (2009) extended the date of the TERP to 2019 and required the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

The 82nd Legislature (2011) increased the Laboratory's responsibilities under TERP with the introduction of new energy efficiency initiatives:

- Each political subdivision, institution of higher education or state agency shall establish a goal to reduce the electric consumption by the entity by at least 5% each fiscal year for 10 years, beginning September 1, 2011. Each entity shall report annually to SECO, on forms provided by SECO, regarding the entity's goal, the entity's efforts to meet the goal, and progress the entity has made. The Laboratory is required to calculate energy savings and emissions reduction for each political subdivision, institution of higher education or state agency, based on the information collected by SECO.
- Beginning April 1, 2012, all electric cooperatives that had retail sales of more than 500,000 MWh in 2005 and all municipally owned utilities must report annually to SECO, on a standardized form developed by SECO, information regarding the combined effects of the energy efficiency activities of the electric cooperative/utility from the previous calendar year, including the annual goals, programs enacted to achieve those goals, and any achieved energy demand or savings goals. The Laboratory is required to calculate energy savings and emissions reduction for municipally owned utilities and for electric cooperatives, based on the information collected by SECO.
- SECO is required to appoint a new advisory committee for selecting high-performance building design evaluation systems. The Laboratory will send a representative to participate at the new advisory committee.
- The Laboratory may conduct outreach to the real estate industry on the value of energy code compliance and above code construction.

The 83rd Legislature (2013) did not change any of the Laboratory's previously established responsibilities under TERP.

During the 84th Legislature session (2015), changes to the Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards, with the passage of HB 1736, affected the Laboratory's responsibilities under TERP:

- 2015 residential energy codes (IRC/IECC) editions are in effect starting Sept 1, 2016. 2015 commercial energy codes (IECC) are in effect starting Nov 1, 2016. The Laboratory's responsibilities of reviewing new energy codes and local code amendments remain. New codes will be reviewed no sooner than every 6 years.
- The legislation introduces a new energy rating index (ERI) as a voluntary compliance path for local code amendments. With the introduction of the ERI as another compliance path, the Laboratory is required to consider it when local amendments are reviewed and needs to update the web-based code compliance tool and emissions reduction calculator to allow for the new optional compliance path.

The 85th Legislature (2017) did not change any of the Laboratory's previously established responsibilities under TERP.

The 86th Legislature (2019) did not change any of the Laboratory's previously established responsibilities under TERP.

1.2 Laboratory Funding for the TERP

The Laboratory expended $181,855 in FY 2002; $372,226 in FY 2003; $635,683.84 in FY 2004; $1,107,366.13 in FY 2005; $952,012.70 in 2006; $947,114.62 in FY 2007; $908,512.65 in FY 2008; $949,927.94 in FY 2009; $902,843.35 in FY 2010, $853,421.69 in FY 2011; $434,481.91 in FY 2012 (with the 50% Legislature cut in ESL funding), $447,907.94 in FY 2013; $453,122.25 in FY 2014; $454,571.79 in FY 2015; $459,845.41 in FY 2016; $460,409.98 in FY 2017; $440,558.76 in FY 2018; and $443,310.85 in FY 2019. In FY 2020 the Laboratory expended $421,131.25 (with additional 5% Legislature cut in ESL funding). Throughout the years, the Laboratory has also supplemented these funds with competitively awarded Federal and State 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. In addition, the ESL received 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 has helped to enhance the EE/RE emissions calculations.

1.3 Code Adoption

One of the TERP's energy efficiency programs to reduce emissions from stationary sources was the establishment of the Texas Building Energy Performance Standards (TBEPS) that define the building energy codes for all new residential and commercial construction statewide. The original TBEPS were based on the energy efficiency chapter of the 2000 International Residential Code (IRC), including the 2001 Supplement, for Single-Family residences, (i.e., one- and two-family residences, R-2, R-3 and R-4 multi-family of three stories or less above grade) and the 2000 International Energy Conservation Code (IECC), including the 2001 Supplement, for commercial, industrial and residential buildings not defined as Residential.

Over the years since the establishment of the TERP, newer editions of the IRC and the IECC have been published. The Energy Systems Laboratory is mandated to review the stringency of the new code editions and provide recommendations to the State on whether to upgrade the TBEPS to the new editions.

In the time frame of 2002-2009, the laboratory provided recommendations and considered additional input from stakeholder meetings and public comment periods on the 2003 and 2006 editions of the IRC/IECC energy efficiency codes. The State of Texas did not adopt any of the newer editions of the energy efficiency codes as the TBEPS during this timeframe. Although several individual jurisdictions did adopt the newer editions.

In the time frame of 2002-2012, the laboratory provided recommendations and considered additional input from stakeholder meetings and public comment periods on the 2009 edition of the IRC/IECC energy efficiency codes. With the laboratory's recommendation, SECO updated the TBEPS energy efficiency codes to the 2009 IRC/IECC.

In the timeframe of 2013-2015, the laboratory provided recommendations and considered additional input from stakeholder meetings and public comment periods on the 2012 and 2015 editions of the IRC/IECC energy efficiency codes. The State of Texas did not adopt the 2012 edition of the energy efficiency codes as the TBEPS. During this time, several individual jurisdictions did adopt the 2012 and the 2015 editions of the IRC/IECC.

During the 84th Legislature session (2015), the legislature adopted the 2015 residential energy codes (IRC/IECC) editions effective September 1, 2016. The 2015 IECC – Commercial (IECC-C) were effective November 1, 2016. The Legislation also included statues providing the Laboratory's responsibilities of reviewing new energy codes and local code amendments remain. New codes residential codes and provisions will be reviewed no sooner than every 6 years (next review will be of 2021 code editions). The 2015 residendial energy codes also established a new energy rating index (ERI) as a voluntary compliance path and the legislation amended the index values published in the IECC. With the introduction of the ERI as another compliance path, the Laboratory is required to consider it when local amendments are reviewed.

In the timeframe of 2016-2019, the laboratory provided recommendations and considered additional input from stakeholder meetings and public comment periods on the 2018 edition of the IRC/IECC energy efficiency codes as requested by several jurisdictions. The Laboratory updated the IC3 web-based code compliance tool and emissions reduction calculator to allow for the new optional compliance path and for compliance with the latest adoped editions of the IECC.

1.4 Accomplishments since January 2020

Since January 2020, the Laboratory has 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 Laboratory's IECC/IRC Code-Traceable Test Suite for determining emissions reduction due to code and above-code programs;
- Enhanced the IC3 calculator, which is an energy code compliance software based on the Texas Building Energy Performance Standards by resolving minor defects found in the model and webpage.
- Continued development and testing of key procedures for validating simulations of building energy performance;
- Provided energy code training workshops, including: residential and commercial IECC/IRC sessions at the 27th Building Professional Institute (BPI), UT Arlington.;
- Provided energy code training workshops, including: residential and commercial IECC/IRC sessions to the following local juridictionss: Killeen, Victoria, and Amarillo;
- Provided energy code training workshops, including: residential and commercial IECC/IRC sessions to the following institues of higher education:Austin Community College, University of Texas Project Management and Construction Services and Stephen F. Austin State Univeristy;
- Provided energy code training workshops, including: residential and commercial IECC/IRC sessions to Texas Associaton of Professional Real Estate Inspectors and the North Central Texas Council of Governments;
- 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;
- Hosted the Texas Energy Summit in November 2020, virtual event. Conference sessions included key talks by the TCEQ, PUCT, ERCOT, EPA, SECO, several ISDs and cities, and the Laboratory about quantifying emissions reduction from EE/RE opportunities and guidance on key energy efficiency and renewable energy topics; the various topics covered:
  Polices to Reduce Emissions from Electricity; Policies to Promote Smart, Healthy, Resilient, Emission Free Buildings; Policies to Extend Texas's leadership in Hydrogen, Carbon, Capture Utilization and Storage, and Direct Air Capture; Policies to Increase Transportation Equity in the Energy Transition, Policies to Electrify Transportation; Policies to Accelerate Financing Solutions; Policies to Transition to Cleaner Sources of Power; Electrification of Buildings and Transportation with Clean Energy; Policies to Electrify Fleets; Policies to Electrify Freight; Organizing for Policies to Increase Climate Resilience and Justice; Polices to Reduce Energy Burden and Increase Equity; Policies to Reduce Pollution in Communities; Policies to Improve Indoor Air Quality in the Age of COVID-19; Climate Policies to Promote Economic Development; Policies to Grow the Benefits of Renewable Energy to Rural Texas; Policies to Increase Efficient Use of Energy and Energy Efficiency Jobs; Policies to Bring Clean Energy Manufacturing and Supply Chains to Texas; CCS/Hydrogen Potential in Texas and the UK; Policies to Accelerate Climate Justice; Policies to Reduce Waste of Natural Resources; Policies to Increase Renewables and Storage; Policies for Cleaner Air from Zero Emission Vehicles.
- Provided technical assistance to the TCEQ regarding specific issues, including:
  - Enhancement of the standardized, integrated NOx emissions reduction reporting procedures to the TCEQ for EE/RE projects, and
  - Enhancement of the procedures for weather normalizing NOx emissions reduction from renewable projects.
- Participated as exhibitors at several conferences, including at the Texas Energy Summit in Houston, Texas, and
- The ESL participated in the South-central Partnership for Energy Efficiency as a Resource (SPEER), funded and administered by the Texas Comptroller of Public Accounts State Energy Conservation Office (SECO).
- Continued work toward the code compliance tools for commercial buildings, retail and school buildings, and new Application Programming Interface (API).

1.5 Technology Transfer

To accelerate the transfer of technology developed as part of the TERP program, the Laboratory:

- 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, was host to the annual Texas Energy Summit, attended by top Texas and national experts, and policy makers; and
- 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.

One presentation to the Texas Energy Summit held online, November 2020.

- Haberl, J.; Yazdani, B.; Baltazar, J., 2020 "Energy Efficiency and Renewable Energy Impacts on NOx Emission Reductions in Texas" *Texas Energy Summit,* Online Virtual Event, November 2020

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 NOx 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.

1.6 Energy and NOx Reductions from New Residential and Commercial Construction, Including 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, 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, 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 2020, the following savings were calculated (2018 base year):

- In 2020, the annual electricity savings from code-compliant residential and commercial construction are 249,931 MWh/year (0.3% of the total electricity savings),
- Savings from residential air conditioner retrofits[2] are 1,626,346 MWh/year (2.0%).

- In 2020, the OSP electricity savings from code-compliant residential and commercial construction are 685 MWh/day (0.3%),
- Savings from residential air conditioner retrofits are 10,750 MWh/day (4.5%).

- By 2025, the annual electricity savings from code-compliant residential and commercial construction will be 1,643,386 MWh/year (1.3% of the total electricity savings),
- Savings from residential air conditioner retrofits will be 1,258,435 MWh/year (1.0%).

- By 2025, the OSP electricity savings from code-compliant residential and commercial construction will be 4,502 MWh/day (1.2%),
- Savings from residential air conditioner retrofits will be 8,318 MWh/day (2.3%).

- In 2020, the annual NOx emissions reduction from code-compliant residential and commercial construction are 104 tons-NOx/year (0.2% of the total NOx savings),
- NOx emissions reductions from residential air conditioner retrofits are 746 tons-NOx/year (1.5%).

- In 2020, the OSP NOx emissions reduction from code-compliant residential and commercial construction are 0.27 tons-NOx/day (0.2%),
- NOx emissions reductions from residential air conditioner retrofits are 1.28 tons-NOx/day (0.9%).

- By 2025, the NOx emissions reduction from code-compliant residential and commercial construction will be 686 tons-NOx/year (0.9% of the total NOx savings),
- NOx emissions reductions from residential air conditioner retrofits will be 578 tons-NOx/year (0.8%).

- By 2025, the OSP NOx emissions reduction from code-compliant residential and commercial Construction will be 1.75 tons-NOx/day (0.8%),
- NOx emissions reductions from residential air conditioner retrofits will be 3.60 tons-NOx/day (1.7%).

[2] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13/14 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

1.7 Integrated NOx Emissions Reductions Reporting Across State Agencies

In 2005, the Laboratory began to work 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 the following reports:

- From the Laboratory, savings from code compliance and renewables;
- From the Laboratory, in cooperation with the Electric Reliability Council of Texas (ERCOT), the savings from electricity generated from wind power;
- From the Public Utility 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 2020 (Table 22), the total integrated annual savings from all programs are 81,073,322 MWh/year (2018 base year). The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 249,931 MWh/year (0.3% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 1,263,892 MWh/year (1.6%),
- Savings from SECO's Senate Bill 5 program are 567,339 MWh/year (0.7%),
- Electricity savings from renewable power generation are 77,365,814 MWh/year (95.4%), and
- Savings from residential air conditioner retrofits are 1,626,346 MWh/year (2.0%).

In 2020, the total integrated OSP savings from all programs are 239,245 MWh/day, which would be 9,969 MW average hourly load reduction during the OSP period (2018 base year). The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 685 MWh/day (0.3%),
- Savings from the PUC's Senate Bill 7 programs are 3,463 MWh/day (1.4%),
- Savings from SECO's Senate Bill 5 program are 1,553 MWh/day (0.6%),
- Electricity savings from renewable power generation are 222,795 MWh/day (93.1%), and
- Savings from residential air conditioner retrofits are 10,750 MWh/day (4.5%).

By 2025, the total integrated annual savings from all programs will be 124,686,284 MWh/year (2018 base year). The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 1,643,386 MWh/year (1.3% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 3,990,544 MWh/year (3.2%),
- Savings from SECO's Senate Bill 5 program will be 1,462,295 MWh/year (1.2%),
- Electricity savings from renewable power generation will be 116,331,624 MWh/year (93.3%), and
- Savings from residential air conditioner retrofits will be 1,258,435 MWh/year (1.0%).

By 2025, the total integrated OSP savings from all programs will be 360,973 MWh/day, which would be 15,041 MW average hourly load reduction during the OSP (2018 base year). The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 4,502 MWh/day (1.2%),
- Savings from the PUC's Senate Bill 7 programs will be 9,588 MWh/day (2.7%),
- Savings from SECO's Senate Bill 5 program will be 3,557 MWh/day (1.0%),
- Electricity savings from renewable power generation will be 335,007 MWh/day (92.8%), and
- Savings from residential air conditioner retrofits will be 8,318 MWh/day (2.3%).

In 2020 (Table 23), the total integrated annual NOx emissions reductions from all programs are 49,450 tons-NOx/year (2018 base year). The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 104 tons-NOx/year (0.2% of the total NOx savings),

- NOx emissions reductions from the PUC's Senate Bill 7 programs are 496 tons-NOx/year (1.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 230 tons-NOx/year (0.5%),
- NOx emissions reductions from renewable power generation are 47,874 tons-NOx/year (96.8%), and
- NOx emissions reductions from residential air conditioner retrofits are 746 tons-NOx/year (1.5%).

In 2020, the total integrated OSP NOx emissions reductions from all programs are 136.79 tons-NOx/day (2018 base year). The integrated OSP NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 0.27 tons-NOx/day (0.2%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 1.28 tons-NOx/day (0.9%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.59 tons-NOx/day (0.4%),
- NOx emissions reductions from renewable power generation are 130 tons-NOx/day (95.0%), and
- NOx emissions reductions from residential air conditioner retrofits are 4.56 tons-NOx/day (3.4%).

By 2025, the total integrated annual NOx emissions reductions from all programs will be 75,496 tons-NOx/year (2018 base year). The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 686 tons-NOx/year (0.9% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1,571 tons-NOx/year (2.1%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 676 tons-NOx/year (0.9%),
- NOx emissions reductions from renewable power generation will be 71,985 tons-NOx/year (95.3%), and
- NOx emissions reductions from residential air conditioner retrofits will be 578 tons-NOx/year (0.8%).

By 2025, the total integrated OSP NOx emissions reductions from all programs will be 206.62 tons-NOx/day (2018 base year). The integrated OSP NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 1.75 tons-NOx/day (0.8%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 4.06 tons-NOx/day (2.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 1.74 tons-NOx/day (0.8%),
- NOx emissions reductions from renewable power generation will be 195.47 tons-NOx/day (94.6%), and
- NOx emissions reductions from residential air conditioner retrofits will be 3.60 tons-NOx/day (1.7%).

Table 3: Adjustment Factors used for the Calculation of the Annual and OSP NOx Savings for the Different Programs

	ESL-Single Family	ESL-Multifamily	ESL-Commercial	PUC (SB7)	SECO	Renewables-ERCOT	SEER 13/14 Single Family	SEER 13/14 Multi Family
Annual Degradation Factor	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%
T&D Loss	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor	20.0%	20.0%	20.0%	10.0%	30.0%	5.0%	20.0%	20.0%
Growth Factor	4.1%	6.1%	5.3%	0.0%	0.0%	8.5%	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	Yes	Yes

Note: For Renewables-ERCOT, the OSP energy consumption is the average daily consumption of the measured data from May 1 to September 30.

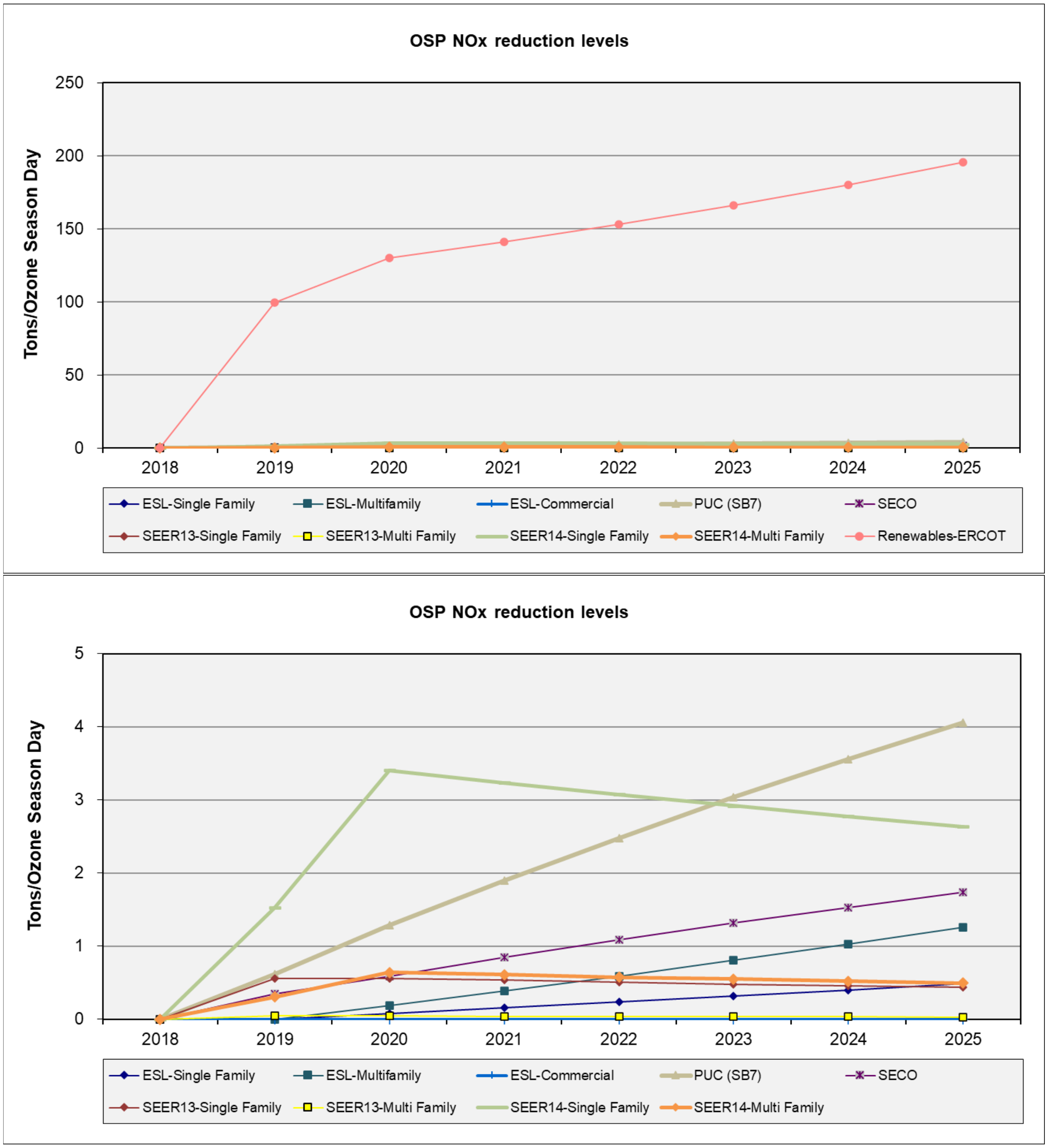


Figure 2: Integrated OSP Individual Programs NOx Emissions Reduction Projections through 2025 (Base Year 2018). (Upper plot) all programs, (lower plot) all programs except Renewables.

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 user.[3] The emissions reduction calculator was 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

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

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

In 2009, IC3 developments included:

- A sister product, AIM was created for the State Comptroller's office.
- Usage statistics continue to climb.
- Updated to v3.6 which included 3 story houses, external cladding, more sophisticated ceiling/roof models, enhanced foundation modeling and the ability to copy projects.

In 2010 there were several software updates including:

- IC3
  - 3.9.0 – Slab Insulation Support
  - 3.7.0 – 3.8.0 First Version of Multifamily Released along with numerous tweaks and fixes
  - 3.6.2 – New Building Model Integrated, Updated Artwork and Illustrations
- DDP
  - 1.7.05 – Added Heat Reject Recording for Electric and Gas
- Web Reports and Texas Building Registry
  - Registry 0.x – First versions of the Web Reports on TCV, eCalc, and IC3
  - Registry 1.0 – City and County Reports
  - Registry 1.1 – Cross-linked Reports for City and County
  - IC3 Reports 1.0 – Updated Certificate Reports which replace Registry 1.1 and evolve into the Texas Building Registry

The 2011 software updates include:

- IC3
  - 3.9.4 – Added approval workflow to start a new 2009 IECC job as further refinements were needed to the BDL
  - 3.9.5 – Various IECC 2009 fixes and refinements implemented
  - 3.9.6 – Updated BDL to 4.01.08, SHGC max does not apply to Climate Zone 4, 0.35 ACH minimum to all projects, Ventilation Fans added to % Air Conditioning Calculation
  - 3.9.7 - Corrected Certificate and Status screens to reflect insulation and floor construction.
  - 3.9.8- Set minimum R-value for insulated sheathing to R-2;
  - 3.10.0 - Updated and corrected problems with several text and value fields; Corrected and printed MF and SF Certificates;
  - 3.10.3 - Changed Certificate to Energy Audit Report; Added a new Certificate to be printed out; Added Inspector's list for a project; Added Pagination in projects page

- 3.11.0 12/22/2011-Added Austin Energy 2009 IECC Energy Code Support
- Web Reports and Texas Building Registry
  - TBR Reports 1.0.5 – Added 4 new reports
  - TBR Reports 1.0.6 – Added 9 new reports
  - Registry 2.0 – Included 7 new Parameterized reports

The 2012 software updates include:

- IC3
  - 3.12 – Deprecated the 2000/2001 and 2006 Code (as of 1/1/2012)
  - 3.12.1 – Added a version of the energy report with a signature line, as requested by some municipalities. Improved the algorithm.
  - 3.12.2 – Alter help text to be more clear. Improved the algorithm.
  - 3.12.3 – Alter help pictures to make them clearer.
  - 3.12.4 – Added optional input for water heaters to allow for better detail. Updated user manual. Improved the transform algorithms.

The 2013 software updates include:

- IC3
  - 3.12.5 – Bug fix in energy report
  - 3.13.0 – Added support for manual J. Added NCTCOG 2012 amendments

There were no significant enhancements to IC3 in the calendar year 2014. We performed routine maintenance on the program and the database during this time. The API interface was under development.

The 2015 software updates include:

- IC3
  - Version 4.0 – Single Family version of IC3 version 4, implementing IECC 2015
  - Version 4.0.1 –Added builder information. Changed format of energy report

The 2016 software updates include:

- IC3
  - Version 4.0.2 – Clarified some error messages. Revised model of attic. Added check for fresh air standards,
  - Version 4.1 – Added ERI
  - Version 4.1.1 – Some bug fixes
  - Version 4.1.2 – Altered appliance energy calculation in ERI to improve accuracy
  - Version 4.2 – Added NCTCOG 2015 IECC amendment

The 2017 software updates include:

- IC3
  - Version 4.3 – Added Austin Energy IECC 2015 amendment. Improved accuracy of duct model
  - Version 4.3.1– Added NCTCOG 2015 ERI amendment

The 2018 software updates include:

- IC3
  - Bug fixes only
- CEXIS API
  - Rewrote the CEXIS API to properly interface with the new Poller API (see below)
- Poller API

  - Rewrote the polling software (the client software that actually performs the DOE2 runs) as a web-based service. This solved several ongoing maintenance and security issues we were having.

The 2019 software updates include:

- IC3
  - Bug fixes
  - Added 2018 IECC
  - Added support for tankless water heater equipment
- CEXIS API
  - Updated all weather information
  - Major revision of ERI calculation
- POLLER API
  - Improved Performance

The 2020 software updates include:

- IC3
  - Bug fixes
  - Revised 2015 AE IECC
- CEXIS API
  - Added support for 4 floor residential building required by 2015 IECC AE (revised)
- POLLER API
  - Added support for 4 floor residential building required by 2015 IECC AE (revised)

1.9 Evaluation of Additional Technologies for Reducing Energy Use in Existing Buildings

The Laboratory provided technical assistance to the TCEQ, the PUCT, SECO and ERCOT, as well as Stakeholders participating in the Energy Code and Renewables programs.

- In 2020, the Laboratory continued to work with the TCEQ to develop an integrated NOx emissions reductions calculation that provided the TCEQ with a creditable NOx emissions reductions from energy efficiency and renewable energy (EE/RE) programs reported to the TCEQ in 2018 by the Laboratory, PUCT, SECO, and ERCOT (i.e., renewables).
- At the request of the TCEQ, the Laboratory has continued the development of procedures for quantifying NOx emissions reductions from renewables and the quantification of NOx emissions reductions from the new Federal regulations for SEER 14 air conditioners.

1.10 Planned Focus for 2021

In FY 2021, the Energy Systems Laboratory will continue in its cooperative efforts with the TCEQ, PUCT, SECO, US EPA and others to evaluate the energy savings resulted from the EE/RE measures and programs of the TERP and their impact on air quality, and continue with the energy code state-wide implementation assistance under the Texas Building Energy Performance Standards program of the TERP. The Laboratory team will:

- 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 affected county using the TCEQ/US EPA approved technology.
- Assist the PUCT with determining emissions reductions credits from energy efficiency programs funded by SB 7 and SB 5.

- Assist political subdivisions and Councils of Governments with calculating emissions reductions from local code changes and voluntary EE/RE programs for SIP inclusion.
- Continue to refine the cost-effective techniques to implement 15% above code (2009 IECC) energy efficiency in low-priced and moderately-priced residential housing.
- Continue to refine the cost-effective methods and techniques to implement 15% above code energy efficiency in commercial buildings.
- Continue to develop creditable procedures for calculating NOx emissions reductions from green renewable technologies, including wind power, solar energy and geothermal energy systems.
- Continue development of well-documented, integrated NOx emissions reductions methodologies for calculating and reporting NOx reductions, including a unified database framework for required reporting to TCEQ of potentially creditable measures from the ESL, PUCT, and SECO SB 5 initiatives.
- Upon request, provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of the 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 2009 IRC/IECC. This will consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.
- 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.
- Continue 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 reductions benefits of the home energy rating program.
- Include all benefits attained from this program in an annual report to the commission.
- Engage production builders and municipalities in overcoming obstacles to use IC3 for their new home construction.
- Complete RESNET certification for the ERI path in IC3.
- ~~Release version 2015 AE IECC (Austin Energy Amendments). This is not mandated by the State but has been requested by Austin Energy~~
- Release 2021 IECC version for IC3
- Continue to update all websites managed by the lab to meet the evolving TEES standards.

The Laboratory has and will continue to provide leading-edge technical assistance to 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 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.
If any questions arise, please contact us by phone at 979-845-9213.

2 Introduction

2.1 Background

In 2001, the Texas Legislature adopted the Texas Emissions Reduction Plan, identifying thirty-eight counties in Texas where a focus on air quality improvements was deemed critical to public health and economic growth. In 2008, twenty counties were designated as non-attainment counties that include: Brazoria, Chambers, Collin, Dallas, Denton, Ellis, Fort Bend, Hardin, Harris, Jefferson, Galveston, Johnson, Kaufman, Liberty, Montgomery, Orange, Parker, Rockwall, Tarrant, and Waller. There were also fourteen counties designated as Ozone Early Action Compact counties include: Bastrop, Bexar, Caldwell, Comal, Gregg, Guadalupe, Harrison, Hays, Rusk, Smith, Travis, Upshur, Williamson, and Wilson. By ~~2017~~ 2020, forty-one counties are designated as non-attainment counties that include: Bastrop, Bexar, Brazoria, Caldwell, Chambers, Collin, Comal, Dallas, Denton, El Paso, Ellis, Fort Bend, Galveston, Gregg, Guadalupe, Hardin, Harris, Harrison, Hays, ~~Henderson,~~ Hood, Hunt, Jefferson, Kaufman, Liberty, Montgomery, Nueces, Orange, Parker, Rockwall, Rusk, San Patricio, Smith, Tarrant, Travis, Upshur, Victoria, Waller, Williamson, Wilson, and Wise (TCEQ 2020). These areas are shown on the map in Figure 3 as non-attainment and near non-attainment.

These counties represent several geographic areas of the state, which have been assigned to different climate zones by the 2015 IECC[4] as shown in Figure 4, based primarily on Cooling Degree Days (CDD) and Heating Degree Days (HDD). These include climate zone 3 (i.e., $4,500 < CDD_{50} \leq 6,300$ and $HDD_{65} \leq 5,400$) for the Dallas-Ft. Worth and El Paso areas, and climate zone 2 (i.e., $6,300 < CDD_{50}$ ss$\leq 9,000$) for the Houston-Galveston-Beaumont-Port Arthur-Brazoria areas. Also shown in Figure 4 are the locations of the various weather data sources, including the Local Climatological Data (LCD) (NOAA 2018), and the Typical Meteorological Year (TMY3) (NREL 2019) stations, which are used for simulation purposes.

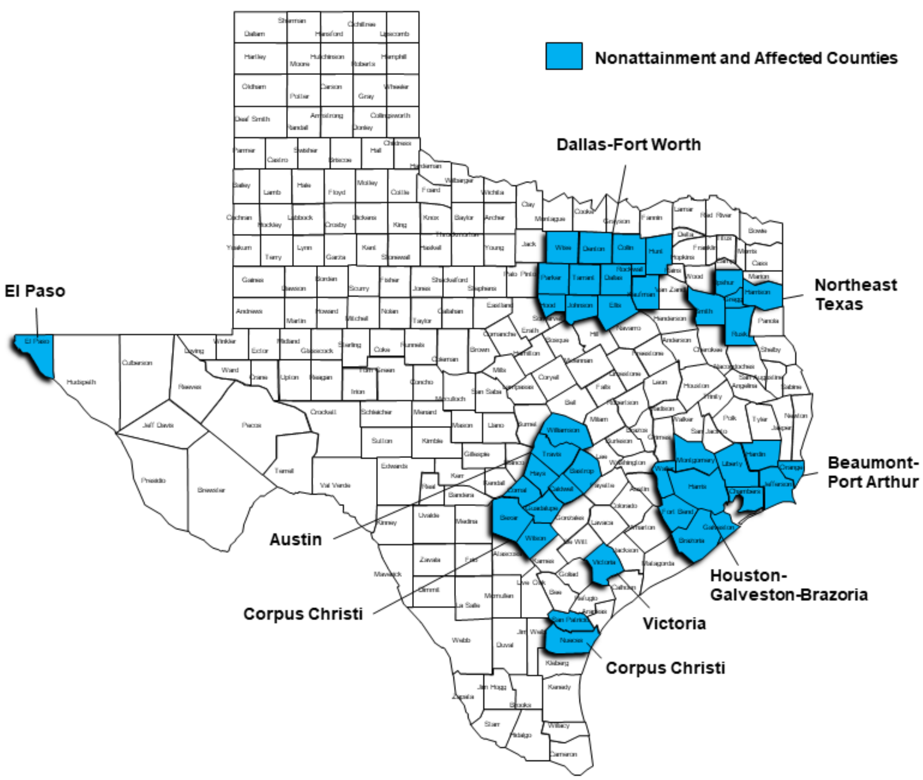
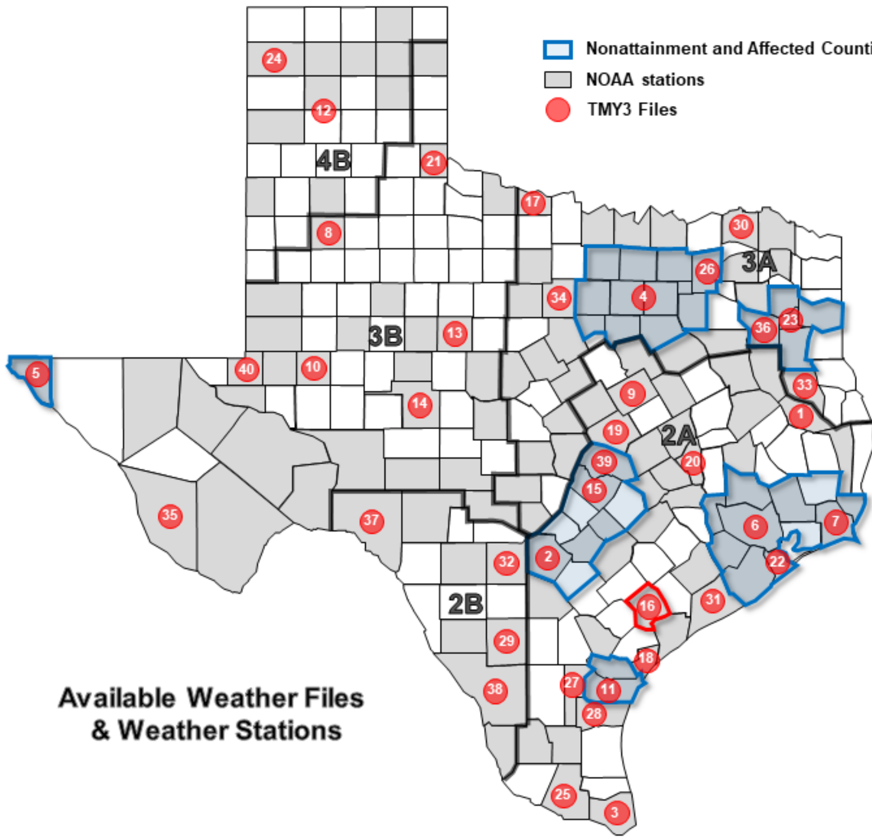


Figure 3: TCEQ Nonattainment and Affected Counties

[4] The "2000 IECC" notation is used to signify the 2000 International Residential Code (IRC), which includes the International Energy Conservation Code (IECC). The 2000 IECC, as modified by the 2001 Supplement (IECC 2001), published by the ICC in March of 2001, as was referenced by Senate Bill 5. The latest version adoption of IECC in Texas is IECC 2015.



List of Available TMY3 Weather Files

Texas TMY3 Weather Files

1	Lufkin Angelina Co (LFK)
2	San Antonio Intl AP (SAT)
3	Brownsville S Padre Isl Intl (BRO)
4	Dallas-Fort Worth Intl AP (DFW)
5	El Paso International AP [UT] (ELP)
6	Houston Bush Intercontinental (IAH)
7	Port Arthur Jefferson County (BPT)
8	Lubbock International AP (LBB)
9	Waco Regional AP (ACT)
10	Midland International AP (MAF)
11	Corpus Christi Intl Arpt [UT] (CRP)
12	Amarillo International AP [Canyon - UT] (AMA)
13	Abilene Regional AP [UT] (ABI)
14	San Angelo Mathis Field (SJT)
15	Austin Mueller Municipal AP [UT] (ATT)
16	Victoria Regional AP (VCT)
17	Wichita Falls Municipal Arpt (SPS)
18	Rockport/Aransas Co (RKP)
19	Fort Hood (ILE)
20	College Station Easterwood Fl (CLL)
21	Childress Municipal AP (CDS)
22	Galveston/Scholes (GLS)
23	Longview Gregg County AP [Overton - UT] (GGG)
24	Dalhart Municipal AP (DHK)
25	McAllen Miller Intl AP [Edinburg - UT] (EBG)
26	Greenville/Majors (GVT)
27	Alice Intl AP (ALI)
28	Kingsville (IKG)
29	Cotulla Faa AP (COT)
30	Cox Fld (PRX)
31	Palacios Municipal AP (PSX)
32	Hondo Municipal AP (HDO)
33	Nacogdoches (AWOS) (OCH)
34	Mineral Wells Municipal AP (MWL)
35	Marfa AP (MRF)
36	Tyler/Pounds Fld (TYR)
37	Del Rio Laughlin AFB (DRT)
38	Laredo Intl AP [UT] (LRD)
39	Georgetown (AWOS) (GTU)
40	Wink Winkler County AP (INK)

Figure 4: Available weather data, and TMY3 weather files compared to IECC weather zones for Texas

2.2 Energy Systems Laboratory's Responsibilities in the TERP

In 2001, Texas Senate Bill 5 outlined the following responsibilities for the Energy Systems Laboratory (ESL) within the TERP:

- Sec. 386.205. Evaluation of State Energy Efficiency Programs.
- Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards.
- Sec. 388.004. Enforcement of Energy Standards Outside of Municipality.
- Sec. 388.007. Distribution of Information and Technical Assistance.
- Sec. 388.008. Development of Home Energy Ratings.

In 2003 these responsibilities were modified by the following:

- House Bill 1365, including modifications to:
  - Sec. 388.004. Enforcement of Energy Standards Outside of Municipality
  - Sec. 388.009. Energy-Efficient Building Program
- House Bill 3235 which includes modifications to
  - Sec. 388.009. Certification of Municipal Building Inspectors.

In 2005 these same responsibilities were further updated:

- with Senate Bill 20, House Bill 2481, and 2129.

These responsibilities were further updated in 2007:

- with Senate Bill 12 and House Bill 3693.

These responsibilities were further updated in 2009:

- with House Bill 1796.

These responsibilities were further updated in 2011:

- with Senate Bills 898 and 924, and House Bill 51.

These responsibilities were not updated in 2012.

These responsibilities were not updated in 2013.

These responsibilities were not updated in 2014.

These responsibilities were further updated in 2015:

- Changes to Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards with House Bill 1736.

These responsibilities were not updated in 2017.

These responsibilities were not updated in 2018.

These responsibilities were not updated in 2019.

These responsibilities were not updated in 2020.

In the following sections, each of these tasks is further described.

2.2.1 (SB 5) Section 386.205. Evaluation of State Energy Efficiency Programs (w/PUCT)

The Laboratory is instructed to assist the Public Utility Commission of Texas (PUCT) and provide an annual report that quantifies by county the reductions of energy demand, peak loads, and associated emissions of air contaminants achieved from the programs implemented under this subchapter and from those implemented under Section 39.905, Utilities Code (i.e., Senate Bill 7).

To implement procedures for evaluating state energy-efficiency programs, in 2004, the Laboratory held several meetings with the Public Utility Commission of Texas to discuss the development of a framework for reporting emissions reduction from the State Energy Efficiency Programs administered by the PUCT. The State Energy-Efficiency Programs administered by the PUCT include programs under Senate Bill 7 (i.e., Section 39.905 Utilities Code) and Senate Bill 5.

In 2003 and 2004, the Laboratory worked with the TCEQ to identify a method to help the PUCT more accurately report their deemed savings as peak-day savings in 1999, using the Laboratory's new emissions reductions calculator.

In 2005, this method was implemented in the TCEQ's Integrated Emissions Calculations, which was reported in previous (from 2005-2018) annual reports.

2.2.2 (SB 5) Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards

In 2001, TERP adopts the energy efficiency chapter of the 2001 International Residential Code (2001 IRC) as an energy code for Single-Family residential construction, and the 2001 International Energy Conservation Code (2001 IECC) for all other residential, commercial and industrial construction in the state. It requires that municipalities establish procedures for administration and enforcement, and ensure that code-certified inspectors perform inspections.

TERP provides that local amendments, in non-attainment areas and affected counties, may not result in less stringent energy efficiency requirements. The Laboratory is to review local amendments, if requested, and submit an annual report of savings impacts to the TCEQ. The Laboratory is also authorized to collect fees for certain of its tasks in Sections 388.004, 388.007 and 388.008.

2.2.3 (SB 5) Sec. 388.004. Enforcement of Energy Standards Outside of Municipality

For construction outside of the local jurisdiction of a municipality, TERP provides for a building to comply if:

- the building is certified by a national, state, or local accredited energy efficiency program;
- the building was subjected to inspections from private code-certified inspectors using the energy efficiency chapter of the International Residential Code or International Energy Conservation Code; or
- the builder who does not have access to either of the above methods for a building certifies compliance using a form provided by the Laboratory, enumerating the code-compliance features of the building.
- That builders shall retain for three years documentation which shows their building is in compliance with the Texas Building Energy Performance Standards, and that builders shall provide a copy of the compliance documentation to homeowners. (HB1365, 2003)
- That Single-Family residences built in unincorporated areas of counties, which were completed on or after September 1, 2001, but not later than August 31, 2003, are considered in compliance with the Texas Building Energy Performance Standards. (HB1365, 2003)

2.2.4 (SB 5) Sec. 388.007. Distribution of Information and Technical Assistance

The Laboratory is required to make available to builders, designers, engineers, and architects code implementation materials that explain the requirements of the International Energy Conservation Code and the energy efficiency chapter of the International Residential Code. TERP authorizes the Laboratory to develop simplified materials to be designed for projects in which a design professional is not involved. It also authorizes the Laboratory to provide local jurisdictions with technical assistance concerning implementation and enforcement of the International Energy Conservation Code and the energy efficiency chapter of the International Residential Code.

2.2.5 (SB 5) Sec. 388.008. Development of Home Energy Ratings

TERP requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings (HERs). The form must be designed to give potential buyers information on a structure's energy performance, including certain equipment. TERP requires the Laboratory to establish a public information program to inform homeowners, sellers, buyers, and others regarding home energy ratings.

2.2.6 (HB 1365) Sec. 388.004. Enforcement of Energy Standards Outside of Municipality

This section has been merged into Section 2.2.3.

2.2.7 (HB 1365) Sec. 388.009. Energy-Efficient Building Program, renamed in 2005 (HB 2129) Sec. 388.012. Development of Alternative Energy-Saving Methods.

In this Section, the laboratory shall develop at least three alternative methods for achieving a 15% greater potential energy savings in residential, commercial, and industrial construction than the potential energy savings of construction that is in minimum compliance with Section 388.003. The alternative methods:

(1) may include both prescriptive and performance-based approaches, such as the approach of the United States Environmental Protection Agency's Energy Star qualified new home labeling program; and
(2) must include estimates of the implementation costs and energy savings to consumers and the related emissions reductions.

2.2.8 (HB 3235) Sec. 388.009. Certification of Municipal Inspectors renamed in 2005 (HB 2018) Sec. 388.011. Certification of Municipal Building Inspectors.

Also in 2003, House Bill 3235 modified the TERP to add the new Section 388.009. In this section the Laboratory is required to develop and administer a state-wide training program for municipal building inspectors who seek to become code-certified inspectors. To accomplish this, the Laboratory will work with national code organizations to assist participants in the certification program and is allowed to collect a reasonable fee from participants in the program to pay for the costs of administering the program. This program was required to be developed no later than January 1, 2004, with state-wide training sessions starting no later than March 1, 2004.

2.2.9 (SB 20, HB 2481, HB 2129). Additional Energy-Efficiency Initiatives

The 79th Legislature (2005), through SB 20, HB 2481 and HB 2129, amended SB 5 to enhance its effectiveness by adding the following additional energy-efficiency initiatives, including requiring 5,880 MW of generating capacity from renewable energy technologies by 2015, and 500 MW from non-wind renewables.

This legislation also requires PUCT to establish a target of 10,000 MW of installed renewable capacity by 2025, and requires TCEQ to develop a methodology for computing emissions reductions from renewable energy initiatives and the associated credits. The Laboratory is to assist TCEQ in quantifying emissions reductions credits from energy-efficiency and renewable-energy programs, through a contract with the Texas Environmental Research Consortium (TERC) to develop and annually calculate creditable emissions reductions from wind and other renewable energy resources for the state’s SIP.

Finally, this legislation requires the Laboratory to develop at least 3 alternative methods for achieving a 15% greater potential energy savings in residential, commercial and industrial construction. To accomplish this, the Laboratory will be using the code-compliance calculator to ascertain which measures are best suited for reducing energy use without requiring substantial investments.

2.2.10 (SB 12, HB 3693). Additional Energy-Efficiency Initiatives

The 80th Legislature (2007), through SB 12, and HB 3693 amended SB 5 to enhance its effectiveness by adding several new energy efficiency initiatives. First, it 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 not 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. As part of this work with SECO, the Laboratory is required to consider comments made by persons who have an interest in the adoption of the energy codes in the recommendations made to SECO.

In addition, it 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.

It also 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 reductions benefits of the home energy ratings program. Finally, it requires the Laboratory shall include information on the benefits attained from this program in an annual report to the commission.

2.2.11 (HB 1796). TERP Term & Additional Energy- Efficiency Initiatives

The 81st Legislature (2009), through HB 1796, amended sections Sec. 386.252 (a) and (b), to extend the date of the TERP to 2019 and require the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

2.2.12 (HB 51, SB 898, SB 924). Additional Energy-Efficiency Initiatives & Refinement of Ongoing Initiatives

The 82nd Legislature (2011) through HB-1, the Laboratory's responsibilities under TERP increased:

The 82nd Legislature (2011), through SB 898, amended Sec 388.005 (c), (d) and (e), which per the amendment, requires each political subdivision, institution of higher education or state agency to establish a goal to reduce the electric consumption by the entity by at least 5% each fiscal year for 10 years, beginning September 1, 2011. SB 898 further elaborated and enhanced the annual reporting requirements for those entities, and required SECO to develop a standardized form for reporting. SB 898 adds the Laboratory as the entity in charge of calculating energy savings and estimated emissions reduction for each political subdivision, institution of higher education or state agency, based on the information collected by SECO. The Laboratory shall share the analysis with the TCEQ, EPA and ERCOT.

The 82nd Legislature (2011), through SB 924, amended Sec 39.9051, Utilities Code, (f), (g) and (h), to enhance the reporting requirements by all municipally owned utilities and electric cooperatives that had retail sales of more than 500,000 MWh in 2005, regarding combined effects of their energy efficiency activities. Per the amended sections, beginning April 1, 2012, these entities must report each year to SECO, on a standardized form developed by SECO. The report of information regarding the combined effects of the energy efficiency activities of the electric cooperative/utility from the previous calendar year should include the annual goals, programs enacted to achieve those goals, and any achieved energy demand or savings goals. SB 924 adds the Laboratory as the entity in charge of calculating energy savings and estimated emissions reduction for municipally owned utilities and for electric cooperatives, based on the information collected by SECO. The Laboratory shall share the analysis with the PUCT, ERCOT, EPA and TCEQ.

The 82nd Legislature, through HB 51, required SECO to appoint a new advisory committee for selecting high-performance building design evaluation systems. The committee includes a representative from the Laboratory and meets at least once every two years.

The 82nd Legislature, through HB 51, modified Sec 388.003 (e) on the Laboratory's review of proposed local code amendments, which should be compared to the unamended code (instead of the "base" code), and added to Sec 388.007 (c) the fact that Laboratory is allowed to provide technical assistance concerning the implementation of local code amendments.

In addition, HB 51 added Sec 388.007 (d), which allows The Laboratory to conduct outreach to the real estate industry on the value of energy code compliance and above code construction.

The 83rd Legislature (2013) did not change any of the Laboratory's previously established responsibilities under TERP.

During the 84th Legislature session (2015), changes to the Sec. 388.003. Adoption of Building Energy Efficiency Performance Standards, with the passage of HB 1736, affected the Laboratory's responsibilities under TERP:

- 2015 residential energy codes (IRC/IECC) editions are in effect starting Sept 1, 2016. 2015 commercial energy codes (IECC) are in effect starting Nov 1, 2016. The Laboratory's responsibilities of reviewing new energy codes and local code amendments remain. New codes will be reviewed no sooner than every 6 years.
- The legislation introduces a new energy rating index (ERI) as a voluntary compliance path for local code amendments. With the introduction of the ERI as another compliance path, the Laboratory is required to consider it when local amendments are reviewed, and needs to update the web-based code compliance tool and emissions reduction calculator to allow for the new optional compliance path.

The 85th Legislature (2017) did not change any of the Laboratory's previously established responsibilities under TERP.

The 86th Legislature (2019) did not change any of the Laboratory's previously established responsibilities under TERP.

3 Statewide Air Emissions Calculations from Wind and Other Renewables

The Energy Systems Laboratory, in fulfillment of its responsibilities under this Legislation, submits its tenth annual report, "Statewide Air Emissions Calculations from Wind and Other Renewables," to the Texas Commission on Environmental Quality.

The report is organized in several deliverables:

- A Summary Report, which details the key areas of work
- A Volume I Summary Report, and
- Supporting data files (Volume II Technical Appendix), including weather data, and wind energy production data.

This executive summary provides key areas of accomplishment this year, including:

- Continuation of stakeholder's meetings
- Analysis of power generation from wind farms using the improved method and 2020 data
- Analysis of emissions reductions from wind farms
- Updates on degradation analysis
- Analysis of other renewables, including solar PV, solar thermal, biomass, hydroelectric, geothermal, and landfill gas
- Review of electricity generation by renewable sources and transmission planning study reported by ERCOT

3.1 Analysis of wind farms using an improved method and 2020 data

In this report, the weather normalization procedures, to develop together with the Stakeholders, were presented, and applied all the wind farms that reported their data to ERCOT during the 2020 measurement period, together with wind data from ~~the nearby NOAA weather stations or~~ the zone average wind speed provided from ERCOT.

In the previous Wind and Renewables report to the TCEQ, weather normalization analysis methods were reviewed. This report used the same analysis method as the previous reports to present the same weather normalization procedure, including:

- the processing of weather and power generation data, modeling of daily power generation versus daily wind speed using the ASHRAE Inverse Model Toolkit (IMT) for two separate periods, i.e., Ozone Season Period (OSP), from May 1 to September 30, and Non-Ozone Season Period (Non-OSP).
- predicting 2018 wind power generation as a baseline, using developed coefficients from 2020 daily OSP and Non-OSP models for all the wind farms; and
- the analysis of monthly capacity factors generated using the models.

A summary of total wind power production in the base year (2018) for all of the wind farms in the ERCOT region using the developed procedure is presented, and the twenty seven new wind farms which started operation in 2020 were added, including Gopher Creek Wind, Wilson Ranch, Blue Summit, Blue Summit III, Ranchero Wind, Peyton Creek Wind, Palmas Altas Wind, Whitehorse Wind, Aviator Wind, Mesteno Wind , RTS 2 Wind, Hidalgo II Wind, Harald, Cranel Wind, Vera Wind, Vera Wind V110, Shaffer Wind, Oveja Wind, Sage Draw Wind, WKN Amadeus Wind, Barrow Ranch Wind, East Raymond Wind, High Lonesome W, High Lonesome Wind Phase II, Cactus Flats Wind, Maverick Creek I W, and Prairie Hill Wind. Figure 5 shows the measured annual wind power generation in 2020 and the estimated wind power generation in 2018 using the developed method for those wind farms in the ERCOT region. The total measured wind power generation in 2020 [5] is 85,565,799 MWh MWh/yr, which is 5.69% lower than what the same wind farms would have produced in 2018. Figure 6 shows the same comparison but for the Ozone Season Period. The measured wind power generation in the OSP of 2020[6] is 223,327 MWh/day, which is 8.25% lower than the 2018 OSP baseline wind production. For the analysis of this year, the measured 2020 wind power generation is slightly lower than the 2018 baseline wind power production.

[55] Total wind power generation of wind farms with more than six months of recorded data

This report also includes an uncertainty analysis that was performed on all the daily regression models for the entire year and Ozone Season Period.

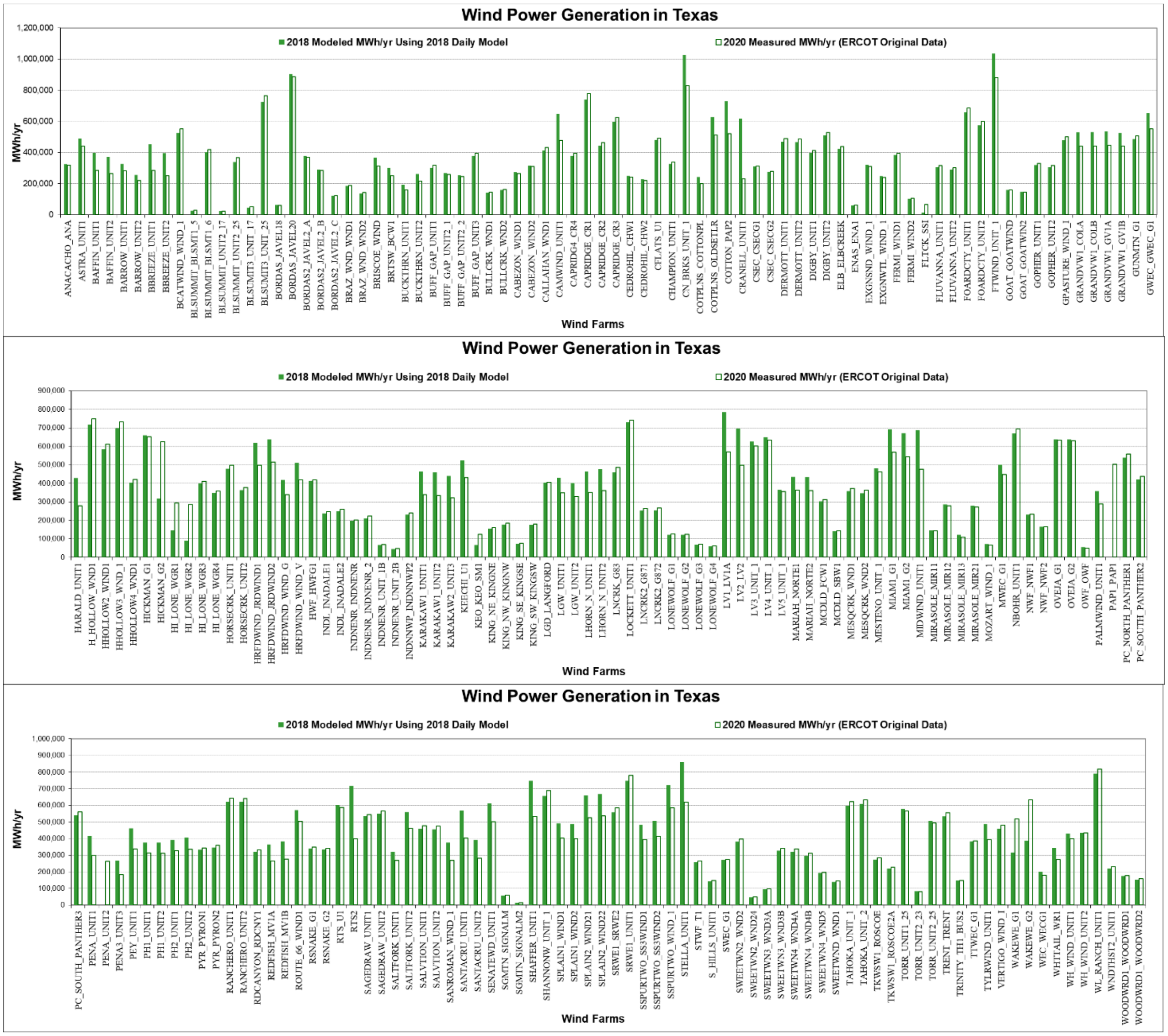
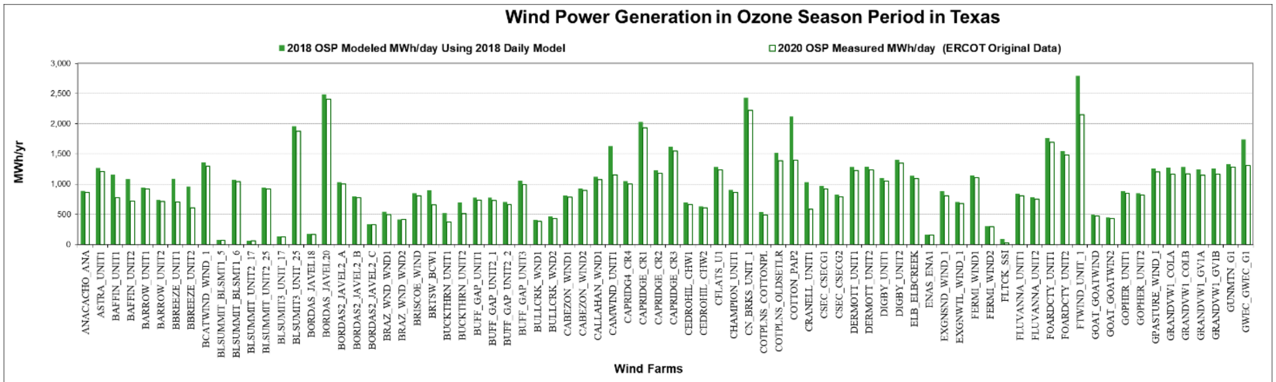
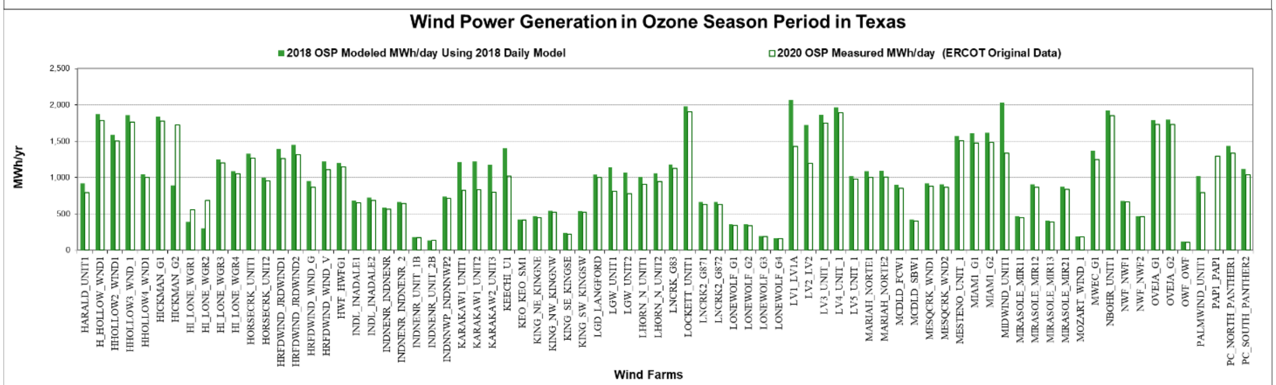
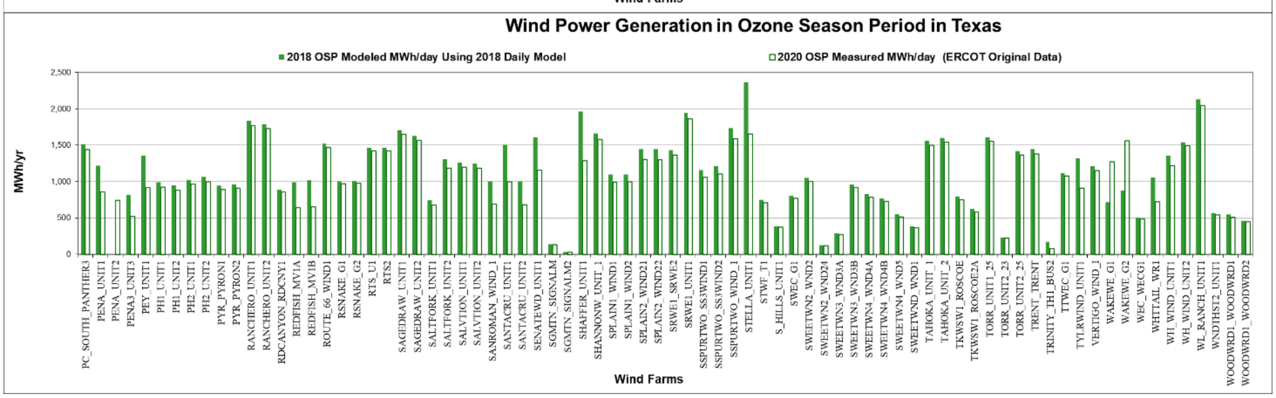


Figure 5: Comparison of 2020 Measured and 2018 Estimated Wind Power Production for Each Wind Farm


Wind Power Generation in Ozone Season Period in Texas
2018 OSP Modeled MWh/day Using 2018 Daily Model
2020 OSP Measured MWh/day (ERCOT Original Data)
MWh/yr
3,000
2,500
2,000
1,500
1,000
500
0
ANACACHO_ANA
ASTRA_UNIT1
BAFFIN_UNIT1
BAFFIN_UNIT2
BARROW_UNIT1
BARROW_UNIT2
BBREEZE_UNIT1
BBREEZE_UNIT2
BCATWIND_WIND_1
BLSUMMIT_BLSMT1_5
BLSUMMIT_BLSMT1_6
BLSUMMIT_UNIT2_17
BLSUMMIT_UNIT2_25
BLSUMIT3_UNIT_17
BLSUMIT3_UNIT_25
BORDAS_JAVEL18
BORDAS_JAVEL20
BORDAS2_JAVEL2_A
BORDAS2_JAVEL2_B
BORDAS2_JAVEL2_C
BRAZ_WND_WND1
BRAZ_WND_WND2
BRISCOE_WIND
BRTSW_BCW1
BUCKTHRN_UNIT1
BUCKTHRN_UNIT2
BUFF_GAP_UNIT1
BUFF_GAP_UNIT2_1
BUFF_GAP_UNIT2_2
BUFF_GAP_UNIT3
BULLCRK_WND1
BULLCRK_WND2
CABEZON_WND1
CABEZON_WND2
CALLAHAN_WND1
CAMWIND_UNIT1
CAPRIDG4_CR4
CAPRIDGE_CR1
CAPRIDGE_CR2
CAPRIDGE_CR3
CEDROHIL_CHW1
CEDROHIL_CHW2
CFLATS_U1
CHAMPION_UNIT1
CN_BRKS_UNIT_1
COTPLNS_COTTONPL
COTPLNS_OLDSETLR
COTTON_PAP2
CRANELL_UNIT1
CSEC_CSECG1
CSEC_CSECG2
DERMOTT_UNIT1
DERMOTT_UNIT2
DIGBY_UNIT1
DIGBY_UNIT2
ELB_ELBCREEK
ENAS_ENA1
EXGNSND_WIND_1
EXGNWTL_WIND_1
FERMI_WIND1
FERMI_WIND2
FLTCK_SSI
FLUVANNA_UNIT1
FLUVANNA_UNIT2
FOARDCTY_UNIT1
FOARDCTY_UNIT2
FTWIND_UNIT_1
GOAT_GOATWIND
GOAT_GOATWIN2
GOPHER_UNIT1
GOPHER_UNIT2
GPASTURE_WIND_I
GRANDVW1_COLA
GRANDVW1_COLB
GRANDVW1_GV1A
GRANDVW1_GV1B
GUNMTN_G1
GWEC_GWEC_G1
Wind Farms


Wind Power Generation in Ozone Season Period in Texas
2018 OSP Modeled MWh/day Using 2018 Daily Model
2020 OSP Measured MWh/day (ERCOT Original Data)
MWh/yr
2,500
2,000
1,500
1,000
500
0
HARALD_UNIT1
H_HOLLOW_WND1
HHOLLOW2_WIND1
HHOLLOW3_WND_1
HHOLLOW4_WND1
HICKMAN_G1
HICKMAN_G2
HI_LONE_WGR1
HI_LONE_WGR2
HI_LONE_WGR3
HI_LONE_WGR4
HORSECRK_UNIT1
HORSECRK_UNIT2
HRFDWIND_JRDWIND1
HRFDWIND_JRDWIND2
HRFDWIND_WIND_G
HRFDWIND_WIND_V
HWF_HWFG1
INDL_INADALE1
INDL_INADALE2
INDNENR_INDNENR
INDNENR_INDNENR_2
INDNENR_UNIT_1B
INDNENR_UNIT_2B
INDNNWP_INDNNWP2
KARAKAW1_UNIT1
KARAKAW1_UNIT2
KARAKAW2_UNIT3
KEECHI_U1
KEO_KEO_SM1
KING_NE_KINGNE
KING_NW_KINGNW
KING_SE_KINGSE
KING_SW_KINGSW
LGD_LANGFORD
LGW_UNIT1
LGW_UNIT2
LHORN_N_UNIT1
LHORN_N_UNIT2
LNCRK_G83
LOCKETT_UNIT1
LNCRK2_G871
LNCRK2_G872
LONEWOLF_G1
LONEWOLF_G2
LONEWOLF_G3
LONEWOLF_G4
LV1_LV1A
LV2_LV2
LV3_UNIT_1
LV4_UNIT_1
LV5_UNIT_1
MARIAH_NORTE1
MARIAH_NORTE2
MCDLD_FCW1
MCDLD_SBW1
MESQCRK_WND1
MESQCRK_WND2
MESTENO_UNIT_1
MIAMI_G1
MIAMI_G2
MIDWIND_UNIT1
MIRASOLE_MIR11
MIRASOLE_MIR12
MIRASOLE_MIR13
MIRASOLE_MIR21
MOZART_WIND_1
MWEC_G1
NBOHR_UNIT1
NWF_NWF1
NWF_NWF2
OVEJA_G1
OVEJA_G2
OWF_OWF
PALMWIND_UNIT1
PAP1_PAP1
PC_NORTH_PANTHER1
PC_SOUTH_PANTHER2
Wind Farms


Wind Power Generation in Ozone Season Period in Texas
2018 OSP Modeled MWh/day Using 2018 Daily Model
2020 OSP Measured MWh/day (ERCOT Original Data)
MWh/yr
2,500
2,000
1,500
1,000
500
0
PC_SOUTH_PANTHER3
PENA_UNIT1
PENA_UNIT2
PENA3_UNIT3
PEY_UNIT1
PH1_UNIT1
PH1_UNIT2
PH2_UNIT1
PH2_UNIT2
PYR_PYRON1
PYR_PYRON2
RANCHERO_UNIT1
RANCHERO_UNIT2
RDCANYON_RDCNY1
REDFISH_MV1A
REDFISH_MV1B
ROUTE_66_WIND1
RSNAKE_G1
RSNAKE_G2
RTS_U1
RTS2
SAGEDRAW_UNIT1
SAGEDRAW_UNIT2
SALTFORK_UNIT1
SALTFORK_UNIT2
SALVTION_UNIT1
SALVTION_UNIT2
SANROMAN_WIND_1
SANTACRU_UNIT1
SANTACRU_UNIT2
SENATEWD_UNIT1
SGMTN_SIGNALM
SGMTN_SIGNALM2
SHAFFER_UNIT1
SHANNONW_UNIT_1
SPLAIN1_WIND1
SPLAIN1_WIND2
SPLAIN2_WIND21
SPLAIN2_WIND22
SRWE1_SRWE2
SRWE1_UNIT1
SSPURTWO_SS3WIND1
SSPURTWO_SS3WIND2
SSPURTWO_WIND_1
STELLA_UNIT1
STWF_T1
S_HILLS_UNIT1
SWEC_G1
SWEETWN2_WND2
SWEETWN2_WND24
SWEETWN3_WND3A
SWEETWN3_WND3B
SWEETWN4_WND4A
SWEETWN4_WND4B
SWEETWN4_WND5
SWEETWND_WND1
TAHOKA_UNIT_1
TAHOKA_UNIT_2
TKWSW1_ROSCOE
TKWSW1_ROSCOE2A
TORR_UNIT1_25
TORR_UNIT2_23
TORR_UNIT2_25
TRENT_TRENT
TRINITY_TH1_BUS2
TTWEC_G1
TYLRWIND_UNIT1
VERTIGO_WIND_I
WAKEWE_G1
WAKEWE_G2
WEC_WECG1
WHTTAIL_WR1
WH_WIND_UNIT1
WH_WIND_UNIT2
WL_RANCH_UNIT1
WNDTHST2_UNIT1
WOODWRD1_WOODWRD1
WOODWRD1_WOODWRD2
Wind Farms

3.2 Analysis of emissions reductions from wind farms

In this report, the procedure for calculating annual and peak-day, county-wide NOx reductions from electricity savings from wind projects implemented in the Competitive Load (CL) zones in ERCOT was presented. The calculation of the NOx emission reductions is based on the 2018 eGRID as modified according to ESL-TR-08-12-04 report (US EPA and ESL, 2008). As shown in Table 4 based on the 2020 measured ERCOT data, the total MWh savings for all the wind farms within the ERCOT region are 87,079,414 MWh/yr and 225,118 MWh/day for an average day in the OSP. The total NOx emissions reductions in 2020 across all the counties amounts are 53,492.4 tons/yr and 130.5 tons/day for the OSP.

Table 4: Electricity Generation and NOx Emission Reductions for All the Wind Farms in ERCOT Region in *2020*

	Annual	OSP
Measured Electricity Generation in 2020	87,079,414 [MWh/yr]	225,118 [MWh/day]
NOx Emission Reduction in 2020	53,492.4 [Tons/yr]	130.5 [Tons/day]

3.3 Degradation analysis

This report contains an updated analysis to determine what degradation could be observed in the measured power from Texas wind farms. By TCEQ request on reference to the degradation of the wind farm power output, the ESL has been evaluating observed degradations from the measured data for all the Texas wind farms.

In this analysis, a sliding statistical index was established for each site that used the 10th, 25th, 50th, 75th, 90th, and 99th percentiles of the hourly power generation over a 12-month sliding period, as well as mean, minimum and maximum hourly power generation of the same 12-month period. These indices were then displayed using one data symbol for each 12-month slide, beginning from the first 12-month period until the last 12-month period for each of the wind farms.

As shown in Table 5, of the one hundred and fifty-seven sites analyzed, ninety-four sites showed an increase when one compares the 90th percentile of the whole period to the 90th percentile of the first 12-month period, ranging from 0.2% to 59.9%, The remaining sixty-one sites showed a decrease from -0.2% to -33.5%, and two sites did not show any change. The weighted average of this increase across all wind farms studied is 3.3% (positive), which indicates that no degradation was observed from the aggregated energy production from these wind farms over the studied operation period. Based on the observations, special attention needs to be paid to sites Roscoe Wind Farm (-10.0%), Papalote Creek Wind Farm (-10.8%), Chapman Ranch Wind IA (Santa Cruz) (-12.9%), Chapman Ranch Wind IB (Santa Cruz) (-13.9%), Penascal Wind 3 (-14.8%), Big Spring Wind Farm (-21.5%), Harbor Wind (-31.5%), and Sherbino 2 Wind (-33.5%). Those wind farms have comparison percentages larger than 10%, which may be caused by wind farm operation issues, meter problems or other similar issues.

Table 5: Summary of 90th Percentile Hourly Wind Power Analysis for 157 Sites in Texas

Wind Farm	12-Month Sliding 90th Percentile Hourly Wind Report								No. of Months of Data	Capacity (MW)
	First Year		Average		Minimum		Maximum			
	First 12-mo Ending Mo.	MW	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo		
Anacacho Wind	Nov-13	83.4	86.4	3.6%	81.2	-2.7%	89.2	6.9%	86	100
Baffin Wind 1	Dec-16	80.5	83.6	3.8%	76.5	-5.0%	86.3	7.2%	49	100
Baffin Wind 2	Dec-16	73.3	79.8	8.9%	71.8	-2.0%	83.3	13.6%	49	102
Barton Chapel Wind 1	Dec-09	74.9	74.6	-0.4%	61.2	-18.2%	89.1	19.0%	133	120
Big Spring Wind Farm	Dec-02	27.2	21.4	-21.5%	11.1	-59.2%	27.2	0.0%	217	41
Blue Summit Wind	Oct-13	121.9	119.0	-2.4%	112.3	-7.9%	128.5	5.4%	87	135
Bobcat Bluff Wind	Nov-13	115.0	110.4	-4.0%	92.8	-19.4%	129.8	12.9%	86	150
Brazos Wind Ranch	Dec-04	127.5	122.0	-4.3%	93.5	-26.7%	139.4	9.3%	193	160
Briscoe Wind_19	Jun-16	123.4	113.5	-8.0%	96.8	-21.5%	128.3	4.0%	55	149.8
Buckthorn Wind 1 A	May-18	36.9	39.7	7.4%	36.9	0.0%	41.1	11.2%	32	44.9
Buckthorn Wind 1 B	May-18	47.7	49.7	4.3%	47.6	-0.1%	52.5	10.1%	32	55.7
Buffalo Gap 1	Nov-06	100.9	97.3	-3.5%	75.4	-25.2%	105.7	4.8%	170	120
Buffalo Gap 2	Apr-08	183.4	177.4	-3.3%	104.9	-42.8%	207.6	13.2%	153	233
Buffalo Gap 3	Apr-10	122.4	138.1	12.8%	109.5	-10.5%	152.1	24.2%	129	170
Bull Creek Wind Plant	Dec-09	93.9	95.3	1.5%	41.5	-55.8%	130.4	38.9%	133	180
Callahan Divide Wind	Feb-06	93.3	94.7	1.5%	83.9	-10.0%	101.5	8.8%	179	114
Cameron County Wind (Camwind_Unit1)	Dec-16	128.0	130.0	1.6%	119.8	-6.4%	142.5	11.4%	49	165
Camp Springs Wind 2	Jan-09	94.0	95.9	2.1%	78.8	-16.1%	107.9	14.8%	144	120
Camp Springs Wind Energy Center	Apr-08	111.3	105.0	-5.7%	87.0	-21.8%	120.9	8.6%	153	130
Capricorn Ridge Wind 1&2	Aug-08	258.0	260.4	0.9%	174.5	-32.4%	309.3	19.9%	149	364
Capricorn Ridge Wind 3	Jan-09	120.3	139.0	15.5%	97.9	-18.6%	157.2	30.7%	144	186
Capricorn Ridge Wind 4	May-09	83.5	87.7	5.1%	67.6	-19.0%	100.2	20.0%	140	112.5
Cedro Hill Wind	Dec-11	136.3	123.1	-9.7%	101.9	-25.2%	136.9	0.4%	109	150
Champion Wind Farm	Jan-09	89.4	101.5	13.5%	87.7	-1.9%	113.2	26.6%	144	126.5
Chapman Ranch Wind IA (Santa Cruz)	Mar-18	104.4	91.0	-12.9%	54.6	-47.7%	122.0	16.8%	34	150.6
Chapman Ranch Wind IB (Santa Cruz)	Mar-18	71.1	61.2	-13.9%	41.5	-41.7%	78.9	11.0%	34	98.4
Desert Sky Wind Farm	Dec-02	89.0	115.8	30.1%	83.1	-6.7%	134.4	50.9%	217	160.5
Doug Colbeck's Corner (Conway) A	Jan-17	92.6	93.0	0.4%	91.2	-1.5%	95.2	2.8%	48	100.2
Doug Colbeck's Corner (Conway) B	Jan-17	90.1	92.2	2.4%	85.7	-4.8%	94.7	5.2%	48	100.2
Elbow Creek Wind	Dec-09	94.5	93.8	-0.8%	70.2	-25.7%	105.7	11.8%	133	121.9
Falvez Astra Wind	Jan-18	149.3	141.3	-5.3%	121.0	-18.9%	155.6	4.2%	36	163.2
Forest Creek Wind	Dec-07	105.2	103.1	-2.0%	85.6	-18.6%	111.2	5.7%	157	124.2
Goat Wind	Apr-09	67.0	103.5	54.6%	61.8	-7.8%	122.6	83.0%	141	150
Goldthwaite Wind 1	Dec-14	122.8	127.6	3.9%	115.8	-5.7%	134.4	9.4%	73	149
Grandview Wind 1 (Conway) GV1A	Nov-15	99.3	97.9	-1.3%	91.0	-8.3%	101.4	2.2%	62	107
Grandview Wind 1 (Conway) GV1B	Nov-15	94.0	93.8	-0.3%	89.5	-4.8%	98.0	4.2%	62	104
Green Mountain Wind 1 (Brazos)	Aug-18	92.7	97.7	5.4%	87.7	-5.4%	103.3	11.4%	29	120
Green Mountain Wind 2 (Brazos)	Aug-18	82.8	86.2	4.2%	76.9	-7.1%	90.0	8.8%	29	108
Green Pastures Wind I_19	Feb-16	125.2	133.9	7.0%	125.2	0.0%	139.2	11.2%	59	150
Gulf Wind 1	Jun-10	108.6	99.7	-8.2%	1.9	-98.2%	119.4	9.9%	127	141.6
Gulf Wind 2	Jun-10	116.5	108.9	-6.5%	3.1	-97.3%	126.3	8.4%	127	141.6
Gunsight Mountain Wind	Jan-17	109.5	113.4	3.5%	109.5	0.0%	115.2	5.2%	48	119.9
Hackberry Wind	Dec-09	138.0	126.5	-8.3%	105.8	-23.3%	140.6	1.9%	133	165.5
Harbor Wind	Jan-13	6.1	4.2	-31.5%	0.0	-100.0%	7.1	15.9%	96	9
Hereford Wind G_19	Dec-15	80.9	83.3	3.0%	79.9	-1.2%	86.9	7.5%	61	99.9
Hereford Wind V_19	Dec-15	90.4	94.0	4.0%	90.4	0.0%	95.7	5.8%	61	100
Hidalgo & Starr Wind 11	Jul-17	45.1	45.8	1.6%	39.8	-11.6%	47.3	5.1%	42	52
Hidalgo & Starr Wind 12	Jul-17	85.8	87.7	2.2%	76.5	-10.9%	91.2	6.3%	42	98
Hidalgo & Starr Wind 21	Jul-17	85.0	86.4	1.6%	76.5	-10.1%	89.2	4.9%	42	100
Horse Creek Wind 1	Dec-17	121.6	122.6	0.9%	121.3	-0.2%	123.6	1.7%	37	131.1
Horse Creek Wind 2	Dec-17	92.3	92.4	0.2%	90.8	-1.6%	93.8	1.6%	37	98.9
Horse Hollow Phase 1	Jun-06	157.0	167.4	6.7%	141.3	-10.0%	185.1	17.9%	175	213
Horse Hollow Phase 2	Aug-07	145.7	141.2	-3.1%	99.0	-32.1%	164.9	13.2%	161	184
Horse Hollow Phase 3	May-07	169.2	168.8	-0.3%	123.9	-26.8%	187.7	11.0%	164	223.5
Horse Hollow Phase 4	Jun-07	88.6	90.9	2.5%	80.9	-8.7%	103.1	16.3%	163	115
Inadale Wind	Sep-10	117.9	139.9	18.7%	99.0	-16.0%	166.3	41.1%	124	197
Indian Mesa Wind Farm	Dec-02	48.0	54.7	14.0%	36.0	-24.9%	72.2	50.5%	217	82.5
Javelina II Wind 1	Dec-17	86.2	87.4	1.3%	83.4	-3.3%	89.1	3.3%	37	96
Javelina II Wind 2	Dec-17	64.9	66.4	2.2%	63.4	-2.3%	68.0	4.7%	37	74
Javelina II Wind 3	Dec-17	27.5	27.7	0.8%	26.4	-3.9%	28.5	3.8%	37	30
Javelina Wind 18&20_19	Sep-16	211.0	221.6	5.0%	211.0	0.0%	229.3	8.7%	52	249.7
Jumbo Road Wind 1_19	Mar-16	117.3	123.9	5.6%	117.3	0.0%	129.1	10.1%	58	146.2
Jumbo Road Wind 2_19	Mar-16	119.7	127.6	6.6%	119.7	0.0%	133.0	11.1%	58	153.6
Keechi Wind 138 Kv Joplin_19	Dec-15	99.7	102.5	2.8%	99.5	-0.2%	103.8	4.1%	61	110
King Mountain-NE Wind Farm	Dec-02	41.8	43.4	3.8%	20.8	-50.3%	56.4	34.8%	217	79.3
King Mountain-NW Wind Farm	Dec-02	44.7	51.6	15.4%	27.7	-37.9%	65.3	46.1%	217	79.3
King Mountain-SE Wind Farm	Dec-02	21.6	21.9	1.3%	11.8	-45.7%	28.1	29.8%	217	40.3
King Mountain-SW Wind Farm	Dec-02	41.6	44.3	6.5%	22.9	-44.9%	53.7	29.1%	217	79.3
Langford Wind	Dec-10	115.7	124.5	7.6%	107.8	-6.9%	134.3	16.0%	121	150
Logans Gap Wind I U1_19	Apr-16	88.5	85.9	-2.9%	80.6	-9.0%	90.6	2.3%	57	103.8
Logans Gap Wind I U2_19	Apr-16	83.8	83.4	-0.5%	77.5	-7.6%	86.6	3.3%	57	106.3
Lone Star-Mesquite Wind	Sep-08	140.4	145.8	3.8%	121.0	-13.9%	168.1	19.7%	148	200
Lone Star-Post Oak Wind	Mar-09	149.1	150.9	1.2%	128.1	-14.1%	170.5	14.4%	142	200
Longhorn Wind North U1_19	Mar-16	91.0	92.7	1.8%	91.0	0.0%	94.0	3.3%	58	100
Longhorn Wind North U2_19	Dec-15	88.9	93.1	4.8%	88.9	0.0%	95.0	6.9%	61	100
Loraine Windpark I	Dec-10	30.4	35.9	18.0%	25.9	-14.8%	42.3	39.2%	121	126
Loraine Windpark II	Dec-10	27.8	36.5	31.2%	25.7	-7.6%	43.3	55.7%	121	124.5
Loraine Windpark III	Jan-12	16.2	20.4	25.7%	16.2	0.0%	22.6	39.4%	108	26
Loraine Windpark IV	Dec-12	17.4	17.3	-0.6%	5.0	-71.5%	20.8	19.1%	97	24
Los Vientos I Wind	Oct-13	148.5	164.6	10.8%	148.5	0.0%	175.1	17.9%	87	200.1
Los Vientos II Wind	Nov-13	153.3	149.3	-2.6%	124.6	-18.7%	164.3	7.2%	86	201.6
Los Vientos Iii Wind_19	Feb-16	154.0	167.3	8.7%	154.0	0.0%	175.9	14.3%	59	200
Los Vientos IV Wind	Apr-17	167.7	173.3	3.4%	160.1	-4.5%	180.0	7.3%	45	200
Los Vientos V Wind	Dec-16	92.1	93.6	1.6%	89.4	-3.0%	96.9	5.2%	49	110

Table 5: Summary of 90th Percentile Hourly Wind Power Analysis for 157 Sites in Texas (Continued)

Wind Farm	12-Month Sliding 90th Percentile Hourly Wind Report								No. of Months of Data	Capacity (MW)
	First Year		Average		Minimum		Maximum			
	First 12-mo Ending Mo.	MW	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo		
Magic Valley Wind (Redfish) 1A	Apr-13	88.6	85.1	-3.9%	70.8	-20.0%	90.7	2.4%	93	99.8
Magic Valley Wind (Redfish) 1B	Jul-13	94.2	88.9	-5.7%	76.5	-18.8%	94.6	0.4%	90	103.5
Mariah Del Norte 1	Dec-17	103.7	103.5	-0.3%	98.6	-5.0%	106.7	2.8%	37	115.2
Mariah Del Norte 2	Dec-17	105.6	104.0	-1.5%	97.6	-7.6%	107.9	2.2%	37	115.2
McAdoo Wind	Dec-09	111.7	135.5	21.3%	111.7	0.0%	143.6	28.5%	133	150
Mesquite Creek Wind 1_19	Dec-15	93.3	91.7	-1.7%	83.6	-10.3%	97.7	4.7%	61	105.6
Mesquite Creek Wind 2_19	Dec-15	90.5	90.2	-0.3%	83.6	-7.6%	96.2	6.2%	61	105.6
Miami Wind G1	Aug-15	125.8	129.4	2.8%	124.9	-0.8%	132.6	5.4%	65	144
Miami Wind G2	Aug-15	126.0	129.8	3.1%	125.4	-0.5%	133.4	5.9%	65	144
Notrees Windpower	Feb-10	103.7	112.3	8.3%	103.7	0.0%	122.9	18.6%	131	153
Ocotillo Windpower	Dec-09	39.1	38.3	-2.1%	16.4	-58.0%	47.2	20.7%	133	58.8
Panhandle Wind 1 U1	May-15	94.5	95.5	1.0%	82.7	-12.5%	101.3	7.2%	68	109
Panhandle Wind 1 U2	May-15	90.6	91.7	1.2%	80.4	-11.2%	98.0	8.2%	68	109
Panhandle Wind 2 U1	Oct-15	88.2	87.1	-1.3%	82.3	-6.6%	90.0	2.0%	63	94
Panhandle Wind 2 U2	Sep-15	90.2	90.0	-0.2%	85.8	-4.8%	93.4	3.6%	64	97
Panther Creek 2	Dec-09	91.8	96.7	5.4%	83.5	-9.0%	107.7	17.3%	133	115.5
Panther Creek 3	Aug-10	128.5	154.8	20.5%	120.0	-6.6%	177.1	37.8%	125	199.5
Panther Creek	Dec-09	114.4	121.7	6.4%	107.8	-5.8%	130.4	14.0%	133	142.5
Papalote Creek Phase II	Dec-11	174.2	163.5	-6.1%	148.5	-14.8%	176.3	1.2%	109	200.1
Papalote Creek Wind Farm	Dec-10	150.1	133.9	-10.8%	39.6	-73.6%	157.9	5.2%	121	180
Penascal Wind 1	Feb-11	133.2	121.9	-8.5%	85.2	-36.0%	141.5	6.2%	119	161
Penascal Wind 2	Dec-09	83.3	106.4	27.8%	74.9	-10.0%	125.4	50.5%	133	142
Penascal Wind 3	May-11	87.1	74.2	-14.8%	53.0	-39.2%	88.8	2.0%	116	101
Pyron	Dec-09	157.2	192.5	22.5%	151.4	-3.7%	220.1	40.0%	133	249
Rattlesnake Den Wind Phase 1 G1_19	Mar-16	97.0	92.4	-4.8%	78.6	-18.9%	99.7	2.8%	58	104.3
Rattlesnake Den Wind Phase 1 G2_19	Mar-16	93.5	89.6	-4.2%	76.2	-18.5%	97.3	4.0%	58	103
Red Canyon1	Aug-07	76.4	75.8	-0.8%	71.0	-7.0%	79.5	4.1%	161	84
Roscoe Wind Farm	Dec-08	169.4	152.4	-10.0%	108.1	-36.2%	179.8	6.2%	145	209
Route 66 Wind_19	Mar-16	139.0	139.3	0.2%	132.9	-4.4%	142.6	2.5%	58	150
Saltfork_Unit1	Aug-17	58.1	60.7	4.5%	58.1	0.0%	61.7	6.2%	41	64
Saltfork_Unit2	Aug-17	100.9	104.3	3.3%	100.9	0.0%	105.4	4.4%	41	110
San Roman Wind	Dec-17	82.1	79.6	-3.1%	72.5	-11.7%	82.9	1.0%	37	95.2
Sand Bluff Wind	Nov-08	69.4	62.9	-9.3%	39.8	-42.6%	75.4	8.6%	146	90
Senate Wind	Sep-13	127.1	125.3	-1.4%	119.0	-6.4%	132.2	4.0%	88	150
Sendero Wind Energy_19	Aug-16	67.2	70.5	5.0%	67.2	0.0%	72.6	8.1%	53	76
Shannon Wind_19	Oct-16	175.3	178.8	2.0%	174.6	-0.4%	183.9	4.9%	51	204.1
Sherbino 1 Wind	Dec-09	104.7	102.9	-1.7%	42.1	-59.8%	128.1	22.4%	133	150
Sherbino 2 Wind	Dec-12	125.7	83.6	-33.5%	13.3	-89.5%	125.7	0.0%	97	150
Silver Star Wind	Apr-09	40.6	40.1	-1.2%	6.1	-85.0%	50.5	24.4%	141	60
Snyder Wind Project	Dec-08	46.5	42.4	-8.7%	17.4	-62.6%	50.9	9.6%	145	63
South Plains Wind 2_19	Jul-16	89.2	90.4	1.4%	88.1	-1.2%	92.5	3.7%	54	98
South Plains Wind I_19	Jul-16	94.8	93.4	-1.5%	90.7	-4.4%	95.5	0.8%	54	102
South Plains Wind II A	Dec-16	120.2	135.6	12.8%	120.2	0.0%	141.3	17.5%	49	148.5
South Plains Wind II B	Dec-16	128.1	140.9	10.0%	128.1	0.0%	145.1	13.2%	49	151.8
South Trent Wind Farm	Dec-09	67.7	82.7	22.2%	65.4	-3.5%	91.0	34.4%	133	101.2
Spinning Spur 3 (Wind 1)_19	Apr-16	87.5	90.6	3.5%	87.5	0.0%	91.6	4.7%	57	96
Spinning Spur 3 (Wind 2)_19	Apr-16	88.4	92.9	5.1%	88.4	0.0%	93.9	6.2%	57	98
Spinning Spur Wind Two	May-15	140.9	145.7	3.4%	140.9	0.0%	149.4	6.1%	68	161
Stanton Wind Energy	Dec-08	79.4	94.9	19.6%	75.3	-5.2%	107.1	34.8%	145	120
Stephens Ranch Wind 2_19	Mar-16	144.3	148.7	3.1%	144.3	0.0%	151.9	5.3%	58	164.7
Stephens Ranch Wind Phase 1	Nov-15	182.9	189.0	3.3%	182.9	0.0%	193.1	5.6%	62	211
Sweetwater Wind 1	Dec-04	34.1	33.1	-2.9%	28.8	-15.4%	36.2	6.2%	193	37.5
Sweetwater Wind 2	Jan-06	71.4	82.6	15.8%	71.4	0.0%	89.6	25.6%	180	97.5
Sweetwater Wind 3	Dec-06	99.6	101.1	1.5%	67.1	-32.7%	111.2	11.6%	169	135
Sweetwater Wind 4	Mar-08	161.0	171.2	6.3%	153.2	-4.9%	182.2	13.2%	154	240.8
Sweetwater Wind 5	Dec-08	66.5	61.7	-7.2%	45.6	-31.4%	69.3	4.3%	145	80.5
Sweetwater Wind24	Mar-08	13.1	13.7	4.3%	12.0	-8.7%	14.8	13.3%	154	16
Trent Mesa Wind Farm	Dec-02	108.8	108.8	0.0%	33.4	-69.3%	132.8	22.0%	217	150
Trinity Hills Wind Farm1	Dec-12	78.8	71.2	-9.7%	12.5	-84.2%	89.3	13.3%	97	118
Trinity Hills Wind Farm2	Dec-12	74.8	70.4	-5.9%	23.9	-68.0%	88.0	17.7%	97	108
Turkey Track Wind Energy Center	Dec-09	77.4	123.7	59.9%	76.5	-1.1%	143.1	85.0%	133	169.5
Tyler Bluff Wind	Aug-17	104.0	108.2	4.0%	104.0	0.0%	110.7	6.5%	41	125.6
Vertigo Wind (Formerly Green Pastures Wind 2)_19	Nov-16	123.5	129.1	4.6%	121.3	-1.8%	133.4	8.0%	50	150
Wake Wind 1	Apr-17	109.3	109.0	-0.3%	107.4	-1.8%	110.2	0.8%	45	114.9
Wake Wind 2	Apr-17	136.0	135.3	-0.5%	133.3	-2.0%	137.0	0.7%	45	142.3
Whirlwind	Dec-08	54.0	52.0	-3.7%	39.8	-26.3%	56.9	5.4%	145	60
Whitetail Wind	Oct-13	72.9	67.7	-7.0%	60.2	-17.4%	73.1	0.3%	87	92
Willow Springs Wind A	Jul-18	118.1	118.4	0.2%	116.8	-1.2%	119.6	1.2%	30	125
Willow Springs Wind B	Jul-18	117.7	118.3	0.5%	117.4	-0.2%	119.3	1.4%	30	125
Windthorst 2	Oct-15	50.3	56.3	11.9%	50.3	0.0%	59.4	18.1%	63	68
WKN Mozart Wind	Oct-13	22.4	22.0	-1.9%	19.4	-13.4%	25.8	15.0%	87	30
Wolf Ridge Wind	Dec-09	105.9	99.9	-5.7%	81.2	-23.4%	108.8	2.7%	133	112.5
Woodward Wind Farm	Dec-02	85.3	94.1	10.4%	65.2	-23.5%	112.4	31.8%	217	159.7
Weighted Average:				**0.0%**		**0.0%**		**0.0%**	**Total:**	**19,786**

3.4 Analysis of other renewable sources

Five specific renewable sources were determined: solar, biomass, hydroelectric, geothermal, and landfill gas-fired. To generate/save energy throughout the State of Texas, six types of renewable energy projects were identified: solar photovoltaic (PV) including solar power, solar thermal, biomass power, hydroelectric power, geothermal HVAC, and landfill gas-fired power projects. The solar photovoltaic project accounts for non-utility scale PV installations in Texas whereas the solar power project accounts for utility-scale (solar power plant) constructions. Table 6 presents the number of newly located renewable energy projects and total renewable energy projects included in this report.

This report also presents county-wide annual/OSP energy savings and annual NOx emission reductions for solar photovoltaic including solar power, solar thermal, biomass, and hydroelectric projects. The annual/OSP energy savings calculation for solar photovoltaic was conducted based on the Lawrence Berkeley National Laboratory (LBNL) public dataset. In addition, the annual/OSP energy savings calculation for solar thermal was conducted based on the project data from various web sources. Finally, the power generation data for the other renewable energy projects (solar power, biomass, and hydroelectric), which were obtained from the ERCOT, were used to evaluate the annual/OSP energy generation. Then, the annual NOx emission reductions calculation was conducted with the special version of Texas 2018 eGRID.

In 2020, the total annual/OSP energy savings from each renewable projects across all the counties were:

- solar photovoltaic projects (non-utility scale): 451,803 MWh/yr and 1,400 MWh/day;
  in addition, solar power projects (utility-scale): 8,450,944 MWh/yr and 31,762 MWh/day,
- solar thermal projects: 255 MWh/yr and 0.7 MWh/day,
- biomass projects: 352,924 MWh/yr and 1,069 MWh/day, and
- hydroelectric projects: 632,438 MWh/yr and 1,845 MWh/day.

In 2020, the annual NOx emission reductions from renewable projects across all the counties were:

- solar photovoltaic projects (non-utility scale): 222.7 tons/yr;
  in addition, solar power projects (utility-scale): 5,458.6 tons/yr,
- solar thermal projects: 0.1 tons/yr and,
- hydroelectric projects: 188 tons/yr.

Table 6: Number of Identified Projects for Other Renewable Sources

Renewable Energy Projects	Number of 2020 New Projects	Total Number of Projects in 2020	Annual Measured/ Estimated Electricity Generation in 2020 [MWh/yr]	OSP Measured/ Estimated Electricity Generation in 2020 [MWh/day]	NOx Emission Reductions in 2020 [tons/yr]
Solar photovoltaic[4]	5,375	34,781	451,803	1,400.0	222.7
Solar Power[5]	7	82	8,450,944	31,762.0	5,458.6
Solar Thermal	1	41	255	0.7	0.1
Biomass[6]	0	12	352,924	1,069.0	-
Hydroelectric	0	30	632,438	1,845.0	188.0
Geothermal[7]	12	306	-	-	-
Landfill Gas-Fired[8]	1	34	-	-	-

[4] This TERP report used the "Tracking the Sun" project dataset of Lawrence Berkeley National Laboratory (LBNL) (https://emp.lbl.gov/tracking-the-sun/). The Tracking the Sun project public database included 34,781 projects from 2004 to 2020.
[5] Two solar power projects that were retrieved from the Open PV Project Database of the National Renewable Energy Laboratory (NREL) in 2019 are excluded because the information not available anymore.
[6] Two biomass projects had no generation compared to 2019 list. Therefore, they are excluded from the list for this year. Also, NOx emission reductions for biomass are not reported since biomass itself has high NOx emissions.
[7] Annual or OSP electricity savings and NOx emission reductions from the geothermal and landfill gas-fired could not be estimated due to limited information.
[8] Landfill gas-fired project information from EPA have seven sub-categories for their status: operational, candidates, potential, construction, shutdown, planned, and others. EPA rearranged/added/removed some projects information within the seven sub-categories. Operational projects were considered for the number of projects.

3.5 Review of electricity savings and transmission planning study reported by ERCOT

In this report, the information posted on ERCOT's Renewable Energy Credit (REC) Program site www.texasrenewables.com was reviewed. In particular, information posted under the "Public Reports" tab was downloaded and assembled into an appropriate format for review. This includes ERCOT's 2001 through 2020 reports to the Legislature and information from ERCOT's listing of REC generators.

Each year ERCOT is required to compile a list of grid-connected sources that generate electricity from renewable energy and report them to the Legislature. Table 7 contains the data reported by ERCOT from 2001 to 2020. Figure 7 is included to better illustrate the annual data collected by ERCOT. Other sources present different renewable electricity generation values on biomass, wind and hydro, but those are explained in general because the numbers reported in this report are focused on the ERCOT region.

Table 7: Annual Electricity Generation by Renewable Resources (MWh, ERCOT: 2001 - 2020)

Year	Biomass (MWh)	Hydro (MWh)	Landfill gas (MWh)	Solar* (MWh)	Wind (MWh)	Total (MWh)
2001	0	30,639	0	0	565,597	596,236
2002	0	312,093	29,412	87	2,451,484	2,793,076
2003	39,496	239,684	154,206	220	2,515,482	2,949,087
2004	36,940	234,791	203,443	211	3,209,630	3,685,014
2005	58,637	310,302	213,777	227	4,221,568	4,804,512
2006	60,569	210,077	306,087	470	6,530,928	7,108,131
2007	54,101	382,882	356,339	1,844	9,351,168	10,146,333
2008	70,833	445,428	387,110	3,338	16,286,440	17,193,150
2009	73,364	507,507	412,923	4,492	20,596,105	21,594,390
2010	97,535	609,257	464,904	14,449	26,828,660	28,014,805
2011	137,004	267,113	497,645	36,580	30,769,674	31,708,016
2012	288,988	389,197	549,037	139,439	32,746,534	34,113,195
2013	200,564	294,238	550,845	178,326	36,909,385	38,133,358
2014	343,469	240,792	518,580	312,757	40,644,362	42,059,961
2015	349,600	414,289	561,915	410,318	45,165,341	46,901,462
2016	247,643	393,740	518,403	848,410	57,796,161	59,804,357
2017	216,431	444,453	446,119	2,289,394	66,076,742	69,473,139
2018	287,014	334,460	395,428	3,183,238	73,960,577	78,160,716
2019**	153,531	266,718	335,361	4,466,873	81,770,300	86,992,784
2020	140,878	207,373	270,377	8,746,022	93,387,597	102,752,245

* Solar includes the utility scale solar power only
** 2019 hydro, solar and wind REC data is updated due to ERCOT's data modification this year

NOTE: The REC Program tracks renewable generation in Texas, including non-ERCOT regions of Texas. Not all renewable is eligible for REC credit.

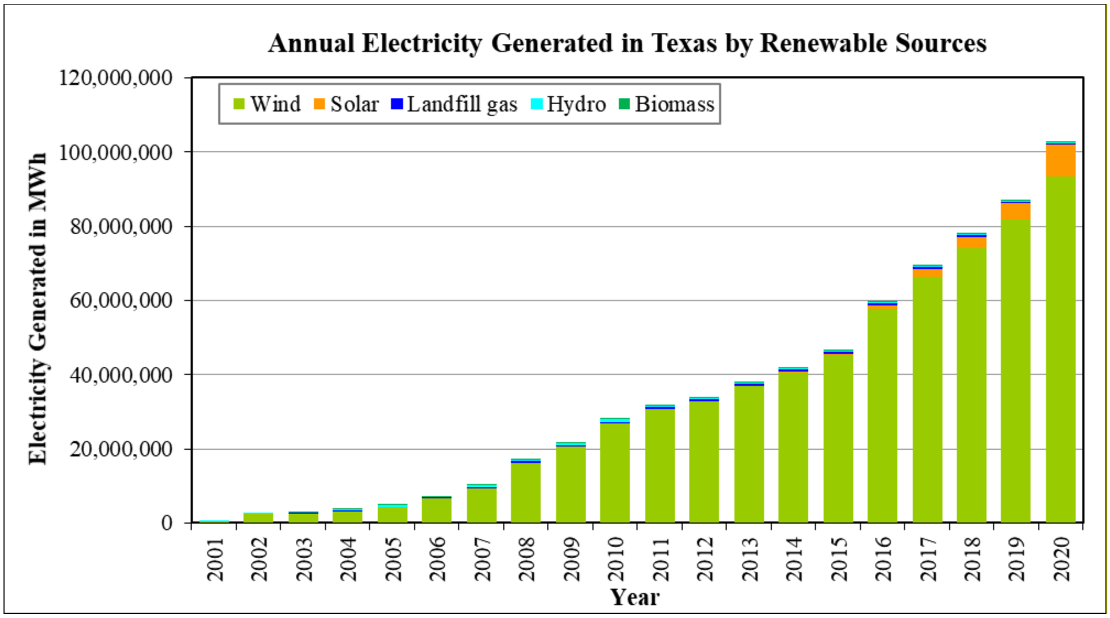


Figure 7: Electricity Generation by Renewable Resources (ERCOT: 2001–2020 Annual)

4 Calculated NOx Reductions Potential from Energy Savings of New Construction in 2020

A complete reporting of the savings, using 2018 base year (the implementation of the 2015 IECC and the ASHRAE Standard 90.1-2013), requires tracking and analyzing savings for new construction buildings that undergo a building permit. The adoption of the energy code and standard in Texas is expected to impact the following types of buildings:

- single-family residential
- multi-family residential
- commercial
- industrial

The following sections report the calculated energy savings associated with new construction activities for both residential (i.e., single-family and multi-family[7]) and commercial buildings.

4.1 2020 Results for New Single-family Residential Construction

This section provides the potential electricity and natural gas savings and the associated NOx emissions reductions in 2020 using the 2018 base year which implemented the 2015 IECC for new single-family residences in Texas, including the 42 non-attainment and affected counties as well as other counties in the ERCOT region[8]. To calculate the NOx emissions reductions, the following procedures were adopted. First, new construction activity was determined by county. To accomplish this, the number of 2020 building permits per county was obtained from the Real Estate Center at Texas A&M University (REC 2021). Next, energy savings attributable to the 2015 IECC were calculated using the Laboratory's code-traceable, DOE-2.1e simulation, which was developed for the TERP. For the savings calculation, the 2020 Home Innovation Research Labs (HIRL) data[9] were used to determine the appropriate construction data corresponding to housing types. Then the NOx reductions potential from the electricity and natural gas savings in each county was calculated using the US EPA's 2018 eGRID database (USEPA 2018)[10].

In Table 8, the 2020 new single-family and 2015 IECC code-compliant building characteristics are shown for each county. The building characteristics reflect those published by the HIRL, ARI, and GAMA for Texas. The 2015 IECC code-compliant characteristics are the minimum building code characteristics required for each county for single-family residences (i.e., Type A.1). In Table 8, the rows are first sorted by the US EPA's non-attainment, affected designation, and then other ERCOT counties alphabetically. Next, in the fourth column, the HIRL's survey classification is listed. The fifth through eighth columns show the HIRL's survey data: average glazing U-value, Solar Heat Gain Coefficient (SHGC), roof insulation, and wall insulation, respectively. In addition, the ninth through twelfth columns show the 2015 IECC minimum requirements for glazing U-value, SHGC, roof insulation, and wall insulation.

The corresponding values in IECC and effective regulations are applied to the air-conditioner efficiency, furnace efficiency (AFUE), and domestic water heater efficiency. The values shown in Table 8 represent the only changes that were made to the simulation to obtain the savings calculations. In cases where the 2020 values were more efficient than the 2015 IECC requirements, the 2020 values were used in the 2020 new single-family simulations. Otherwise, the 2015 IECC values were used in both simulations[11]. For example, in Collin County, according to the HIRL's survey data, the roof insulation is R-32.41, which is less than the code-required insulation of R-38. Therefore, R-38 was used in the 2020 simulation.

[7] The potential energy savings and NOx reductions analysis from energy savings of new single- and multi-family constructions in 2016 through 2019 includes the related provisions for both *systems* and *envelope* in 2015 IECC, whereas in previous years analysis only the related provisions to the *envelope* from the corresponding code were included.
[8] The three new counties added in the 2003 Legislative session (i.e., Henderson, Hood, and Hunt) were included in the ERCOT region.
[9] In 2013, the NAHB Research Center announced that it has changed its name to Home Innovation Research Labs (HIRL). See more at: http://www.homeinnovation.com
[10] This preliminary analysis does not include actual power transfers on the grid and assumes transmission and distribution losses of 7%. Counties were assigned to utility service districts as indicated.
[11] 2020 HIRL data and 2015 IECC are used for the 2020 new code-compliant simulations and 2018 HIRL data and 2015 IECC are used for the 2018 base-year simulations

In Table 9 the code-traceable simulation results for single-family residences are shown for each county. In a similar fashion to Table 8, Table 9 is first divided into the US EPA's non-attainment and affected classifications, followed by an alphabetical list of other ERCOT counties and other counties in Texas. In the third column, the 2015 IECC climate zone is listed followed by the number of new projected housing units[12] in the fourth column. In the fifth column, the total simulated energy use is listed if all-new Construction had been built to 2018 base-year specifications. In the sixth column, the total county-wide energy use for the 2020 Construction is shown. The values in the fifth and sixth columns come from the associated 24 simulation runs for each county, which were then distributed according to the HIRL's survey data, to account for 1 story, 2 story, slab-on-grade, crawlspace, and three different system types (i.e., central air conditioning with electric resistance heating, heat pump heating, or a natural gas-fired furnace). In the seventh column, the total annual electricity savings are shown for each county. A 7% transmission and distribution loss are used in the 2020 report, which represents a fixed 1.07 multiplier for the electricity use. In the eighth and ninth columns, the total annual 2018 base-year and 2020 natural gas use is shown for those residences that had natural gas-fired furnaces and domestic water heaters. Finally, in the tenth column, the total annual natural gas savings are shown for each county.

In Table 10, the annual electricity savings are assigned to CL Zones[13]. The total electricity savings for each CL Zone, as shown in Table 10, then entered into the bottom row of Table 11, which is the 2018 US EPA's eGRID database for Texas. Next, the county's NOx reductions (lbs) are calculated using the assigned 2018 eGRID proportions (lbs-NOx/MWh) to each electric power market and each CL zone in the county. The calculated NOx reductions are presented in the columns adjacent to the corresponding each electric power market and CL Zone columns. By adding the NOx reductions values in each row, then, the total of the NOx reductions per county (lbs and Tons) is calculated. Counties that do not show NOx reductions represent counties that do not have power plants in eGRID's database.

[12] The number of the new housing units in 2020 were obtained from the Real Estate Center at Texas A&M University.
[13] ERCOT region has employed the Competitive Load (CL) zones, and it is currently divided into four zones: Houston (H), North (N), South (S), and West (W)

Table 8: 2020 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Single-family Residences

	County	Climate Zone	Division	2020 Average				2015 IECC			
			East or West	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)
Non-attainment	BRAZORIA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	CHAMBERS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	COLLIN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DALLAS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DENTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	EL PASO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ELLIS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FORT BEND	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	GALVESTON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	HARRIS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	JOHNSON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KAUFMAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	LIBERTY	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	MONTGOMERY	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	PARKER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ROCKWALL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TARRANT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	WALLER	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WISE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
Affected	BASTROP	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BEXAR	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	CALDWELL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	COMAL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	GREGG	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	GUADALUPE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	HARRISON	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	HAYS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	NUECES	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	RUSK	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	SAN PATRICIO	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	SMITH	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	TRAVIS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	UPSHUR	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	VICTORIA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WILLIAMSON	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	WILSON	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
ERCOT	ANDERSON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	ANDREWS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ANGELINA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	ARANSAS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	ARCHER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ATASCOSA	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	AUSTIN	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BANDERA	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BASTROP	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BAYLOR	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	BEE	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BELL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BEXAR	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BLANCO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	BORDEN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	BOSQUE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	BRAZORIA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BRAZOS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BREWSTER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	BRISCOE	4	West Texas	0.39	0.53	32.4	16.2	0.35	0.4	49	20
	BROOKS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BROWN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	BURLESON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	BURNET	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CALDWELL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	CALHOUN	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	CALLAHAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CAMERON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	CHAMBERS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	CHEROKEE	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	CHILDRESS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CLAY	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	COKE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	COLEMAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	COLLIN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	COLORADO	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	COMAL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	COMANCHE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CONCHO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	COOKE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CORYELL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	COTTLE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20

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	County	Climate Zone	Division	2020 Average				2015 IECC			
			East or West	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)
ERCOT	CRANE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CROCKETT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CROSBY	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	CULBERSON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DALLAS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DAWSON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DE WITT	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	DELTA	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DENTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DICKENS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	DIMMIT	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	DUVAL	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	EASTLAND	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ECTOR	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	EDWARDS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	ELLIS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ERATH	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FALLS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	FANNIN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FAYETTE	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	FISHER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FOARD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FORT BEND	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	FRANKLIN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	FREESTONE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	FRIO	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	GALVESTON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	GILLESPIE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	GLASSCOCK	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	GOLIAD	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	GONZALES	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	GRAYSON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	GRIMES	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	GUADALUPE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	HALL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HAMILTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HARDEMAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HARRIS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	HASKELL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HAYS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	HENDERSON	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	HIDALGO	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	HILL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	HOOD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HOPKINS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HOUSTON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	HOWARD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HUDSPETH	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	HUNT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	IRION	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	JACK	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	JACKSON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	JEFF DAVIS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	JIM HOGG	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	JIM WELLS	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	JOHNSON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	JONES	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KARNES	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	KAUFMAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KENDALL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KENEDY	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	KENT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KERR	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KIMBLE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KING	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	KINNEY	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	KLEBERG	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	KNOX	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	LA SALLE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	LAMAR	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	LAMPASAS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	LAVACA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	LEE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	LEON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13

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			East or West	Glazing U-value (Btu/hr-ft²-F)	SHGC	Roof Insulation (hr-ft²-F/Btu)	Wall Insulation (hr-ft²-F/Btu)	Glazing U-value (Btu/hr-ft²-F)	SHGC	Roof Insulation (hr-ft²-F/Btu)	Wall Insulation (hr-ft²-F/Btu)
ERCOT	LIMESTONE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	LIVE OAK	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	LLANO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	LOVING	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MADISON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	MARTIN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MASON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MATAGORDA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	MAVERICK	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	MCCULLOCH	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MCLENNAN	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	MCMULLEN	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	MEDINA	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	MENARD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MIDLAND	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MILAM	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	MILLS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MITCHELL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MONTAGUE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	MONTGOMERY	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	MOTLEY	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	NACOGDOCHES	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	NAVARRO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	NOLAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	NUECES	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	PALO PINTO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	PARKER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	PECOS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	PRESIDIO	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	RAINS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	REAGAN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	REAL	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	RED RIVER	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	REEVES	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	REFUGIO	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	ROBERTSON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	ROCKWALL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	RUNNELS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	RUSK	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	SAN PATRICIO	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	SAN SABA	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	SCHLEICHER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	SCURRY	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	SHACKELFORD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	SMITH	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	SOMERVELL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	STARR	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	STEPHENS	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	STERLING	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	STONEWALL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	SUTTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TARRANT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TAYLOR	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TERRELL	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	THROCKMORTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TITUS	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	TOM GREEN	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	TRAVIS	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	UPTON	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	UVALDE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	VAL VERDE	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	VAN ZANDT	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	VICTORIA	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WALLER	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WARD	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	WASHINGTON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WEBB	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	WHARTON	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WICHITA	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	WILBARGER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	WILLACY	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	WILLIAMSON	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	WILSON	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	WINKLER	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	WISE	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	YOUNG	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	ZAPATA	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	ZAVALA	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13

Table 9: 2020 Annual Electricity and Natural Gas Savings from New Single-family Residences

2020 Summary TRY 2018									
	County	**Climate Zone**	**No. of Projected Units (2020)**	**2018 Base-year Total Annual Elec. Use (MWh/yr)**	**2020 Total Annual Elec. Use (MWh/yr)**	**Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss**	**2018 Base-year Total Annual NG Use (Therm/yr)**	**2020 Total Annual NG Use (Therm/yr)**	**Total Annual NG Savings (Therm/yr)**
Nonattain-ment County	BRAZORIA	3	3,895	64,026	61,623	**2,571**	721,009	692,361	**28,648**
	CHAMBERS	3	932	14,957	14,460	**532**	185,849	178,825	**7,024**
	COLLIN	3	12,586	190,755	185,180	**5,965**	6,019,708	5,949,112	**70,595**
	DALLAS	3	5,577	85,389	82,673	**2,905**	2,353,223	2,316,246	**36,977**
	DENTON	3	7,222	110,623	107,112	**3,756**	3,034,753	2,984,553	**50,200**
	EL PASO	2	2,330	32,953	32,054	**962**	888,991	872,749	**16,242**
	ELLIS	3	2,548	39,012	37,772	**1,327**	1,075,132	1,058,238	**16,894**
	FORT BEND	3	11,403	183,647	177,321	**6,768**	2,237,234	2,151,295	**85,939**
	GALVESTON	3	2,926	48,098	46,293	**1,931**	541,636	520,115	**21,521**
	HARDIN	2	263	4,221	4,081	**150**	52,402	50,411	**1,991**
	HARRIS	2	20,834	335,534	323,977	**12,366**	4,087,568	3,930,552	**157,016**
	JEFFERSON	2	1,081	17,351	16,773	**618**	215,041	206,858	**8,184**
	JOHNSON	2	1,365	20,899	20,235	**711**	575,964	566,913	**9,050**
	KAUFMAN	2	860	13,034	12,653	**408**	411,326	406,502	**4,824**
	LIBERTY	2	964	15,528	14,993	**573**	188,670	181,372	**7,298**
	MONTGOMERY	3	8,901	143,352	138,414	**5,283**	1,746,349	1,679,267	**67,082**
	ORANGE	2	211	3,387	3,274	**121**	41,974	40,376	**1,597**
	PARKER	2	517	7,690	7,466	**240**	219,278	215,684	**3,594**
	ROCKWALL	2	2,306	34,950	33,929	**1,093**	1,102,928	1,089,993	**12,934**
	TARRANT	2	10,266	157,181	152,183	**5,348**	4,331,753	4,263,687	**68,066**
	WALLER	2	31	499	482	**18**	6,082	5,848	**234**
	WISE	3	88	1,334	1,295	**42**	42,089	41,596	**494**
Affected County	BASTROP	2	1,028	16,848	16,340	**544**	205,570	200,014	**5,556**
	BEXAR	2	5,337	79,975	77,346	**2,812**	1,508,092	1,471,051	**37,041**
	CALDWELL	3	368	5,377	5,208	**181**	97,895	95,330	**2,565**
	COMAL	3	3,389	50,784	49,115	**1,786**	957,640	934,119	**23,521**
	GREGG	3	259	4,189	4,087	**109**	68,616	67,282	**1,334**
	GUADALUPE	2	1,258	18,851	18,232	**663**	355,477	346,746	**8,731**
	HARRISON	2	82	1,326	1,294	**35**	21,724	21,302	**422**
	HAYS	2	4,106	60,011	58,120	**2,023**	1,090,749	1,062,251	**28,498**
	NUECES	3	1,370	22,630	21,769	**922**	228,023	218,124	**9,899**
	RUSK	2	3	49	47	**1**	796	781	**15**
	SAN PATRICIO	2	276	4,559	4,385	**186**	45,937	43,943	**1,994**
	SMITH	2	635	10,322	10,076	**262**	178,159	174,687	**3,472**
	TRAVIS	3	10,361	151,430	146,659	**5,105**	2,752,373	2,680,463	**71,911**
	UPSHUR	3	19	318	310	**9**	5,485	5,385	**100**
	VICTORIA	2	132	2,151	2,075	**81**	25,304	24,305	**999**
	WILLIAMSON	3	7,271	109,695	106,189	**3,751**	2,609,464	2,561,262	**48,202**
	WILSON	2	141	2,113	2,043	**74**	39,843	38,864	**979**
ERCOT	ANDERSON	2	21	340	331	**9**	5,571	5,466	**105**
	ANDREWS	3	16	231	225	**7**	7,277	7,177	**101**
	ANGELINA	2	120	1,940	1,893	**50**	31,835	31,235	**600**
	ARANSAS	2	173	2,858	2,749	**116**	28,794	27,544	**1,250**
	ARCHER	3	38	588	569	**20**	19,808	19,595	**213**
	ATASCOSA	2	67	1,004	971	**35**	18,956	18,489	**467**
	AUSTIN	2	289	4,654	4,494	**172**	56,701	54,523	**2,178**
	BANDERA	2	1	15	14	**0**	293	286	**7**
	BAYLOR	3	0	0	0	**0**	0	0	**0**
	BEE	2	19	310	299	**12**	3,642	3,498	**144**
	BELL	2	2,542	39,741	38,311	**1,530**	982,044	966,056	**15,988**
	BLANCO	3	22	322	311	**11**	5,844	5,692	**153**
	BORDEN	3	19	351	341	**11**	7,687	7,596	**91**
	BOSQUE	2	6	94	90	**4**	2,318	2,280	**38**
	BRAZOS	2	1,230	19,809	19,127	**730**	241,322	232,052	**9,270**
	BREWSTER	3	21	309	300	**9**	9,345	9,220	**125**
	BRISCOE	4	7	107	104	**3**	4,156	4,153	**3**
	BROOKS	2	1	31	30	**1**	262	250	**12**
	BROWN	3	98	1,532	1,477	**59**	37,860	37,244	**616**
	BURLESON	2	36	580	560	**21**	7,063	6,792	**271**
	BURNET	3	658	9,617	9,314	**324**	174,796	170,229	**4,567**
	CALHOUN	2	113	1,841	1,776	**70**	21,662	20,807	**855**
	CALLAHAN	3	12	184	178	**6**	6,446	6,375	**72**
	CAMERON	2	1,576	26,673	25,566	**1,185**	221,903	211,094	**10,809**
	CHEROKEE	2	13	210	205	**5**	3,449	3,384	**65**
	CHILDRESS	3	0	0	0	**0**	0	0	**0**
	CLAY	3	3	46	45	**2**	1,564	1,547	**17**
	COKE	3	3	44	43	**1**	1,334	1,315	**19**
	COLEMAN	3	0	0	0	**0**	0	0	**0**
	COLORADO	2	16	258	249	**9**	3,139	3,019	**121**
	COMANCHE	3	1	16	15	**1**	386	380	**6**
	CONCHO	3	1	15	14	**0**	445	439	**6**
	COOKE	3	68	1,030	1,000	**32**	32,594	32,190	**405**
	CORYELL	2	332	5,190	5,004	**200**	128,261	126,173	**2,088**
	COTTLE	3	0	0	0	**0**	0	0	**0**
	CRANE	3	1	14	14	**0**	456	449	**7**
	CROCKETT	3	19	279	271	**9**	8,455	8,342	**113**
	CROSBY	3	4	74	72	**2**	1,618	1,599	**19**
	CULBERSON	3	0	0	0	**0**	0	0	**0**
	DAWSON	3	0	0	0	**0**	0	0	**0**
	DE WITT	2	4	65	63	**2**	767	737	**30**
	DELTA	3	7	106	103	**3**	3,348	3,309	**39**
	DICKENS	3	0	0	0	**0**	0	0	**0**
	DIMMIT	2	0	0	0	**0**	0	0	**0**
	DUVAL	2	0	0	0	**0**	0	0	**0**
	EASTLAND	3	2	31	30	**1**	1,074	1,062	**12**

Table 9: 2020 Annual Electricity and Natural Gas Savings from New Single-family Residences (Continued)

2020 Summary TRY 2018									
	County	Climate Zone	No. of Projected Units (2020)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2020 Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	2018 Base-year Total Annual NG Use (Therm/yr)	2020 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
	ECTOR	3	898	12,984	12,628	380	408,446	402,798	5,648
	EDWARDS	2	0	0	0	0	0	0	0
	ERATH	3	37	568	550	19	19,876	19,656	220
	FALLS	2	13	203	196	8	5,022	4,940	82
	FANNIN	3	34	515	500	16	16,297	16,095	202
	FAYETTE	2	46	741	715	27	9,025	8,678	347
	FISHER	3	0	0	0	0	0	0	0
	FOARD	3	0	0	0	0	0	0	0
	FRANKLIN	3	5	76	74	2	2,391	2,363	28
	FREESTONE	2	4	63	60	2	1,545	1,520	25
	FRIO	2	8	120	116	4	2,263	2,208	56
	GILLESPIE	3	70	1,023	991	34	18,595	18,109	486
	GLASSCOCK	3	0	0	0	0	0	0	0
	GOLIAD	2	0	0	0	0	0	0	0
	GONZALES	2	14	210	203	7	3,956	3,859	97
	GRAYSON	3	798	12,093	11,740	378	382,503	377,756	4,747
	GRIMES	2	87	1,401	1,353	52	17,069	16,413	656
	HALL	3	0	0	0	0	0	0	0
	HAMILTON	3	13	203	196	8	5,022	4,940	82
	HARDEMAN	3	0	0	0	0	0	0	0
	HASKELL	3	0	0	0	0	0	0	0
	HENDERSON	2	173	2,812	2,745	71	48,538	47,592	946
	HIDALGO	2	3,491	59,083	56,630	2,624	491,538	467,596	23,942
	HILL	2	50	782	754	30	19,316	19,002	314
	HOPKINS	3	13	197	191	6	6,218	6,145	73
	HOUSTON	2	0	0	0	0	0	0	0
	HOWARD	3	43	622	605	18	19,558	19,288	270
	HOOD	2	389	5,784	5,616	181	165,666	163,083	2,583
	HUDSPETH	3	0	0	0	0	0	0	0
	HUNT	2	670	10,153	9,856	318	321,149	317,164	3,986
	IRION	3	0	0	0	0	0	0	0
	JACK	3	0	0	0	0	0	0	0
	JACKSON	2	9	147	141	6	1,725	1,657	68
	JEFF DAVIS	3	0	0	0	0	0	0	0
	JIM HOGG	2	0	0	0	0	0	0	0
	JIM WELLS	2	17	281	270	11	2,829	2,707	123
	JONES	3	1	15	15	1	537	531	6
	KARNES	2	72	1,080	1,044	38	20,345	19,846	500
	KENDALL	3	314	4,621	4,479	153	91,930	89,854	2,076
	KENEDY	2	0	0	0	0	0	0	0
	KENT	3	0	0	0	0	0	0	0
	KERR	3	83	1,213	1,175	41	22,049	21,473	576
ERCOT	KIMBLE	3	0	0	0	0	0	0	0
	KING	3	0	0	0	0	0	0	0
	KINNEY	2	0	0	0	0	0	0	0
	KLEBERG	2	24	392	377	16	3,647	3,482	165
	KNOX	3	0	0	0	0	0	0	0
	LA SALLE	2	11	180	173	8	2,724	2,648	76
	LAMAR	3	24	388	379	10	6,342	6,222	120
	LAMPASAS	3	49	766	738	29	18,930	18,622	308
	LAVACA	2	9	159	152	7	2,240	2,160	79
	LEE	2	15	219	212	7	3,990	3,886	105
	LEON	2	0	0	0	0	0	0	0
	LIMESTONE	2	4	63	60	2	1,545	1,520	25
	LIVE OAK	2	5	83	79	3	832	796	36
	LLANO	3	288	4,209	4,077	142	76,506	74,508	1,999
	LOVING	3	0	0	0	0	0	0	0
	MADISON	2	5	81	78	3	981	943	38
	MARTIN	3	3	43	42	1	1,365	1,346	19
	MASON	3	7	102	99	3	1,860	1,811	49
	MATAGORDA	2	176	2,868	2,766	109	33,739	32,407	1,332
	MAVERICK	2	121	1,981	1,898	89	29,966	29,126	840
	MCCULLOCH	3	0	0	0	0	0	0	0
	MCLENNAN	2	958	14,977	14,438	577	370,101	364,076	6,025
	MCMULLEN	2	0	0	0	0	0	0	0
	MEDINA	2	34	509	493	18	9,607	9,372	236
	MENARD	3	0	0	0	0	0	0	0
	MIDLAND	3	1,289	18,637	18,127	546	586,289	578,182	8,107
	MILAM	2	11	172	166	7	4,250	4,180	69
	MILLS	3	0	0	0	0	0	0	0
	MITCHELL	3	0	0	0	0	0	0	0
	MONTAGUE	3	16	242	235	8	7,669	7,574	95
	MOTLEY	3	0	0	0	0	0	0	0
	NACOGDOCHES	3	23	372	363	10	6,102	5,987	115
	NAVARRO	3	52	813	784	31	20,089	19,762	327
	NOLAN	3	4	61	59	2	2,149	2,125	24
	PALO PINTO	3	11	169	164	6	5,909	5,844	66
	PECOS	3	7	103	100	3	3,115	3,073	42
	POTTER	4	560	9,205	8,860	370	103,662	99,544	4,119
	PRESIDIO	3	9	132	128	4	4,005	3,952	54
	RAINS	3	30	455	441	14	14,349	14,180	168
	REAGAN	3	1	14	14	0	456	449	7
	REAL	2	0	0	0	0	0	0	0
	RED RIVER	3	13	210	205	5	3,435	3,370	65
	REEVES	3	73	1,055	1,027	31	33,203	32,744	459

Table 9: 2020 Annual Electricity and Natural Gas Savings from New Single-family Residences (Continued)

2020 Summary TRY 2018

	County	Climate Zone	No. of Projected Units (2020)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2020 Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	2018 Base-year Total Annual NG Use (Therm/yr)	2020 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
	REFUGIO	2	51	831	802	**31**	9,777	9,391	**386**
	ROBERTSON	2	126	2,029	1,959	**75**	24,721	23,771	**950**
	RUNNELS	3	8	118	114	**4**	3,560	3,512	**48**
	SAN SABA	3	1	15	14	**0**	266	259	**7**
	SCHLEICHER	3	0	0	0	**0**	0	0	**0**
	SCURRY	3	3	55	54	**2**	1,214	1,199	**14**
	SHACKELFORD	3	0	0	0	**0**	0	0	**0**
	SOMERVELL	3	21	322	311	**11**	8,861	8,722	**139**
	STARR	2	1	17	16	**1**	141	134	**7**
	STEPHENS	3	3	46	45	**2**	1,612	1,594	**18**
	STERLING	3	0	0	0	**0**	0	0	**0**
	STONEWALL	3	0	0	0	**0**	0	0	**0**
	SUTTON	3	0	0	0	**0**	0	0	**0**
	TAYLOR	3	384	5,892	5,710	**195**	206,282	203,993	**2,288**
	TERRELL	3	0	0	0	**0**	0	0	**0**
	THROCKMORTON	3	0	0	0	**0**	0	0	**0**
ERCOT	TITUS	3	32	518	505	**13**	8,456	8,296	**160**
	TOM GREEN	3	686	10,081	9,794	**307**	305,273	301,192	**4,081**
	UPTON	3	0	0	0	**0**	0	0	**0**
	UVALDE	2	19	285	275	**10**	5,369	5,237	**132**
	VAL VERDE	2	109	1,633	1,580	**57**	30,800	30,044	**757**
	VAN ZANDT	3	42	637	618	**20**	20,088	19,852	**236**
	WARD	3	0	0	0	**0**	0	0	**0**
	WASHINGTON	2	90	1,449	1,400	**53**	17,658	16,979	**678**
	WEBB	2	1,274	20,855	19,980	**936**	315,509	306,667	**8,842**
	WHARTON	2	171	2,786	2,688	**105**	32,781	31,486	**1,295**
	WICHITA	3	169	2,614	2,531	**89**	88,093	87,145	**948**
	WILBARGER	3	3	46	45	**2**	1,564	1,547	**17**
	WILLACY	2	52	880	844	**39**	7,322	6,965	**357**
	WINKLER	3	2	29	28	**1**	910	897	**13**
	WOOD	3	21	352	343	**10**	6,063	5,952	**111**
	YOUNG	3	7	107	104	**4**	3,760	3,719	**42**
	ZAPATA	2	0	0	0	**0**	0	0	**0**
	ZAVALA	2	0	0	0	**0**	0	0	**0**
	ARMSTRONG	4	2	31	30	**1**	1,187	1,187	**1**
	BAILEY	4	0	0	0	**0**	0	0	**0**
	BOWIE	3	68	1,100	1,073	**29**	17,970	17,630	**340**
	CAMP	3	10	162	158	**4**	2,643	2,593	**50**
	CARSON	4	2	31	30	**1**	1,187	1,187	**1**
	CASS	3	10	162	158	**4**	2,643	2,593	**50**
	CASTRO	4	1	15	15	**0**	594	593	**0**
	COCHRAN	4	0	0	0	**0**	0	0	**0**
	COLLINGSWORTH	3	0	0	0	**0**	0	0	**0**
	DALLAM	4	5	76	74	**2**	2,968	2,966	**2**
	DEAF SMITH	4	2	31	30	**1**	1,187	1,187	**1**
	DONLEY	4	0	0	0	**0**	0	0	**0**
	FLOYD	4	0	0	0	**0**	0	0	**0**
	Gaines	3	2	29	28	**1**	910	897	**13**
	GARZA	3	5	77	74	**3**	2,684	2,653	**31**
	GRAY	4	1	15	15	**0**	594	593	**0**
	HALE	4	22	336	327	**9**	13,061	13,052	**9**
	HANSFORD	4	3	46	45	**1**	1,781	1,780	**1**
	HARTLEY	4	0	0	0	**0**	0	0	**0**
	HEMPHILL	3	0	0	0	**0**	0	0	**0**
	HOCKLEY	4	9	137	134	**4**	5,343	5,339	**4**
	HUTCHINSON	4	1	15	15	**0**	594	593	**0**
	JASPER	2	68	1,092	1,055	**39**	13,527	13,012	**515**
	LAMB	4	9	137	134	**4**	5,343	5,339	**4**
OTHER TEXAS COUNTIES	LIPSCOMB	4	0	0	0	**0**	0	0	**0**
	LUBBOCK	3	2,017	30,933	29,982	**1,017**	1,082,809	1,070,142	**12,667**
	LYNN	3	2	31	30	**1**	1,074	1,061	**13**
	MARION	3	11	178	174	**5**	2,914	2,858	**57**
	MOORE	4	12	183	178	**5**	7,124	7,119	**5**
	MORRIS	3	3	49	47	**1**	793	778	**15**
	NEWTON	2	0	0	0	**0**	0	0	**0**
	OCHILTREE	4	1	15	15	**0**	594	593	**0**
	OLDHAM	4	0	0	0	**0**	0	0	**0**
	PANOLA	3	13	210	205	**5**	3,449	3,384	**65**
	PARMER	4	4	61	59	**2**	2,375	2,373	**2**
	POLK	2	551	8,844	8,549	**315**	109,784	105,613	**4,171**
	RANDALL	4	157	2,397	2,335	**67**	93,208	93,142	**66**
	ROBERTS	4	0	0	0	**0**	0	0	**0**
	SABINE	3	1	16	16	**0**	265	260	**5**
	San Augustine	3	0	0	0	**0**	0	0	**0**
	SAN JACINTO	2	457	7,361	7,108	**271**	89,442	85,982	**3,460**
	SHELBY	3	1	16	16	**0**	265	260	**5**
	SHERMAN	4	12	183	178	**5**	7,124	7,119	**5**
	SWISHER	4	0	0	0	**0**	0	0	**0**
	TERRY	3	5	77	74	**3**	2,684	2,653	**31**
	TRINITY	2	4	64	62	**2**	850	818	**32**
	TYLER	2	22	353	341	**13**	4,383	4,217	**167**
	WALKER	2	455	7,328	7,075	**270**	89,270	85,841	**3,429**
	WHEELER	3	0	0	0	**0**	0	0	**0**
	YOAKUM	4	5	76	74	**2**	2,968	2,966	**2**
	TOTAL		**159,112**			**87,442**			**1,095,455**

Table 10: 2020 Totalized Annual Electricity Savings by Electric Power Markets and CL Zones from New Single-family Residences

Electric Power Market	CL Zone	Total Electricity Savings by CL Zone (MWh) [2020-TRY 2018]
ERCOT	Houston (H)	24,187
	North (N)	26,868
	West (W)	1,668
	South (S)	24,676
SPP	-	1,696
SERC	-	7,385
WECC	-	962
Total		87,442

Table 11: 2020 Annual NOx Reductions from New Single-family Residences Using 2018 eGRID

Area	County	ERCOT-H	NOx Reductions (lbs)	ERCOT-N	NOx Reductions (lbs)	ERCOT-W	NOx Reductions (lbs/year)	ERCOT-S	NOx Reductions (lbs)	SPP	NOx Reductions (lbs)	SERC	NOx Reductions (lbs)	WECC	NOx Reductions (lbs)	Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
Houston-Galveston Area	Brazoria	0.1445243	3495.63	0.0000183	0.49	0.0000009	0.00	0.0013540	33.41	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3529.53	1.76
	Chambers	0.0232302	561.87	0.0000029	0.08	0.0000001	0.00	0.0002176	5.37	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	567.32	0.28
	Fort Bend	0.0925360	2238.18	0.0000117	0.32	0.0000006	0.00	0.0008669	21.39	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2259.89	1.13
	Galveston	0.0189140	457.48	0.0000024	0.06	0.0000001	0.00	0.0001772	4.37	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	461.91	0.23
	Harris	0.1374166	3323.71	0.0000174	0.47	0.0000008	0.00	0.0012874	31.77	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3355.95	1.68
	Liberty	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Montgomery	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0587430	433.82	0.0000000	0.00	433.82	0.22
	Waller	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0027101	20.01	0.0000000	0.00	20.01	0.01
	Jefferson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.9687861	7154.46	0.0000000	0.00	7154.46	3.58
	Orange	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.8865417	6547.09	0.0000000	0.00	6547.09	3.27
Dallas/ Fort Worth Area	Collin	0.0000743	1.80	0.0004556	12.24	0.0000220	0.04	0.0000046	0.11	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	14.19	0.01
	Dallas	0.0019090	46.17	0.0117105	314.64	0.0005656	0.94	0.0001195	2.95	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	364.70	0.18
	Denton	0.0066429	160.67	0.0407509	1094.90	0.0019683	3.28	0.0004158	10.26	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1269.11	0.63
	Henderson	0.0001509	3.65	0.0009255	24.87	0.0000447	0.07	0.0000094	0.23	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	28.82	0.01
	Hood	0.0008451	20.44	0.0051842	139.29	0.0002504	0.42	0.0000529	1.31	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	161.45	0.08
	Hunt	0.0000043	0.10	0.0000263	0.71	0.0000013	0.00	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.82	0.00
	Tarrant	0.0004188	10.13	0.0025693	69.03	0.0001241	0.21	0.0000262	0.65	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	80.02	0.04
	Ellis	0.0013349	32.29	0.0081890	220.02	0.0003955	0.66	0.0000835	2.06	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	255.03	0.13
	Johnson	0.0002010	4.86	0.0012332	33.13	0.0000596	0.10	0.0000126	0.31	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	38.41	0.02
	Kaufman	0.0034596	83.68	0.0212228	570.22	0.0010251	1.71	0.0002165	5.34	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	660.95	0.33
	Parker	0.0005940	14.37	0.0036438	97.90	0.0001760	0.29	0.0000372	0.92	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	113.48	0.06
	Rockwall	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Wise	0.0031300	75.71	0.0192012	515.90	0.0009275	1.55	0.0001959	4.83	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	597.99	0.30
El Paso Area	El Paso	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1.2223686	1175.60	1175.60	0.59
San Antonio Area	Bexar	0.0253670	613.56	0.0017108	45.97	0.0000826	0.14	0.2025905	4999.18	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5658.84	2.83
	Comal	0.0005285	12.78	0.0000356	0.96	0.0000017	0.00	0.0042210	104.16	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	117.90	0.06
	Guadalupe	0.0030546	73.88	0.0002060	5.54	0.0000100	0.02	0.0243949	601.98	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	681.41	0.34
	Wilson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Austin Area	Bastrop	0.0024800	59.98	0.0001673	4.49	0.0000081	0.01	0.0198060	488.74	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	553.23	0.28
	Caldwell	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hays	0.0004731	11.44	0.0000319	0.86	0.0000015	0.00	0.0037782	93.23	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	105.53	0.05
	Travis	0.0046184	111.71	0.0003115	8.37	0.0000150	0.03	0.0368846	910.18	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1030.28	0.52
	Williamson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
North East Texas Area	Gregg	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0053705	9.11	0.0000000	0.00	0.0000000	0.00	9.11	0.00
	Harrison	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2702671	458.48	0.0000000	0.00	0.0000000	0.00	458.48	0.23
	Rusk	0.0322708	780.54	0.1979648	5318.94	0.0095620	15.94	0.0020197	49.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6165.26	3.08
	Smith	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upshur	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Corpus Christi Area	Nueces	0.0042426	102.62	0.0002861	7.69	0.0000138	0.02	0.0338828	836.10	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	946.43	0.47
	San Patricio	0.0063692	154.05	0.0004296	11.54	0.0000207	0.03	0.0508668	1255.20	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1420.83	0.71
Victoria Area	Victoria	0.0016730	40.47	0.0001128	3.03	0.0000054	0.01	0.0133614	329.71	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	373.22	0.19
Other ERCOT Counties	Anderson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Angelina	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Atascosa	0.0077084	186.44	0.0005199	13.97	0.0000251	0.04	0.0615620	1519.12	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1719.58	0.86
	Bell	0.0004444	10.75	0.0027262	73.25	0.0001317	0.22	0.0000278	0.69	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	84.90	0.04
	Bosque	0.0007214	17.45	0.0044257	118.91	0.0002138	0.36	0.0000452	1.11	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	137.83	0.07
	Brazos	0.0005654	13.68	0.0034687	93.20	0.0001675	0.28	0.0000354	0.87	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	108.03	0.05
	Calhoun	0.0111852	270.54	0.0007544	20.27	0.0000364	0.06	0.0893292	2204.31	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2495.18	1.25
	Cameron	0.0000231	0.56	0.0000016	0.04	0.0000001	0.00	0.0001843	4.55	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5.15	0.00
	Cherokee	0.0001844	4.46	0.0011310	30.39	0.0000546	0.09	0.0000115	0.28	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	35.22	0.02
	Coke	0.0000223	0.54	0.0001365	3.67	0.0231815	38.66	0.0000014	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	42.90	0.02
	Colorado	0.0016158	39.08	0.0001090	2.93	0.0000053	0.01	0.0129041	318.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	360.44	0.18
	Ector	0.0001338	3.24	0.0008206	22.05	0.1393442	232.36	0.0000084	0.21	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	257.85	0.13
	Fayette	0.0204274	494.08	0.0013777	37.02	0.0000665	0.11	0.1631405	4025.71	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4556.91	2.28
	Freestone	0.0042261	102.22	0.0259247	696.55	0.0012522	2.09	0.0002645	6.53	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	807.38	0.40
	Frio	0.0097614	236.10	0.0006583	17.69	0.0000318	0.05	0.0779581	1923.72	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2177.56	1.09
	Goliad	0.0077047	186.36	0.0005196	13.96	0.0000251	0.04	0.0615328	1518.40	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1718.76	0.86
	Grayson	0.0002857	6.91	0.0017525	47.09	0.0000846	0.14	0.0000179	0.44	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	54.58	0.03
	Grimes	0.0029942	72.42	0.0183678	493.51	0.0008872	1.48	0.0001874	4.62	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	572.03	0.29
	Hidalgo	0.0140830	340.63	0.0009498	25.52	0.0000459	0.08	0.1124720	2775.39	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3141.62	1.57
	Hill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Howard	0.0000467	1.13	0.0002865	7.70	0.0486558	81.13	0.0000029	0.07	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	90.03	0.05
	Lamar	0.0031379	75.90	0.0192492	517.19	0.0009298	1.55	0.0001964	4.85	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	599.48	0.30
	Limestone	0.0231674	560.35	0.1421203	3818.50	0.0068646	11.45	0.0014500	35.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4426.08	2.21
	Llano	0.0001855	4.49	0.0000125	0.34	0.0000006	0.00	0.0014818	36.56	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	41.39	0.02
	McLennan	0.0043688	105.67	0.0268006	720.08	0.0012945	2.16	0.0002734	6.75	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	834.66	0.42
	Milam	0.0002486	6.01	0.0000168	0.45	0.0000008	0.00	0.0019850	48.98	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	55.45	0.03
	Mitchell	0.0000072	0.17	0.0000443	1.19	0.0075244	12.55	0.0000005	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	13.92	0.01
	Nacogdoches	0.0002714	6.56	0.0016647	44.73	0.0000804	0.13	0.0000170	0.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	51.84	0.03
	Nolan	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Palo Pinto	0.0010391	25.13	0.0063745	171.27	0.0003079	0.51	0.0000650	1.60	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	198.52	0.10
	Pecos	0.0000029	0.07	0.0000180	0.48	0.0030637	5.11	0.0000002	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5.67	0.00
	Reagan	0.0000002	0.01	0.0000015	0.04	0.0002476	0.41	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.46	0.00
	Red River	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Robertson	0.0184177	445.47	0.1129830	3035.64	0.0054573	9.10	0.0011527	28.44	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3518.65	1.76
	Scurry	0.0001246	3.01	0.0007646	20.54	0.1298311	216.49	0.0000078	0.19	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	240.24	0.12
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Ward	0.0000206	0.50	0.0001265	3.40	0.0214790	35.82	0.0000013	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	39.75	0.02
	Webb	0.0000253	0.61	0.0000017	0.05	0.0000001	0.00	0.0002020	4.98	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5.64	0.00
	Wharton	0.0006585	15.93	0.0000444	1.19	0.0000021	0.00	0.0052594	129.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	146.91	0.07
	Wichita	0.0000051	0.12	0.0000315	0.85	0.0053432	8.91	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	9.89	0.00
	Wilbarger	0.0008609	20.82	0.0052810	141.89	0.8967472	1495.33	0.0000539	1.33	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1659.38	0.83
	Wood	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Young	0.0000257	0.62	0.0001578	4.24	0.0267892	44.67	0.0000016	0.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	49.57	0.02
Other SPP Counties	Cass	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0127595	21.65	0.0000000	0.00	0.0000000	0.00	21.65	0.01
	Gaines	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Gray	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hale	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0616792	104.63	0.0000000	0.00	0.0000000	0.00	104.63	0.05
	Hemphill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0246062	41.74	0.0000000	0.00	0.0000000	0.00	41.74	0.02
	Hutchinson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0134856	22.88	0.0000000	0.00	0.0000000	0.00	22.88	0.01
	Lamb	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2117054	359.14	0.0000000	0.00	0.0000000	0.00	359.14	0.18
	Lubbock	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0695988	118.07	0.0000000	0.00	0.0000000	0.00	118.07	0.06
	Marion	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0272898	46.29	0.0000000	0.00	0.0000000	0.00	46.29	0.02
	Moore	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Morris	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0002270	0.39	0.0000000	0.00	0.0000000	0.00	0.39	0.00
	Potter	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2710995	459.89	0.0000000	0.00	0.0000000	0.00	459.89	0.23
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Yoakum	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0438855	74.45	0.0000000	0.00	0.0000000	0.00	74.45	0.04
Other SERC Counties	Jasper	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Newton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0870000	642.49	0.0000000	0.00	642.49	0.32
	San Jacinto	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0072219	53.33	0.0000000	0.00	53.33	0.03
	Tyler	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Total	**0.6511639**	**15749.78**	**0.6960448**	**18701.41**	**1.3354567**	**2226.88**	**0.9887171**	**24397.88**	**1.3648074**	**2315.25**	**2.0110028**	**14851.21**	**1.2223686**	**1175.60**	**79418.01**	**39.71**

Energy Savings (MWh)		24,187		26,868		1,668		24,676		1,696		7,385		962	

4.2 2020 Results for New Multi-family Residential Construction

This section provides the potential electricity and natural gas savings and the associated NOx emissions reductions in 2020 using the 2018 base year which implemented the 2015 IECC for new multi-family residences in the 42 non-attainment and affected counties as well as other counties in the ERCOT region[14]. To calculate the NOx emissions reductions, the following procedures were adopted. First, new construction activity was determined by county. To accomplish this, the number of 2020 building permits per county was obtained from the Real Estate Center at Texas A&M University (REC 2021). Next, energy savings attributable to the 2015 IECC were calculated using the Laboratory's code-traceable, DOE-2.1e simulation, which was developed for the TERP. For the savings calculation, the 2020 HIRL's survey data[15] were used to determine the appropriate construction data corresponding to housing types. Then, the NOx reductions potential from the electricity and natural gas savings in each county was calculated using the US EPA's 2018 eGRID database[16].

In Table 12, the 2020 new multi-family and 2015 IECC code-compliant building characteristics are shown for each county. The 2015 IECC code-compliant characteristics are the minimum building code characteristics required for each county for multi-family residences (i.e., Type A.2). In Table 12, the rows are first sorted by the US EPA's non-attainment, affected designation, and other ERCOT counties, alphabetically. Next, in the fourth column, the HIRL's survey classification is listed. The fifth through eighth columns show the HIRL's survey data including: average glazing U-value, Solar Heat Gain Coefficient (SHGC), roof insulation, and wall insulation, respectively. In addition, the ninth through twelfth columns show the 2015 IECC minimum requirements for glazing U-value, SHGC, roof insulation, and wall insulation.

The corresponding values in IECC and effective regulations are applied to the air-conditioner efficiency, furnace efficiency (AFUE), and domestic water heater efficiency. The values shown in Table 12 represent the changes for building envelope that were made to the simulations to obtain the savings calculations. In cases where the 2020 new multi-family values were more efficient than the 2015 IECC requirements, the 2020 new multi-family values were used in 2020 new multi-family simulations. Otherwise, the 2015 IECC values were used in both simulations. For the 2020 new multi-family simulations, the more efficient values from 2020 HIRL data and 2015 IECC were applied. Similarly, for the base-year simulations, the more efficient values from 2018 HIRL data and 2015 IECC were used.

In Table 13, the code-traceable simulation results for multi-family residences are shown for each county. In a similar fashion to Table 12, Table 13 is first divided into the US EPA's non-attainment and affected classifications, followed by an alphabetical list of other ERCOT counties. In the third column, the 2015 IECC climate zone is listed followed by the number of new projected housing units[17] in the fourth column. In the fifth column, the total simulated energy use is listed if all-new Construction had been built to 2018 base-year specifications. In the sixth column, the total county-wide energy use for the 2020 Construction is shown. The values in the fifth and sixth columns come from the associated 144 simulation runs for each county, which were then distributed according to the HIRL's survey data to account for 1, 2 or 3 story, and 3 different fuel options (i.e., central air conditioning with electric resistance heating, heat pump heating, or a natural gas-fired furnace). In the seventh column, the total annual electricity savings are shown for each county. A 7% transmission and distribution loss is used, which represents a fixed 1.07 multiplier for electricity use. In the eighth and ninth columns, the total annual 2018 base-year and 2020 natural gas use is shown for those residences that had natural gas-fired furnaces and domestic water heaters. Finally, in the tenth column, the total annual natural gas savings are shown for each county.

The annual electricity savings from Table 13 are assigned to CL Zones[18] in a similar fashion to the single-family residential assignments. The total electricity savings for each CL Zone, as shown in Table 14, are then entered into the bottom row of Table 15, the 2018 US EPA's eGRID database for Texas. Next, the county's NOx reductions (lbs) are calculated using the assigned 2018 eGRID proportions (lbs-NOx/MWh) to each electric power market and each CL zone in the county. The calculated NOx reductions are presented in the columns adjacent to the corresponding

[19] The three new counties added in the 2003 Legislative session (i.e., Henderson, Hood, and Hunt) were included in the ERCOT region.
[20] The NAHB Research Center announced that it has changed its name to Home Innovation Research Labs (HIRL). See more at: http://www.homeinnovation.com
[21] This analysis assumes transmission and distribution losses of 7%. Counties were assigned to utility service districts as indicated.
[22] The number of the new housing units in 2020 were obtained from the Real Estate Center at Texas A&M University.
[23] ERCOT region has employed the Competitive Load (CL), and it is currently divided into four zones: Houston (H), North (N), South (S), and West (W).

CL Zone columns. By adding the NOx reductions values in each row, then, the total of the NOx reductions per county (lbs and Tons) is calculated. Counties that do not show NOx reductions represent counties that do not have power plants in eGRID's database.

Table 12: 2020 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences

	County	Climate Zone	Division	2020 Average				2015 IECC			
			East or West	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)	Glazing U-value (Btu/hr-ft^2-F)	SHGC	Roof Insulation (hr-ft^2-F/Btu)	Wall Insulation (hr-ft^2-F/Btu)
Non-attainment	BRAZORIA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CHAMBERS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	COLLIN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DALLAS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DENTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	EL PASO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ELLIS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FORT BEND	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GALVESTON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HARRIS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	JOHNSON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KAUFMAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	LIBERTY	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MONTGOMERY	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	PARKER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ROCKWALL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TARRANT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	WALLER	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WISE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
Affected	BASTROP	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BEXAR	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CALDWELL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	COMAL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GREGG	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	GUADALUPE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HARRISON	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HAYS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	NUECES	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	RUSK	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SAN PATRICIO	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	SMITH	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TRAVIS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	UPSHUR	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	VICTORIA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WILLIAMSON	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WILSON	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
ERCOT	ANDERSON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ANDREWS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ANGELINA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ARANSAS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ARCHER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ATASCOSA	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	AUSTIN	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BANDERA	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BASTROP	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BAYLOR	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	BEE	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BELL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BEXAR	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BLANCO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	BORDEN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	BOSQUE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BRAZORIA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BRAZOS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BREWSTER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	BRISCOE	4	West Texas	0.39	0.53	35.2	15.5	0.35	0.4	49	20
	BROOKS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BROWN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	BURLESON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	BURNET	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CALDWELL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CALHOUN	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CALLAHAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CAMERON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CHAMBERS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CHEROKEE	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	CHILDRESS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CLAY	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	COKE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	COLEMAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	COLLIN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	COLORADO	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	COMAL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	COMANCHE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CONCHO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	COOKE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CORYELL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	COTTLE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20

Table 12: 2020 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences (Continued)

	County	Climate Zone	Division East or West	2020 Average Glazing U-value (Btu/hr-ft^2-F)	2020 Average SHGC	2020 Average Roof Insulation (hr-ft^2-F/Btu)	2020 Average Wall Insulation (hr-ft^2-F/Btu)	2015 IECC Glazing U-value (Btu/hr-ft^2-F)	2015 IECC SHGC	2015 IECC Roof Insulation (hr-ft^2-F/Btu)	2015 IECC Wall Insulation (hr-ft^2-F/Btu)
ERCOT	CRANE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CROCKETT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CROSBY	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	CULBERSON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DALLAS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DAWSON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DE WITT	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	DELTA	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DENTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DICKENS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	DIMMIT	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	DUVAL	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	EASTLAND	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ECTOR	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	EDWARDS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ELLIS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ERATH	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FALLS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	FANNIN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FAYETTE	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	FISHER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FOARD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FORT BEND	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	FRANKLIN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	FREESTONE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	FRIO	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GALVESTON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GILLESPIE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	GLASSCOCK	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	GOLIAD	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GONZALES	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GRAYSON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	GRIMES	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	GUADALUPE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HALL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HAMILTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HARDEMAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HARRIS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HASKELL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HAYS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HENDERSON	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HIDALGO	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HILL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HOOD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HOPKINS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HOUSTON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	HOWARD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HUDSPETH	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	HUNT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	IRION	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	JACK	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	JACKSON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	JEFF DAVIS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	JIM HOGG	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	JIM WELLS	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	JOHNSON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	JONES	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KARNES	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	KAUFMAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KENDALL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KENEDY	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	KENT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KERR	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KIMBLE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KING	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	KINNEY	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	KLEBERG	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	KNOX	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	LA SALLE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	LAMAR	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	LAMPASAS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	LAVACA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	LEE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	LEON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13

Table 12: 2020 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences (Continued)

	County	Climate Zone	Division	2020 Average				2015 IECC			
			East or West	Glazing U-value (Btu/hr-ft²-F)	SHGC	Roof Insulation (hr-ft²-F/Btu)	Wall Insulation (hr-ft²-F/Btu)	Glazing U-value (Btu/hr-ft²-F)	SHGC	Roof Insulation (hr-ft²-F/Btu)	Wall Insulation (hr-ft²-F/Btu)
ERCOT	LIMESTONE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	LIVE OAK	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	LLANO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	LOVING	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MADISON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MARTIN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MASON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MATAGORDA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MAVERICK	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MCCULLOCH	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MCLENNAN	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MCMULLEN	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MEDINA	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MENARD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MIDLAND	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MILAM	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MILLS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MITCHELL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MONTAGUE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	MONTGOMERY	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	MOTLEY	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	NACOGDOCHES	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	NAVARRO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	NOLAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	NUECES	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	PALO PINTO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	PARKER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	PECOS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	PRESIDIO	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	RAINS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	REAGAN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	REAL	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	RED RIVER	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	REEVES	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	REFUGIO	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ROBERTSON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ROCKWALL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	RUNNELS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	RUSK	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SAN PATRICIO	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	SAN SABA	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SCHLEICHER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SCURRY	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SHACKELFORD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SMITH	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SOMERVELL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	STARR	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	STEPHENS	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	STERLING	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	STONEWALL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	SUTTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TARRANT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TAYLOR	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TERRELL	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	THROCKMORTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TITUS	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TOM GREEN	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	TRAVIS	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	UPTON	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	UVALDE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	VAL VERDE	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	VAN ZANDT	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	VICTORIA	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WALLER	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WARD	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	WASHINGTON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WEBB	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WHARTON	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WICHITA	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	WILBARGER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	WILLACY	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WILLIAMSON	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WILSON	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	WINKLER	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	WISE	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	YOUNG	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	ZAPATA	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	ZAVALA	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13

Table 13: 2020 Annual Electricity and Natural Gas Savings from New Multi-family Residences

2020 Summary TRY 2018									
	County	Climate Zone	No. of Projected Units (2020)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2020 Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	2018 Base-year Total Annual NG Use (Therm/yr)	2020 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Nonattain-ment County	BRAZORIA	2	2	193	187	6.06	1,335	1,314	21.01
	CHAMBERS	2	0	0	0	0.00	0	0	0.00
	COLLIN	2	2,208	212,936	207,631	5,676.13	2,400,163	2,343,313	56,849.89
	DALLAS	2	5,051	488,015	475,277	13,629.74	4,898,327	4,787,886	110,441.13
	DENTON	2	2,752	266,103	259,143	7,446.88	2,662,658	2,601,870	60,788.33
	EL PASO	3	232	21,458	20,975	516.36	201,353	197,145	4,208.71
	ELLIS	3	183	17,681	17,220	493.81	177,469	173,467	4,001.33
	FORT BEND	2	2,690	256,461	249,363	7,595.16	1,882,038	1,847,332	34,706.68
	GALVESTON	2	352	33,897	32,900	1,066.91	235,021	231,322	3,698.20
	HARDIN	2	150	14,285	13,898	414.72	106,694	104,679	2,014.89
	HARRIS	2	16,127	1,537,527	1,494,971	45,534.25	11,283,136	11,075,063	208,072.36
	JEFFERSON	2	34	3,238	3,150	94.06	24,173	23,722	451.34
	JOHNSON	3	1,217	117,584	114,514	3,283.98	1,180,215	1,153,605	26,609.95
	KAUFMAN	2	208	20,059	19,559	534.71	226,102	220,747	5,355.42
	LIBERTY	3	0	0	0	0.00	0	0	0.00
	MONTGOMERY	3	1,318	125,656	122,178	3,721.35	922,129	905,124	17,004.98
	ORANGE	2	14	1,334	1,297	38.74	9,954	9,770	183.64
	PARKER	2	596	56,689	55,323	1,461.56	573,106	560,495	12,610.99
	ROCKWALL	2	393	37,900	36,956	1,010.29	427,203	417,084	10,118.66
	TARRANT	3	3,958	382,412	372,431	10,680.36	3,838,364	3,751,822	86,542.46
	WALLER	2	136	12,966	12,607	383.99	95,151	93,397	1,754.69
	WISE	3	7	675	658	17.99	7,609	7,429	180.23
Affected County	BASTROP	3	15	1,426	1,387	41.98	10,235	10,060	175.41
	BEXAR	3	5,055	487,040	473,170	14,841.84	3,598,589	3,528,715	69,874.01
	CALDWELL	3	66	6,275	6,103	184.69	0	0	0.00
	COMAL	3	808	77,849	75,632	2,372.35	575,205	564,036	11,168.78
	GREGG	2	16	1,495	1,461	36.56	14,051	13,763	288.47
	GUADALUPE	3	291	28,037	27,239	854.40	207,159	203,137	4,022.42
	HARRISON	3	0	0	0	0.00	0	0	0.00
	HAYS	3	829	78,834	76,663	2,323.17	565,443	555,979	9,463.81
	NUECES	2	187	18,315	17,750	603.89	119,339	117,490	1,849.90
	RUSK	2	0	0	0	0.00	0	0	0.00
	SAN PATRICIO	3	90	8,815	8,543	290.64	57,436	56,546	890.32
	SMITH	3	193	18,047	17,642	432.65	177,325	173,485	3,840.08
	TRAVIS	3	16,749	1,592,748	1,548,882	46,937.10	11,424,125	11,232,920	191,205.51
	UPSHUR	3	8	748	731	18.31	7,021	6,875	146.32
	VICTORIA	2	0	0	0	0.00	0	0	0.00
	WILLIAMSON	2	2,046	197,540	192,161	5,755.74	1,731,015	1,691,105	39,910.52
	WILSON	2	0	0	0	0.00	0	0	0.00
ERCOT	ANDERSON	2	155	14,476	14,147	352.51	136,306	133,409	2,896.79
	ANDREWS	3	0	0	0	0.00	0	0	0.00
	ANGELINA	2	2	187	183	4.55	1,759	1,721	37.38
	ARANSAS	2	0	0	0	0.00	0	0	0.00
	ARCHER	3	6	588	570	18.48	7,058	6,845	212.47
	ATASCOSA	2	0	0	0	0.00	0	0	0.00
	AUSTIN	2	0	0	0	0.00	0	0	0.00
	BANDERA	2	0	0	0	0.00	0	0	0.00
	BAYLOR	3	0	0	0	0.00	0	0	0.00
	BEE	2	12	1,157	1,124	35.42	8,370	8,223	146.91
	BELL	2	566	56,027	54,162	1,995.80	516,287	501,967	14,319.84
	BLANCO	3	2	190	185	5.60	1,364	1,341	22.83
	BORDEN	3	0	0	0	0.00	0	0	0.00
	BOSQUE	2	0	0	0	0.00	0	0	0.00
	BRAZOS	2	707	67,404	65,539	1,996.20	494,647	485,525	9,121.79
	BREWSTER	3	0	0	0	0.00	0	0	0.00
	BRISCOE	4	0	0	0	0.00	0	0	0.00
	BROOKS	2	0	0	0	0.00	0	0	0.00
	BROWN	3	4	396	383	14.10	3,649	3,547	101.20
	BURLESON	2	0	0	0	0.00	0	0	0.00
	BURNET	3	62	5,896	5,734	173.75	42,289	41,581	707.79
	CALHOUN	2	26	2,506	2,435	76.75	18,136	17,817	318.30
	CALLAHAN	3	2	195	190	6.08	2,430	2,355	74.71
	CAMERON	2	328	33,049	31,838	1,294.97	189,927	187,111	2,815.51
	CHEROKEE	2	0	0	0	0.00	0	0	0.00
	CHILDRESS	3	0	0	0	0.00	0	0	0.00
	CLAY	3	4	392	380	12.32	4,705	4,563	141.65
	COKE	3	0	0	0	0.00	0	0	0.00
	COLEMAN	3	0	0	0	0.00	0	0	0.00
	COLORADO	2	0	0	0	0.00	0	0	0.00
	COMANCHE	3	0	0	0	0.00	0	0	0.00
	CONCHO	3	0	0	0	0.00	0	0	0.00
	COOKE	3	0	0	0	0.00	0	0	0.00
	CORYELL	2	140	13,858	13,397	493.66	127,704	124,161	3,542.01
	COTTLE	3	0	0	0	0.00	0	0	0.00
	CRANE	3	0	0	0	0.00	0	0	0.00
	CROCKETT	3	0	0	0	0.00	0	0	0.00
	CROSBY	3	0	0	0	0.00	0	0	0.00
	CULBERSON	3	48	4,473	4,358	123.70	42,108	41,046	1,061.95
	DAWSON	3	0	0	0	0.00	0	0	0.00
	DEWITT	2	0	0	0	0.00	0	0	0.00
	DELTA	3	2	193	188	5.14	2,174	2,123	51.49
	DICKENS	3	0	0	0	0.00	0	0	0.00
	DIMMIT	2	0	0	0	0.00	0	0	0.00
	DUVAL	2	0	0	0	0.00	0	0	0.00
	EASTLAND	3	0	0	0	0.00	0	0	0.00

Table 13: 2020 Annual Electricity and Natural Gas Savings from New Multi-family Residences (Continued)

2020 Summary TRY 2018									
	County	Climate Zone	No. of Projected Units (2020)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2020 Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	2018 Base-year Total Annual NG Use (Therm/yr)	2020 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
ERCOT	ECTOR	3	290	27,404	26,693	761.13	298,466	289,871	8,595.66
	EDWARDS	2	0	0	0	0.00	0	0	0.00
	ERATH	3	25	2,443	2,372	75.96	30,373	29,439	933.85
	FALLS	2	0	0	0	0.00	0	0	0.00
	FANNIN	3	8	771	752	20.53	8,711	8,500	210.82
	FAYETTE	2	2	191	185	5.65	1,399	1,373	25.80
	FISHER	3	0	0	0	0.00	0	0	0.00
	FOARD	3	0	0	0	0.00	0	0	0.00
	FRANKLIN	3	0	0	0	0.00	0	0	0.00
	FREESTONE	2	0	0	0	0.00	0	0	0.00
	FRIO	2	0	0	0	0.00	0	0	0.00
	GILLESPIE	3	2	190	185	5.60	1,364	1,341	22.83
	GLASSCOCK	3	0	0	0	0.00	0	0	0.00
	GOLIAD	2	0	0	0	0.00	0	0	0.00
	GONZALES	2	0	0	0	0.00	0	0	0.00
	GRAYSON	3	383	36,927	36,008	982.94	417,019	406,926	10,092.90
	GRIMES	2	0	0	0	0.00	0	0	0.00
	HALL	3	0	0	0	0.00	0	0	0.00
	HAMILTON	3	0	0	0	0.00	0	0	0.00
	HARDEMAN	3	0	0	0	0.00	0	0	0.00
	HASKELL	3	0	0	0	0.00	0	0	0.00
	HENDERSON	2	30	2,805	2,742	67.25	27,563	26,967	596.90
	HIDALGO	2	1,403	141,363	136,186	5,539.15	812,401	800,357	12,043.17
	HILL	2	0	0	0	0.00	0	0	0.00
	HOOD	3	0	0	0	0.00	0	0	0.00
	HOPKINS	3	0	0	0	0.00	0	0	0.00
	HOUSTON	2	0	0	0	0.00	0	0	0.00
	HOWARD	3	2	189	184	5.25	2,058	1,999	59.28
	HUDSPETH	3	0	0	0	0.00	0	0	0.00
	HUNT	2	234	22,561	22,000	600.54	254,785	248,618	6,166.42
	IRION	3	0	0	0	0.00	0	0	0.00
	JACK	3	0	0	0	0.00	0	0	0.00
	JACKSON	2	0	0	0	0.00	0	0	0.00
	JEFF DAVIS	3	0	0	0	0.00	0	0	0.00
	JIM HOGG	2	0	0	0	0.00	0	0	0.00
	JIM WELLS	2	0	0	0	0.00	0	0	0.00
	JONES	3	0	0	0	0.00	0	0	0.00
	KARNES	2	0	0	0	0.00	0	0	0.00
	KENDALL	3	0	0	0	0.00	0	0	0.00
	KENEDY	2	0	0	0	0.00	0	0	0.00
	KENT	3	0	0	0	0.00	0	0	0.00
	KERR	3	8	761	740	22.42	5,457	5,365	91.33
	KIMBLE	3	0	0	0	0.00	0	0	0.00
	KING	3	0	0	0	0.00	0	0	0.00
	KINNEY	2	0	0	0	0.00	0	0	0.00
	KLEBERG	2	20	1,973	1,905	72.50	12,080	11,905	174.48
	KNOX	3	0	0	0	0.00	0	0	0.00
	LA SALLE	2	0	0	0	0.00	0	0	0.00
	LAMAR	3	10	964	940	25.71	10,870	10,613	257.47
	LAMPASAS	3	0	0	0	0.00	0	0	0.00
	LAVACA	2	0	0	0	0.00	0	0	0.00
	LEE	2	8	761	740	22.39	5,459	5,365	93.55
	LEON	2	0	0	0	0.00	0	0	0.00
	LIMESTONE	2	0	0	0	0.00	0	0	0.00
	LIVE OAK	2	0	0	0	0.00	0	0	0.00
	LLANO	3	12	1,141	1,110	33.63	8,185	8,048	136.99
	LOVING	3	0	0	0	0.00	0	0	0.00
	MADISON	2	0	0	0	0.00	0	0	0.00
	MARTIN	3	0	0	0	0.00	0	0	0.00
	MASON	3	0	0	0	0.00	0	0	0.00
	MATAGORDA	2	0	0	0	0.00	0	0	0.00
	MAVERICK	2	18	1,763	1,709	58.13	11,487	11,309	178.06
	MCCULLOCH	3	0	0	0	0.00	0	0	0.00
	MCLENNAN	2	243	24,054	23,253	856.86	221,657	215,509	6,147.92
	MCMULLEN	2	0	0	0	0.00	0	0	0.00
	MEDINA	2	2	193	187	5.87	1,424	1,396	27.65
	MENARD	3	0	0	0	0.00	0	0	0.00
	MIDLAND	3	0	0	0	0.00	0	0	0.00
	MILAM	2	0	0	0	0.00	0	0	0.00
	MILLS	3	0	0	0	0.00	0	0	0.00
	MITCHELL	3	0	0	0	0.00	0	0	0.00
	MONTAGUE	3	0	0	0	0.00	0	0	0.00
	MOTLEY	3	0	0	0	0.00	0	0	0.00
	NACOGDOCHES	3	2	187	183	4.55	1,759	1,721	37.38
	NAVARRO	3	18	1,782	1,722	63.47	16,419	15,964	455.40
	NOLAN	3	0	0	0	0.00	0	0	0.00
	PALO PINTO	3	0	0	0	0.00	0	0	0.00
	PECOS	3	40	3,834	3,729	112.83	41,225	40,081	1,143.96
	POTTER	4	285	27,445	26,637	863.84	190,287	187,292	2,994.28
	PRESIDIO	3	0	0	0	0.00	0	0	0.00
	RAINS	3	0	0	0	0.00	0	0	0.00
	REAGAN	3	0	0	0	0.00	0	0	0.00
	REAL	2	0	0	0	0.00	0	0	0.00
	RED RIVER	3	0	0	0	0.00	0	0	0.00
	REEVES	3	0	0	0	0.00	0	0	0.00

Table 13: 2020 Annual Electricity and Natural Gas Savings from New Multi-family Residences (Continued)

2020 Summary TRY 2018									
	County	Climate Zone	No. of Projected Units (2020)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2020 Total Annual Elec. Use (MWh/yr)	Total Annual Elec. Savings (MWh/yr) w/ 7% of T&D Loss	2018 Base-year Total Annual NG Use (Therm/yr)	2020 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
ERCOT	REFUGIO	2	32	3,085	2,996	94.47	22,321	21,929	391.75
	ROBERTSON	2	4	381	371	11.29	2,799	2,747	51.61
	RUNNELS	3	0	0	0	0.00	0	0	0.00
	SAN SABA	3	0	0	0	0.00	0	0	0.00
	SCHLEICHER	3	0	0	0	0.00	0	0	0.00
	SCURRY	3	0	0	0	0.00	0	0	0.00
	SHACKELFORD	3	0	0	0	0.00	0	0	0.00
	SOMERVELL	3	0	0	0	0.00	0	0	0.00
	STARR	2	0	0	0	0.00	0	0	0.00
	STEPHENS	3	0	0	0	0.00	0	0	0.00
	STERLING	3	0	0	0	0.00	0	0	0.00
	STONEWALL	3	0	0	0	0.00	0	0	0.00
	SUTTON	3	0	0	0	0.00	0	0	0.00
	TAYLOR	3	264	25,801	25,051	802.14	320,742	310,881	9,861.42
	TERRELL	3	0	0	0	0.00	0	0	0.00
	THROCKMORTON	3	0	0	0	0.00	0	0	0.00
	TITUS	3	16	1,543	1,505	41.13	17,392	16,981	411.96
	TOM GREEN	3	0	0	0	0.00	0	0	0.00
	UPTON	3	0	0	0	0.00	0	0	0.00
	UVALDE	2	0	0	0	0.00	0	0	0.00
	VAL VERDE	2	0	0	0	0.00	0	0	0.00
	VAN ZANDT	3	4	386	376	10.28	4,348	4,245	102.99
	WARD	3	0	0	0	0.00	0	0	0.00
	WASHINGTON	2	506	48,241	46,906	1,428.68	354,019	347,491	6,528.47
	WEBB	2	173	16,944	16,422	558.68	110,405	108,694	1,711.40
	WHARTON	2	2	193	187	5.90	1,395	1,371	24.48
	WICHITA	3	18	1,763	1,711	55.45	21,173	20,535	637.41
	WILBARGER	3	0	0	0	0.00	0	0	0.00
	WILLACY	2	0	0	0	0.00	0	0	0.00
	WINKLER	3	0	0	0	0.00	0	0	0.00
	WOOD	3	4	374	365	9.15	3,511	3,437	73.16
	YOUNG	3	0	0	0	0.00	0	0	0.00
	ZAPATA	2	0	0	0	0.00	0	0	0.00
	ZAVALA	2	0	0	0	0.00	0	0	0.00
OTHER TEXAS COUNTIES	ARMSTRONG	4	0	0	0	0.00	0	0	0.00
	BAILEY	4	0	0	0	0.00	0	0	0.00
	BOWIE	3	4	0	0	0.00	0	0	0.00
	CAMP	3	0	0	0	0.00	0	0	0.00
	CARSON	4	0	0	0	0.00	0	0	0.00
	CASS	3	8	0	0	0.00	0	0	0.00
	CASTRO	4	0	0	0	0.00	0	0	0.00
	COCHRAN	4	0	0	0	0.00	0	0	0.00
	COLLINGSWORTH	3	0	0	0	0.00	0	0	0.00
	DALLAM	4	0	0	0	0.00	0	0	0.00
	DEAF SMITH	4	0	0	0	0.00	0	0	0.00
	DONLEY	4	0	0	0	0.00	0	0	0.00
	FLOYD	4	0	0	0	0.00	0	0	0.00
	Gaines	3	0	0	0	0.00	0	0	0.00
	GARZA	3	0	0	0	0.00	0	0	0.00
	GRAY	4	0	0	0	0.00	0	0	0.00
	HALE	4	0	0	0	0.00	0	0	0.00
	HANSFORD	4	0	0	0	0.00	0	0	0.00
	HARTLEY	4	0	0	0	0.00	0	0	0.00
	HEMPHILL	3	0	0	0	0.00	0	0	0.00
	HOCKLEY	4	0	0	0	0.00	0	0	0.00
	HUTCHINSON	4	0	0	0	0.00	0	0	0.00
	JASPER	2	209	19,908	19,368	578.32	148,594	145,853	2,741.44
	LAMB	4	4	389	380	9.41	5,315	5,249	65.35
	LIPSCOMB	4	0	0	0	0.00	0	0	0.00
	LUBBOCK	3	1,834	179,153	173,972	5,543.96	2,226,978	2,158,881	68,096.95
	LYNN	3	0	0	0	0.00	0	0	0.00
	MARION	3	0	0	0	0.00	0	0	0.00
	MOORE	4	0	0	0	0.00	0	0	0.00
	MORRIS	3	0	0	0	0.00	0	0	0.00
	NEWTON	2	0	0	0	0.00	0	0	0.00
	OCHILTREE	4	0	0	0	0.00	0	0	0.00
	OLDHAM	4	0	0	0	0.00	0	0	0.00
	PANOLA	3	0	0	0	0.00	0	0	0.00
	PARMER	4	0	0	0	0.00	0	0	0.00
	POLK	2	14	1,333	1,297	38.71	9,958	9,770	188.06
	RANDALL	4	16	1,555	1,520	37.63	21,258	20,997	261.39
	ROBERTS	4	0	0	0	0.00	0	0	0.00
	SABINE	3	0	0	0	0.00	0	0	0.00
	San Augustine	3	0	0	0	0.00	0	0	0.00
	SAN JACINTO	2	0	0	0	0.00	0	0	0.00
	SHELBY	3	0	0	0	0.00	0	0	0.00
	SHERMAN	4	0	0	0	0.00	0	0	0.00
	SWISHER	4	0	0	0	0.00	0	0	0.00
	TERRY	3	0	0	0	0.00	0	0	0.00
	TRINITY	2	0	0	0	0.00	0	0	0.00
	TYLER	2	0	0	0	0.00	0	0	0.00
	WALKER	2	68	6,483	6,304	192.00	47,576	46,698	877.34
	WHEELER	3	0	0	0	0.00	0	0	0.00
	YOAKUM	4	0	0	0	0.00	0	0	0.00
	TOTAL		72,272			204,533			1,156,534

Table 14: 2020 Totalized Annual Electricity Savings by CL Zone from New Multi-family Residences

Electric Power Market	CL Zone	Total Electricity Savings by CL Zone (MWh) [2020-TRY 2018]
ERCOT	Houston (H)	54,586
	North (N)	52,492
	West (W)	1,897
	South (S)	83,645
SPP	-	6,510
SERC	-	4,886
WECC	-	516
Total		204,533

Table 15: 2020 Annual NOx Reductions from New Multi-family Residences Using 2018 eGRID

Area	County	ERCOT-H	NOx Reductions (lbs)	ERCOT-N	NOx Reductions (lbs)	ERCOT-W	NOx Reductions (lbs/year)	ERCOT-S	NOx Reductions (lbs)	SPP	NOx Reductions (lbs)	SERC	NOx Reductions (lbs)	WECC	NOx Reductions (lbs)	Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
Houston-Galveston Area	Brazoria	0.1445243	7889.06	0.0000183	0.96	0.0000009	0.00	0.0013540	113.25	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	8003.28	4.00
	Chambers	0.0232302	1268.05	0.0000029	0.15	0.0000001	0.00	0.0002176	18.20	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1286.41	0.64
	Fort Bend	0.0925360	5051.21	0.0000117	0.62	0.0000006	0.00	0.0008669	72.51	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5124.34	2.56
	Galveston	0.0189140	1032.45	0.0000024	0.13	0.0000001	0.00	0.0001772	14.82	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1047.40	0.52
	Harris	0.1374166	7501.07	0.0000174	0.92	0.0000008	0.00	0.0012874	107.68	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7609.67	3.80
	Liberty	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Montgomery	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0587430	287.01	0.0000000	0.00	287.01	0.14
	Waller	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0027101	13.24	0.0000000	0.00	13.24	0.01
	Jefferson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.9687861	4733.38	0.0000000	0.00	4733.38	2.37
	Orange	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.8865417	4331.55	0.0000000	0.00	4331.55	2.17
Dallas/ Fort Worth Area	Collin	0.0000743	4.05	0.0004556	23.92	0.0000220	0.04	0.0000046	0.39	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	28.40	0.01
	Dallas	0.0019090	104.20	0.0117105	614.70	0.0005656	1.07	0.0001195	9.99	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	729.97	0.36
	Denton	0.0066429	362.61	0.0407509	2139.09	0.0019683	3.73	0.0004158	34.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2540.21	1.27
	Henderson	0.0001509	8.24	0.0009255	48.58	0.0000447	0.08	0.0000094	0.79	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	57.69	0.03
	Hood	0.0008451	46.13	0.0051842	272.13	0.0002504	0.48	0.0000529	4.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	323.16	0.16
	Hunt	0.0000043	0.23	0.0000263	1.38	0.0000013	0.00	0.0000003	0.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1.64	0.00
	Tarrant	0.0004188	22.86	0.0025693	134.87	0.0001241	0.24	0.0000262	2.19	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	160.16	0.08
	Ellis	0.0013349	72.87	0.0081890	429.85	0.0003955	0.75	0.0000835	6.99	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	510.46	0.26
	Johnson	0.0002010	10.97	0.0012332	64.74	0.0000596	0.11	0.0000126	1.05	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	76.87	0.04
	Kaufman	0.0034596	188.85	0.0212228	1114.02	0.0010251	1.95	0.0002165	18.11	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1322.92	0.66
	Parker	0.0005940	32.42	0.0036438	191.27	0.0001760	0.33	0.0000372	3.11	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	227.14	0.11
	Rockwall	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Wise	0.0031300	170.86	0.0192012	1007.91	0.0009275	1.76	0.0001959	16.39	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1196.91	0.60
El Paso Area	El Paso	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1.2223686	631.18	631.18	0.32
San Antonio Area	Bexar	0.0253670	1384.69	0.0017108	89.80	0.0000826	0.16	0.2025905	16945.75	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	18420.41	9.21
	Comal	0.0005285	28.85	0.0000356	1.87	0.0000017	0.00	0.0042210	353.06	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	383.79	0.19
	Guadalupe	0.0030546	166.74	0.0002060	10.81	0.0000100	0.02	0.0243949	2040.52	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2218.09	1.11
	Wilson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Austin Area	Bastrop	0.0024800	135.37	0.0001673	8.78	0.0000081	0.02	0.0198060	1656.68	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1800.85	0.90
	Caldwell	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hays	0.0004731	25.82	0.0000319	1.67	0.0000015	0.00	0.0037782	316.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	343.53	0.17
	Travis	0.0046184	252.10	0.0003115	16.35	0.0000150	0.03	0.0368846	3085.23	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3353.71	1.68
	Williamson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
North East Texas Area	Gregg	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0053705	34.96	0.0000000	0.00	0.0000000	0.00	34.96	0.02
	Harrison	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2702671	1759.36	0.0000000	0.00	0.0000000	0.00	1759.36	0.88
	Rusk	0.0322708	1761.54	0.1979648	10391.52	0.0095620	18.14	0.0020197	168.94	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	12340.14	6.17
	Smith	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upshur	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Corpus Christi Area	Nueces	0.0042426	231.59	0.0002861	15.02	0.0000138	0.03	0.0338828	2834.14	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3080.77	1.54
	San Patricio	0.0063692	347.67	0.0004296	22.55	0.0000207	0.04	0.0508668	4254.77	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4625.03	2.31
Victoria Area	Victoria	0.0016730	91.32	0.0001128	5.92	0.0000054	0.01	0.0133614	1117.62	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1214.87	0.61
Other ERCOT Counties	Anderson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Angelina	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Atascosa	0.0077084	420.77	0.0005199	27.29	0.0000251	0.05	0.0615620	5149.38	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5597.49	2.80
	Bell	0.0004444	24.26	0.0027262	143.10	0.0001317	0.25	0.0000278	2.33	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	169.94	0.08
	Bosque	0.0007214	39.38	0.0044257	232.31	0.0002138	0.41	0.0000452	3.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	275.87	0.14
	Brazos	0.0005654	30.87	0.0034687	182.08	0.0001675	0.32	0.0000354	2.96	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	216.22	0.11
	Calhoun	0.0111852	610.56	0.0007544	39.60	0.0000364	0.07	0.0893292	7471.97	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	8122.20	4.06
	Cameron	0.0000231	1.26	0.0000016	0.08	0.0000001	0.00	0.0001843	15.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	16.76	0.01
	Cherokee	0.0001844	10.06	0.0011310	59.37	0.0000546	0.10	0.0000115	0.97	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	70.50	0.04
	Coke	0.0000223	1.21	0.0001365	7.17	0.0231815	43.98	0.0000014	0.12	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	52.48	0.03
	Colorado	0.0016158	88.20	0.0001090	5.72	0.0000053	0.01	0.0129041	1079.36	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1173.29	0.59
	Ector	0.0001338	7.30	0.0008206	43.08	0.1393442	264.39	0.0000084	0.70	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	315.47	0.16
	Fayette	0.0204274	1115.06	0.0013777	72.32	0.0000665	0.13	0.1631405	13645.95	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	14833.45	7.42
	Freestone	0.0042261	230.69	0.0259247	1360.83	0.0012522	2.38	0.0002645	22.12	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1616.02	0.81
	Frio	0.0097614	532.84	0.0006583	34.56	0.0000318	0.06	0.0779581	6520.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7088.29	3.54
	Goliad	0.0077047	420.57	0.0005196	27.28	0.0000251	0.05	0.0615328	5146.94	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5594.83	2.80
	Grayson	0.0002857	15.59	0.0017525	91.99	0.0000846	0.16	0.0000179	1.50	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	109.24	0.05
	Grimes	0.0029942	163.44	0.0183678	964.16	0.0008872	1.68	0.0001874	15.67	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1144.96	0.57
	Hidalgo	0.0140830	768.74	0.0009498	49.86	0.0000459	0.09	0.1124720	9407.76	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	10226.45	5.11
	Hill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Howard	0.0000467	2.55	0.0002865	15.04	0.0486558	92.32	0.0000029	0.24	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	110.15	0.06
	Lamar	0.0031379	171.29	0.0192492	1010.43	0.0009298	1.76	0.0001964	16.43	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1199.90	0.60
	Limestone	0.0231674	1264.63	0.1421203	7460.14	0.0068646	13.02	0.0014500	121.28	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	8859.07	4.43
	Llano	0.0001855	10.13	0.0000125	0.66	0.0000006	0.00	0.0014818	123.94	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	134.73	0.07
	McLennan	0.0043688	238.48	0.0268006	1406.81	0.0012945	2.46	0.0002734	22.87	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1670.61	0.84
	Milam	0.0002486	13.57	0.0000168	0.88	0.0000008	0.00	0.0019850	166.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	180.49	0.09
	Mitchell	0.0000072	0.39	0.0000443	2.33	0.0075244	14.28	0.0000005	0.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	17.03	0.01
	Nacogdoches	0.0002714	14.81	0.0016647	87.38	0.0000804	0.15	0.0000170	1.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	103.77	0.05
	Nolan	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Palo Pinto	0.0010391	56.72	0.0063745	334.61	0.0003079	0.58	0.0000650	5.44	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	397.35	0.20
	Pecos	0.0000029	0.16	0.0000180	0.95	0.0030637	5.81	0.0000002	0.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6.94	0.00
	Reagan	0.0000002	0.01	0.0000015	0.08	0.0002476	0.47	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.56	0.00
	Red River	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Robertson	0.0184177	1005.35	0.1129830	5930.67	0.0054573	10.35	0.0011527	96.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7042.80	3.52
	Scurry	0.0001246	6.80	0.0007646	40.13	0.1298311	246.34	0.0000078	0.65	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	293.93	0.15
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Ward	0.0000206	1.13	0.0001265	6.64	0.0214790	40.75	0.0000013	0.11	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	48.63	0.02
	Webb	0.0000253	1.38	0.0000017	0.09	0.0000001	0.00	0.0002020	16.89	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	18.36	0.01
	Wharton	0.0006585	35.95	0.0000444	2.33	0.0000021	0.00	0.0052594	439.92	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	478.21	0.24
	Wichita	0.0000051	0.28	0.0000315	1.65	0.0053432	10.14	0.0000003	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	12.10	0.01
	Wilbarger	0.0008609	46.99	0.0052810	277.21	0.8967472	1701.47	0.0000539	4.51	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2030.18	1.02
	Wood	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Young	0.0000257	1.40	0.0001578	8.28	0.0267892	50.83	0.0000016	0.13	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	60.65	0.03
Other SPP Counties	Cass	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0127595	83.06	0.0000000	0.00	0.0000000	0.00	83.06	0.04
	Gaines	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Gray	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hale	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0616792	401.51	0.0000000	0.00	0.0000000	0.00	401.51	0.20
	Hemphill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0246062	160.18	0.0000000	0.00	0.0000000	0.00	160.18	0.08
	Hutchinson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0134856	87.79	0.0000000	0.00	0.0000000	0.00	87.79	0.04
	Lamb	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2117054	1378.14	0.0000000	0.00	0.0000000	0.00	1378.14	0.69
	Lubbock	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0695988	453.07	0.0000000	0.00	0.0000000	0.00	453.07	0.23
	Marion	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0272898	177.65	0.0000000	0.00	0.0000000	0.00	177.65	0.09
	Moore	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Morris	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0002270	1.48	0.0000000	0.00	0.0000000	0.00	1.48	0.00
	Potter	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2710995	1764.78	0.0000000	0.00	0.0000000	0.00	1764.78	0.88
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Yoakum	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0438855	285.68	0.0000000	0.00	0.0000000	0.00	285.68	0.14
Other SERC Counties	Jasper	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Newton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0870000	425.07	0.0000000	0.00	425.07	0.21
	San Jacinto	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0072219	35.29	0.0000000	0.00	35.29	0.02
	Tyler	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Total	**0.6511639**	**35544.68**	**0.6960448**	**36536.61**	**1.3354567**	**2533.87**	**0.9887171**	**82701.60**	**1.3648074**	**8884.49**	**2.0110028**	**9825.54**	**1.2223686**	**631.18**	**176657.97**	**88.33**

Energy Savings (MWh)		54,586		52,492		1,897		83,645		6,510		4,886		516	

4.3 2020 Results for New Residential Construction (Single-family and Multi-family)

Table 16 presents the individual and combined annual electricity savings and NOx emissions reductions resulted from the new single-family and multi-family Construction in 2020. In addition, Table 16 includes the combined natural gas savings from the new Construction for both single-family and multi-family and the corresponding NOx emissions reductions[19].

The total NOx reductions from electricity and natural gas savings from total new single-family and multi-family Construction in 2020 are 138.38 tons NOx/year, including 39.71 tons NOx/year (28.69 %) from single-family residential electricity savings, 88.33 tons NOx/year (63.83 %) from multi-family residential electricity savings, and 10.35 tons NOx/year (7.48 %) from natural gas savings from both single-family and multi-family residences. Figure 8 through Figure 12 show the electricity savings and NOx reductions tabulated in Table 16. Figure 8 shows the annual electricity savings by county using a stacked bar chart and Figure 9 shows the spatial distribution of the electricity savings by county across the state.

Figure 10 shows the annual NOx reductions by using a stacked bar chart. Figure 11 and Figure 12 show the spatial distribution of the NOx reductions from electricity only, and electricity and natural gas, by county across the state, respectively.

[24] 0.092 lb-NOx/MMBtu of emission rate was used for the calculation.

Table 16: 2020 Annual NOx Reductions from New Single-family and Multi-family Residences

	County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Total Electricity Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Nox Reductions
		Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual Nox Reductions (Tons)	Annual Nox Reductions (Tons)
Non-attainment and Affected Counties	HARDIN	150.33	0.01	414.72	0.01	565.06	0.02	4,005.96	0.02	0.04
	HARRIS	12,365.98	1.68	45,534.25	3.80	57,900.23	5.48	365,088.01	1.68	7.16
	JEFFERSON	618.12	3.58	94.06	2.37	712.18	5.94	8,635.19	0.04	5.98
	ORANGE	120.68	3.27	38.74	2.17	159.42	5.44	1,781.04	0.01	5.45
	TARRANT	5,348.19	0.04	10,680.36	0.08	16,028.55	0.12	154,608.51	0.71	0.83
	COLLIN	5,964.94	0.01	5,676.13	0.01	11,641.06	0.02	127,445.24	0.59	0.61
	DALLAS	2,905.40	0.18	13,629.74	0.36	16,535.14	0.55	147,417.98	0.68	1.23
	HOOD	180.76	0.08	0.00	0.16	180.76	0.24	2,582.89	0.01	0.25
	HUNT	317.71	0.00	600.54	0.00	918.26	0.00	10,152.13	0.05	0.05
	HENDERSON	71.45	0.01	67.25	0.03	138.71	0.04	1,542.80	0.01	0.05
	BEXAR	2,812.03	2.83	14,841.84	9.21	17,653.87	12.04	106,915.46	0.49	12.53
	TRAVIS	5,104.95	0.52	46,937.10	1.68	52,042.05	2.19	263,116.03	1.21	3.40
	DENTON	3,756.03	0.63	7,446.88	1.27	11,202.91	1.90	110,988.16	0.51	2.42
	WILLIAMSON	3,750.56		5,755.74		9,506.30	0.00	88,112.59	0.41	0.41
	EL PASO	961.74	0.59	516.36	0.32	1,478.09	0.90	20,451.14	0.09	1.00
	MONTGOMERY	5,283.17	0.22	3,721.35	0.14	9,004.52	0.36	84,087.46	0.39	0.75
	GALVESTON	1,931.32	0.23	1,066.91	0.52	2,998.23	0.75	25,218.85	0.12	0.87
	BRAZORIA	2,570.91	1.76	6.06	4.00	2,576.97	5.77	28,668.63	0.13	5.90
	COMAL	1,785.64	0.06	2,372.35	0.19	4,157.99	0.25	34,690.14	0.16	0.41
	ROCKWALL	1,092.89		1,010.29		2,103.18	0.00	23,053.10	0.11	0.11
	HAYS	2,023.06	0.05	2,323.17	0.17	4,346.24	0.22	37,961.50	0.17	0.40
	NUECES	922.04	0.47	603.89	1.54	1,525.93	2.01	11,749.29	0.05	2.07
	FORT BEND	6,768.23	1.13	7,595.16	2.56	14,363.39	3.69	120,645.50	0.55	4.25
	ELLIS	1,327.41	0.13	493.81	0.26	1,821.22	0.38	20,895.18	0.10	0.48
	JOHNSON	711.11	0.02	3,283.98	0.04	3,995.09	0.06	35,660.23	0.16	0.22
	GUADALUPE	662.83	0.34	854.40	1.11	1,517.23	1.45	12,753.57	0.06	1.51
	KAUFMAN	407.58	0.33	534.71	0.66	942.29	0.99	10,179.20	0.05	1.04
	PARKER	240.25	0.06	1,461.56	0.11	1,701.80	0.17	16,204.63	0.07	0.24
	SMITH	262.27		432.65		694.93	0.00	7,312.02	0.03	0.03
	BASTROP	543.55	0.28	41.98	0.90	585.52	1.18	5,731.02	0.03	1.20
	CHAMBERS	532.28	0.28	0.00	0.64	532.28	0.93	7,024.03	0.03	0.96
	GREGG	109.16	0.00	36.56	0.02	145.72	0.02	1,622.32	0.01	0.03
	SAN PATRICIO	185.75	0.71	290.64	2.31	476.40	3.02	2,884.66	0.01	3.04
	LIBERTY	572.59		0.00		572.59	0.00	7,298.09	0.03	0.03
	VICTORIA	81.42	0.19	0.00	0.61	81.42	0.79	999.32	0.00	0.80
	CALDWELL	181.20		184.69		365.89	0.00	2,564.97	0.01	0.01
	WILSON	74.29		0.00		74.29	0.00	978.61	0.00	0.00
	WALLER	18.40		383.99		402.39	0.00	1,988.32	0.01	0.01
	UPSHUR	8.68		18.31		26.99	0.00	246.42	0.00	0.00
	RUSK	1.26	3.08	0.00	6.17	1.26	9.25	15.01	0.00	9.25
	HARRISON	34.56	0.23	0.00	0.88	34.56	1.11	422.30	0.00	1.11
	WISE	41.71	0.30	17.99	0.60	59.70	0.90	673.83	0.00	0.90
Other ERCOT Counties	HIDALGO	2,624.18	1.57	5,539.15	5.11	8,163.34	6.68	35,985.34	0.17	6.85
	CAMERON	1,184.68	0.00	1,294.97	0.01	2,479.65	0.01	13,624.12	0.06	0.07
	BELL	1,529.72	0.04	1,995.80	0.08	3,525.53	0.13	30,307.94	0.14	0.27
	WEBB	936.02	0.00	558.68	0.01	1,494.70	0.01	10,553.60	0.05	0.06
	BRAZOS	730.06	0.05	1,996.20	0.11	2,726.26	0.16	18,391.70	0.08	0.25
	KENDALL	152.74		0.00		152.74	0.00	2,075.60	0.01	0.01
	BURNET	324.20		173.75		497.95	0.00	5,274.64	0.02	0.02
	GRAYSON	378.41	0.03	982.94	0.05	1,361.35	0.08	14,840.06	0.07	0.15
	CORYELL	199.79		493.66		693.45	0.00	5,630.15	0.03	0.03
	MIDLAND	545.58		0.00		545.58	0.00	8,107.27	0.04	0.04
	LLANO	141.90	0.02	33.63	0.07	175.53	0.09	2,135.86	0.01	0.10
	MAVERICK	88.90		58.13		147.03	0.00	1,017.87	0.00	0.00
	MCMULLEN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	ARANSAS	116.43		0.00		116.43	0.00	1,250.07	0.01	0.01
	WICHITA	89.45	0.00	55.45	0.01	144.90	0.01	1,585.34	0.01	0.02
	TAYLOR	194.58		802.14		996.72	0.00	12,149.79	0.06	0.06
	TOM GREEN	307.38		0.00		307.38	0.00	4,080.89	0.02	0.02
	MCLENNAN	576.50	0.42	856.86	0.84	1,433.36	1.25	12,173.33	0.06	1.31
	MCCULLOCH	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	JIM HOGG	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	VAL VERDE	57.43		0.00		57.43	0.00	756.51	0.00	0.00
	ECTOR	380.09	0.13	761.13	0.16	1,141.22	0.29	14,243.71	0.07	0.35
	WHARTON	105.48	0.07	5.90	0.24	111.38	0.31	1,319.06	0.01	0.32
	KERR	40.89		22.42		63.31	0.00	667.39	0.00	0.00
	PRESIDIO	4.03		0.00		4.03	0.00	53.54	0.00	0.00
	JIM WELLS	11.44		0.00		11.44	0.00	122.84	0.00	0.00
	CALHOUN	69.70	1.25	76.75	4.06	146.46	5.31	1,173.78	0.01	5.31
	GILLESPIE	34.49		5.60		40.09	0.00	508.67	0.00	0.00
	MATAGORDA	108.56		0.00		108.56	0.00	1,332.43	0.01	0.01
	NAVARRO	31.29		63.47		94.76	0.00	782.46	0.00	0.00
	ANGELINA	50.38		4.55		54.93	0.00	637.69	0.00	0.00
	NACOGDOCHES	9.66	0.03	4.55	0.05	14.20	0.08	152.44	0.00	0.08
	FANNIN	16.12		20.53		36.65	0.00	413.08	0.00	0.00
	ATASCOSA	35.45	0.86	0.00	2.80	35.45	3.66	466.99	0.00	3.66
	WASHINGTON	53.42		1,428.68		1,482.10	0.00	7,206.75	0.03	0.03
	LAMAR	10.12	0.30	25.71	0.60	35.83	0.90	377.53	0.00	0.90
	VAN ZANDT	19.91		10.28		30.19	0.00	338.57	0.00	0.00
	WILLACY	39.09		0.00		39.09	0.00	356.63	0.00	0.00
	BROWN	58.97		14.10		73.08	0.00	717.58	0.00	0.00
	ERATH	18.75		75.96		94.71	0.00	1,154.34	0.01	0.01
	AUSTIN	171.54		0.00		171.54	0.00	2,178.05	0.01	0.01
	COOKE	32.25		0.00		32.25	0.00	404.52	0.00	0.00
	MEDINA	17.91		5.87		23.79	0.00	263.62	0.00	0.00

Table 16: 2020 Annual NOx Reductions from New Single-family and Multi-family Residences (Continued)

	County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Total Electricity Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Nox Reductions
		Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual Nox Reductions (Tons)	Annual Nox Reductions (Tons)
Other ERCOT Counties	TITUS	13.49	0.30	41.13	1.15	54.62	1.45	572.04	0.00	1.45
	UVALDE	10.01		0.00		10.01	0.00	131.87	0.00	0.00
	FAYETTE	27.30	2.28	5.65	7.42	32.95	9.70	372.48	0.00	9.70
	CALLAHAN	6.08		6.08		12.16	0.00	146.22	0.00	0.00
	HOPKINS	6.16		0.00		6.16	0.00	72.92	0.00	0.00
	LAMPASAS	29.49		0.00		29.49	0.00	308.19	0.00	0.00
	BLANCO	10.84		5.60		16.44	0.00	175.52	0.00	0.00
	FREESTONE	2.41	0.40	0.00	0.81	2.41	1.21	25.16	0.00	1.21
	GRIMES	51.64	0.29	0.00	0.57	51.64	0.86	655.68	0.00	0.86
	LEE	7.39		22.39		29.77	0.00	198.10	0.00	0.00
	SOMERVELL	10.94		0.00		10.94	0.00	139.24	0.00	0.00
	ANDREWS	6.77		0.00		6.77	0.00	100.63	0.00	0.00
	BORDEN	10.69		0.00		10.69	0.00	91.26	0.00	0.00
	CHEROKEE	5.46	0.02	0.00	0.04	5.46	0.05	65.03	0.00	0.05
	DIMMIT	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	FALLS	7.82		0.00		7.82	0.00	81.76	0.00	0.00
	COLORADO	9.50	0.18	0.00	0.59	9.50	0.77	120.58	0.00	0.77
	FRIO	4.23	1.09	0.00	3.54	4.23	4.63	55.76	0.00	4.63
	MILAM	6.65	0.03	0.00	0.09	6.65	0.12	69.19	0.00	0.12
	JACKSON	5.55		0.00		5.55	0.00	68.14	0.00	0.00
	ANDERSON	8.82		352.51		361.33	0.00	3,001.85	0.01	0.01
	HILL	30.09		0.00		30.09	0.00	314.48	0.00	0.00
	CULBERSON	0.00		123.70		123.70	0.00	1,061.95	0.00	0.00
	MASON	3.45		0.00		3.45	0.00	48.58	0.00	0.00
	POTTER	369.63	0.23	863.84	0.88	1,233.47	1.11	7,113.07	0.03	1.15
	PECOS	3.14	0.00	112.83	0.00	115.97	0.01	1,185.60	0.01	0.01
	RAINS	14.22		0.00		14.22	0.00	168.27	0.00	0.00
	LAVACA	6.94		0.00		6.94	0.00	79.32	0.00	0.00
	PALO PINTO	5.57	0.10	0.00	0.20	5.57	0.30	65.55	0.00	0.30
	KIMBLE	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	MADISON	2.97		0.00		2.97	0.00	37.68	0.00	0.00
	ARCHER	20.11		18.48		38.60	0.00	425.61	0.00	0.00
	REFUGIO	31.46		94.47		125.92	0.00	777.86	0.00	0.00
	LIMESTONE	2.41	2.21	0.00	4.43	2.41	6.64	25.16	0.00	6.64
	CLAY	1.59		12.32		13.91	0.00	158.47	0.00	0.00
	BEE	11.72		35.42		47.14	0.00	290.75	0.00	0.00
	MARTIN	1.27		0.00		1.27	0.00	18.87	0.00	0.00
	GONZALES	7.38		0.00		7.38	0.00	97.17	0.00	0.00
	BURLESON	21.37		0.00		21.37	0.00	271.31	0.00	0.00
	KARNES	38.27		0.00		38.27	0.00	499.72	0.00	0.00
	KLEBERG	15.87		72.50		88.37	0.00	339.46	0.00	0.00
	BREWSTER	9.41		0.00		9.41	0.00	124.93	0.00	0.00
	WINKLER	0.85		0.00		0.85	0.00	12.58	0.00	0.00
	WOOD	9.59		9.15		18.75	0.00	183.79	0.00	0.00
	FRANKLIN	2.37		0.00		2.37	0.00	28.05	0.00	0.00
	YOUNG	3.55	0.02	0.00	0.03	3.55	0.06	41.71	0.00	0.06
	HOUSTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SCURRY	1.69	0.12	0.00	0.15	1.69	0.27	14.41	0.00	0.27
	BOSQUE	3.61	0.07	0.00	0.14	3.61	0.21	37.74	0.00	0.21
	COMANCHE	0.60		0.00		0.60	0.00	6.29	0.00	0.00
	BRISCOE	3.00		0.00		3.00	0.00	2.95	0.00	0.00
	CONCHO	0.45		0.00		0.45	0.00	5.95	0.00	0.00
	ZAVALA	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	NOLAN	2.03		0.00		2.03	0.00	23.84	0.00	0.00
	BROOKS	1.43		0.00		1.43	0.00	12.39	0.00	0.00
	ROBERTSON	74.79	1.76	11.29	3.52	86.08	5.28	1,001.21	0.00	5.29
	LIVE OAK	3.37		0.00		3.37	0.00	36.13	0.00	0.00
	HAMILTON	7.82		0.00		7.82	0.00	81.76	0.00	0.00
	JONES	0.51		0.00		0.51	0.00	5.96	0.00	0.00
	REAGAN	0.42	0.00	0.00	0.00	0.42	0.00	6.64	0.00	0.00
	WARD	0.00	0.02	0.00	0.02	0.00	0.04	0.00	0.00	0.04
	RED RIVER	5.48		0.00		5.48	0.00	65.03	0.00	0.00
	HASKELL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	HOWARD	18.20	0.05	5.25	0.06	23.45	0.10	329.73	0.00	0.10
	SAN SABA	0.49		0.00		0.49	0.00	6.94	0.00	0.00
	JACK	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	STEPHENS	1.52		0.00		1.52	0.00	17.88	0.00	0.00
	RUNNELS	3.58		0.00		3.58	0.00	47.59	0.00	0.00
	REEVES	30.90		0.00		30.90	0.00	459.14	0.00	0.00
	DE WITT	2.47		0.00		2.47	0.00	30.28	0.00	0.00
	CHILDRESS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	CROSBY	2.25		0.00		2.25	0.00	19.21	0.00	0.00
	DAWSON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	MITCHELL	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.00	0.02
	WILBARGER	1.59	0.83	0.00	1.02	1.59	1.84	16.83	0.00	1.84
	COLEMAN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	UPTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	COKE	1.34	0.02	0.00	0.03	1.34	0.05	18.84	0.00	0.05
	CROCKETT	8.51		0.00		8.51	0.00	113.03	0.00	0.00
	HARDEMAN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	BANDERA	0.49		0.00		0.49	0.00	6.61	0.00	0.00
	BAYLOR	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	COTTLE	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	CRANE	0.42		0.00		0.42	0.00	6.64	0.00	0.00
	DELTA	3.32		5.14		8.46	0.00	90.76	0.00	0.00

Table 16: 2020 Annual NOx Reductions from New Single-family and Multi-family Residences (Continued)

	County	Electricity Savings and Resultant NOx Reductions (Single Family Houses)		Electricity Savings and Resultant NOx Reductions (Multifamily Houses)		Total Electricity Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Natural Gas Savings and Resultant NOx Reductions (Single and Multi-Family Houses)		Total Nox Reductions
		Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual Electricity Savings per County w/ 7% T&D Loss (MWh/County)	Annual Nox Reductions (Tons)	Total Annual N.G. Savings (Therm/County)	Annual Nox Reductions (Tons)	Annual Nox Reductions (Tons)
Other ERCOT Counties	DICKENS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	DUVAL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	EASTLAND	1.01		0.00		1.01	0.00	11.92	0.00	0.00
	EDWARDS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	FISHER	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	FOARD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	GLASSCOCK	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	GOLIAD	0.00	0.86	0.00	2.80	0.00	3.66	0.00	0.00	3.66
	HALL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	HUDSPETH	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	IRION	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	JEFF DAVIS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	KENEDY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	KENT	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	KING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	KINNEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	KNOX	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	LA SALLE	8.08		0.00		8.08	0.00	76.35	0.00	0.00
	LEON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	LOVING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	MENARD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	MILLS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	MONTAGUE	7.59		0.00		7.59	0.00	95.18	0.00	0.00
	MOTLEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	REAL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SCHLEICHER	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SHACKELFORD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	STARR	0.75		0.00		0.75	0.00	6.86	0.00	0.00
	STERLING	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	STONEWALL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SUTTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	TERRELL	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	THROCKMORTON	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	ZAPATA	0.00		0.00		0.00	0.00	0.00	0.00	0.00
Other TEXAS Counties	ARMSTRONG	0.86		0.00		0.86	0.00	0.84	0.00	0.00
	BAILEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	BOWIE	28.67		0.00		28.67	0.00	340.18	0.00	0.00
	CAMP	4.22		0.00		4.22	0.00	50.03	0.00	0.00
	CARSON	0.86		0.00		0.86	0.00	0.84	0.00	0.00
	CASS	4.22	0.01	0.00	0.04	4.22	0.05	50.03	0.00	0.05
	CASTRO	0.43		0.00		0.43	0.00	0.42	0.00	0.00
	COCHRAN	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	COLLINGSWORTH	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	DALLAM	2.14		0.00		2.14	0.00	2.10	0.00	0.00
	DEAF SMITH	0.86		0.00		0.86	0.00	0.84	0.00	0.00
	DONLEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	FLOYD	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Gaines	0.85		0.00		0.85	0.00	12.58	0.00	0.00
	GARZA	2.52		0.00		2.52	0.00	31.40	0.00	0.00
	GRAY	0.43		0.00		0.43	0.00	0.42	0.00	0.00
	HALE	9.42	0.05	0.00	0.20	9.42	0.25	9.26	0.00	0.25
	HANSFORD	1.28		0.00		1.28	0.00	1.26	0.00	0.00
	HARTLEY	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	HEMPHILL	0.00	0.02	0.00	0.08	0.00	0.10	0.00	0.00	0.10
	HOCKLEY	3.85		0.00		3.85	0.00	3.79	0.00	0.00
	HUTCHINSON	0.43	0.01	0.00	0.04	0.43	0.06	0.42	0.00	0.06
	JASPER	38.89		578.32		617.21	0.00	3,256.24	0.01	0.01
	LAMB	3.85	0.18	9.41	0.69	13.26	0.87	69.14	0.00	0.87
	LIPSCOMB	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	LUBBOCK	1,017.47	0.06	5,543.96	0.23	6,561.43	0.29	80,763.71	0.37	0.66
	LYNN	1.01		0.00		1.01	0.00	12.56	0.00	0.00
	MARION	4.64	0.02	0.00	0.09	4.64	0.11	56.65	0.00	0.11
	MOORE	5.14		0.00		5.14	0.00	5.05	0.00	0.00
	MORRIS	1.26	0.00	0.00	0.00	1.26	0.00	15.01	0.00	0.00
	NEWTON	0.00	0.32	0.00	0.21	0.00	0.53	0.00	0.00	0.53
	OCHILTREE	0.43		0.00		0.43	0.00	0.42	0.00	0.00
	OLDHAM	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	PANOLA	5.46		0.00		5.46	0.00	65.03	0.00	0.00
	PARMER	1.71		0.00		1.71	0.00	1.68	0.00	0.00
	POLK	314.96		38.71		353.67	0.00	4,359.47	0.02	0.02
	RANDALL	67.24		37.63		104.87	0.00	327.48	0.00	0.00
	ROBERTS	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SABINE	0.42		0.00		0.42	0.00	5.00	0.00	0.00
	San Augustine	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	SAN JACINTO	271.44	0.03	0.00	0.02	271.44	0.04	3,459.78	0.02	0.06
	SHELBY	0.42		0.00		0.42	0.00	5.00	0.00	0.00
	SHERMAN	5.14		0.00		5.14	0.00	5.05	0.00	0.00
	SWISHER	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	TERRY	2.52		0.00		2.52	0.00	31.40	0.00	0.00
	TRINITY	2.21		0.00		2.21	0.00	32.34	0.00	0.00
	TYLER	12.58		0.00		12.58	0.00	166.55	0.00	0.00
	WALKER	270.06		192.00		462.06	0.00	4,306.46	0.02	0.02
	WHEELER	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	YOAKUM	2.14	0.04	0.00	0.14	2.14	0.18	2.10	0.00	0.18
	TOTAL	**87,442.14**	**39.71**	**204,532.82**	**88.33**	**291,974.96**	**128.04**	**2,249,109.20**	**10.35**	**138.38**

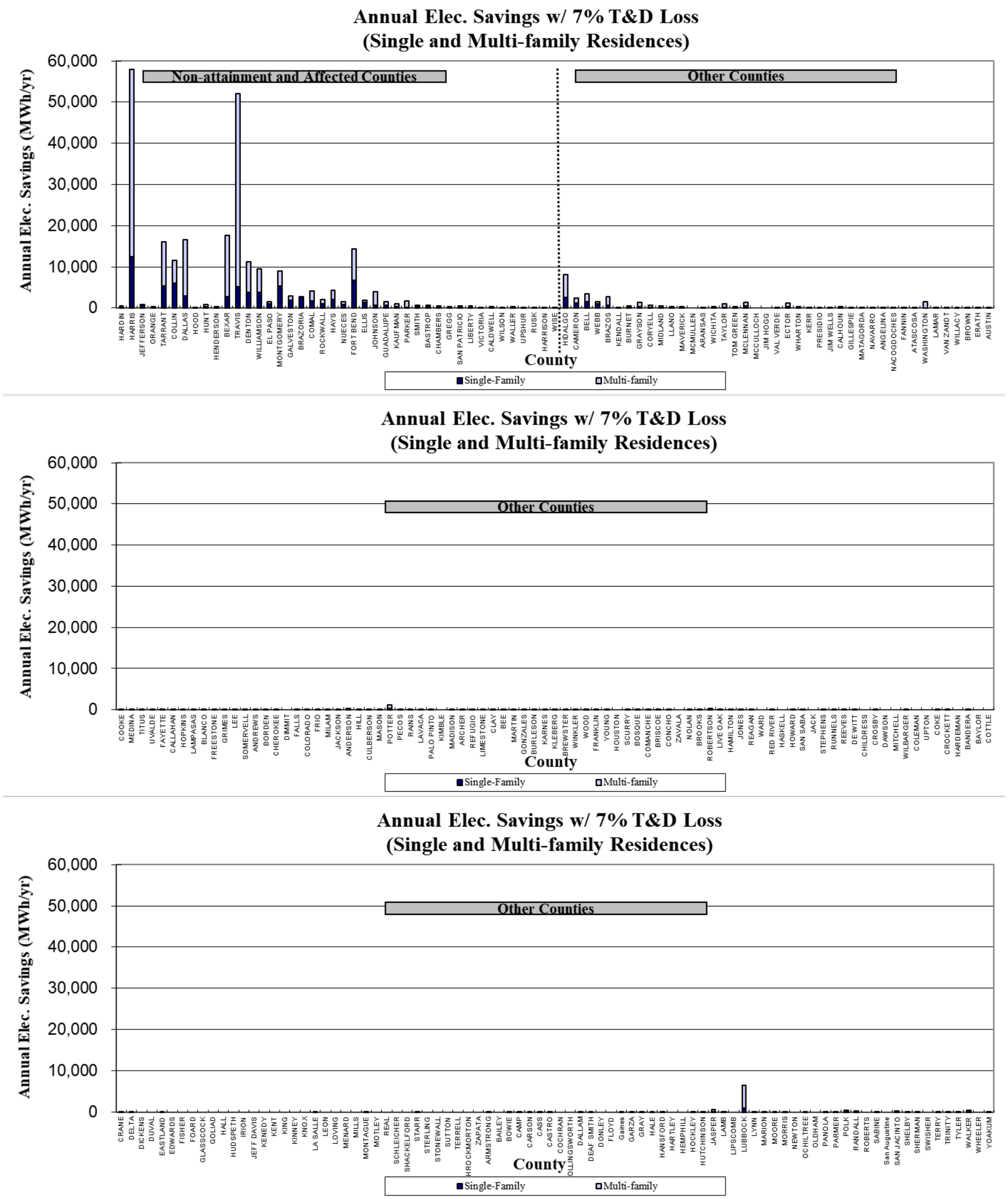


Figure 8: 2020 Annual Electricity Savings by County from New Single-family and Multi-family Residences

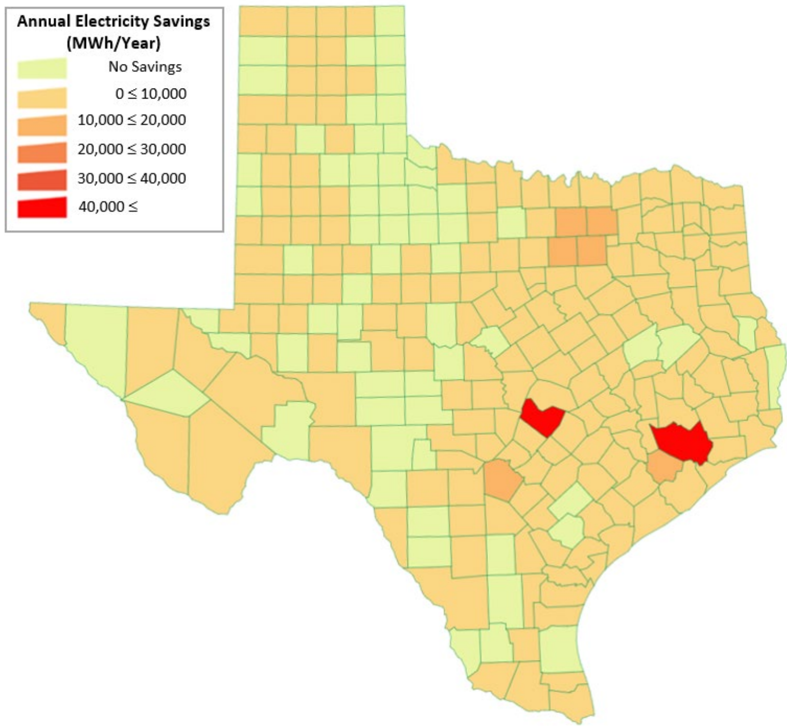


Figure 9: Map of 2020 Annual Electricity Savings by County from New Single-family and Multi-family Residences

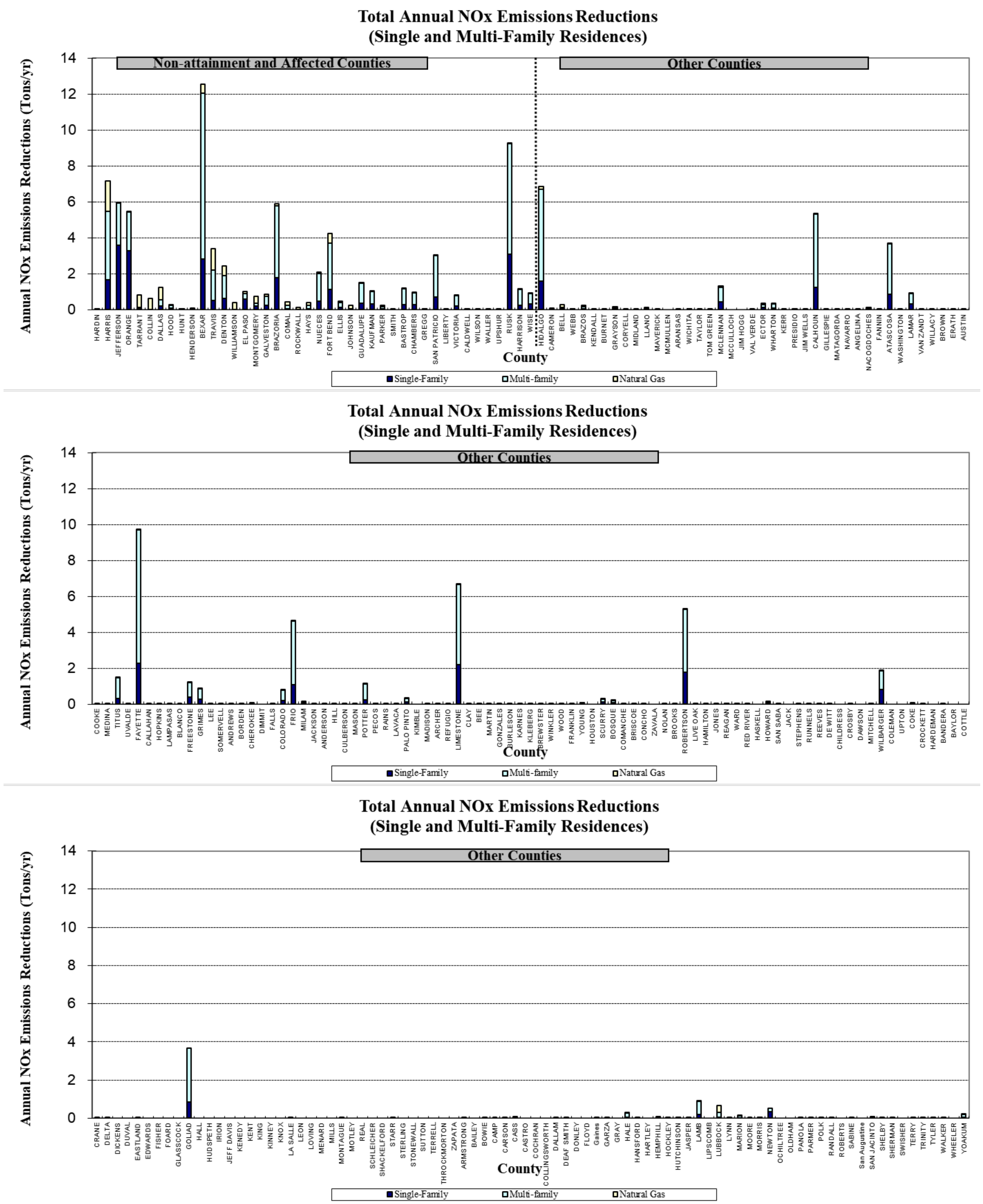


Figure 10: 2020 Annual NOx Reductions by County from New Single-family and Multi-family Residences

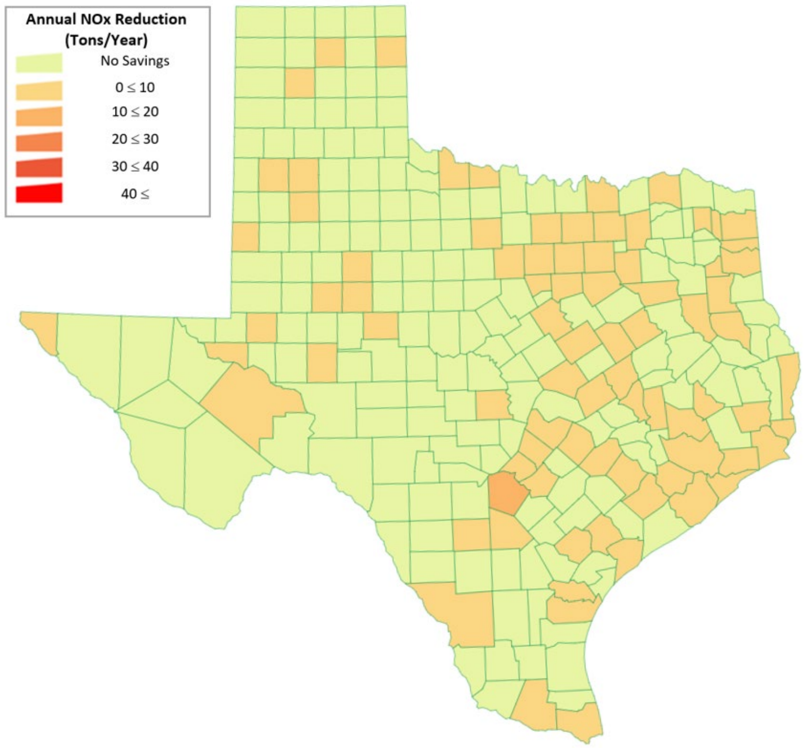


Figure 11: Map of 2020 Annual NOx Reductions from Electricity by County from New Single-family and Multi-family Residences

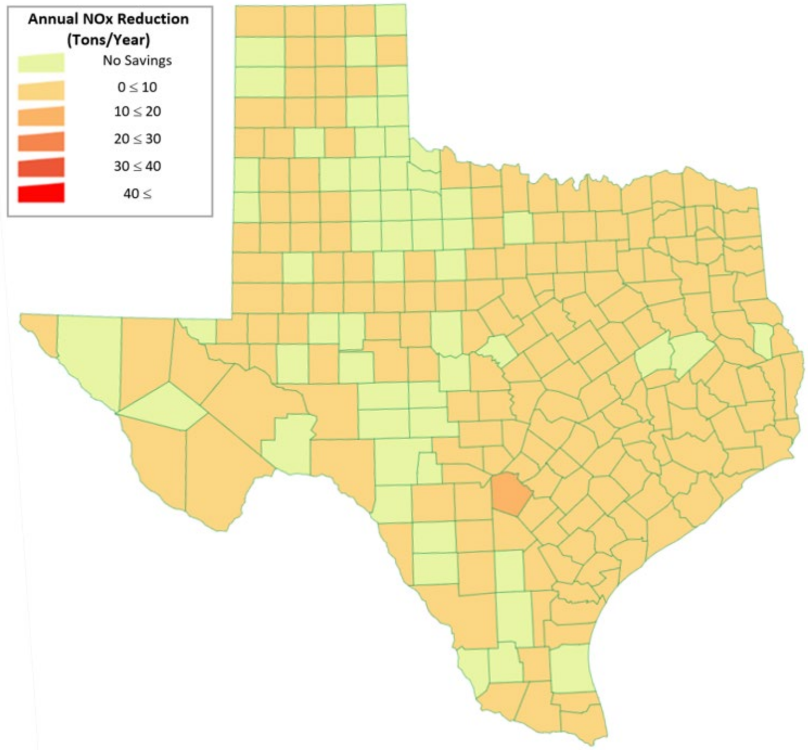


Figure 12: Map of 2020 Annual NOx Reductions from Electricity and Natural Gas by County from New Single-family and Multi-family Residences

4.4 2020 Results for Commercial Construction

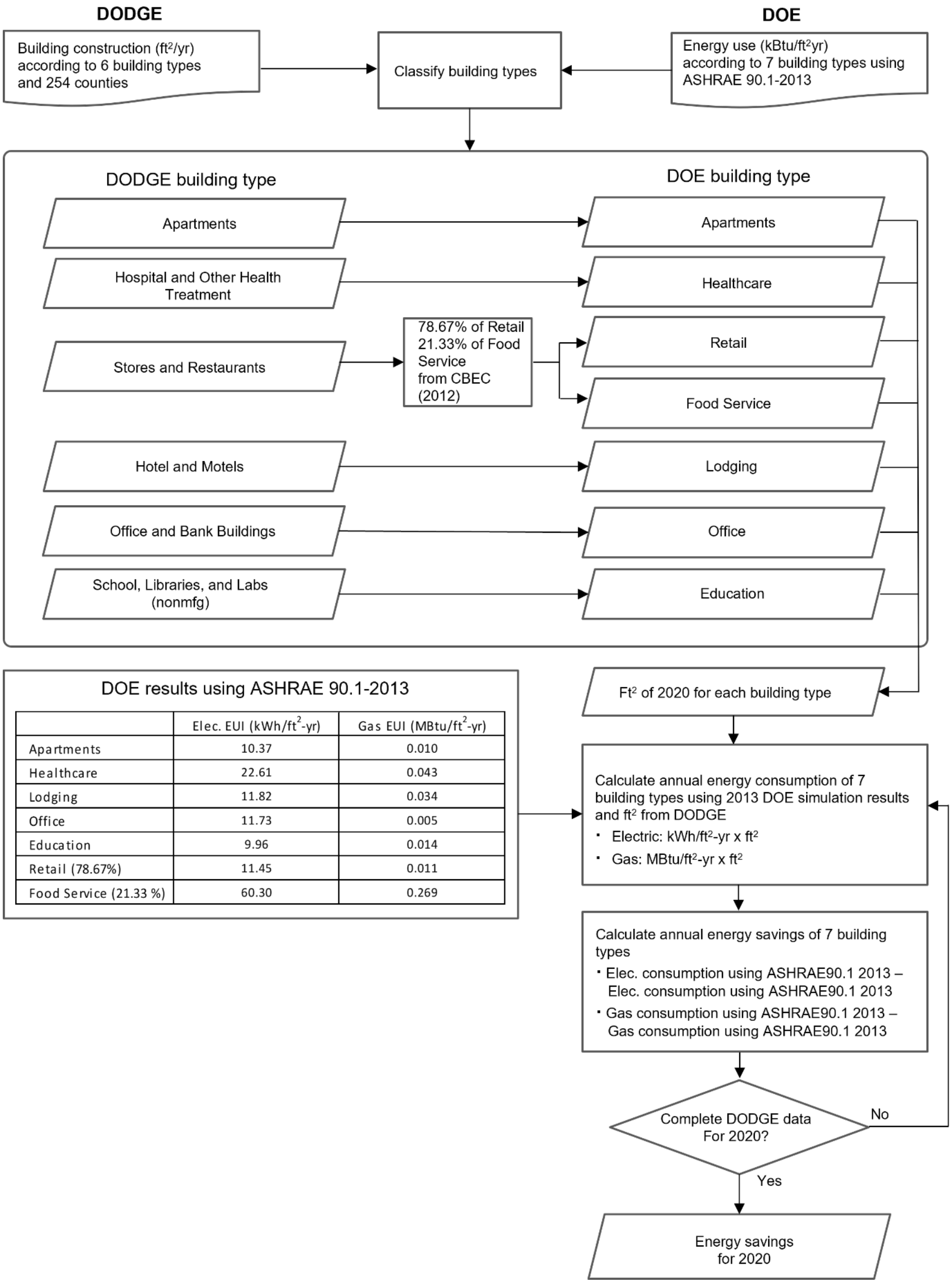
This section reports the calculated energy savings and emissions reductions from new commercial construction in 2020 that was built to meet ASHRAE Standard 90.1-2013.

To determine the energy savings and emissions reductions from new commercial construction in all counties in Texas, including the 42 non-attainment and affected counties, data from two sources (i.e., Dodge and USDOE) were merged into one analysis as shown in Figure 13. Beginning in the upper left of Figure 13, the Dodge database of the square footage of new commercial construction per county in Texas was categorized by the building types in the report published by the US Department of Energy (DOE) (USDOE 2014). This allowed for the new construction to be tracked by county and building type. The next block in Figure 13 and Table 17 show the categories from the Dodge database and the DOE report. The Dodge "stores and restaurant" category had to be split into two categories to match the two DOE categories for "retail" and "food." To accomplish this, information published in the 2012 CBECS database by the US DOE's EIA was used to determine the percentages used to split the Dodge conditioned area for each county as shown in Table 18 (i.e., 21.33% for food and 78.67% for retail). As a result, six Dodge building types were categorized into seven DOE building types and the resultant square footage of new commercial construction by the seven DOE building types is shown in Figure 14 for all building types and in Figure 15 for each building type.

In the next step, the annual energy savings were calculated. To accomplish this, this report used the resultant square footage and savings of the annual energy use intensity (EUI). The DOE report included the annual EUI values, which comply with the ASHRAE Standard 90.1-2013, by seven building types (USDOE 2011). The annual energy use for each building type was calculated by multiplying the annual EUI value by the resultant square footage. Then, the annual energy savings of seven building types were calculated.

This year, the ESL collected data for new commercial construction in Texas from Dodge. The Dodge data for 2020 provided square footage of new commercial construction per county in Texas. In 2020, the ESL estimated the new commercial construction in Texas using the 2019 Dodge data (Dodge 2020a) that included an 18% commercial construction decrease in Texas in 2020 due to COVID-19 (Dodge 2020b). The article also provided the total construction cost and percent decrease for new commercial buildings and multi-family housing construction in U.S. metropolitan areas from the 2017 to 2020. Using this information, the ESL determined that an 18% commercial construction decrease had occurred in Texas in 2020. As a result, six Dodge building types were categorized into seven DOE building types is shown in Figure 14 for all building types and in Figure 15 for each building types.

In addition, the commercial energy savings for 2020 were estimated against the baseline year of 2018. Therefore, the annual energy savings for new commercial construction in 2020 were not generated as shown in Table *19* since Texas has been complying with the ASHRAE Standard 90.1-2013 as the commercial code in both the 2018 and 2020.



	Elec. EUI (kWh/ft^2-yr)	Gas EUI (MBtu/ft^2-yr)
Apartments	10.37	0.010
Healthcare	22.61	0.043
Lodging	11.82	0.034
Office	11.73	0.005
Education	9.96	0.014
Retail (78.67%)	11.45	0.011
Food Service (21.33 %)	60.30	0.269

Figure 13: Calculation Method for 2020 Energy Savings from New Commercial Buildings

Table 17: Commercial Building Types in the US DOE Report and Dodge Database

No.	DOE Building Types	Dodge Building Types
1	Apartments	Apartments
2	Healthcare	Hospitals and Other Health Treatment
3	Lodging	Hotels and Motels
4	Office	Office and Bank Buildings
5	Education	Schools, Libraries, and Labs (nonmfg)
6	Retail	Stores and Restaurants
7	Food Service	

Table 18: Commercial Building Floor Area for Retail and Food Service Types from CBECS Database

		CBECS (2012)	
		Total Floor Area (million square feet)	% Distribution of Floor Area
Food	Food Sales	1,252	21.33
	Food Service	1,819	
Retail	Retail (Other Than Mall)	5,439	78.67
	Enclosed and Strip Malls	5,890	

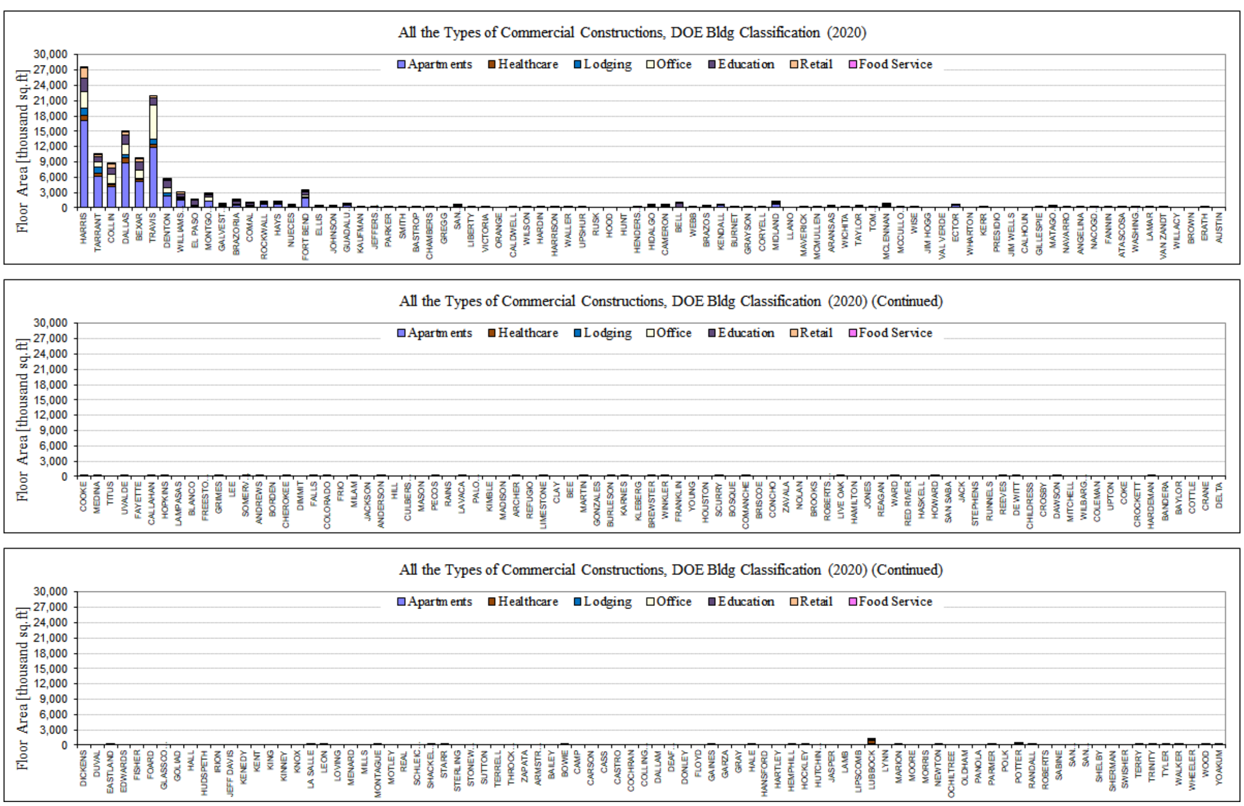
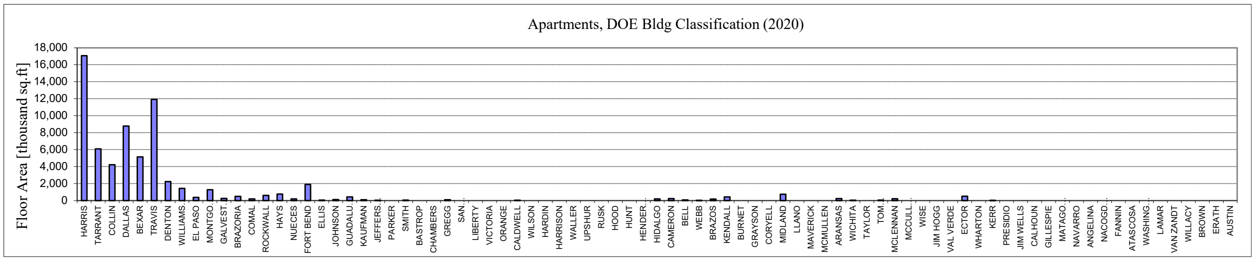
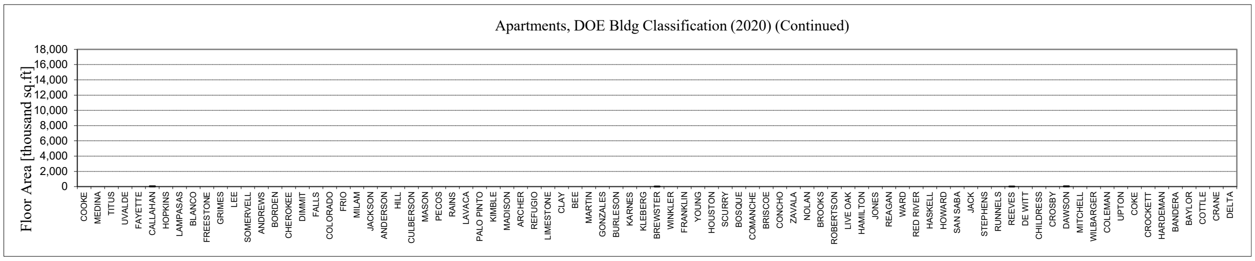
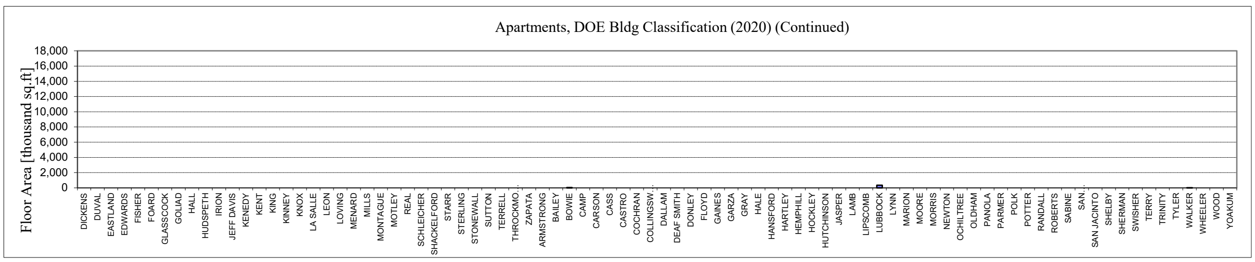
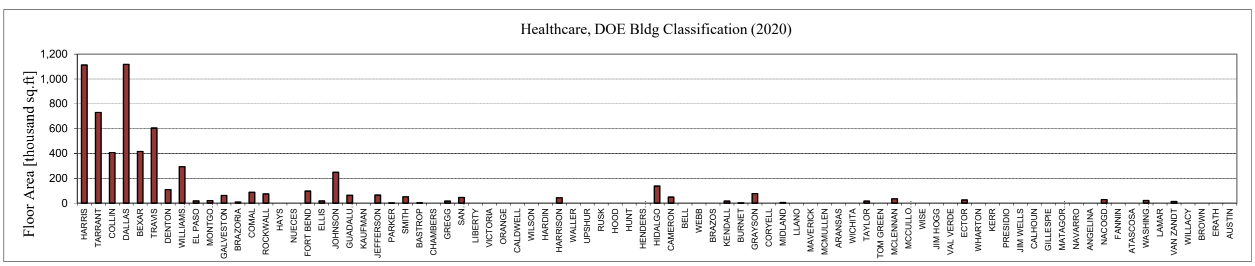


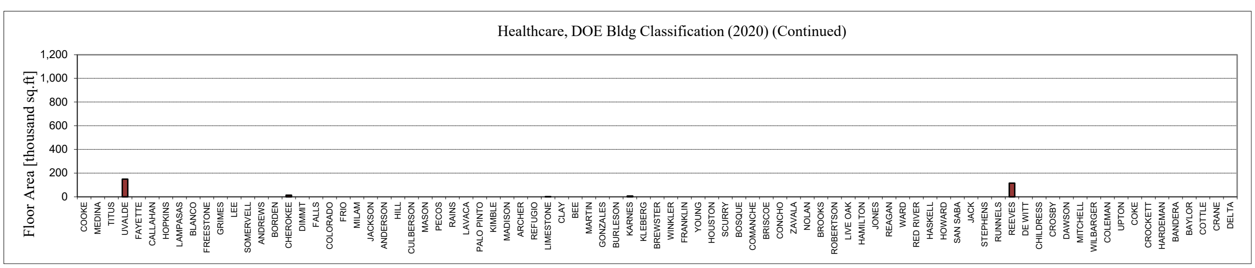
Figure 14: All the Types of 2020 New Commercial Building Construction (18% Reduction from the 2019 Dodge Data)











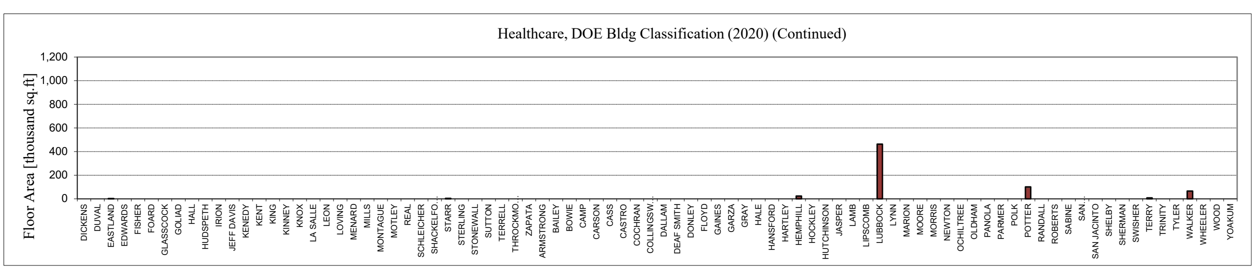
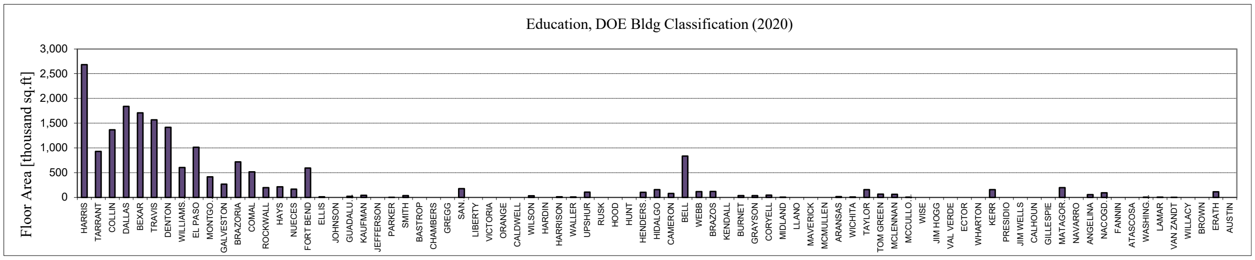
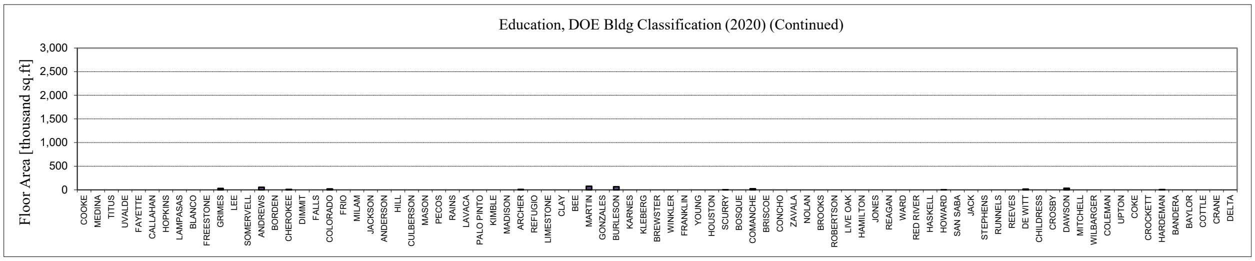
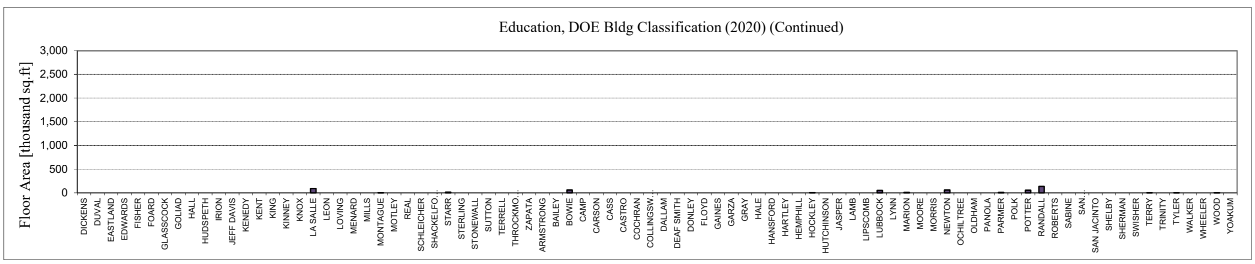


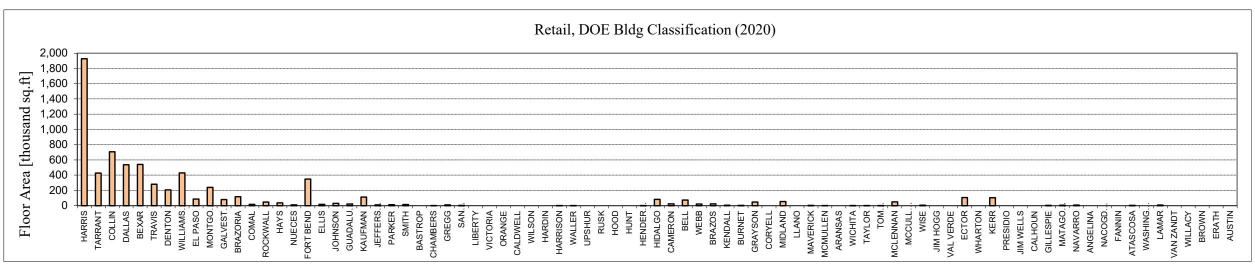
Figure 15: 2020 New Commercial Building Construction by Type (18% Reduction from the 2019 Dodge Data)

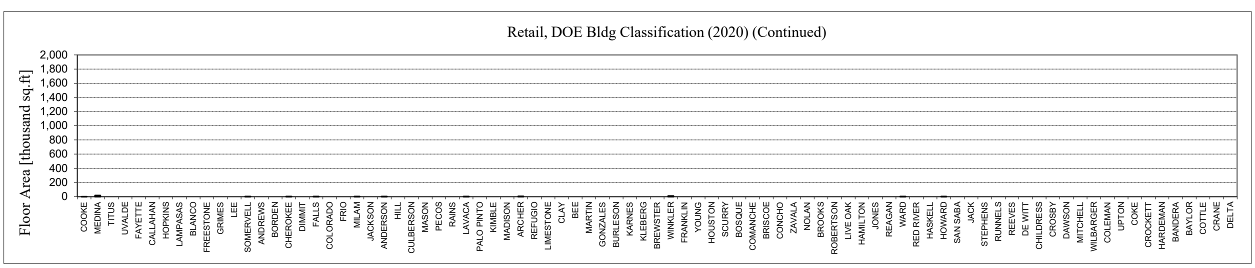
Figure 15: 2020 New Commercial Building Construction by Type (18% Reduction from the 2019 Dodge Data) (Continued)











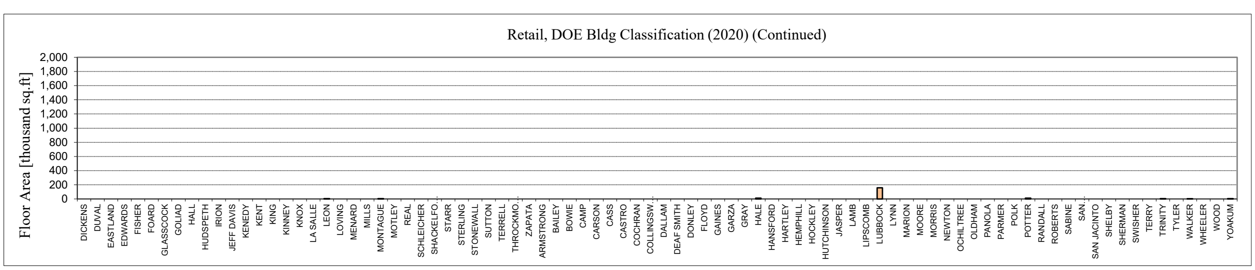
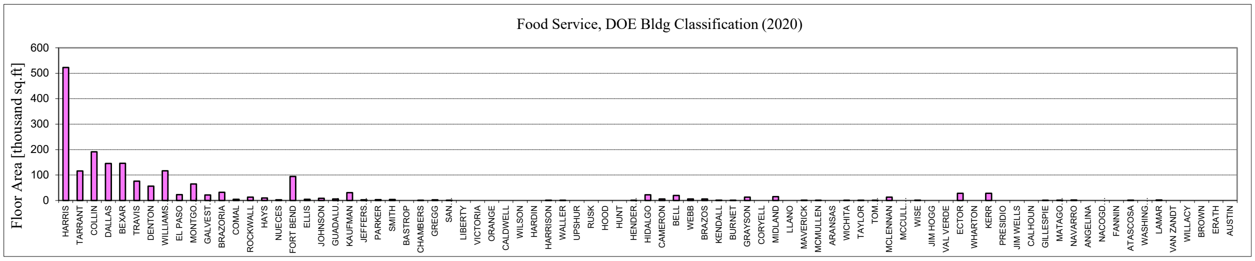
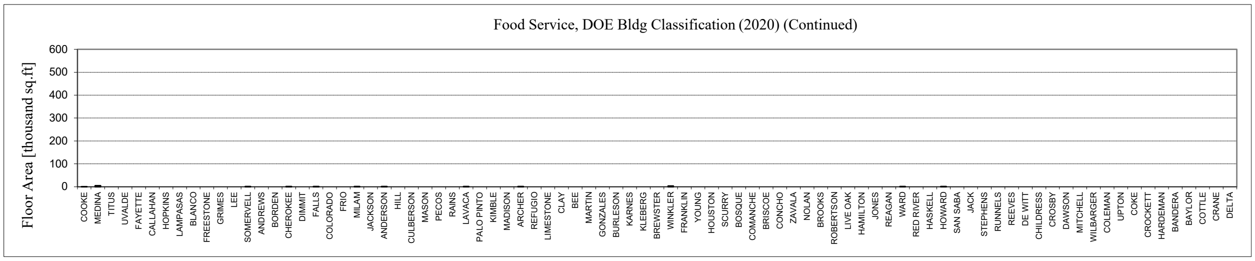


Figure 15: 2020 New Commercial Building Construction by Type (18% Reduction from the 2019 Dodge Data) (Continued)





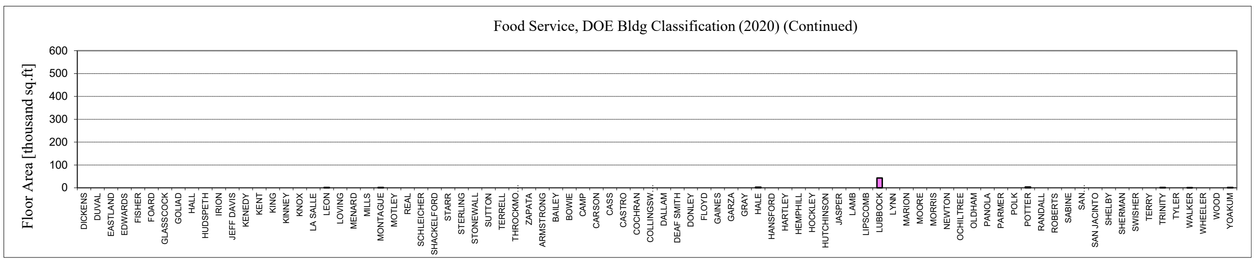


Figure 15: 2020 New Commercial Building Construction by Type (18% Reduction from the 2019 Dodge Data) (Continued)

Table 19: 2020 Totalized Annual Electricity Savings by CL Zone from New Commercial Construction

Electric Power Market	CL Zone	Total Electricity Savings by CL Zone (MWh) [2020-TRY 2018]
ERCOT	Houston (H)	0
	North (N)	0
	West (W)	0
	South (S)	0
SPP	-	0
SERC	-	0
WECC	-	0
Total		0

5 Calculation of Integrated NOx Emissions Reductions from Multiple State Agencies Participating in the Texas Emissions Reduction Plan (TERP)

5.1 Background

In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 could be reported in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2025 for both the annual and Ozone Season Period (OSP) NOx reductions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2018 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose. The different programs included in this 2020 integrated analysis are:

- ESL Single-family new construction
- ESL Multi-family new construction
- ESL Commercial new construction
- PUC Senate Bill 7 Program
- SECO Senate Bill 5 Program
- Electricity generated by renewables in Texas (ERCOT)
- SEER 13/14 upgrades to Single-family and Multi-family residences

The Laboratory's single-family and multi-family programs include the energy savings attained by the construction of new residences in Texas. To estimate energy savings, the published data on residential construction characteristics provided by the Home Innovation Research Labs (HIRL) is used as a baseline as well as the adopted energy code in 2018 (i.e., the 2015 IECC). Annual electricity savings (MWh) are obtained from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002 - 2020).

The Laboratory's commercial program includes the energy savings attained by constructing new commercial buildings in Texas, including office, apartment, healthcare, education, retail, food, and lodging as defined by Dodge building type (Dodge 2011). Energy savings were estimated from code-compliant buildings (ASHRAE Standard 90.1-2013) against pre-code buildings (ASHRAE Standard 90.1-2007) using EUI in the USDOE report and constructed square footage in Dodge data (Dodge 2020).

The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes the energy efficiency programs implemented by electric utilities under the Public Utility Regulatory Act §39.905. The PUC regulated energy efficiency program was adopted pursuant to 1999 legislation (SB 7) and subsequent legislation in 2001 (SB 5), 2007 (HB 3693), and 2011 (SB 1125). The energy efficiency measures include high-efficiency HVAC equipment, variable speed drives, increased insulation levels, infiltration reduction, duct sealing, Energy Star Homes, etc. Annual electricity savings claimed by the utilities were reported for the different programs completed in the years ~~2001 through~~ 2020.

The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs that are directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers. For the 2020 reporting year SECO submitted annual energy savings values for projects funded by SECO (SECO 2020) and by Energy Service projects.

The *Electric Reliability Council of Texas (ERCOT) electricity production from currently installed green power generation* in Texas is reported. In this report, the measured electricity productions for 2001 through 2020 were included. For projections to 2025, an annual growth factor was estimated using the last six years of installed power capacity.

Finally, NOx emissions reductions from *the installation of SEER 13 and SEER 14 air conditioners in existing residences* are also reported.

5.2 Description of the Analysis Method

Annual and Ozone Season Period (OSP) NOx emissions reductions were calculated for 2020 and integrated ~~from 2009 to~~ through 2025 using several factors to discount the potential savings. These factors include an annual degradation factor, a transmission and distribution factor, a discount factor, and growth factors as shown in Table 20 and are described as follows:

Annual degradation factor: This factor was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. With the exception of electricity generated from renewables, an annual degradation factor of 2% was used for ESL Single-family, Multi-family, and Commercial programs and an annual degradation factor of 5% was used for all other programs. The value of the 5% degradation factor was taken from a study by Kats et al. (1996).

Transmission and distribution loss: This factor adjusts the reported savings to account for the loss in energy resulting from the transmission and distribution of the power from the electricity producers to the electricity consumers. For this calculation, the energy savings reported at the consumer level are increased by 7% to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer. In the case of electricity generated by renewables, the T&D losses were assumed to cancel out since renewable energy is displacing power produced by conventional power plants; therefore, there is no net increase or decrease in T&D losses.

Initial discount factor: This factor was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures. For the Laboratory's Single, Multi-family and Commercial program, the discount factor was assumed to be 20%. For PUC's Senate Bill 7 program, the discount factor was taken as 10%. For the savings in the SECO program, the discount factor was 30% for the estimations. For the electricity from renewables, the discount factor was taken as 5%. In addition, the discount factor for SEER 13/SEER 14 single-family and multi-family program was 20%.

Growth factor: The growth factors shown in Table 20 were used to account for several different factors. Growth factors for single-family (4.1%), multi-family residential (6.1%), and commercial (5.3%) construction are projections based on the average growth rate for these housing types from recent U.S. Census data for Texas. The growth factor for renewable energy (8.5%) is a linear projection based on the installed renewable power generation capacity in 2020 from the Public Utility Commission of Texas. No growth was assumed for PUC programs, SECO, and SEER 13/14 entries.

Figure 16 shows the overall information flow that was used to calculate the NOx emissions savings from the annual and OSP electricity savings (MWh) from all programs. For the Laboratory's single-family and multi-family code-implementation programs, the annual and OSP were calculated from DOE-2 hourly simulation models[20]. The base case is taken as the average characteristics of single-family and multi-family residences for Texas published the Home Innovation Research Labs (HIRL) based on the performance path of the 2015 IECC. The annual electricity savings from PUC's energy efficiency programs were calculated using PUC approved demand savings calculations or tables or industry accepted measurement and verification methods (PUC 2021). The OSP consumption is the average daily consumption for the period between May 1 and September 30.

The SECO electricity savings were submitted as annual savings by project[21]. A description of the measures completed for the project was also submitted for information purposes. The electricity production from renewables farms in Texas was from the actual on-site metered data measured at 15-minute intervals except non-utility scale solar photovoltaic (PV) projects.

Integration of the savings from the different programs into a uniform format allowed for creditable NOx emissions to be evaluated using different criteria as shown in Table 20. These include evaluation across programs, evaluation

[20] These values are based on a performance analysis as defined by Chapter 4 of the 2006, 2009 and 2015 IECC, plus the corresponding NAHB and HIRL data. This analysis is discussed in the Laboratory's annual reports to the TCEQ.

[21] The reporting requirements to the SECO did not require energy savings by project type, although for selected sites, energy savings by project type was available.

across individual counties by program, evaluation by SIP area, evaluation for all ERCOT counties except Houston/Galveston, and evaluation within a 200 km radius of Dallas/Ft.Worth.

5.3 Calculation Procedure

The electricity savings in this report were estimated based on the baseline year of 2018. In addition, the emissions estimation throughout this report was updated to include the 2018 eGrid database, which is applied to the four different Competitive Load (CL) zones: Houston, North, West, and South as well as other counties in Texas. For all the programs, except renewable projects, the corresponding OSP emissions reductions were calculated using an annual daily average. The OSP emissions reductions from the electricity generated by renewables except non-utility scale solar PV projects were estimated by actual measured data.

ESL Single-family and Multi-family. The calculation of the annual electricity savings reported for the years 2002 through 2019 included the savings from code-compliant new housing in all 42 non-attainment and affected counties as reported in the Laboratory's annual report submitted by the Laboratory to the Texas Commission of Environmental Quality (TCEQ). From 2018 to 2020, based on year 2018, the annual electricity savings were calculated for new residential construction in all the counties in ERCOT region as well as other counties in Texas, which includes the 42 non-attainment and affected counties. These savings were then tabulated by county and program. Using the calculated values through 2020, savings were then projected to 2025 by incorporating the different adjustment factors mentioned above.

In these calculations, it was assumed that the same amount of electricity savings from the code-compliant construction would be achieved for each year after 2020 through 2025[22]. The projected energy savings through 2025, according to county, were then divided into the CL zones in the 2018 eGRID. To determine which CL zone was to be used, or in counties with multiple CL zone, the allocation to each CL zone by county was obtained from CL zone's listing published in the Laboratory's 2019 annual report[23].

For the 2020 annual NOx emissions calculations, the US EPA's 2018 eGRID was used. An example of the eGRID spreadsheet is given in Table 21. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors contained in eGRID. Similar calculations were performed for each year for which the analysis was required.

ESL-Commercial Buildings. The annual electricity savings for 2018 through 2020 for commercial buildings were obtained from the annual reports for 2018 through 2020 submitted by the Laboratory to TCEQ. From 2018 to 2020, based on year 2018, the annual electricity savings were also calculated for new commercial construction by county. Using the calculated savings through 2020, savings were then projected to 2025 by incorporating the different adjustment factors mentioned above. In the projected annual electricity savings, it was assumed that the same 2020 amount of electricity savings would be achieved for each year through 2024. Similarly to the single-family calculations, the projected energy saving numbers through 2025, by county, were allocated into the appropriate CL zones.

PUC-Senate Bill 7. For the PUC Senate Bill 7 program savings, the annual electricity savings for 2020 were obtained from the Public Utility Commission of Texas. Using these savings were projected through 2025 by incorporating the different adjustment factors mentioned above. Similar savings were assumed for each year after 2020 until 2025. The 2018 annual eGRID was used to calculate the NOx emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each county using the emissions factors contained in the US EPA's eGRID spreadsheet, which then were used to estimate the integrated NOx emissions reductions for each county.

SECO Savings. The annual electricity consumption reported by political subdivisions for 2020 was obtained from the State Energy Conservation Office (SECO). Using the reported consumption, the annual and OSP electricity savings resulted from energy conservation projects were then calculated. To achieve this, the annual energy use

[22] This would include the appropriate discount and degradation factors for each year.
[23] Haberl et al., 2020, Annual Report Volume I, pp. 60.

intensity (EUI) for each county was estimated and the county's energy savings for each year against the baseline year of 2018 were then calculated[24]. In addition, the savings through 2025 were projected using the different adjustment factors mentioned above. In a similar fashion to the previous programs, it was assumed that the same amount of electricity savings will be achieved for each year through 2025. The 2018 annual eGRID was also used to calculate the NOx emissions savings for the SECO program.

Electricity Generated by Renewables. The measured and estimated electricity production from renewables in Texas for 2018 through 2020 was obtained from the reports *Statewide Air Emissions Calculations from Wind and Other Renewables (2018-2020)*. Using the reported numbers for 2020, savings through 2025 were projected incorporating the different adjustment factors mentioned above. The 2016 eGRID was used for the 2019, and the 2018 eGRID was used for the period of 2020 through 2025 to calculate the NOx emissions reductions for the electricity generated by renewables in Texas. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties.

SEER 13 and 14 Single-Family and Multi-Family. In January of 2006, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 13 from the previous SEER 10. Although the electricity savings from new construction reflected this change in values, the annual and OSP electricity savings from the replacement of the air conditioning units by air conditioners with an efficiency of SEER 13 in existing residences needed to be calculated. In this analysis, it was assumed that an equal number of existing houses had their air conditioners replaced, as reported for 2006, by the air conditioner manufacturers[25]. In this report, the annual and OSP electricity savings were calculated for all the counties in ERCOT region, which include the 42 non-attainment and affected counties, were calculated. Based on the energy use and electricity generated for 2018, the savings after 2019 until 2025 were projected by incorporating the appropriate adjustment factors[26]. Similarly, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 14. The savings estimation considers the replacement of air-conditioning units by units with an efficiency of SEER 14 in existing residences that were built seventeen years ago[27]. The total SEER 13/ SEER 14 electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors contained in the 2018 eGRID. Integrated NOx emissions reductions for each county by non-attainment and affected counties were also calculated.

In this report, the annual and OSP electricity savings for all the counties in ERCOT region as well as the 42 non-attainment and affected counties were calculated. Using the numbers for 2018, the savings after 2018 until 2025 were projected by incorporating the appropriate adjustment factors[28]. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors contained in the 2018 eGRID. Integrated NOx emissions reductions for each county by ozone non-attainment and affected counties were also calculated.

[24] In this report, EUI values were used to calculate the electricity savings. This calculation method was also applied to savings estimation for the previous years from 2018 to 2020.
[25] In 2011, the U.S.DOE revised the energy conservation standards for residential HVAC systems. Beginning in January 2015, split-system central air conditioners installed in Texas must be at least SEER 14. NOx emissions reductions from SEER 14 replacement air conditioners will be included in future TERP reports as statewide sales data can be evaluated.
[26] Additional details about this calculation are contained in the Laboratory's 2008 Annual Report to the TCEQ, available at the ESL web site "http://esl.tamu.edu/".
[27] The "lifespan" of a central air conditioner is about 15 to 20 years. Department Of Energy (DOE): https://www.energy.gov/energysaver/central-air-conditioning#:~:text=The%20%22lifespan%22%20of%20a%20central,new%20standard%20goes%20into%20effect.
[28] Additional details about this calculation are contained in the Laboratory's 2018 Annual Report to the TCEQ, available at the Senate Bill 5 web site "http://esl.tamu.edu/".

5.4 Results (Base year 2018)

The total integrated annual and OSP electricity savings for all the different programs in the integrated format were calculated for 2019 through 2025 as shown in Table 22, using the adjustment factors shown in Table 20. Annual and OSP NOx emissions reductions from the electricity savings (presented in Table 22) for all the programs in the integrated format were shown in Table 23. Integrated OSP NOx emissions reduction projection and integrated OSP individual programs NOx emissions reduction projection were presented in Figure 17 and Figure 18.

In 2020, the total integrated annual savings from all programs are 81,073,322 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 249,931 MWh/year (0.3% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 1,263,892 MWh/year (1.6%),
- Savings from SECO's Senate Bill 5 program are 567,339 MWh/year (0.7%),
- Electricity savings from renewable power generation are 77,365,814 MWh/year (95.4%), and
- Savings from residential air conditioner retrofits[29] are 1,626,346 MWh/year (2.0%).

In 2020, the total integrated OSP savings from all programs are 239,245 MWh/day, which would be 9,969 MW average hourly load reduction during the OSP period. The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 685 MWh/day (0.3%),
- Savings from the PUC's Senate Bill 7 programs are 3,463 MWh/day (1.4%),
- Savings from SECO's Senate Bill 5 program are 1,553 MWh/day (0.6%),
- Electricity savings from renewable power generation are 222,795 MWh/day (93.1%), and
- Savings from residential air conditioner retrofits are 10,750 MWh/day (4.5%).

By 2025, the total integrated annual savings from all programs will be 124,686,284 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 1,643,386 MWh/year (1.3% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 3,990,544 MWh/year (3.2%),
- Savings from SECO's Senate Bill 5 program will be 1,462,295 MWh/year (1.2%),
- Electricity savings from renewable power generation will be 116,331,624 MWh/year (93.3%), and
- Savings from residential air conditioner retrofits will be 1,258,435 MWh/year (1.0%).

By 2025, the total integrated OSP savings from all programs will be 360,973 MWh/day, which would be 15,041 MW average hourly load reduction during the OSP. The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 4,502 MWh/day (1.2%),
- Savings from the PUC's Senate Bill 7 programs will be 9,588 MWh/day (2.7%),
- Savings from SECO's Senate Bill 5 program will be 3,557 MWh/day (1.0%),
- Electricity savings from renewable power generation will be 335,007 MWh/day (92.8%), and
- Savings from residential air conditioner retrofits will be 8,318 MWh/day (2.3%).

In 2020 (Table 23), the total integrated annual NOx emissions reductions from all programs are 49,450 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 104 tons-NOx/year (0.2% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 496 tons-NOx/year (1.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 230 tons-NOx/year (0.5%),
- NOx emissions reductions from renewable power generation are 47,874 tons-NOx/year (96.8%), and

[29] This assumes air conditioners in existing homes are replaced with the more efficient SEER 13/14 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- NOx emissions reductions from residential air conditioner retrofits are 746 tons-NOx/year (1.5%).

In 2020, the total integrated OSP NOx emissions reductions from all programs are 136.79 tons-NOx/day. The integrated OSP NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction are 0.27 tons-NOx/day (0.2%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 1.28 tons-NOx/day (0.9%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.59 tons-NOx/day (0.4%),
- NOx emissions reductions from renewable power generation are 130 tons-NOx/day (95.0%), and
- NOx emissions reductions from residential air conditioner retrofits are 4.56 tons-NOx/day (3.4%).

By 2025, the total integrated annual NOx emissions reductions from all programs will be 75,496 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 686 tons-NOx/year (0.9% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1,571 tons-NOx/year (2.1%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 676 tons-NOx/year (0.9%),
- NOx emissions reductions from renewable power generation will be 71,985 tons-NOx/year (95.3%), and
- NOx emissions reductions from residential air conditioner retrofits will be 578 tons-NOx/year (0.8%).

By 2025, the total integrated OSP NOx emissions reductions from all programs will be 206.62 tons-NOx/day. The integrated OSP NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 1.75 tons-NOx/day (0.8%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 4.06 tons-NOx/day (2.0%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 1.74 tons-NOx/day (0.8%),
- NOx emissions reductions from renewable power generation will be 195.47 tons-NOx/day (94.6%), and
- NOx emissions reductions from residential air conditioner retrofits will be 3.60 tons-NOx/day (1.7%).

Corresponding 2008 base year annual energy savings and NOx emission reductions are also included in the Table 24 and Table 25 and shown in Figure 19 and Figure 20.

Table 20: Final Adjustment Factors used for the Calculation of the Annual and OSP NOx Savings for the Different Programs

	ESL-Single Family	ESL-Multifamily	ESL-Commercial	PUC (SB7)	SECO	Renewables-ERCOT	SEER 13/14 Single Family	SEER 13/14 Multi Family
Annual Degradation Factor	**2.0%**	**2.0%**	**2.0%**	**5.0%**	**5.0%**	**0.0%**	**5.0%**	**5.0%**
T&D Loss	**7.0%**	**7.0%**	**7.0%**	**7.0%**	**7.0%**	**0.0%**	**7.0%**	**7.0%**
Initial Discount Factor	**20.0%**	**20.0%**	**20.0%**	**10.0%**	**30.0%**	**5.0%**	**20.0%**	**20.0%**
Growth Factor	**4.1%**	**6.1%**	**5.3%**	**0.0%**	**0.0%**	**8.5%**	**N.A.**	**N.A.**
Weather Normalized	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**	**Yes**

~~Note: For Renewables-ERCOT, the OSP energy consumption is the average daily consumption of the measured data from May 1 to September 30. In the SECO calculations, a 30% initial discount factor is used from 2019 and before 2019, a 60% initial discount factor was used for the estimations. SEER 14 calculations were added for 2019-2024 projections.~~

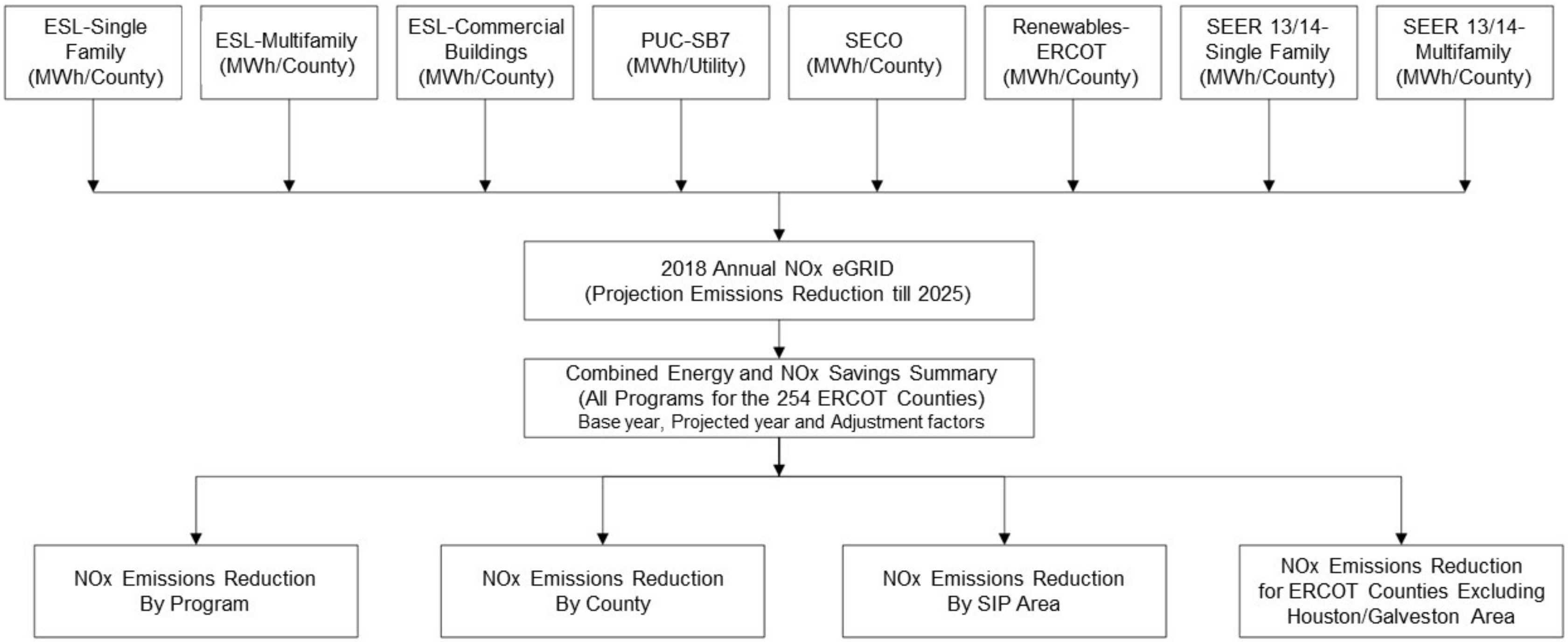


Figure 16: Process Flow Diagram of the NOx Emissions Reduction Calculations

Table 21: Example of NOx Emissions Reduction Calculations using 2018 eGRID

Area	County	ERCOT-H	NOx Reductions (lbs)	ERCOT-N	NOx Reductions (lbs)	ERCOT-W	NOx Reductions (lbs/year)	ERCOT-S	NOx Reductions (lbs)	SPP	NOx Reductions (lbs)	SERC	NOx Reductions (lbs)	WECC	NOx Reductions (lbs)	Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
Houston-Galveston Area	Brazoria	0.1445243	3645.85	0.0000183	0.42	0.0000009	0.00	0.0013540	28.60	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3674.87	1.84
	Chambers	0.0232302	586.02	0.0000029	0.07	0.0000001	0.00	0.0002176	4.60	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	590.68	0.30
	Fort Bend	0.0925360	2334.37	0.0000117	0.27	0.0000006	0.00	0.0008669	18.31	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2352.95	1.18
	Galveston	0.0189140	477.14	0.0000024	0.06	0.0000001	0.00	0.0001772	3.74	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	480.93	0.24
	Harris	0.1374166	3466.55	0.0000174	0.40	0.0000008	0.00	0.0012874	27.19	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3494.14	1.75
	Liberty	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Montgomery	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0587430	105.69	0.0000000	0.00	105.69	0.05
	Waller	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Beaumont/ Port Arthur Area	Hardin	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0027101	4.88	0.0000000	0.00	4.88	0.00
	Jefferson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.9687861	1742.99	0.0000000	0.00	1742.99	0.87
	Orange	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.8865417	1595.02	0.0000000	0.00	1595.02	0.80
Dallas/ Fort Worth Area	Collin	0.0000743	1.87	0.0004556	10.48	0.0000220	0.04	0.0000046	0.10	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	12.49	0.01
	Dallas	0.0019090	48.16	0.0117105	269.33	0.0005656	0.99	0.0001195	2.52	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	321.00	0.16
	Denton	0.0066429	167.58	0.0407509	937.23	0.0019683	3.43	0.0004158	8.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1117.03	0.56
	Henderson	0.0001509	3.81	0.0009255	21.29	0.0000447	0.08	0.0000094	0.20	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	25.37	0.01
	Hood	0.0008451	21.32	0.0051842	119.23	0.0002504	0.44	0.0000529	1.12	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	142.10	0.07
	Hunt	0.0000043	0.11	0.0000263	0.61	0.0000013	0.00	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.72	0.00
	Tarrant	0.0004188	10.57	0.0025693	59.09	0.0001241	0.22	0.0000262	0.55	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	70.43	0.04
	Ellis	0.0013349	33.68	0.0081890	188.34	0.0003955	0.69	0.0000835	1.76	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	224.47	0.11
	Johnson	0.0002010	5.07	0.0012332	28.36	0.0000596	0.10	0.0000126	0.27	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	33.80	0.02
	Kaufman	0.0034596	87.27	0.0212228	488.11	0.0010251	1.79	0.0002165	4.57	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	581.74	0.29
	Parker	0.0005940	14.98	0.0036438	83.80	0.0001760	0.31	0.0000372	0.79	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	99.88	0.05
	Rockwall	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Wise	0.0031300	78.96	0.0192012	441.61	0.0009275	1.62	0.0001959	4.14	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	526.33	0.26
El Paso Area	El Paso	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1.2223686	1006.31	1006.31	0.50
San Antonio Area	Bexar	0.0253670	639.92	0.0017108	39.35	0.0000826	0.14	0.2025905	4278.87	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4958.29	2.48
	Comal	0.0005285	13.33	0.0000356	0.82	0.0000017	0.00	0.0042210	89.15	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	103.31	0.05
	Guadalupe	0.0030546	77.06	0.0002060	4.74	0.0000100	0.02	0.0243949	515.24	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	597.05	0.30
	Wilson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Austin Area	Bastrop	0.0024800	62.56	0.0001673	3.85	0.0000081	0.01	0.0198060	418.32	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	484.74	0.24
	Caldwell	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hays	0.0004731	11.93	0.0000319	0.73	0.0000015	0.00	0.0037782	79.80	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	92.47	0.05
	Travis	0.0046184	116.51	0.0003115	7.16	0.0000150	0.03	0.0368846	779.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	902.73	0.45
	Williamson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
North East Texas Area	Gregg	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0053705	6.10	0.0000000	0.00	0.0000000	0.00	6.10	0.00
	Harrison	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2702671	306.85	0.0000000	0.00	0.0000000	0.00	306.85	0.15
	Rusk	0.0322708	814.08	0.1979648	4553.01	0.0095620	16.68	0.0020197	42.66	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5426.43	2.71
	Smith	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upshur	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
Corpus Christi Area	Nueces	0.0042426	107.03	0.0002861	6.58	0.0000138	0.02	0.0338828	715.63	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	829.26	0.41
	San Patricio	0.0063692	160.67	0.0004296	9.88	0.0000207	0.04	0.0508668	1074.35	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1244.94	0.62
Victoria Area	Victoria	0.0016730	42.20	0.0001128	2.60	0.0000054	0.01	0.0133614	282.20	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	327.01	0.16
Other ERCOT Counties	Anderson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Angelina	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Atascosa	0.0077084	194.46	0.0005199	11.96	0.0000251	0.04	0.0615620	1300.24	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1506.70	0.75
	Bell	0.0004444	11.21	0.0027262	62.70	0.0001317	0.23	0.0000278	0.59	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	74.73	0.04
	Bosque	0.0007214	18.20	0.0044257	101.79	0.0002138	0.37	0.0000452	0.95	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	121.31	0.06
	Brazos	0.0005654	14.26	0.0034687	79.78	0.0001675	0.29	0.0000354	0.75	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	95.08	0.05
	Calhoun	0.0111852	282.16	0.0007544	17.35	0.0000364	0.06	0.0893292	1886.70	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2186.28	1.09
	Cameron	0.0000231	0.58	0.0000016	0.04	0.0000001	0.00	0.0001843	3.89	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4.51	0.00
	Cherokee	0.0001844	4.65	0.0011310	26.01	0.0000546	0.10	0.0000115	0.24	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	31.00	0.02
	Coke	0.0000223	0.56	0.0001365	3.14	0.0231815	40.43	0.0000014	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	44.16	0.02
	Colorado	0.0016158	40.76	0.0001090	2.51	0.0000053	0.01	0.0129041	272.54	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	315.82	0.16
	Ector	0.0001338	3.37	0.0008206	18.87	0.1393442	243.04	0.0000084	0.18	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	265.46	0.13
	Fayette	0.0204274	515.31	0.0013777	31.69	0.0000665	0.12	0.1631405	3445.66	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3992.77	2.00
	Freestone	0.0042261	106.61	0.0259247	596.25	0.0012522	2.18	0.0002645	5.59	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	710.63	0.36
	Frio	0.0097614	246.25	0.0006583	15.14	0.0000318	0.06	0.0779581	1646.54	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1907.98	0.95
	Goliad	0.0077047	194.36	0.0005196	11.95	0.0000251	0.04	0.0615328	1299.62	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1505.98	0.75
	Grayson	0.0002857	7.21	0.0017525	40.31	0.0000846	0.15	0.0000179	0.38	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	48.04	0.02
	Grimes	0.0029942	75.53	0.0183678	422.44	0.0008872	1.55	0.0001874	3.96	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	503.48	0.25
	Hidalgo	0.0140830	355.27	0.0009498	21.84	0.0000459	0.08	0.1124720	2375.50	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2752.69	1.38
	Hill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Howard	0.0000467	1.18	0.0002865	6.59	0.0486558	84.86	0.0000029	0.06	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	92.69	0.05
	Lamar	0.0031379	79.16	0.0192492	442.72	0.0009298	1.62	0.0001964	4.15	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	527.64	0.26
	Limestone	0.0231674	584.43	0.1421203	3268.64	0.0068646	11.97	0.0014500	30.62	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3895.67	1.95
	Llano	0.0001855	4.68	0.0000125	0.29	0.0000006	0.00	0.0014818	31.30	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	36.27	0.02
	McLennan	0.0043688	110.21	0.0268006	616.39	0.0012945	2.26	0.0002734	5.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	734.63	0.37
	Milam	0.0002486	6.27	0.0000168	0.39	0.0000008	0.00	0.0019850	41.93	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	48.58	0.02
	Mitchell	0.0000072	0.18	0.0000443	1.02	0.0075244	13.12	0.0000005	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	14.33	0.01
	Nacogdoches	0.0002714	6.85	0.0016647	38.29	0.0000804	0.14	0.0000170	0.36	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	45.63	0.02
	Nolan	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Palo Pinto	0.0010391	26.21	0.0063745	146.61	0.0003079	0.54	0.0000650	1.37	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	174.73	0.09
	Pecos	0.0000029	0.07	0.0000180	0.41	0.0030637	5.34	0.0000002	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5.84	0.00
	Reagan	0.0000002	0.01	0.0000015	0.03	0.0002476	0.43	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.47	0.00
	Red River	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Robertson	0.0184177	464.61	0.1129830	2598.51	0.0054573	9.52	0.0011527	24.35	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3096.98	1.55
	Scurry	0.0001246	3.14	0.0007646	17.58	0.1298311	226.45	0.0000078	0.16	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	247.34	0.12
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Upton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Ward	0.0000206	0.52	0.0001265	2.91	0.0214790	37.46	0.0000013	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	40.92	0.02
	Webb	0.0000253	0.64	0.0000017	0.04	0.0000001	0.00	0.0002020	4.27	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4.94	0.00
	Wharton	0.0006585	16.61	0.0000444	1.02	0.0000021	0.00	0.0052594	111.08	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	128.72	0.06
	Wichita	0.0000051	0.13	0.0000315	0.72	0.0053432	9.32	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	10.18	0.01
	Wilbarger	0.0008609	21.72	0.0052810	121.46	0.8967472	1564.07	0.0000539	1.14	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1708.38	0.85
	Wood	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Young	0.0000257	0.65	0.0001578	3.63	0.0267892	46.72	0.0000016	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	51.04	0.03
Other SPP Counties	Cass	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0127595	14.49	0.0000000	0.00	0.0000000	0.00	14.49	0.01
	Gaines	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Gray	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Hale	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0616792	70.03	0.0000000	0.00	0.0000000	0.00	70.03	0.04
	Hemphill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0246062	27.94	0.0000000	0.00	0.0000000	0.00	27.94	0.01
	Hutchinson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0134856	15.31	0.0000000	0.00	0.0000000	0.00	15.31	0.01
	Lamb	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2117054	240.36	0.0000000	0.00	0.0000000	0.00	240.36	0.12
	Lubbock	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0695988	79.02	0.0000000	0.00	0.0000000	0.00	79.02	0.04
	Marion	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0272898	30.98	0.0000000	0.00	0.0000000	0.00	30.98	0.02
	Moore	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Morris	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0002270	0.26	0.0000000	0.00	0.0000000	0.00	0.26	0.00
	Potter	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2710995	307.79	0.0000000	0.00	0.0000000	0.00	307.79	0.15
	Titus	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Yoakum	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0438855	49.83	0.0000000	0.00	0.0000000	0.00	49.83	0.02
Other SERC Counties	Jasper	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Newton	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0870000	156.53	0.0000000	0.00	156.53	0.08
	San Jacinto	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0072219	12.99	0.0000000	0.00	12.99	0.01
	Tyler	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.00	0.00
	Total	**0.4927768**	**12431.07**	**0.6891868**	**15850.68**	**0.9589944**	**1672.64**	**0.7276081**	**15367.67**	**1.3340545**	**1514.61**	**0.4990937**	**897.94**	**1.2223686**	**1006.31**	**805950.57**	**402.98**

Energy Savings (MWh)		ERCOT-H		ERCOT-N		ERCOT-W		ERCOT-S		SPP		SERC		WECC	
		25,227		22,999		1,744		21,121		1,135		1,799		823	

Table 22: Annual and OSP Electricity Savings for the Different Programs (Base Year 2018)

PROGRAM	ANNUAL (MWh)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	74,850	151,273	229,361	309,214	390,931	474,618
ESL-Multifamily	0	0	175,080	357,338	547,283	745,451	952,412	1,168,768
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	629,516	1,263,892	1,866,549	2,439,074	2,982,972	3,499,676	3,990,544
SECO	0	359,121	567,339	765,147	953,064	1,131,585	1,301,180	1,462,295
Renewables-ERCOT	0	62,168,032	77,365,814	83,941,908	91,076,970	98,818,513	107,218,086	116,331,624
SEER13-Single Family	0	217,605	206,725	196,389	186,569	177,241	168,379	159,960
SEER13-Multi Family	0	18,420	17,499	16,624	15,793	15,003	14,253	13,541
SEER14-Single Family	0	567,976	1,171,988	1,113,389	1,057,719	1,004,833	954,592	906,862
SEER14-Multi Family	0	116,741	230,133	218,627	207,695	197,311	187,445	178,073
Total Annual (MWh)	**0**	**64,077,411**	**81,073,322**	**88,627,244**	**96,713,529**	**105,382,123**	**114,686,954**	**124,686,284**

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	205	414	628	847	1,071	1,300
ESL-Multifamily	0	0	480	979	1,499	2,042	2,609	3,202
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	1,725	3,463	5,114	6,682	8,173	9,588	9,588
SECO	0	984	1,553	2,093	2,606	3,094	3,557	3,557
Renewables-ERCOT	0	187,283	222,795	241,732	262,279	284,573	308,762	335,007
SEER13-Single Family	0	1,546	1,468	1,395	1,325	1,259	1,196	1,136
SEER13-Multi Family	0	124	118	112	106	101	96	91
SEER14-Single Family	0	3,712	7,660	7,277	6,913	6,568	6,239	5,927
SEER14-Multi Family	0	763	1,504	1,429	1,357	1,290	1,225	1,164
Total OSP (MWh)	**0**	**196,136**	**239,245**	**260,545**	**283,398**	**307,946**	**334,344**	**360,973**

Table 23: Annual and OSP NOx Emissions Reduction Values for the Different Programs (Base Year 2018)

PROGRAM	ANNUAL (in tons NOx)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	0	31	62	95	128	161	196
ESL-Multifamily	0	0	73	150	230	313	399	490
ESL-Commercial	0	0	0	0	0	0	0	0
PUC (SB7)	0	208	496	734	959	1,174	1,377	1,571
SECO	0	121	230	329	422	511	596	676
Renewables-ERCOT	0	27,757	47,874	51,943	56,358	61,148	66,346	71,985
SEER13-Single Family	0	73	85	80	76	72	69	65
SEER13-Multi Family	0	6	7	7	6	6	6	5
SEER14-Single Family	0	219	552	524	497	473	450	427
SEER14-Multi Family	0	44	103	98	93	88	84	80
Total Annual (Tons NOx)	**0**	**28,428**	**49,450**	**53,927**	**58,736**	**63,914**	**69,488**	**75,496**

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)							
	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0.00	0.00	0.08	0.16	0.24	0.32	0.40	0.49
ESL-Multifamily	0.00	0.00	0.19	0.39	0.59	0.80	1.03	1.26
ESL-Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUC (SB7)	0.00	0.62	1.28	1.90	2.48	3.03	3.56	4.06
SECO	0.00	0.35	0.59	0.84	1.08	1.31	1.53	1.74
Renewables-ERCOT	0.00	99.65	130.00	141.05	153.04	166.05	180.16	195.47
SEER13-Single Family	0.00	0.56	0.56	0.53	0.51	0.48	0.46	0.43
SEER13-Multi Family	0.00	0.04	0.04	0.04	0.04	0.04	0.03	0.03
SEER14-Single Family	0.00	1.53	3.41	3.24	3.08	2.92	2.78	2.64
SEER14-Multi Family	0.00	0.31	0.64	0.61	0.58	0.55	0.52	0.49
Total OSP (Tons NOx)	**0.00**	**103.06**	**136.79**	**148.75**	**161.63**	**175.51**	**190.47**	**206.62**

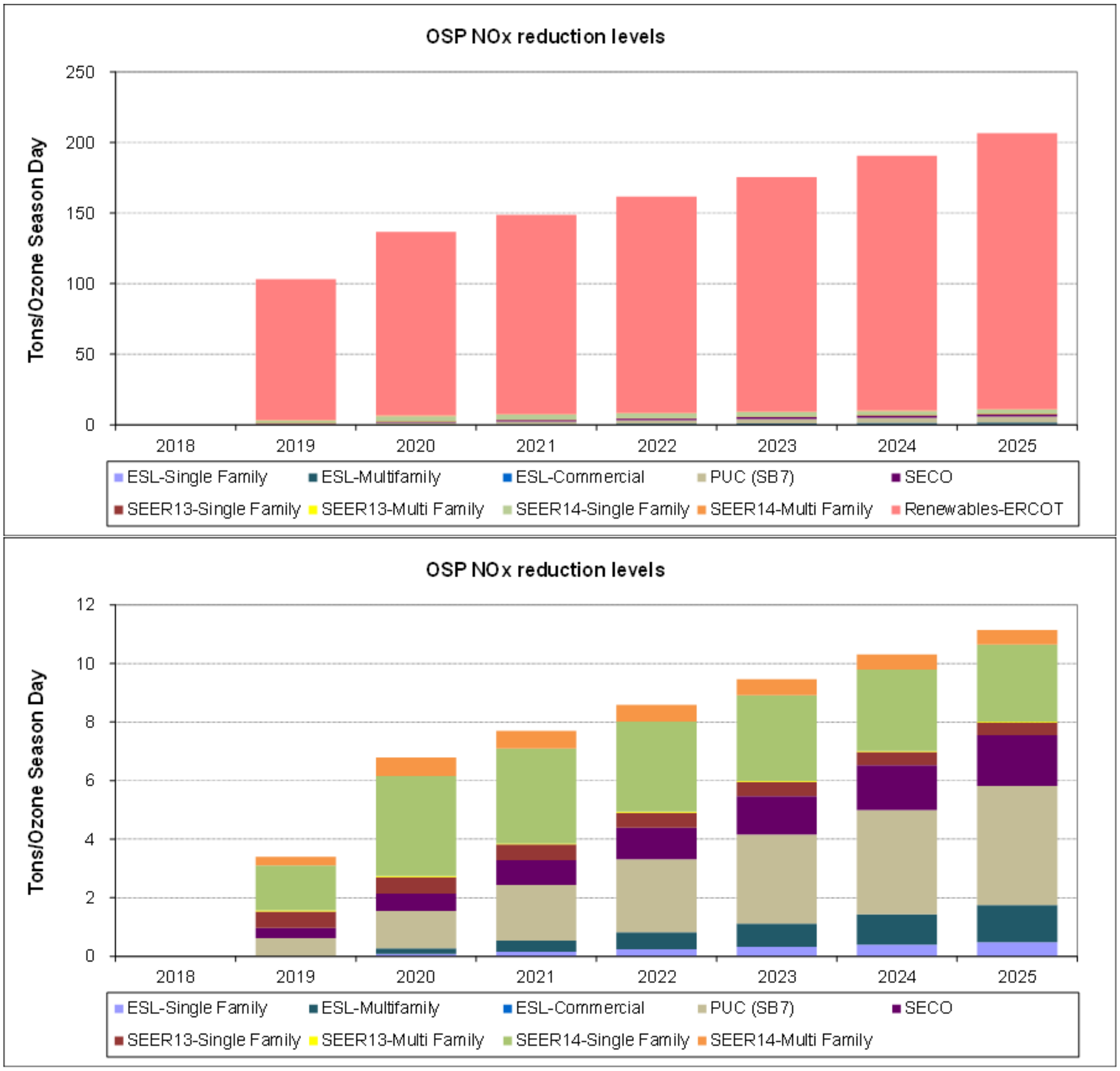


Figure 17: Integrated OSP NOx Emissions Reduction Projections from 2018 to 2025 (Base Year 2018). (Upper plot) all programs, (lower plot) all programs except Renewables.

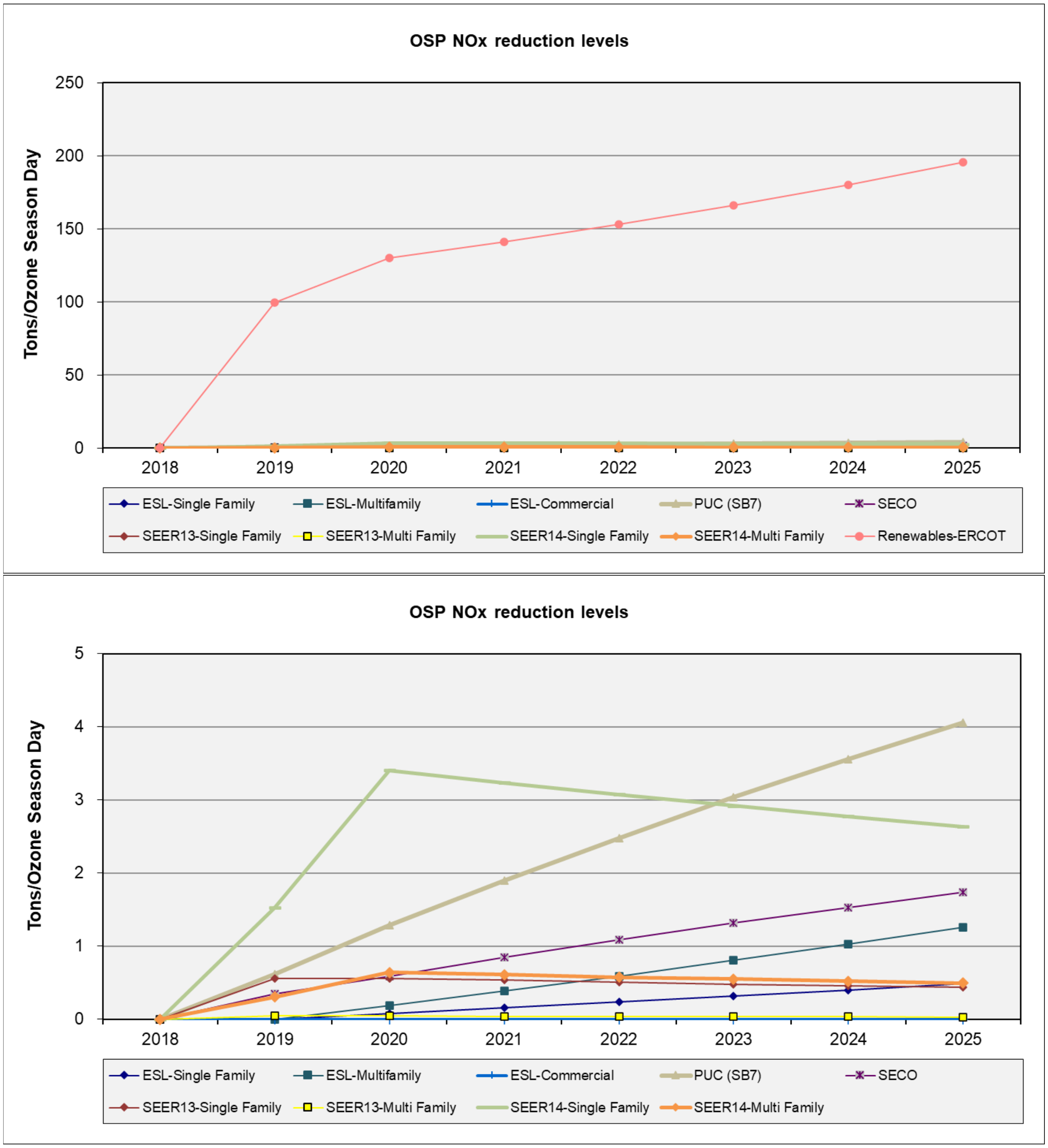


Figure 18: Integrated OSP Individual Programs NOx Emissions Reduction Projections from 2018 to 2025 (Base Year 2018). (Upper plot) all programs, (lower plot) all programs except Renewables.

5.5 Results (Base year 2008)

Table 24 and Table 25 and Figure 19 and Figure 20 showed the 2008 base year annual energy savings and NOx emission reductions.

Table 24: Annual and OSP Electricity Savings for the Different Programs (Base Year 2008)

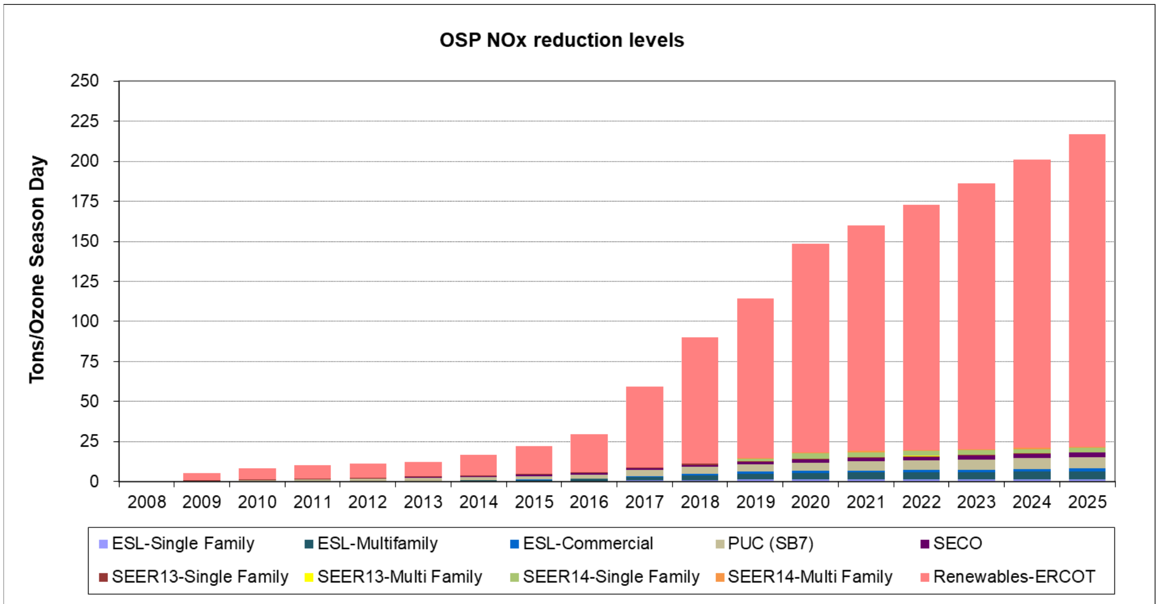
PROGRAM	ANNUAL (MWh)																	
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	25,031	47,000	74,109	153,562	215,164	275,535	360,010	533,473	722,595	967,082	1,212,227	1,456,896	1,707,697	1,964,960	2,229,026	2,500,248	2,778,993
ESL-Multifamily	0	50,784	108,018	200,414	332,835	527,292	774,578	1,225,617	1,856,682	2,472,527	3,151,036	3,962,565	4,421,272	4,903,620	5,411,139	5,945,449	6,508,266	7,101,413
ESL-Commercial	0	0	24,066	83,255	119,422	247,952	400,015	559,947	696,924	850,020	983,858	1,104,834	1,198,073	1,295,560	1,397,534	1,504,246	1,615,961	1,732,957
PUC (SB7)	0	538,841	976,984	1,437,883	1,831,318	2,267,414	2,675,295	3,079,759	3,498,867	3,844,949	4,209,108	4,628,168	5,062,612	5,475,333	5,867,419	6,239,900	6,593,757	6,929,921
SECO	0	74,198	157,524	349,845	512,539	713,477	1,015,815	1,019,507	1,117,717	1,296,153	1,402,040	1,691,059	1,832,680	1,967,221	2,095,034	2,216,456	2,331,808	2,441,392
Renewables-ERCOT	0	3,454,992	8,351,369	12,158,649	13,392,752	17,028,343	18,753,002	20,883,590	34,193,486	47,055,032	49,700,002	62,168,032	77,365,814	83,941,908	91,076,970	98,818,513	107,218,086	116,331,624
SEER13-Single Family	0	363,440	345,268	328,005	311,605	296,024	281,223	267,162	253,804	241,114	229,058	217,605	206,725	196,389	186,569	177,241	168,379	159,960
SEER13-Multi Family	0	30,765	29,227	27,766	26,377	25,059	23,806	22,615	21,485	20,410	19,390	18,420	17,499	16,624	15,793	15,003	14,253	13,541
SEER14-Single Family	0	0	0	0	0	0	0	0	0	0	0	567,976	1,171,988	1,113,389	1,057,719	1,004,833	954,592	906,862
SEER14-Multi Family	0	0	0	0	0	0	0	0	0	0	0	116,741	230,133	218,627	207,695	197,311	187,445	178,073
Total Annual (MWh)	0	4,538,051	10,039,456	14,659,925	16,680,410	21,320,725	24,199,269	27,418,208	42,172,438	56,502,800	60,661,574	75,687,627	92,963,693	100,836,368	109,280,832	118,347,977	128,092,795	138,574,735

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)																	
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	69	129	203	421	589	755	986	1,462	1,980	2,650	3,321	3,991	4,679	5,383	6,107	6,850	7,614
ESL-Multifamily	0	139	296	549	912	1,445	2,122	3,358	5,087	6,774	8,633	10,856	12,113	13,435	14,825	16,289	17,831	19,456
ESL-Commercial	0	0	66	228	327	679	1,096	1,534	1,909	2,329	2,696	3,027	3,282	3,549	3,829	4,121	4,427	4,748
PUC (SB7)	0	1,476	2,677	3,939	5,017	6,212	7,330	8,438	9,586	10,534	11,532	12,680	13,870	15,001	16,075	17,096	18,065	18,986
SECO	0	203	432	958	1,404	1,955	2,783	2,793	3,062	3,551	3,841	4,633	5,019	5,386	5,735	6,066	6,381	6,680
Renewables-ERCOT	0	15,037	26,234	30,736	32,528	31,695	46,338	63,604	86,957	96,446	145,063	187,283	222,795	241,732	262,279	284,573	308,762	335,007
SEER13-Single Family	0	2,582	2,453	2,330	2,214	2,103	1,998	1,898	1,803	1,713	1,627	1,546	1,468	1,395	1,325	1,259	1,196	1,136
SEER13-Multi Family	0	207	196	187	177	168	160	152	144	137	130	124	118	112	106	101	96	91
SEER14-Single Family	0	0	0	0	0	0	0	0	0	0	0	3,712	7,660	7,277	6,913	6,568	6,239	5,927
SEER14-Multi Family	0	0	0	0	0	0	0	0	0	0	0	763	1,504	1,429	1,357	1,290	1,225	1,164
Total OSP (MWh)	0	19,713	32,482	39,130	43,000	44,846	62,581	82,763	110,011	123,464	176,172	227,945	271,821	293,995	317,829	343,469	371,072	400,808

Table 25: Annual and OSP NOx Emissions Reduction Values for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (in tons NOx)																	
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0	3	8	15	34	50	65	86	129	224	320	403	511	533	556	580	604	630
ESL-Multifamily	0	4	19	43	77	127	190	305	468	810	1,061	1,333	1,606	1,652	1,702	1,755	1,813	1,876
ESL-Commercial	0	0	5	16	22	47	79	114	141	229	310	363	603	652	703	757	813	871
PUC (SB7)	0	135	246	362	460	567	669	770	874	1,326	1,410	1,547	1,893	2,046	2,191	2,329	2,460	2,584
SECO	0	20	44	92	134	185	267	269	298	407	285	546	773	852	927	999	1,067	1,131
Renewables-ERCOT	0	951	2,645	3,258	3,561	4,693	5,116	5,683	9,359	24,054	22,408	27,757	47,874	51,943	56,358	61,148	66,346	71,985
SEER13-Single Family	0	86	81	77	73	70	66	63	60	72	77	73	85	80	76	72	69	65
SEER13-Multi Family	0	7	7	7	6	6	6	5	5	6	6	6	7	7	6	6	6	5
SEER14-Single Family	0	0	0	0	0	0	0	0	0	0	0	219	552	524	497	473	450	427
SEER14-Multi Family	0	0	0	0	0	0	0	0	0	0	0	44	103	98	93	88	84	80
Total Annual (Tons NOx)	0	1,205	3,054	3,870	4,369	5,744	6,457	7,294	11,335	27,127	25,876	32,291	54,006	58,386	63,109	68,208	73,711	79,656

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)																	
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ESL-Single Family	0.00	0.01	0.02	0.04	0.09	0.14	0.18	0.24	0.35	0.62	0.93	1.18	1.30	1.36	1.41	1.47	1.53	1.60
ESL-Multifamily	0.00	0.01	0.05	0.12	0.21	0.35	0.52	0.83	1.28	2.24	3.09	3.88	4.13	4.25	4.37	4.51	4.66	4.82
ESL-Commercial	0.00	0.00	0.01	0.04	0.06	0.13	0.22	0.31	0.39	0.64	0.91	1.07	1.22	1.32	1.42	1.53	1.64	1.76
PUC (SB7)	0.00	0.37	0.67	0.99	1.26	1.55	1.83	2.11	2.39	3.75	4.21	4.62	5.19	5.60	6.00	6.38	6.74	7.08
SECO	0.00	0.05	0.12	0.25	0.37	0.51	0.73	0.74	0.82	1.14	1.30	1.58	1.86	2.06	2.24	2.41	2.57	2.73
Renewables-ERCOT	0.00	4.15	6.85	8.42	8.91	9.03	12.87	17.55	24.11	50.25	78.80	99.65	130.00	141.05	153.04	166.05	180.16	195.47
SEER13-Single Family	0.00	0.60	0.57	0.54	0.52	0.49	0.47	0.44	0.42	0.52	0.59	0.56	0.56	0.53	0.51	0.48	0.46	0.43
SEER13-Multi Family	0.00	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03
SEER14-Single Family	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	3.41	3.24	3.08	2.92	2.78	2.64
SEER14-Multi Family	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.64	0.61	0.58	0.55	0.52	0.49
Total OSP (Tons NOx)	0.00	5.24	8.34	10.45	11.46	12.23	16.85	22.26	29.80	59.21	89.87	114.42	148.36	160.05	172.69	186.34	201.09	217.06



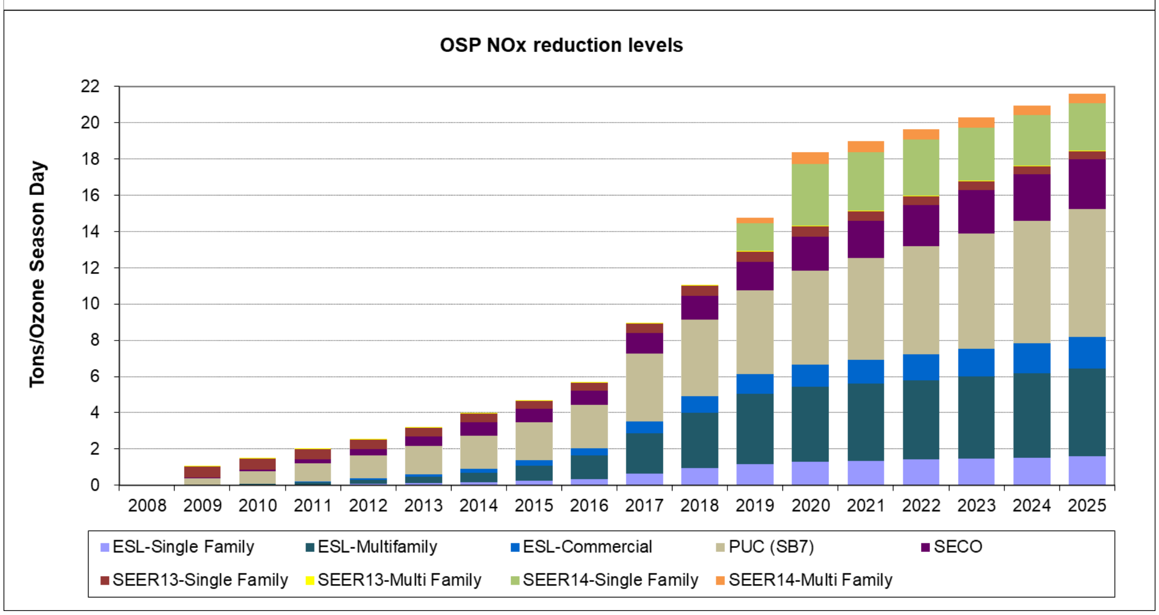
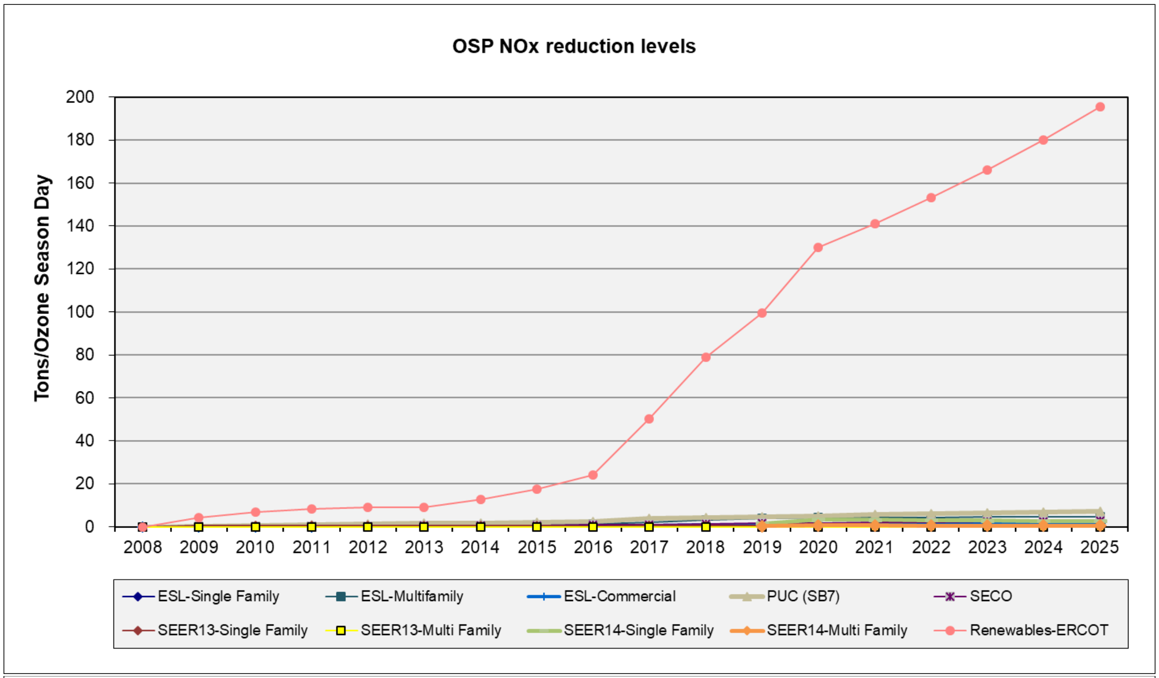


Figure 19: Integrated OSP NOx Emissions Reduction Projections from 2008 to 2025 (Base Year 2008). (Upper plot) all programs, (lower plot) all programs except Renewables.



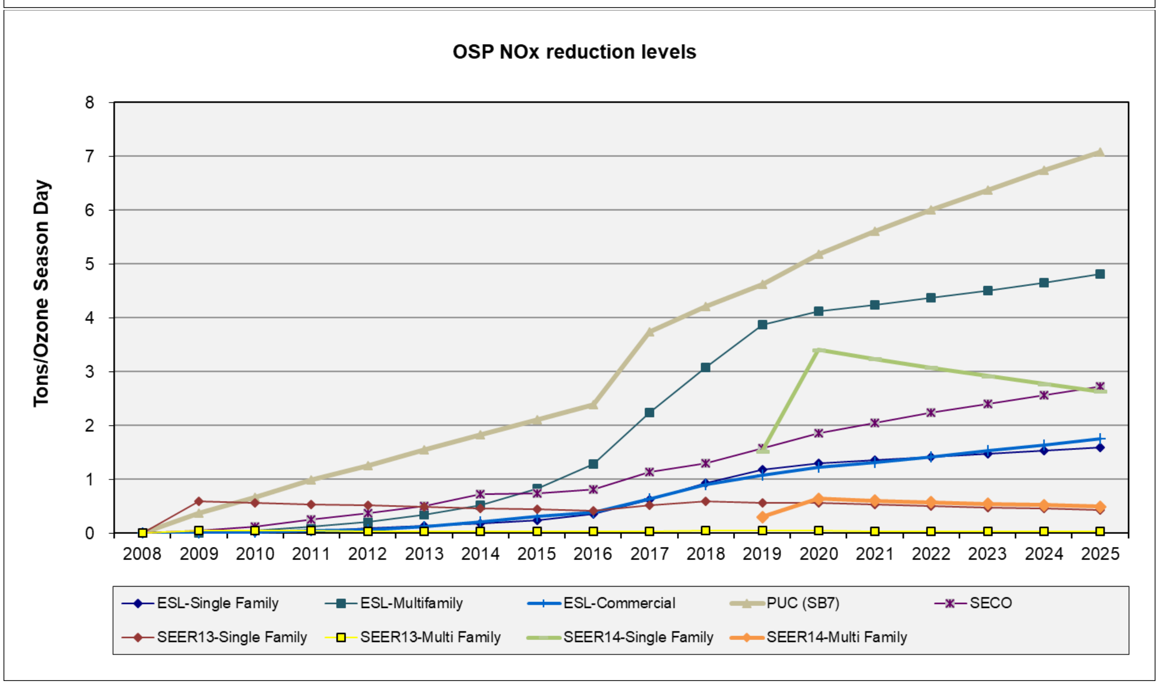


Figure 20: Integrated OSP Individual Programs NOx Emissions Reduction Projections from 2008 to 2025 (Base Year 2008). (Upper plot) all programs, (lower plot) all programs except Renewables.

6 2020 Year Activities of Energy Systems Laboratory (ESL) for Texas Emissions Reduction Plan

6.1 IC3 Texas Building Registry (TBR)

6.1.1 Background

In 2008, the 81st Texas Legislature amended the Texas Administrative Code (TAC .§388.008, 2009) to develop a Registry of Above-Code homes. The ESL built the first version of the Registry in 2009. This preliminary version allowed to provide basic metrics on usage of the ESL's above code calculators, *IC3*[30] and *TCV*.[31] By running reports against the calculator's databases, the ESL could determine calculator usage by month for Texas' cities and counties. These reports allowed a better understanding of how builders were adopting the calculators across the State, which helped to improve the calculators. In 2020, the reports continued, and numbers were gathered. Figure 21 shows the projects issued each month from January to December 2020. The projects are differentiated by the basic types, IECC performance path and ERI path. Figure 22 shows the cumulative users and projects through 2020. The data are only valid for IC3 version 4, and so the counts begin from September 2015. The largest adopter of the IC3 software was the North Central Texas Council of Governments (NCTCOG) area, closely followed by the Austin-San Antonio corridor, see Figure 23. Only counties with at least 10 new projects in 2020 are included in the chart. Figure 24 shows the certifications issued by city in 2020. Only those cities with at least 50 new projects are shown on the chart.

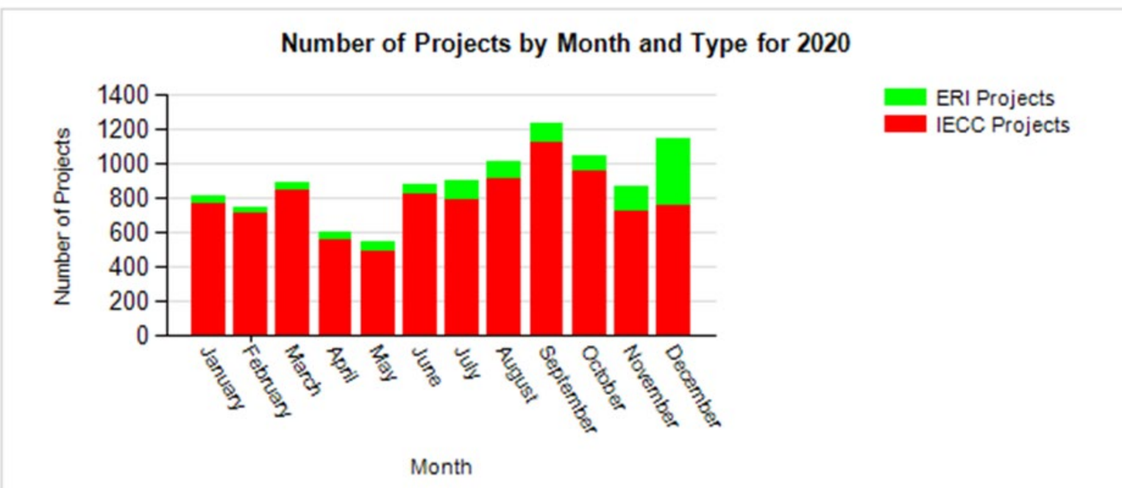


Figure 21: *IC3* 2020 Projects

[30] International Code Compliance Calculator, a web based, above code calculator for single family, detached, new construction in Texas.
[31] Texas Climate Vision, a web based, above code calculator for single family, detached, new construction in Austin Energy's service area.

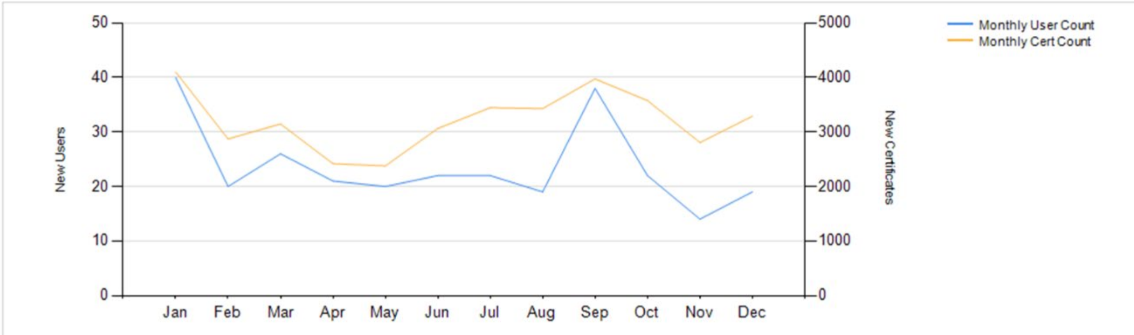


Figure 22: *IC3* 2020 New Users and Certificates

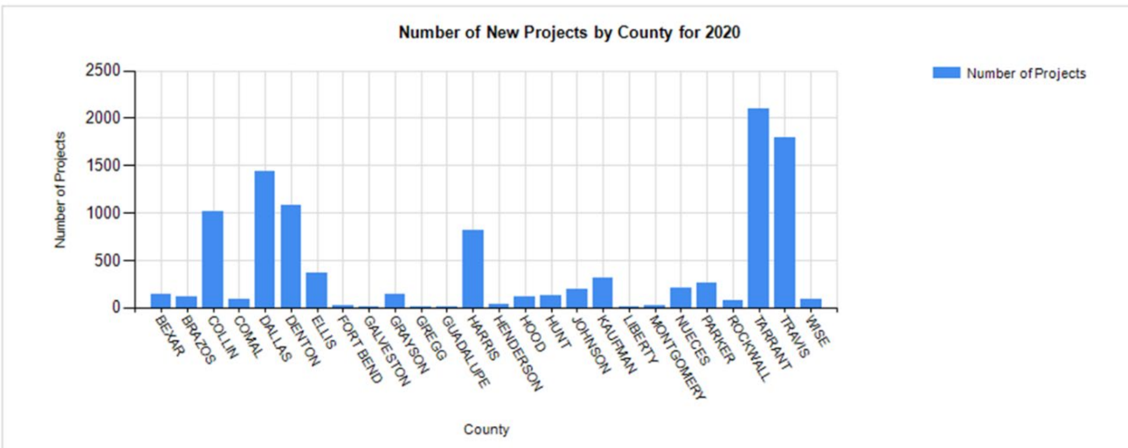


Figure 23: *IC3* 2020 Certificates – Counties with at least 10 Certificates

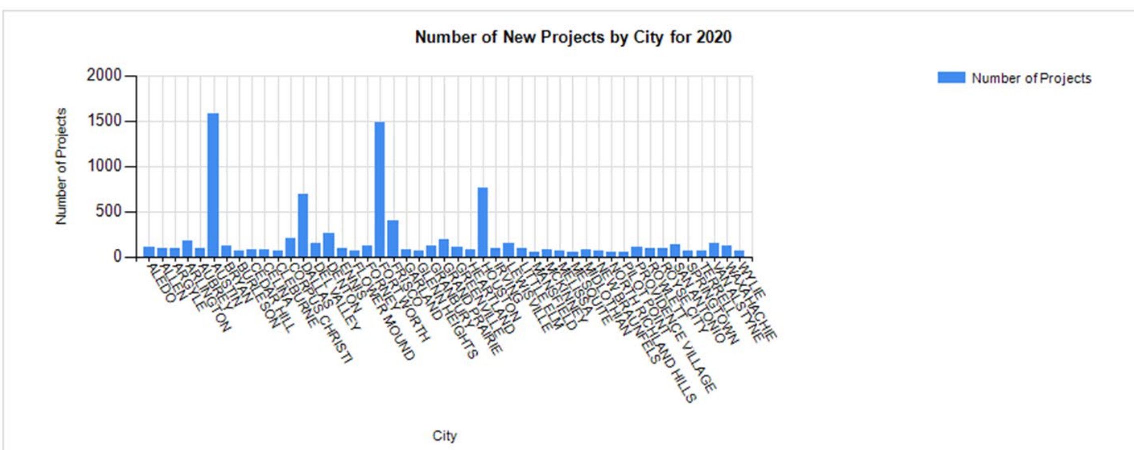


Figure 24: *IC3* 2020 Certificates – Cities with at least 50 Certificates

6.1.2 Texas Building Registry Current Version

As illustrated below and in the "*Report on the Development of the Format for a Texas Residential Registry* (Gilman, et al., 2008), the underlying database was optimized for supporting the *IC3* and *TCV* calculators and therefore needed a transformation to allow for seamless reporting. Consequently, the ESL has been steadily adding reporting capability and has been making software changes to reflect the new reporting requirements and analysis capabilities.

The underlying technology of the *IC3* and *TCV* calculators is *Microsoft SQL Server 2016*. This product offers reporting capabilities through various tools.

Figure 25 shows the "layout" of the IC3 (v3.x and above) and TCV[32] (v1.1) databases. It gives a rough overview of the different tables (called "entities") found in the *IC3* database. The center entity is the project, which is the center of the *IC3* software's abstraction of a house. The other tables include floors, walls, electrical, and systems.

[32] The *TCV* v1.1 database has different fields due to the built-in inspection module and the fact it was completed two years earlier than the described *IC3* v3.6.

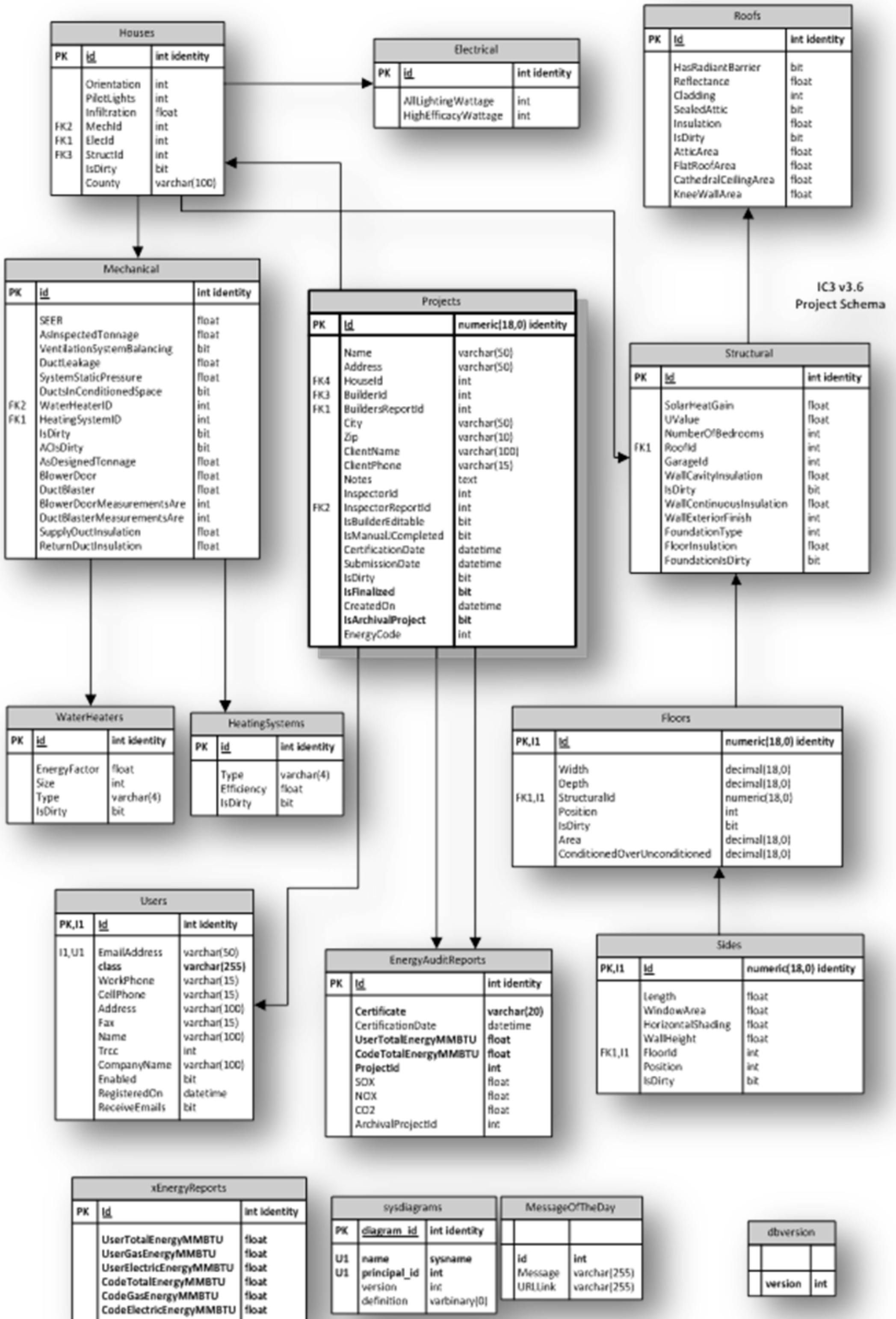


Figure 25: Database Schema

6.1.3 Usage Reports

Figure 22 in Section 6.1.1 shows the correlation between users and their successful projects (i.e. those that generate certificates). The graph shows that users were generating more projects, and were doing so at a much faster rate than the rate of adding new users.

Table 26 shows where the usage was using Counties as the grouping entity. The North Central Texas Council of Governments (NCTCOG) led the way in usage during 2020.

Table 26 Counties Generating IC3 Certificates in 2020.

County Name	January	February	March	April	May	June	July	August	September	October	November	December
AUSTIN			1									
BASTROP	1		1									
BELL							2					
BEXAR	29	13	4	28	5	9	7	9	4	18	7	10
BLANCO		1										
BRAZORIA								3				1
BRAZOS	19	9	9	6	7	5	8	9	15	5	7	15
BURNET	3	1		2		1						
CALDWELL			1			1	1					
COLEMAN				1								
COLLIN	88	100	74	35	40	69	108	93	84	73	112	137
COMAL	4	5	1	4	7	2	4	18	12	15	9	3
COOKE						1			1			
DALLAS	133	102	115	82	85	129	115	124	114	149	109	183
DEAF SMITH	1											
DENTON	78	63	109	67	39	78	87	63	133	151	110	105
ECTOR	1											
ELLIS	31	33	28	29	23	19	38	48	25	19	17	62
FANNIN			1							3	3	
FORT BEND			12	5								1
FRIO							1		1			
GALVESTON		2	2	1			3	3	1	2		1
GRAY											1	
GRAYSON	3	14	7	6	13	15	7	18	17	18	14	13
GREGG			1		1	1	1	2	2	4		
GUADALUPE	2	1		2		1	2	1				2
HARRIS	69	60	62	45	40	58	74	48	102	100	64	88
HAYS			2						2	2		1
HENDERSON	4	1	2	1	1	10	5	7	1	2	3	3
HILL							1			2		3
HOOD	6	6	4	1	6	12	18	22	12	6	12	10
HOPKINS											1	1
HUNT	9	11	10	4	8	5	16	8	16	9	15	16
JEFFERSON	1											1
JOHNSON	14	9	6	6	26	10	19	26	22	11	20	28
KAUFMAN	13	7	34	17	29	20	43	24	58	22	24	23
LIBERTY	2		2		1	2				2	2	
LLANO	1					1						
MASON		1	1			1						2
MCLENNAN										2		
MEDINA						1						
MONTAGUE								3				
MONTGOMERY		1			1		1			6		8
NAVARRO	2		1	1		2		1			1	
NUECES	17	14	18	13	7	12	22	24	15	20	18	25
PALO PINTO	2		1									
PARKER	11	14	40	20	20	15	18	26	26	35	12	22
POTTER										1		
RAINS				1								
RANDALL	1											1
ROCKWALL	8	4	2	2	3	6	6	9	10	4	9	15
SAN PATRICIO	1	1	1									
SOMERVELL							1					
TARRANT	112	116	142	154	144	169	213	206	188	168	221	266
TITUS									1	1	2	1

Table 26 Counties Generating IC3 Certificates in 2020 (Continued).

County Name	January	February	March	April	May	June	July	August	September	October	November	December
TRAVIS	144	152	194	67	33	214	76	201	365	186	76	84
TRINITY										1		
VAN ZANDT						1	1	2	2			1
WALLER		1			1							
WILLIAMSON				1				1				2
WILSON								1				
WISE	5	7	10	3	7	10	9	14	5	6	4	7
YOUNG		1										
ZAPATA											1	6

6.1.4 Parameter Reports

A unique and valuable use of the Registry is to look at building trends across the State. Appendix C shows the yearly average parameter values by county.

This report shows the yearly average wall cavity insulation distribution in Texas for 2020 (Figure 26 - Figure 55). The colors in the figure show the relevant insulation values.

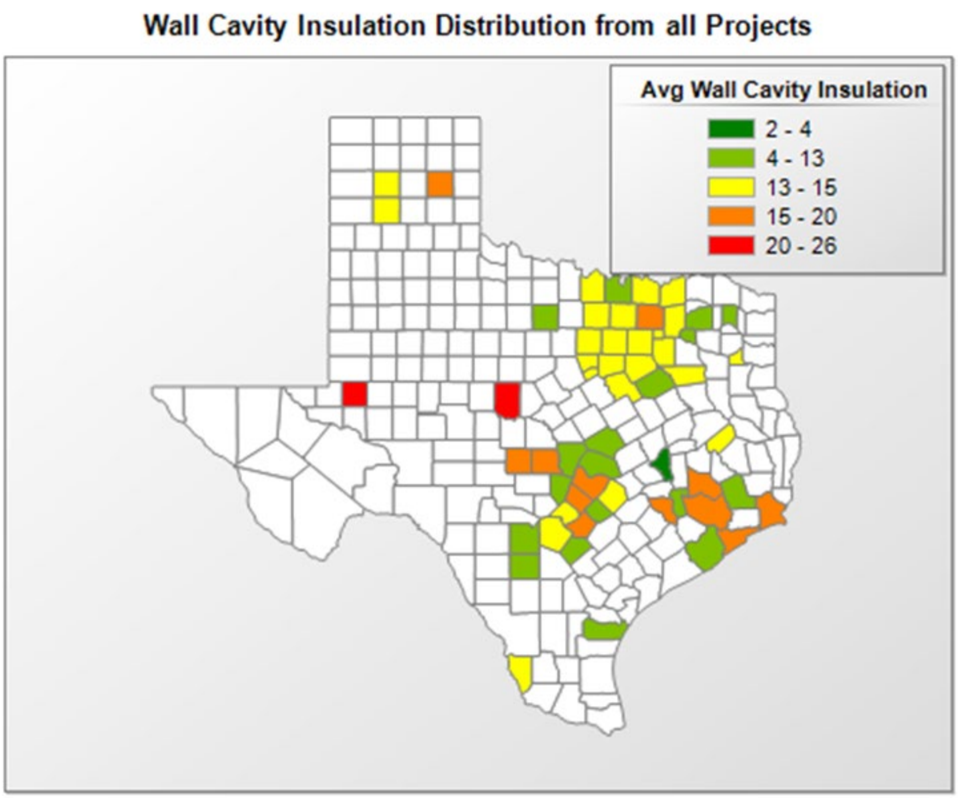


Figure 26: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (All Projects)

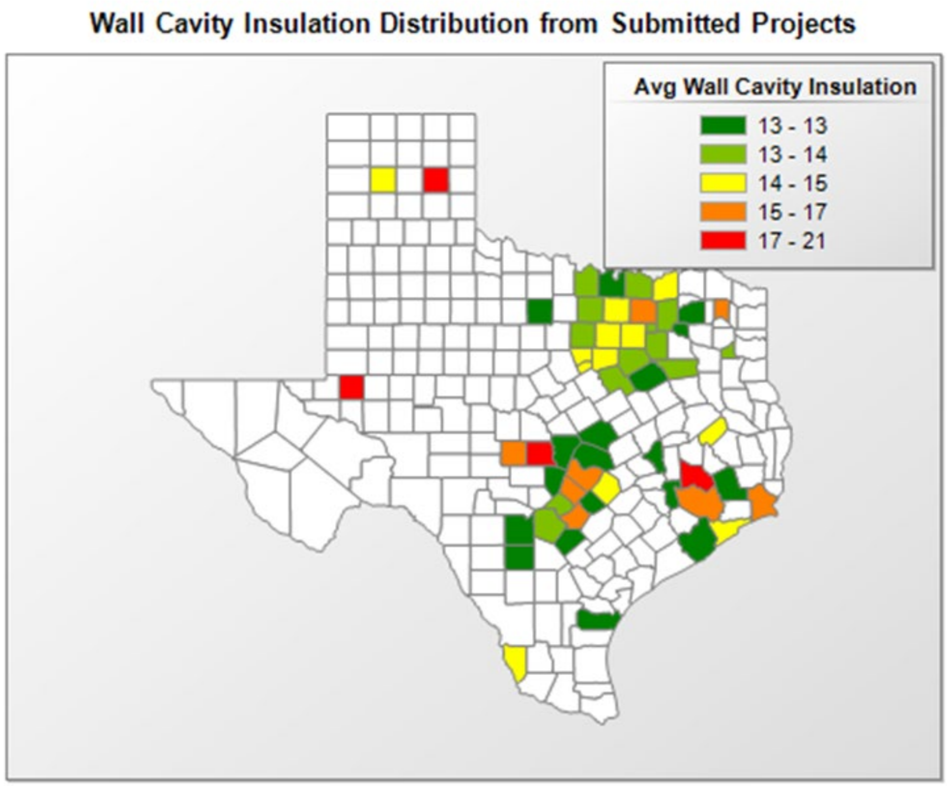


Figure 27: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (Submitted Projects)

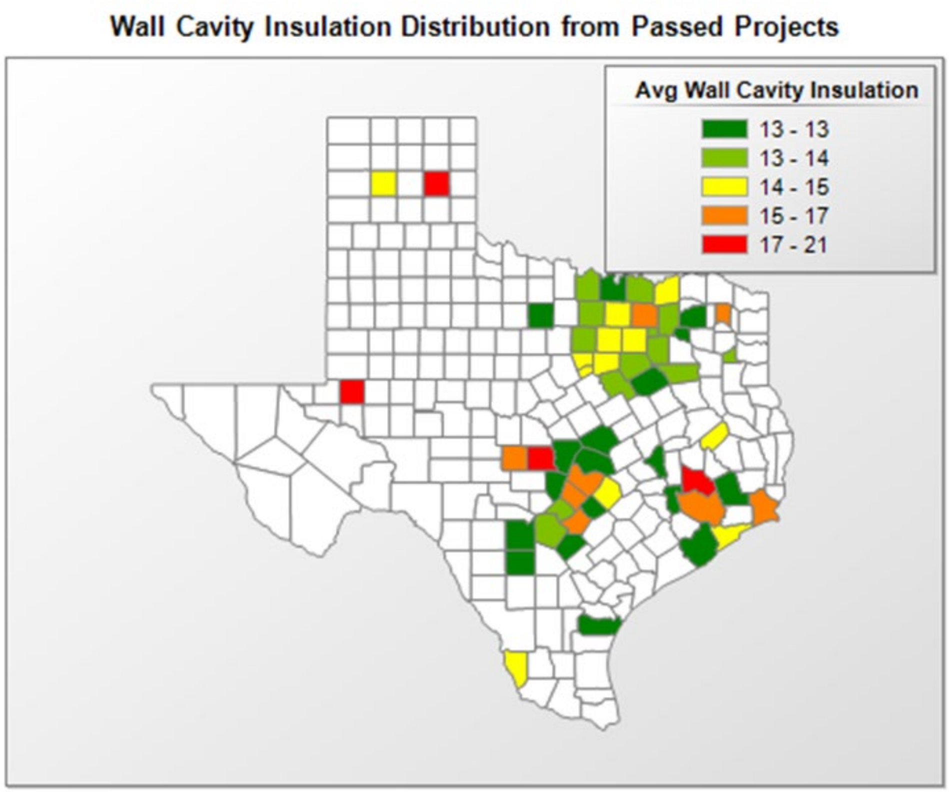


Figure 28: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (Passed Projects)

This report shows water heater efficiencies across Texas in 2020

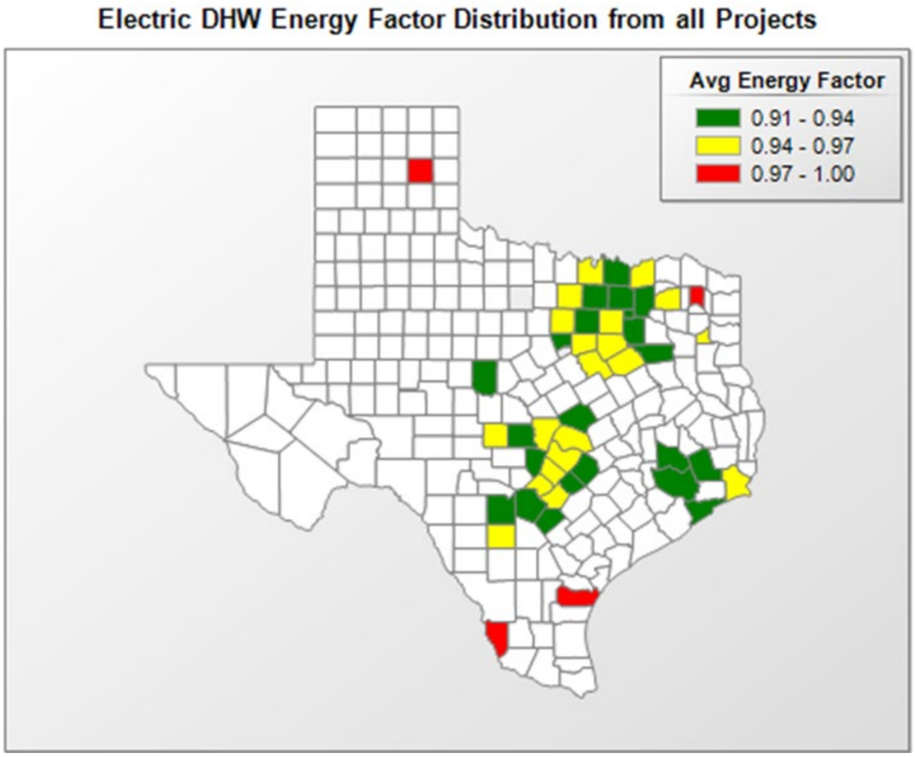


Figure 29: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (All Projects)

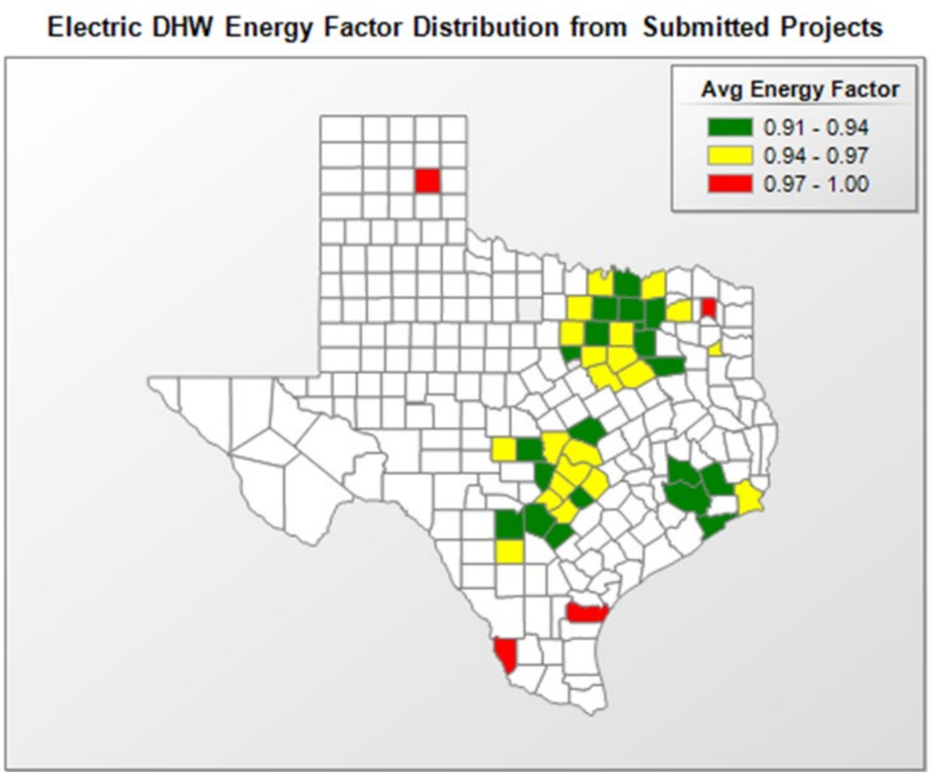


Figure 30: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

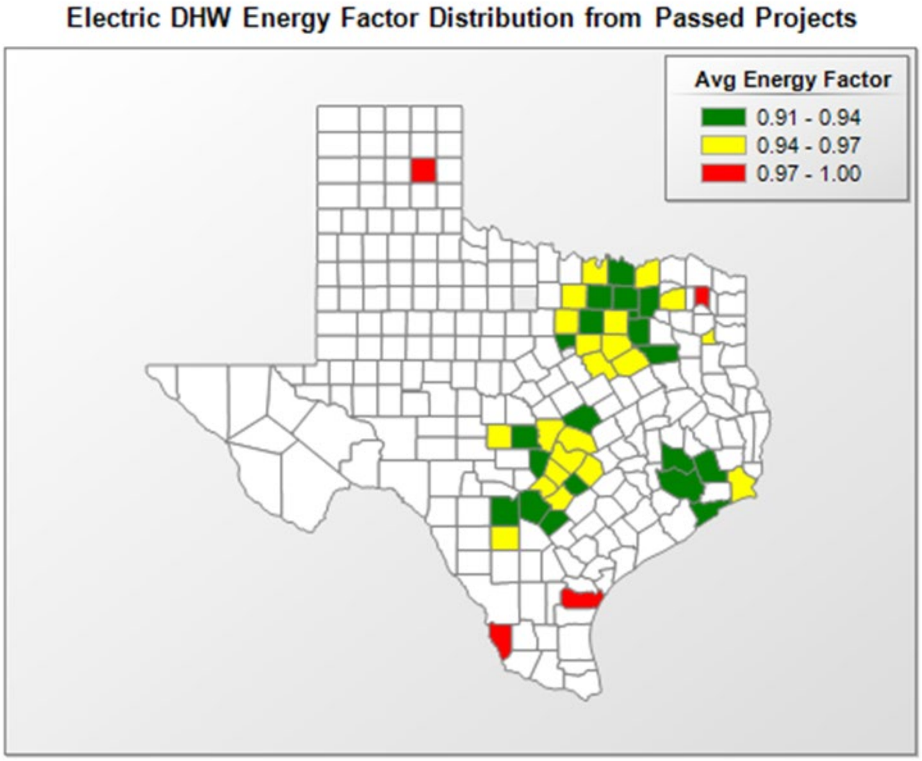


Figure 31: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

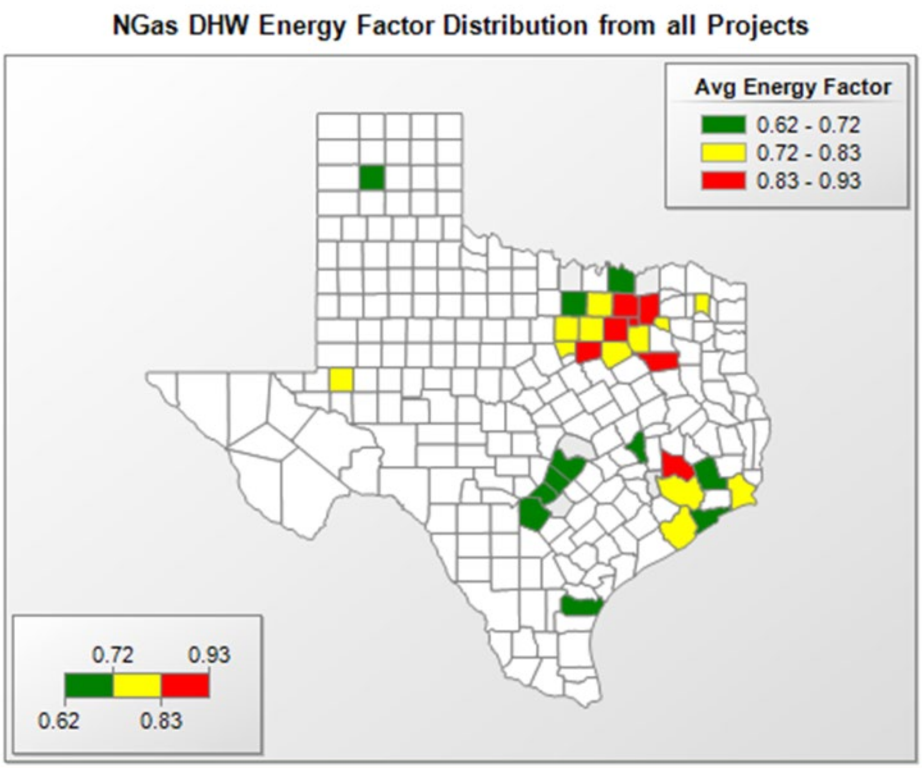


Figure 32: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (All Projects)

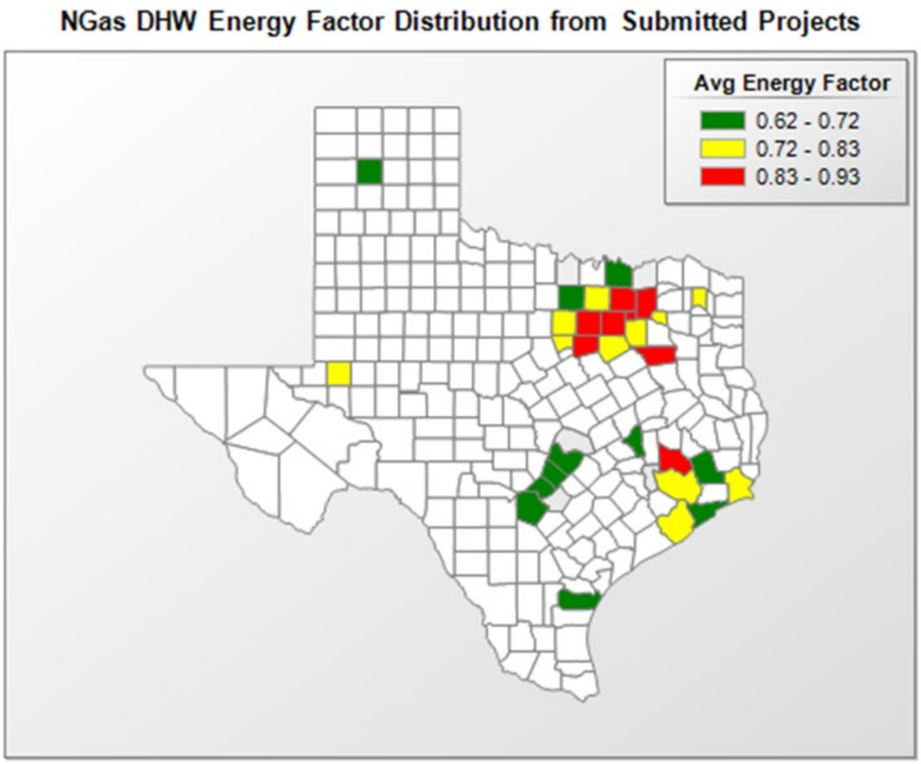


Figure 33: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

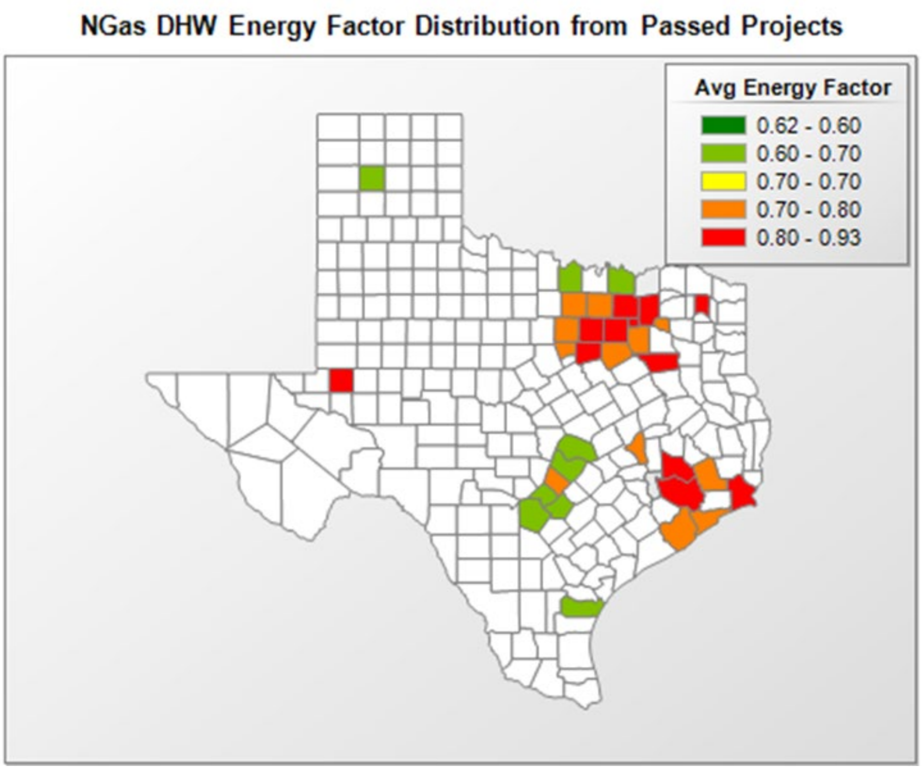


Figure 34: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

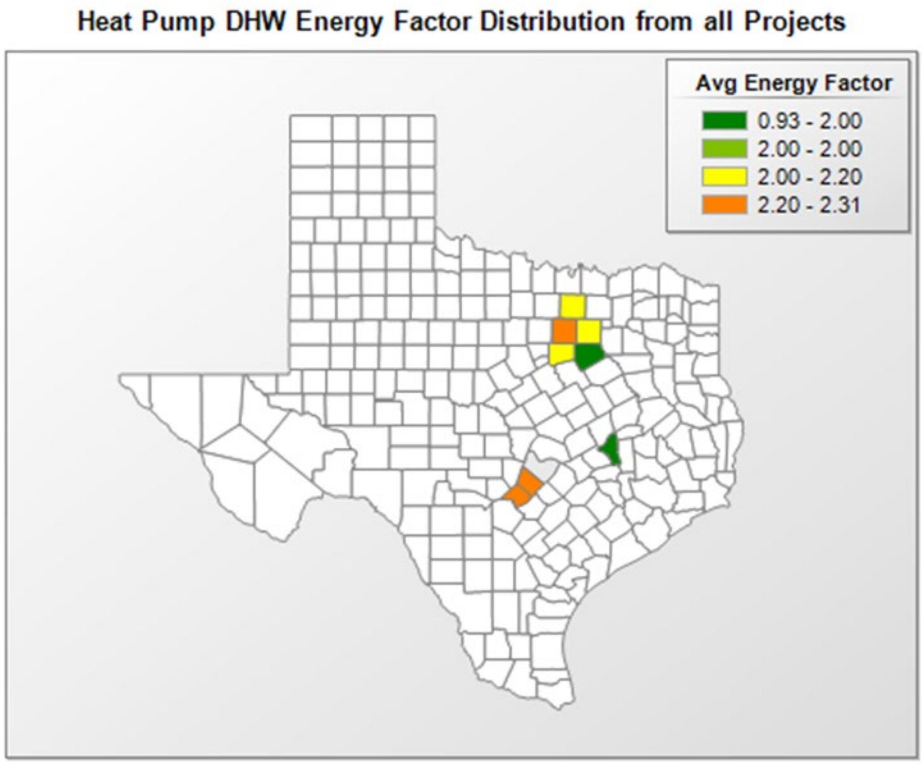


Figure 35: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (All Projects)

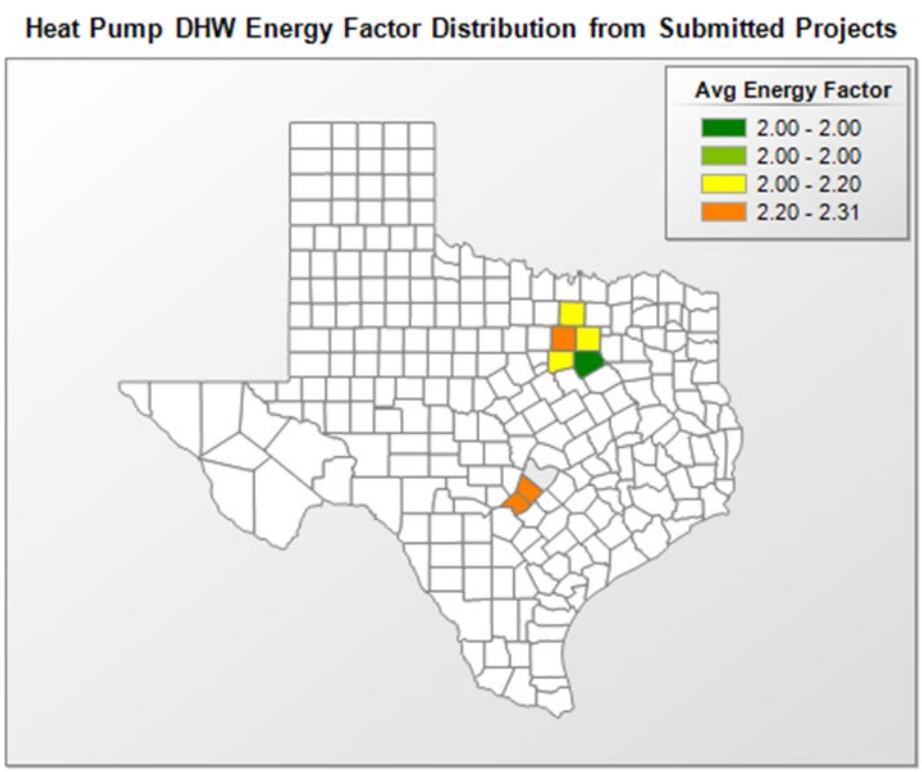


Figure 36: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

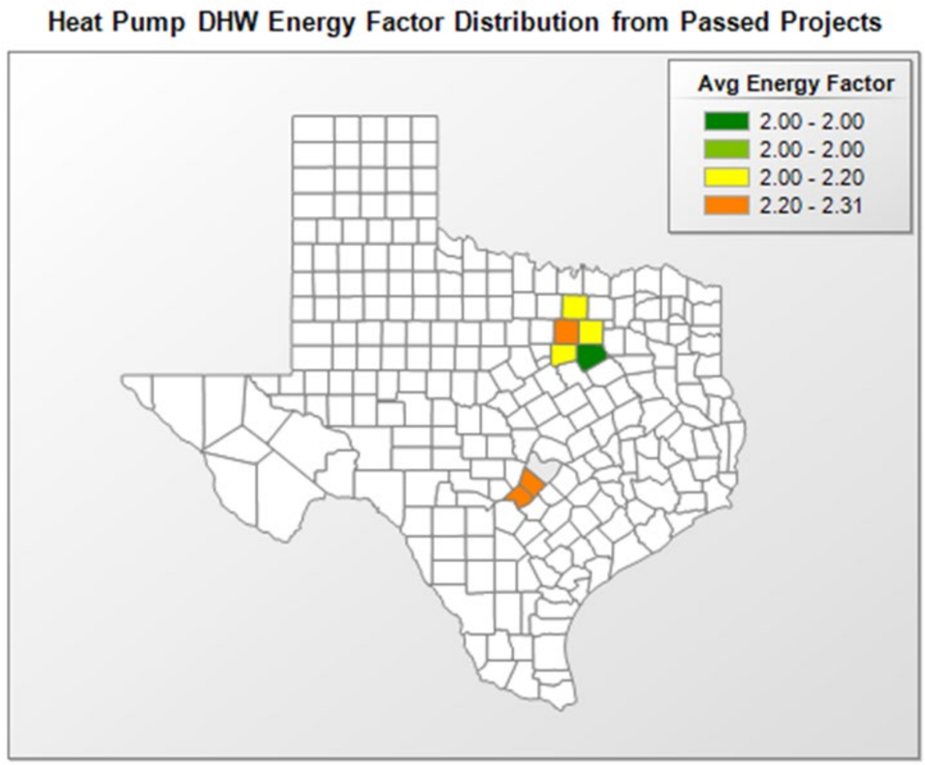


Figure 37: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

This report shows the average A/C SEER across Texas in 2020. The efficiency (and sizing) of air conditioning is a vital component of energy efficiency in Texas.

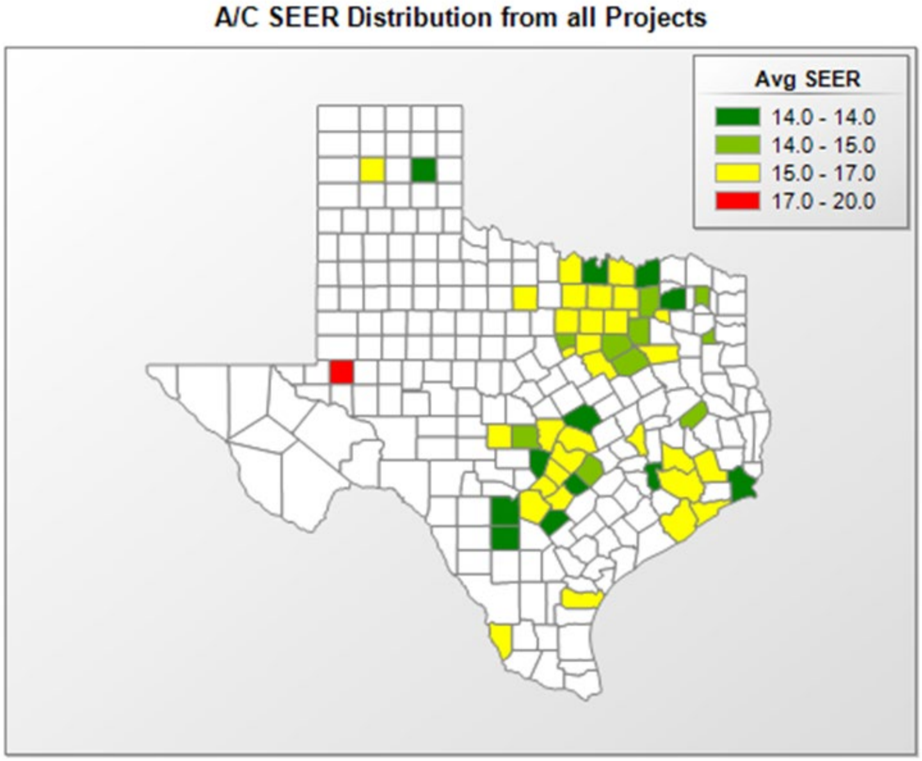


Figure 38: Average A/C SEER across Counties in 2020 (All Projects)

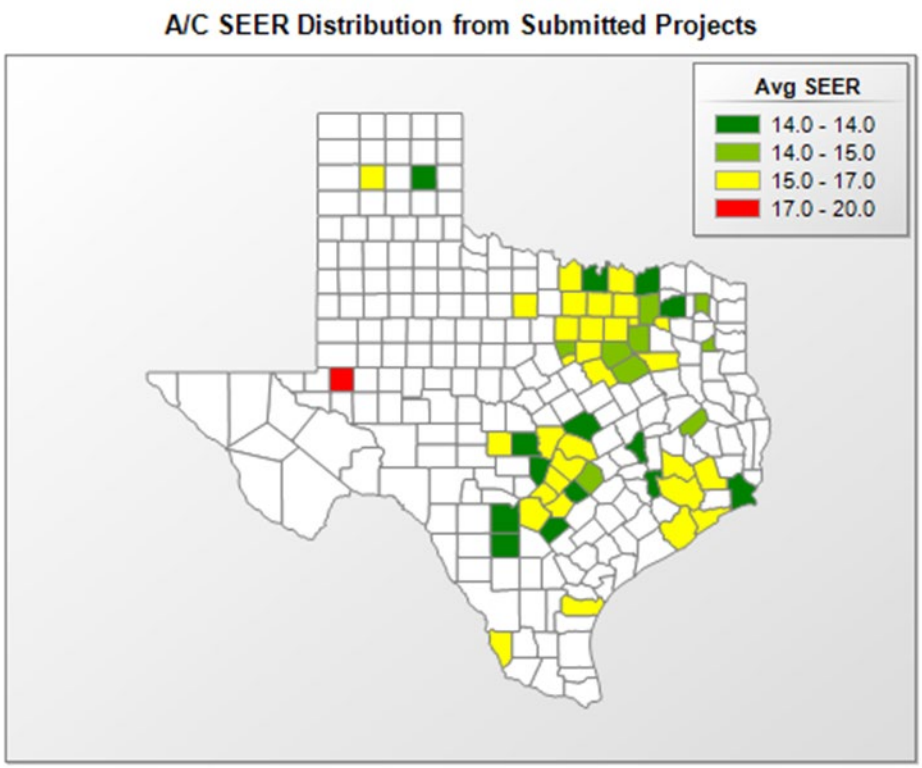


Figure 39: Average A/C SEER across Counties in 2020 (Submitted Projects)

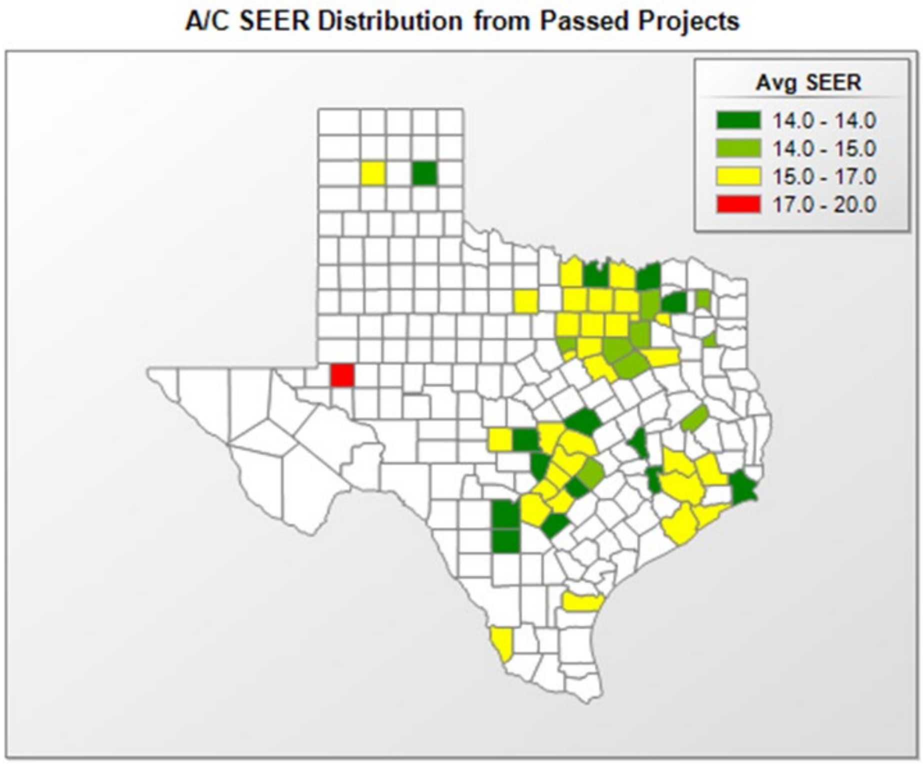


Figure 40: Average A/C SEER across Counties in 2020 (Passed Projects)

This report shows the average ceiling insulation across Texas in 2020.

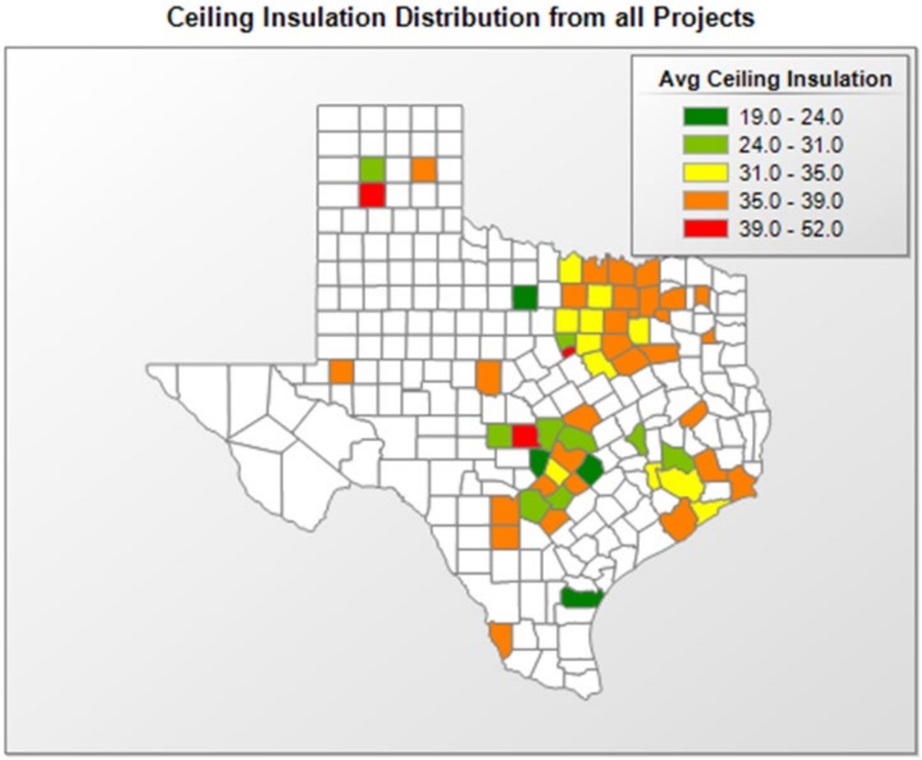


Figure 41: Average Ceiling Insulation across Counties in 2020 (All Projects)

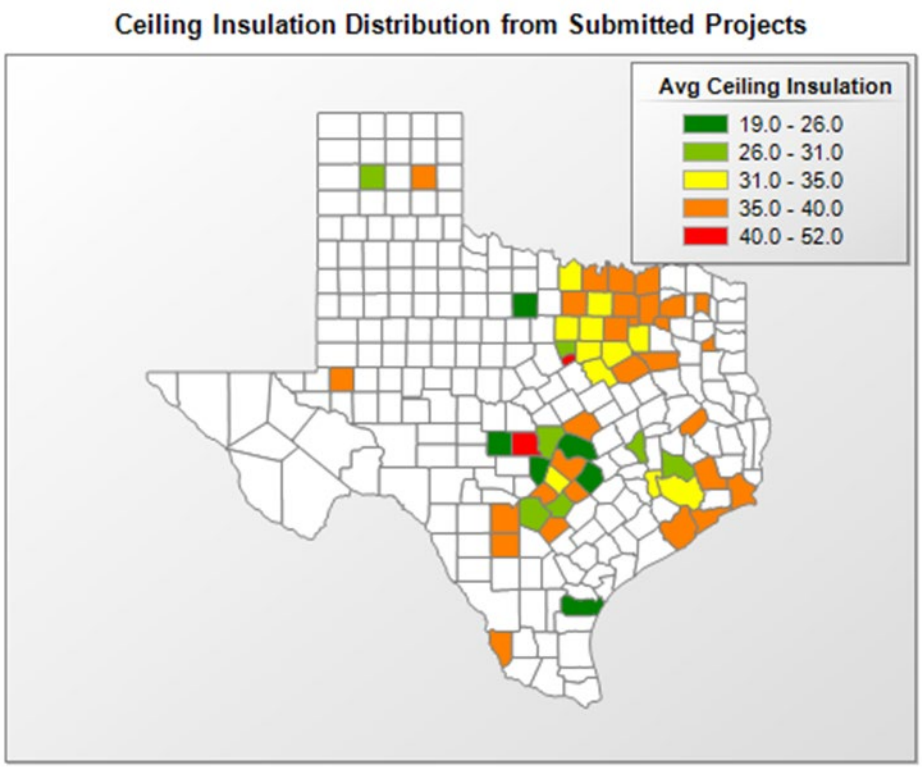


Figure 42: Average Ceiling Insulation across Counties in 2020 (Submitted Projects)

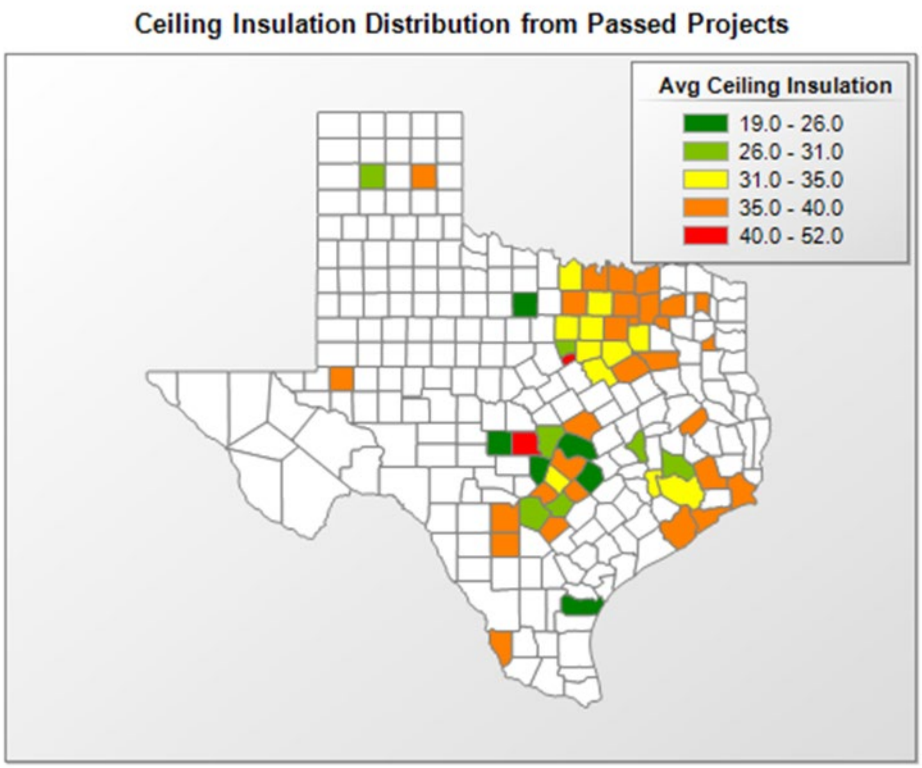


Figure 43: Average Ceiling Insulation across Counties in 2020 (Passed Projects)

This report shows the average heating efficiency across Texas in 2020.

NGas Heating Efficiency Distribution from all Projects

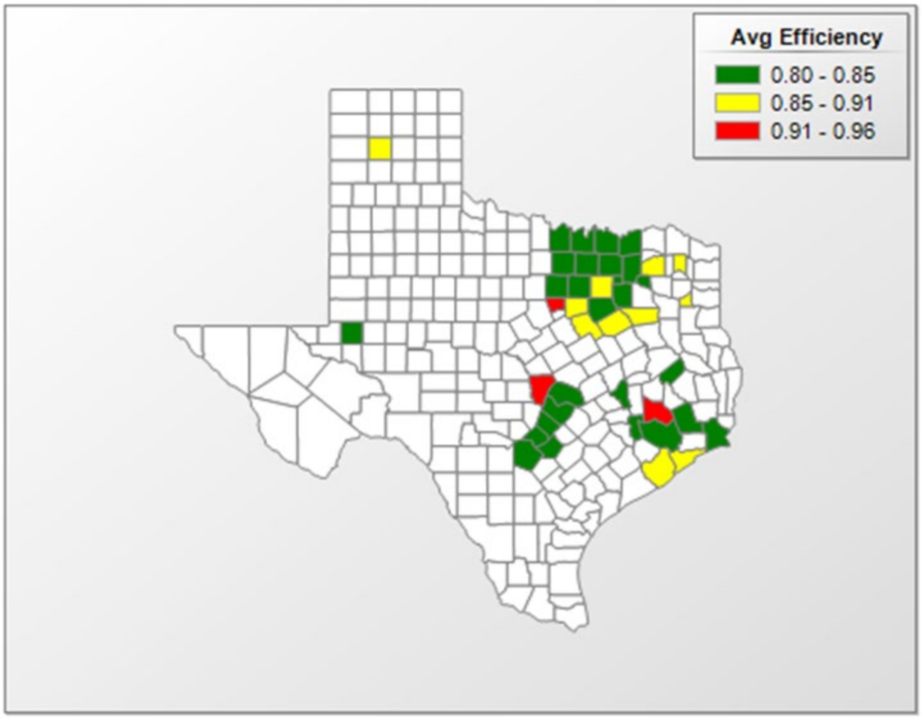


Figure 44: Average NGas Heating Efficiency across Counties in 2020 (All Projects)

NGas Heating Efficiency Distribution from Submitted Projects

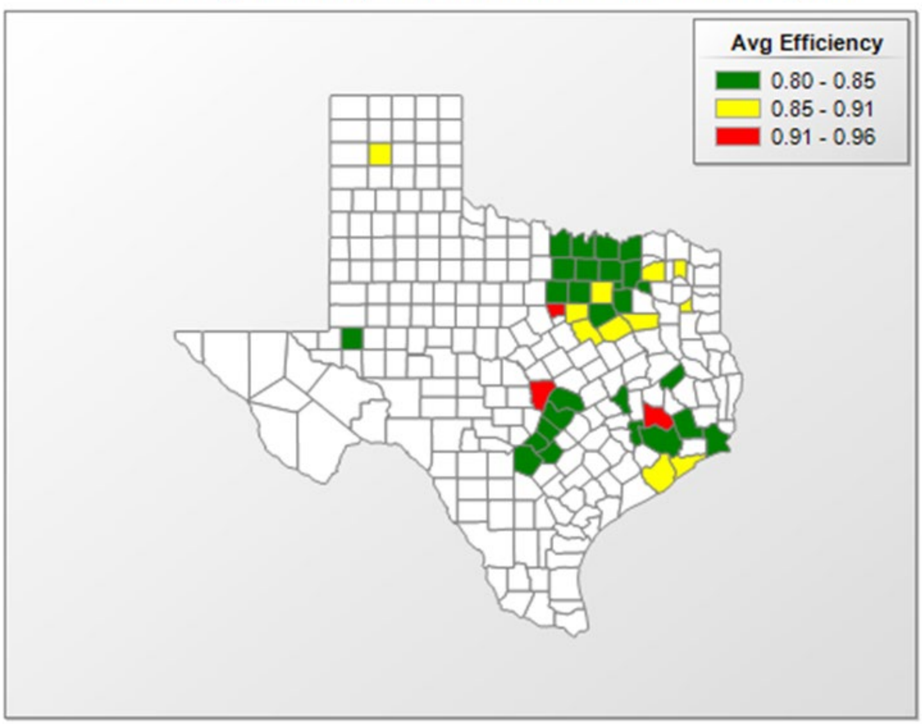


Figure 45: Average NGas Heating Efficiency across Counties in 2020 (Submitted Projects)

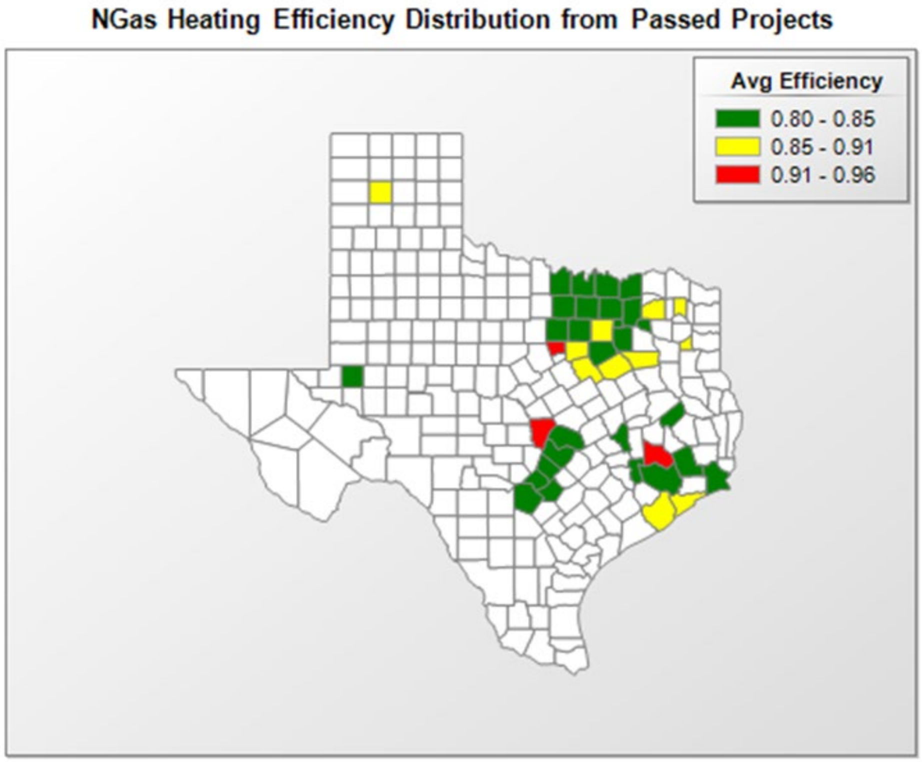


Figure 46: Average NGas Heating Efficiency across Counties in 2020 (Passed Projects)

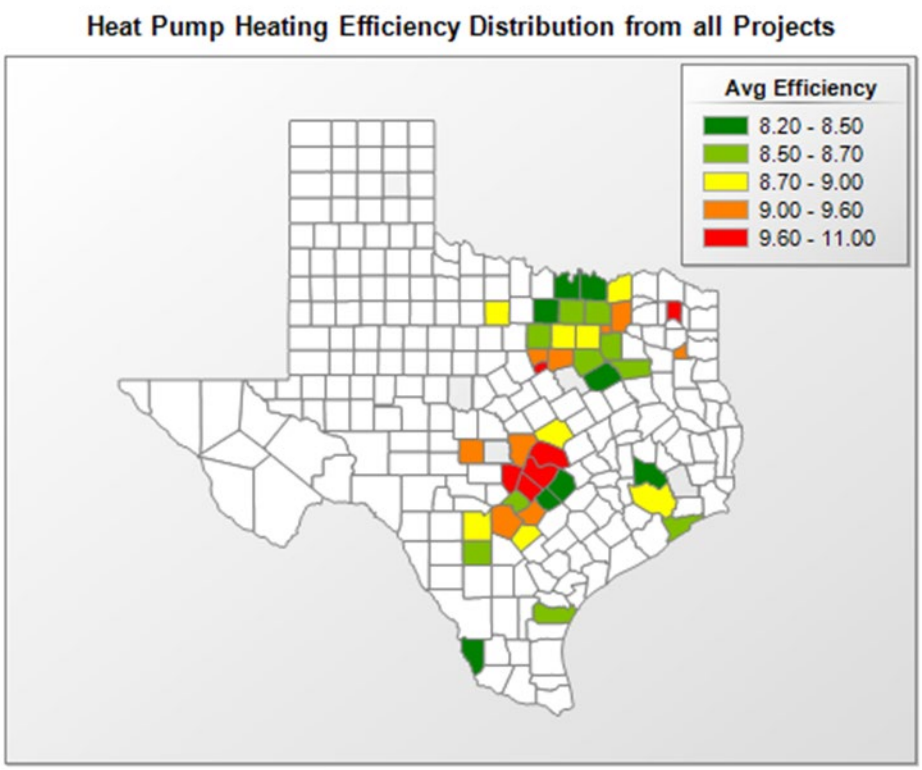


Figure 47: Average Heat Pump Heating Efficiency across Counties in 2020 (All Projects)

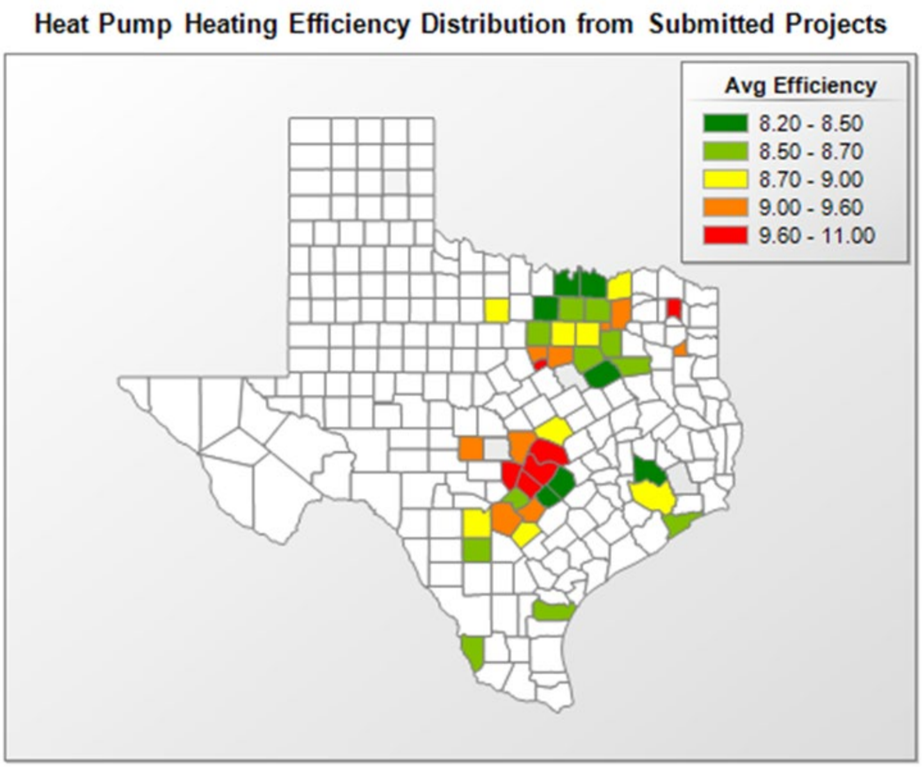


Figure 48: Average Heat Pump Heating Efficiency across Counties in 2020 (Submitted Projects)

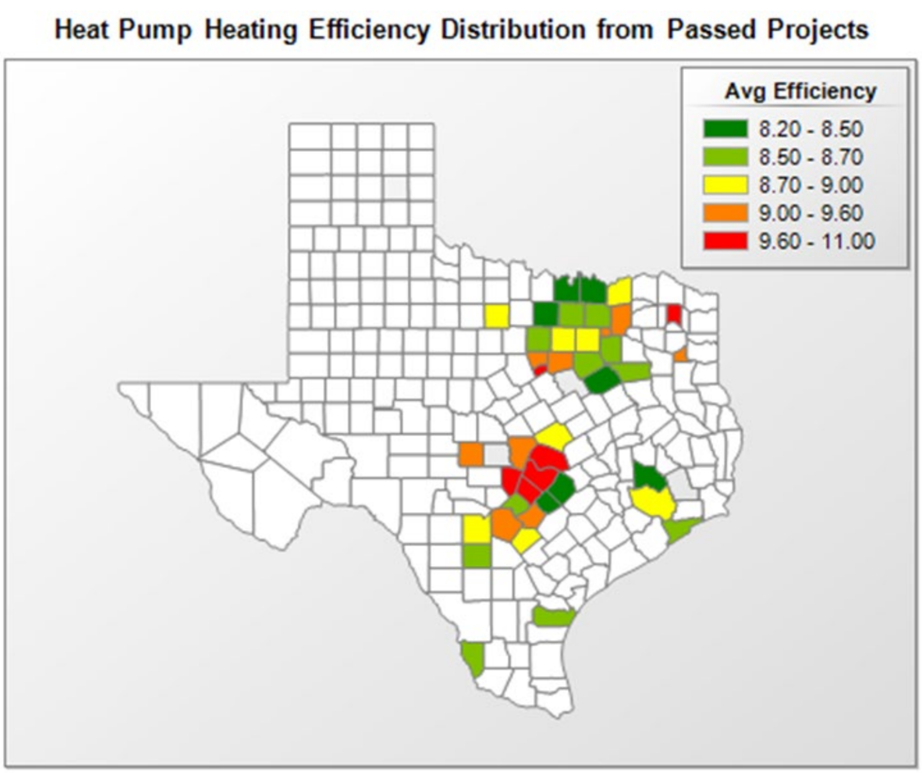


Figure 49: Average Heat Pump Heating Efficiency across Counties in 2020 (Passed Projects)

This report shows the average SHGC across Texas in 2020.

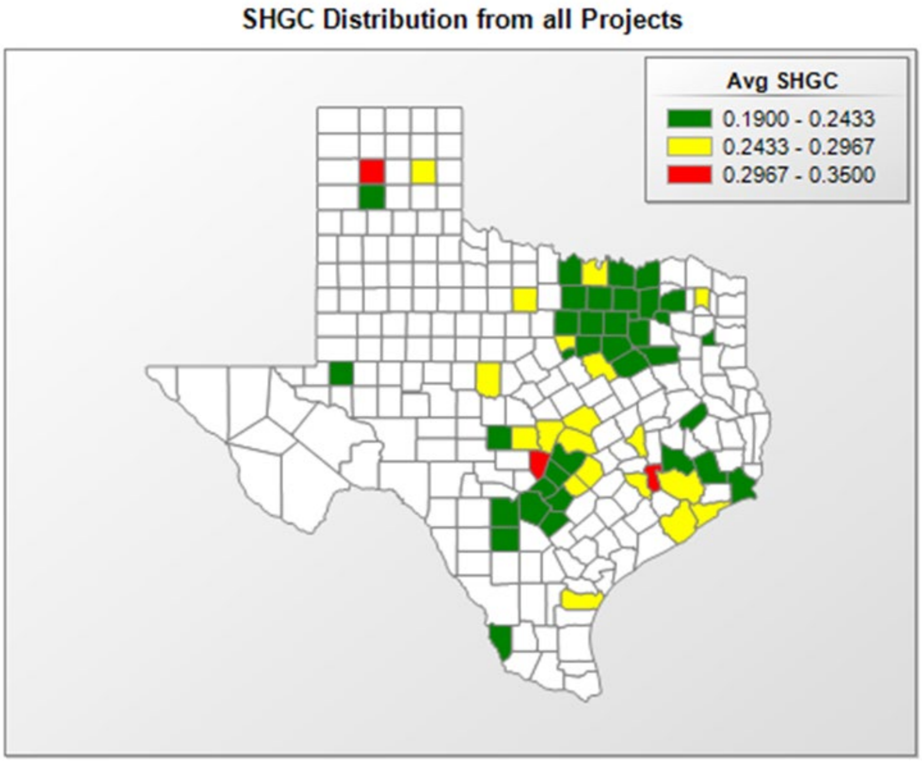


Figure 50: Average SHGC across Counties in 2020 (All Projects)

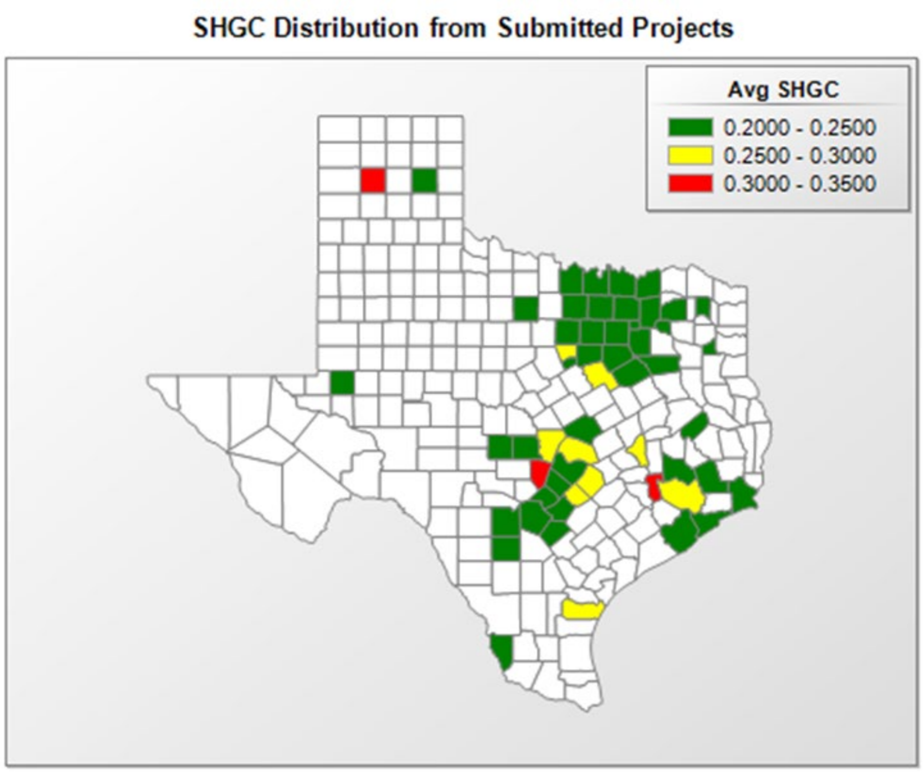


Figure 51: Average SHGC across Counties in 2020 (Submitted Projects)

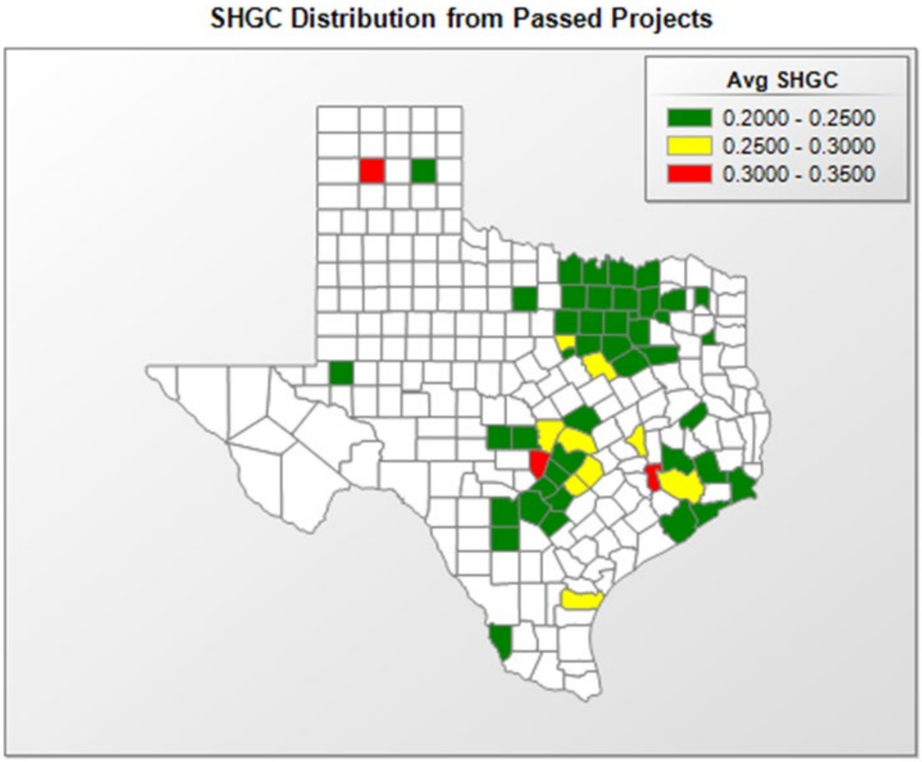


Figure 52: Average SHGC across Counties in 2020 (Passed Projects)

This report shows the average U Factor across Texas in 2020. The U Factor applies to the heat transfer of a window caused by temperature, no direct solar radiation.

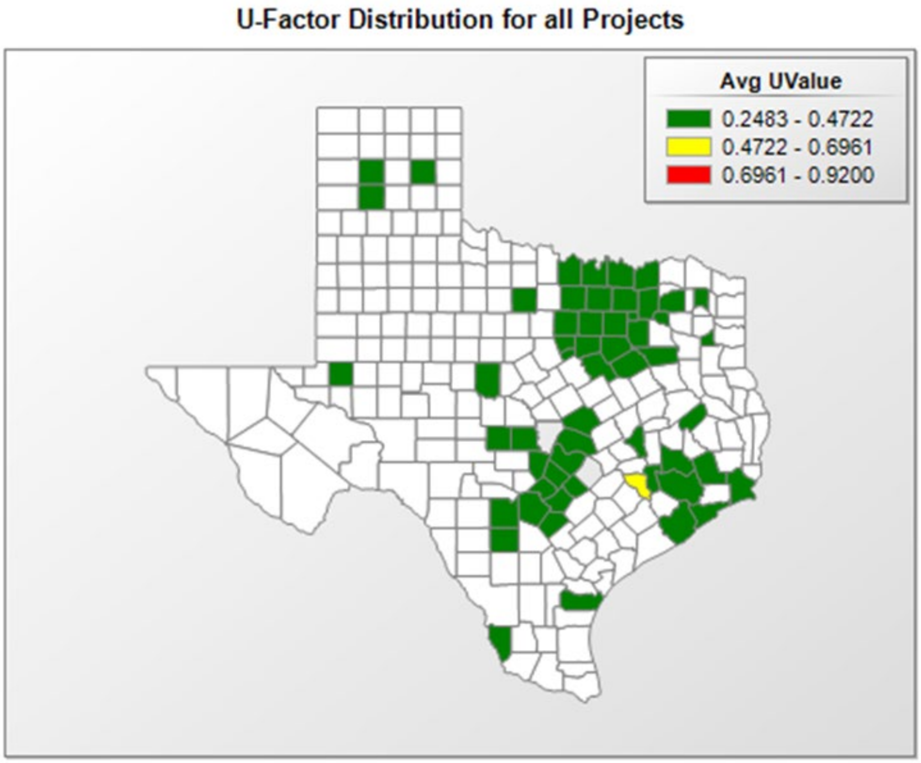


Figure 53: Average U Factor across Counties for Single-Family Homes in 2020 (All Projects)

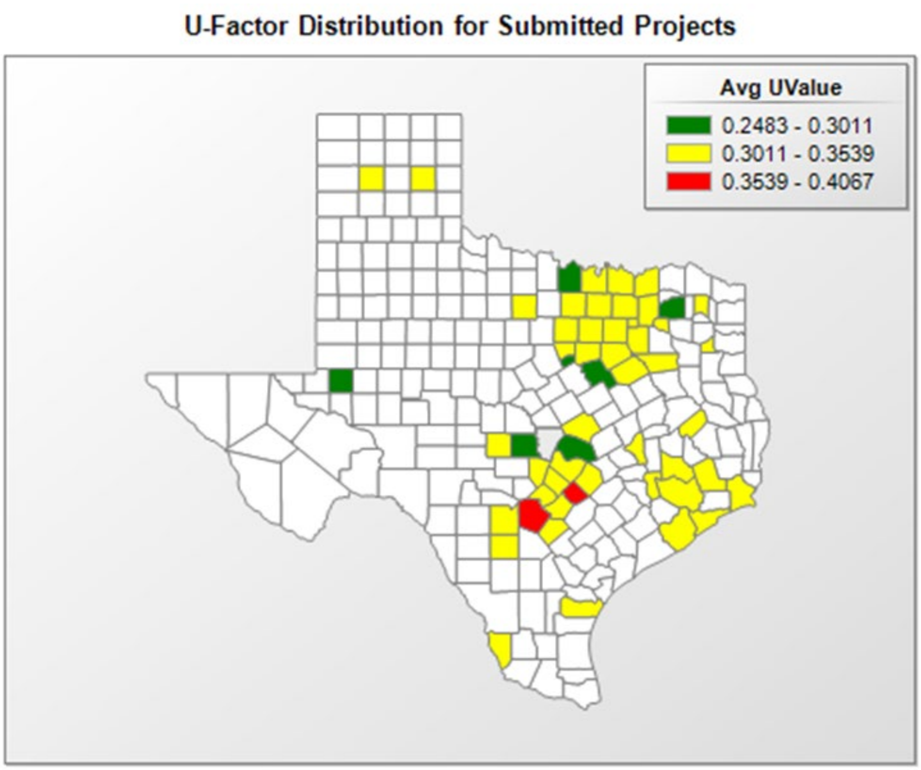


Figure 54: Average U Factor across Counties for Single-Family Homes in 2020 (Submitted Projects)

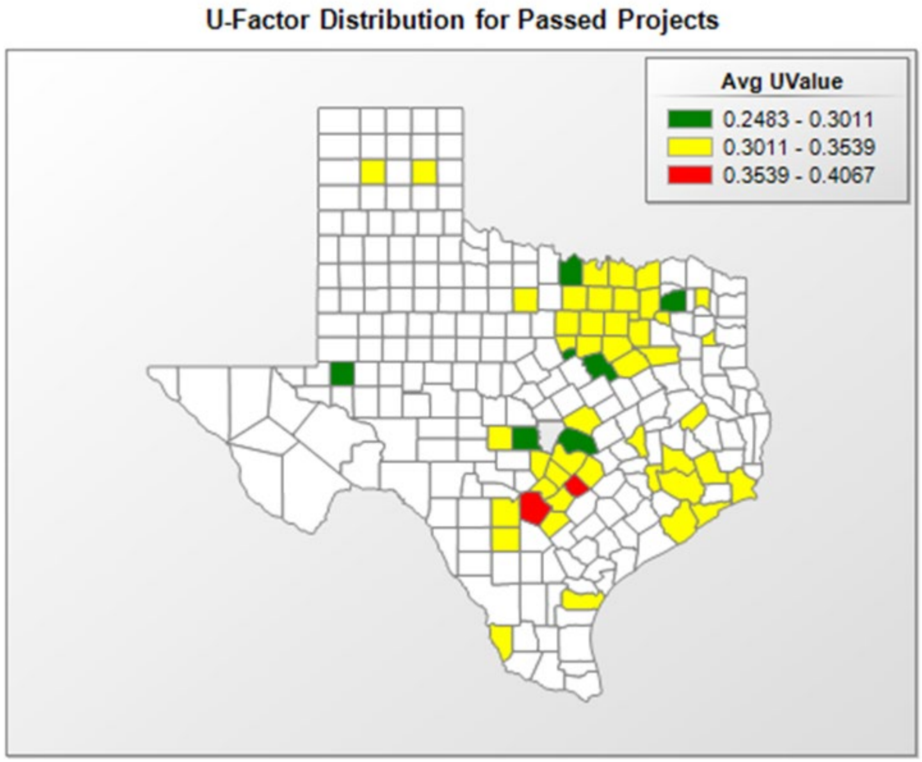


Figure 55: Average U Factor across Counties for Single-Family Homes in 2020 (Passed Projects)

6.2 IC3 Enhancements

IC3 is continuously being enhanced since 2009 released Version 3.5.2 to 2017 released Version 4.3.1. Numerous enhancements have been made and are detailed out in section 6.2.1 and section 6.2.2.

6.2.1 History of IC3 version 3 Enhancements

Most of the enhancements that are being added to IC3 in recent years are summarized next:

In Version 3.5.2 (November 2009)

- Three code choices: IECC 2009, IECC 2006 (with Houston Amendments) and IECC 2000/2001.
- Duct insulation values
- Improved input of overhang values to allow for just inches

In Version 3.6.1 (December 2009)

- Foundations
- Opt out of emails
- Copy a project
- Moved orientation from Floors tab to Project Information

In Version 3.6.2 (April 2010)

- Fixed defect in 2nd Floor, Back Window issue
- Reference A\C tonnage matches the proposed A\C tonnage.
- Updated model
- Updated illustrations

In Version 3.7.x (June 2010)

- Simple multi-family code compliance
- Updated model
    a. Floor Insulation R-Value
    b. Four foundation types
- Updated illustrations
- Updated manual

In Version 3.8.x (September 2010)

- Fixed default of Multi-family Units to be "Ducts in Conditioned Space" to YES
- Fixed wrong IECC code version on certificate
- Enhanced input screens by moving several fields from Units to Floor
- Plans

In Version 3.9.x (October 2010)

- Added slab insulation
- Updated the manual

In Version 3.10 (September 2011)

- Three IECC 2009 compliant reports (i.e. energy, inspection list, and certificate)
- Paging enhancements on "My Page" to help organize large quantities of projects.
- Multi-family usability increased with Plan/Unit information being displayed on pages.
- Elimination of flash animation (so we will become iPad compatible).

- Updated/expanded help text.
- Updated illustrations.
- Tweaked min/max values on duct insulation, water heaters.

In Version 3.11 (December 2011)

- Added support for IECC 2009 Austin Amendments

In version 3.12.x (January 2012)

- Deprecated 2000/2001 and 2006 Houston Code.
- Added a button to generate Energy Report w/ a signature line. The original energy report still exists
- Improvements in the algorithm
- Help images/ text updated
- Updated manual

In version 3.13.x (August 2013)

- Added Manual J.
- Added 2009 NCTCOG code. This is the 2012 IECC w/ NCTCOG amendments. It is slightly less stringent than the base 2012 code and is optimized for climate zone 3.

In version 3.14.x (March 2015)

- Added 2012 AE Code.
- Added heat-pump water heater option
- Added sealed attic option.
- Revised energy report to make it clearer

6.2.2 History of IC3 version 4 Enhancements

Version 4.0 (June 2015)

- Initial release
- Originally has only 2015 IECC single-family

Version 4.0.1 (July 2015)

- The original version (4.0) printed the logged-in user's name, phone number, and email address in the builder's fields on the certificate and energy report. These can now be overridden on a project-by-project basis. The new input fields on the left side of the screen are now the values that will be printed on the certificate and energy reports.
- The project notes will now appear on the Energy Report. Due to spacing issues, only the first 60 characters will be printed. If the project notes are longer, they will be truncated in the energy report.
- On a user's main user screen (the one immediately after login that lists all of your projects), a button has been added to the top: 'Edit User Information'. This button allows you to edit the logged-in user's contact information that you entered when registering on the site.
- On a user's main user screen (the one immediately after login that lists all of your projects), a button has been added to the top: 'Import Project from IC3 version 3.x '. Several users have requested the ability to 'import' projects from the old version of IC3. This is now possible. Users will be prompted to enter their IC3 version 3.x credentials and select a project to import. Only single-family project import is available at this time.
    - The user will be prompted for a new project name, project address, and orientation (just as when you are copying an existing project from version 4.x).
    - Aside from these fields, the project is copied without alteration except that the code is changed to IECC 2015. Of course, there is no guarantee that a project that passes 2009 or 2012 will still pass 2015 without some modifications.
- Some rounding issues on the energy report have been fixed.

In version 4.0.2 (April 2016)
- Clean up of some error messages
- Revised attic model to give better results
- The webpage will now check that the house meets the minimum fresh air standards as given by the IRC and will post an error message upon submission if it does not meet the minimum standards.

In version 4.1 (September 2016)
- Added ERI calculation mode

In version 4.1.1 (September 2016)
- Some bug fixes

In version 4.1.2 (October 2016)
- Altered appliance energy calculation for ERI

In version 4.2 (October 2016)
- Added NCTCOG 2015 IECC amendment to list of codes

In version 4.3 (March 2017)
- Added 2015 Austin Energy Amendments to list of codes
- Altered the duct model to improve accuracy

In version 4.3.1 (July 2017)
- Added NCTCOG 2015 ERI amendment to list of codes

In version 4.4 (July 2019)
- Updated weather files. This increases the temperature slightly and will increase energy usage in the summer months•
- Major update of ERI calculation to reflect the changes made to RESNET HERS rating algorithm. Importance: The amount of calculation needed for this calculation has more than doubled. An ERI calculation will now take up to 1 minute to complete

In version 4.4.1 (July 2019)
- Bug Fixes

In version 4.4.3 (July 2019)
- Bug Fixes

In version 4.5 (September 2019)
- Added IECC 2018 code support
- Added support for tankless NGas DHW

In version 4.5.2 (September 2020)
- Revised IECC 2015 AE code

In version 4.5.3 (September 2020)
- Bug Fixes

6.2.3 Changes in Single-Family Input File

There have been two major version changes according to the changes in the Single-Family Input file since the 2012 annual simulations. Table 27 presents the summarized description of the changes in Single-Family Input file since the 2012 annual simulation.

Table 27: Changes in Single-Family Input file

BDL Version	Description	Date Modified
4.01.08	BDL used for the 2012 annual report.	03/10/2011
4.01.09	Added sensible and latent components for equipment heat gain.	07/31/2013
4.01.10	Added special construction for knee wall. Corrected plywood layers for floor. Corrected construction for floor-over-ambient conditions. Added heat-pump water heater module. Corrected layers for cathedral ceiling.	08/27/2013 10/20/2013 12/11/2013
4.01.11	Added option to include attic volume in conditioned space in case of sealed attic. Added option for roof insulation to go over roof studs.	05/29/2014 04/09/2014
4.01.12	Added option to include mixed ceilings for sealed attics.	10/28/2014
4.01.13	Natural ventilation module.	02/04/2015
4.01.14	Updated to match spec sheet version 4.01.14. Fixed bug in tcv schedules. incorporated provision for heat-pump dhw heater.	04/08/2015 06/16/2015
4.01.15	Corrected total room volume to include attic volume for different roof types.	10//22/2015
4.01.16	Modified setback schedule for thermostat schedule based on resnet 301-2014.	07/28/2016
4.01.17	Changed supply and return duct r-value= p-rsupply/p-return = [p-supplyductr[] + 0.5]/[p-returnductr[] + 0.5]. Change[p-atticfla[] eqs 0] to [p-atticfla[] eq 0].	04/09/2019 04/09/2019
4.02	Changed the bdl name from ver 4.01.17 to ver 4.02	05/13/2019
4.02.03	Added support for vevised 2015 IECC AE code. Specifically, added 4th floor support.	

Added sensible and latent components for equipment heat gain

In order to incorporate the HERS Index calculations in IC3, it became necessary to elaborate the input for lighting, equipment and occupants.[33] Equipment loads were now divided into sensible and latent components. Two new parameters were added in Version 4.01.09 to incorporate the sensible and latent components of the equipment load.

Added special construction for knee wall

In BDL Version 4.01.10 specifications were added to represent knee wall construction. Previous versions of the BDL did not have a separate entry for knee wall construction. Specifications for exterior wall construction was used to represent construction for knee walls.

Corrected plywood layers for floor

In BDL Version 4.01.10 specifications for floor construction was modified to better account for standard practice. Previous versions of the BDL had thinner layer of plywood specified. The current version specifies a more appropriate thickness of plywood used in the construction of floors, which include floors over basements and crawl spaces.

Corrected construction for floor over ambient

In BDL Version 4.01.10 specifications for floor-over-ambient construction was created. Previous versions of the BDL used specifications for ceiling insulation for floor-over-ambient conditions. The current version appropriately incorporates floor insulation in floor-over-ambient construction. The specification in the BDL limits the thickness of floor insulation to the thickness of floor studs input in the model.

Added heat-pump water heater module

In BDL Version 4.01.10 specifications for heat-pump water heaters were added. These specifications include the addition of the heat-pump option as an option available in the BDL to be modeled as a DHW type. When the heat-pump option is selected, several inputs are now modified by the software team. These include values for energy input ratio (DHW-EIR) and heat rate (DHW-HEAT-RATE). The equation for converting EF to COP is adopted from the specifications in EnergyGauge USA (Version 3.1.02).

$$\text{DHW-EIR} = 1/\text{COP} = 0.781/(\text{EF})$$

The heat rate values of 7,700 Btu/hr are adopted from EnergyGauge regardless of the size of the tank.[34]
In addition, the curves used for the energy input ratio as a function of part load ratio are the same curves that are used for heat pump space heating obtained from Henderson et al. (2000).[35]

Corrected layers for cathedral ceiling

In BDL Version 4.01.10 specifications for the cathedral ceiling were added to the BDL. The modification included providing a separate entry in the BDL for cathedral ceiling insulation. Previous versions of the BDL used ceiling insulation for cathedral ceilings.

Added option to include attic volume in conditioned space in case of sealed attic

In BDL Version 4.01.11 modifications were made to include attic volume in conditioned space in the case of sealed attic was simulated. The modifications were made to ‘ROOM’ space conditions.

Added 4th floor support

In BDL Version 4.02.03 specifications for a fourth floor were added to the BDL.

[33] It should be noted that loads from occupants were included in the loads for equipment.
[34] Email correspondence with Jeff Myron, EnergyGauge Technical Support (10/18/2013).
[35] Henderson, H., D. Parker, Huang, Y. (2000). Improving DOE-2’s RESYS Routine: User Defined Functions to Provide More Accurate Part Load Energy Use and Humidity Predictions. Presented at the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA.

6.3 Laboratory's TERP Web Site "esl.tamu.edu/terp"

Since the fall of 2001, the Laboratory has maintained a TERP webpage, where information is provided to builders, code officials, the design community and homeowners about TERP. In 2019, the Laboratory redesigned its website to make navigation easier. On the navigation bar is a tab that links to the TERP homepage (Figure 56). The homepage contains the following items:

- Texas Emissions Reduction Program
- Texas Work
    - TERP Objectives
    - TERP Elements
    - ESL's TERP Responsibilities
    - Texas Energy Summit
- National Work
    - National Center of Excellence on Displaced Emission Reductions (CEDER)
    - Our Work
        - EPA Recognizes ESL and Dallas Partners

The TERP tab also contains a dropdown menu which provides links to the following sections (Figure 57)

- History
- Code Compliance Calculator
    - IC3
        - City Amendments to the State Energy Code
            - City of Austin
            - City of Houston
            - North Central Texas COG
        - Resources
            - IC3 User Manual
            - IC3 Release Notes
            - RESNET Validation Report
            - FBI IC3 Unit
            - Aggregate Reports from IC3
        - FAQs
- Data
    - Texas Building Registry
        - IC3 Usage
        - IC3 House Construction
    - Weather
- Letters and Reports
    - Legislative Documents
    - EPA/CEDER Work
    - Builders Information
    - Reports – listed by year from 2002-2020
    - Presentations
- Workshops
    - International Code Compliance Calculator
    - ASHRAE
    - IECC Commercial Energy Code Training

- IECC Residential Energy Code Training
- Continuous Commissioning

- TERP Links (Figure 58)
  - International Code Compliance Calculator (IC3)
  - Public Utility Commission of Texas (PUC)
  - U.S. Department of Energy (DOE)
  - Texas State Energy Conservation Office (SECO)
  - U.S. Environmental Protection Agency (EPA)
  - International Code Council (ICC)
  - American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
  - North Central Texas Council of Governments (NCTCOG)
  - Alamo Area Council of Governments (AACOG)
  - Circle of Ten

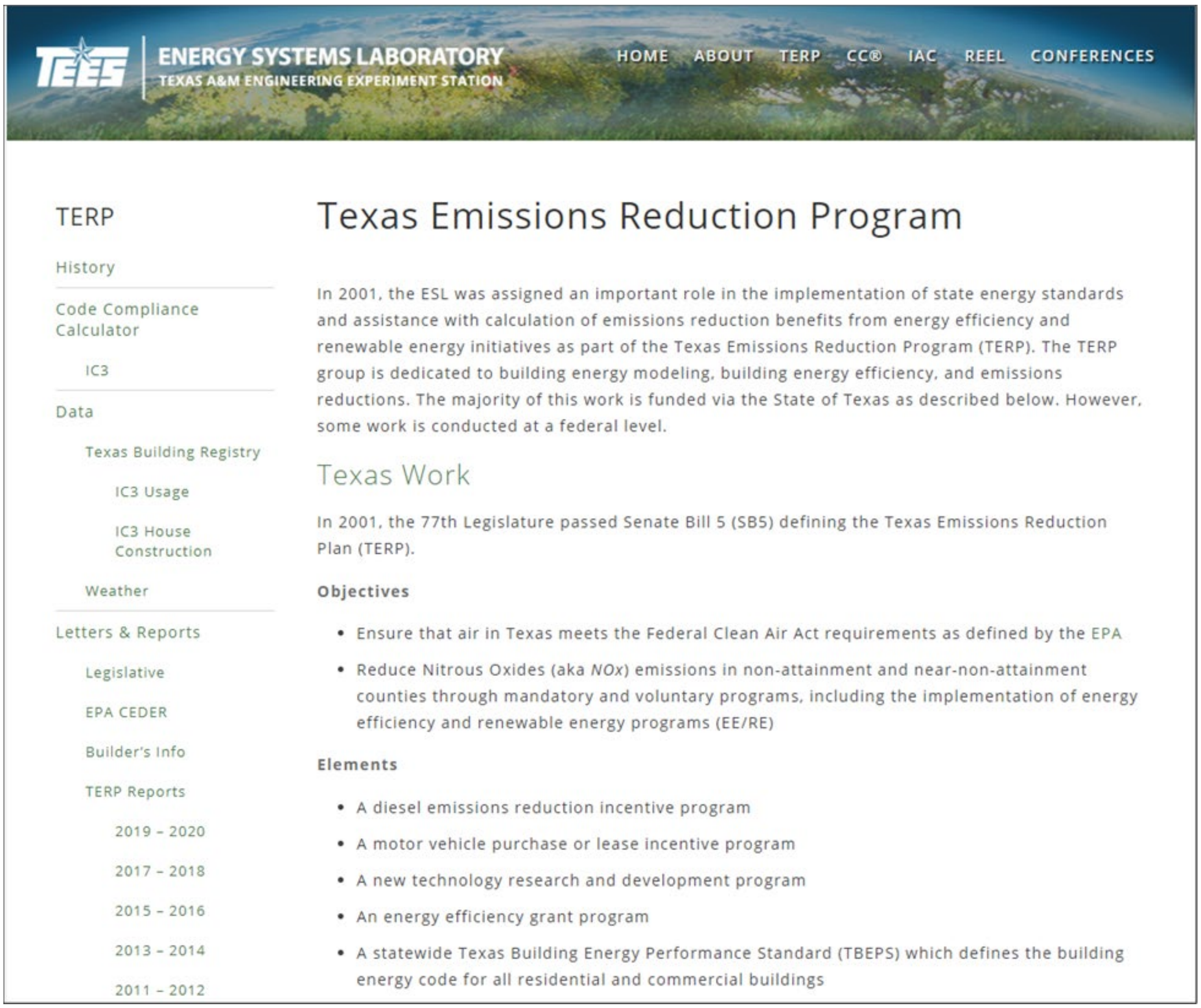


Figure 56. TERP Home Page


ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

HOME ABOUT TERP CC® IAC REEL CONFERENCES

TERP

- History
- Code Compliance Calculator
  - IC3
- Data
  - Texas Building Registry
    - IC3 Usage
    - IC3 House Construction
  - Weather
- Letters & Reports
  - **Legislative**
  - EPA CEDER
  - Builder's Info
  - TERP Reports
    - 2019 – 2020
    - 2017 – 2018
    - 2015 – 2016
    - 2013 – 2014
    - 2011 – 2012
    - 2009 – 2010

Legislative Documents

Highlights of our activities can be found in our legislative testimony.

Below are documents prepared by the Energy Systems Laboratory to fulfill TERP Legislative Objectives. The ESL also conducts stringency reviews of the latest published editions of building energy codes in comparison to the Texas Building Energy Performance Standards (TBEPS), for consideration for adoption by the State Energy Conservation Office (SECO).

- **Nov 2014** Final recommendation to SECO, including stringency analysis & review of public comments, regarding the 2015 IRC, Chapter 11, and the 2015 vs. the 2009 IECC codes
- **Aug 2014** Letter to SECO regarding the stringency of the 2015 IRC, Chapter 11, and the 2015 vs. the 2009 IECC codes
- **Aug 2012** Final recommendation to SECO, including stringency analysis & review of public comments, regarding the 2012 IRC, Chapter 11, and the 2012 vs. the 2009 IECC codes
- **Aug 2012** Detailed stringency analysis of suggested amendments to Chapter 11 of the 2012 IRC and the 2012 IECC that were submitted to SECO during March 30-April 30, 2012 comment period ESL-TR-12-08-01
- **Dec 2011** A Comparison of Building Energy Code Stringency: 2009 IECC vs. 2012 IECC for Commercial Construction in Texas. Revised Jul 2012 ESL-TR-11-12-07
- **Dec 2011** A Comparison of Building Energy Code Stringency: 2009 IRC vs. 2012 IRC for Single Family Residences in Texas. Revised Aug 2012 ESL-TR-11-12-05
- **Dec 2011** Letter to SECO regarding the stringency of the 2012 IRC, Chapter 11, and the 2012 IECC vs. the 2009 codes
- **Oct 2011** Letter to DOE in response to Building Energy Codes Cost Analysis notice in Federal Register
- **May 2011** General Memo and Information on 15% Above-code Energy Efficiency Measures for Residential Buildings in Texas Regarding the 2009 codes

Figure 57: TERP –Legislative Documents

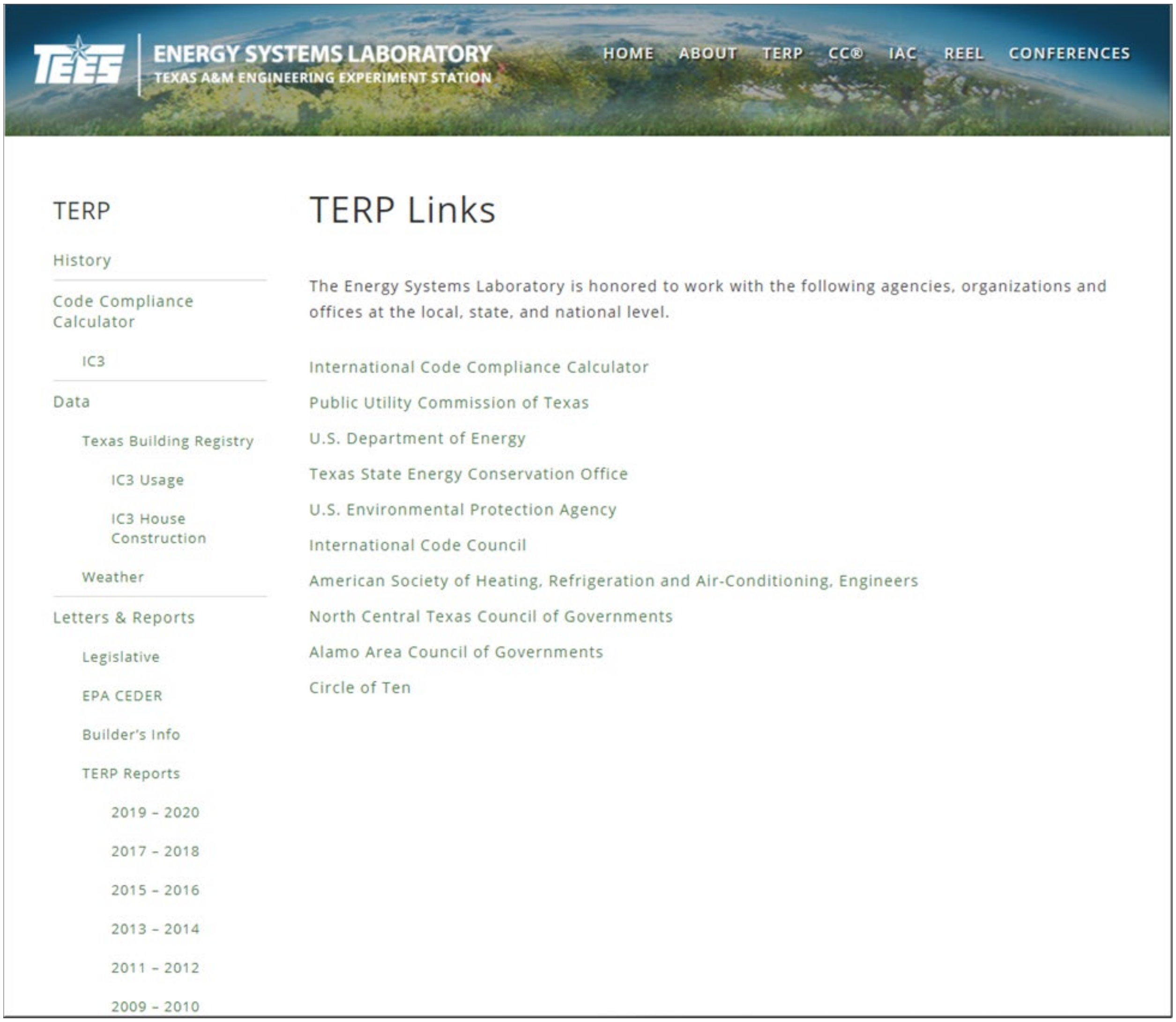


Figure 58: TERP Links

In addition, the Energy Systems Lab. (ESL) also hosted the Texas Energy Summit (previously Clear Air Through Energy Efficiency Conference (CATEE)). The Texas Energy Summit website and information are linked in the menu of the Conference tab in the ESL website.

6.4 Activities of Technical Transfer

6.4.1 Technical Assistance to the TCEQ

The Laboratory received dozens of calls per week from code officials, builders, home owners and municipal officials regarding the building code and emissions calculations. A file of these transactions is maintained at the Laboratory.

The Laboratory provides technical assistance to the TCEQ, PUC, SECO and ERCOT, as well as Stakeholders participating in a number of conferences and presentations. In 2011, the Laboratory continued to work closely with the TCEQ to develop an integrated emissions calculation, which provided the TCEQ with a creditable NOx emissions reduction from energy efficiency and renewable energy (EE/RE) programs reported to the TCEQ in 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 by the Laboratory, PUC, SECO, and Renewables-ERCOT.

The Laboratory has and will continue to provide leading edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering the emissions and improving the air 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.

6.4.2 Code Training

Section 388.009 of HB 3235 requires the Laboratory to develop and administer a state-wide training program for municipal building inspectors who seek to become code-certified inspectors. To accomplish this, the Laboratory originally developed the Energy Code Workshops which were based on the 2006 International Energy Conservation Code (IECC) as published by the International Code Council (ICC) for residential and commercial buildings, with amendments. Since then, the Laboratory has updated the workshops to the 2015 IECC, and developed 2018 code workshops.

6.4.3 ASHRAE Winter Conference Standards Committee Activities in Orlando, Florida, 2020 (To be completed)

The following sections are the minutes and transactions of Standards Committee activities at the ASHRAE Winter Conference in Orlando, Florida, 2020 , Jan 28 to Feb 05, 2020.

6.4.3.1 ASHRAE HC

6.4.3.2 ASHRAE BIM MTG

6.4.3.3 ASHRAE SSPC 62.1

6.4.3.4 ASHRAE SSPC 140

6.4.3.1 ASHRAE TC 1.5

6.4.3.2 ASHRAE TC 4.7

6.4.3.3 ASHRAE TC 7.5

6.4.3.4 ASHRAE TC 7.6

6.4.4 ASHRAE Summer Conference Standards Committee Activities online event, 2020 (To be completed)

The following sections are the minutes and transactions of Standards Committee activities at the ASHRAE Summer Conference online event, 2020.

6.4.4.1 ASHRAE HC

6.4.4.2 ASHRAE BIM MTG

6.4.4.3 ASHRAE SSPC 90.1

6.4.4.4 ASHRAE SSPC 140

6.4.4.5 ASHRAE SSPC 189.1

6.4.4.6 ASHRAE TC 1.5

6.4.4.7 ASHRAE TC 4.7

6.4.4.8 ASHRAE TC 7.6

6.4.5 Other Meetings

The following meetings were held in Austin to discuss the 2018 IECC.

2018 IECC in Texas What, Why and How Workshop	4/23/2020
2018 IECC Commercial Additional Efficiency, Performance and Commissioning Workshop	4/23/2020
2018 IECC Commercial Additions, Alterations, and Repairs Workshop	4/23/2020
2018 IECC Residential Envelope Provisions	4/27/2020
2018 IECC Commercial Envelope Provisions Workshop	4/30/2020
2018 IECC Residential Building Systems and IC3 Workshop	5/4/2020
2018 IECC Commercial Mechanical Systems Workshop	5/7/2020
2018 IECC Commercial Lighting Systems Workshop	5/28/2020
2015 IECC Commercial Provisions Workshop	9/11/2020

6.4.5.1. Texas Energy Summit

The Texas Energy Summit is hosted by the Energy Systems Laboratory (ESL) of the Texas A&M Engineering Experiment Station (TEES). The following pages are conference program agendas from the Texas Energy Summit 2020. This conference was 100% online due to Covid-19 restrictions.

Texas Energy Summit 2020


3PM - 4PM
BREAKOUT SESSION 3: Policies to extend Texas' leadership in Hydrogen, Carbon Capture Utilization and Storage, + Direct Air Capture
Ken Medlock
Senior Director, Center for Energy Studies
Rice University
Rich Powell
Executive Director
ClearPath Action
Steve Oldham
Chief Executive Officer
Carbon Engineering
Paula Gant
SVP, Strategy & Innovation
Gas Technology Institute
Drew Nelson
Clean Energy Program Officer
Cynthia and George Mitchell Foundation
3PM - 4PM
BREAKOUT SESSION 4:
Policies to Increase Transportation Equity in the Energy Transition
Oni Blair
Executive Director
LINK Houston
Shelley Francis
Co-Founder
EVHybridNoire (EVHN)
Nancy Seidman
Senior Advisor
Regulatory Assistance Project (RAP)
3PM - 4PM
BREAKOUT SESSION 5:
Policies to Electrify Transportation
Tom "Smitty" Smith
Director
Texas Electric Transportation Resources Alliance (TxETRA)
Christopher George
Executive Director
at Evolve Houston
Alex Mennella
Sustainability and Electrification at Uber
Buzz Smith
Britta Gross
Rocky Mountain Institute
4PM - 5PM
Discussion Lounges, Networking, Expo Hall + Student Posters


DAY 2 | NOVEMBER 11
ELECTRIFY TEXAS
Click on the session option below to view the session recordings for Day 2
Plenary 0
Session 1
Session 2
Session 3
Session 4
Session 5
1PM - 2PM
Arrival, Expo Hall, Student Posters + Networking
2PM - 3PM
PLENARY SESSION: ELECTRIFY TEXAS
KEYNOTE
Saul Griffith
PANEL
Ben Sharpe
Sara Berman
Rafael Anchia
Nate Hill
David Visneau
3PM - 4PM
BREAKOUT SESSION 1:
Policies to Accelerate Financing Solutions
Eddy Trevino
Jennifer Lancaster
Marina Badoian
Charlene Heydinger
Dan Yeoman
3PM - 4PM
BREAKOUT SESSION 2:
Policies to Transition to Cleaner Sources of Power
Uday Varadarajan
Beth Garza
David Hudson
Matthew Crosby


3PM - 4PM
BREAKOUT SESSION 3: Putting the Pieces Together | Electrification of Buildings and Transportation with Clean Energy
Travis Sheehan
Lead for City Solutions, North America, Shell New Energies
Shell New Energies
David Visneau
Executive Vice President of Strategy & Operations
MP2 Energy
Tom Ashley
VP Policy + Market Dev
Michael Jewell (Mod)
Jewell and Associates
3PM - 4PM
BREAKOUT SESSION 4: Policies to Electrify Fleets
Lori Clark
Program Manager, Clean Fleet and Energy Improvements and DFW Clean Cities Coordinator North Central Texas Council of Governments (NCTCOG)
Duncan McIntyre
CEO
Highland Electric Transportation
Nate Hill
Head of Energy Policy
Amazon
Surya Swamy
Senior Director, Fleet Solutions
EVgo
3PM - 4PM
BREAKOUT SESSION 5: Policies to Electrify Freight
Elizabeth Fretheim
Head of Business Development and National Accounts
Nikola Motor Corporation
Mario Bravo
Project Manager, Partnerships Outreach
Environmental Defense Fund
Ben Sharpe
Senior Researcher
The International Council On Clean Transportation
Sara Berman
Mike Moynahan Sr.
Porne Cavan
4PM - 5PM
Discussion Lounges, Networking, Expo Hall + Student Posters

DAY 3 | NOVEMBER 12 JUSTICE EQUITY + HEALTH

Click on the session option below to view the session recordings for Day 3

Plenary 0 | Session 1 | Session 2 | Session 3 | Session 4

1PM - 2PM — Arrival, Expo Hall, Student Posters + Networking

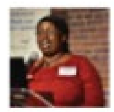
2PM - 3PM

PLENARY SESSION: JUSTICE EQUITY + HEALTH

Kimberly Lewis
Senior Vice President Market Transformation & Development
U.S. Green Building Council

Abigail Hopper
President and CEO
Solar Energy Industries Association

Val Benavidez
Incoming President and CEO
Texas Freedom Network

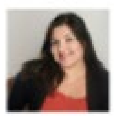


Jacqui Patterson
Senior Director
NAACP Environmental and Climate Justice Program

Barbara Gervin-Hawkins
Representative
Texas Legislature

3PM - 4PM

BREAKOUT SESSION 1: Organizing for Policies to Increase Climate Resilience and Justice



Iris Gonzalez
Coalition Director
Coalition for Environment, Equity & Resilience (CEER)

Angelica Razo
Texas State Director
Mi Familia Vota

Alan De Leon
Houston Advocacy Organizer
MOVE Texas

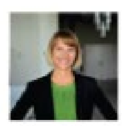
Rick Levy
President
Texas AFL-CIO

3PM - 4PM

BREAKOUT SESSION 2: Policies to Reduce Energy Burden and Increase Equity

Efrem Jernigan
President at South Union Community Development Corporation

Monisha Shah
Researcher IV
Policy Analysis
NREL



Suzanne Russo
Chief Executive Officer at Pecan Street Inc.

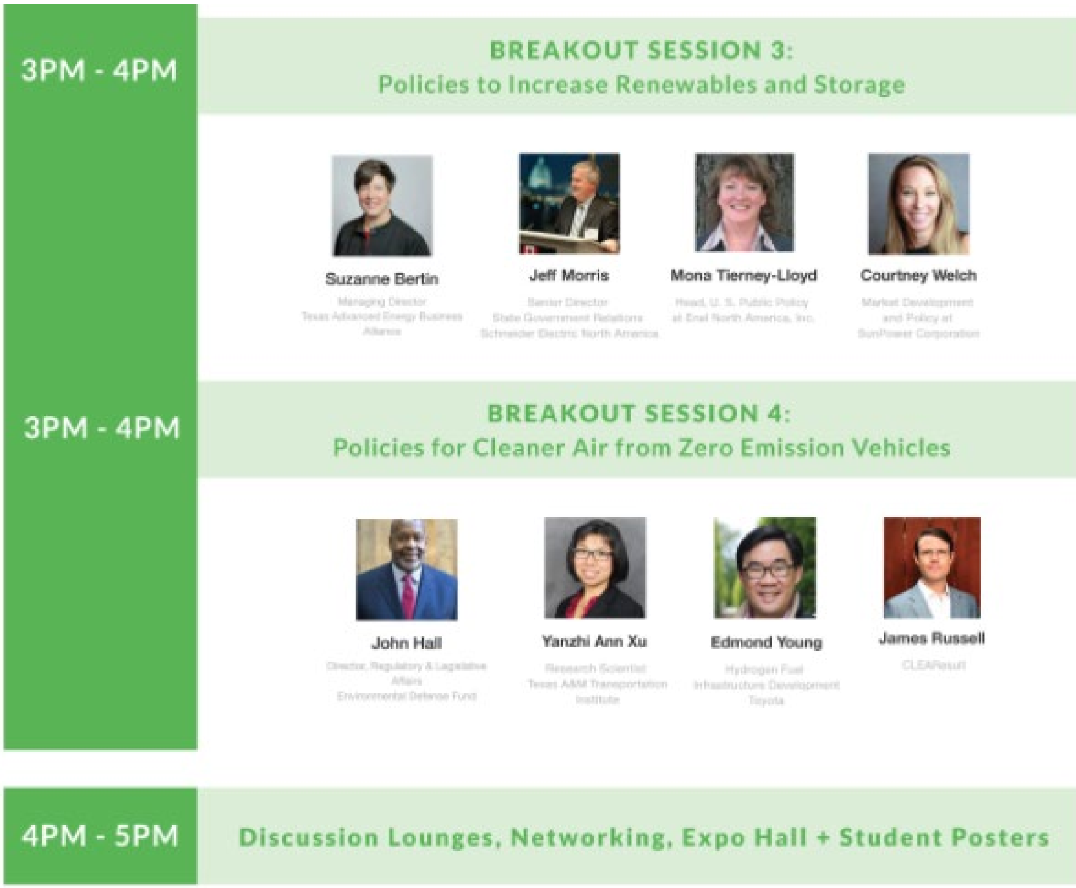
Ariane Beck, PhD
Research Fellow in the Energy Systems Transformation Research Group (EST) at the LBJ School of Public Affairs at The University of Texas at Austin


3PM - 4PM
BREAKOUT SESSION 3:
Policies to Reduce Pollution in Communities
John Hall
Director, Regulatory & Legislative Affairs
Environmental Defense Fund
Bakeyah Nelson
Executive Director
Air Alliance Houston
Dr. William Perkison
MD
UT Health Sciences Center
Donna Thomas
Ft. Bend Co.
Environment Chair,
Community Leader, Pct. 3123
3PM - 4PM
BREAKOUT SESSION 4:
Policies to Improve Indoor Air Quality in the Age of COVID-19
Glen Rhoden
Round Rock ISD
Jim Brown
Sr Principal at ESA
Energy Systems Associates
David Hoedebeck
Director of Maintenance
Round Rock ISD
Tim McSwain
Sales Engineer at
Advanced Filtration Systems
Ashley Williams
Chief Operating Officer
Texas Energy Managers Association
4PM - 5PM
Discussion Lounges, Networking, Expo Hall + Student Posters


DAY 4 | NOVEMBER 17
JOBS + INVESTMENT
Click on the session option below to view the session recordings for Day 4
Session 0
Session 1
Session 2
Session 3
Session 4
Session 5
1PM - 2PM
Arrival, Expo Hall, Student Posters + Networking
2PM - 3PM
PLENARY SESSION: JOBS + INVESTMENT
Emily Reichert
Chief Executive Officer
Greentown Labs
Rohan Patel
Senior Director, Public Policy and Business Development
Tesla
Scott Boose
President & CEO
CLEAResult
Jose Beceiro
Senior Director of Global Energy 2.0
Greater Houston Partnership
Sen. Beverly Powell
Texas State Senator
3PM - 4PM
BREAKOUT SESSION 1:
Climate Policies to Promote Economic Development
Lara Cottingham
Chief of Staff &
Chief Sustainability Officer
City of Houston
Cristina Tzintzún Ramirez
Founder
Jolt Initiative
Maggie Molina
Branch Chief,
State and Local Energy
and Environment Program
at the US EPA
Helen Ramirez
City of Brownsville
3PM - 4PM
BREAKOUT SESSION 2:
Policies to Grow the Benefits of Renewable Energy to Rural Texas
Susan Sloan
Vice President, State Affairs
American Wind Energy Association
Mark Stover
Director, Government + Regulatory Affairs
Apex Clean Energy
Charlie Hemmeline
Texas Solar Power Association
Joshua Rhodes
Univ. of Texas at Austin
Rose Benevidez
President
Starr Co. Industrial Foundation


3PM - 4PM
BREAKOUT SESSION 3:
Policies to Increase Efficient Use of Energy and Energy Efficiency Jobs
Vince Zubicek
E3 Entegral Solutions
Michael Romeo
CLEAResult
Adrienne Atchley
Piper Maddox
Peter Aguirre
Private Sector Development
Ameresco
3PM - 4PM
BREAKOUT SESSION 4:
Policies to Bring Clean Energy Manufacturing and Supply Chains to Texas
Claire Alford
Policy Associate
Texas Advanced Energy Business Alliance
Rohan Patel
Senior Global Director
Public Policy and
Business Development
Tesla
Dave Treichler
Director Strategy and Technology
Oncor Electric Delivery
Phil Jordan
VP
BW Research Partnership
3PM - 4PM
BREAKOUT SESSION 5:
Breakout 5: CCS/Hydrogen Potential in Texas and the UK
Timothy "Tip" Meckle
Senior Research Scientist
Bureau of Economic Geology
The University of Texas at Austin
Julio Friedmann
Center on Global Energy Policy
Columbia University
Bryony Livesey
Director
Industrial Decarbonization
Challenge
Jon Rosenthal
Texas House of
Representatives
Andy Lane
Vice President at CCUS Solutions
and Managing Director
Net Zero Teesside, BP
4PM - 5PM
Discussion Lounges, Networking, Expo Hall + Student Posters


DAY 5 | NOVEMBER 18
ENERGY ISSUES IN 2021
Click on the session option below to view the session recordings for Day 5
Plenary 0
Session 1
Session 2
Session 3
Session 4
1PM - 2PM
Arrival, Expo Hall, Student Posters + Networking
2PM - 3PM
PLENARY SESSION: A LOOK AHEAD TO ENERGY ISSUES IN 2021
Pat Wood, III
Chief Executive Officer
Hunt Energy Network
Charles Hernick
Vice President of
Policy and Advocacy
Citizens for Responsible
Energy Solutions
Sen. Sarah Eckhardt
Texas State Senator
Chris Tomlinson
Business Columnist
Houston Chronicle +
San Antonio Express - News
Alison Silverstein
Energy Consultant
Alison Silverstein Consulting
3PM - 4PM
BREAKOUT SESSION 1:
Policies to Accelerate Climate Justice
Catherine Flowers
Texas Field Consultant
Moms Clean Air Force
Phoebe Romero
Environmental Program
Coordinator, Office of
Sustainability
City of Austin
Caroline Spears
Executive Director
at Climate Cabinet
3PM - 4PM
BREAKOUT SESSION 2:
Policies to Reduce Waste of Natural Resources
Colin Leyden
Director State Regulatory &
Legislative Affairs, Oil & Gas
Environmental Defense Fund
Sharlene Leurig
Chief Executive Officer
Texas Water Trade
Todd McAllister
Executive Director
at SPEER
Rep. Erin Zwiener
Representative
Texas Legislature


3PM - 4PM
BREAKOUT SESSION 3:
Policies to Increase Renewables and Storage
Suzanne Bertin
Managing Director
Texas Advanced Energy Business
Alliance
Jeff Morris
Senior Director
State Government Relations
Schneider Electric North America
Mona Tierney-Lloyd
Head, U. S. Public Policy
at Enel North America, Inc.
Courtney Welch
Market Development
and Policy at
SunPower Corporation
3PM - 4PM
BREAKOUT SESSION 4:
Policies for Cleaner Air from Zero Emission Vehicles
John Hall
Director, Regulatory & Legislative
Affairs
Environmental Defense Fund
Yanzhi Ann Xu
Research Scientist
Texas A&M Transportation
Institute
Edmond Young
Hydrogen Fuel
Infrastructure Development
Toyota
James Russell
CLEAResult
4PM - 5PM
Discussion Lounges, Networking, Expo Hall + Student Posters

6.4.6 Papers, Theses, etc.

6.4.6.1 Theses and Dissertations.

The following theses and dissertations were published in 2020 incorporating work related to the Texas Emissions Reduction Plan (TERP).

- Kota S., "*Development of a prototype for integrating building information model (BIM) with daylighting simulation tools for designing high- performance building*", Ph.D., Department of Architecture, May 2020.

  The outcome of this study is the development of a prototype REVIT2RADIANCE add-in program for a Building Information Modeling (BIM) authoring tool Autodesk Revit to perform daylighting studies with ease by architects and simulation experts alike for designing High-Performance Buildings. To achieve this, first, a literature survey of several different daylighting calculation methods and tools was conducted to identify their capabilities and limitations, which include a comparative analysis of tools that are widely used and comparative analysis of daylighting simulation tools was ascertained from the comparative analysis. The results of the comparative analysis revealed that the state-of-the-art daylighting simulation tool RADIANCE has the most advanced capabilities to perform daylighting simulation, followed by RADIANCE based tool DAYSIM. Second, a survey of the previous methodologies that explored the integration of CAD (e.g., AutoCAD) or BIM authoring tools (e.g., Revit) with daylighting simulation tools was conducted. The survey provided: an overview of different aspects involved in the integration process; the shortcomings of each method; the necessity for a better integration process; and finally, the need for integration of Revit, a BIM-authoring tool with RADIANCE and DAYSIM. Third, for integrating Revit with RADIANCE and DAYSIM, different methods were explored. First, the conventional method that uses Radiance utilities that facilitate the translation of geometry created by various CAD-based tools into RADIANCE geometry and material information. Several significant limitations were observed in these methods, one of which is the partial translation involving only geometry but not the material information from Revit to RADIANCE. To address these limitations, a second method using a custom prototype REVIT2RADIANCE comprising of several Revit add-in programs was developed using the Revit API and C# programing language. The new prototype provides seamless integration of Revit with RADIANCE and DAYSIM, not only translating both geometry and material information but also simultaneously performing a daylighting simulation using RADIANCE and DAYSIM that generates results in a widely-used format. Finally, the prototype was tested using two different test cases, one with simple geometry and a second comprising of complex geometry. Validation of the prototype REVIT2RADIANCE was performed to check the accuracy in translating the Revit geometry and material in to RADIANCE and DAYSIM geometry and translating the material information necessary to perform the daylighting simulation. The first validation test was performed by visually comparing the Revit model with the rendered RADIANCE model, generated using the RVIEW program of the input file created by the prototype. In the second validation test, the parameter values of the RADIANCE Materials written by the prototype were compared with the parameter values obtained using hand calculations. Both the validation tests confirmed the accuracy in the translation of geometry and material information contained in Revit into the proper RADIANCE and DAYSIM formats.

- Lee S., "*Analysis of Support Vector Machine Regression for Building Energy Use Prediction*", M.S., Department of Architecture, August 2020.

  There are many inverse modeling methods to model the whole building energy use. Multiple linear regression (MLR) and change-point liner regression (CPLR) have been some of the most common methods due to their direct interpretation concerning building energy modeling and their fair accuracy. Recently, as machine-learning techniques have become more accessible, there have been many attempts to apply these techniques to building energy modeling. However, no studies have conducted an in-depth comparison with the conventional inverse model methods using large buildings sample size. This study conducted a comprehensive comparative study based on Support Vector Machine

(SVM), one of the most widely used machine-learning methods for flexibility and accuracy, with enough cases to draw a reasonable conclusion between models generated from conventional methods such as MLR and CPLR, and those from SVM. This work, besides the comparative analysis, included a thorough SVM performance analysis for building energy modeling. It described in detail its implementation, and showed its performance as a regression technique for building energy modeling under the influence of different variables. The comparative study focused on modeling whole building chilled water use (CHW) and heating hot water use (HHW), and analyzed the influence of such variables as the outdoor dry-bulb temperature (OAT), the outdoor dew-point temperature (DPT), the outdoor air enthalpy (OAE), and the operational effective enthalpy (OEE). The numerical experiments were based on a sample of 41 whole year daily and hourly building energy use datasets that were converted from hourly data. According to the comparative analysis between SVM and MLR, based on CHW data, SVM consistently showed higher performances by an average of 6.8% on daily and 2.0% on monthly models, respectively. For the SVM and CPLR performance analysis, four pairs of dependent and independent variables were considered: CHW-OAT, CHWOAE, CHW-OEE, and HHW-OAT. On daily modeling, SVM demonstrated consistently higher performance, although most of the cases resulted in a marginal advantage by less than 1% for all variables utilized. Despite such marginal gains in mean performance, SVM showed advantages by up to 3% for some datasets. On the monthly model, however, SVM did not exhibit better results for any dependent-independent variable pair.

- Kheiri F., "*An Improved Method for the Estimation of the Energy Consumption and Savings of Code-Compliant office Buildings in Different Climates*", Ph.D., Department of Architecture, December 2020.

  Degree day methods are used in the estimation of building energy consumption and climate classification for buildings (e.g. in ASHRAE Standard 169-2013, which is adopted in ASHRAE Standard 90.1-2016). This study, first assessed the effectiveness of the conventional degree days in estimating building energy consumption in different moisture regimes. The analysis was done by comparing the energy performance of the DOE/PNNL medium office prototype building models in the 801 locations in the U.S. The results revealed large variations in the annual energy consumption of the models in the different moisture regimes within each climate zone. Furthermore, large differences in the estimated energy savings by utilization of daylight were shown in different locations. In addition, detailed pairwise analyses were performed to analyze the large variation in the cooling or heating energy consumption in sites with similar Cooling Degree Days (CDD) or Heating Degree Days (HDD), respectively. The analysis revealed that the influential weather parameters that affected the building energy consumption were not fully accounted for in a conventional degree day method. In other words, the level of aggregation of the data in the conventional degree day method masks some of the informative characteristics of the outdoor dry-bulb temperature. To resolve these discrepancies, a split-degree day method was proposed to calculate the split-Cooling Degree Days (sCDD) and the split-Heating Degree Days (sHDD). The results show that in the regression models using the split degree days compared to the conventional degree days, the coefficient of determination of the estimations of the energy consumption increased for the total annual energy use (from 0.913 to 0.965), the heating energy use (from 0.891 to 0.981), the cooling energy use (from 0.979 to 0.982), and the fan energy use (from 0.383 to 0.722). Similar results were shown for the models with higher thermal mass. The proposed method can be used for building energy consumption estimation, weather-normalized building energy savings calculation, and climate classification. Moreover, a new adjustment method was developed using the proposed split-degree day method that reduces the variations in the above code values in the performance compliance path in different locations from 14% to 2%.

- Jung S., "*Analysis of Residential Building Energy Code Compliance for New and Existing Buildings Based on Building Energy*", Ph.D., Department of Architecture, December 2020.

  Currently, the International Energy Conservation Code (IECC) is the most widely-used residential building energy code in the United States. Either the IECC or IECC with amendments has been adopted by 33 states. The latest version of the IECC contains three compliance requirements, including: mandatory, prescriptive, and performance paths for compliance. The performance path includes specifications for the standard house design and the proposed design to be analyzed using whole-building energy simulations. In the performance path, the annual simulated energy cost of the proposed house must be less than the annual energy cost (or source energy usage) of the standard reference house. Unfortunately, most of the whole-building energy simulation programs are too complicated to be used by building energy code officials or homeowners without special training. To resolve this problem, simplified simulation tools have been developed that require fewer user input parameters. Such simplified software tools have had a significant impact on the increased use of the performance-based code compliance path for residential analysis. However, many of the simplified features may not represent the energy efficient features found in an existing residence. This may mis-represent the potential energy saving when/if a house owner decides to invest in a retrofit to reduce their annual energy costs. Currently, there are building energy simulation validation methods developed by ASHRAE, and RESNET including: ASHRAE Standard-140, IEA BESTEST, HVAC BESTEST, and BESTEST-EX. These tests have been developed to test the algorithms of building energy performance simulation, which require complex inputs and outputs to view the test results. Unfortunately, even though two different building simulation validation programs may produce the necessary inputs/outputs for certification, they are rarely tested side-by-side or on actual residences. Furthermore, results from a simplified analysis of a building is rarely compared against a detailed simulation of an existing building. Therefore, there is a need to compare the results of a simplified simulation versus a detailed simulation of an existing residence to better determine which parameters best represent the existing house so more accurate code-compliant simulations can be performed on existing structures. The purpose of this study is to develop an accurate, detailed simulation model of an existing single-family residence that is compared with a simplified building energy simulation of the same residence to help determine which on-site measurements can be made to help tune the simplified model so it better represents the existing residence. Such an improved building energy simulation can be used to better represent annual energy cost savings from retrofits to an existing building.

- Kim C., "*A study of occupancy-based smart building controls in commercial buildings*", Ph.D., Department of Architecture, December 2020.

  Occupant behavior has a significant influence on energy consumption in buildings because HVAC, lighting, equipment, and ventilation operations are often tied to occupancybased controls. However, currently, the traditional methods for the prediction of occupant behavior using a building energy modeling approach has begun to face difficulties due to the complex nature of occupant behavior and the introduction of the new technologies (i.e., occupancy sensors) in new and renovated construction. Research in the previous studies revealed that actual occupancy rates in office buildings were quite different compared to typical simulation schedules used in the analysis of building codes and standards. Therefore, large potential energy use reductions are expected when occupancy-based controls are used in building operations. In addition, many workers are recently encouraged to work more at home, which may cause larger unoccupied periods for a significant portion of time at a commercial office building. This fact further increases the need to better understand various occupancy schedules and usage trends in building energy simulations. However, currently, the U.S. commercial building energy codes and standards (i.e., ASHRAE Standard 90.1) do not fully support building energy modeling for occupancy-based controls for code-compliance. Performance paths (i.e., Appendix G method) in Standard 90.1- 2016 offer only partial credits for occupancy-based lighting controls, which tend to underestimate the potential reduction from the use of occupancy-based controls. Also, the requirements of the ASHRAE Standard 90.1 performance path require the mandatory use of identical schedules for the baseline and the proposed design models, which do not present the calculation of reduction from occupancy-based controls. Therefore, this study seeks to analyze occupancy-based controls to determine how varying factors may impact energy use reduction predictions in commercial office buildings. These factors include: different building types (i.e., lightweight versus heavyweight), with different system types (e.g., variable air volume versus packaged single-zone systems) by orientation (i.e., N,S,E,W) in different climates (e.g., cold and hot climates). To achieve the goal of this study, a reference office building was analyzed based on the prototype office building model that was developed by the U.S. DOE and PNNL for small office building for Standard 90.1-2016. Using this model, different thermal zoning models were developed for single-zone and five-zone models to evaluate the impact of occupancy-based controls in the prototype office building. The impact of occupancy-based controls was then evaluated using simulation to study the influence of occupant behavior on HVAC, lighting, equipment, and ventilation system energy use. A sensitivity analysis of each occupancy control schedule (i.e., occupancy, lighting, equipment) was performed in 100%-0% variations to determine interactions between occupancy variables. In addition, simulations for a set of specific occupancy control schedules (i.e., occupancy, lighting, equipment) were conducted in hot-humid and cold-humid climate zones with different building designs (i.e., a raised floor lightweight building and a heavyweight building with varying window-to-wall ratios) and different HVAC system types (i.e., packaged variable air volume versus packaged single-zone systems) to identify potential energy use reduction of occupancy-based building controls on annual energy consumption. The results showed substantial energy reduction potential from varying factors related to occupancy-based controls in commercial office buildings. The evaluation in two climate zones showed a range of energy reduction in Houston and Chicago due to the weatherdependent loads (i.e., heating, cooling, ventilation). Heavyweight material models showed higher percent energy use reduction potential ratios and less energy use compared to the reference building and lightweight models. Also, smaller window-to-wall models represented less total energy use than higher window-to-wall models, which led to higher energy use reduction ratios for smaller window-to-wall ratios. The PVAV systems had higher total load reduction ratios and less total energy use than PSZ systems in Houston and Chicago, especially for heating loads. Whole-building occupancy-based controls revealed more energy use reduction potential ratios in Houston compared to Chicago. The impact of orientation was different depending on thermal zone locations. However, the impact was not fully analyzed because this study did not evaluate combined occupancy sensor controls, daylight controls, and daylighting-based schedules. The largest energy use reduction contributors to occupancy modeling were the internal load factors (e.g., lighting, equipment). The outcome of this study should help guide the development of a guideline for evaluating how occupancy-based building controls can be better incorporated in different building types for different climate zones to reach compliance with ASHRAE Standard 90.1- 2016.

- Li, Q., "Analysis of Optimal Façade System Design in High Performance Buildings", Ph.D., Department of Architecture, December 2020.

This dissertation presents a new, optimal window design procedure for an office that uses a combined daylighting and thermal simulation in a hot and dry climate. The purpose of this work is to better inform the design of building windows used for daylighting in the preliminary design stage for improving building performance. This study used a simple office model to develop and test a prototype for the combined daylighting+thermal simulation by comparing the combined simulation methods of DOE-2+Split-Flux, EnergyPlus+Split-Flux, EnergyPlus+Radiosity, and EnergyPlus+Radiance. The results showed that different window size and location designs could have very different annual energy consumption results when using the combined EnergyPlus+Radiance simulation tool for North, South, East, and West orientations. However, the other three combined simulation methods could not simulate the differences between the different window size and placement designs (with same window areas). Therefore, this study proposes guidelines for how to conduct a combined daylighting and thermal simulation to obtain more accurate results. This study demonstrated the use of an improved procedure for using the Radiance simulation for speeding up the daylighting optimization. This new method produces accurate annual daylighting results while minimizing run time. This study also proposes a new customized, Radiance rendering parameters (called custom preset) into the DIVA software to simulate the annual daylighting. This custom preset only took 30 seconds to obtain annual daylighting results, while the most accurate preset (high-quality preset) in DIVA takes over one hour to complete the same simulation. The statistical software JMP Pro 14 was used to calculate the correlation between high-quality preset and custom preset. The results show that the high accuracy annual daylighting results can be predicted using the simulation results from the custom preset together with the multi-linear regression method that was developed. This study developed a window design plugin in grasshopper using Python. This new window design plugin was used generate thousands of different window sizes and placement designs. The window design plugin used a Multi-Objective Optimization (MOO) tool for analyzing different window size and placement designs. Finally, four optimization studies were conducted for the case-study office. The results showed that top positioned windows had the best daylighting and thermal performance, whereas lower positioned windows had the worst results. Therefore, national standards, such as ASHRAE Standard 90.1 and the IECC should not give the same credits for all the window location placements on an external wall. The Standard should provide the guidelines for the combined thermal and daylighting simulation. In addition, standardized testing of combined simulation programs that model the daylighting and thermal characteristics of a building, similar to the existing ASHRAE Standard 140 procedures, need to be developed and used by whole-building energy simulation programs.

Papers

Published Papers in 2020

The following papers were published in 2020 incorporating work related to the Texas Emissions Reduction Plan (TERP).

- Azizkhani, M., Haberl, J. 2020. "*Assessment and discussion of the level of application of passive/natural systems and daylighting systems by practioners in the US*", Science and Technology in the Built Environment, Vol. 26, No. 9.

  This paper assesses the current level of the application of passive/natural and daylighting systems in the US by architects and engineers. Although an extensive list of publications about passive/natural and daylighting systems exists, there are very few studies addressing the degree of applying these systems in practice. This paper, through the application of a survey methodology, evaluates the level of the application of passive and daylighting systems in the US and discusses the survey findings and variables that may increase the application of these systems in practice. The findings indicate a low level of the application of passive systems that need complex designs. In this case, daylighting systems were more regularly applied, while the application of passive cooling in the US was more common than passive heating systems. To promote the application of passive systems, the clients' desire/collaboration, building code/rating systems, and simulation tools for passive design were the most influential factors according to the survey findings. The focus of this study was on the application of passive systems as a part of a larger research focused on the application, education, and best-practices of passive design in the US.

Link: https://www.tandfonline.com/doi/full/10.1080/23744731.2020.1783961

- Haberl, J., Comstock, S., Hallstrom, A., Stamper, G. 2020. "*The Evolution of ASHRAE's Electronic Communication and Publication Technology*", ASHRAE Transactions Research, Vol. 126, Issue 1.

  Over the last 23 years ASHRAE has made dramatic progress towards the use of the electronic communication/publication technology and the internet for technical Society publications and communications. Prior to 1976 publications were created on a society mainframe computer at headquarters and distribution was only by paper copies. The development of desktop personal computers in the 1980's led Steve Comstock, ASHRAE Publisher, to start investigating and adopting workstations, computers and software to better handle the highly technical literature ASHRAE was producing. In 1987 ASHRAE Research Project RP 457 created the first ASHRAE electronic CD product--"Update of the Bibliography of Available Computer Programs in the area of HVAC&R". From this first electronic publication to today's 24/7 use of the internet ASHRAE Society electronic communication has been transformed beyond anything imaginable 23+ years ago. During this time, prior to 1990, ASHRAE relied primarily on the United States Postal Service (USPS), FedEX for overnight deliveries, fax and the telephone for Society communications, since the Society's technical literature was not easily accessible to all members electronically. Then, beginning in June of 1995, ASHRAE's entry onto the internet was officially begun with the appointment of the first Electronic Communication Ad Hoc Committee (ECAHC) by ASHRAE President Richard Hayter, followed shortly thereafter by ASHRAE's first official web page appearance in October 1995 and announcement in the November 1995 ASHRAE Journal. The first ECAHC was followed by a second ECAHC appointed in 1996 by ASHRAE President James Hill. These first two ECAHCs were assigned the task of reviewing, prioritizing and recommending ASHRAE's first policies and guidelines that would move ASHRAE into the rapidly evolving world of internet-based communications, including the parallel development of ASHRAE's first web page. This paper presents an historical review of these early developments to help document how ASHRAE moved rapidly to a web-based existence from the previous paper-based existence, and attempts to include recognition for the key ASHRAE members and ASHRAE Staff who made this all possible.

  Link: https://www.techstreet.com/standards/or-20-006-the-evolution-of-ashrae-s-electronic-communication-and-publication-technology?product_id=2113193#jumps

- Miller, C., Balbach, C., Haberl, J. 2020. "*The ASHRAE Great Energy Predictor III Competition: Overview and Results*", Science and Technology for the Built Environment, Vol 26, No. 10.

  In late 2019, ASHRAE hosted the Great Energy Predictor III (GEPIII) machine learning competition on the Kaggle platform. This launch marked the third energy prediction competition from ASHRAE and the first since the mid-1990s. In this updated version, the competitors were provided with over 20 million points of training data from 2,380 energy meters collected for 1,448 buildings from 16 sources. This competition's overall objective was to find the most accurate modeling solutions for the prediction of over 41 million private and public test data points. The competition had 4,370 participants, split across 3,614 teams from 94 countries who submitted 39,403 predictions. In addition to the top five winning workflows, the competitors publicly shared 415 reproducible online machine learning workflow examples (notebooks), including over 40 additional, full solutions. This paper gives a high-level overview of the competition preparation and dataset, competitors and their discussions, machine learning workflows and models generated, winners and their submissions, discussion of lessons learned, and competition outputs and next steps. The most popular and accurate machine learning workflows used large ensembles of mostly gradient boosting tree models, such as LightGBM. Similar to the first predictor competition, preprocessing of the data sets emerged as a key differentiator.

  Link: https://www.tandfonline.com/doi/full/10.1080/23744731.2020.1795514

- Oh, S., Baltazar, J.C., Haberl, J. 2020. "*Analysis of zone-by-zone indoor environmental conditions and electricity savings from the use of a smart thermostat: A residential case study*", Science and Technology for the Built Environment, Vol. 26, No. 3.

  Smart thermostats are becoming an important tool that saves Heating, Ventilating, and Air Conditioning (HVAC) system energy use by optimizing thermostat settings. This paper presents the results of an analysis of measured, zone-by-zone indoor environmental conditions and electricity savings from the use of a smart thermostat that includes temperature and occupancy data from each zone in a single-family residence. In this analysis, statistical indoor air temperature profiles were developed for each zone before and after the installation of the smart thermostat. The analysis shows that the temperature and occupancy-based control of the system produced significant changes to the indoor air temperature profiles in each zone. Although these indoor condition changes were acceptable to the homeowner of the case-study residence, the changes to the before-after indoor air temperature profiles also present new challenges to simulating the annual savings with a calibrated building energy simulation program. The results also show that a residence with a single-zone HVAC system controlled by a single thermostat that was retrofitted with wireless occupancy and temperature sensors in each zone achieved significant electricity savings for the homeowner, as well as electric demand reductions for the electric utility.

  Link: https://www.tandfonline.com/doi/full/10.1080/23744731.2019.1707618

- Oh, S., Haberl, J. Baltazar J-C. 2020. "*Analysis methods for characterizing energy savings opportunities from home automation devices using smart meter data*", Energy and Buildings, Vol. 216.

  Many utility companies have installed Smart Meters (SMs) for residential and commercial buildings in the U.S., which are the part of the Smart Grid (SG) that integrates the electricity grid with communication networks. Along with the growing interest in SMs, the development of the wireless technologies and smart phones has accelerated the applications of Home Automation Devices (HADs) that can also communicate with SMs, Home Energy Management Systems (HEMS), and smart phones. However, there are few if any previous studies that analyze the potential energy saving opportunities for homeowners from HADs using interval data recorded by SMs. Therefore, this paper presents five new pre-screening analysis methods that use interval energy consumption data to better characterize building energy use for the residential customers who want energy savings from the use of HADs before they are installed. This paper is part of a larger study that analyzed and measured energy savings from the use of HADs with smart meter data.

  Link: https://www.sciencedirect.com/science/article/pii/S037877881931535X?via%3Dihub

6.5 Solar Test Bench (STB)

This section introduces the activities that were carried out using the Solar Test Bench (STB) during the calendar year of 2019, and the activities summary is listed as follow:

- Regular maintenance
- Weekly report.

6.5.1 Solar Test Bench Setup

Figure 59 shows the exterior view of the STB. In addition, the whole STB setup comprises the sensors indicated in Table 28, which includes the sensor name, make, model and serial number along with the multiplier, offset and unit.

Figure 59. Exterior View of the Solar Test Bench

Table 28. List of the sensors updated to the end of 2019

Index Number	Sensor Name	Make	Model	Serial Number	Multiplier	Offset	Unit
					0.18	-40	° F
1	TOA/RH[1]	Vaisala	HMP45A	D2430006	0.10	NA	%
					0.18	-40	° F
2	TOA/RH[2]	Vaisala	HMP155A	G3220004	0.10	NA	%
					1.79	0.629	MPH
3	WS/WD[1]	Met One	034B	H4735	712	NA	Degree
					1.79	0.629	MPH
4	WS/WD[2]	Met One	034B	M5048	712	NA	Degree
5	LICOR[3]	Licor	Li-cor	PY15L25	75.59	NA	W/m^2
6	LICOR[4]	Licor	Li-cor	PY49745	75.03	NA	W/m^2
7	LICOR[5]	Licor	Li-cor	PY 74409	200	NA	W/m^2
8	LICOR[6]	Licor	Li-cor	PY 74438	200	NA	W/m^2
9	LICOR[7]	Licor	Li-cor	PY 74439	200	NA	W/m^2
10	LICOR[8]	Licor	Li-cor	PY 474450	200	NA	W/m^2
11	PSP[1]	Eppley	PSP	13673F3	125.63	NA	W/m^2
12	PSP[2]	Eppley	PSP	16881F3	103.09	NA	W/m^2
13	PSP[3]	Eppley	PSP	35417F3	112.74	NA	W/m^2
14	NIP[1]	Eppley	NIP	14851E6	118.06	NA	W/m^2
15	NIP[2]	Eppley	NIP	16620E6	117.79	NA	W/m^2
16	BW[1]	Eppley	8-48	20226	96.99	NA	W/m^2
17	BW[2]	Eppley	8-48	33886	98.62	NA	W/m^2

6.5.2 2019 STB Activities

6.5.2.1 Regular Maintenance

The solar test bench regular maintenance is carried out every two weeks, the desiccants for PSPs, B&Ws are replaced, and the used one are recycled. The alignment for the solar tracker and the covers for the B&Ws are checked, and the occurred problems were fixed by restarting the solar tracker and manually adjusting the devices. The sensor wiring connections are checked and fixed as needed.

6.5.2.2 Weekly Report

The data logger downloaded data have been checked every week, and the STB data was compared with NOAA data in STB weekly report. Figure 60 shows the example plots comparing the STB data with the NOAA data.

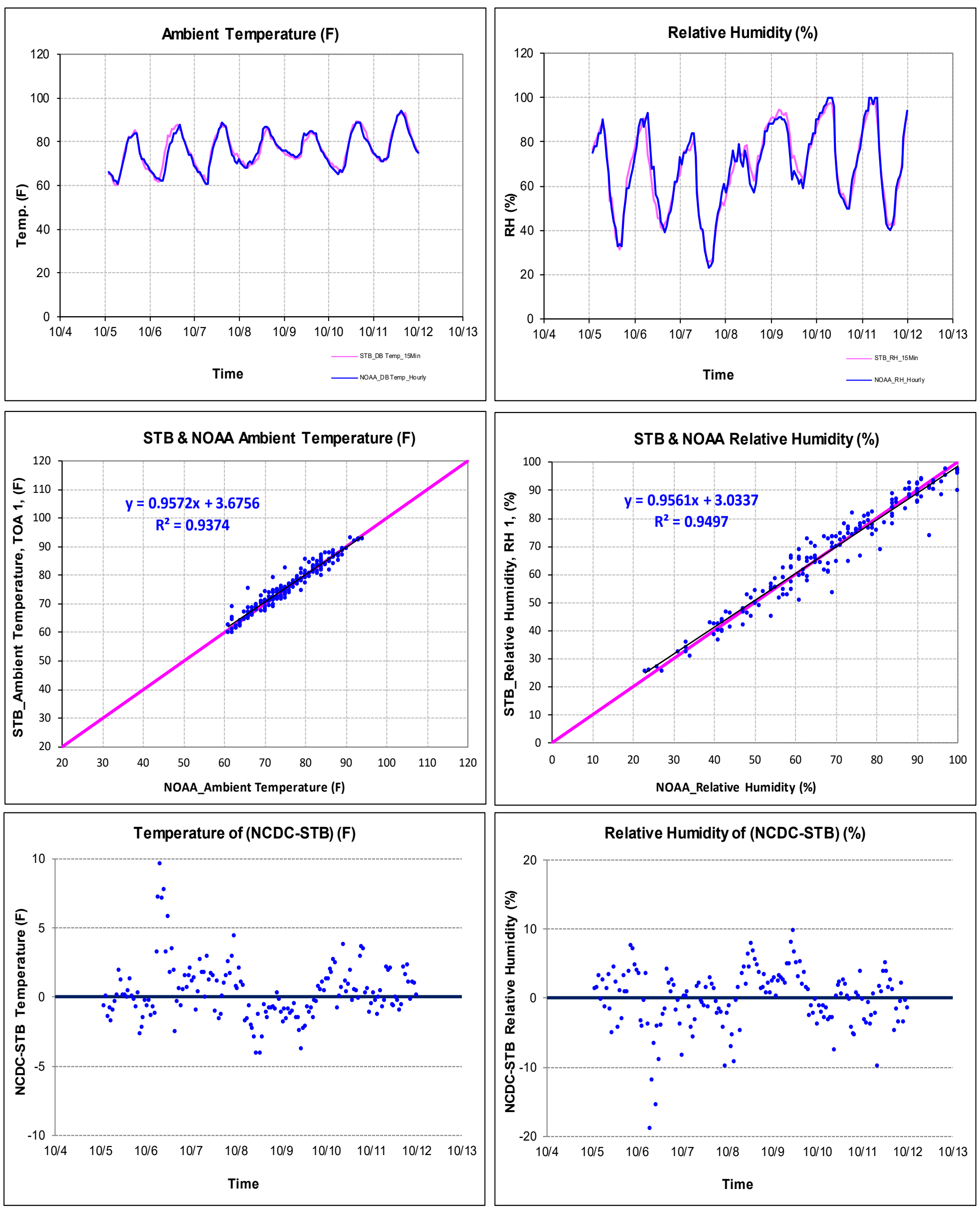


Figure 60: Comparisons of the STB Data with the NOAA Data

6.5.3 Future work Plan

- Datalogger firmware update
- New global solar radiation (the combination of direct and diffuse solar radiation) measurement instrument installation
- Remote weather station installation

6.5.4 Acknowledgements

This task could not be completed without the help of many students/staffs among another Mitra Azimi , Jounghwan Ahn, and Yu Sun from ESL, TAMU.

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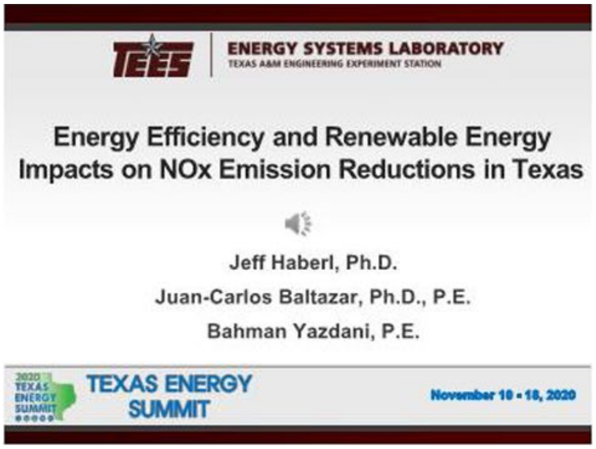
Appendix A: Presentations to Various Entities at Conferences and Workshops in 2020

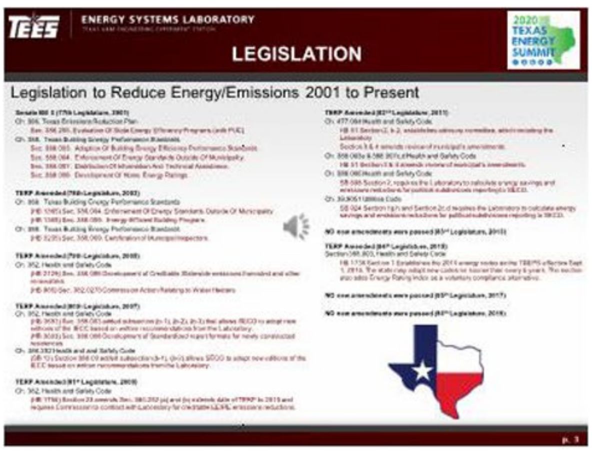
Appendix B: IC3 Parameter Reports

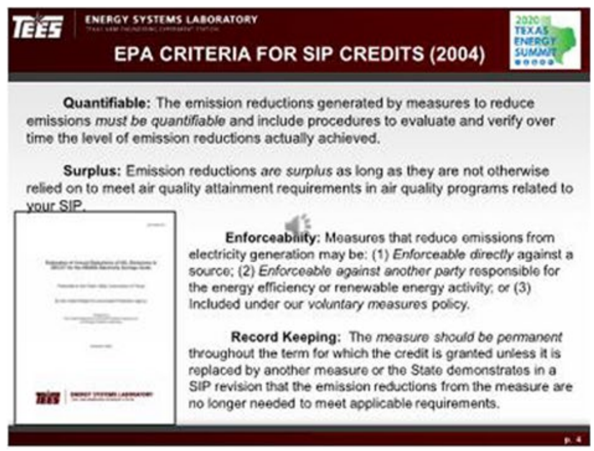
Appendix A: Presentations to Various Entities at Conferences and Workshops in 2020

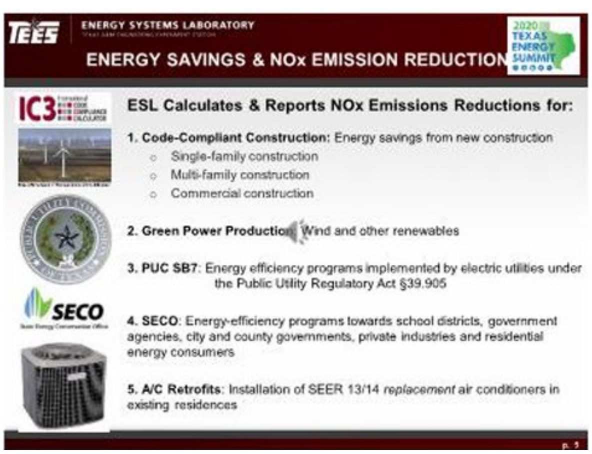
The Energy Systems Laboratory made presentations at several conferences and workshops about ways to save energy, and the appendix shows the presentation slides.

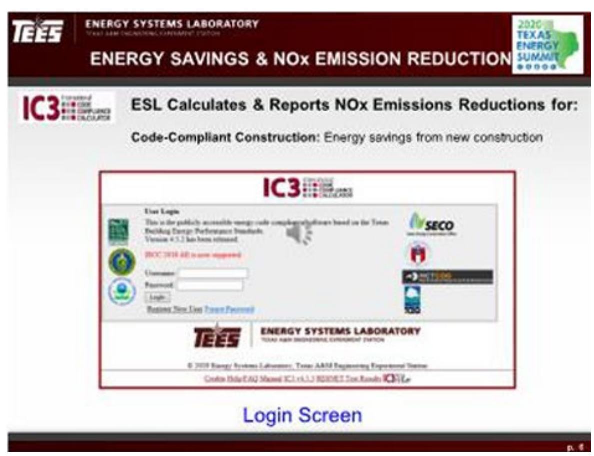
- "Energy Efficiency and Renewable Energy Impacts on NOx Emission Reductions" Texas Energy Summit conference, Online Virtual Event, Nov 2020, presented by Jeff Haberl.

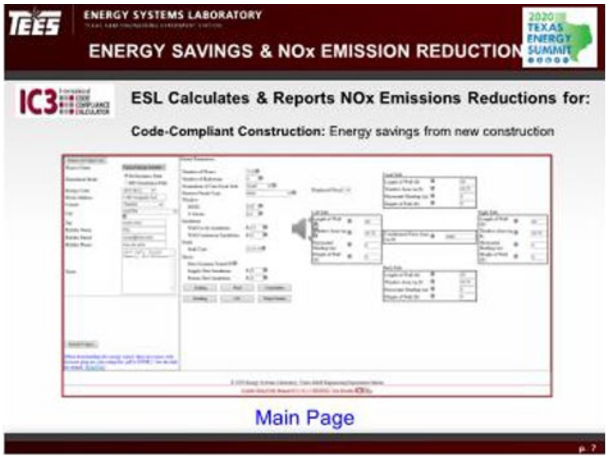


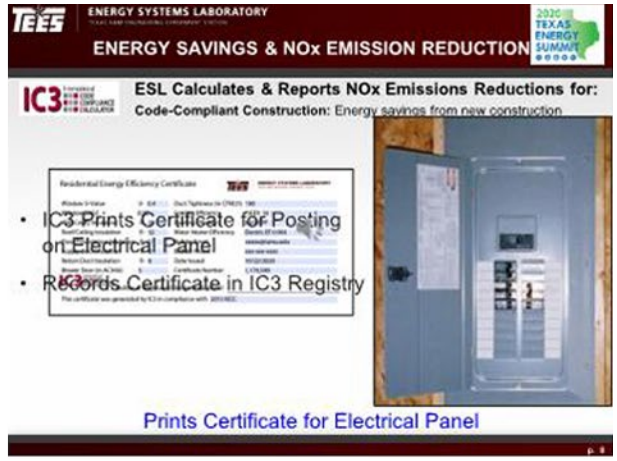




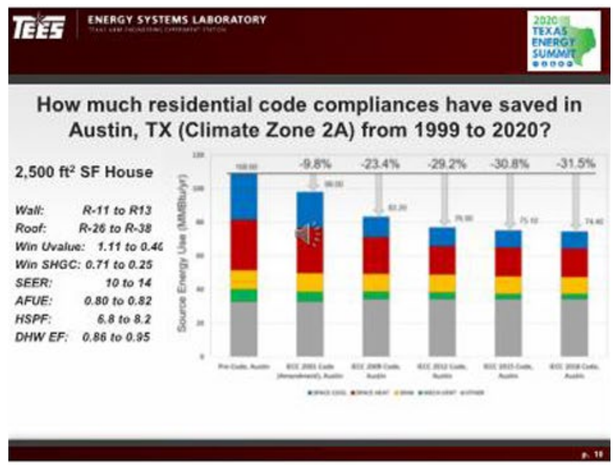


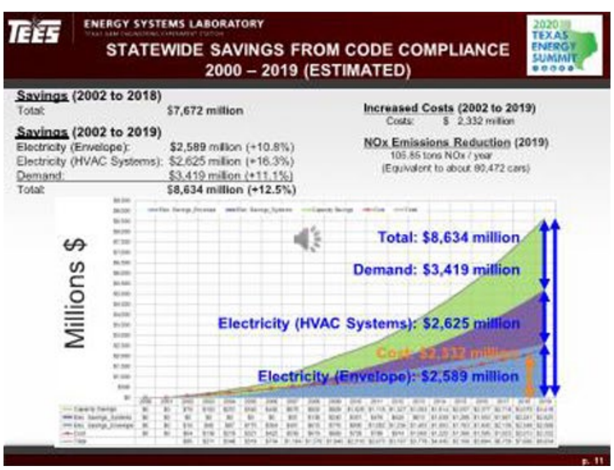


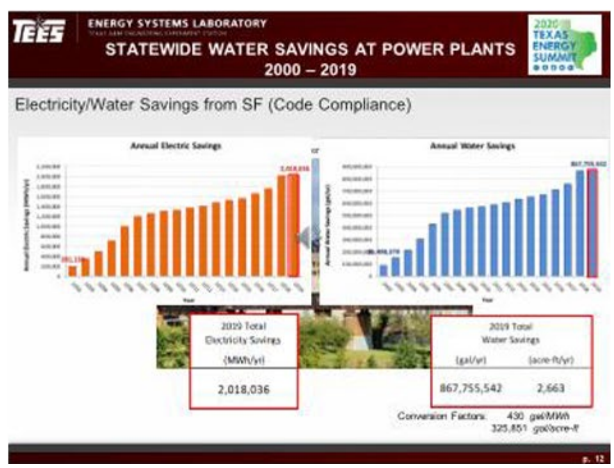

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS & NOx EMISSION REDUCTION
2020 TEXAS ENERGY SUMMIT
ESL Calculates & Reports NOx Emissions Reductions for:
Code-Compliant Construction: Energy savings from new construction
Main Page


ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS & NOx EMISSION REDUCTION
2020 TEXAS ENERGY SUMMIT
ESL Calculates & Reports NOx Emissions Reductions for:
Code-Compliant Construction: Energy savings from new construction
• IC3 Prints Certificate for Posting on Electrical Panel
• Records Certificate in IC3 Registry
Prints Certificate for Electrical Panel

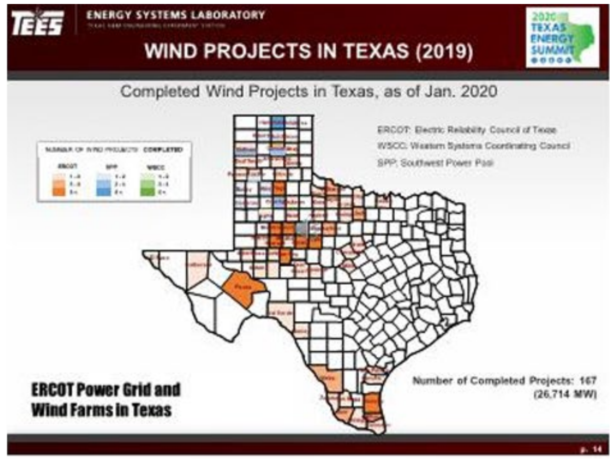

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
2020 TEXAS ENERGY SUMMIT
How much electricity has been saved from residential code compliance for all single-family housing 2000-2020?
2003
Projects/Certificates in IC3 Registry
2016
2017
2018
2019
2020

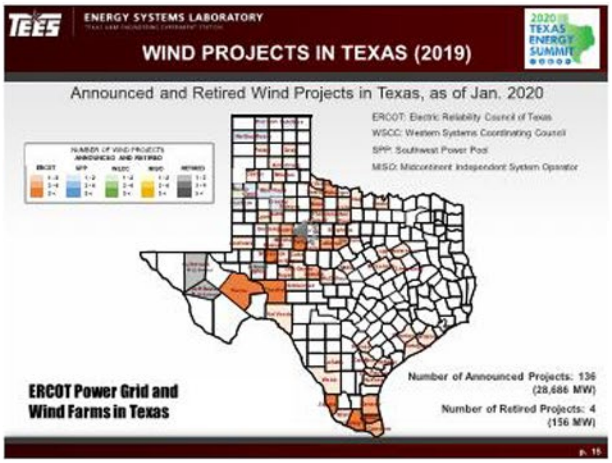

ENERGY SYSTEMS LABORATORY
2020 TEXAS ENERGY SUMMIT
How much residential code compliances have saved in Austin, TX (Climate Zone 2A) from 1999 to 2020?
2,500 ft² SF House
Wall: R-11 to R13
Roof: R-26 to R-38
Win Uvalue: 1.11 to 0.40
Win SHGC: 0.71 to 0.25
SEER: 10 to 14
AFUE: 0.80 to 0.82
HSPF: 6.8 to 8.2
DHW EF: 0.86 to 0.95
-9.8%
-23.4%
-29.2%
-30.8%
-31.5%
Source Energy Use (MMBtu/yr)

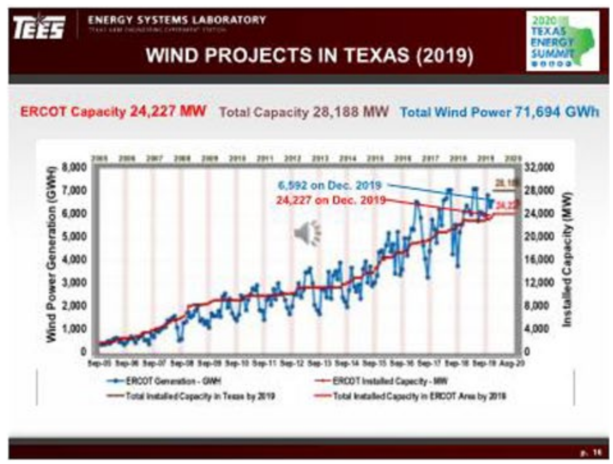

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
2000 – 2019 (ESTIMATED)
2020 TEXAS ENERGY SUMMIT
Savings (2002 to 2018)
Total: $7,672 million
Savings (2002 to 2019)
Electricity (Envelope): $2,589 million (+10.8%)
Electricity (HVAC Systems): $2,625 million (+16.3%)
Demand: $3,419 million (+11.1%)
Total: $8,634 million (+12.5%)
Increased Costs (2002 to 2019)
Costs: $ 2,332 million
NOx Emissions Reduction (2019)
105.85 tons NOx / year
(Equivalent to about 80,472 cars)
Millions $
Total: $8,634 million
Demand: $3,419 million
Electricity (HVAC Systems): $2,625 million
Cost: $2,332 million
Electricity (Envelope): $2,589 million

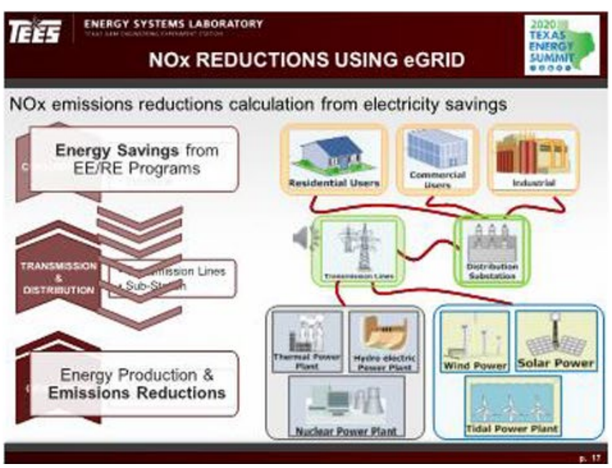

ENERGY SYSTEMS LABORATORY
STATEWIDE WATER SAVINGS AT POWER PLANTS
2000 – 2019
2020 TEXAS ENERGY SUMMIT
Electricity/Water Savings from SF (Code Compliance)
Annual Electric Savings
Annual Water Savings
2019 Total Electricity Savings (MWh/yr)
2,018,036
2019 Total Water Savings
(gal/yr) (acre-ft/yr)
867,755,542 2,663
Conversion Factors: 430 gal/MWh
325,851 gal/acre-ft

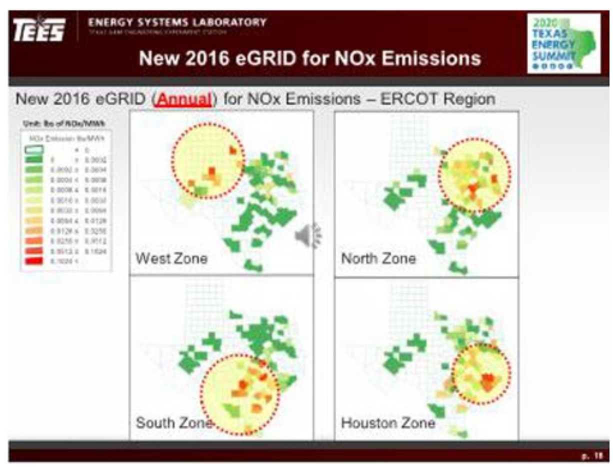

ENERGY SYSTEMS LABORATORY
SAVINGS FROM RENEWABLES
Wind Turbines, TX
Biomass
Landfill Gas
Geothermal

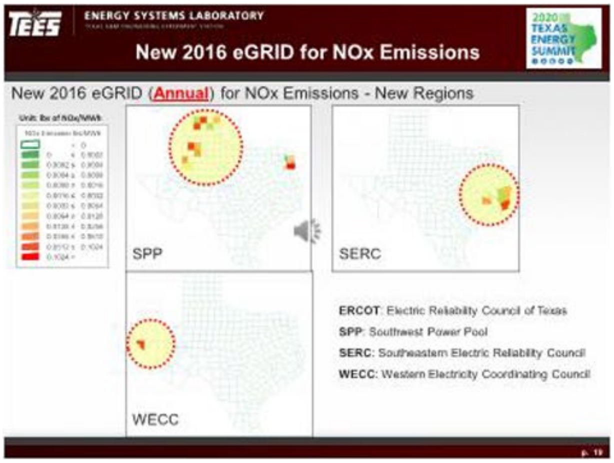

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2019)
Completed Wind Projects in Texas, as of Jan. 2020
ERCOT: Electric Reliability Council of Texas
WSCC: Western Systems Coordinating Council
SPP: Southwest Power Pool
ERCOT Power Grid and Wind Farms in Texas
Number of Completed Projects: 167 (26,714 MW)

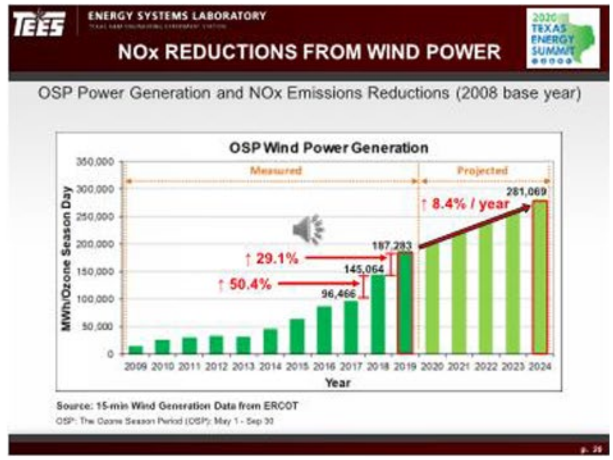

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2019)
Announced and Retired Wind Projects in Texas, as of Jan. 2020
ERCOT: Electric Reliability Council of Texas
WSCC: Western Systems Coordinating Council
SPP: Southwest Power Pool
MISO: Midcontinent Independent System Operator
ERCOT Power Grid and Wind Farms in Texas
Number of Announced Projects: 136 (28,686 MW)
Number of Retired Projects: 4 (156 MW)

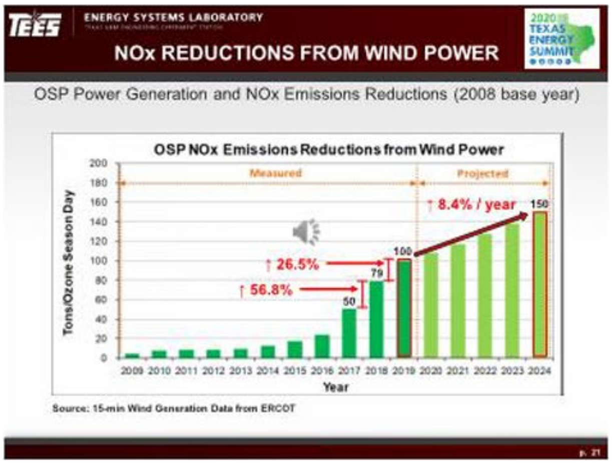

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2019)
ERCOT Capacity 24,227 MW
Total Capacity 28,188 MW
Total Wind Power 71,694 GWh
6,592 on Dec. 2019
24,227 on Dec. 2019
Wind Power Generation (GWh)
Installed Capacity (MW)
ERCOT Generation - GWH
ERCOT Installed Capacity - MW
Total Installed Capacity in Texas by 2019
Total Installed Capacity in ERCOT Area by 2019

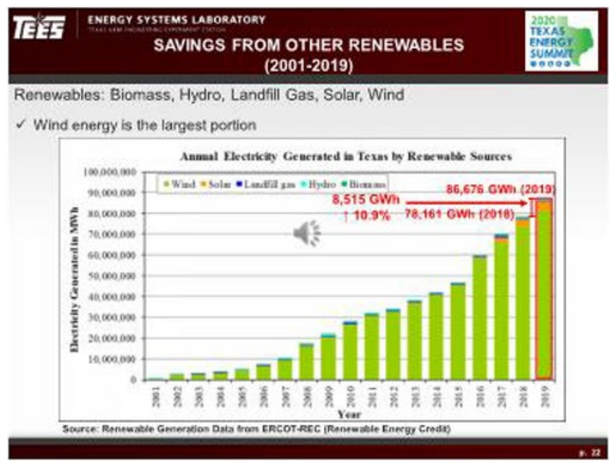

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS USING eGRID
NOx emissions reductions calculation from electricity savings
Energy Savings from EE/RE Programs
Residential Users
Commercial Users
Industrial
TRANSMISSION & DISTRIBUTION
Transmission Lines
Distribution Substation
Energy Production & Emissions Reductions
Thermal Power Plant
Hydro-electric Power Plant
Wind Power
Solar Power
Nuclear Power Plant
Tidal Power Plant

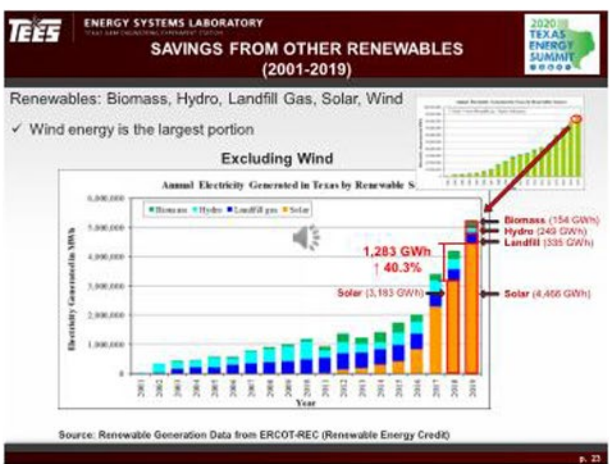

ENERGY SYSTEMS LABORATORY
New 2016 eGRID for NOx Emissions
New 2016 eGRID (Annual) for NOx Emissions – ERCOT Region
West Zone
North Zone
South Zone
Houston Zone

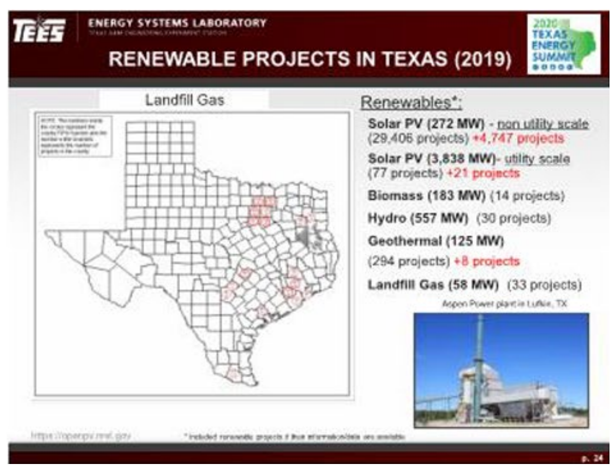

ENERGY SYSTEMS LABORATORY
New 2016 eGRID for NOx Emissions
New 2016 eGRID (Annual) for NOx Emissions - New Regions
SPP
SERC
WECC
ERCOT: Electric Reliability Council of Texas
SPP: Southwest Power Pool
SERC: Southeastern Electric Reliability Council
WECC: Western Electricity Coordinating Council

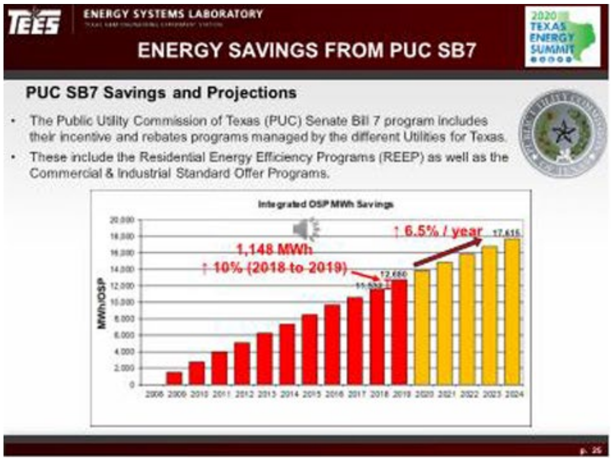

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS FROM WIND POWER
OSP Power Generation and NOx Emissions Reductions (2008 base year)
OSP Wind Power Generation
Measured
Projected
↑ 8.4% / year
281,069
187,283
↑ 29.1%
145,064
↑ 50.4%
96,466
MWh/Ozone Season Day
Year
Source: 15-min Wind Generation Data from ERCOT
OSP: The Ozone Season Period (OSP): May 1 - Sep 30

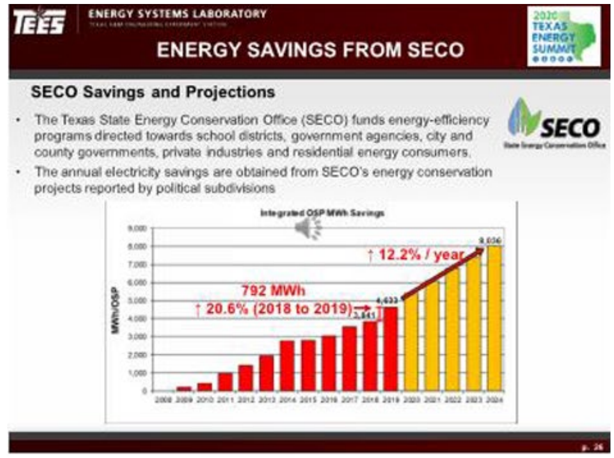

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS FROM WIND POWER
OSP Power Generation and NOx Emissions Reductions (2008 base year)
OSP NOx Emissions Reductions from Wind Power
Measured
Projected
↑ 8.4% / year
150
100
↑ 26.5%
79
↑ 56.8%
50
Tons/Ozone Season Day
Year
Source: 15-min Wind Generation Data from ERCOT

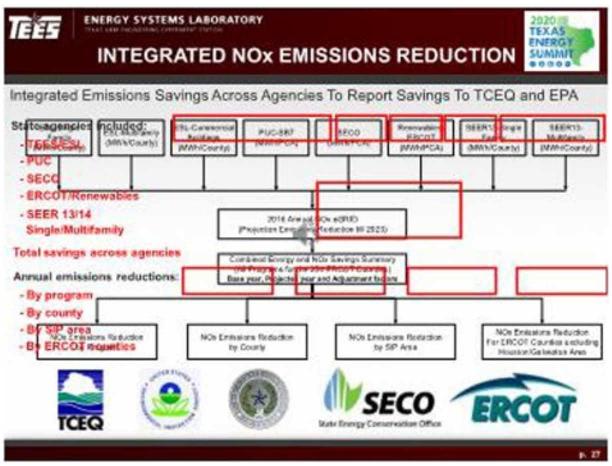

ENERGY SYSTEMS LABORATORY
SAVINGS FROM OTHER RENEWABLES (2001-2019)
Renewables: Biomass, Hydro, Landfill Gas, Solar, Wind
✓ Wind energy is the largest portion
Annual Electricity Generated in Texas by Renewable Sources
86,676 GWh (2019)
8,515 GWh
↑ 10.9%
78,161 GWh (2018)
Electricity Generated in MWh
Year
Source: Renewable Generation Data from ERCOT-REC (Renewable Energy Credit)

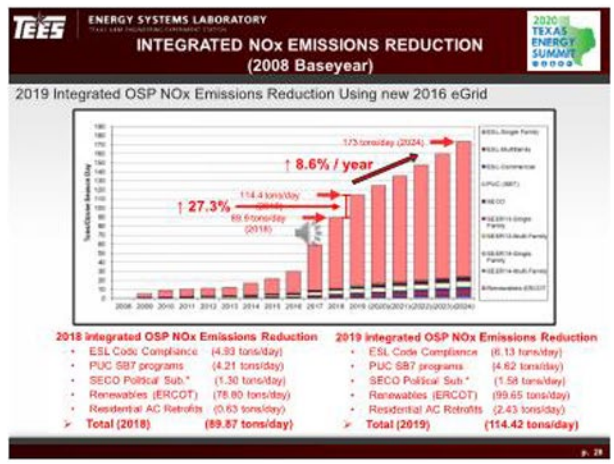

ENERGY SYSTEMS LABORATORY
SAVINGS FROM OTHER RENEWABLES (2001-2019)
Renewables: Biomass, Hydro, Landfill Gas, Solar, Wind
✓ Wind energy is the largest portion
Excluding Wind
Annual Electricity Generated in Texas by Renewable S
Biomass (154 GWh)
Hydro (249 GWh)
Landfill (335 GWh)
1,283 GWh
↑ 40.3%
Solar (3,183 GWh)
Solar (4,466 GWh)
Source: Renewable Generation Data from ERCOT-REC (Renewable Energy Credit)

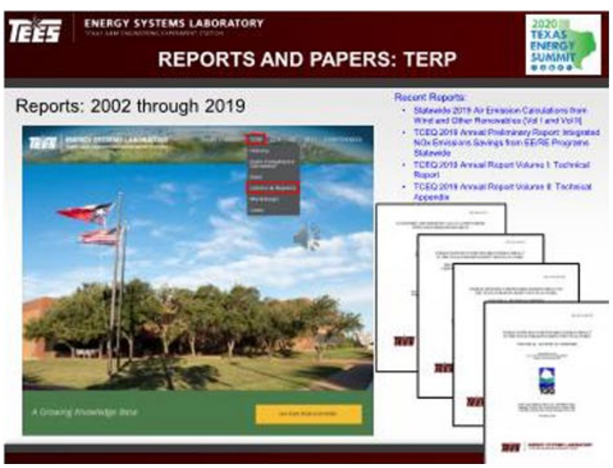

ENERGY SYSTEMS LABORATORY
RENEWABLE PROJECTS IN TEXAS (2019)
Landfill Gas
Renewables*:
Solar PV (272 MW) - non utility scale (29,406 projects) +4,747 projects
Solar PV (3,838 MW)- utility scale (77 projects) +21 projects
Biomass (183 MW) (14 projects)
Hydro (557 MW) (30 projects)
Geothermal (125 MW) (294 projects) +8 projects
Landfill Gas (58 MW) (33 projects)
Aspen Power plant in Lufkin, TX

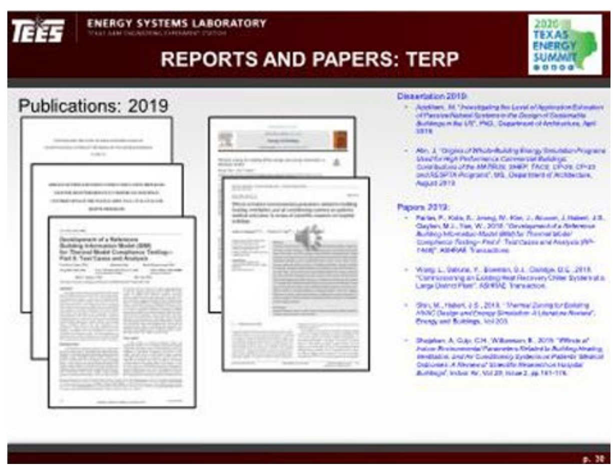

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS FROM PUC SB7
PUC SB7 Savings and Projections
The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes their incentive and rebates programs managed by the different Utilities for Texas.
These include the Residential Energy Efficiency Programs (REEP) as well as the Commercial & Industrial Standard Offer Programs.
Integrated OSP MWh Savings
1,148 MWh
↑ 10% (2018 to 2019)
↑ 6.5% / year
12,680
17,615
MWh/OSP
p. 25


ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS FROM SECO
SECO Savings and Projections
The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers.
The annual electricity savings are obtained from SECO's energy conservation projects reported by political subdivisions
SECO
Integrated OSP MWh Savings
792 MWh
↑ 20.6% (2018 to 2019)
↑ 12.2% / year
8,036
MWh/OSP
p. 26


ENERGY SYSTEMS LABORATORY
INTEGRATED NOx EMISSIONS REDUCTION
Integrated Emissions Savings Across Agencies To Report Savings To TCEQ and EPA
State agencies included:
- TCEQ/ESL
- PUC
- SECO
- ERCOT/Renewables
- SEER 13/14 Single/Multifamily
Total savings across agencies
Annual emissions reductions:
- By program
- By county
- By SIP area
- By ERCOT counties
TCEQ
SECO
ERCOT
p. 27


ENERGY SYSTEMS LABORATORY
INTEGRATED NOx EMISSIONS REDUCTION (2008 Baseyear)
2019 Integrated OSP NOx Emissions Reduction Using new 2016 eGrid
173 tons/day (2024)
↑ 8.6% / year
↑ 27.3%
114.4 tons/day (2019)
89.9 tons/day (2018)
2018 Integrated OSP NOx Emissions Reduction
ESL Code Compliance (4.93 tons/day)
PUC SB7 programs (4.21 tons/day)
SECO Political Sub.* (1.30 tons/day)
Renewables (ERCOT) (78.80 tons/day)
Residential AC Retrofits (0.63 tons/day)
Total (2018) (89.87 tons/day)
2019 Integrated OSP NOx Emissions Reduction
ESL Code Compliance (6.13 tons/day)
PUC SB7 programs (4.62 tons/day)
SECO Political Sub.* (1.58 tons/day)
Renewables (ERCOT) (99.65 tons/day)
Residential AC Retrofits (2.43 tons/day)
Total (2019) (114.42 tons/day)
p. 28


ENERGY SYSTEMS LABORATORY
REPORTS AND PAPERS: TERP
Reports: 2002 through 2019
Recent Reports:


ENERGY SYSTEMS LABORATORY
REPORTS AND PAPERS: TERP
Publications: 2019
Dissertation 2019:
Papers 2019:
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http://esl.tamu.edu/terp
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Appendix B: IC3 Parameter Reports

Tables between Table 29 and Table 58 show the yearly average parameter values by county. These tables show wall cavity insulation across Texas in 2020.

Table 29: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (All Projects)

County	Avg Wall Insulation (R-value)	House Count		County	Avg Wall Insulation	House Count
Austin	18.0	1		Hunt	13.5	127
Bastrop	14.0	2		Jefferson	16.5	2
Bell	6.5	2		Johnson	14.2	197
Bexar	13.1	143		Kaufman	13.1	314
Blanco	13.0	1		Liberty	13.0	11
Brazoria	9.8	4		Llano	17.0	2
Brazos	1.5	114		Mason	16.8	5
Burnet	11.1	7		Mclennan	13.0	2
Caldwell	13.0	3		Medina	13.0	1
Coleman	26.0	1		Montague	13.3	3
Collin	15.9	1013		Montgomery	17.9	17
Comal	13.1	84		Navarro	13.0	8
Cooke	13.0	2		Nueces	13.0	205
Dallas	14.6	1440		Palo pinto	16.3	3
Deaf smith	15.0	1		Parker	13.7	259
Denton	14.0	1083		Potter	15.0	1
Ector	21.0	1		Rains	13.0	1
Ellis	13.5	372		Randall	14.0	2
Fannin	14.7	7		Rockwall	13.5	78
Fort bend	13.0	18		San patricio	13.0	3
Frio	13.0	2		Somervell	15.0	1
Galveston	15.1	15		Tarrant	13.9	2098
Gray	19.0	1		Titus	12.8	5
Grayson	13.1	145		Travis	15.4	1792
Gregg	13.2	12		Trinity	15.0	1
Guadalupe	15.5	11		Van zandt	15.0	7
Harris	15.1	810		Waller	13.0	2
Hays	17.0	7		Williamson	13.0	4
Henderson	13.6	40		Wilson	13.0	1
Hill	13.7	6		Wise	13.7	87
Hood	14.6	115		Young	13.0	1
Hopkins	13.0	2		Zapata	15.0	7

Table 30: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (Submitted Projects)

County	Avg Wall Insulation (R-value)	House Count		County	Avg Wall Insulation	House Count
Bastrop	15.0	1		Jefferson	16.5	2
Bell	13.0	1		Johnson	14.1	186
Bexar	13.3	136		Kaufman	13.1	310
Blanco	13.0	1		Liberty	13.0	10
Brazoria	13.0	3		Llano	19.0	1
Brazos	13.0	2		Mason	16.8	5
Burnet	13.0	6		Mclennan	13.0	2
Caldwell	13.0	3		Medina	13.0	2
Collin	15.9	990		Montague	13.3	2
Comal	13.1	81		Montgomery	17.6	13
Cooke	13.0	2		Navarro	13.0	7
Dallas	14.8	1383		Nueces	13.0	205
Deaf smith	15.0	1		Palo pinto	16.3	3
Denton	14.1	1042		Parker	13.8	249
Ector	21.0	1		Potter	15.0	1
Ellis	13.6	357		Rains	13.0	1
Fannin	14.7	7		Rockwall	13.5	77
Fort bend	13.0	18		San patricio	13.0	3
Frio	13.0	2		Somervell	15.0	1
Galveston	14.8	14		Tarrant	14.1	1985
Gray	19.0	1		Titus	16.0	4
Grayson	13.3	140		Travis	15.4	1701
Gregg	13.2	11		Trinity	15.0	1
Guadalupe	15.7	10		Van zandt	15.0	7
Harris	15.3	745		Waller	13.0	2
Hays	17.0	7		Williamson	13.0	3
Henderson	14.0	39		Wilson	13.0	1
Hill	13.7	6		Wise	13.7	83
Hood	14.6	115		Young	13.0	1
Hopkins	13.0	2		Zapata	15.0	6
Hunt	13.5	123				

Table 31: Yearly Average Wall Cavity Insulation Distribution by County in 2020 (Passed Projects)

County	Avg Wall Insulation (R-value)	House Count		County	Avg Wall Insulation	House Count
Bastrop	15.0	1		Jefferson	16.5	2
Bell	13.0	1		Johnson	14.1	186
Bexar	13.3	136		Kaufman	13.1	310
Blanco	13.0	1		Liberty	13.0	10
Brazoria	13.0	3		Llano	19.0	1
Brazos	13.0	2		Mason	16.8	5
Burnet	13.0	6		Mclennan	13.0	2
Caldwell	13.0	3		Medina	13.0	2
Collin	15.9	990		Montague	13.3	2
Comal	13.1	81		Montgomery	17.6	13
Cooke	13.0	2		Navarro	13.0	7
Dallas	14.8	1382		Nueces	13.0	205
Deaf smith	15.0	1		Palo pinto	16.3	3
Denton	14.1	1042		Parker	13.8	249
Ector	21.0	1		Potter	15.0	1
Ellis	13.6	357		Rains	13.0	1
Fannin	14.7	7		Rockwall	13.5	77
Fort bend	13.0	18		San patricio	13.0	3
Frio	13.0	2		Somervell	15.0	1
Galveston	14.8	14		Tarrant	14.1	1984
Gray	19.0	1		Titus	16.0	4
Grayson	13.3	140		Travis	15.4	1701
Gregg	13.2	11		Trinity	15.0	1
Guadalupe	15.7	10		Van zandt	15.0	7
Harris	15.3	745		Waller	13.0	2
Hays	17.0	7		Williamson	13.0	3
Henderson	14.0	39		Wilson	13.0	1
Hill	13.7	6		Wise	13.7	83
Hood	14.6	115		Young	13.0	1
Hopkins	13.0	2		Zapata	15.0	6
Hunt	13.5	123				

These tables show water heater efficiencies across Texas in 2020

Table 32: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (All Projects)

County	Avg Electric Energy Factor	House Count		County	Avg Electric Energy Factor	House Count
Bastrop	0.9	2		Hunt	0.9	66
Bell	0.9	1		Jefferson	0.9	1
Bexar	0.9	37		Johnson	0.9	171
Blanco	0.9	1		Kaufman	0.9	162
Burnet	0.9	4		Liberty	0.9	1
Caldwell	0.9	3		Llano	0.9	1
Coleman	0.9	1		Mason	0.9	5
Collin	0.9	183		Mclennan	0.9	2
Comal	0.9	2		Medina	0.9	1
Cooke	0.9	2		Montgomery	0.9	1
Dallas	0.9	672		Navarro	0.9	7
Denton	0.9	521		Nueces	1.0	72
Ellis	0.9	198		Palo pinto	0.9	3
Fannin	1.0	6		Parker	0.9	175
Fort bend	0.9	1		Rockwall	0.9	11
Frio	0.9	2		San patricio	1.0	3
Galveston	0.9	10		Somervell	0.9	1
Gray	1.0	1		Tarrant	0.9	930
Grayson	0.9	98		Titus	1.0	1
Gregg	0.9	11		Travis	1.0	56
Guadalupe	1.0	9		Van zandt	0.9	6
Harris	0.9	98		Williamson	0.9	2
Hays	0.9	1		Wilson	0.9	1
Henderson	0.9	36		Wise	1.0	74
Hill	1.0	6		Young	0.9	1
Hood	0.9	99		Zapata	1.0	7
Hopkins	0.9	2				

Table 33: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

County	Avg Electric Energy Factor	House Count		County	Avg Electric Energy Factor	House Count
Bastrop	0.9	1		Hunt	0.9	65
Bell	0.9	1		Jefferson	0.9	1
Bexar	0.9	37		Johnson	0.9	162
Blanco	0.9	1		Kaufman	0.9	159
Burnet	0.9	4		Liberty	0.9	1
Caldwell	0.9	3		Llano	0.9	1
Collin	0.9	181		Mason	0.9	5
Comal	0.9	2		Mclennan	0.9	2
Cooke	0.9	2		Medina	0.9	1
Dallas	0.9	656		Montgomery	0.9	1
Denton	0.9	509		Navarro	0.9	6
Ellis	0.9	194		Nueces	1.0	72
Fannin	1.0	6		Palo pinto	0.9	3
Fort bend	0.9	1		Parker	0.9	169
Frio	0.9	2		Rockwall	0.9	11
Galveston	0.9	10		San patricio	1.0	3
Gray	1.0	1		Somervell	0.9	1
Grayson	0.9	97		Tarrant	0.9	897
Gregg	0.9	10		Titus	1.0	1
Guadalupe	1.0	9		Travis	1.0	45
Harris	0.9	96		Van zandt	0.9	6
Hays	0.9	1		Williamson	0.9	2
Henderson	0.9	36		Wilson	0.9	1
Hill	1.0	6		Wise	1.0	70
Hood	0.9	99		Young	0.9	1
Hopkins	0.9	2		Zapata	1.0	6

Table 34: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

County	Avg Electric Energy Factor	House Count		County	Avg Electric Energy Factor	House Count
Bastrop	0.9	1		Hunt	0.9	65
Bell	0.9	1		Jefferson	0.9	1
Bexar	0.9	37		Johnson	0.9	162
Blanco	0.9	1		Kaufman	0.9	159
Burnet	0.9	4		Liberty	0.9	1
Caldwell	0.9	3		Llano	0.9	1
Collin	0.9	181		Mason	0.9	5
Comal	0.9	2		Mclennan	0.9	2
Cooke	0.9	2		Medina	0.9	1
Dallas	0.9	656		Montgomery	0.9	1
Denton	0.9	509		Navarro	0.9	6
Ellis	0.9	194		Nueces	1.0	72
Fannin	1.0	6		Palo pinto	0.9	3
Fort bend	0.9	1		Parker	0.9	169
Frio	0.9	2		Rockwall	0.9	11
Galveston	0.9	10		San patricio	1.0	3
Gray	1.0	1		Somervell	0.9	1
Grayson	0.9	97		Tarrant	0.9	896
Gregg	0.9	10		Titus	1.0	1
Guadalupe	1.0	9		Travis	1.0	45
Harris	0.9	96		Van zandt	0.9	6
Hays	0.9	1		Williamson	0.9	2
Henderson	0.9	36		Wilson	0.9	1
Hill	1.0	6		Wise	1.0	70
Hood	0.9	99		Young	0.9	1
Hopkins	0.9	2		Zapata	1.0	6

Table 35: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (All Projects)

County	Avg NGas Energy Factor	House Count		County	Avg NGas Energy Factor	House Count
Bexar	0.7	70		Jefferson	0.8	1
Brazoria	0.7	3		Johnson	0.9	14
Brazos	0.7	3		Kaufman	0.8	152
Collin	0.8	367		Liberty	0.7	10
Comal	0.6	80		Medina	0.6	1
Dallas	0.8	623		Montague	0.6	3
Deaf smith	0.8	1		Montgomery	0.8	3
Denton	0.8	482		Nueces	0.7	133
Ector	0.8	1		Parker	0.8	80
Ellis	0.7	161		Potter	0.7	1
Fannin	0.9	1		Rains	0.8	1
Fort bend	0.6	17		Rockwall	0.9	65
Galveston	0.7	5		Tarrant	0.8	988
Grayson	0.7	41		Titus	0.8	1
Guadalupe	0.6	1		Travis	0.7	1500
Harris	0.8	680		Van zandt	0.9	1
Hays	0.7	3		Waller	0.9	2
Henderson	0.9	3		Williamson	0.6	1
Hood	0.8	13		Wise	0.7	11
Hunt	0.9	59				

Table 36: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

County	Avg NGas Energy Factor	House Count		County	Avg NGas Energy Factor	House Count
Bexar	0.7	67		Jefferson	0.8	1
Brazoria	0.7	3		Johnson	0.9	13
Brazos	0.7	2		Kaufman	0.8	151
Collin	0.8	356		Liberty	0.7	9
Comal	0.6	78		Medina	0.6	1
Dallas	0.8	609		Montague	0.6	2
Deaf smith	0.8	1		Montgomery	0.8	3
Denton	0.8	462		Nueces	0.7	133
Ector	0.8	1		Parker	0.8	78
Ellis	0.7	152		Potter	0.7	1
Fannin	0.9	1		Rains	0.8	1
Fort bend	0.6	17		Rockwall	0.9	64
Galveston	0.7	4		Tarrant	0.8	957
Grayson	0.7	39		Titus	0.8	1
Guadalupe	0.6	1		Travis	0.7	1459
Harris	0.8	632		Van zandt	0.9	1
Hays	0.7	3		Waller	0.9	2
Henderson	0.9	3		Williamson	0.6	1
Hood	0.8	13		Wise	0.7	11
Hunt	0.9	57				

Table 37: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

County	Avg NGas Energy Factor	House Count		County	Avg NGas Energy Factor	House Count
Bexar	0.7	67		Jefferson	0.8	1
Brazoria	0.7	3		Johnson	0.9	13
Brazos	0.7	2		Kaufman	0.8	151
Collin	0.8	356		Liberty	0.7	9
Comal	0.6	78		Medina	0.6	1
Dallas	0.8	608		Montague	0.6	2
Deaf smith	0.8	1		Montgomery	0.8	3
Denton	0.8	462		Nueces	0.7	133
Ector	0.8	1		Parker	0.8	78
Ellis	0.7	152		Potter	0.7	1
Fannin	0.9	1		Rains	0.8	1
Fort bend	0.6	17		Rockwall	0.9	64
Galveston	0.7	4		Tarrant	0.8	957
Grayson	0.7	39		Titus	0.8	1
Guadalupe	0.6	1		Travis	0.7	1459
Harris	0.8	632		Van zandt	0.9	1
Hays	0.7	3		Waller	0.9	2
Henderson	0.9	3		Williamson	0.6	1
Hood	0.8	13		Wise	0.7	11
Hunt	0.9	57				

Table 38: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (All Projects)

County	Avg Heat Pump WH Energy Factor	House Count
Brazos	0.9	1
Comal	2.2	1
Dallas	2.1	4
Denton	2.0	1
Ellis	2.0	1
Hays	2.3	1
Johnson	2.1	3
Tarrant	2.2	20
Travis	2.3	27

Table 39: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (Submitted Projects)

County	Avg Heat Pump WH Energy Factor	House Count
Comal	2.2	1.0
Dallas	2.1	4.0
Denton	2.0	1.0
Ellis	2.0	1.0
Hays	2.3	1.0
Johnson	2.1	3.0
Tarrant	2.2	20.0
Travis	2.3	27.0

Table 40: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2020 (Passed Projects)

County	Avg Heat Pump WH Energy Factor	House Count
Comal	2.2	1.0
Dallas	2.1	4.0
Denton	2.0	1.0
Ellis	2.0	1.0
Hays	2.3	1.0
Johnson	2.1	3.0
Tarrant	2.2	20.0
Travis	2.3	27.0

These tables show the average A/C SEER across Texas in 2020.

Table 41: Average A/C SEER across Counties in 2020 (All Projects)

County	Avg A/C SEER	House Count		County	Avg A/C SEER	House Count
Bastrop	14.5	2		Jefferson	14.0	2
Bell	14.0	1		Johnson	15.1	196
Bexar	15.3	140		Kaufman	14.9	314
Blanco	14.0	1		Liberty	15.5	11
Brazoria	16.0	3		Llano	15.0	2
Brazos	15.6	5		Mason	15.8	5
Burnet	16.1	6		Mclennan	14.0	2
Caldwell	14.0	3		Medina	14.5	2
Collin	15.3	1010		Montague	16.0	3
Comal	15.6	83		Montgomery	15.8	17
Cooke	14.0	2		Navarro	14.9	8
Dallas	15.1	1418		Nueces	16.0	205
Deaf smith	14.0	1		Palo pinto	15.3	3
Denton	15.0	1074		Parker	15.4	257
Ector	20.0	1		Potter	16.0	1
Ellis	14.7	370		Rains	16.0	1
Fannin	14.0	7		Rockwall	15.4	78
Fort bend	15.9	18		San patricio	16.0	3
Frio	14.0	2		Somervell	17.0	1
Galveston	16.0	15		Tarrant	15.1	2054
Gray	14.0	1		Titus	15.0	4
Grayson	15.1	143		Travis	16.1	1779
Gregg	14.3	12		Trinity	15.0	1
Guadalupe	15.3	10		Van zandt	15.4	7
Harris	15.2	798		Waller	14.0	2
Hays	16.1	7		Williamson	15.9	4.0
Henderson	15.1	39		Wilson	14.0	1.0
Hill	15.3	6		Wise	15.0	87.0
Hood	14.6	115		Young	17.0	1.0
Hopkins	14.0	2		Zapata	16.0	7.0
Hunt	14.5	126				

Table 42: Average A/C SEER across Counties in 2020 (Submitted Projects)

County	Avg A/C SEER	House Count		County	Avg A/C SEER	House Count
Bastrop	15.0	1		Jefferson	14.0	2
Bell	14.0	1		Johnson	15.1	185
Bexar	15.3	136		Kaufman	14.9	310
Blanco	14.0	1		Liberty	15.5	10
Brazoria	16.0	3		Llano	14.0	1
Brazos	14.0	2		Mason	15.8	5
Burnet	16.1	6		Mclennan	14.0	2
Caldwell	14.0	3		Medina	14.5	2
Collin	15.4	990		Montague	16.0	2
Comal	15.6	81		Montgomery	15.7	13
Cooke	14.0	2		Navarro	14.7	7
Dallas	15.1	1383		Nueces	16.0	205
Deaf smith	14.0	1		Palo pinto	15.3	3
Denton	15.0	1041		Parker	15.4	249
Ector	20.0	1		Potter	16.0	1
Ellis	14.7	357		Rains	16.0	1
Fannin	14.0	7		Rockwall	15.4	77
Fort bend	15.9	18		San patricio	16.0	3
Frio	14.0	2		Somervell	17.0	1
Galveston	16.0	14		Tarrant	15.1	1985
Gray	14.0	1		Titus	15.0	4
Grayson	15.1	140		Travis	16.1	1701
Gregg	14.4	11		Trinity	15.0	1
Guadalupe	15.3	10		Van zandt	15.4	7
Harris	15.2	745		Waller	14.0	2
Hays	16.1	7		Williamson	16.3	3.0
Henderson	15.1	39		Wilson	14.0	1.0
Hill	15.3	6		Wise	15.0	83.0
Hood	14.6	115		Young	17.0	1.0
Hopkins	14.0	2		Zapata	16.0	6.0
Hunt	14.5	123				

Table 43: Average A/C SEER across Counties in 2020 (Passed Projects)

County	Avg A/C SEER	House Count		County	Avg A/C SEER	House Count
Bastrop	15.0	1		Jefferson	14.0	2
Bell	14.0	1		Johnson	15.1	185
Bexar	15.3	136		Kaufman	14.9	310
Blanco	14.0	1		Liberty	15.5	10
Brazoria	16.0	3		Llano	14.0	1
Brazos	14.0	2		Mason	15.8	5
Burnet	16.1	6		Mclennan	14.0	2
Caldwell	14.0	3		Medina	14.5	2
Collin	15.4	990		Montague	16.0	2
Comal	15.6	81		Montgomery	15.7	13
Cooke	14.0	2		Navarro	14.7	7
Dallas	15.1	1382		Nueces	16.0	205
Deaf smith	14.0	1		Palo pinto	15.3	3
Denton	15.0	1041		Parker	15.4	249
Ector	20.0	1		Potter	16.0	1
Ellis	14.7	357		Rains	16.0	1
Fannin	14.0	7		Rockwall	15.4	77
Fort bend	15.9	18		San patricio	16.0	3
Frio	14.0	2		Somervell	17.0	1
Galveston	16.0	14		Tarrant	15.1	1984
Gray	14.0	1		Titus	15.0	4
Grayson	15.1	140		Travis	16.1	1701
Gregg	14.4	11		Trinity	15.0	1
Guadalupe	15.3	10		Van zandt	15.4	7
Harris	15.2	745		Waller	14.0	2
Hays	16.1	7		Williamson	16.3	3.0
Henderson	15.1	39		Wilson	14.0	1.0
Hill	15.3	6		Wise	15.0	83.0
Hood	14.6	115		Young	17.0	1.0
Hopkins	14.0	2		Zapata	16.0	6.0
Hunt	14.5	123				

These tables show the average ceiling insulation across Texas in 2020.

Table 44: Average Ceiling Insulation across Counties in 2020 (All Projects)

County	Avg Ceiling Insulation	House Count		County	Avg Ceiling Insulation	House Count
Bastrop	23.0	2		Jefferson	38.0	2
Bell	38.0	1		Johnson	33.6	196
Bexar	31.0	140		Kaufman	34.3	314
Blanco	20.0	1		Liberty	38.0	11
Brazoria	35.3	3		Llano	40.0	2
Brazos	30.8	4		Mason	24.8	5
Burnet	29.5	6		Mclennan	38.0	2
Caldwell	36.0	3		Medina	34.0	2
Coleman	38.0	1		Montague	34.3	3
Collin	35.5	1010		Montgomery	29.9	17
Comal	37.1	83		Navarro	38.4	8
Cooke	38.0	2		Nueces	23.9	205
Dallas	36.2	1417		Palo pinto	32.3	3
Deaf smith	38.0	1		Parker	33.7	258
Denton	33.7	1074		Potter	30.0	1
Ector	38.0	1		Rains	38.0	1
Ellis	35.0	370		Randall	49.0	1
Fannin	38.0	7		Rockwall	35.4	78
Fort bend	38.0	18		San patricio	22.0	3
Frio	38.0	2		Somervell	52.0	1
Galveston	34.8	15		Tarrant	34.7	2063
Gray	38.0	1		Titus	36.8	4
Grayson	36.8	143		Travis	36.7	1780
Gregg	38.0	12		Trinity	38.0	1
Guadalupe	28.7	11		Van zandt	34.7	7
Harris	34.1	799		Waller	33.0	2
Hays	31.6	7		Williamson	29.0	4
Henderson	36.3	39		Wilson	38.0	1
Hill	33.3	6		Wise	36.7	87
Hood	30.7	115		Young	19.0	1
Hopkins	38.0	2		Zapata	36.9	7
Hunt	38.0	126				

Table 45: Average Ceiling Insulation across Counties in 2020 (Submitted Projects)

County	Avg Ceiling Insulation	House Count		County	Avg Ceiling Insulation	House Count
Bastrop	26.0	1		Jefferson	38.0	2
Bell	38.0	1		Johnson	33.5	185
Bexar	30.9	136		Kaufman	34.3	310
Blanco	20.0	1		Liberty	38.0	10
Brazoria	35.3	3		Llano	42.0	1
Brazos	27.5	2		Mason	24.8	5
Burnet	29.5	6		Mclennan	38.0	2
Caldwell	36.0	3		Medina	34.0	2
Collin	35.5	990		Montague	34.5	2
Comal	37.1	81		Montgomery	29.8	13
Cooke	38.0	2		Navarro	38.4	7
Dallas	36.3	1383		Nueces	23.9	205
Deaf smith	38.0	1		Palo pinto	32.3	3
Denton	33.7	1042		Parker	33.6	249
Ector	38.0	1		Potter	30.0	1
Ellis	35.0	357		Rains	38.0	1
Fannin	38.0	7		Rockwall	35.4	77
Fort bend	38.0	18		San patricio	22.0	3
Frio	38.0	2		Somervell	52.0	1
Galveston	35.1	14		Tarrant	34.8	1985
Gray	38.0	1		Titus	36.8	4
Grayson	36.9	140		Travis	36.8	1701
Gregg	38.0	11		Trinity	38.0	1
Guadalupe	28.6	10		Van zandt	34.7	7
Harris	34.3	745		Waller	33.0	2
Hays	31.6	7		Williamson	26.0	3
Henderson	36.3	39		Wilson	38.0	1
Hill	33.3	6		Wise	36.6	83
Hood	30.7	115		Young	19.0	1
Hopkins	38.0	2		Zapata	38.0	6
Hunt	38.0	123				

Table 46: Average Ceiling Insulation across Counties in 2020 (Passed Projects)

County	Avg Ceiling Insulation	House Count		County	Avg Ceiling Insulation	House Count
Bastrop	26.0	1		Jefferson	38.0	2
Bell	38.0	1		Johnson	33.5	185
Bexar	30.9	136		Kaufman	34.3	310
Blanco	20.0	1		Liberty	38.0	10
Brazoria	35.3	3		Llano	42.0	1
Brazos	27.5	2		Mason	24.8	5
Burnet	29.5	6		Mclennan	38.0	2
Caldwell	36.0	3		Medina	34.0	2
Collin	35.5	990		Montague	34.5	2
Comal	37.1	81		Montgomery	29.8	13
Cooke	38.0	2		Navarro	38.4	7
Dallas	36.3	1382		Nueces	23.9	205
Deaf smith	38.0	1		Palo pinto	32.3	3
Denton	33.7	1042		Parker	33.6	249
Ector	38.0	1		Potter	30.0	1
Ellis	35.0	357		Rains	38.0	1
Fannin	38.0	7		Rockwall	35.4	77
Fort bend	38.0	18		San patricio	22.0	3
Frio	38.0	2		Somervell	52.0	1
Galveston	35.1	14		Tarrant	34.8	1984
Gray	38.0	1		Titus	36.8	4
Grayson	36.9	140		Travis	36.8	1701
Gregg	38.0	11		Trinity	38.0	1
Guadalupe	28.6	10		Van zandt	34.7	7
Harris	34.3	745		Waller	33.0	2
Hays	31.6	7		Williamson	26.0	3
Henderson	36.3	39		Wilson	38.0	1
Hill	33.3	6		Wise	36.6	83
Hood	30.7	115		Young	19.0	1
Hopkins	38.0	2		Zapata	38.0	6
Hunt	38.0	123				

These table show the average heating efficiency across Texas in 2020

Table 47: Average NGas Heating Efficiency across Counties in 2020 (All Projects)

County	Avg NGas Efficiency	House Count		County	Avg NGas Efficiency	House Count
Bexar	0.8	99		Hopkins	0.9	2
Brazoria	0.9	3		Hunt	0.8	95
Brazos	0.8	3		Jefferson	0.8	1
Burnet	1.0	1		Johnson	0.9	53
Collin	0.8	837		Kaufman	0.8	167
Comal	0.8	79		Liberty	0.8	10
Cooke	0.8	1		Mclennan	0.9	1
Dallas	0.9	975		Medina	0.8	1
Deaf smith	0.8	1		Montague	0.8	3
Denton	0.8	557		Montgomery	0.9	16
Ector	0.8	1		Navarro	0.9	4
Ellis	0.8	206		Parker	0.8	146
Fannin	0.8	2		Potter	0.9	1
Fort bend	0.8	18		Rains	0.8	1
Galveston	0.9	5		Rockwall	0.8	69
Grayson	0.8	45		Tarrant	0.8	1046
Gregg	0.9	9		Titus	0.9	3
Guadalupe	0.8	1		Travis	0.8	1631
Harris	0.8	702		Trinity	0.8	1
Hays	0.8	3		Van zandt	0.9	3
Henderson	0.9	8		Waller	0.8	2
Hill	0.9	3		Williamson	0.8	1
Hood	0.9	11		Wise	0.8	12

Table 48: Average NGas Heating Efficiency across Counties in 2020 (Submitted Projects)

County	Avg NGas Efficiency	House Count		County	Avg NGas Efficiency	House Count
Bexar	0.8	97		Hopkins	0.9	2
Brazoria	0.9	3		Hunt	0.8	93
Brazos	0.8	2		Jefferson	0.8	1
Burnet	1.0	1		Johnson	0.9	51
Collin	0.8	819		Kaufman	0.8	165
Comal	0.8	77		Liberty	0.8	9
Cooke	0.8	1		Mclennan	0.9	1
Dallas	0.9	950		Medina	0.8	1
Deaf smith	0.8	1		Montague	0.8	2
Denton	0.8	537		Montgomery	0.9	12
Ector	0.8	1		Navarro	0.9	4
Ellis	0.8	195		Parker	0.8	143
Fannin	0.8	2		Potter	0.9	1
Fort bend	0.8	18		Rains	0.8	1
Galveston	0.9	4		Rockwall	0.8	68
Grayson	0.8	44		Tarrant	0.8	1013
Gregg	0.9	8		Titus	0.9	3
Guadalupe	0.8	1		Travis	0.8	1566
Harris	0.8	654		Trinity	0.8	1
Hays	0.8	3		Van zandt	0.9	3
Henderson	0.9	8		Waller	0.8	2
Hill	0.9	3		Williamson	0.8	1
Hood	0.9	11		Wise	0.8	11

Table 49: Average NGas Heating Efficiency across Counties in 2020 (Passed Projects)

County	Avg NGas Efficiency	House Count		County	Avg NGas Efficiency	House Count
Bexar	0.8	97		Hopkins	0.9	2
Brazoria	0.9	3		Hunt	0.8	93
Brazos	0.8	2		Jefferson	0.8	1
Burnet	1.0	1		Johnson	0.9	51
Collin	0.8	819		Kaufman	0.8	165
Comal	0.8	77		Liberty	0.8	9
Cooke	0.8	1		Mclennan	0.9	1
Dallas	0.9	949		Medina	0.8	1
Deaf smith	0.8	1		Montague	0.8	2
Denton	0.8	537		Montgomery	0.9	12
Ector	0.8	1		Navarro	0.9	4
Ellis	0.8	195		Parker	0.8	143
Fannin	0.8	2		Potter	0.9	1
Fort bend	0.8	18		Rains	0.8	1
Galveston	0.9	4		Rockwall	0.8	68
Grayson	0.8	44		Tarrant	0.8	1013
Gregg	0.9	8		Titus	0.9	3
Guadalupe	0.8	1		Travis	0.8	1566
Harris	0.8	654		Trinity	0.8	1
Hays	0.8	3		Van zandt	0.9	3
Henderson	0.9	8		Waller	0.8	2
Hill	0.9	3		Williamson	0.8	1
Hood	0.9	11		Wise	0.8	11

Table 50: Average Heat Pump Heating Efficiency across Counties in 2020 (All Projects)

County	Avg Heat Pump	House Count
Bastrop	8.5	1
Bell	9.0	1
Bexar	9.3	41
Blanco	10.0	1
Burnet	9.2	5
Caldwell	8.5	3
Coleman	8.2	1
Collin	8.7	173
Comal	8.5	4
Cooke	8.5	1
Dallas	8.8	440
Denton	8.6	516
Ellis	8.7	164
Fannin	8.7	5
Frio	8.6	2
Galveston	8.5	8
Gray	8.2	1
Grayson	8.2	98
Gregg	9.3	3
Guadalupe	9.6	9
Harris	8.9	87
Hays	9.9	4
Henderson	8.6	31
Hill	8.2	3
Hood	9.3	104

County	Avg Heat Pump	House Count
Hunt	9.5	31
Johnson	9.2	142
Kaufman	8.6	147
Liberty	8.2	1
Llano	8.2	1
Mason	9.4	5
Mclennan	8.2	1
Medina	9.0	1
Montgomery	8.5	1
Navarro	8.3	4
Nueces	8.7	205
Palo pinto	11.0	3
Parker	8.6	110
Rockwall	9.0	9
San patricio	8.7	3
Somervell	9.6	1
Tarrant	8.9	1002
Titus	10.0	1
Travis	10.4	145
Van zandt	8.5	4
Williamson	10.0	2
Wilson	9.0	1
Wise	8.4	75
Young	8.8	1
Zapata	8.5	7

Table 51: Average Heat Pump Heating Efficiency across Counties in 2020 (Submitted Projects)

County	Avg Heat Pump	House Count	County	Avg Heat Pump	House Count
Bastrop	8.5	1.0	Johnson	9.2	134.0
Bell	9.0	1.0	Kaufman	8.6	145.0
Bexar	9.3	39.0	Liberty	8.2	1.0
Blanco	10.0	1.0	Llano	8.2	1.0
Burnet	9.2	5.0	Mason	9.4	5.0
Caldwell	8.5	3.0	Mclennan	8.2	1.0
Collin	8.7	171.0	Medina	9.0	1.0
Comal	8.5	4.0	Montgomery	8.5	1.0
Cooke	8.5	1.0	Navarro	8.3	3.0
Dallas	8.8	431.0	Nueces	8.7	205.0
Denton	8.6	504.0	Palo pinto	11.0	3.0
Ellis	8.7	162.0	Parker	8.6	105.0
Fannin	8.7	5.0	Rockwall	9.0	9.0
Frio	8.6	2.0	San patricio	8.7	3.0
Galveston	8.5	8.0	Somervell	9.6	1.0
Gray	8.2	1.0	Tarrant	8.9	971.0
Grayson	8.2	96.0	Titus	10.0	1.0
Gregg	9.3	3.0	Travis	10.3	135.0
Guadalupe	9.6	9.0	Van zandt	8.5	4.0
Harris	8.8	84.0	Williamson	10.0	2.0
Hays	9.9	4.0	Wilson	9.0	1.0
Henderson	8.6	31.0	Wise	8.4	72.0
Hill	8.2	3.0	Young	8.8	1.0
Hood	9.3	104.0	Zapata	8.5	6.0
Hunt	9.5	30.0			

Table 52: Average Heat Pump Heating Efficiency across Counties in 2020 (Passed Projects)

County	Avg Heat Pump	House Count	County	Avg Heat Pump	House Count
Bastrop	8.5	1.0	Johnson	9.2	134.0
Bell	9.0	1.0	Kaufman	8.6	145.0
Bexar	9.3	39.0	Liberty	8.2	1.0
Blanco	10.0	1.0	Llano	8.2	1.0
Burnet	9.2	5.0	Mason	9.4	5.0
Caldwell	8.5	3.0	Mclennan	8.2	1.0
Collin	8.7	171.0	Medina	9.0	1.0
Comal	8.5	4.0	Montgomery	8.5	1.0
Cooke	8.5	1.0	Navarro	8.3	3.0
Dallas	8.8	431.0	Nueces	8.7	205.0
Denton	8.6	504.0	Palo pinto	11.0	3.0
Ellis	8.7	162.0	Parker	8.6	105.0
Fannin	8.7	5.0	Rockwall	9.0	9.0
Frio	8.6	2.0	San patricio	8.7	3.0
Galveston	8.5	8.0	Somervell	9.6	1.0
Gray	8.2	1.0	Tarrant	8.9	970.0
Grayson	8.2	96.0	Titus	10.0	1.0
Gregg	9.3	3.0	Travis	10.3	135.0
Guadalupe	9.6	9.0	Van zandt	8.5	4.0
Harris	8.8	84.0	Williamson	10.0	2.0
Hays	9.9	4.0	Wilson	9.0	1.0
Henderson	8.6	31.0	Wise	8.4	72.0
Hill	8.2	3.0	Young	8.8	1.0
Hood	9.3	104.0	Zapata	8.5	6.0
Hunt	9.5	30.0			

These tables show the average SHGC across Texas in 2020

Table 53: Average SHGC across Counties in 2020 (All Projects)

County	Avg SHGC	House Count		County	Avg SHGC	House Count
Austin	0.3	1		Hunt	0.2	127
Bastrop	0.3	1		Jefferson	0.2	2
Bell	0.3	1		Johnson	0.2	197
Bexar	0.2	139		Kaufman	0.2	314
Blanco	0.3	1		Liberty	0.2	11
Brazoria	0.2	3		Llano	0.3	2
Brazos	0.3	7		Mason	0.2	5
Burnet	0.3	6		Mclennan	0.2	2
Caldwell	0.3	3		Medina	0.2	2
Coleman	0.3	1		Montague	0.2	3
Collin	0.2	1011		Montgomery	0.2	17
Comal	0.2	83		Navarro	0.2	7
Cooke	0.3	2		Nueces	0.3	205
Dallas	0.2	1419		Palo pinto	0.3	3
Deaf smith	0.3	1		Parker	0.2	258
Denton	0.2	1076		Potter	0.3	1
Ector	0.2	1		Rains	0.2	1
Ellis	0.2	371		Randall	0.2	1
Fannin	0.2	7		Rockwall	0.2	78
Fort bend	0.2	18		San patricio	0.3	3
Frio	0.2	2		Somervell	0.2	1
Galveston	0.2	15		Tarrant	0.2	2058
Gray	0.3	1		Titus	0.2	4
Grayson	0.2	144		Travis	0.2	1783
Gregg	0.2	12		Trinity	0.2	1
Guadalupe	0.2	10		Van zandt	0.2	7
Harris	0.3	800		Waller	0.3	2
Hays	0.2	7		Williamson	0.3	4
Henderson	0.2	39		Wilson	0.2	1
Hill	0.3	6		Wise	0.2	87
Hood	0.3	115		Young	0.3	1
Hopkins	0.2	2		Zapata	0.2	7

Table 54: Average SHGC across Counties in 2020 (Submitted Projects)

County	Avg SHGC	House Count		County	Avg SHGC	House Count
Bastrop	0.3	1		Jefferson	0.2	2
Bell	0.3	1		Johnson	0.2	186
Bexar	0.2	135		Kaufman	0.2	310
Blanco	0.3	1		Liberty	0.2	10
Brazoria	0.2	3		Llano	0.2	1
Brazos	0.3	2		Mason	0.2	5
Burnet	0.3	6		Mclennan	0.2	2
Caldwell	0.3	3		Medina	0.2	2
Collin	0.2	990		Montague	0.2	2
Comal	0.2	81		Montgomery	0.2	13
Cooke	0.3	2		Navarro	0.2	7
Dallas	0.2	1382		Nueces	0.3	205
Deaf smith	0.3	1		Palo pinto	0.3	3
Denton	0.2	1042		Parker	0.2	249
Ector	0.2	1		Potter	0.3	1
Ellis	0.2	357		Rains	0.2	1
Fannin	0.2	7		Rockwall	0.2	77
Fort bend	0.2	18		San patricio	0.3	3
Frio	0.2	2		Somervell	0.2	1
Galveston	0.2	14		Tarrant	0.2	1985
Gray	0.3	1		Titus	0.2	4
Grayson	0.2	140		Travis	0.2	1701
Gregg	0.2	11		Trinity	0.2	1
Guadalupe	0.2	10		Van zandt	0.2	7
Harris	0.3	744		Waller	0.3	2
Hays	0.2	7		Williamson	0.3	3
Henderson	0.2	39		Wilson	0.2	1
Hill	0.3	6		Wise	0.2	83
Hood	0.3	115		Young	0.3	1
Hopkins	0.2	2		Zapata	0.2	6
Hunt	0.2	123				

Table 55: Average SHGC across Counties in 2020 (Passed Projects)

County	Avg SHGC	House Count		County	Avg SHGC	House Count
Bastrop	0.3	1		Jefferson	0.2	2
Bell	0.3	1		Johnson	0.2	186
Bexar	0.2	135		Kaufman	0.2	310
Blanco	0.3	1		Liberty	0.2	10
Brazoria	0.2	3		Llano	0.2	1
Brazos	0.3	2		Mason	0.2	5
Burnet	0.3	6		Mclennan	0.2	2
Caldwell	0.3	3		Medina	0.2	2
Collin	0.2	990		Montague	0.2	2
Comal	0.2	81		Montgomery	0.2	13
Cooke	0.3	2		Navarro	0.2	7
Dallas	0.2	1381		Nueces	0.3	205
Deaf smith	0.3	1		Palo pinto	0.3	3
Denton	0.2	1042		Parker	0.2	249
Ector	0.2	1		Potter	0.3	1
Ellis	0.2	357		Rains	0.2	1
Fannin	0.2	7		Rockwall	0.2	77
Fort bend	0.2	18		San patricio	0.3	3
Frio	0.2	2		Somervell	0.2	1
Galveston	0.2	14		Tarrant	0.2	1984
Gray	0.3	1		Titus	0.2	4
Grayson	0.2	140		Travis	0.2	1701
Gregg	0.2	11		Trinity	0.2	1
Guadalupe	0.2	10		Van zandt	0.2	7
Harris	0.3	744		Waller	0.3	2
Hays	0.2	7		Williamson	0.3	3
Henderson	0.2	39		Wilson	0.2	1
Hill	0.3	6		Wise	0.2	83
Hood	0.3	115		Young	0.3	1
Hopkins	0.2	2		Zapata	0.2	6
Hunt	0.2	123				

These tables show the average window U-Factor across Texas in 2020

Table 56: Average Window U-Factor across Counties in 2020 (All Projects)

County	Avg U-Factor	House Count		County	Avg U-Factor	House Count
Austin	0.5	1		Hunt	0.3	127
Bastrop	0.9	2		Jefferson	0.3	2
Bell	0.3	1		Johnson	0.3	197
Bexar	0.4	140		Kaufman	0.3	314
Blanco	0.3	1		Liberty	0.3	11
Brazoria	0.3	3		Llano	0.3	2
Brazos	0.3	6		Mason	0.3	5
Burnet	0.2	6		Mclennan	0.3	2
Caldwell	0.4	3		Medina	0.3	2
Coleman	0.3	1		Montague	0.3	3
Collin	0.3	1011		Montgomery	0.3	17
Comal	0.3	83		Navarro	0.3	7
Cooke	0.3	2		Nueces	0.3	205
Dallas	0.3	1420		Palo pinto	0.3	3
Deaf smith	0.3	1		Parker	0.3	258
Denton	0.3	1076		Potter	0.3	1
Ector	0.3	1		Rains	0.3	1
Ellis	0.3	371		Randall	0.3	1
Fannin	0.3	7		Rockwall	0.3	78
Fort bend	0.3	18		San patricio	0.3	3
Frio	0.3	2		Somervell	0.3	1
Galveston	0.3	15		Tarrant	0.3	2059
Gray	0.3	1		Titus	0.3	4
Grayson	0.3	143		Travis	0.3	1783
Gregg	0.3	12		Trinity	0.3	1
Guadalupe	0.3	10		Van zandt	0.3	7
Harris	0.3	801		Waller	0.3	2
Hays	0.3	7		Williamson	0.3	4
Henderson	0.3	39		Wilson	0.3	1
Hill	0.3	6		Wise	0.3	87
Hood	0.3	115		Young	0.3	1
Hopkins	0.3	2		Zapata	0.3	7

Table 57: Average Window U-Factor across Counties in 2020 (Submitted Projects)

County	Avg U-Factor	House Count		County	Avg U-Factor	House Count
Bastrop	0.3	1		Jefferson	0.3	2
Bell	0.3	1		Johnson	0.3	186
Bexar	0.4	136		Kaufman	0.3	310
Blanco	0.3	1		Liberty	0.3	10
Brazoria	0.3	3		Llano	0.3	1
Brazos	0.3	2		Mason	0.3	5
Burnet	0.2	6		Mclennan	0.3	2
Caldwell	0.4	3		Medina	0.3	2
Collin	0.3	990		Montague	0.3	2
Comal	0.3	81		Montgomery	0.3	13
Cooke	0.3	2		Navarro	0.3	7
Dallas	0.3	1383		Nueces	0.3	205
Deaf smith	0.3	1		Palo pinto	0.3	3
Denton	0.3	1042		Parker	0.3	249
Ector	0.3	1		Potter	0.3	1
Ellis	0.3	357		Rains	0.3	1
Fannin	0.3	7		Rockwall	0.3	77
Fort bend	0.3	18		San patricio	0.3	3
Frio	0.3	2		Somervell	0.3	1
Galveston	0.3	14		Tarrant	0.3	1985
Gray	0.3	1		Titus	0.3	4
Grayson	0.3	140		Travis	0.3	1701
Gregg	0.3	11		Trinity	0.3	1
Guadalupe	0.3	10		Van zandt	0.3	7
Harris	0.3	745		Waller	0.3	2
Hays	0.3	7		Williamson	0.3	3
Henderson	0.3	39		Wilson	0.3	1
Hill	0.3	6		Wise	0.3	83
Hood	0.3	115		Young	0.3	1
Hopkins	0.3	2		Zapata	0.3	6
Hunt	0.3	123				

Table 58: Average Window U-Factor across Counties in 2020 (Passed Projects)

County	Avg U-Factor	House Count		County	Avg U-Factor	House Count
Bastrop	0.3	1		Jefferson	0.3	2
Bell	0.3	1		Johnson	0.3	186
Bexar	0.4	136		Kaufman	0.3	310
Blanco	0.3	1		Liberty	0.3	10
Brazoria	0.3	3		Llano	0.3	1
Brazos	0.3	2		Mason	0.3	5
Burnet	0.2	6		Mclennan	0.3	2
Caldwell	0.4	3		Medina	0.3	2
Collin	0.3	990		Montague	0.3	2
Comal	0.3	81		Montgomery	0.3	13
Cooke	0.3	2		Navarro	0.3	7
Dallas	0.3	1382		Nueces	0.3	205
Deaf smith	0.3	1		Palo pinto	0.3	3
Denton	0.3	1042		Parker	0.3	249
Ector	0.3	1		Potter	0.3	1
Ellis	0.3	357		Rains	0.3	1
Fannin	0.3	7		Rockwall	0.3	77
Fort bend	0.3	18		San patricio	0.3	3
Frio	0.3	2		Somervell	0.3	1
Galveston	0.3	14		Tarrant	0.3	1984
Gray	0.3	1		Titus	0.3	4
Grayson	0.3	140		Travis	0.3	1701
Gregg	0.3	11		Trinity	0.3	1
Guadalupe	0.3	10		Van zandt	0.3	7
Harris	0.3	745		Waller	0.3	2
Hays	0.3	7		Williamson	0.3	3
Henderson	0.3	39		Wilson	0.3	1
Hill	0.3	6		Wise	0.3	83
Hood	0.3	115		Young	0.3	1
Hopkins	0.3	2		Zapata	0.3	6
Hunt	0.3	123				