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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 2021-December 2021

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ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

TEXAS A&M ENGINEERING EXPERIMENT STATION

Energy Systems Laboratory

October 21, 2022

Mr. David Serrins
Mobile Source Programs Team Leader
Air Quality Division
Texas Commission on Environmental Quality
Austin, TX 78711-3087

Dear Mr. Serrins:

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

Enclosure

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 2026 for the electricity and natural gas savings from the various EE/RE programs.

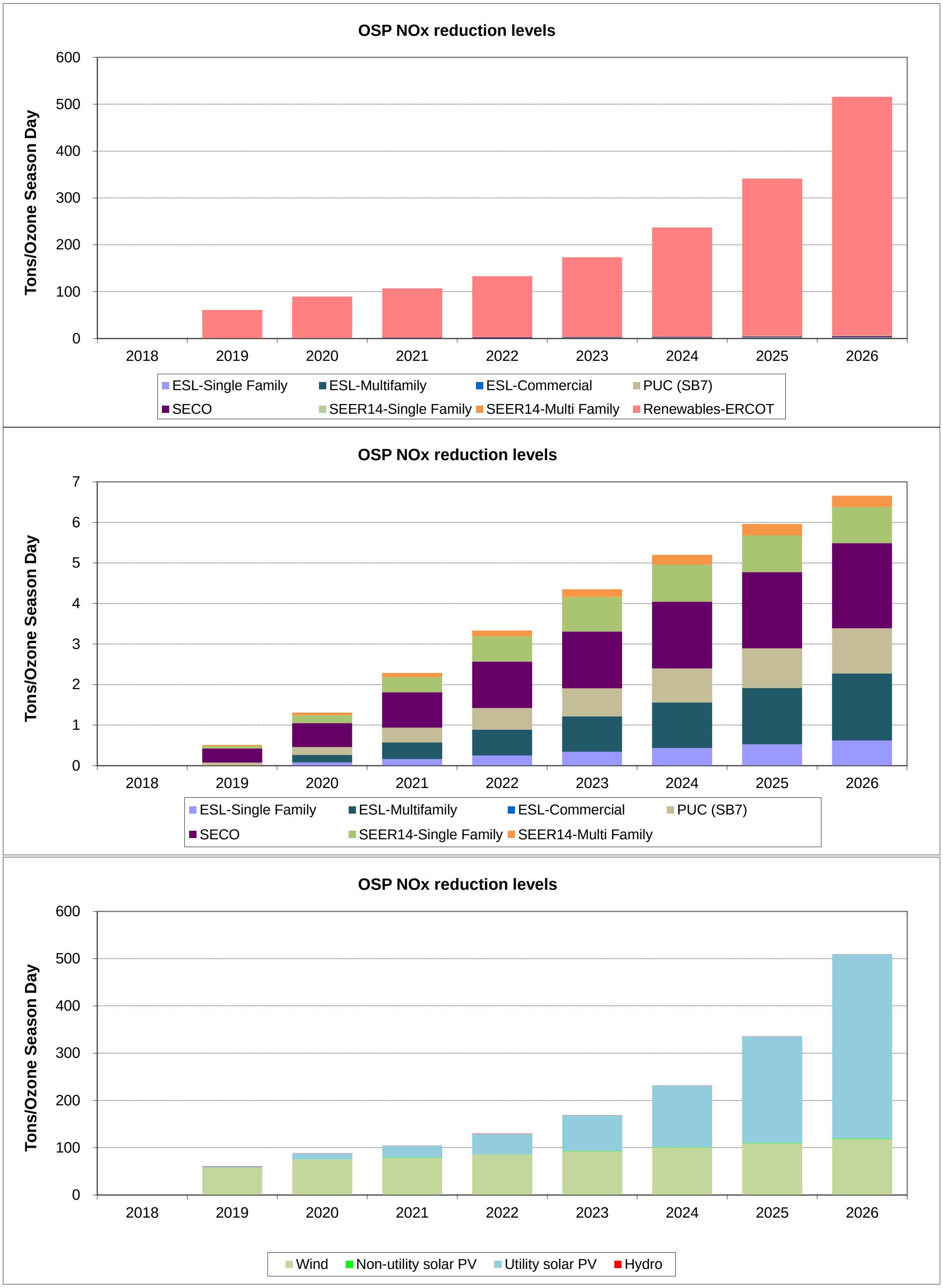


Figure 1: Integrated OSP NOx Emissions Reduction Projections through 2026. (Upper plot) all programs, (middle plot) all programs except Renewables, (lower plot) Renewables.

In 2021 (Table 1), the total integrated annual savings from all programs are 39,483,996 MWh/year[1]. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 538,354 MWh/year (1.4% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 376,958 MWh/year (1.0%),
- Savings from SECO's Senate Bill 5 program are 828,391 MWh/year (2.1%),
- Electricity savings from renewable power generation are 37,278,263 MWh/year (94.4%), and
- Savings from residential air conditioner retrofits2 are 462,030 MWh/year (1.2%).

In 2021, the total integrated OSP savings from all programs are 187,558 MWh/day, which would be 7,815 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 1,475 MWh/day (0.8%),
- Savings from the PUC's Senate Bill 7 programs are 1,033 MWh/day (0.6%),
- Savings from SECO's Senate Bill 5 program are 2,268 MWh/day (1.2%),
- Electricity savings from renewable power generation are 181,516 MWh/day (96.8%), and
- Savings from residential air conditioner retrofits are 1,266 MWh/day (0.7%).

By 2026, the total integrated annual savings from all programs will be 228,293,006 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 2,151,776 MWh/year (0.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 1,155,231 MWh/year (0.5%),
- Savings from SECO's Senate Bill 5 program will be 1,950,433 MWh/year (0.9%),
- Electricity savings from renewable power generation will be 221,888,583 MWh/year (97.2%), and
- Savings from residential air conditioner retrofits will be 1,146,983 MWh/year (0.5%).

By 2026, the total integrated OSP savings from all programs will be 887,442 MWh/day, which would be 36,977 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 5,895 MWh/day (0.7%),
- Savings from the PUC's Senate Bill 7 programs will be 3,165 MWh/day (0.4%),
- Savings from SECO's Senate Bill 5 program will be 5,342 MWh/day (0.6%),
- Electricity savings from renewable power generation will be 869,897 MWh/day (98.0%), and
- Savings from residential air conditioner retrofits will be 3,142 MWh/day (0.4%).

In 2021 (Table 2), the total integrated annual NOx emissions reductions from all programs are 23,275 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 225 tons-NOx/year (1.0% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 141 tons-NOx/year (0.6%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 341 tons-NOx/year (1.5%),
- NOx emissions reductions from renewable power generation are 22,385 tons-NOx/year (96.2%), and
- NOx emissions reductions from residential air conditioner retrofits are 183 tons-NOx/year (0.8%).

In 2021, the total integrated OSP NOx emissions reductions from all programs are 106.93tons-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 0.57 tons-NOx/day (0.5%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 0.37 tons-NOx/day (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.87 tons-NOx/day (0.8%),

[1] The savings reported for 2021 utilize the 2018 base year as required by the U.S.E.P.A.
[2] This assumes air conditioners in existing homes are replaced with the more efficient 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 renewable power generation are 104.65 tons-NOx/day (97.9%), and
- NOx emissions reductions from residential air conditioner retrofits are 0.47 tons-NOx/day (0.4%).

By 2026, the total integrated annual NOx emissions reductions from all programs will be 139,621 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 892 tons-NOx/year (0.6% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 430 tons-NOx/year (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 819 tons-NOx/year (0.6%),
- NOx emissions reductions from renewable power generation will be 137,026 tons-NOx/year (98.1%), and
- NOx emissions reductions from residential air conditioner retrofits will be 455 tons-NOx/year (0.3%).

By 2026, the total integrated OSP NOx emissions reductions from all programs will be 515.87 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 2.27 tons-NOx/day (0.4%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1.11 tons-NOx/day (0.2%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 2.1 tons-NOx/day (0.4%),
- NOx emissions reductions from renewable power generation will be 509.21 tons-NOx/day (98.7%), and
- NOx emissions reductions from residential air conditioner retrofits will be 1.17 tons-NOx/day (0.2%).

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**	**2026**
ESL-Single Family	0	0	74,850	158,185	243,332	330,396	419,488	510,722	604,216
ESL-Multifamily	0	0	175,080	380,168	593,879	816,815	1,049,617	1,292,959	1,547,560
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	83,347	195,887	376,958	548,976	712,392	867,638	1,015,122	1,155,231
SECO	0	359,121	567,339	828,391	1,076,390	1,311,989	1,535,808	1,748,437	1,950,433
Renewables-ERCOT	0	4,091,723	22,537,959	37,278,263	48,106,652	65,434,397	93,882,613	141,434,510	221,888,583
SEER14-Single Family	0	60,071	181,188	356,259	599,673	820,221	883,003	875,735	863,529
SEER14-Multi Family	0	33,152	74,374	105,771	139,362	186,930	243,587	287,869	283,454
Total Annual (MWh)	**0**	**4,627,414**	**23,806,679**	**39,483,996**	**51,308,263**	**69,613,140**	**98,881,754**	**147,165,354**	**228,293,006**

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)								
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
ESL-Single Family	0	0	205	433	667	905	1,149	1,399	1,655
ESL-Multifamily	0	0	480	1,042	1,627	2,238	2,876	3,542	4,240
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	228	537	1,033	1,504	1,952	2,377	2,781	3,165
SECO	0	984	1,553	2,268	2,947	3,593	4,206	4,789	5,342
Renewables-ERCOT	0	114,596	150,844	181,516	224,490	291,205	398,333	574,655	869,897
SEER14-Single Family	0	165	496	976	1,643	2,247	2,419	2,399	2,366
SEER14-Multi Family	0	91	204	290	382	512	667	789	777
Total OSP (MWh)	**0**	**116,063**	**154,318**	**187,558**	**233,260**	**302,653**	**412,028**	**590,354**	**887,442**

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**	**2026**
ESL-Single Family	0	0	31	66	101	137	174	212	249
ESL-Multifamily	0	0	73	159	248	341	438	540	643
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	25	74	141	205	265	323	378	430
SECO	0	121	230	341	447	547	642	733	819
Renewables-ERCOT	0	1,800	13,849	22,385	29,062	39,788	57,446	87,019	137,026
SEER14-Single Family	0	20	74	143	241	329	354	352	347
SEER14-Multi Family	0	10	27	40	55	72	93	109	108
Total Annual (Tons NOx)	**0**	**1,975**	**14,358**	**23,275**	**30,358**	**41,480**	**59,471**	**89,343**	**139,621**

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)								
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
ESL-Single Family	0.00	0.00	0.08	0.16	0.25	0.34	0.43	0.53	0.62
ESL-Multifamily	0.00	0.00	0.19	0.41	0.64	0.88	1.13	1.39	1.65
ESL-Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUC (SB7)	0.00	0.07	0.19	0.37	0.53	0.69	0.84	0.98	1.11
SECO	0.00	0.35	0.59	0.87	1.14	1.40	1.65	1.88	2.10
Renewables-ERCOT	0.00	60.45	88.21	104.65	129.77	168.87	231.77	335.44	509.21
SEER14-Single Family	0.00	0.06	0.19	0.37	0.62	0.85	0.91	0.91	0.89
SEER14-Multi Family	0.00	0.03	0.07	0.10	0.14	0.19	0.24	0.29	0.28
Total OSP (Tons NOx)	**0.00**	**60.96**	**89.52**	**106.93**	**133.10**	**173.21**	**236.97**	**341.41**	**515.87**

d. Technology Transfer

In 2021, The Laboratory, hosted the 2021 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 2021 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: David Serrins, TCEQ, Dan Mantena, ERCOT, Therese Harris, PUCT, Eddy Trevino and Fred Yebra, SECO. Numerous additional individuals at the Energy Systems Laboratory contributed significantly to this report, including: Mitra Azimi, Yu Sun, and Jounghwan Ahn.

Table of Contents

List of Figures

List of Tables

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), made 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.

The 87th Legislature (2021) amended Sec. 388.003 (i), (j) and (k) through H.B. 3215. The amendment focused on:

- Tying the energy rating index (ERI) voluntary compliance path with Standard 301 of the American National Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index, commonly cited as ANSI/RESNET/ICC 301, as it existed on January 1, 2021. A building using this standard will be considered in compliance provided that:
  (1) the building meets the mandatory requirements of Section R406.2 of the 2018 International Energy Conservation Code; and
  (2) the building thermal envelope is equal to or greater than the levels of efficiency and solar heat gain coefficient in Table R402.1.2 or Table R402.1.4 of the 2018 International Energy Conservation Code.
- Updates to the energy rating index (ERI) values: ERI values for 2016 were deleted; ERI values for 2022 remained unchanged; new values for 2025 and 2028 were added for each climate zone. In each year jump (from 2022 to 2025 and from 2025 to 2028) the ERI values decrease by 2.

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; $443,310.85 in FY 2019; and $421,131.25 in FY 2020 (with additional 5% Legislature cut in ESL funding). In FY 2021 the Laboratory expended $415,847.31. 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 adopted editions of the IECC.

1.4 Accomplishments since January 2021

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;
- 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 2021, 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:
  Resilience and Health in an Age of Extreme Weather; Emissions reductions benefits from energy efficiency and renewable energy; Conversation between Matt Tejada, EPA Office of Environmental Justice, and Amal Ahmed, Texas Observer; Discussion between Commissioner Allison Clements, Federal Energy Regulatory Commission (FERC), and Russell Gold, Texas Monthly Editor and author of Superpower; Discussion between Commissioner Glotfelty, Public Utility Commission of Texas, and Russell Gold, Texas Monthly; Discussion between Amy Myers Jaffe, author of Energy's Digital Future and Doug Lewin, Texas Energy Summit Director; Panel Discussion: Focusing on the Demand Side: Energy Efficiency and Distributed Energy for Emissions Reductions and Resilience.
- 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 2021.

- Haberl, J.; Yazdani, B.; Baltazar, J., 2021 "Energy Efficiency and Renewable Energy Impacts on NOx Emission Reductions in Texas" *Texas Energy Summit*, Online Virtual Event, November 2021

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 2021, the following savings were calculated (2018 base year)[3]:

- In 2021, the annual electricity savings from code-compliant residential and commercial construction are 538,354 MWh/year (1.4% of the total electricity savings),
- Savings from residential air conditioner retrofits[4] are 462,030 MWh/year (1.2%).

- In 2021, the OSP electricity savings from code-compliant residential and commercial construction are 1,475 MWh/day (0.8%),
- Savings from residential air conditioner retrofits are 1,266 MWh/day (0.7%).

- By 2026, the annual electricity savings from code-compliant residential and commercial construction will be 2,151,776 MWh/year (0.9% of the total electricity savings),
- Savings from residential air conditioner retrofits will be 1,146,983 MWh/year (0.5%).

- By 2026, the OSP electricity savings from code-compliant residential and commercial construction will be 5,895 MWh/day (0.7%),

[3] The savings reported for 2021 utilize the 2018 base year as required by the U.S.E.P.A.
[4] This assumes air conditioners in existing homes are replaced with the more efficient SEER 14 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

- Savings from residential air conditioner retrofits will be 3,142 MWh/day (0.4%).

- In 2021, the annual NOx emissions reduction from code-compliant residential and commercial construction are 225 tons-NOx/year (1.0% of the total NOx savings),
- NOx emissions reductions from residential air conditioner retrofits are 183 tons-NOx/year (0.8%).

- In 2021, the OSP NOx emissions reduction from code-compliant residential and commercial construction are 0.57 tons-NOx/day (0.5%),
- NOx emissions reductions from residential air conditioner retrofits are 0.47 tons-NOx/day (0.4%).

- By 2026, the NOx emissions reduction from code-compliant residential and commercial construction will be 892 tons-NOx/year (0.6% of the total NOx savings),
- NOx emissions reductions from residential air conditioner retrofits will be 455 tons-NOx/year (0.3%).

- By 2026, the OSP NOx emissions reduction from code-compliant residential and commercial Construction will be 2.27 tons-NOx/day (0.4%),
- NOx emissions reductions from residential air conditioner retrofits will be 1.17 tons-NOx/day (0.2%).

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, renewables, and residential air conditioner retrofits;
- 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 2021 (Table 24), the total integrated annual savings from all programs are 39,483,996 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 538,354 MWh/year (1.4% of the total electricity savings),
- Savings from the PUC’s Senate Bill 7 program are 376,958 MWh/year (1.0%),
- Savings from SECO’s Senate Bill 5 program are 828,391 MWh/year (2.1%),
- Electricity savings from renewable power generation are 37,278,263 MWh/year (94.4%), and
- Savings from residential air conditioner retrofits[5] are 462,030 MWh/year (1.2%).

In 2021, the total integrated Ozone Season Period (OSP) savings from all programs are 187,558 MWh/day, which would be 7,815 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 1,475 MWh/day (0.8%),
- Savings from the PUC’s Senate Bill 7 programs are 1,033 MWh/day (0.6%),
- Savings from SECO’s Senate Bill 5 program are 2,268 MWh/day (1.2%),
- Electricity savings from renewable power generation are 181,516 MWh/day (96.8%), and
- Savings from residential air conditioner retrofits are 1,266 MWh/day (0.7%).

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

By 2026, the total integrated annual savings from all programs will be 228,293,006 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 2,151,776 MWh/year (0.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 1,155,231 MWh/year (0.5%),
- Savings from SECO's Senate Bill 5 program will be 1,950,433 MWh/year (0.9%),
- Electricity savings from renewable power generation will be 221,888,583 MWh/year (97.2%), and
- Savings from residential air conditioner retrofits will be 1,146,983 MWh/year (0.5%).

By 2026, the total integrated OSP savings from all programs will be 887,442 MWh/day, which would be 36,977 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 5,895 MWh/day (0.7%),
- Savings from the PUC's Senate Bill 7 programs will be 3,165 MWh/day (0.4%),
- Savings from SECO's Senate Bill 5 program will be 5,342 MWh/day (0.6%),
- Electricity savings from renewable power generation will be 869,897 MWh/day (98.0%), and
- Savings from residential air conditioner retrofits will be 3,142 MWh/day (0.4%).

In 2021 (

Table 25), the total integrated annual NOx emissions reductions from all programs are 23,275 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 225 tons-NOx/year (1.0% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 141 tons-NOx/year (0.6%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 341 tons-NOx/year (1.5%),
- NOx emissions reductions from renewable power generation are 22,385 tons-NOx/year (96.2%), and
- NOx emissions reductions from residential air conditioner retrofits are 183 tons-NOx/year (0.8%).

In 2021 (Figure 1-1), the total integrated OSP NOx emissions reductions from all programs are 106.93 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 0.57 tons-NOx/day (0.5%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 0.37 tons-NOx/day (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.87 tons-NOx/day (0.8%),
- NOx emissions reductions from renewable power generation are 104.65 tons-NOx/day (97.9%), and
- NOx emissions reductions from residential air conditioner retrofits are 0.47 tons-NOx/day (0.4%).

By 2026, the total integrated annual NOx emissions reductions from all programs will be 139,621 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 892 tons-NOx/year (0.6% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 430 tons-NOx/year (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 819 tons-NOx/year (0.6%),
- NOx emissions reductions from renewable power generation will be 137,026 tons-NOx/year (98.1%), and
- NOx emissions reductions from residential air conditioner retrofits will be 455 tons-NOx/year (0.3%).

By 2026, the total integrated OSP NOx emissions reductions from all programs will be 515.87 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 2.27 tons-NOx/day (0.4%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1.11 tons-NOx/day (0.2%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 2.1 tons-NOx/day (0.4%),
- NOx emissions reductions from renewable power generation will be 509.21 tons-NOx/day (98.7%), and
- NOx emissions reductions from residential air conditioner retrofits will be 1.17 tons-NOx/day (0.2%).

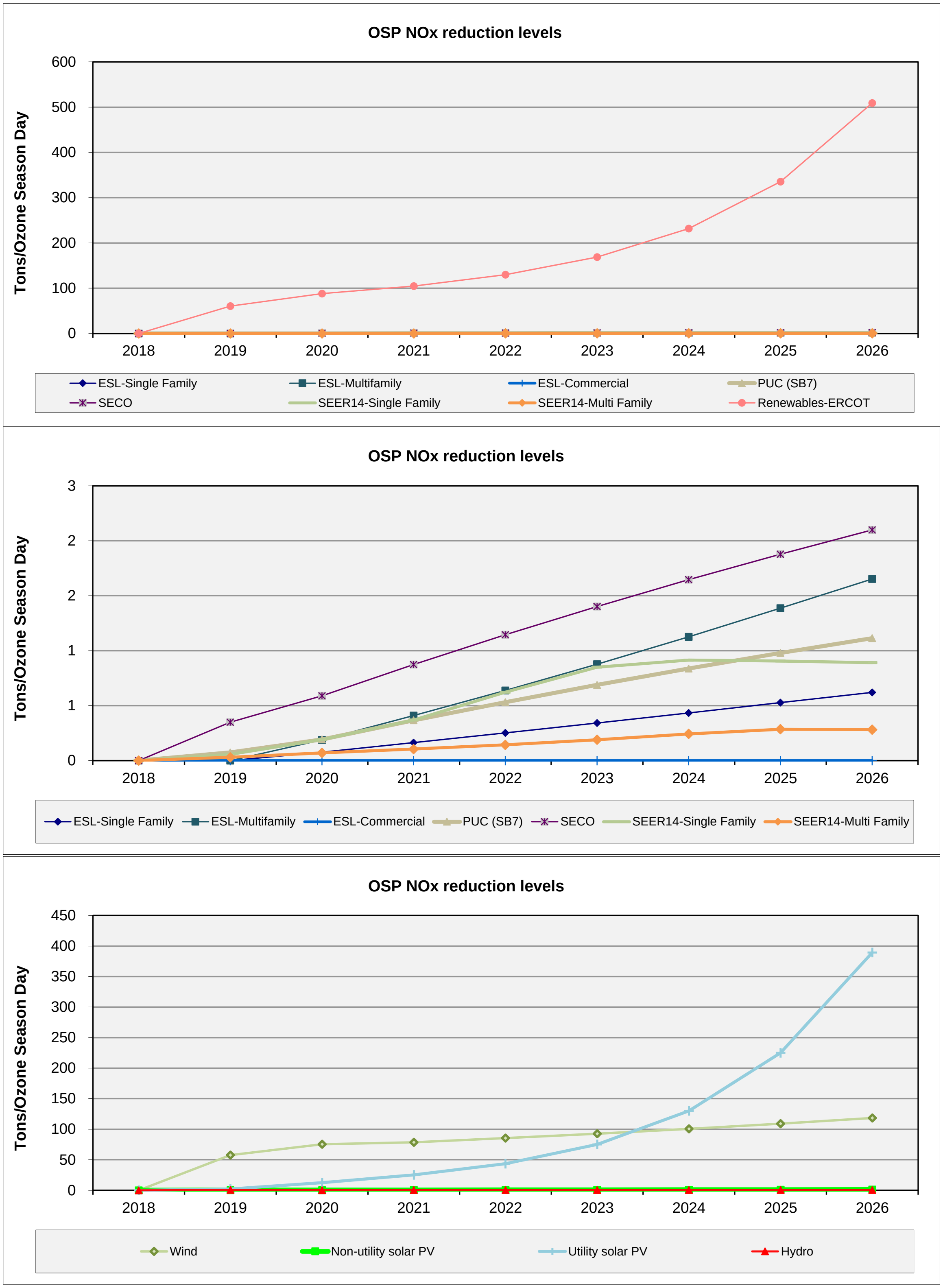


Figure 1-1: Integrated OSP Individual Programs NOx Emissions Reduction Projections through 2026. (Upper plot) all programs, (middle plot) all programs except Renewables, (lower plot) Renewables.

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

In 2004 and 2005, the Laboratory developed a web-based Emissions Reduction Calculator, known as "*eCalc*," which contains the underlying technology for determining NOx emissions reduction from power plants that generate the electricity for the user.[6] 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
- 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

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

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)

The 2021 software updates include:

- IC3
  - Bug fixes
  - Added base 2021 IECC
  - Added 2021 AE IECC
  - Changed EF to UEF for DHW
  - New Duct System Interface added
- CEXIS API
  - Added support for IECC 2021
- POLLER API
  - Added support for IECC 2021

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 2021, 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 2022

In FY 2022, 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.
- Continue to update all websites managed by the lab to meet the evolving TEES standards.
- Begin planning for the next version of IC3 to replace the current version which has become dated.

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 2021, twenty-eight counties are designated as non-attainment counties that include: Brazoria, Chambers, Fort Bend, Galveston, Harris, Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Tarrant, Wise, Bexar, Freestone, Howard, Rusk, Anderson, El Paso, Hutchinson, Liberty, Montgomery, Navarro, Panola, Rockwall, Titus, and Waller[7]. These areas are shown on the map in Figure 2-1 as non-attainment.

These counties represent several geographic areas of the state, which have been assigned to different climate zones by the 2015 IECC[8] as shown in Figure 2-2, 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 2-2 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.

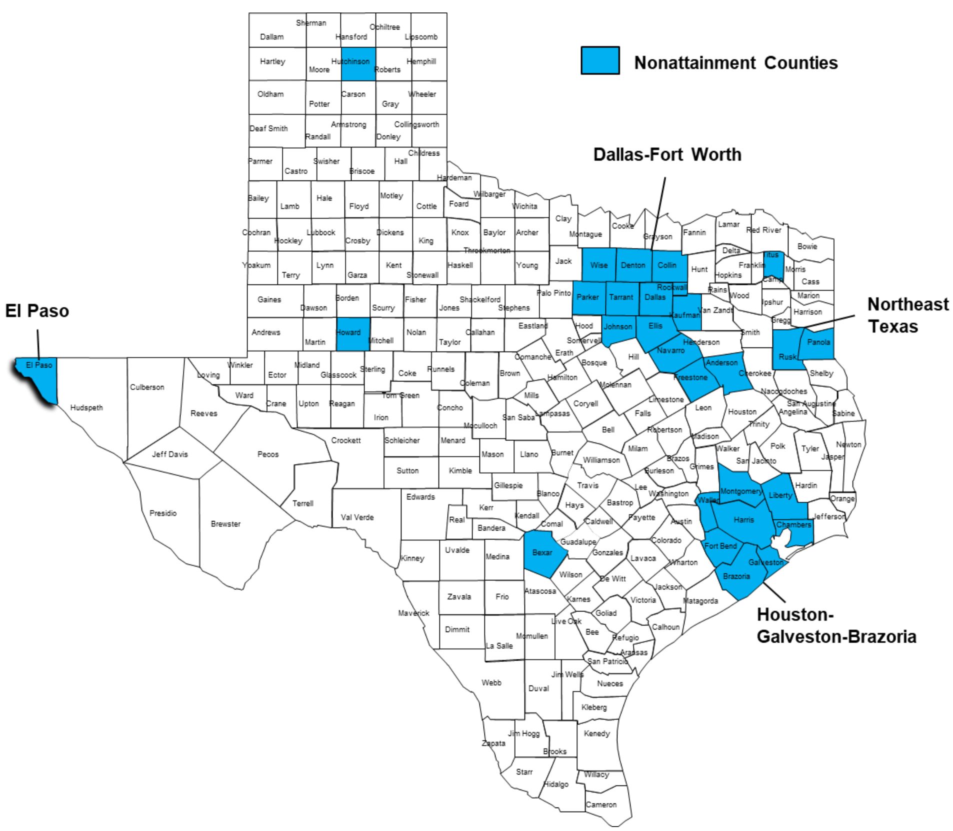
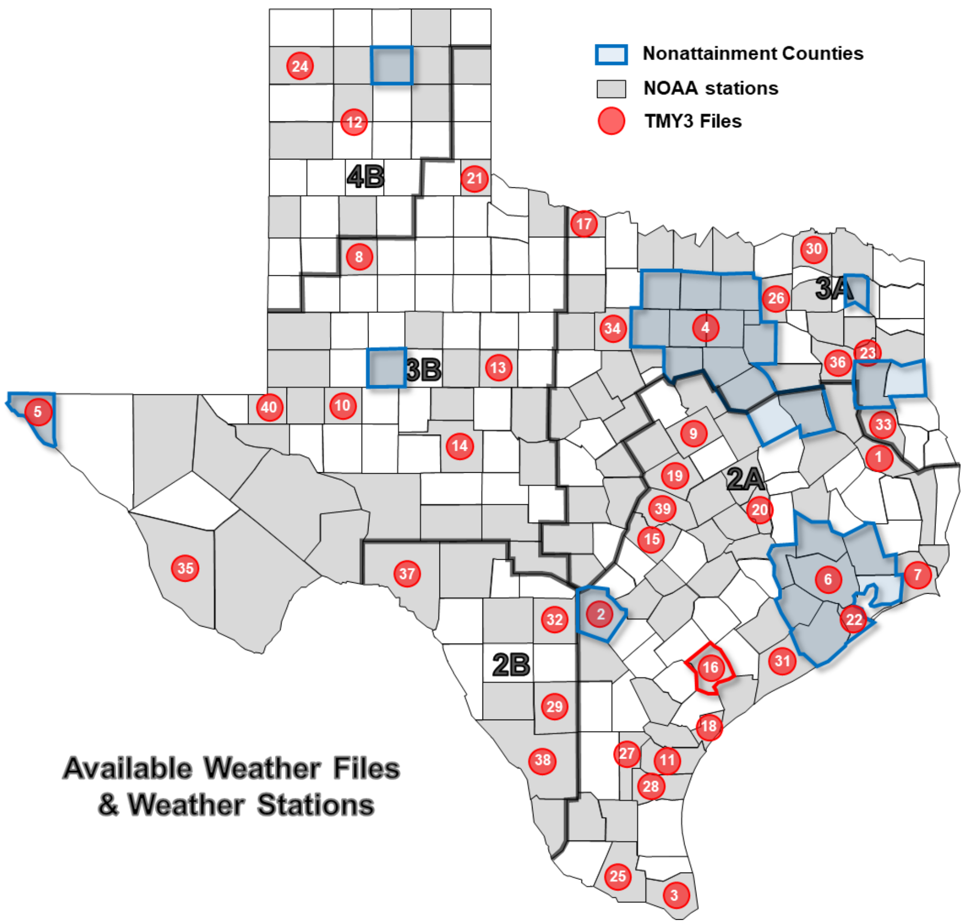


Figure 2-1: TCEQ Nonattainment Counties

[7] The EPA finalized nonattainment county designations were retrieved at https://www.tceq.texas.gov/airquality/sip/texas-sip

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

Figure 2-2: Available weather data and TMY3 weather files in the 2015 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 were made 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.

The 87th Legislature (2021) amended Sec. 388.003 (i), (j) and (k) through H.B. 3215. The amendment focused on:

- Tying the energy rating index (ERI) voluntary compliance path with Standard 301 of the American National Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index, commonly cited as ANSI/RESNET/ICC 301, as it existed on January 1, 2021. A building using this standard will be considered in compliance provided that:
  (1) the building meets the mandatory requirements of Section R406.2 of the 2018 International Energy Conservation Code; and
  (2) the building thermal envelope is equal to or greater than the levels of efficiency and solar heat gain coefficient in Table R402.1.2 or Table R402.1.4 of the 2018 International Energy Conservation Code.
- Updates to the energy rating index (ERI) values: ERI values for 2016 were deleted; ERI values for 2022 remained unchanged; new values for 2025 and 2028 were added for each climate zone. In each year jump (from 2022 to 2025 and from 2025 to 2028) the ERI values decrease by 2.

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 2021 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 2021 measurement period, together with wind data from 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 2021 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 eleven new wind farms with twenty-eight new meters which started operation in 2021 were added, including Western Trail Wind (AJAX Wind), Aquilla Lake Wind, Baird North Wind, Coyote Wind Unit3, Griffin Trail, Priddy Wind Project, Panther Creek Wind3 (A&B), West Raymond (EL Trueno) Wind, Tg East Wind, White Mesa wind, and Wildcat Creek Wind Farm. Figure 3-1 shows the measured annual wind power generation in 2021 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 2021 [9] is 93,119,496 MWh MWh/yr, which is 16.1% lower than what the same wind farms would have produced in 2018. Figure 3-2 shows the same comparison but for the Ozone Season Period. The measured wind power generation in the OSP of 2021[6] is 230,679 MWh/day, which is 28.8% lower than the 2018 OSP baseline wind production. For the analysis of this year, the measured 2021 wind power generation is slightly lower than the 2018 baseline wind power production.

[99] 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.

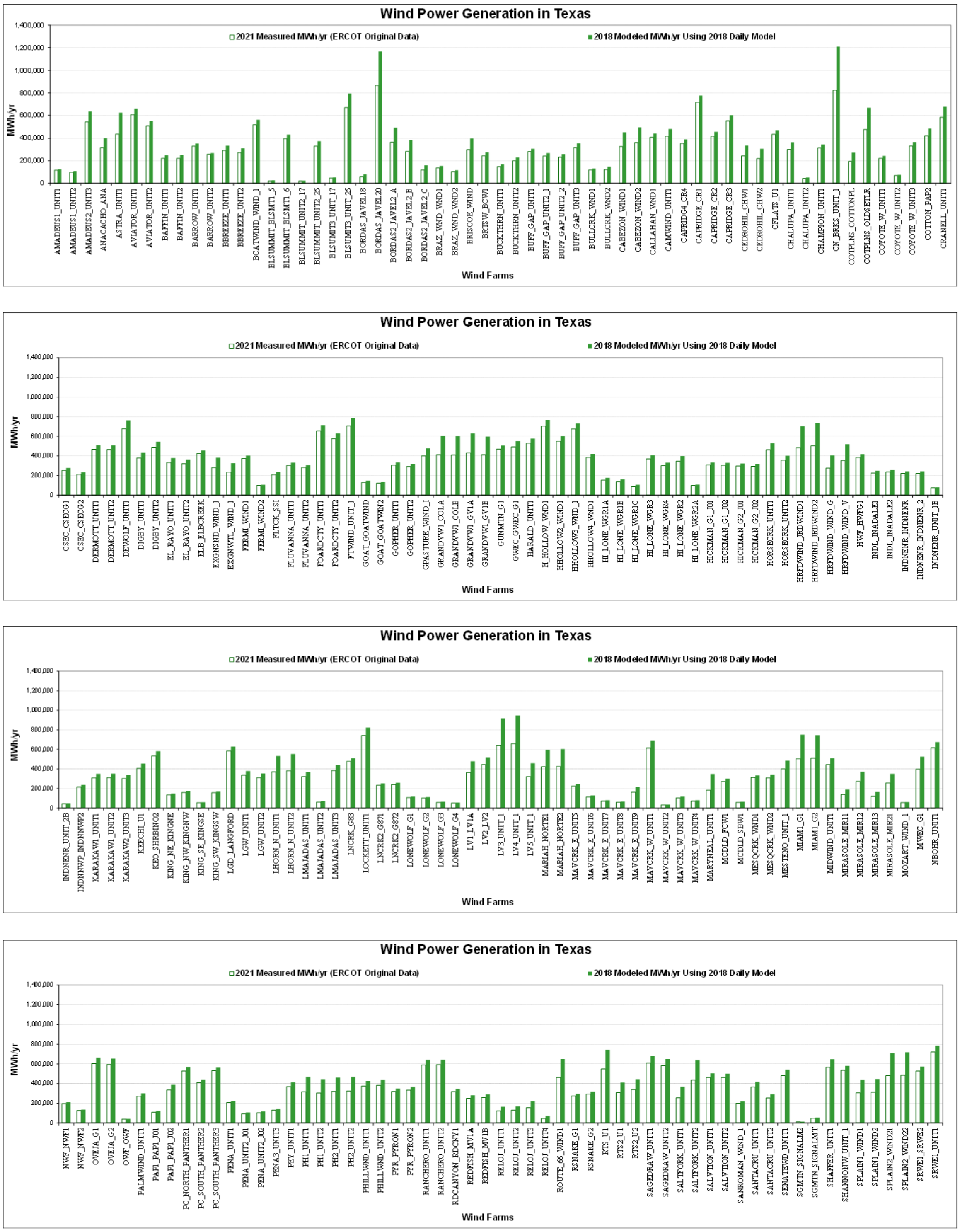


Figure 3-1: Comparison of 2021 Measured and 2018 Estimated Wind Power Production for Each Wind Farm

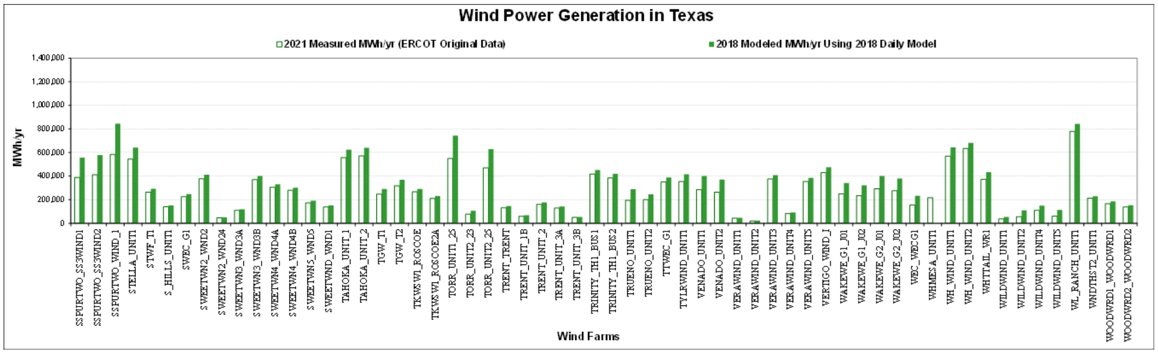


Figure 3-1: Comparison of 2021 Measured and 2018 Estimated Wind Power Production for Each Wind Farm (Continued)

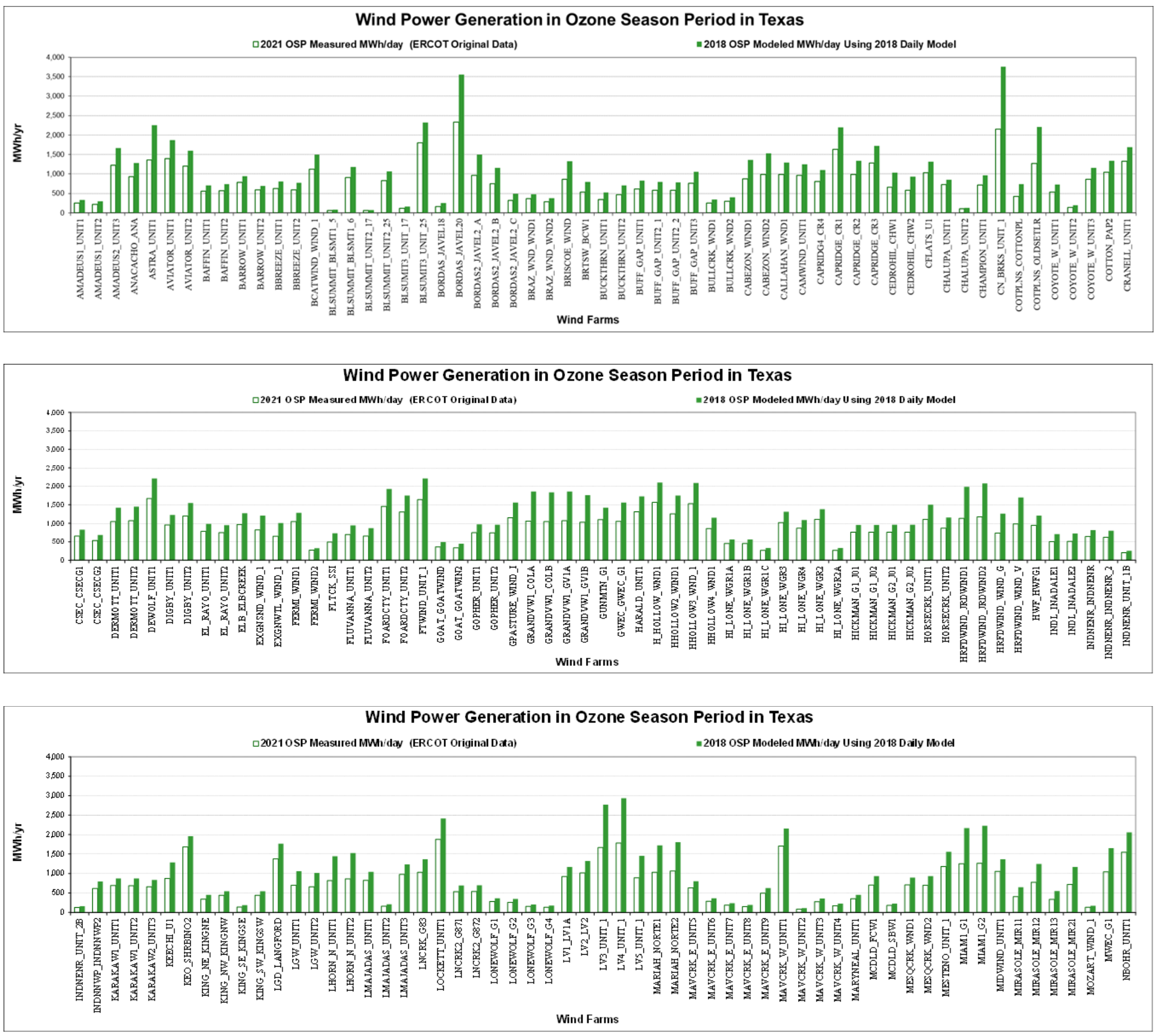


Figure 3-2: Comparison of 2021 OSP Measured and 2018 OSP Estimated Wind Power Production for Each Wind Farm

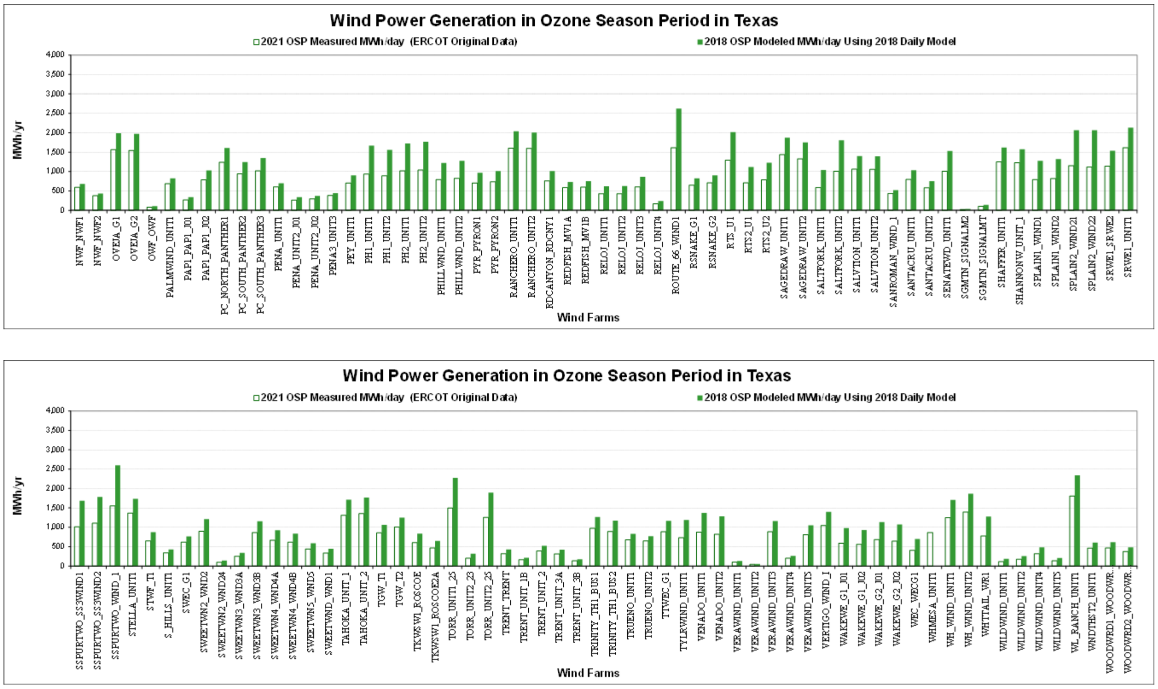


Figure 3-2: Comparison of 2021 OSP Measured and 2018 OSP Estimated Wind Power Production for Each Wind Farm (Continued)

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 3 based on the 2021 measured ERCOT data, the total MWh savings for all the wind farms within the ERCOT region are 93,119,496 MWh/yr and 230,679 MWh/day for an average day in the OSP. The total NOx emissions reductions in 2021 across all the counties amounts are 56,732.0 tons/yr and 132.6 tons/day for the OSP.

Table 3: Electricity Generation and NOx Emission Reductions for All the Wind Farms in ERCOT Region in *2021*

	Annual	**OSP**
Measured Electricity Generation in 2020	93,119,496 [MWh/yr]	230,679 [MWh/day]
NOx Emission Reduction in 2020	56,732.0 [Tons/yr]	132.6 [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 4, 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 4: Summary of 90th Percentile Hourly Wind Power Analysis for 157 Sites in Texas

Wind Farm	12-Month Sliding 90th PercentileHourly 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 4: 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 Farm 1	Dec-12	78.8	71.2	-9.7%	12.5	-84.2%	89.3	13.3%	97	118
Trinity Hills Wind Farm 2	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 5 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 and the EIA, 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 2021, the total annual/OSP energy savings from each renewable projects across all the counties were:

- solar photovoltaic projects (non-utility scale): 607,389 MWh/yr and 1,885 MWh/day;
  in addition, solar power projects (utility-scale): 15,562,995 MWh/yr and 55,457 MWh/day,
- solar thermal projects: 255 MWh/yr and 0.7 MWh/day,
- biomass projects: 434,278 MWh/yr and 1,663 MWh/day, and
- hydroelectric projects: 597,687 MWh/yr and 2,316 MWh/day.

In 2021, the annual NOx emission reductions from renewable projects across all the counties were:

- solar photovoltaic projects (non-utility scale): 299.6 tons/yr;
  in addition, solar power projects (utility-scale): 9,584.4 tons/yr,
- solar thermal projects: 0.1 tons/yr,
- hydroelectric projects: 239.2 tons/yr.

Table 5: Number of Identified Projects for Other Renewable Sources

Renewable Energy Projects	Number of New Projects in 2021	Total Number of Projects in 2021	Annual Measured/ Estimated Electricity Generation in 2021 [MWh/yr]	OSP Measured/ Estimated Electricity Generation in 2021 [MWh/day]	NOx Emission Reductions in 2021 [tons/yr]
Solar Photovoltaic[10]	5,919	40,700	607,389	1,885.0	299.6
Solar Power	35	117	15,562,995	55,457.0	9,584.4
Solar Thermal	0	41	255	0.7	0.1
Biomass	0	12	434,278	1,663.0	-
Hydroelectric	3	33	597,687	2,316.0	239.2
Geothermal	0	306	-	-	-
Landfill Gas-Fired[11]	3	35[12]	-	-	-

[10] This TERP report used the “Tracking the Sun” public dataset of Lawrence Berkeley National Laboratory (LBNL) (https://emp.lbl.gov/tracking-the-sun/).
[11] Landfill gas-fired project information from EPA have seven sub-categories for their status: operational, candidates, potential, construction, shutdown, planned, and others. Only operational projects were considered.
[12] Three (3) new landfill projects were added to the operational list while two projects from last year’s operational list (2020) were removed.

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 (https://sa.ercot.com/rec/home) 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 2021 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. Five specific renewable sources were analyzed for this report. Table 6 contains the data reported by ERCOT from 2001 to 2021. Figure 3-3 is included to better illustrate the annual data collected by ERCOT.

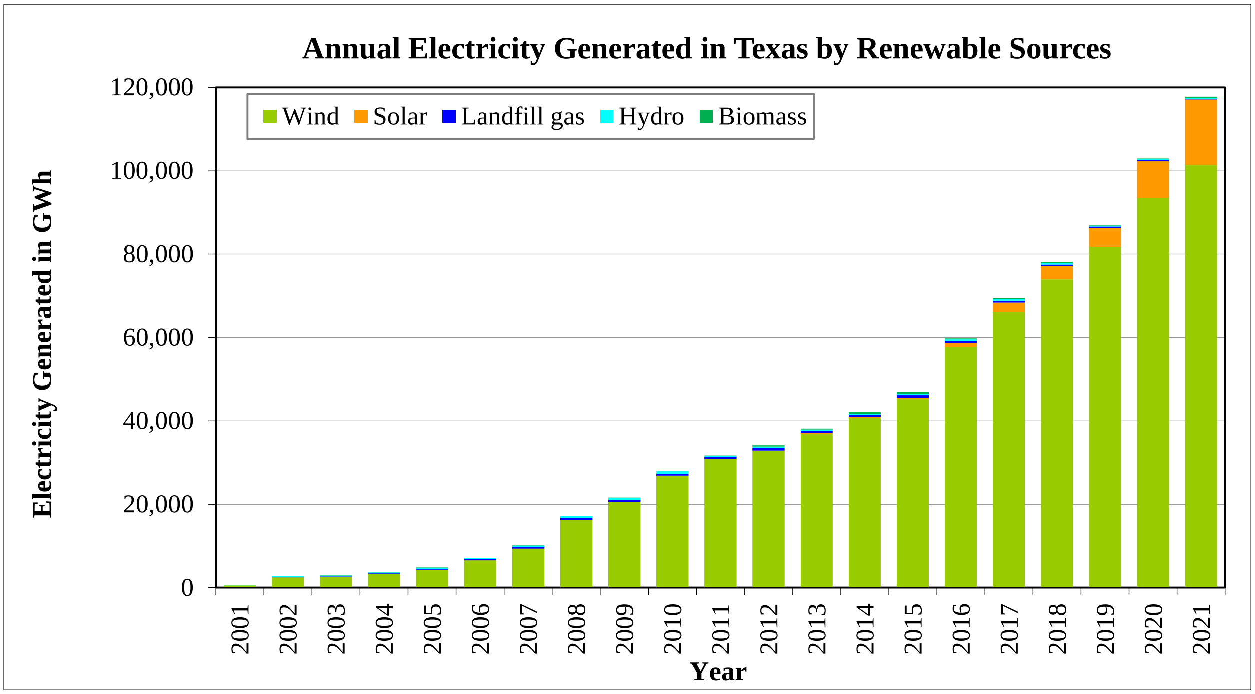
Table 6: Annual Electricity Generation by Renewable Resources (MWh, ERCOT: 2001 - 2021)

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	4,492,846	81,770,300	87,018,756
2020**	140,878	222,252	270,377	8,769,838	93,507,058	102,910,401
2021	248,245	222,136	209,019	15,761,965	101,310,613	117,751,978

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

* Solar includes the utility scale solar power only

** 2019 solar and 2020 wind, solar, and hydro REC data is updated this year since the ERCOT updated these data



Note: In 2021, the unit for the annual electricity generation was revised from MWh to GWh.

Figure 3-3: Electricity Generation by Renewable Resources (ERCOT: 2001–2021 Annual)

4 Calculated NOx Reductions Potential from Energy Savings of New Construction in 2021

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[13]) and commercial buildings.

4.1 2021 Results for New Single-family Residential Construction

This section provides the potential electricity and natural gas savings and the associated NOx emissions reductions in 2021 using the 2018 base year which implemented the 2015 IECC for new single-family residences in Texas, including the 28 non-attainment 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 2021 building permits per county was obtained from the Real Estate Research Center at Texas A&M University (RERC 2022). 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 2021 Home Innovation Research Labs (HIRL) 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 (USEPA 2018)[16].

In Table 7, the 2021 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 7, the rows are first sorted by the US EPA's non-attainment 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 7 represent the only changes that were made to the simulation to obtain the savings calculations. In cases where the 2021 values were more efficient than the 2015 IECC requirements, the 2021 values were used in the 2021 new single-family simulations. Otherwise, the 2015 IECC values were used in both simulations[17]. 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 2021 simulation.

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[13] 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.

[14] The three new counties added in the 2003 Legislative session (i.e., Henderson, Hood, and Hunt) were included in the ERCOT region.

[15] 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

[16] 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.

[17] 2021 HIRL data and 2015 IECC are used for the 2021 new code-compliant simulations and 2018 HIRL data and 2015 IECC are used for the 2018 base-year simulations

In Table 8 the code-traceable simulation results for single-family residences are shown for each county. In a similar fashion to Table 7, Table 8 is first divided into the US EPA's non-attainment classification, 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[18] 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 2021 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 2021 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 2021 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 9, the annual electricity savings are assigned to CL Zones[19]. The total electricity savings for each CL Zone, as shown in Table 9, then entered into the bottom row of Table 10, 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.

[18] The number of the new housing units in 2021 were obtained from the Real Estate Research Center at Texas A&M University.
[19] 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 7: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Single-family Residences

	County	Climate Zone	Division	2021 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 County	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
	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
	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
	Ellis	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	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
	Parker	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
	Wise	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	Bexar	2	West Texas	0.39	0.53	32.4	16.2	0.4	0.25	38	13
	Freestone	2	West Texas	0.39	0.53	32.4	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
	Rusk	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	Anderson	2	East Texas	0.39	0.53	28.6	16.2	0.4	0.25	38	13
	El Paso	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	Hutchinson	4	West Texas	0.39	0.53	32.4	16.2	0.35	0.40	49	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
	Navarro	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	Panola	3	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
	Titus	3	East Texas	0.39	0.53	28.6	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
Other ERCOT County	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
	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

Table 7: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Single-family Residences (Continued)

	County	Climate Zone	Division	2021 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)
Other ERCOT County	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
	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
	Gregg	3	East Texas	0.39	0.53	28.6	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
	Harrison	3	East Texas	0.39	0.53	28.6	16.2	0.35	0.25	38	20
	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
	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
	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

Table 7: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Single-family Residences (Continued)

	County	Climate Zone	Division	2021 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)
	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
	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
Other ERCOT County	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
	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
	Upshur	3	West Texas	0.39	0.53	32.4	16.2	0.35	0.25	38	20
	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 8: 2021 Annual Electricity and Natural Gas Savings from New Single-family Residences

2021 Summary TRY 2018

	County	Climate Zone	No. of Projected Units (2021)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2021 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)	2021 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Non-attainment County	Brazoria	3	4,455	73,232	70,483	**2,941**	824,671	791,905	**32,766**
	Chambers	3	1,052	16,883	16,322	**601**	209,778	201,850	**7,928**
	Fort Bend	3	9,938	160,053	154,540	**5,899**	1,949,806	1,874,908	**74,898**
	Galveston	3	2,474	40,668	39,142	**1,633**	457,965	439,769	**18,196**
	Harris	2	21,260	342,395	330,602	**12,619**	4,171,148	4,010,922	**160,226**
	Collin	3	13,496	204,547	198,569	**6,396**	6,454,948	6,379,249	**75,700**
	Dallas	3	7,728	118,322	114,560	**4,026**	3,260,840	3,209,602	**51,238**
	Denton	3	9,076	139,021	134,610	**4,720**	3,813,822	3,750,735	**63,087**
	Ellis	3	2,871	43,958	42,560	**1,496**	1,211,422	1,192,387	**19,035**
	Johnson	2	1,358	20,792	20,131	**707**	573,010	564,006	**9,004**
	Kaufman	2	1,563	23,689	22,997	**741**	747,561	738,794	**8,767**
	Parker	2	719	10,695	10,382	**334**	304,953	299,955	**4,998**
	Tarrant	2	11,220	171,788	166,325	**5,845**	4,734,294	4,659,903	**74,391**
	Wise	3	124	1,879	1,824	**59**	59,307	58,612	**696**
	Bexar	2	7,714	115,594	111,795	**4,064**	2,179,768	2,126,229	**53,539**
	Freestone	2	4	63	60	**2**	1,545	1,520	**25**
	Howard	3	2	29	28	**1**	910	897	**13**
	Rusk	2	3	49	47	**1**	796	781	**15**
	Anderson	2	27	437	426	**11**	7,163	7,028	**135**
	El Paso	2	2,655	37,549	36,525	**1,096**	1,012,992	994,484	**18,508**
	Hutchinson	4	4	61	59	**2**	2,375	2,373	**2**
	Liberty	2	1,234	19,877	19,192	**733**	241,514	232,172	**9,342**
	Montgomery	3	12,227	196,918	190,135	**7,257**	2,398,901	2,306,752	**92,149**
	Navarro	3	464	7,254	6,993	**279**	179,256	176,337	**2,918**
	Panola	3	10	162	158	**4**	2,653	2,603	**50**
	Rockwall	2	2,830	42,892	41,638	**1,341**	1,353,549	1,337,676	**15,874**
	Titus	3	8	129	126	**3**	2,114	2,074	**40**
	Waller	2	57	918	886	**34**	11,183	10,754	**430**
Other ERCOT County	Andrews	3	20	289	281	**8**	9,097	8,971	**126**
	Angelina	2	138	2,231	2,177	**58**	36,611	35,920	**690**
	Aransas	2	210	3,469	3,337	**141**	34,952	33,435	**1,517**
	Archer	3	42	650	629	**22**	21,893	21,657	**236**
	Atascosa	2	79	1,184	1,145	**42**	22,351	21,800	**551**
	Austin	2	43	693	669	**26**	8,436	8,112	**324**
	Bandera	2	1	15	14	**0**	293	286	**7**
	Bastrop	2	1,500	24,584	23,843	**793**	299,956	291,850	**8,106**
	Baylor	3	0	0	0	**0**	0	0	**0**
	Bee	2	6	98	94	**4**	1,150	1,105	**45**
	Bell	2	2,437	38,099	36,729	**1,467**	941,479	926,152	**15,328**
	Blanco	3	27	395	382	**13**	7,172	6,985	**187**
	Borden	3	19	351	341	**11**	7,687	7,596	**91**
	Bosque	2	9	141	136	**5**	3,477	3,420	**57**
	Brazos	2	1,681	27,073	26,140	**998**	329,807	317,138	**12,669**
	Brewster	3	0	0	0	**0**	0	0	**0**
	Briscoe	4	7	107	104	**3**	4,156	4,153	**3**
	Brooks	2	1	31	30	**1**	262	250	**12**
	Brown	3	121	1,892	1,824	**73**	46,746	45,985	**761**
	Burleson	2	53	854	824	**31**	10,398	9,999	**399**
	Burnet	3	991	14,484	14,028	**488**	263,257	256,379	**6,878**
	Caldwell	3	410	5,991	5,803	**202**	109,067	106,210	**2,858**
	Calhoun	2	123	2,004	1,933	**76**	23,579	22,648	**931**
	Callahan	3	0	0	0	**0**	0	0	**0**
	Cameron	2	1,573	26,622	25,517	**1,182**	221,481	210,693	**10,788**
	Cherokee	2	18	291	284	**8**	4,775	4,685	**90**
	Childress	3	0	0	0	**0**	0	0	**0**
	Clay	3	2	31	30	**1**	1,043	1,031	**11**
	Coke	3	3	44	43	**1**	1,334	1,315	**19**
	Coleman	3	5	77	74	**3**	2,693	2,661	**31**
	Colorado	2	15	242	233	**9**	2,943	2,830	**113**
	Comal	3	3,858	57,812	55,912	**2,033**	1,090,167	1,063,390	**26,776**
	Comanche	3	1	16	15	**1**	386	380	**6**
	Concho	3	1	15	14	**0**	445	439	**6**
	Cooke	3	47	712	691	**22**	22,528	22,249	**280**
	Coryell	2	93	1,454	1,402	**56**	35,928	35,344	**585**
	Cottle	3	0	0	0	**0**	0	0	**0**
	Crane	3	2	29	28	**1**	911	898	**13**
	Crockett	3	19	279	271	**9**	8,455	8,342	**113**
	Crosby	3	0	0	0	**0**	0	0	**0**
	Culberson	3	1	14	14	**0**	381	374	**7**
	Dawson	3	0	0	0	**0**	0	0	**0**
	De Witt	2	11	179	173	**7**	2,109	2,025	**83**
	Delta	3	14	212	206	**7**	6,696	6,617	**79**
	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	12	184	178	**6**	6,446	6,375	**72**
	Ector	3	1,373	19,851	19,308	**581**	624,496	615,860	**8,636**
	Edwards	2	0	0	0	**0**	0	0	**0**
	Erath	3	42	644	625	**21**	22,562	22,312	**250**
	Falls	2	10	156	151	**6**	3,863	3,800	**63**
	Fannin	3	45	682	662	**21**	21,570	21,302	**268**
	Fayette	2	11	177	171	**7**	2,158	2,075	**83**
	Fisher	3	0	0	0	**0**	0	0	**0**
	Foard	3	0	0	0	**0**	0	0	**0**
	Franklin	3	0	0	0	**0**	0	0	**0**

Table 8: 2021 Annual Electricity and Natural Gas Savings from New Single-family Residences (Continued)

2021 Summary TRY 2018

	County	Climate Zone	No. of Projected Units (2021)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2021 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)	2021 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Other ERCOT County	Frio	2	10	150	145	**5**	2,829	2,760	**70**
	Gillespie	3	85	1,242	1,203	**42**	22,580	21,990	**590**
	Glasscock	3	0	0	0	**0**	0	0	**0**
	Goliad	2	42	684	660	**26**	8,051	7,733	**318**
	Gonzales	2	17	255	246	**9**	4,804	4,686	**118**
	Grayson	3	932	14,124	13,711	**442**	446,733	441,189	**5,544**
	Grimes	2	90	1,449	1,400	**53**	17,658	16,979	**678**
	Guadalupe	2	1,730	25,924	25,072	**912**	488,851	476,844	**12,007**
	Hall	3	0	0	0	**0**	0	0	**0**
	Hamilton	3	19	297	286	**11**	7,340	7,221	**120**
	Hardeman	3	0	0	0	**0**	0	0	**0**
	Haskell	3	0	0	0	**0**	0	0	**0**
	Hays	2	4,623	67,567	65,438	**2,278**	1,228,088	1,196,002	**32,086**
	Henderson	2	241	3,917	3,824	**100**	67,616	66,299	**1,318**
	Hidalgo	2	4,844	81,982	78,579	**3,641**	682,042	648,821	**33,221**
	Hill	2	106	1,657	1,598	**64**	40,951	40,284	**667**
	Hopkins	3	47	712	692	**22**	22,479	22,216	**264**
	Houston	2	0	0	0	**0**	0	0	**0**
	Hood	2	227	3,376	3,277	**105**	96,674	95,167	**1,507**
	Hudspeth	3	0	0	0	**0**	0	0	**0**
	Hunt	2	1,011	15,321	14,873	**479**	484,600	478,586	**6,014**
	Irion	3	0	0	0	**0**	0	0	**0**
	Jack	3	1	15	15	**1**	537	531	**6**
	Jackson	2	2	33	31	**1**	383	368	**15**
	Jeff Davis	3	0	0	0	**0**	0	0	**0**
	Jim Hogg	2	0	0	0	**0**	0	0	**0**
	Jim Wells	2	5	83	79	**3**	832	796	**36**
	Jones	3	1	15	15	**1**	537	531	**6**
	Karnes	2	81	1,215	1,175	**43**	22,888	22,326	**562**
	Kendall	3	387	5,696	5,520	**188**	113,302	110,744	**2,558**
	Kenedy	2	0	0	0	**0**	0	0	**0**
	Kent	3	0	0	0	**0**	0	0	**0**
	Kerr	3	98	1,432	1,387	**48**	26,033	25,353	**680**
	Kimble	3	1	15	14	**0**	445	439	**6**
	King	3	0	0	0	**0**	0	0	**0**
	Kinney	2	0	0	0	**0**	0	0	**0**
	Kleberg	2	27	441	425	**18**	4,103	3,917	**186**
	Knox	3	0	0	0	**0**	0	0	**0**
	La Salle	2	4	65	63	**3**	991	963	**28**
	Lamar	3	32	518	505	**13**	8,456	8,296	**160**
	Lampasas	3	46	719	693	**28**	17,771	17,482	**289**
	Lavaca	2	10	176	169	**8**	2,488	2,400	**88**
	Lee	2	30	438	425	**15**	7,981	7,771	**209**
	Leon	2	0	0	0	**0**	0	0	**0**
	Limestone	2	8	125	121	**5**	3,091	3,040	**50**
	Live Oak	2	0	0	0	**0**	0	0	**0**
	Llano	3	248	3,625	3,510	**122**	65,881	64,159	**1,721**
	Loving	3	0	0	0	**0**	0	0	**0**
	Madison	2	6	97	93	**4**	1,177	1,132	**45**
	Martin	3	14	202	197	**6**	6,368	6,280	**88**
	Mason	3	8	117	113	**4**	2,125	2,070	**56**
	Matagorda	2	506	8,245	7,954	**312**	97,000	93,170	**3,831**
	Maverick	2	126	2,063	1,976	**93**	31,204	30,330	**875**
	Mcculloch	3	0	0	0	**0**	0	0	**0**
	Mclennan	2	973	15,212	14,664	**586**	375,896	369,777	**6,120**
	Mcmullen	2	0	0	0	**0**	0	0	**0**
	Medina	2	27	405	391	**14**	7,629	7,442	**187**
	Menard	3	0	0	0	**0**	0	0	**0**
	Midland	3	858	12,405	12,066	**363**	390,253	384,856	**5,396**
	Milam	2	13	203	196	**8**	5,022	4,940	**82**
	Mills	3	0	0	0	**0**	0	0	**0**
	Mitchell	3	0	0	0	**0**	0	0	**0**
	Montague	3	22	333	324	**10**	10,545	10,414	**131**
	Motley	3	0	0	0	**0**	0	0	**0**
	Nacogdoches	3	29	469	457	**12**	7,694	7,548	**145**
	Nolan	3	1	15	15	**1**	537	531	**6**
	Nueces	3	1,716	28,346	27,266	**1,155**	285,611	273,212	**12,400**
	Palo Pinto	3	13	199	193	**7**	6,983	6,906	**77**
	Pecos	3	13	191	186	**6**	5,785	5,708	**77**
	Potter	4	542	8,909	8,575	**358**	100,330	96,344	**3,986**
	Presidio	3	8	118	114	**4**	3,560	3,512	**48**
	Rains	3	25	379	368	**12**	11,957	11,817	**140**
	Reagan	3	1	14	14	**0**	456	449	**7**
	Real	2	0	0	0	**0**	0	0	**0**
	Red River	3	21	340	331	**9**	5,550	5,445	**105**
	Reeves	3	29	419	408	**12**	13,190	13,008	**182**
	Refugio	2	33	538	519	**20**	6,326	6,076	**250**
	Robertson	2	31	499	482	**18**	6,082	5,848	**234**
	Runnels	3	6	88	86	**3**	2,670	2,634	**36**
	San Patricio	2	497	8,210	7,897	**334**	82,721	79,130	**3,591**
	San Saba	3	0	0	0	**0**	0	0	**0**
	Schleicher	3	0	0	0	**0**	0	0	**0**
	Scurry	3	4	74	72	**2**	1,618	1,599	**19**
	Shackelford	3	0	0	0	**0**	0	0	**0**
	Smith	2	741	12,045	11,759	**306**	207,899	203,848	**4,052**

Table 8: 2021 Annual Electricity and Natural Gas Savings from New Single-family Residences (Continued)

2021 Summary TRY 2018

	County	Climate Zone	No. of Projected Units (2021)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2021 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)	2021 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Other ERCOT County	Somervell	3	1	15	15	**1**	422	415	**7**
	Starr	2	1	17	16	**1**	141	134	**7**
	Stephens	3	4	61	59	**2**	2,149	2,125	**24**
	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	505	7,749	7,510	**256**	271,282	268,272	**3,009**
	Terrell	3	0	0	0	**0**	0	0	**0**
	Throckmorton	3	0	0	0	**0**	0	0	**0**
	Travis	3	9,204	134,520	130,282	**4,535**	2,445,019	2,381,139	**63,880**
	Tom Green	3	333	4,894	4,754	**149**	148,187	146,206	**1,981**
	Upton	3	1	14	14	**0**	456	449	**7**
	Uvalde	2	24	360	348	**13**	6,782	6,615	**167**
	Val Verde	2	155	2,323	2,246	**82**	43,799	42,723	**1,076**
	Van Zandt	3	22	333	324	**10**	10,522	10,399	**123**
	Victoria	2	181	2,949	2,845	**112**	34,698	33,327	**1,370**
	Ward	3	0	0	0	**0**	0	0	**0**
	Washington	2	190	3,060	2,955	**113**	37,277	35,845	**1,432**
	Webb	2	1,462	23,932	22,928	**1,074**	362,067	351,920	**10,147**
	Wharton	2	245	3,992	3,851	**151**	46,967	45,112	**1,855**
	Wichita	3	145	2,243	2,171	**77**	75,582	74,769	**813**
	Wilbarger	3	2	31	30	**1**	1,043	1,031	**11**
	Willacy	2	47	795	762	**35**	6,618	6,295	**322**
	Williamson	3	9,437	142,372	137,823	**4,868**	3,386,812	3,324,251	**62,561**
	Wilson	2	149	2,233	2,159	**79**	42,103	41,069	**1,034**
	Winkler	3	2	29	28	**1**	910	897	**13**
	Wood	3	18	302	294	**8**	5,197	5,102	**95**
	Young	3	5	77	74	**3**	2,686	2,656	**30**
	Zapata	2	0	0	0	**0**	0	0	**0**
	Zavala	2	3	49	47	**2**	743	722	**21**
Other TEXAS County	Armstrong	4	8	122	119	**3**	4,749	4,746	**3**
	Bailey	4	0	0	0	**0**	0	0	**0**
	Bowie	3	229	3,703	3,613	**97**	60,517	59,371	**1,146**
	Camp	3	4	65	63	**2**	1,057	1,037	**20**
	Carson	4	2	31	30	**1**	1,187	1,187	**1**
	Cass	3	7	113	110	**3**	1,850	1,815	**35**
	Castro	4	0	0	0	**0**	0	0	**0**
	Cochran	4	43	657	639	**18**	25,528	25,510	**18**
	Collingsworth	3	0	0	0	**0**	0	0	**0**
	Dallam	4	6	92	89	**3**	3,562	3,560	**3**
	Deaf Smith	4	2	31	30	**1**	1,187	1,187	**1**
	Donley	4	6	92	89	**3**	3,562	3,560	**3**
	Floyd	4	0	0	0	**0**	0	0	**0**
	Gaines	3	3	43	42	**1**	1,365	1,346	**19**
	Garza	3	0	0	0	**0**	0	0	**0**
	Gray	4	0	0	0	**0**	0	0	**0**
	Gregg	3	255	4,124	4,024	**107**	67,556	66,243	**1,313**
	Hale	4	26	397	387	**11**	15,436	15,425	**11**
	Hansford	4	0	0	0	**0**	0	0	**0**
	Hardin	2	449	7,206	6,967	**257**	89,461	86,062	**3,399**
	Harrison	2	114	1,844	1,799	**48**	30,202	29,615	**587**
	Hartley	4	0	0	0	**0**	0	0	**0**
	Hemphill	3	0	0	0	**0**	0	0	**0**
	Hockley	4	17	260	253	**7**	10,093	10,085	**7**
	Jasper	2	71	1,140	1,102	**41**	14,124	13,586	**538**
	Jefferson	2	761	12,215	11,808	**435**	151,384	145,623	**5,761**
	Lamb	4	0	0	0	**0**	0	0	**0**
	Lipscomb	4	1	15	15	**0**	594	593	**0**
	Lubbock	3	2,723	41,760	40,477	**1,374**	1,461,819	1,444,719	**17,100**
	Lynn	3	2	31	30	**1**	1,074	1,061	**13**
	Marion	3	6	97	95	**3**	1,590	1,559	**31**
	Moore	4	5	76	74	**2**	2,968	2,966	**2**
	Morris	3	4	65	63	**2**	1,057	1,037	**20**
	Newton	2	0	0	0	**0**	0	0	**0**
	Ochiltree	4	0	0	0	**0**	0	0	**0**
	Oldham	4	0	0	0	**0**	0	0	**0**
	Orange	2	191	3,066	2,964	**109**	37,995	36,549	**1,446**
	Parmer	4	8	122	119	**3**	4,749	4,746	**3**
	Polk	2	958	15,376	14,864	**548**	190,878	183,625	**7,253**
	Randall	4	130	1,985	1,933	**56**	77,179	77,124	**55**
	Roberts	4	0	0	0	**0**	0	0	**0**
	Sabine	3	0	0	0	**0**	0	0	**0**
	San Augustine	3	6	97	95	**3**	1,592	1,562	**30**
	San Jacinto	2	575	9,262	8,943	**342**	112,537	108,184	**4,353**
	Shelby	3	1	16	16	**0**	265	260	**5**
	Sherman	4	15	229	223	**6**	8,905	8,899	**6**
	Swisher	4	0	0	0	**0**	0	0	**0**
	Terry	3	1	15	15	**1**	537	531	**6**
	Trinity	2	4	64	62	**2**	850	818	**32**
	Tyler	2	9	144	140	**5**	1,793	1,725	**68**
	Upshur	3	23	385	376	**11**	6,640	6,519	**121**
	Walker	2	659	10,613	10,248	**391**	129,294	124,327	**4,967**
	Wheeler	3	0	0	0	**0**	0	0	**0**
	Yoakum	4	0	0	0	**0**	0	0	**0**
	TOTAL		**180,375**			**99,103**			**1,235,767**

Table 9: 2021 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) [2021-TRY 2018]
ERCOT	Houston (H)	23,726
	North (N)	31,403
	West (W)	1,539
	South (S)	29,487
SPP	-	2,124
SERC	-	9,728
WECC	-	1,096
Total		99,103

Table 10: 2021 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	3428.94	0.0000183	0.58	0.0000009	0.00	0.0013540	39.92	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3469.44	1.73
	Chambers	0.0232302	551.15	0.0000029	0.09	0.0000001	0.00	0.0002176	6.42	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	557.66	0.28
	Fort Bend	0.0925360	2195.48	0.0000117	0.37	0.0000006	0.00	0.0008669	25.56	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2221.41	1.11
	Galveston	0.0189140	448.75	0.0000024	0.08	0.0000001	0.00	0.0001772	5.22	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	454.05	0.23
	Harris	0.1374166	3260.30	0.0000174	0.55	0.0000008	0.00	0.0012874	37.96	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3298.81	1.65
	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	571.48	0.0000000	0.00	571.48	0.29
	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	26.37	0.0000000	0.00	26.37	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	9424.75	0.0000000	0.00	9424.75	4.71
	Orange	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.8865417	8624.64	0.0000000	0.00	8624.64	4.31
Dallas/ Fort Worth Area	Collin	0.0000743	1.76	0.0004556	14.31	0.0000220	0.03	0.0000046	0.14	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	16.24	0.01
	Dallas	0.0019090	45.29	0.0117105	367.74	0.0005656	0.87	0.0001195	3.52	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	417.43	0.21
	Denton	0.0066429	157.61	0.0407509	1279.70	0.0019683	3.03	0.0004158	12.26	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1452.60	0.73
	Henderson	0.0001509	3.58	0.0009255	29.06	0.0000447	0.07	0.0000094	0.28	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	32.99	0.02
	Hood	0.0008451	20.05	0.0051842	162.80	0.0002504	0.39	0.0000529	1.56	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	184.79	0.09
	Hunt	0.0000043	0.10	0.0000263	0.83	0.0000013	0.00	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.94	0.00
	Tarrant	0.0004188	9.94	0.0025693	80.68	0.0001241	0.19	0.0000262	0.77	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	91.58	0.05
	Ellis	0.0013349	31.67	0.0081890	257.16	0.0003955	0.61	0.0000835	2.46	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	291.90	0.15
	Johnson	0.0002010	4.77	0.0012332	38.73	0.0000596	0.09	0.0000126	0.37	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	43.96	0.02
	Kaufman	0.0034596	82.08	0.0212228	666.46	0.0010251	1.58	0.0002165	6.38	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	756.50	0.38
	Parker	0.0005940	14.09	0.0036438	114.43	0.0001760	0.27	0.0000372	1.10	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	129.89	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	74.26	0.0192012	602.98	0.0009275	1.43	0.0001959	5.78	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	684.44	0.34
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	1339.58	1339.58	0.67
San Antonio Area	Bexar	0.0253670	601.85	0.0017108	53.72	0.0000826	0.13	0.2025905	5973.73	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6629.43	3.31
	Comal	0.0005285	12.54	0.0000356	1.12	0.0000017	0.00	0.0042210	124.46	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	138.12	0.07
	Guadalupe	0.0030546	72.47	0.0002060	6.47	0.0000100	0.02	0.0243949	719.32	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	798.28	0.40
	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	58.84	0.0001673	5.25	0.0000081	0.01	0.0198060	584.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	648.12	0.32
	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	11.22	0.0000319	1.00	0.0000015	0.00	0.0037782	111.41	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	123.64	0.06
	Travis	0.0046184	109.58	0.0003115	9.78	0.0000150	0.02	0.0368846	1087.61	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1206.99	0.60
	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	11.41	0.0000000	0.00	0.0000000	0.00	11.41	0.01
	Harrison	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2702671	574.18	0.0000000	0.00	0.0000000	0.00	574.18	0.29
	Rusk	0.0322708	765.65	0.1979648	6216.68	0.0095620	14.71	0.0020197	59.55	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7056.60	3.53
	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	100.66	0.0002861	8.99	0.0000138	0.02	0.0338828	999.09	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1108.76	0.55
	San Patricio	0.0063692	151.11	0.0004296	13.49	0.0000207	0.03	0.0508668	1499.89	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1664.53	0.83
Victoria Area	Victoria	0.0016730	39.69	0.0001128	3.54	0.0000054	0.01	0.0133614	393.98	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	437.23	0.22
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	182.89	0.0005199	16.33	0.0000251	0.04	0.0615620	1815.26	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2014.51	1.01
	Bell	0.0004444	10.54	0.0027262	85.61	0.0001317	0.20	0.0000278	0.82	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	97.18	0.05
	Bosque	0.0007214	17.12	0.0044257	138.98	0.0002138	0.33	0.0000452	1.33	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	157.76	0.08
	Brazos	0.0005654	13.42	0.0034687	108.93	0.0001675	0.26	0.0000354	1.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	123.64	0.06
	Calhoun	0.0111852	265.38	0.0007544	23.69	0.0000364	0.06	0.0893292	2634.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2923.14	1.46
	Cameron	0.0000231	0.55	0.0000016	0.05	0.0000001	0.00	0.0001843	5.44	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6.03	0.00
	Cherokee	0.0001844	4.37	0.0011310	35.52	0.0000546	0.08	0.0000115	0.34	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	40.32	0.02
	Coke	0.0000223	0.53	0.0001365	4.29	0.0231815	35.67	0.0000014	0.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	40.52	0.02
	Colorado	0.0016158	38.33	0.0001090	3.42	0.0000053	0.01	0.0129041	380.50	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	422.26	0.21
	Ector	0.0001338	3.17	0.0008206	25.77	0.1393442	214.40	0.0000084	0.25	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	243.59	0.12
	Fayette	0.0204274	484.65	0.0013777	43.26	0.0000665	0.10	0.1631405	4810.48	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5338.50	2.67
	Freestone	0.0042261	100.27	0.0259247	814.11	0.0012522	1.93	0.0002645	7.80	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	924.11	0.46
	Frio	0.0097614	231.60	0.0006583	20.67	0.0000318	0.05	0.0779581	2298.73	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2551.05	1.28
	Goliad	0.0077047	182.80	0.0005196	16.32	0.0000251	0.04	0.0615328	1814.40	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2013.56	1.01
	Grayson	0.0002857	6.78	0.0017525	55.03	0.0000846	0.13	0.0000179	0.53	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	62.47	0.03
	Grimes	0.0029942	71.04	0.0183678	576.80	0.0008872	1.37	0.0001874	5.53	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	654.73	0.33
	Hidalgo	0.0140830	334.13	0.0009498	29.83	0.0000459	0.07	0.1124720	3316.43	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3680.45	1.84
	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	1.11	0.0002865	9.00	0.0486558	74.86	0.0000029	0.09	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	85.06	0.04
	Lamar	0.0031379	74.45	0.0192492	604.48	0.0009298	1.43	0.0001964	5.79	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	686.15	0.34
	Limestone	0.0231674	549.66	0.1421203	4463.00	0.0068646	10.56	0.0014500	42.75	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5065.98	2.53
	Llano	0.0001855	4.40	0.0000125	0.39	0.0000006	0.00	0.0014818	43.69	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	48.49	0.02
	McLennan	0.0043688	103.65	0.0268006	841.62	0.0012945	1.99	0.0002734	8.06	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	955.33	0.48
	Milam	0.0002486	5.90	0.0000168	0.53	0.0000008	0.00	0.0019850	58.53	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	64.96	0.03
	Mitchell	0.0000072	0.17	0.0000443	1.39	0.0075244	11.58	0.0000005	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	13.15	0.01
	Nacogdoches	0.0002714	6.44	0.0016647	52.28	0.0000804	0.12	0.0000170	0.50	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	59.34	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	24.65	0.0063745	200.18	0.0003079	0.47	0.0000650	1.92	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	227.22	0.11
	Pecos	0.0000029	0.07	0.0000180	0.57	0.0030637	4.71	0.0000002	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5.36	0.00
	Reagan	0.0000002	0.01	0.0000015	0.05	0.0002476	0.38	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.43	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	436.97	0.1129830	3548.00	0.0054573	8.40	0.0011527	33.99	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4027.36	2.01
	Scurry	0.0001246	2.96	0.0007646	24.01	0.1298311	199.76	0.0000078	0.23	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	226.96	0.11
	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	0.49	0.0001265	3.97	0.0214790	33.05	0.0000013	0.04	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	37.55	0.02
	Webb	0.0000253	0.60	0.0000017	0.05	0.0000001	0.00	0.0002020	5.96	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6.61	0.00
	Wharton	0.0006585	15.62	0.0000444	1.39	0.0000021	0.00	0.0052594	155.08	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	172.10	0.09
	Wichita	0.0000051	0.12	0.0000315	0.99	0.0053432	8.22	0.0000003	0.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	9.34	0.00
	Wilbarger	0.0008609	20.42	0.0052810	165.84	0.8967472	1379.75	0.0000539	1.59	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1567.60	0.78
	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	0.61	0.0001578	4.95	0.0267892	41.22	0.0000016	0.05	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	46.83	0.02
Other SPP Counties	Cass	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0127595	27.11	0.0000000	0.00	0.0000000	0.00	27.11	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	131.04	0.0000000	0.00	0.0000000	0.00	131.04	0.07
	Hemphill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0246062	52.28	0.0000000	0.00	0.0000000	0.00	52.28	0.03
	Hutchinson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0134856	28.65	0.0000000	0.00	0.0000000	0.00	28.65	0.01
	Lamb	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2117054	449.77	0.0000000	0.00	0.0000000	0.00	449.77	0.22
	Lubbock	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0695988	147.86	0.0000000	0.00	0.0000000	0.00	147.86	0.07
	Marion	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0272898	57.98	0.0000000	0.00	0.0000000	0.00	57.98	0.03
	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	0.48	0.0000000	0.00	0.0000000	0.00	0.48	0.00
	Potter	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2710995	575.95	0.0000000	0.00	0.0000000	0.00	575.95	0.29
	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	93.23	0.0000000	0.00	0.0000000	0.00	93.23	0.05
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	846.37	0.0000000	0.00	846.37	0.42
	San Jacinto	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0072219	70.26	0.0000000	0.00	70.26	0.04
	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**	**15449.30**	**0.6960448**	**21857.88**	**1.3354567**	**2054.76**	**0.9887171**	**29154.01**	**1.3648074**	**2899.53**	**2.0110028**	**19563.86**	**1.2223686**	**1339.58**	**92318.92**	**46.16**

Energy Savings (MWh)		23,726		31,403		1,539		29,487		2,124		9,728		1,096

4.2 2021 Results for New Multi-family Residential Construction

This section provides the potential electricity and natural gas savings and the associated NOx emissions reductions in 2021 using the 2018 base year which implemented the 2015 IECC for new multi-family residences in the 28 non-attainment counties as well as other counties in the ERCOT region[20]. 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 2021 building permits per county was obtained from the Real Estate Research Center at Texas A&M University (RERC 2022). 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 2021 HIRL's survey data[21] 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[22].

In Table 11, the 2021 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 11, the rows are first sorted by the US EPA's non-attainment 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 11 represent the changes for building envelope that were made to the simulations to obtain the savings calculations. In cases where the 2021 new multi-family values were more efficient than the 2015 IECC requirements, the 2021 new multi-family values were used in 2021 new multi-family simulations. Otherwise, the 2015 IECC values were used in both simulations. For the 2021 new multi-family simulations, the more efficient values from 2021 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 12, the code-traceable simulation results for multi-family residences are shown for each county. In a similar fashion to Table 11, Table 12 is first divided into the US EPA's non-attainment classification, 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[23] 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 2021 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 2021 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 12 are assigned to CL Zones[24] in a similar fashion to the single-family residential assignments. The total electricity savings for each CL Zone, as shown in Table 13, are then entered into the bottom row of Table 14, 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

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[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 2021 were obtained from the Real Estate Research 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 11: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences

	County	Climate Zone	Division	2021 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 County	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
	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
	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
	Ellis	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	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
	Parker	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
	Wise	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	Bexar	2	West Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	Freestone	2	West 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
	Rusk	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	Anderson	2	East Texas	0.39	0.53	35.2	15.5	0.4	0.25	38	13
	El Paso	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	Hutchinson	4	West Texas	0.39	0.53	35.2	15.5	0.35	0.40	49	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
	Navarro	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	Panola	3	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
	Titus	3	East 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
Other ERCOT County	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
	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

Table 11: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences (Continued)

	County	Climate Zone	Division	2021 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)
Other ERCOT County	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
	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
	Gregg	3	East 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
	Harrison	3	East Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	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
	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
	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

Table 11: 2021 and 2015 IECC Code-compliant Building Characteristics Used in the DOE-2 Simulations for New Multi-family Residences (Continued)

	County	Climate Zone	Division	2021 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)
Other ERCOT County	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
	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
	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
	Upshur	3	West Texas	0.39	0.53	35.2	15.5	0.35	0.25	38	20
	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 12: 2021 Annual Electricity and Natural Gas Savings from New Multi-family Residences

2021 Summary TRY 2018									
	County	**Climate Zone**	**No. of Projected Units (2021)**	**2018 Base-year Total Annual Elec. Use (MWh/yr)**	**2021 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)**	**2021 Total Annual NG Use (Therm/yr)**	**Total Annual NG Savings (Therm/yr)**
Non-attainment County	Brazoria	2	7	674	654	21.22	4,674	4,600	73.54
	Chambers	2	0	0	0	0.00	0	0	0.00
	Fort Bend	2	824	78,559	76,385	2,326.55	576,505	565,874	10,631.34
	Galveston	2	38	3,659	3,552	115.18	25,372	24,972	399.24
	Harris	2	13,944	1,329,402	1,292,607	39,370.60	9,755,816	9,575,909	179,907.05
	Collin	2	3,644	351,422	342,667	9,367.66	3,961,139	3,867,316	93,822.91
	Dallas	2	11,071	1,069,653	1,041,734	29,874.24	10,736,364	10,494,295	242,069.63
	Denton	2	2,499	241,639	235,319	6,762.26	2,417,872	2,362,672	55,199.87
	Ellis	3	1,024	98,936	96,354	2,763.19	993,048	970,658	22,389.96
	Johnson	3	860	83,091	80,922	2,320.64	834,005	815,201	18,804.07
	Kaufman	2	26	2,507	2,445	66.84	28,263	27,593	669.43
	Parker	2	46	4,375	4,270	112.80	44,233	43,260	973.33
	Tarrant	3	6,949	671,396	653,871	18,751.34	6,738,957	6,587,016	151,941.27
	Wise	3	8	772	752	20.57	8,696	8,490	205.98
	Bexar	3	7,580	730,320	709,520	22,255.42	5,396,104	5,291,328	104,776.46
	Freestone	2	0	0	0	0.00	0	0	0.00
	Howard	3	0	0	0	0.00	0	0	0.00
	Rusk	2	64	5,977	5,841	145.55	56,281	55,085	1,196.10
	Anderson	2	193	18,025	17,615	438.94	169,723	166,116	3,606.98
	El Paso	3	334	30,892	30,197	743.37	289,879	283,820	6,059.09
	Hutchinson	4	0	0	0	0.00	0	0	0.00
	Liberty	3	0	0	0	0.00	0	0	0.00
	Montgomery	3	1,523	145,201	141,182	4,300.16	1,065,556	1,045,906	19,649.92
	Navarro	3	14	1,386	1,340	49.37	12,770	12,416	354.20
	Panola	3	0	0	0	0.00	0	0	0.00
	Rockwall	2	562	54,198	52,848	1,444.74	610,911	596,441	14,469.94
	Titus	3	0	0	0	0.00	0	0	0.00
	Waller	2	208	19,830	19,282	587.28	145,526	142,842	2,683.64
Other ERCOT County	Andrews	3	0	0	0	0.00	0	0	0.00
	Angelina	2	0	0	0	0.00	0	0	0.00
	Aransas	2	4	392	380	12.92	2,553	2,513	39.57
	Archer	3	2	196	190	6.16	2,353	2,282	70.82
	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
	Bastrop	3	94	8,937	8,691	263.05	64,142	63,042	1,099.27
	Baylor	3	0	0	0	0.00	0	0	0.00
	Bee	2	0	0	0	0.00	0	0	0.00
	Bell	2	1,582	156,599	151,386	5,578.38	1,443,050	1,403,025	40,024.70
	Blanco	3	0	0	0	0.00	0	0	0.00
	Borden	3	0	0	0	0.00	0	0	0.00
	Bosque	2	0	0	0	0.00	0	0	0.00
	Brazos	2	531	50,625	49,224	1,499.27	371,510	364,659	6,851.02
	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	26	2,574	2,488	91.68	23,716	23,059	657.80
	Burleson	2	4	381	371	11.29	2,799	2,747	51.61
	Burnet	3	0	0	0	0.00	0	0	0.00
	Caldwell	3	134	12,740	12,390	374.98	0	0	0.00
	Calhoun	2	14	1,350	1,311	41.33	9,765	9,594	171.39
	Callahan	3	0	0	0	0.00	0	0	0.00
	Cameron	2	479	48,263	46,495	1,891.13	277,363	273,251	4,111.67
	Cherokee	2	0	0	0	0.00	0	0	0.00
	Childress	3	0	0	0	0.00	0	0	0.00
	Clay	3	0	0	0	0.00	0	0	0.00
	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
	Comal	3	601	57,905	56,256	1,764.58	427,844	419,537	8,307.47
	Comanche	3	0	0	0	0.00	0	0	0.00
	Concho	3	0	0	0	0.00	0	0	0.00
	Cooke	3	4	386	376	10.27	4,355	4,250	105.41
	Coryell	2	150	14,848	14,354	528.92	136,825	133,030	3,795.01
	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	22	2,050	1,997	56.69	19,299	18,813	486.72
	Dawson	3	80	7,815	7,589	241.83	97,142	94,171	2,970.42
	De Witt	2	0	0	0	0.00	0	0	0.00
	Delta	3	0	0	0	0.00	0	0	0.00
	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	5	489	474	15.19	6,075	5,888	186.77
	Ector	3	33	3,118	3,037	86.61	33,963	32,985	978.13
	Edwards	2	0	0	0	0.00	0	0	0.00
	Erath	3	12	1,173	1,139	36.46	14,579	14,131	448.25
	Falls	2	0	0	0	0.00	0	0	0.00
	Fannin	3	14	1,350	1,316	35.93	15,244	14,875	368.93
	Fayette	2	0	0	0	0.00	0	0	0.00
	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

Table 12: 2021 Annual Electricity and Natural Gas Savings from New Multi-family Residences (Continued)

2021 Summary TRY 2018									
	County	**Climate Zone**	**No. of Projected Units (2021)**	**2018 Base-year Total Annual Elec. Use (MWh/yr)**	**2021 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)**	**2021 Total Annual NG Use (Therm/yr)**	**Total Annual NG Savings (Therm/yr)**
	Frio	2	0	0	0	0.00	0	0	0.00
	Gillespie	3	0	0	0	0.00	0	0	0.00
	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	116	11,184	10,906	297.71	126,304	123,247	3,056.86
	Grimes	2	2	191	185	5.65	1,399	1,373	25.80
	Guadalupe	3	138	13,296	12,917	405.18	98,240	96,333	1,907.54
	Hall	3	0	0	0	0.00	0	0	0.00
	Hamilton	3	2	198	191	7.05	1,824	1,774	50.60
	Hardeman	3	0	0	0	0.00	0	0	0.00
	Haskell	3	0	0	0	0.00	0	0	0.00
	Hays	3	830	78,929	76,755	2,325.98	566,125	556,650	9,475.23
	Henderson	2	2	187	183	4.48	1,838	1,798	39.79
	Hidalgo	2	1,211	122,018	117,549	4,781.12	701,224	690,829	10,395.07
	Hill	2	6	594	574	21.16	5,473	5,321	151.80
	Hood	3	64	6,083	5,937	156.48	61,684	60,293	1,391.66
	Hopkins	3	81	7,812	7,617	208.23	88,049	85,964	2,085.53
	Houston	2	3	280	274	6.82	2,638	2,582	56.07
	Hudspeth	3	0	0	0	0.00	0	0	0.00
	Hunt	2	20	1,928	1,880	51.33	21,776	21,249	527.04
	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	0	0	0	0.00	0	0	0.00
	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	17	1,677	1,619	61.62	10,268	10,120	148.31
	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	49	4,725	4,608	125.96	53,264	52,003	1,261.61
	Lampasas	3	4	396	383	14.10	3,649	3,547	101.20
Other ERCOT County	Lavaca	2	0	0	0	0.00	0	0	0.00
	Lee	2	0	0	0	0.00	0	0	0.00
	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	13	1,236	1,202	36.43	8,867	8,719	148.41
	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	561	548	13.71	5,269	5,161	108.18
	Mason	3	0	0	0	0.00	0	0	0.00
	Matagorda	2	0	0	0	0.00	0	0	0.00
	Maverick	2	9	881	854	29.06	5,744	5,655	89.03
	Mcculloch	3	0	0	0	0.00	0	0	0.00
	Mclennan	2	124	12,275	11,866	437.24	113,109	109,972	3,137.21
	Mcmullen	2	0	0	0	0.00	0	0	0.00
	Medina	2	0	0	0	0.00	0	0	0.00
	Menard	3	0	0	0	0.00	0	0	0.00
	Midland	3	0	0	0	0.00	0	0	0.00
	Milam	2	12	1,144	1,112	33.88	8,396	8,241	154.83
	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	0	0	0	0.00	0	0	0.00
	Nolan	3	0	0	0	0.00	0	0	0.00
	Nueces	2	234	22,918	22,212	755.67	149,334	147,019	2,314.84
	Palo Pinto	3	0	0	0	0.00	0	0	0.00
	Pecos	3	0	0	0	0.00	0	0	0.00
	Potter	4	32	3,082	2,991	96.99	21,366	21,029	336.20
	Presidio	3	0	0	0	0.00	0	0	0.00
	Rains	3	0	0	0	0.00	0	0	0.00
	Reagan	3	2	189	184	5.27	2,059	1,999	59.73
	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
	Refugio	2	0	0	0	0.00	0	0	0.00
	Robertson	2	0	0	0	0.00	0	0	0.00
	Runnels	3	0	0	0	0.00	0	0	0.00
	San Patricio	3	128	12,536	12,150	413.36	81,687	80,421	1,266.24
	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
	Smith	3	171	15,990	15,631	383.34	157,112	153,709	3,402.35

Table 12: 2021 Annual Electricity and Natural Gas Savings from New Multi-family Residences (Continued)

2021 Summary TRY 2018									
	County	Climate Zone	No. of Projected Units (2021)	2018 Base-year Total Annual Elec. Use (MWh/yr)	2021 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)	2021 Total Annual NG Use (Therm/yr)	Total Annual NG Savings (Therm/yr)
Other ERCOT County	Somervell	3	0	0	0	0.00	0	0	0.00
	Starr	2	3	302	291	11.84	1,737	1,711	25.75
	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	377	36,845	35,774	1,145.48	458,030	443,948	14,082.41
	Terrell	3	0	0	0	0.00	0	0	0.00
	Throckmorton	3	0	0	0	0.00	0	0	0.00
	Tom Green	3	0	0	0	0.00	0	0	0.00
	Travis	3	19,848	1,887,448	1,835,465	55,621.68	13,537,885	13,311,302	226,583.50
	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	60	5,786	5,642	154.24	65,222	63,677	1,544.83
	Victoria	2	168	16,194	15,731	495.95	117,185	115,128	2,056.71
	Ward	3	0	0	0	0.00	0	0	0.00
	Washington	2	129	12,299	11,958	364.23	90,254	88,590	1,664.37
	Webb	2	222	21,743	21,073	716.92	141,676	139,480	2,196.13
	Wharton	2	16	1,542	1,498	47.23	11,160	10,965	195.88
	Wichita	3	0	0	0	0.00	0	0	0.00
	Wilbarger	3	0	0	0	0.00	0	0	0.00
	Willacy	2	0	0	0	0.00	0	0	0.00
	Williamson	2	5,599	540,580	525,859	15,750.91	4,737,025	4,627,808	109,217.50
	Wilson	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 County	Armstrong	4	0	0	0	0.00	0	0	0.00
	Bailey	4	0	0	0	0.00	0	0	0.00
	Bowie	3	0	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	0	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
	Gregg	2	108	10,092	9,861	246.81	94,844	92,897	1,947.15
	Hale	4	0	0	0	0.00	0	0	0.00
	Hansford	4	0	0	0	0.00	0	0	0.00
	Hardin	2	16	1,524	1,482	44.24	11,381	11,166	214.92
	Harrison	3	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
	Jasper	2	90	8,573	8,340	249.04	63,988	62,807	1,180.52
	Jefferson	2	150	14,287	13,899	414.95	106,647	104,655	1,991.21
	Lamb	4	2	194	190	4.70	2,657	2,625	32.67
	Lipscomb	4	0	0	0	0.00	0	0	0.00
	Lubbock	3	679	66,328	64,409	2,052.54	824,492	799,280	25,211.47
	Lynn	3	0	0	0	0.00	0	0	0.00
	Marion	3	6	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
	Orange	2	18	1,715	1,668	49.81	12,798	12,561	236.10
	Parmer	4	4	389	380	9.41	5,315	5,249	65.35
	Polk	2	2	190	185	5.53	1,423	1,396	26.87
	Randall	4	22	2,138	2,090	51.73	29,230	28,871	359.41
	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
	Upshur	3	12	1,122	1,096	27.46	10,532	10,312	219.48
	Walker	2	405	38,612	37,543	1,143.51	283,355	278,130	5,225.36
	Wheeler	3	0	0	0	0.00	0	0	0.00
	Yoakum	4	0	0	0	0.00	0	0	0.00
	TOTAL		**86,419**			**243,680**			**1,436,651**

Table 13: 2021 Totalized Annual Electricity Savings by CL Zone from New Multi-family Residences

Electric Power Market	CL Zone	Total Electricity Savings by CL Zone (MWh) [2021-TRY 2018]
ERCOT	Houston (H)	42,421
	North (N)	82,926
	West (W)	1,571
	South (S)	108,466
SPP	-	2,490
SERC	-	5,064
WECC	-	743
Total		243,680

Table 14: 2021 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	6130.84	0.0000183	1.52	0.0000009	0.00	0.0013540	146.86	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6279.22	3.14
	Chambers	0.0232302	985.44	0.0000029	0.24	0.0000001	0.00	0.0002176	23.61	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1009.29	0.50
	Fort Bend	0.0925360	3925.45	0.0000117	0.97	0.0000006	0.00	0.0008669	94.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4020.46	2.01
	Galveston	0.0189140	802.35	0.0000024	0.20	0.0000001	0.00	0.0001772	19.22	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	821.77	0.41
	Harris	0.1374166	5829.32	0.0000174	1.45	0.0000008	0.00	0.0012874	139.64	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5970.41	2.99
	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	297.46	0.0000000	0.00	297.46	0.15
	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	13.72	0.0000000	0.00	13.72	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	4905.66	0.0000000	0.00	4905.66	2.45
	Orange	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.8865417	4489.20	0.0000000	0.00	4489.20	2.24
Dallas/ Fort Worth Area	Collin	0.0000743	3.15	0.0004556	37.78	0.0000220	0.03	0.0000046	0.50	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	41.47	0.02
	Dallas	0.0019090	80.98	0.0117105	971.10	0.0005656	0.89	0.0001195	12.96	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1065.92	0.53
	Denton	0.0066429	281.80	0.0407509	3379.29	0.0019683	3.09	0.0004158	45.10	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3709.27	1.85
	Henderson	0.0001509	6.40	0.0009255	76.75	0.0000447	0.07	0.0000094	1.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	84.25	0.04
	Hood	0.0008451	35.85	0.0051842	429.90	0.0002504	0.39	0.0000529	5.74	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	471.88	0.24
	Hunt	0.0000043	0.18	0.0000263	2.18	0.0000013	0.00	0.0000003	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2.39	0.00
	Tarrant	0.0004188	17.77	0.0025693	213.06	0.0001241	0.19	0.0000262	2.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	233.87	0.12
	Ellis	0.0013349	56.63	0.0081890	679.08	0.0003955	0.62	0.0000835	9.06	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	745.39	0.37
	Johnson	0.0002010	8.53	0.0012332	102.27	0.0000596	0.09	0.0000126	1.36	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	112.25	0.06
	Kaufman	0.0034596	146.76	0.0212228	1759.91	0.0010251	1.61	0.0002165	23.49	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1931.77	0.97
	Parker	0.0005940	25.20	0.0036438	302.16	0.0001760	0.28	0.0000372	4.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	331.67	0.17
	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	132.78	0.0192012	1592.27	0.0009275	1.46	0.0001959	21.25	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1747.76	0.87
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	908.68	908.68	0.45
San Antonio Area	Bexar	0.0253670	1076.09	0.0017108	141.87	0.0000826	0.13	0.2025905	21974.13	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	23192.22	11.60
	Comal	0.0005285	22.42	0.0000356	2.96	0.0000017	0.00	0.0042210	457.83	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	483.21	0.24
	Guadalupe	0.0030546	129.58	0.0002060	17.08	0.0000100	0.02	0.0243949	2646.01	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2792.68	1.40
	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	105.20	0.0001673	13.87	0.0000081	0.01	0.0198060	2148.28	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2267.36	1.13
	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	20.07	0.0000319	2.65	0.0000015	0.00	0.0037782	409.81	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	432.52	0.22
	Travis	0.0046184	195.92	0.0003115	25.83	0.0000150	0.02	0.0368846	4000.72	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	4222.49	2.11
	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	13.37	0.0000000	0.00	0.0000000	0.00	13.37	0.01
	Harrison	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2702671	672.87	0.0000000	0.00	0.0000000	0.00	672.87	0.34
	Rusk	0.0322708	1368.95	0.1979648	16416.33	0.0095620	15.02	0.0020197	219.07	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	18019.38	9.01
	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	179.97	0.0002861	23.73	0.0000138	0.02	0.0338828	3675.12	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	3878.84	1.94
	San Patricio	0.0063692	270.19	0.0004296	35.62	0.0000207	0.03	0.0508668	5517.30	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	5823.14	2.91
Victoria Area	Victoria	0.0016730	70.97	0.0001128	9.36	0.0000054	0.01	0.0133614	1449.25	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1529.59	0.76
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	327.00	0.0005199	43.11	0.0000251	0.04	0.0615620	6677.37	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7047.52	3.52
	Bell	0.0004444	18.85	0.0027262	226.07	0.0001317	0.21	0.0000278	3.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	248.15	0.12
	Bosque	0.0007214	30.60	0.0044257	367.00	0.0002138	0.34	0.0000452	4.90	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	402.84	0.20
	Brazos	0.0005654	23.99	0.0034687	287.64	0.0001675	0.26	0.0000354	3.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	315.73	0.16
	Calhoun	0.0111852	474.49	0.0007544	62.56	0.0000364	0.06	0.0893292	9689.16	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	10226.25	5.11
	Cameron	0.0000231	0.98	0.0000016	0.13	0.0000001	0.00	0.0001843	19.99	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	21.10	0.01
	Cherokee	0.0001844	7.82	0.0011310	93.79	0.0000546	0.09	0.0000115	1.25	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	102.95	0.05
	Coke	0.0000223	0.94	0.0001365	11.32	0.0231815	36.42	0.0000014	0.15	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	48.83	0.02
	Colorado	0.0016158	68.54	0.0001090	9.04	0.0000053	0.01	0.0129041	1399.65	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1477.24	0.74
	Ector	0.0001338	5.67	0.0008206	68.05	0.1393442	218.90	0.0000084	0.91	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	293.54	0.15
	Fayette	0.0204274	866.55	0.0013777	114.24	0.0000665	0.10	0.1631405	17695.16	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	18676.06	9.34
	Freestone	0.0042261	179.27	0.0259247	2149.82	0.0012522	1.97	0.0002645	28.69	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2359.75	1.18
	Frio	0.0097614	414.09	0.0006583	54.59	0.0000318	0.05	0.0779581	8455.79	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	8924.52	4.46
	Goliad	0.0077047	326.84	0.0005196	43.09	0.0000251	0.04	0.0615328	6674.21	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	7044.18	3.52
	Grayson	0.0002857	12.12	0.0017525	145.33	0.0000846	0.13	0.0000179	1.94	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	159.52	0.08
	Grimes	0.0029942	127.02	0.0183678	1523.16	0.0008872	1.39	0.0001874	20.33	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1671.90	0.84
	Hidalgo	0.0140830	597.41	0.0009498	78.76	0.0000459	0.07	0.1124720	12199.36	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	12875.61	6.44
	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	1.98	0.0002865	23.76	0.0486558	76.44	0.0000029	0.32	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	102.50	0.05
	Lamar	0.0031379	133.11	0.0192492	1596.25	0.0009298	1.46	0.0001964	21.30	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1752.13	0.88
	Limestone	0.0231674	982.78	0.1421203	11785.40	0.0068646	10.78	0.0014500	157.27	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	12936.23	6.47
	Llano	0.0001855	7.87	0.0000125	1.04	0.0000006	0.00	0.0014818	160.72	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	169.63	0.08
	McLennan	0.0043688	185.33	0.0268006	2222.45	0.0012945	2.03	0.0002734	29.66	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	2439.47	1.22
	Milam	0.0002486	10.54	0.0000168	1.39	0.0000008	0.00	0.0019850	215.31	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	227.24	0.11
	Mitchell	0.0000072	0.31	0.0000443	3.67	0.0075244	11.82	0.0000005	0.05	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	15.85	0.01
	Nacogdoches	0.0002714	11.51	0.0016647	138.05	0.0000804	0.13	0.0000170	1.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	151.53	0.08
	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	44.08	0.0063745	528.60	0.0003079	0.48	0.0000650	7.05	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	580.22	0.29
	Pecos	0.0000029	0.12	0.0000180	1.50	0.0030637	4.81	0.0000002	0.02	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	6.45	0.00
	Reagan	0.0000002	0.01	0.0000015	0.12	0.0002476	0.39	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.52	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	781.29	0.1129830	9369.17	0.0054573	8.57	0.0011527	125.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	10284.06	5.14
	Scurry	0.0001246	5.29	0.0007646	63.40	0.1298311	203.96	0.0000078	0.85	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	273.50	0.14
	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	0.87	0.0001265	10.49	0.0214790	33.74	0.0000013	0.14	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	45.25	0.02
	Webb	0.0000253	1.07	0.0000017	0.14	0.0000001	0.00	0.0002020	21.91	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	23.12	0.01
	Wharton	0.0006585	27.94	0.0000444	3.68	0.0000021	0.00	0.0052594	570.47	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	602.09	0.30
	Wichita	0.0000051	0.22	0.0000315	2.61	0.0053432	8.39	0.0000003	0.03	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	11.26	0.01
	Wilbarger	0.0008609	36.52	0.0052810	437.93	0.8967472	1408.75	0.0000539	5.84	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	1889.04	0.94
	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	1.09	0.0001578	13.08	0.0267892	42.08	0.0000016	0.17	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	56.43	0.03
Other SPP Counties	Cass	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0127595	31.77	0.0000000	0.00	0.0000000	0.00	31.77	0.02
	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	153.56	0.0000000	0.00	0.0000000	0.00	153.56	0.08
	Hemphill	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0246062	61.26	0.0000000	0.00	0.0000000	0.00	61.26	0.03
	Hutchinson	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0134856	33.57	0.0000000	0.00	0.0000000	0.00	33.57	0.02
	Lamb	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2117054	527.07	0.0000000	0.00	0.0000000	0.00	527.07	0.26
	Lubbock	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0695988	173.28	0.0000000	0.00	0.0000000	0.00	173.28	0.09
	Marion	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0272898	67.94	0.0000000	0.00	0.0000000	0.00	67.94	0.03
	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	0.57	0.0000000	0.00	0.0000000	0.00	0.57	0.00
	Potter	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.2710995	674.94	0.0000000	0.00	0.0000000	0.00	674.94	0.34
	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	109.26	0.0000000	0.00	0.0000000	0.00	109.26	0.05
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	440.54	0.0000000	0.00	440.54	0.22
	San Jacinto	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0000000	0.00	0.0072219	36.57	0.0000000	0.00	36.57	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**	**27622.91**	**0.6960448**	**57719.87**	**1.3354567**	**2097.94**	**0.9887171**	**107241.96**	**1.3648074**	**3397.89**	**2.0110028**	**10183.16**	**1.2223686**	**908.68**	**209172.40**	**104.59**

Energy Savings (MWh)		42,421		82,926		1,571		108,466		2,490		5,064		743	

4.3 2021 Results for New Residential Construction (Single-family and Multi-family)

Table 15 presents the individual and combined annual electricity savings and NOx emissions reductions resulted from the new single-family and multi-family construction in 2021. In addition, Table 15 includes the combined natural gas savings from the new construction for both single-family and multi-family and the corresponding NOx emissions reductions[25].

The total NOx reductions from electricity and natural gas savings from total new single-family and multi-family construction in 2021 are 162.22 tons NOx/year, including 45.78 tons NOx/year (28.22 %) from single-family residential electricity savings, 104.15 tons NOx/year (64.2 %) from multi-family residential electricity savings, and 12.29 tons NOx/year (7.58 %) from natural gas savings from both single-family and multi-family residences. Figure 4-1 through Figure 4-5 show the electricity savings and NOx reductions tabulated in Table 15. Figure 4-1 shows the annual electricity savings by county using a stacked bar chart and Figure 4-2 shows the spatial distribution of the electricity savings by county across the state. Figure 4-3 shows the annual NOx reductions by using a stacked bar chart. Figure 4-4 and Figure 4-5 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 15: 2021 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 Counties	Brazoria	2,940.54	1.73	21.22	3.14	2,961.76	4.87	32,839.94	0.15	5.03
	Chambers	600.82	0.28	0.00	0.50	600.82	0.78	7,928.41	0.04	0.82
	Fort Bend	5,898.68	1.11	2,326.55	2.01	8,225.23	3.12	85,529.18	0.39	3.51
	Galveston	1,632.97	0.23	115.18	0.41	1,748.15	0.64	18,595.44	0.09	0.72
	Harris	12,618.83	1.65	39,370.60	2.99	51,989.43	4.63	340,133.25	1.56	6.20
	Collin	6,396.22	0.01	9,367.66	0.02	15,763.88	0.03	169,522.49	0.78	0.81
	Dallas	4,025.99	0.21	29,874.24	0.53	33,900.23	0.74	293,308.13	1.35	2.09
	Denton	4,720.27	0.73	6,762.26	1.85	11,482.53	2.58	118,286.78	0.54	3.13
	Ellis	1,495.68	0.15	2,763.19	0.37	4,258.86	0.52	41,425.38	0.19	0.71
	Johnson	707.47	0.02	2,320.64	0.06	3,028.11	0.08	27,807.94	0.13	0.21
	Kaufman	740.76	0.38	66.84	0.97	807.60	1.34	9,436.35	0.04	1.39
	Parker	334.11	0.06	112.80	0.17	446.92	0.23	5,971.07	0.03	0.26
	Tarrant	5,845.18	0.05	18,751.34	0.12	24,596.53	0.16	226,332.57	1.04	1.20
	Wise	58.77	0.34	20.57	0.87	79.33	1.22	901.50	0.00	1.22
	Bexar	4,064.46	3.31	22,255.42	11.60	26,319.88	14.91	158,315.47	0.73	15.64
	Freestone	2.41	0.46	0.00	1.18	2.41	1.64	25.16	0.00	1.64
	Howard	0.85	0.04	0.00	0.05	0.85	0.09	12.58	0.00	0.09
	Rusk	1.26	3.53	145.55	9.01	146.81	12.54	1,211.10	0.01	12.54
	Anderson	11.33		438.94		450.27	0.00	3,742.05	0.02	0.02
	El Paso	1,095.89	0.67	743.37	0.45	1,839.26	1.12	24,567.09	0.11	1.24
	Hutchinson	1.71	0.01	0.00	0.02	1.71	0.03	1.68	0.00	0.03
	Liberty	732.96		0.00		732.96	0.00	9,342.16	0.04	0.04
	Montgomery	7,257.31	0.29	4,300.16	0.15	11,557.47	0.43	111,798.82	0.51	0.95
	Navarro	279.23		49.37		328.59	0.00	3,272.56	0.02	0.02
	Panola	4.20		0.00		4.20	0.00	50.03	0.00	0.00
	Rockwall	1,341.23		1,444.74		2,785.97	0.00	30,343.52	0.14	0.14
	Titus	3.37		0.00		3.37	0.00	40.02	0.00	0.00
	Waller	33.83		587.28		621.12	0.00	3,113.22	0.01	0.01
	Andrews	8.47		0.00		8.47	0.00	125.79	0.00	0.00
	Angelina	57.93		0.00		57.93	0.00	690.36	0.00	0.00
	Aransas	141.33		12.92		154.25	0.00	1,557.00	0.01	0.01
	Archer	22.23		6.16		28.39	0.00	306.40	0.00	0.00
	Armstrong	3.43		0.00		3.43	0.00	3.37	0.00	0.00
	Atascosa	41.80	1.01	0.00	3.52	41.80	4.53	550.63	0.00	4.53
	Austin	25.52		0.00		25.52	0.00	324.07	0.00	0.00
	Bandera	0.49		0.00		0.49	0.00	6.61	0.00	0.00
	Bastrop	793.11	0.32	263.05	1.13	1,056.16	1.46	9,205.69	0.04	1.50
	Baylor	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Bee	3.70		0.00		3.70	0.00	45.42	0.00	0.00
	Bell	1,466.54	0.05	5,578.38	0.12	7,044.91	0.17	55,352.40	0.25	0.43
	Blanco	13.30		0.00		13.30	0.00	187.39	0.00	0.00
	Borden	10.69		0.00		10.69	0.00	91.26	0.00	0.00
Other ERCOT Counties	Bosque	5.42	0.08	0.00	0.20	5.42	0.28	56.61	0.00	0.28
	Brazos	997.75	0.06	1,499.27	0.16	2,497.02	0.22	19,519.89	0.09	0.31
	Brewster	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Briscoe	3.00		0.00		3.00	0.00	2.95	0.00	0.00
	Brooks	1.43		0.00		1.43	0.00	12.39	0.00	0.00
	Brown	72.82		91.68		164.50	0.00	1,418.84	0.01	0.01
	Burleson	31.46		11.29		42.75	0.00	451.04	0.00	0.00
	Burnet	488.27		0.00		488.27	0.00	6,878.03	0.03	0.03
	Caldwell	201.88		374.98		576.86	0.00	2,857.71	0.01	0.01
	Calhoun	75.87	1.46	41.33	5.11	117.20	6.57	1,102.58	0.01	6.58
	Callahan	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Cameron	1,182.42	0.00	1,891.13	0.01	3,073.55	0.01	14,899.71	0.07	0.08
	Carson	0.86		0.00		0.86	0.00	0.84	0.00	0.00
	Castro	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Cherokee	7.56	0.02	0.00	0.05	7.56	0.07	90.05	0.00	0.07
	Childress	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Clay	1.06		0.00		1.06	0.00	11.22	0.00	0.00
	Coke	1.34	0.02	0.00	0.02	1.34	0.04	18.84	0.00	0.04
	Coleman	2.53		0.00		2.53	0.00	31.40	0.00	0.00
	Collingsworth	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Colorado	8.90	0.21	0.00	0.74	8.90	0.95	113.05	0.00	0.95
	Comal	2,032.76	0.07	1,764.58	0.24	3,797.34	0.31	35,083.92	0.16	0.47
	Comanche	0.60		0.00		0.60	0.00	6.29	0.00	0.00
	Concho	0.45		0.00		0.45	0.00	5.95	0.00	0.00
	Cooke	22.29		10.27		32.55	0.00	385.00	0.00	0.00
	Coryell	55.97		528.92		584.89	0.00	4,379.94	0.02	0.02
	Cottle	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Crane	0.85		0.00		0.85	0.00	13.28	0.00	0.00
	Crockett	8.51		0.00		8.51	0.00	113.03	0.00	0.00
	Crosby	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Culberson	0.41		56.69		57.10	0.00	493.69	0.00	0.00
	Dawson	0.00		241.83		241.83	0.00	2,970.42	0.01	0.01
	De Witt	6.79		0.00		6.79	0.00	83.28	0.00	0.00
	Deaf Smith	0.86		0.00		0.86	0.00	0.84	0.00	0.00
	Delta	6.64		0.00		6.64	0.00	78.53	0.00	0.00
	Dickens	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Dimmit	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Donley	2.57		0.00		2.57	0.00	2.53	0.00	0.00
	Duval	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Eastland	6.08		15.19		21.27	0.00	258.28	0.00	0.00
	Ector	581.14	0.12	86.61	0.15	667.75	0.27	9,613.72	0.04	0.31
	Edwards	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Erath	21.28		36.46		57.74	0.00	698.54	0.00	0.00

Table 15: 2021 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	Falls	6.02		0.00		6.02	0.00	62.90	0.00	0.00
	Fannin	21.34		35.93		57.27	0.00	636.63	0.00	0.00
	Fayette	6.53	2.67	0.00	9.34	6.53	12.01	82.90	0.00	12.01
	Fisher	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
	Foard	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Franklin	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Frio	5.29	1.28	0.00	4.46	5.29	5.74	69.70	0.00	5.74
	Garza	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Gillespie	41.88		0.00		41.88	0.00	589.94	0.00	0.00
	Glasscock	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Goliad	25.91	1.01	0.00	3.52	25.91	4.53	317.97	0.00	4.53
	Gonzales	8.96		0.00		8.96	0.00	117.99	0.00	0.00
	Gray	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Grayson	441.95	0.03	297.71	0.08	739.66	0.11	8,601.16	0.04	0.15
	Grimes	53.42	0.33	5.65	0.84	59.07	1.16	704.09	0.00	1.17
	Guadalupe	911.53	0.40	405.18	1.40	1,316.70	1.80	13,914.60	0.06	1.86
	Hale	11.14	0.07	0.00	0.08	11.14	0.14	10.94	0.00	0.14
	Hall	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Hamilton	11.43		7.05		18.49	0.00	170.10	0.00	0.00
	Hardeman	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Haskell	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Hays	2,277.79	0.06	2,325.98	0.22	4,603.77	0.28	41,561.16	0.19	0.47
	Henderson	99.54	0.02	4.48	0.04	104.02	0.06	1,357.49	0.01	0.06
	Hidalgo	3,641.23	1.84	4,781.12	6.44	8,422.36	8.28	43,616.46	0.20	8.48
	Hill	63.79		21.16		84.95	0.00	818.50	0.00	0.00
	Hood	105.48	0.09	156.48	0.24	261.96	0.33	2,898.90	0.01	0.34
	Hopkins	22.27		208.23		230.50	0.00	2,349.15	0.01	0.01
	Houston	0.00		6.82		6.82	0.00	56.07	0.00	0.00
	Hunt	479.41	0.00	51.33	0.00	530.74	0.00	6,541.30	0.03	0.03
	Irion	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Jack	0.51		0.00		0.51	0.00	5.96	0.00	0.00
	Jackson	1.23		0.00		1.23	0.00	15.14	0.00	0.00
	Jeff Davis	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
	Jim Wells	3.37		0.00		3.37	0.00	36.13	0.00	0.00
	Jones	0.51		0.00		0.51	0.00	5.96	0.00	0.00
	Karnes	43.06		0.00		43.06	0.00	562.18	0.00	0.00
	Kendall	188.25		0.00		188.25	0.00	2,558.15	0.01	0.01
	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
	Kerr	48.29		0.00		48.29	0.00	680.17	0.00	0.00
	Kimble	0.45		0.00		0.45	0.00	5.95	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
	Kleberg	17.85		61.62		79.48	0.00	333.91	0.00	0.00
	Knox	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	La Salle	2.94		0.00		2.94	0.00	27.76	0.00	0.00
	Lamar	13.49	0.34	125.96	0.88	139.46	1.22	1,421.70	0.01	1.23
	Lampasas	27.68		14.10		41.79	0.00	390.52	0.00	0.00
	Lavaca	7.71		0.00		7.71	0.00	88.14	0.00	0.00
	Lee	14.77		0.00		14.77	0.00	209.10	0.00	0.00
	Leon	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Limestone	4.81	2.53	0.00	6.47	4.81	9.00	50.32	0.00	9.00
	Live Oak	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Llano	122.19	0.02	36.43	0.08	158.62	0.11	1,869.65	0.01	0.12
	Loving	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Lubbock	1,373.61	0.07	2,052.54	0.09	3,426.14	0.16	42,311.90	0.19	0.36
	Lynn	1.01		0.00		1.01	0.00	12.56	0.00	0.00
	Madison	3.56		0.00		3.56	0.00	45.22	0.00	0.00
	Martin	5.93		13.71		19.64	0.00	196.23	0.00	0.00
	Mason	3.94		0.00		3.94	0.00	55.52	0.00	0.00
	Matagorda	312.12		0.00		312.12	0.00	3,830.74	0.02	0.02
	Maverick	92.57		29.06		121.64	0.00	963.54	0.00	0.00
	Mcculloch	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Mclennan	585.53	0.48	437.24	1.22	1,022.77	1.70	9,256.97	0.04	1.74
	Mcmullen	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Medina	14.23		0.00		14.23	0.00	187.39	0.00	0.00
	Menard	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Midland	363.16		0.00		363.16	0.00	5,396.46	0.02	0.02
	Milam	7.86	0.03	33.88	0.11	41.74	0.15	236.59	0.00	0.15
	Mills	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	0.01	0.00	0.00	0.01
	Montague	10.43		0.00		10.43	0.00	130.87	0.00	0.00
	Motley	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Nacogdoches	12.17	0.03	0.00	0.08	12.17	0.11	145.07	0.00	0.11
	Nolan	0.51		0.00		0.51	0.00	5.96	0.00	0.00
	Nueces	1,154.90	0.55	755.67	1.94	1,910.57	2.49	14,714.38	0.07	2.56
	Oldham	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Palo Pinto	6.59	0.11	0.00	0.29	6.59	0.40	77.47	0.00	0.40
	Parmer	3.43		9.41		12.83	0.00	68.72	0.00	0.00
	Pecos	5.83	0.00	0.00	0.00	5.83	0.01	77.33	0.00	0.01
	Potter	357.75	0.29	96.99	0.34	454.74	0.63	4,322.59	0.02	0.65
	Presidio	3.58		0.00		3.58	0.00	47.59	0.00	0.00
	Rains	11.85		0.00		11.85	0.00	140.23	0.00	0.00

Table 15: 2021 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	Randall	55.68		51.73		107.41	0.00	414.13	0.00	0.00
	Reagan	0.42	0.00	5.27	0.00	5.69	0.00	66.37	0.00	0.00
	Real	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Red River	8.85		0.00		8.85	0.00	105.05	0.00	0.00
	Reeves	12.27		0.00		12.27	0.00	182.40	0.00	0.00
	Refugio	20.36		0.00		20.36	0.00	249.83	0.00	0.00
	Roberts	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Robertson	18.40	2.01	0.00	5.14	18.40	7.16	233.63	0.00	7.16
	Runnels	2.69		0.00		2.69	0.00	35.69	0.00	0.00
	San Patricio	334.49	0.83	413.36	2.91	747.85	3.74	4,857.48	0.02	3.77
	San Saba	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
	Scurry	2.25	0.11	0.00	0.14	2.25	0.25	19.21	0.00	0.25
	Shackelford	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Smith	306.06		383.34		689.39	0.00	7,453.86	0.03	0.03
	Somervell	0.52		0.00		0.52	0.00	6.63	0.00	0.00
	Starr	0.75		11.84		12.60	0.00	32.61	0.00	0.00
	Stephens	2.03		0.00		2.03	0.00	23.84	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
	Swisher	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Taylor	255.90		1,145.48		1,401.38	0.00	17,091.85	0.08	0.08
	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
	Tom Green	149.21		0.00		149.21	0.00	1,980.96	0.01	0.01
	Travis	4,534.89	0.60	55,621.68	2.11	60,156.57	2.71	290,463.85	1.34	4.05
	Upton	0.42		0.00		0.42	0.00	6.64	0.00	0.00
	Uvalde	12.65		0.00		12.65	0.00	166.57	0.00	0.00
	Val Verde	81.67		0.00		81.67	0.00	1,075.78	0.00	0.00
	Van Zandt	10.43		154.24		164.67	0.00	1,668.23	0.01	0.01
	Victoria	111.65	0.22	495.95	0.76	607.59	0.98	3,426.99	0.02	1.00
	Walker	391.15		1,143.51		1,534.66	0.00	10,191.92	0.05	0.05
	Ward	0.00	0.02	0.00	0.02	0.00	0.04	0.00	0.00	0.04
Other TEXAS Counties	Washington	112.77		364.23		477.00	0.00	3,096.31	0.01	0.01
	Webb	1,074.14	0.00	716.92	0.01	1,791.06	0.01	12,343.14	0.06	0.07
	Wharton	151.12	0.09	47.23	0.30	198.36	0.39	2,050.68	0.01	0.40
	Wheeler	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Wichita	76.74	0.00	0.00	0.01	76.74	0.01	813.31	0.00	0.01
	Wilbarger	1.06	0.78	0.00	0.94	1.06	1.73	11.22	0.00	1.73
	Willacy	35.33		0.00		35.33	0.00	322.34	0.00	0.00
	Williamson	4,867.84		15,750.91		20,618.75	0.00	171,778.76	0.79	0.79
	Wilson	78.51		0.00		78.51	0.00	1,034.13	0.00	0.00
	Winkler	0.85		0.00		0.85	0.00	12.58	0.00	0.00
	Wood	8.22		9.15		17.38	0.00	167.99	0.00	0.00
	Young	2.53	0.02	0.00	0.03	2.53	0.05	29.80	0.00	0.05
	Zapata	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Zavala	2.20		0.00		2.20	0.00	20.82	0.00	0.00
	Bailey	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Bowie	96.56		0.00		96.56	0.00	1,145.59	0.01	0.01
	Camp	1.69		0.00		1.69	0.00	20.01	0.00	0.00
	Cass	2.95	0.01	0.00	0.02	2.95	0.03	35.02	0.00	0.03
	Cochran	18.42		0.00		18.42	0.00	18.10	0.00	0.00
	Dallam	2.57		0.00		2.57	0.00	2.53	0.00	0.00
	Gaines	1.27		0.00		1.27	0.00	18.87	0.00	0.00
	Gregg	107.47	0.01	246.81	0.01	354.28	0.01	3,260.40	0.01	0.03
	Hansford	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Hardin	256.65	0.01	44.24	0.01	300.89	0.02	3,614.13	0.02	0.04
	Harrison	48.05	0.29	0.00	0.34	48.05	0.62	587.10	0.00	0.63
	Hartley	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Hemphill	0.00	0.03	0.00	0.03	0.00	0.06	0.00	0.00	0.06
	Hockley	7.28		0.00		7.28	0.00	7.16	0.00	0.00
	Hudspeth	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Jasper	40.61		249.04		289.65	0.00	1,718.04	0.01	0.01
	Jefferson	435.15	4.71	414.95	2.45	850.10	7.17	7,752.46	0.04	7.20
	Lamb	0.00	0.22	4.70	0.26	4.70	0.49	32.67	0.00	0.49
	Lipscomb	0.43		0.00		0.43	0.00	0.42	0.00	0.00
	Marion	2.53	0.03	0.00	0.03	2.53	0.06	30.90	0.00	0.06
	Moore	2.14		0.00		2.14	0.00	2.10	0.00	0.00
	Morris	1.69	0.00	0.00	0.00	1.69	0.00	20.01	0.00	0.00
	Newton	0.00	0.42	0.00	0.22	0.00	0.64	0.00	0.00	0.64
	Ochiltree	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	Orange	109.24	4.31	49.81	2.24	159.05	6.56	1,682.09	0.01	6.56
	Polk	547.61		5.53		553.14	0.00	7,279.53	0.03	0.03
	Sabine	0.00		0.00		0.00	0.00	0.00	0.00	0.00
	San Augustine	2.52		0.00		2.52	0.00	30.02	0.00	0.00
	San Jacinto	341.53	0.04	0.00	0.02	341.53	0.05	4,353.11	0.02	0.07
	Shelby	0.42		0.00		0.42	0.00	5.00	0.00	0.00
	Sherman	6.42		0.00		6.42	0.00	6.31	0.00	0.00
	Terry	0.50		0.00		0.50	0.00	6.28	0.00	0.00
	Trinity	2.21		0.00		2.21	0.00	32.34	0.00	0.00
	Tyler	5.14		0.00		5.14	0.00	68.14	0.00	0.00
	Upshur	10.51		27.46		37.97	0.00	340.65	0.00	0.00
	Yoakum	0.00	0.05	0.00	0.05	0.00	0.10	0.00	0.00	0.10
	TOTAL	**99,102.77**	**45.78**	**243,679.79**	**104.15**	**342,782.56**	**149.93**	**2,672,418.25**	**12.29**	**162.22**

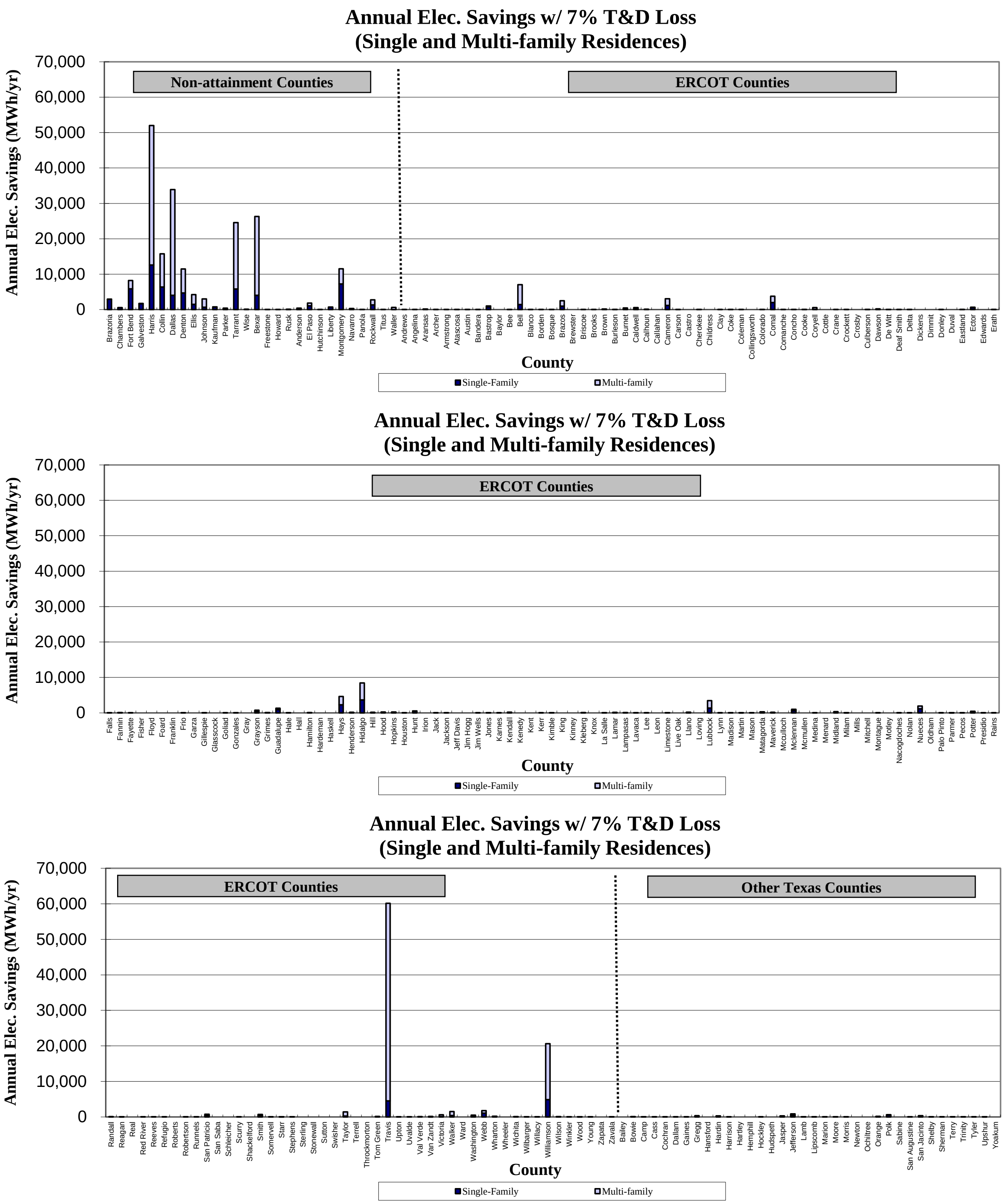


Figure 4-1: 2021 Annual Electricity Savings by County from New Single-family and Multi-family Residences

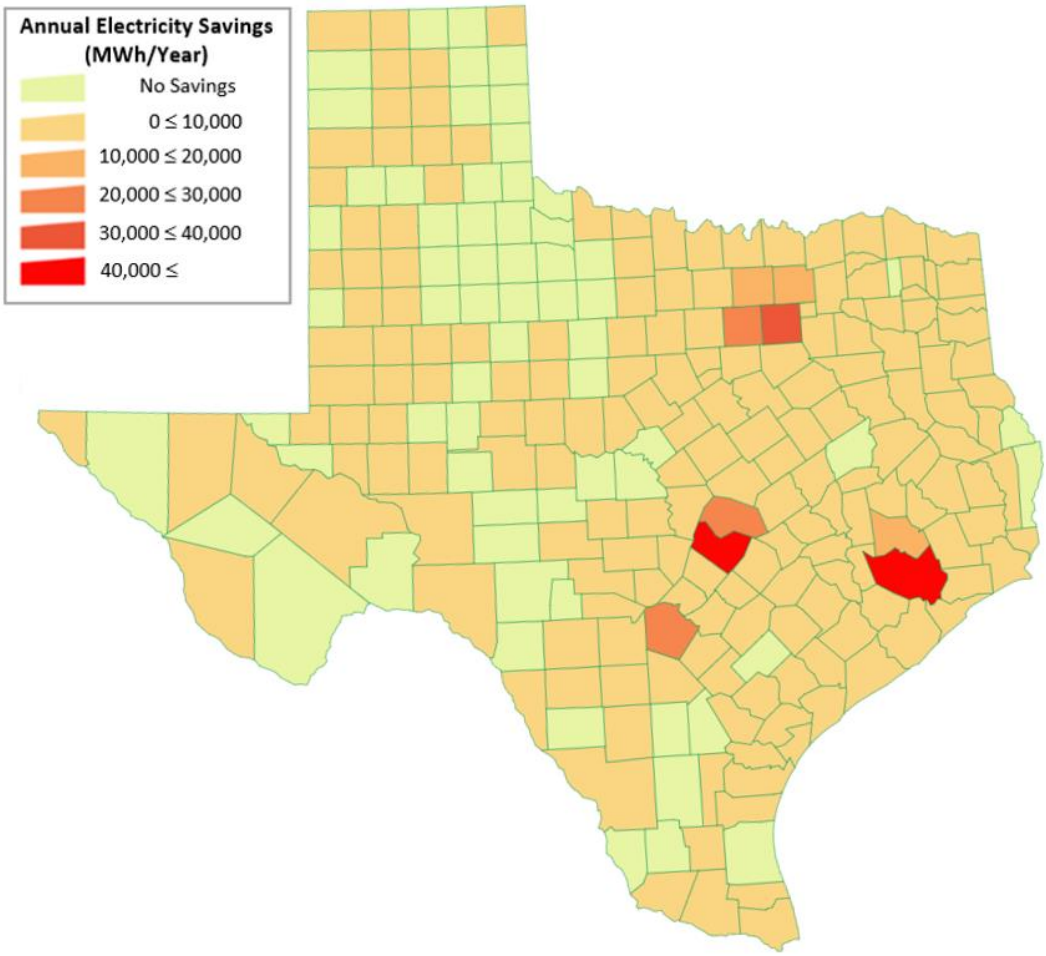


Figure 4-2: Map of 2021 Annual Electricity Savings by County from New Single-family and Multi-family Residences

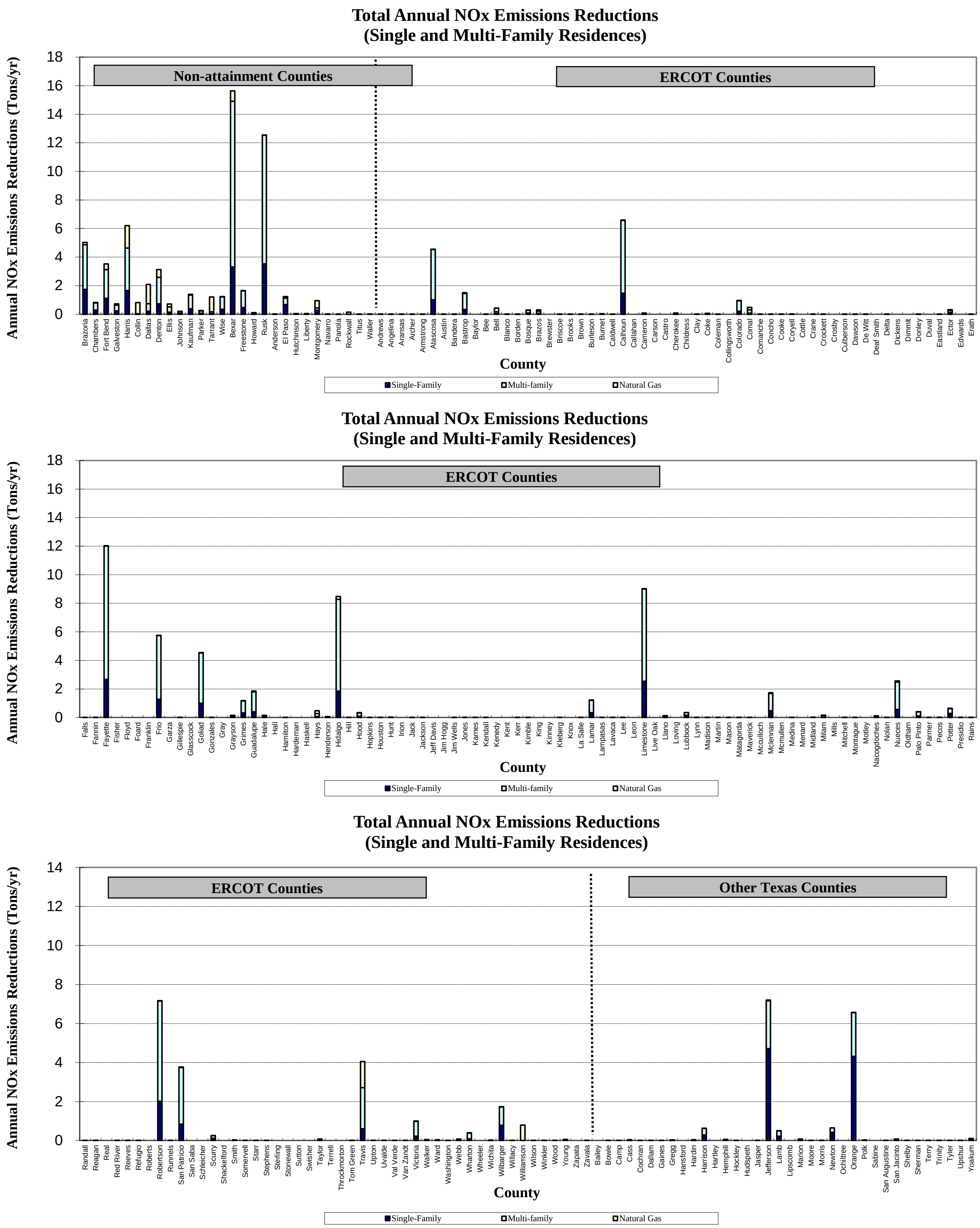


Figure 4-3: 2021 Annual NOx Reductions by County from New Single-family and Multi-family Residences

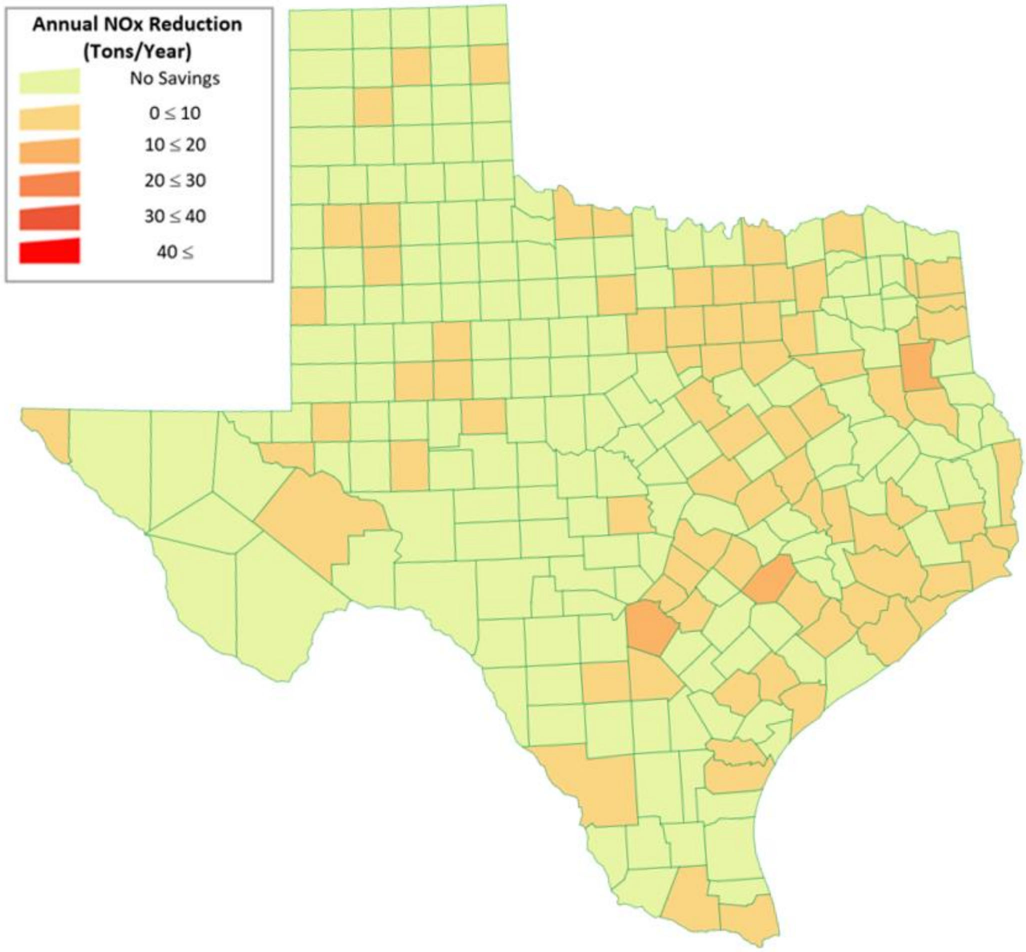


Figure 4-4: Map of 2021 Annual NOx Reductions from Electricity by County from New Single-family and Multi-family Residences

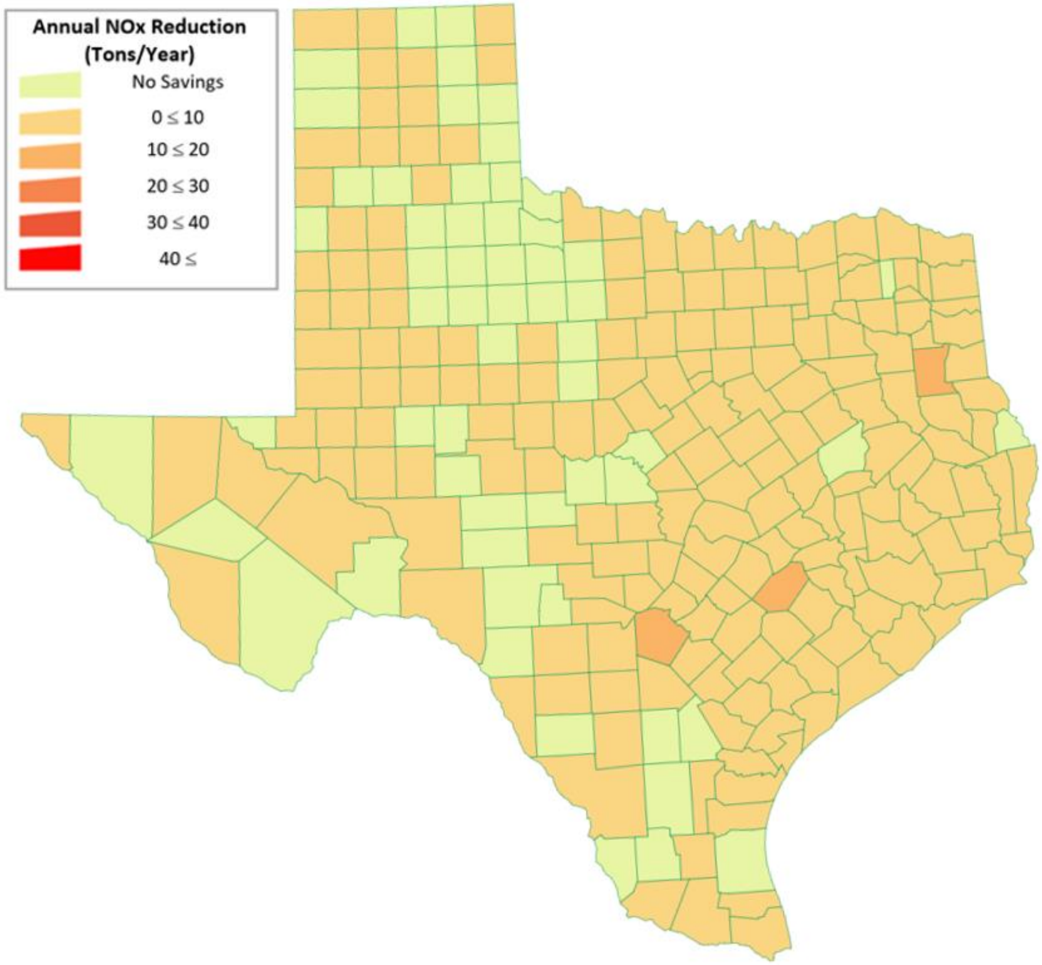


Figure 4-5: Map of 2021 Annual NOx Reductions from Electricity and Natural Gas by County from New Single-family and Multi-family Residences

4.4 2021 Results for Commercial Construction

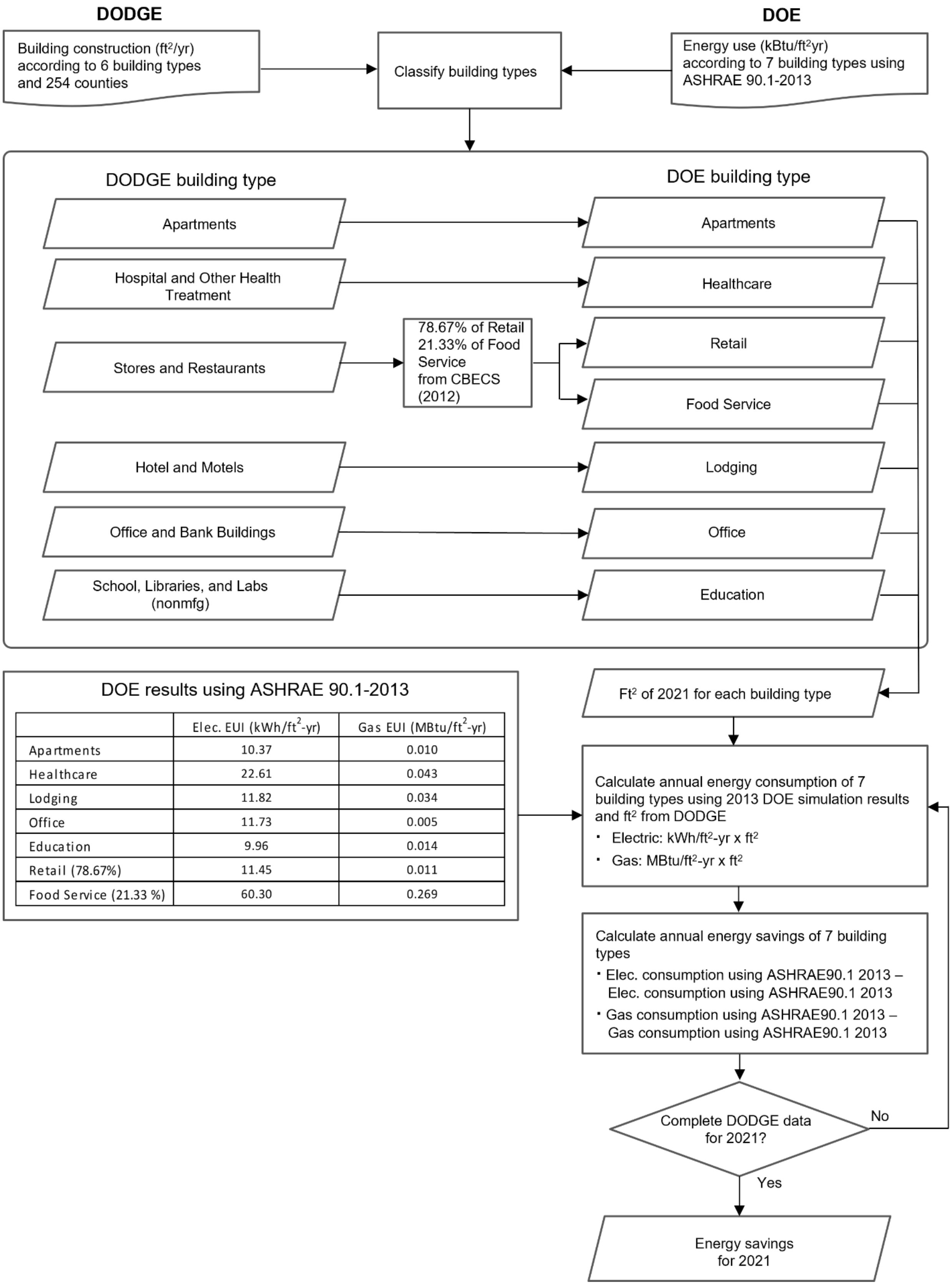
This section reports the calculated energy savings and emissions reductions from new commercial construction in 2021 that was built to meet ASHRAE Standard 90.1-2013.

To determine the energy savings and emissions reductions from new commercial construction in all counties in Texas, including the 28 non-attainment counties, data from two sources (i.e., Dodge and USDOE) were merged into one analysis as shown in Figure 4-6. Beginning in the upper left of Figure 4-6, 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 4-6 and Table 16 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 17 (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 4-7 for all building types and in Figure 4-8 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 the year of 2021 provided square footage of new commercial construction per county in Texas. To prepare the Dodge data for 2021, the ESL used the 2019 Dodge data (Dodge 2019) and the Dodge report for 2021 (Dodge 2022). The Dodge report provided the total construction cost and percent increase and decrease for new commercial buildings and multi-family housing construction in U.S. metropolitan areas from the 2019 to 2021. Using this information, the ESL estimated that an 8% commercial construction decrease had occurred in Texas in 2021 from the year of 2019. As a result, new commercial construction in 2021, that was categorized into seven DOE building types, is shown in Figure 4-7 for all building types and in Figure 4-8 for each building types.

In addition, the commercial energy savings for 2021 were estimated against the baseline year of 2018. Therefore, the annual energy savings for new commercial construction in 2021 were not generated as shown in Table 18 since Texas has been complying with the ASHRAE Standard 90.1-2013 as the commercial code in both the 2018 and 2021.



	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 4-6: Calculation Method for 2021 Energy Savings from New Commercial Buildings

Table 16: 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 17: 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	

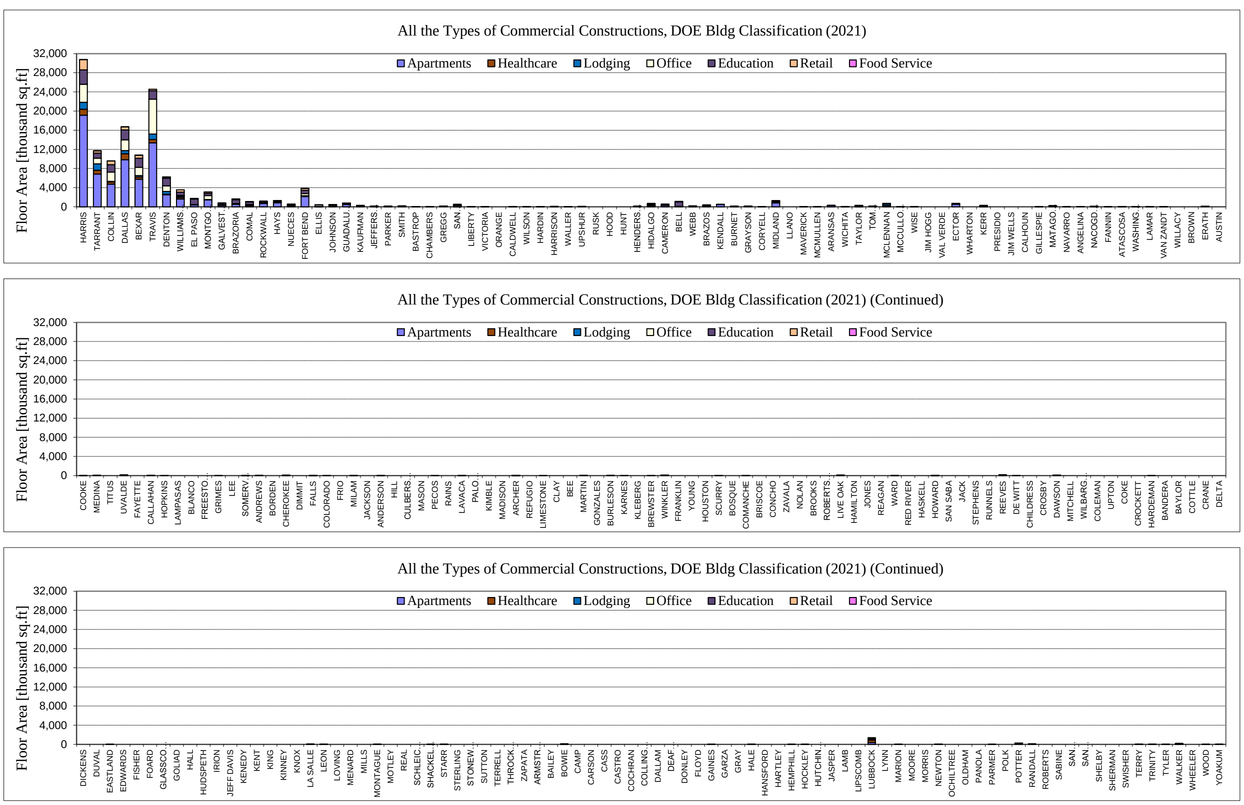
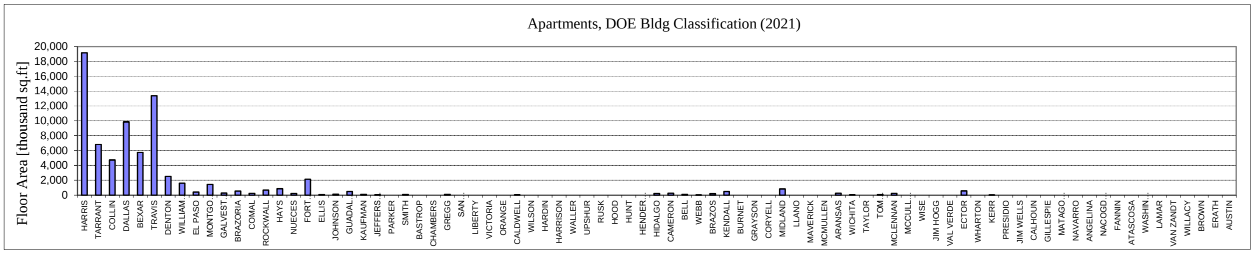
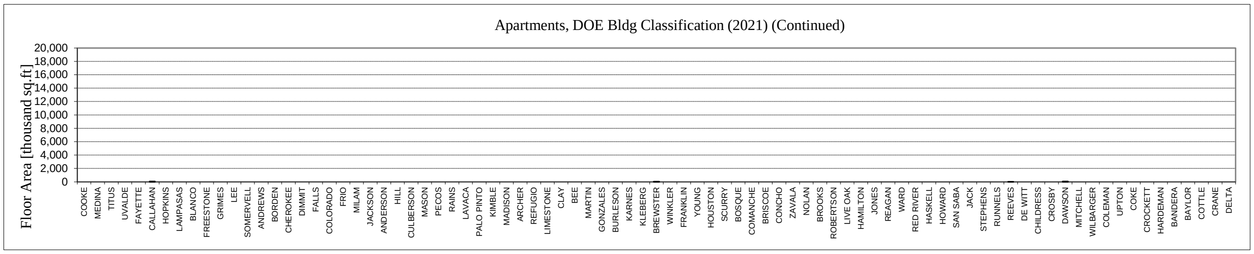
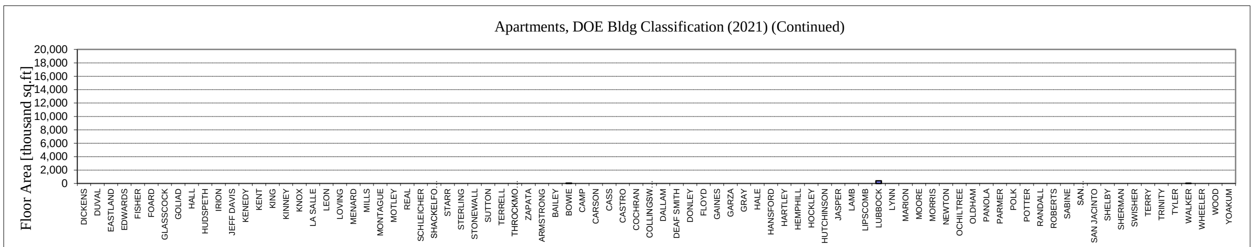
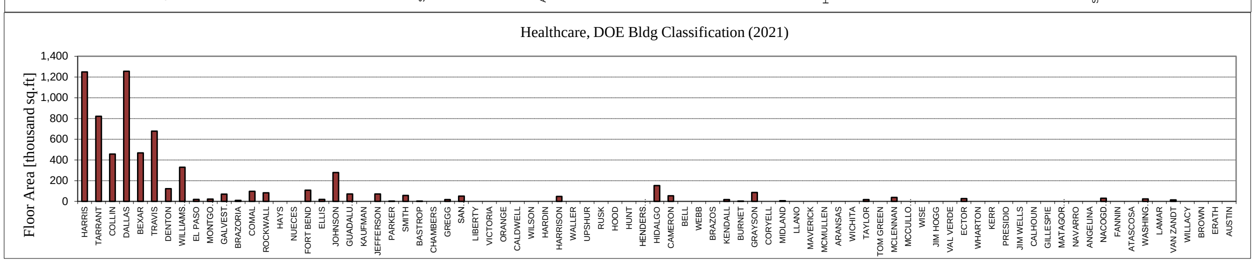


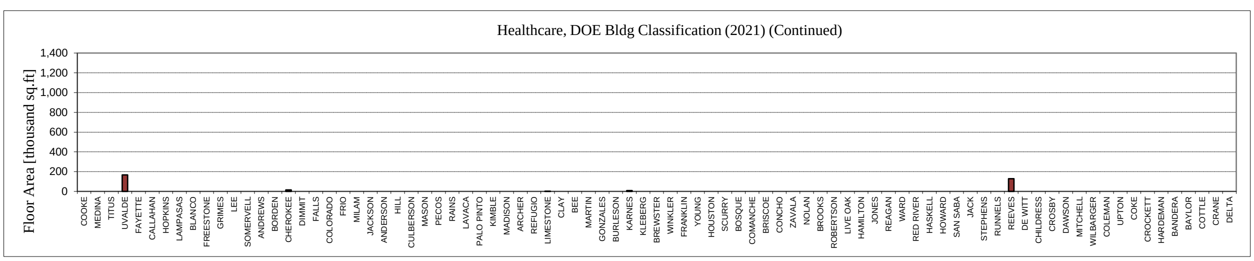
Figure 4-7: All the Types of 2021 New Commercial Building Construction











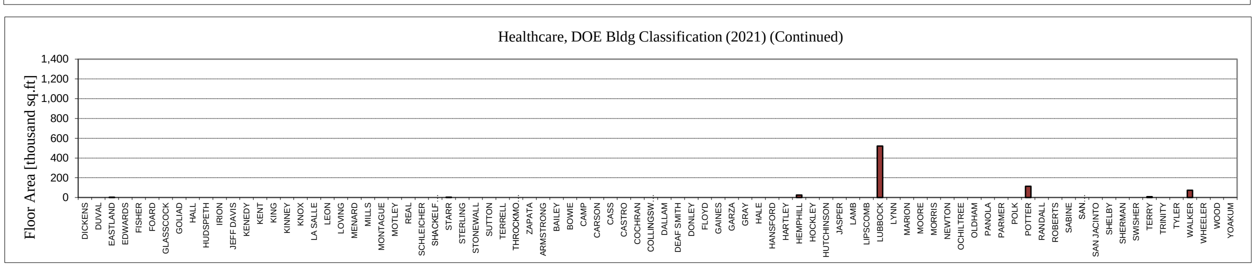
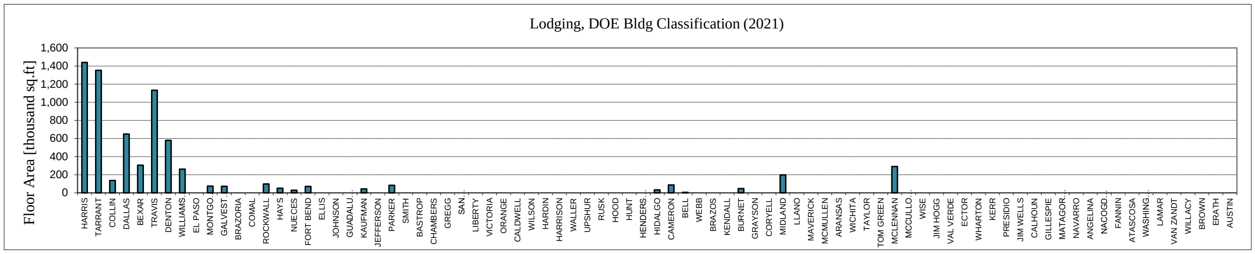
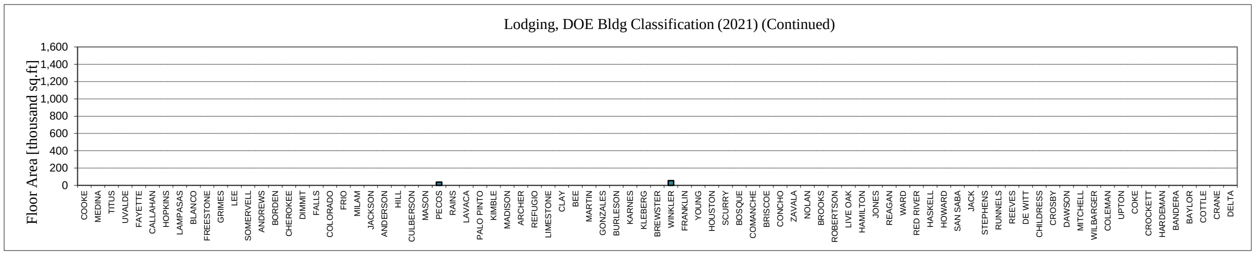
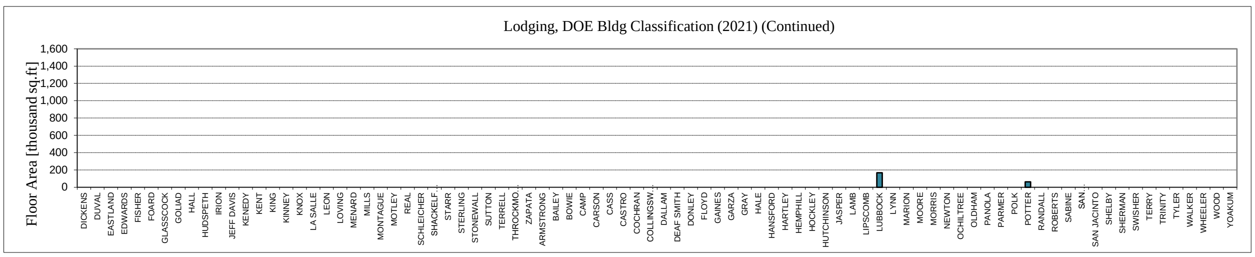
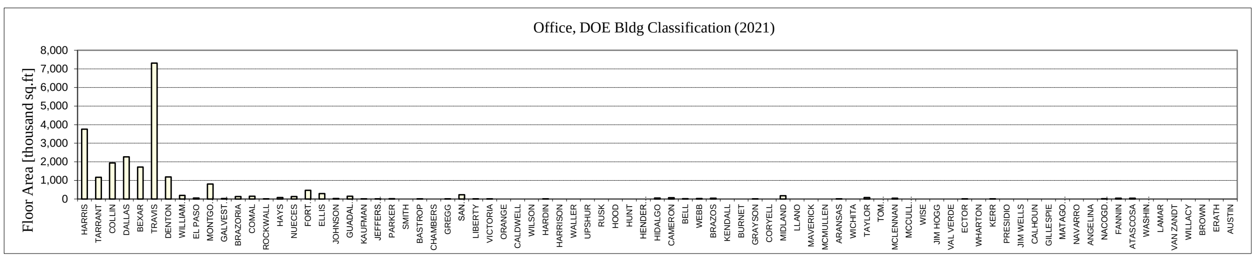


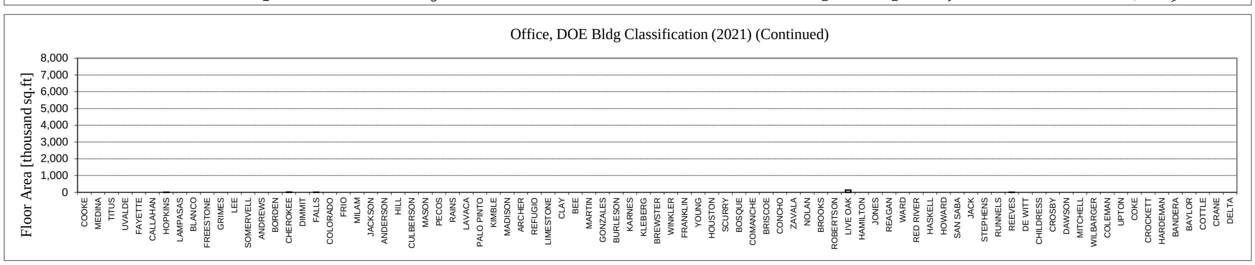
Figure 4-8: 2021 New Commercial Building Construction by Type











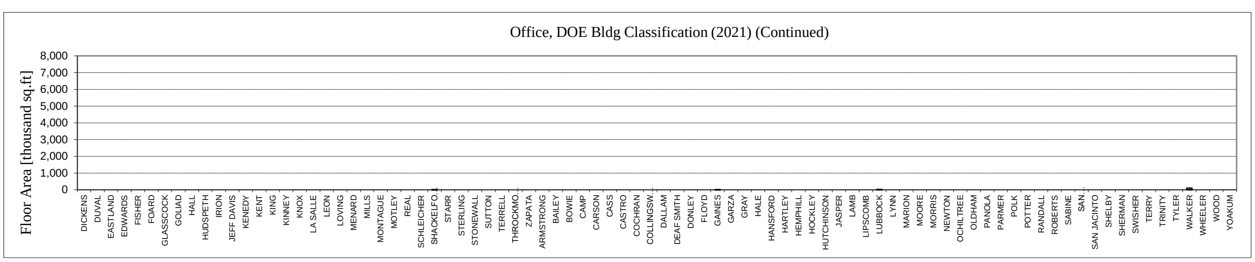
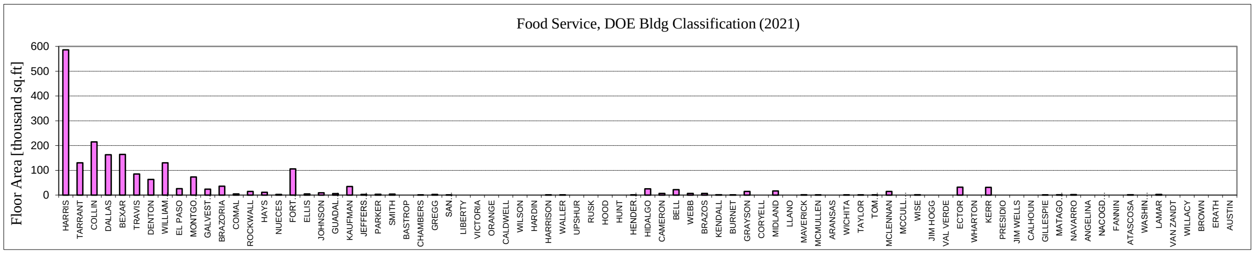
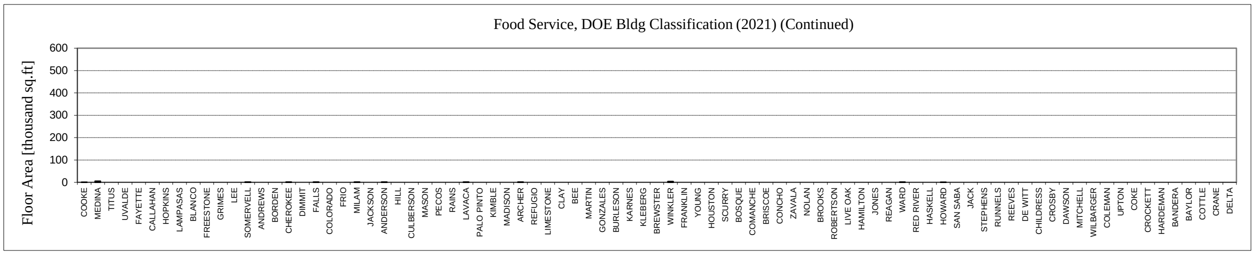


Figure 4-8: 2021 New Commercial Building Construction by Type (Continued)

Figure 4-8: 2021 New Commercial Building Construction by Type (Continued)





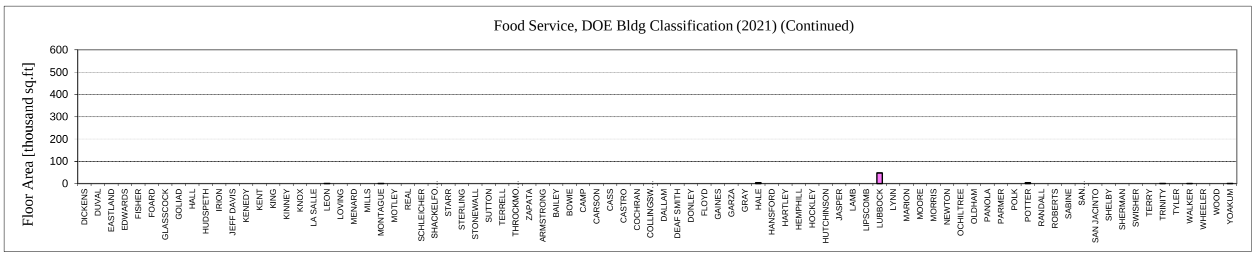


Figure 4-8: 2021 New Commercial Building Construction by Type (Continued)

Table 18: 2021 Totalized Annual Electricity Savings by CL Zone from New Commercial Construction

Electric Power Market	CL Zone	Total Electricity Savings by CL Zone (MWh) [2021-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 2026 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 2021 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 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 - 2018) (Baltazar et al., 2019 - 2021).

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 2021).

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 2021.

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 2021) 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 2021 and integrated through 2026 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 19 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 19 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 5-1 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[26]. 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 2022).

The SECO electricity savings were submitted as annual savings by project[27]. 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.

[26] 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.
[27] 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.

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

Table 19: 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 14 Single Family	SEER 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**

Notes: * SEER 14 growth factor assumes a seventeen-year life. Renewable projects have different growth factors for each type.

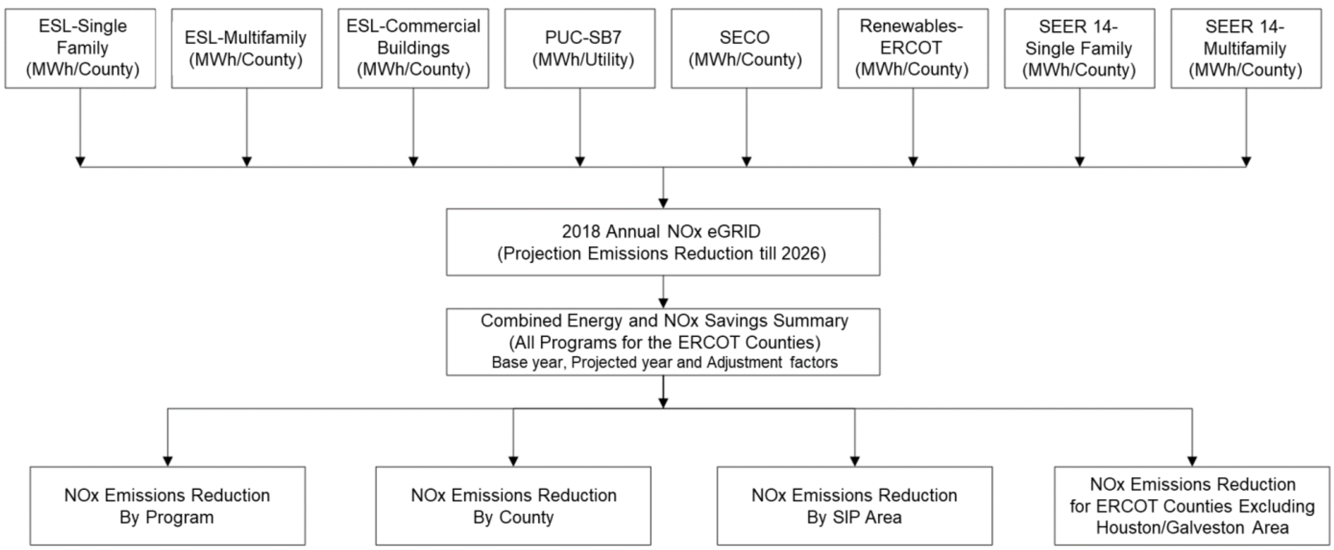


Figure 5-1: Process Flow Diagram of the NOx Emissions Reduction Calculations

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.

5.3.1 Single-Family, Multi-family, and Commercial Buildings

The calculation of the annual electricity savings for single- and multi-family residential construction included the savings from code-compliant housing in all the counties in ERCOT region as well as other counties in Texas, which includes the 28 non-attainment counties. From 2018 to 2021, based on year 2018, the annual electricity savings were calculated for new residential construction in all the counties in Texas. These savings were then tabulated by county and program. Using the calculated values through 2021, savings were then projected to 2026 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 2021 through 2026[28]. The projected energy savings through 2026, 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[29].

For the 2021 annual NOx emissions calculations, the US EPA's 2018 eGRID was used. 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. Figure 5-2 and Figure 5-3 show annual and OSP electricity savings from new single-family residences from 2020 to 2026. Figure 5-4 and Figure 5-5 also show annual and OSP NOx reductions from new single-family residences from 2020 to 2026. In addition, Figure 5-6 and Figure 5-7 show annual and OSP electricity savings from new multi-family residences from 2020 to 2026. Figure 5-8 and Figure 5-9 also show annual and OSP NOx reductions from new multi-family residences from 2020 to 2026.

From 2018 to 2021, based on the year 2018, the annual electricity savings were calculated for new commercial construction by county[30]. Using the calculated savings through 2021, savings were then projected to 2026 by incorporating the different adjustment factors mentioned above[31]. In the projected annual electricity savings, it was assumed that the same 2021 amount of electricity savings would be achieved for each year through 2026. Finally, the projected energy saving numbers through 2026, by county, were allocated into the appropriate CL zones.

[28] This would include the appropriate discount and degradation factors for each year.
[29] Haberl et al., 2020, Annual Report Volume I, pp. 60.
[30] These savings include new construction in office, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 2011), using energy savings from the US DOE's report (USDOE 2014), and data from CBECS (1995 - 2012) and Dodge (2022).
[31] This also includes the appropriate discount and degradation factors for each year.

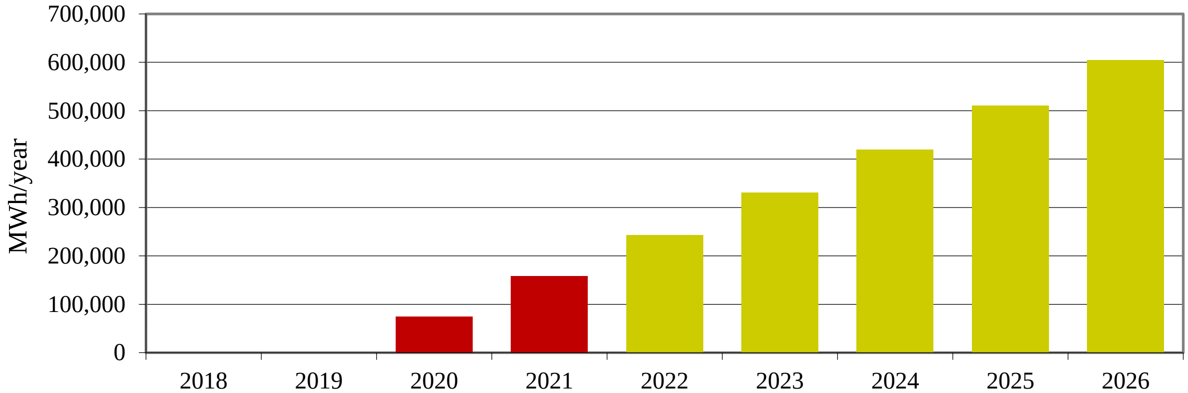


Figure 5-2: Actual and Projected Annual Savings from New Single-family Residences from 2020 to 2026 Based on the Year 2018.

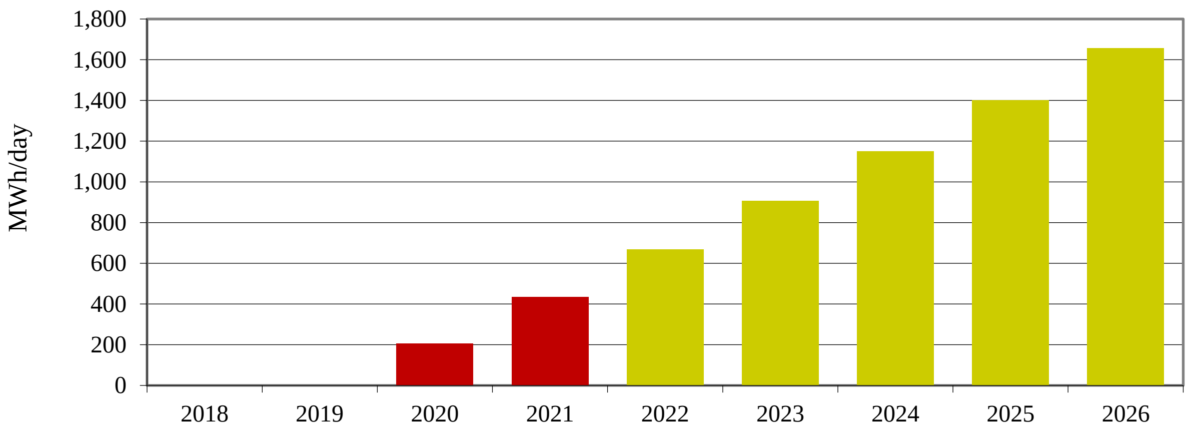


Figure 5-3: Actual and Projected OSP Daily Average Savings from New Single-family Residences from 2020 to 2026 Based on the Year 2018.

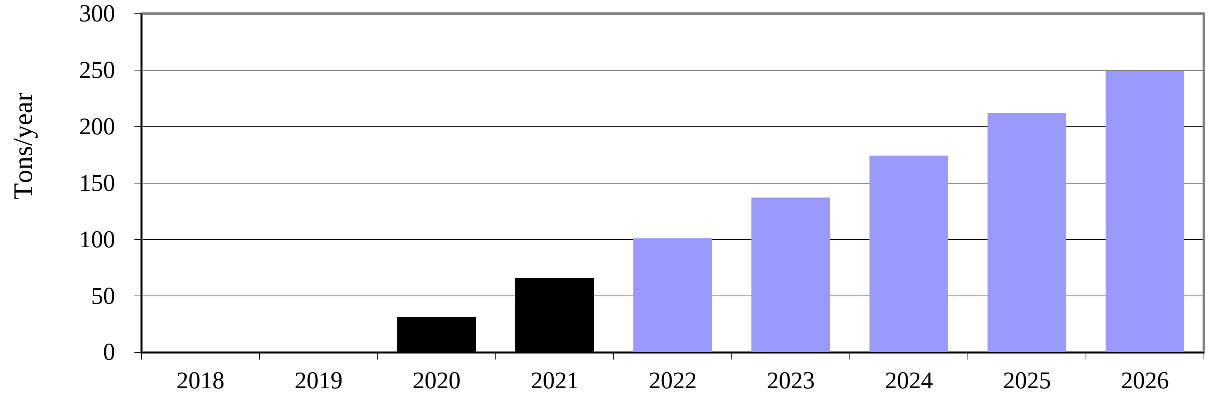


Figure 5-4: Actual and Projected Annual NOx reduction from New Single-family Residences from 2020 to 2026 Based on the Year 2018.

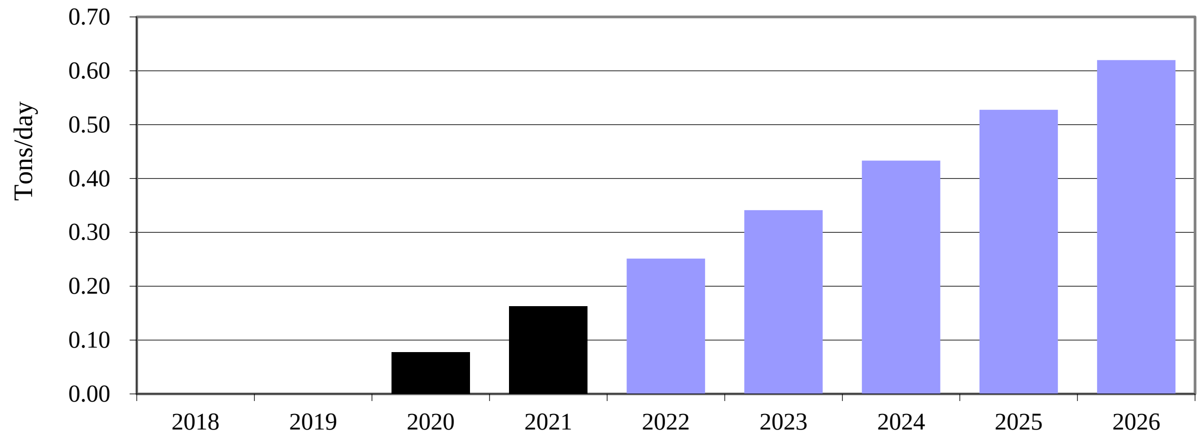


Figure 5-5: Actual and Projected OSP Average Daily NOx reduction from New Single-family Residences from 2020 to 2026 Based on the Year 2018.

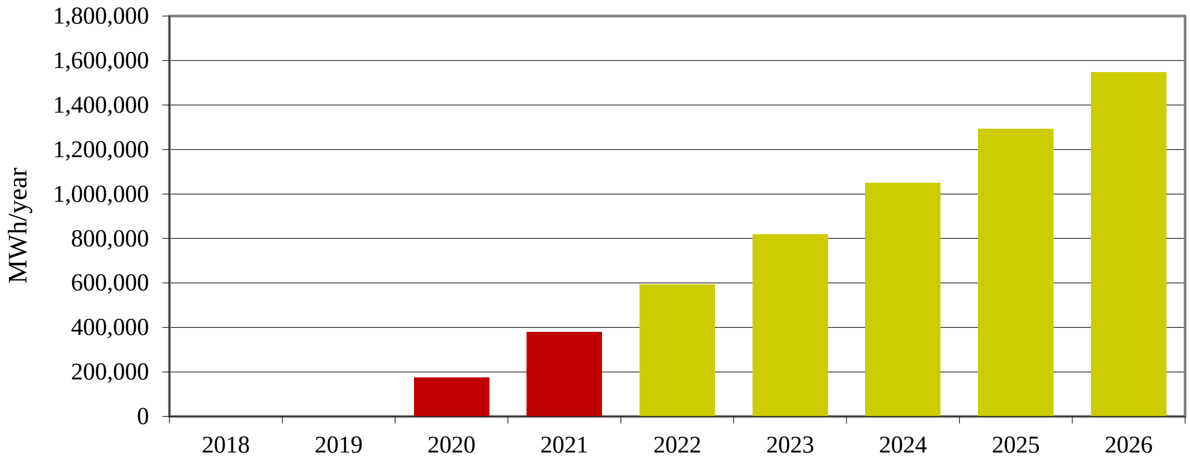


Figure 5-6: Actual and Projected Annual Savings from New Multi-family Residences from 2020 to 2026 Based on the Year 2018.

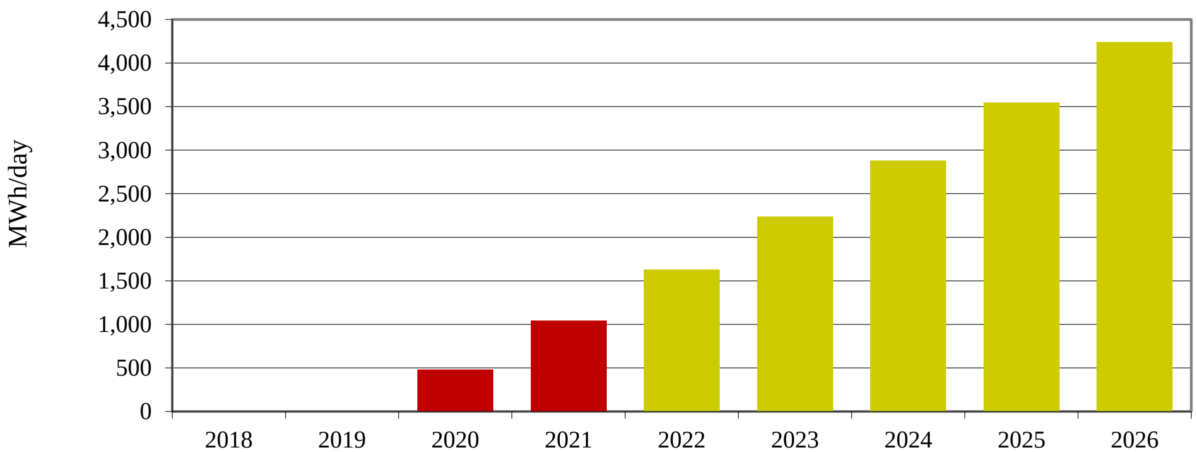


Figure 5-7: Actual and Projected OSP Daily Average Savings from New Multi-family Residences from 2020 to 2026 Based on the Year 2018.

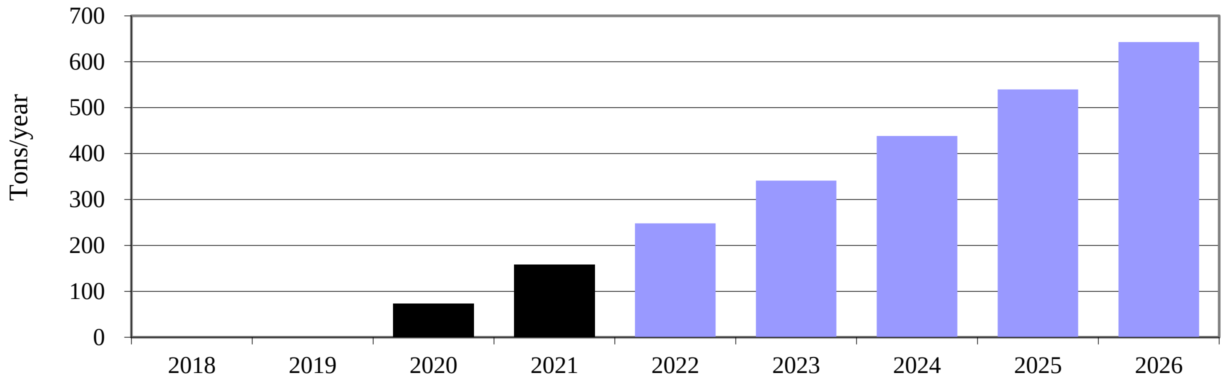


Figure 5-8: Actual and Projected Annual NOx reduction from New Multi-family Residences from 2020 to 2026 Based on the Year 2018.

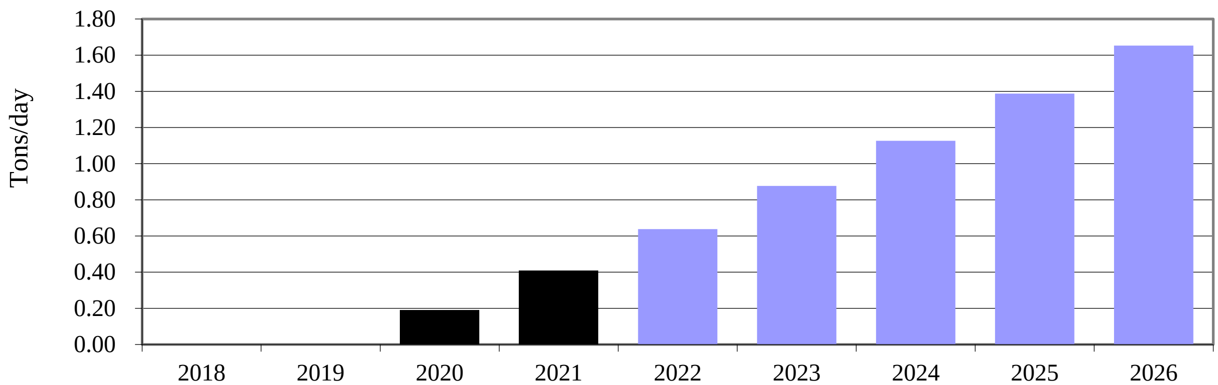


Figure 5-9: Actual and Projected OSP Average Daily NOx reduction from New Multi-family Residences from 2020 to 2026 Based on the Year 2018.

5.3.2 PUC Calculation

PUC-Senate Bill 7. For the PUC Senate Bill 7 program savings, the annual electricity savings for 2021 were obtained from the Public Utility Commission of Texas (PUC 2022). The annual electricity savings from 2018 to 2021 listed in Table 20. Using these savings were projected through 2026 by incorporating the growth factor that listed in Table 19. The annual integrated saving from 2018 base year were calculated based on Table 20 with discount factor, T&D loss, and degradation factor that listed in Table 19. Similar savings were assumed for each year after 2021 until 2026. Figure 5-10 and Figure 5-11 list the annual savings from 2019 to 2026. 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. Figure 5-12 and Figure 5-13 list the integrated annual and OSP NOx reduction from 2019 to 2026.

Table 20: 2019 to 2021 Verified Savings by Utility (PUC 2019, 2020, 2021, 2022)

Utility	Annual Energy Savings 2018		Annual Energy Savings 2019		Annual Energy Savings 2020		Annual Energy Savings 2021	
	Electric		Electric		Electric		Electric	
	MWh	MWh/ ozone season day	MWh	MWh/ ozone season day	MWh	MWh/ ozone season day	MWh	MWh/ ozone season day
AEP-North	12,669	34.7	11,968	32.8	12,785	35.0	83,701	40.7
AEP-Central	62,417	171.0	58,398	160.0	59,265	162.4		188.6
SWEPCO	17,017	46.6	16,233	44.5	16,246	44.5	17,402	47.7
CenterPoint	162,440	445.0	215,620	590.7	189,588	519.4	235,257	644.5
Oncor	218,304	598.1	243,152	666.2	295,496	809.6	309,859	848.9
TNMP	17,204	47.1	15,624	42.8	16,802	46.0	18,924	51.8
Entergy	48,100	131.8	44,554	122.1	44,885	123.0	57,477	157.5
SPS	18,906	51.8	23,328	63.9	25,663	70.3	25,411	69.6
El Paso Electric	20,726	56.8	24,826	68.0	30,704	84.1	27,952	76.6

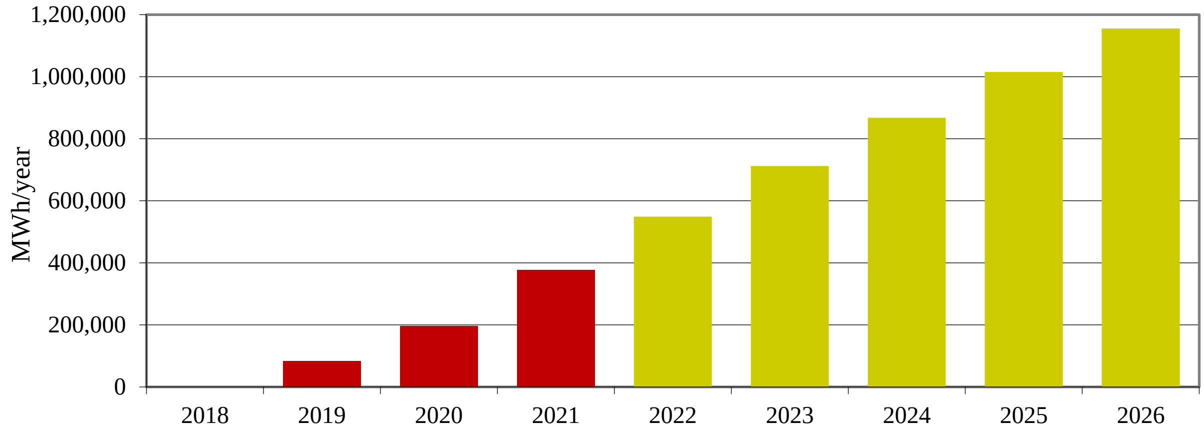


Figure 5-10: Actual and Projected Annual Savings from PUC from 2019 to 2026 Based on the Year 2018.

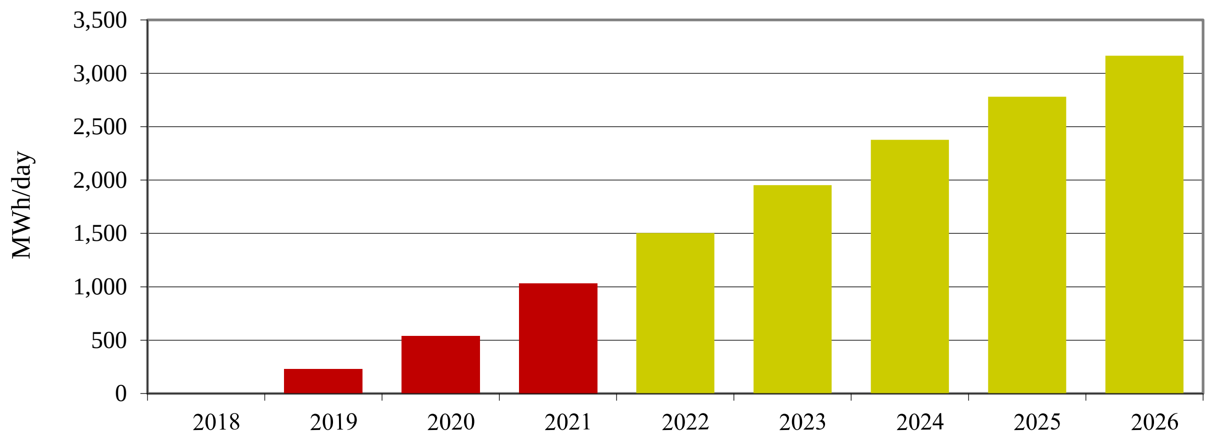


Figure 5-11: Actual and Projected OSP Daily Average Savings from PUC from 2019 to 2026 Based on the Year 2018.

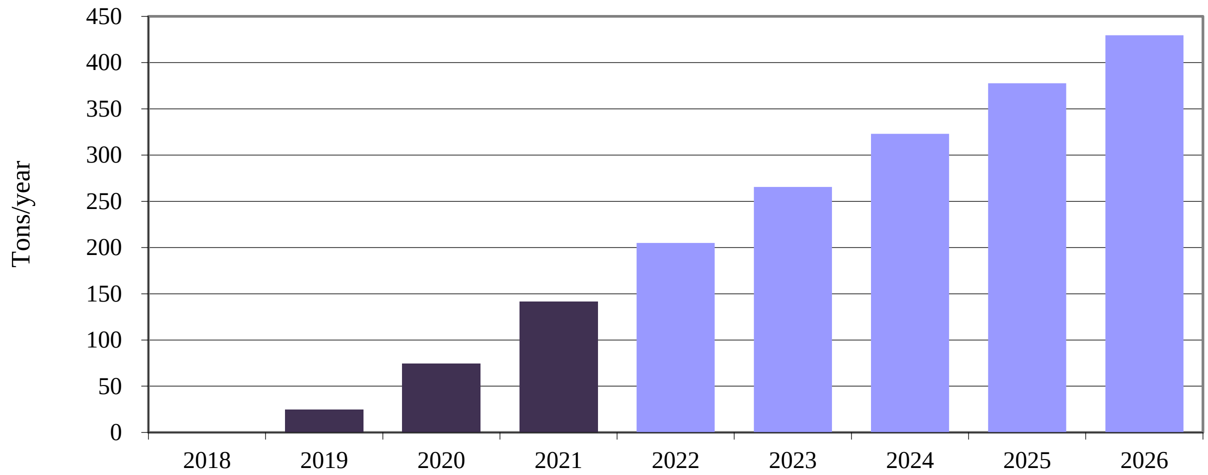


Figure 5-12: Actual and Projected Annual NOx reduction from PUC from 2019 to 2026 Based on the Year 2018.

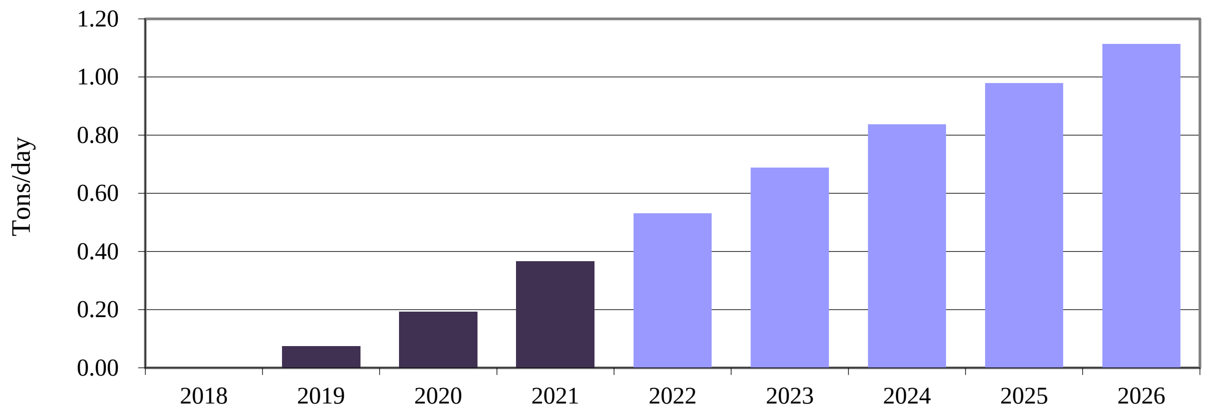


Figure 5-13: Actual and Projected OSP Average Daily NOx reduction from PUC from 2019 to 2026 Based on the Year 2018.

5.3.3 SECO Calculation

This section provides the potential electricity savings and the associated NOx emissions reductions in 2021, which is reported by political subdivisions for 2021 from the Texas State Energy Conservation Office (SECO 2021), including 144 valid entities in 40 surveyed counties in Texas. To calculate the NOx emissions reductions, the following procedures were adopted. First, total annual electricity consumption and total building areas were determined by county. To accomplish this, the 12-month calendar year (January 1st, 2021 – December 31st, 2021), and the 12-month physical year (September 1st, 2020 – August 31st, 2021) data were calculated. Next, the annual energy use intensity (EUI) for each county was estimated and the county's energy savings for 2021 against the baseline year of 2018 were calculated. Using the reported consumption, the annual and OSP electricity savings resulted from energy conservation projects were then calculated. The NOx reductions potential from the electricity savings in each county was calculated using the US EPA's 2018 eGRID database (USEPA 2018)[32].

The electricity savings reported by SECO are shown in Table 21, including 179 entities in 40 counties, and 144 entities are valid for the electricity savings and NOx reduction calculation. The standard for the valid entities selection is based on the 12-month data report. Two reported date methods are included: first method is to start from January 1st, 2021, and end on December 31st, 2021; second method is to start from September 1st, 2020, and end on August 31st, 2021. In Table 21 the rows are first sorted by counties, and then by entities names. Next, the third column and the fourth column show the start report date and the end report date. In addition, the fifth column, the 12-month data classification is listed. The sixth through seventh columns show the building electricity consumption and the building area.

In Table 22, the potential electricity savings and the EUIs are shown for each county. This table contains the 2021 total building areas by counties, the total annual electricity consumptions that are calculated based on all entities in each county, the EUIs in 2021, and the potential electricity savings in 2021. A 7% transmission and distribution loss is used to calculate the annual electricity savings.

Figure 5-14 and Figure 5-15 list the annual savings from 2019 to 2026. The 2018 annual eGRID was used to calculate the NOx emissions savings for the SECO Senate Bill 5 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. Figure 5-16 and Figure 5-17 list the integrated annual and OSP NOx reduction from 2019 to 2026.

[32] 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.

Table 21: 2021 SECO Report

County of Origin	Entity Name	Start Date	End Date	12 months	Building Consumption (kWh)	Entity Square Footage
Bexar	Alamo Colleges District	09/01/2020	08/31/2021	Y	63,677,181	5,641,841
Bexar	City of Fair Oaks Ranch	10/01/2020	09/30/2021	Y	-	-
Bexar	City of San Antonio	01/01/2021	12/31/2021	Y	215,813,502	18,139,845
Bexar	Hhsc - San Antonio State Hospital	09/01/2020	08/31/2021	Y	9,132,939	581,453
Bexar	Hhsc ??? San Antonio State Supported Living Center	09/01/2020	08/31/2021	Y	4,928,000	219,929
Bexar	Hhsc ??? Texas Center For Infectious Diseases	09/01/2020	08/31/2021	Y	5,740,800	193,924
Bexar	Texas A&M University - San Antonio	09/01/2020	08/31/2021	Y	10,184,769	588,878
Bexar	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Bexar	Txdot	09/01/2020	08/01/2021	Y	3,887,050.03	271,386
Brazoria	City of Iowa Colony	01/01/2021	12/31/2021	Y	57,996	7,200
Brazoria	Txdot	09/01/2020	08/01/2021	Y	232,920	40,839
Caldwell	Txdot	09/01/2020	08/01/2021	Y	58,640	17,278
Chambers	Txdot	09/01/2020	08/31/2021	Y	58,887	17,679
Collin	City of Allen	01/01/2021	12/31/2021	Y	29,722,087	697,339
Collin	City of Frisco	01/01/2021	12/31/2021	Y	41,390,314	2,026,998
Collin	City of Josephine	10/01/2020	09/30/2021	Y	-	-
Collin	City of Mckinney	01/01/2021	12/31/2021	Y	19,706,998.52	1,111,019
Collin	City of Parker	01/01/2021	12/31/2021	Y	847,985	20,000
Collin	City of Plano	01/01/2021	12/31/2021	Y	58,497,973	1,709,119
Collin	Collin County Community College District	01/01/2021	12/31/2021	Y	35,126,659	2,963,220
Collin	Town of New Hope	10/01/2020	09/30/2021	Y	-	-
Collin	Town of Prosper	01/01/2021	12/31/2021	Y	6,548,703	116,751
Collin	Txdot	09/01/2020	08/31/2021	Y	67,912	18,720
Comal	Comal County	01/01/2021	12/31/2021	Y	7,616,609	546,302
Comal	Txdot	09/01/2020	08/31/2021	Y	218,069	27,795
Dallas	City of Coppell	01/01/2021	12/21/2021	Y	4,430,351	236,660
Dallas	City of Dallas	01/01/2021	12/31/2021	Y	623,426,988.34	10,780,990
Dallas	City of Desoto	01/01/2021	12/31/2021	Y	3,692,559	250,000
Dallas	City of Farmers Branch	01/01/2021	12/31/2021	Y	9,344,729	340,983
Dallas	City of Irving	01/01/2021	12/31/2021	Y	55,280,455	1,520,948
Dallas	City of Lancaster	01/01/2021	12/31/2021	Y	8,110,574	230,726
Dallas	City of Mesquite	01/01/2021	12/31/2021	Y	24,161,613	724,372
Dallas	City of Richardson	01/01/2021	12/31/2021	Y	28,839,069	1,108,710
Dallas	City of Rowlett	01/01/2021	12/31/2021	Y	10,104,008	207,146
Dallas	City of University Park	10/01/2020	09/30/2021	Y	-	-
Dallas	Dallas Central Appraisal District	01/01/2021	12/31/2021	Y	2,129,732	95,692
Dallas	Dallas College	09/01/2020	08/31/2021	Y	60,504,706	4,900,000
Dallas	Dallas County Hospital District Dba Parkland Health	01/01/2021	12/31/2021	Y	144,197,593	8,940,455
Dallas	Dfw Airport	10/01/2020	09/30/2021	Y	-	-
Dallas	Garland Power & Light	10/01/2020	09/30/2021	Y	-	-
Dallas	Garland Power & Light	10/01/2020	09/30/2021	Y	-	-
Dallas	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Dallas	Town of Addison	01/01/2021	12/31/2021	Y	-	-
Dallas	Town of Highland Park - Highland Park, Tx	01/01/2021	12/31/2021	Y	2,145,422	67,479
Dallas	Town of Sunnyvale, Texas	01/01/2021	12/31/2021	Y	1,466,987	54,200
Dallas	Txdot	09/01/2020	08/31/2021	Y	2,399,518,012	317,461
Denton	City of Aubrey	01/01/2021	12/31/2021	Y	1,364,201	21,368
Denton	City of Denton	01/01/2021	12/31/2021	Y	53,434,400	1,382,813
Denton	City of Lewisville	01/01/2021	12/31/2021	Y	30,953,409	643,843
Denton	City of Pilot Point	01/01/2021	12/31/2021	Y	201,331	28,950
Denton	Denton Central Appraisal District	01/01/2021	12/31/2021	Y	520,548.80	39,673
Denton	Hhsc - Denton State Supported Living Center	09/01/2020	08/31/2021	Y	7,960,981	485,984
Denton	Hickory Creek	10/30/2020	09/30/2021	N	-	-
Denton	Lake Cities Municipal Utility Authority	01/14/2020	01/13/2021	Y	-	-
Denton	Town of Double Oak	01/01/2021	12/31/2021	Y	42,968	6,590
Denton	Town of Little Elm	01/01/2021	12/31/2021	Y	14,029,306	220,000
Denton	Trophy Club Municipal Utility District No. 1	01/01/2021	12/31/2021	Y	4,501,387	8,600
Denton	Txdot	09/01/2020	08/31/2021	Y	334,440	37,283
Denton	University of North Texas	08/01/2020	08/31/2021	N	-	-
El Paso	Hhsc - El Paso Psychiatric Center	09/01/2020	08/31/2021	Y	1,275,900	107,883
El Paso	Hhsc - El Paso State Supported Living Center	09/01/2020	08/31/2021	Y	2,415,700	118,465
El Paso	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
El Paso	Txdot	09/01/2020	08/31/2021	Y	201,143.04	177,062
Ellis	City of Oak Leaf	01/01/2021	12/31/2021	Y	46,225	4,555
Ellis	City of Ovilla	01/01/2021	12/31/2021	Y	599,113	19,242
Ellis	Txdot	09/01/2020	08/31/2021	Y	288,155	38,837
Fort Bend	City of Richmond	01/01/2021	12/31/2021	Y	7,594,042	135,774
Fort Bend	City of Sugar Land	01/01/2021	12/31/2021	Y	7,959,287	291,894
Fort Bend	Hhsc ??? Richmond State Supported Living Center	09/01/2020	08/31/2021	Y	8,476,337	469,752
Fort Bend	Txdot	09/01/2020	08/31/2021	Y	563,335	151,108
Galveston	City of Dickinson	01/01/2021	12/31/2021	Y	1,945,294	73,953
Galveston	Texas A&M University - Galveston	09/01/2020	08/31/2021	Y	22,049,104	1,020,845
Galveston	Txdot	09/01/2020	08/31/2021	Y	253,423	60,183
Gregg	Gregg County - 2021	09/01/2020	08/31/2021	Y	9,468,596	7,590,619
Gregg	Txdot	09/01/2020	08/31/2021	Y	185,000	27,126
Gregg	Txdot	09/01/2020	08/31/2021	Y	2,043	78,789
Guadalupe	Guadalupe Appraisal District	01/01/2021	12/31/2021	Y	82,560	8,300

Table 21: 2021 SECO Report (Continued)

County of Origin	Entity Name	Start Date	End Date	12 months	Building Consumption (kWh)	Entity Square Footage
Hardin	Hardin County Appraisal District	01/01/2021	12/31/2021	Y	49,473	3,312
Hardin	Txdot	09/01/2020	08/31/2021	Y	44,938.00	12,407
Harris	City of Houston	01/01/2021	12/31/2021	Y	1,050,396,522	33,289,313
Harris	Harris County Appraisal District	01/01/2021	12/31/2021	Y	3,836,472	449,127
Harris	Hedwig Village, City Of	01/01/2021	12/31/2021	Y	420,904	366,935
Harris	Houston Community College	09/01/2020	08/31/2021	Y	78,225,221	4,600,921
Harris	San Jacinto Community College	09/01/2020	08/31/2021	Y	42,008,013	3,130,000
Harris	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Harris	Txdot	09/01/2020	08/31/2021	Y	4,575,207.51	547,931
Harrison	Txdot	09/01/2020	08/31/2021	Y	187,888	33,418
Hays	City of San Marcos	01/01/2021	12/31/2021	Y	7,573,640.88	555,266
Hays	Txdot	09/01/2020	08/31/2021	Y	56,589	26,104
Henderson	City of Chandler	01/01/2021	12/31/2021	Y	1,443,624	25,000
Henderson	Town of Enchanted Oaks	12/2/2020	12/01/2021	Y	-	-
Henderson	Txdot	09/01/2020	08/31/2021	Y	152,000	109,772
Hood	Hood County Government	01/01/2021	12/31/2021	Y	5,385,077	321,361
Hunt	City of Quinlan	01/01/2021	12/31/2021	Y	73,915	8,794
Hunt	Texas A&M University - Commerce	09/01/2020	08/31/2021	Y	37,024,446	2,778,748
Jefferson	City of Port Neches	01/01/2021	12/31/2021	Y	4,652,806	56,658
Jefferson	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Jefferson	Txdot	09/01/2020	08/31/2021	Y	270,144	168,565
Johnson	Central Appraisal District of Johnson County	01/01/2021	12/31/2021	Y	136,670	12,667
Johnson	City of Alvarado	01/01/2021	12/31/2021	Y	1,818,913	39,000
Johnson	City of Burleson	12/01/2020	12/01/2021	N	-	-
Johnson	City of Cleburne	01/01/2021	12/31/2021	Y	14,962,589	619,062
Johnson	City of Godley	01/01/2021	12/31/2021	Y	628,264	32,900
Johnson	Txdot	09/01/2020	08/31/2021	Y	208,924	24,051
Kaufman	City of Combine	10/01/2020	09/30/2021	Y	-	-
Kaufman	City of Forney	01/9/2021	12/9/2021	N	-	-
Kaufman	City of Kaufman	01/01/2021	12/31/2021	Y	2,026,978	100,000
Kaufman	City of Kemp	01/01/2021	12/31/2021	Y	559,491	44,852
Kaufman	City of Terrell	01/01/2021	12/31/2021	Y	6,372,111	147,712
Liberty	Txdot	09/01/2020	08/31/2021	Y	64,796	19,535
Lubbock	Texas Tech University Health Sciences Center (Agency 739)	09/01/2020	08/31/2021	Y	2,337,899	71,777
Montgomery	City of Shenandoah	01/01/2021	12/31/2021	Y	3	39,601
Montgomery	Montgomery Central Appraisal District	01/01/2021	12/31/2021	Y	354,441	330,000
Montgomery	Txdot	09/01/2020	08/31/2021	Y	236,000	31,290
Nueces	City of Corpus Christi	01/01/2021	12/31/2021	Y	141,280,345	2,374,594
Nueces	Corpus Christi Regional Transportation Authority	01/01/2021	12/31/2021	Y	4,764,148	165,233
Nueces	Hhsc - Corpus Christi State Supported Living Center	09/01/2020	08/31/2021	Y	5,723,737	261,595
Nueces	Texas A&M University - Corpus Christi	09/01/2020	08/31/2021	Y	39,066,774	3,320,157
Nueces	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Nueces	Txdot	09/01/2020	08/31/2021	Y	2,115,635.99	172,404
Orange	Orange County Navigation And Port District	01/01/2021	12/31/2021	Y	165,804	7,000
Orange	Txdot	09/01/2020	08/31/2021	Y	185,760	36,003
Parker	City of Aledo	01/01/2021	12/31/2021	Y	1,286,837	7,362
Parker	Mineral Wells	12/17/2020	12/17/2021	N	-	-
Parker	Town of Annetta	10/01/2020	09/30/2021	Y	-	-
Parker	Txdot	09/01/2020	08/31/2021	Y	2,073,890.00	33,223
Rockwall	City of Rockwall	10/01/2020	09/30/2021	Y	-	-
Rockwall	Rockwall Central Appraisal District	01/01/2021	12/31/2021	Y	68,760	6,068
San Patricio	City of Ingleside	01/01/2021	12/31/2021	Y	2,749,094	76,590
San Patricio	San Patricio County	01/01/2021	12/31/2021	Y	4,498,903	590,408
San Patricio	Txdot	09/01/2020	08/31/2021	Y	115,961	16,659
Smith	City of Troup	01/01/2021	12/31/2021	Y	1,040,681	22,426
Smith	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Smith	Txdot	09/01/2020	08/31/2021	Y	867,703,00	142,058
Tarrant	City of Benbrook	01/01/2021	12/31/2021	Y	2,041,160	64,188
Tarrant	City of Colleyville	09/01/2020	08/31/2021	Y	4,484,168	179,796
Tarrant	City of Euless	01/01/2021	12/31/2021	Y	10,201,346	205,492
Tarrant	City of Forest Hill	01/01/2021	12/31/2021	Y	1,277,456	89,800
Tarrant	City of Fort Worth	01/01/2021	12/31/2021	Y	285,458,241	10,416,600
Tarrant	City of Grapevine	01/01/2021	12/31/2021	Y	25,953,644	735,094
Tarrant	City of Haltom City	12/17/2020	12/17/2021	N	-	-
Tarrant	City of Keller	01/01/2021	12/31/2021	Y	8,596,390	241,105
Tarrant	City of North Richland Hills	01/01/2021	12/31/2021	Y	9,903,269	555,008
Tarrant	City of Richland Hills	01/01/2021	12/31/2021	Y	2,028,474	74,749
Tarrant	City of Watauga	01/01/2021	12/31/2021	Y	1,991,808	116,308
Tarrant	Tarrant Appraisal District	01/01/2021	12/31/2021	Y	691.3	45,816
Tarrant	Tarrant County College District	09/01/2020	08/31/2021	Y	53,593,939.69	4,665,420
Tarrant	Tarrant Regional Water District	01/01/2021	12/31/2021	Y	96,893,347.89	216,436
Tarrant	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Tarrant	Town of Trophy Club	01/01/2021	12/31/2021	Y	1,857,221	25,429
Tarrant	Txdot	09/01/2020	08/31/2021	Y	167,247	285,585
Tarrant	White Settlement	01/01/2021	12/31/2021	Y	-	-

Table 21: 2021 SECO Report (Continued)

County of Origin	Entity Name	Start Date	End Date	12 months	Building Consumption (kWh)	Entity Square Footage
Travis	Capital Metropolitan Transportation Authority	01/01/2021	12/31/2021	Y	9,924,573	921,732
Travis	City of West Lake Hills	01/01/2021	12/31/2021	Y	81,600	5,940
Travis	Credit Union Department	09/01/2020	08/31/2021	Y	37,440	4,182
Travis	Hhsc - Austin State Hospital	09/01/2020	08/31/2021	Y	17,402,695	755,908
Travis	Hhsc - Austin State Supported Living Center	09/01/2020	08/31/2021	Y	6,088,500	653,163
Travis	Texas Board of Chiropractic Examiners	09/01/2020	08/31/2021	Y	-	-
Travis	Texas Department of Public Safety	09/01/2020	08/31/2021	Y	46,360,896	2,513,237.76
Travis	Texas Funeral Service Commission	09/01/2020	08/31/2021	Y	-	-
Travis	Texas Lottery Commission	09/01/2020	08/31/2021	Y	-	-
Travis	Texas Workforce Commission	09/01/2020	08/31/2021	Y	9,655,167	669,106
Travis	Travis Central Appraisal District	12/16/2020	12/16/2021	N	-	-
Travis	Travis County Government	01/01/2021	12/31/2021	Y	15,023,931	2,362,490
Travis	Txdot	09/01/2020	08/31/2021	Y	167,247	2,631,451
Upshur	Txdot	09/01/2020	08/31/2021	Y	146,535	23,210
Walker	Texas Department of Criminal Justice	09/01/2020	08/31/2021	Y	132,985,694	6,992,778
Waller	Prairie View A&M University	09/01/2020	08/31/2021	Y	43,970,520	2,823,941
Williamson	City of Cedar Park	01/01/2021	12/31/2021	Y	25,613,489	283,781
Williamson	City of Jarrell	01/01/2021	12/31/2021	Y	2,036,064	9,400
Williamson	City of Taylor	01/01/2021	12/31/2021	Y	4,233,415	97,854
Williamson	Txdot	09/01/2020	08/31/2021	Y	74,056	41,635
Williamson	Williamson Central Appraisal District	01/01/2020	12/31/2021	N	-	-
Williamson	Williamson Central Appraisal District	01/01/2021	12/31/2021	Y	504,300	31,000
Wilson	City of Poth	01/01/2021	12/31/2021	Y	525,833	2,400
Wise	City of Decatur	09/01/2020	08/31/2021	Y	-	-
Wise	City of Newark	10/01/2019	09/30/2021	Y	-	-
Wise	City of Runaway Bay	01/01/2021	12/31/2021	Y	896,170	20,199
Wise	Txdot	09/01/2020	08/31/2021	Y	178,465	41,420

Table 22: 2021 SECO Electricity Savings and EUIs

County	2021 Total Building Area (sq.ft)	2021 Total Annual Electricity Consumption (kWh)	2021 EUI (kWh/sq.ft)	2018 EUI (kWh/sq.ft)	2021 Total Annual Electricity Savings (with 7% T&D Loss) (MWh)
Bastrop	-	-	-	-	-
Bexar	25,675,472	315,355,100	12.28	13.54	24,215
Brazoria	48,039	290,916	6.06	0.75	-
Caldwell	17,278	58,640	3.39	-	-
Chambers	17,679	58,887	3.33	-	-
Collin	8,670,954	191,952,776	22.14	28.10	38,711
Comal	574,097	7,834,678	13.65	-	-
Coryell	-	-	-	-	-
Dallas	38,451,838	3,665,540,278	95.33	2.20	-
Denton	10,792,195	237,022,304	21.96	15.37	-
El Paso	403,410	3,892,743	9.65	-	-
Ellis	62,634	933,493	14.90	-	-
Fort Bend	1,048,528	24,593,001	23.45	14.24	-
Fort Worth	-	-	-	-	-
Galveston	1,154,981	24,247,821	20.99	-	-
Grayson	-	-	-	-	-
Gregg	7,696,534	9,655,639	1.25	18.67	100,396
Guadalupe	8,300	82,560	9.95	-	-
Hardin	15,719	94,411	6.01	-	-
Harris	42,384,227	1,179,462,340	27.83	22.95	-
Harrison	33,418	187,888	5.62	-	-
Hays	581,370	7,630,230	13.12	14.91	777
Henderson	138,272	1,640,553	11.86	-	-
Hood	321,361	5,385,077	16.76	-	-
Hunt	2,787,542	37,098,361	13.31	-	-
Jefferson	225,223	4,922,950	21.86	18.79	-
Johnson	992,451	27,055,234	27.26	14.40	-
Kaufman	302,060	12,415,393	41.10	-	-
Liberty	19,535	64,796	3.32	-	-
Mclennan	-	-	-	-	-
Montgdoches	400,891	590,444	1.47	-	-
Nacogdoches	-	-	-	-	-
Nueces	6,293,983	192,950,640	30.66	17.18	-
Orange	43,003	351,564	8.18	20.42	394
Palo Pinto	-	-	-	-	-
Parker	41,985	5,247,118	124.98	12	-
Rockwall	6,083	6,722,817	1105.18	-	-
Rusk	-	-	-	-	-

Table 22: 2021 SECO Electricity Savings and EUIs (Continued)

County	2021 Total Building Area (sq.ft)	2021 Total Annual Electricity Consumption (kWh)	2021 EUI (kWh/sq.ft)	2018 EUI (kWh/sq.ft)	2021 Total Annual Electricity Savings (with 7% T&D Loss) (MWh)
San Patricio	683,657	7,363,958	10.77	9	-
Smith	22,426	1,040,681	46.41	-	-
Tarrant	18,073,919	513,165,695	28.39	12.62	-
Travis	10,589,930	106,130,049	10.02	25.77	124,925
Upshur	23,210	146,535	6.31	-	-
Uvalde	-	-	-	-	-
Victoria	-	-	-	13	-
Walker	-	132,985,694	47.09	-	-
Waller	2,823,941	43,970,520	88.53	-	-
Williamson	496,670	32,924,824	13718.68	14.84	-
Wilson	2,400	525,833	-	-	-

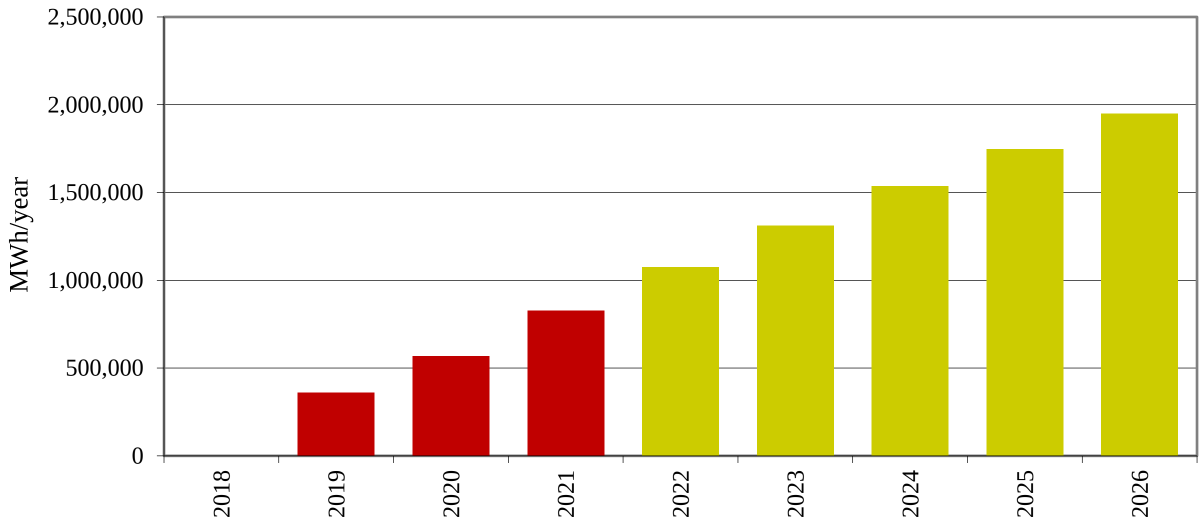


Figure 5-14: Actual and Projected Annual Savings from SECO from 2019 to 2026 Based on the Year 2018.

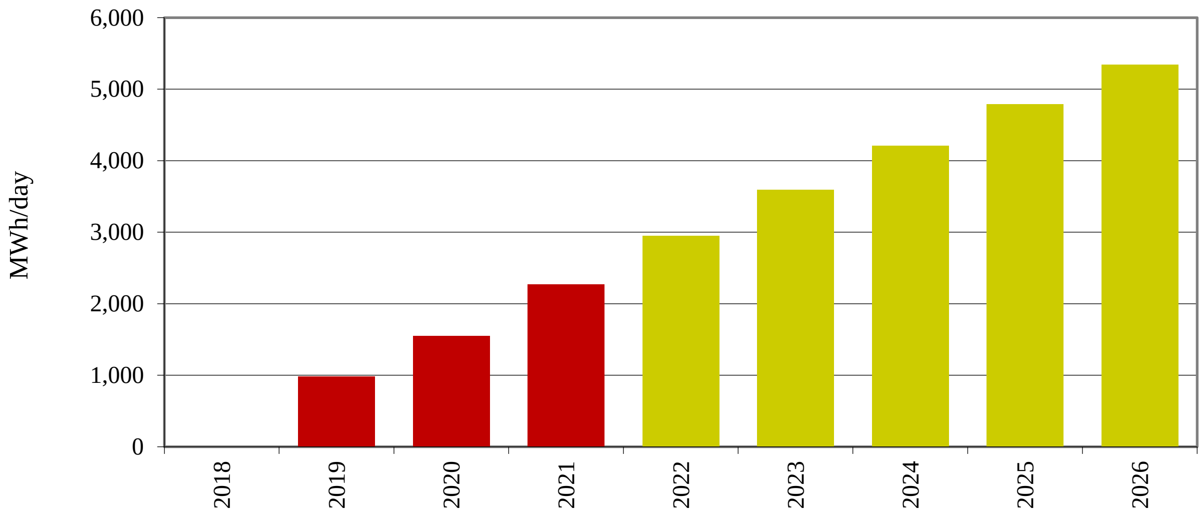


Figure 5-15: Actual and Projected OSP Daily Average Savings from SECO from 2019 to 2026 Based on the Year 2018.

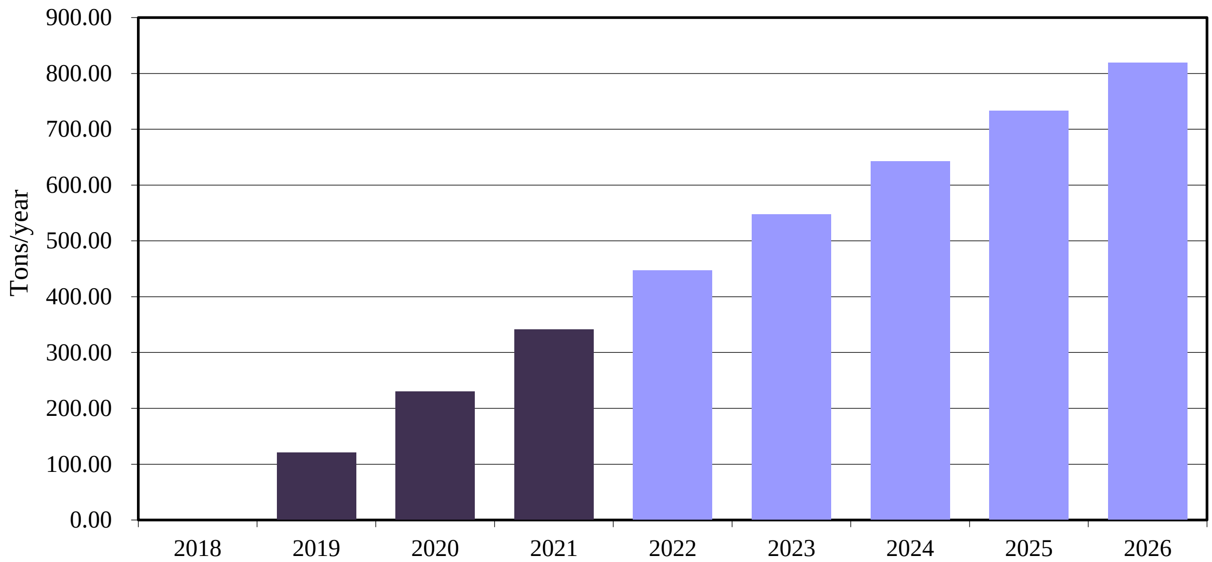


Figure 5-16: Actual and Projected Annual NOx reduction from SECO from 2019 to 2026 Based on the Year 2018.

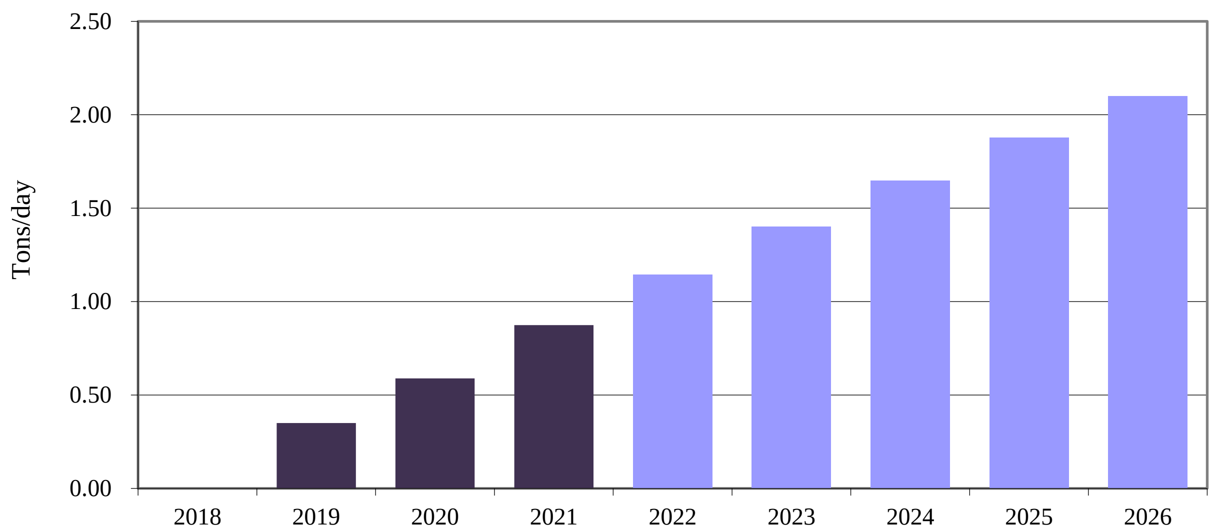


Figure 5-17: Actual and Projected OSP Average Daily NOx reduction from SECO from 2019 to 2026 Based on the Year 2018.

5.3.4 Electricity Generated by Renewables Calculation

The measured and estimated electricity production from renewables in Texas for 2018 through 2021 was obtained from the reports *Statewide Air Emissions Calculations from Wind and Other Renewables (2018-2022)* (Baltazar et al., 2019 - 2022). Using the reported numbers for 2021, savings through 2026 were projected incorporating the different adjustment factors mentioned above. Figure 5-18 and Figure 5-19 list the annual savings from 2019 to 2026. The 2016 eGRID was used for the 2019 calculation, and the 2018 eGRID was used for the calculation during the period of 2020 through 2026 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. Figure 5-20 and Figure 5-21 list the integrated annual and OSP NOx reduction from 2019 to 2026.

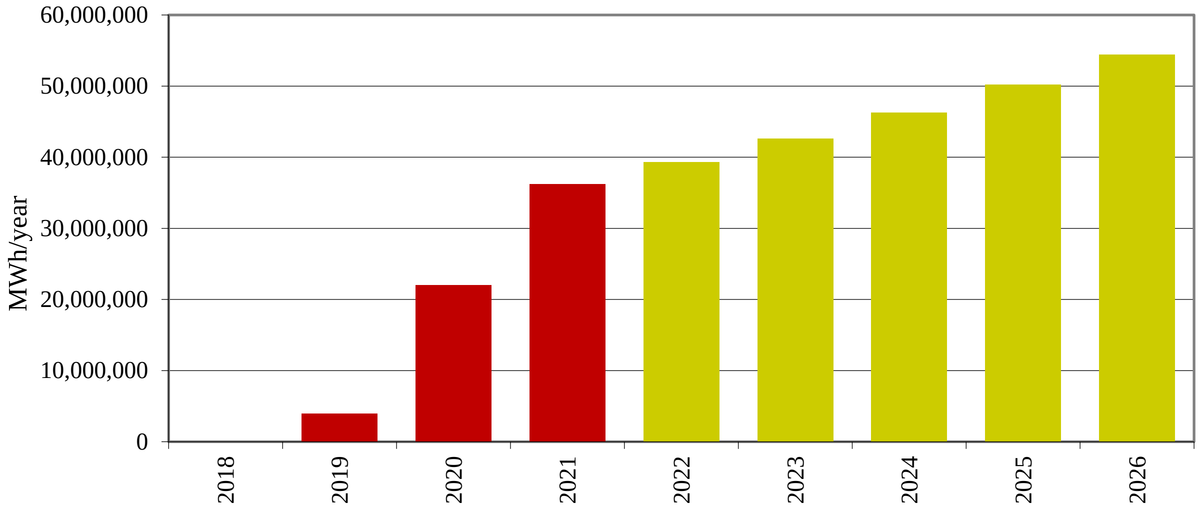


Figure 5-18: Actual and Projected Annual Savings from Renewable from 2019 to 2026 Based on the Year 2018.

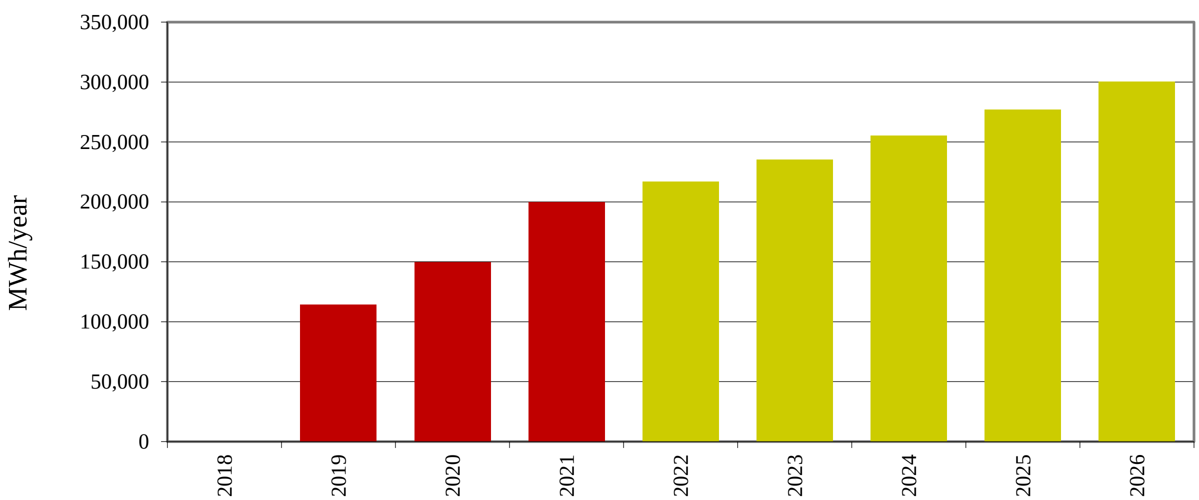


Figure 5-19: Actual and Projected OSP Daily Average Savings from Renewable from 2019 to 2026 Based on the Year 2018.

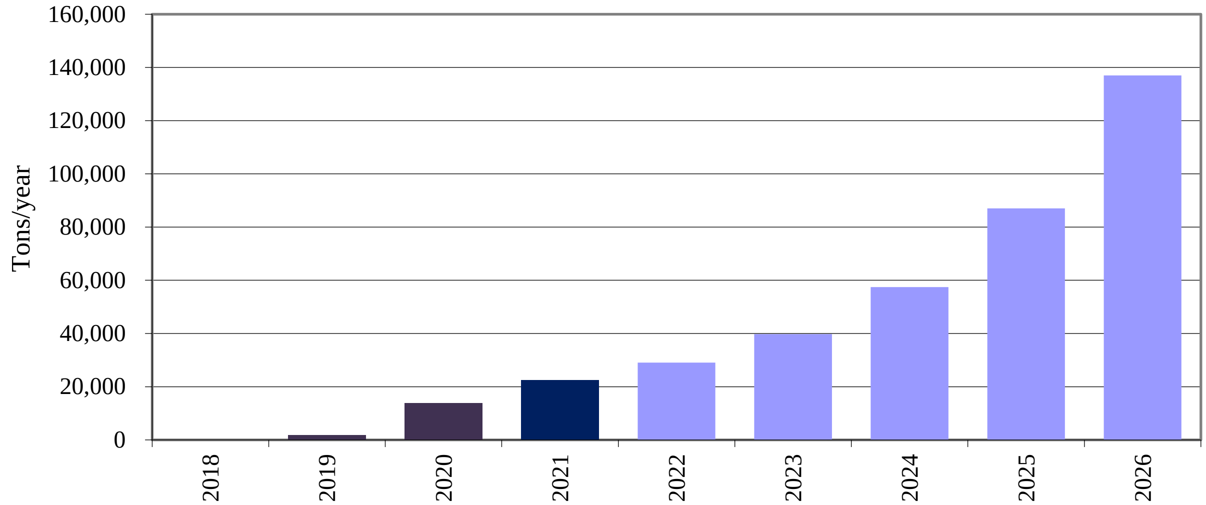


Figure 5-20: Actual and Projected Annual NOx reduction from Renewable from 2019 to 2026 Based on the Year 2018.

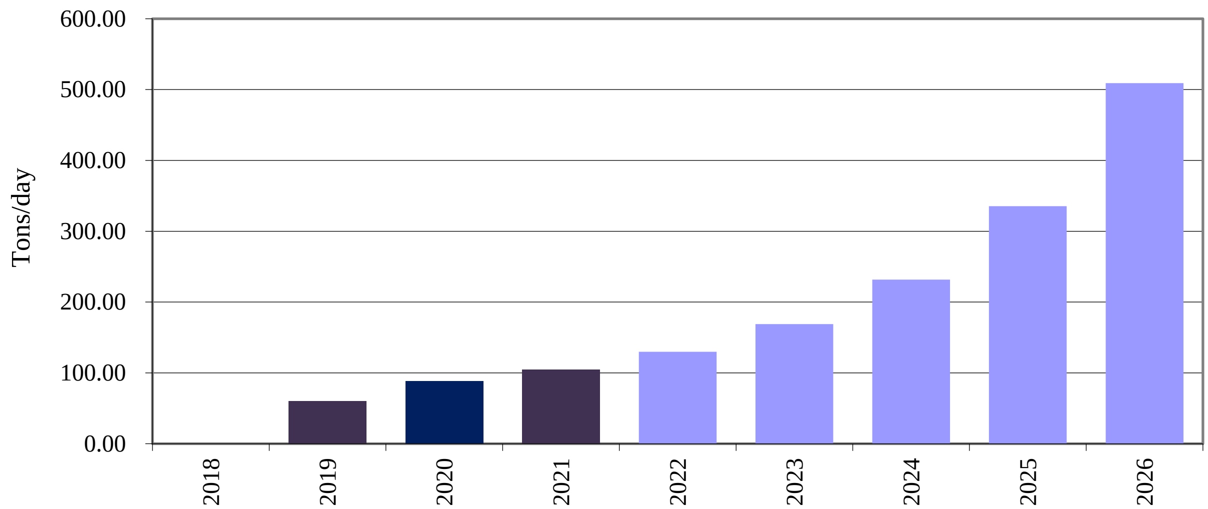


Figure 5-21: Actual and Projected OSP Average Daily NOx reduction from Renewable from 2019 to 2026 Based on the Year 2018.

5.3.5 SEER 14 Single-Family and Multi-Family Calculation

SEER 14 Single-Family and Multi-Family. Beginning in January 2015, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 14. According to the U.S. Department of Energy, the "lifespan" of a central air conditioner is about 15 to 20 years (average 17 years)[33]. Therefore, any existing residences built more than 17 years ago were assumed to have replaced their air conditioning with units with at least SEER 14 efficiency. In this report, 2018 is the base year for energy-saving calculations, and 2026 is the last projection year for analysis. Considering 17 years for air conditioning replacement, all households that were built from 2001 to 2009 are expected to replace their air conditioning units with at least SEER 14 efficiency. The number of single-family and multi-family units built during this period utilize the data from the Texas Real Estate Research Center.

This report estimates the annual cooling energy savings of a typical residential single-family and multi-family construction[34] from replacing air conditioning units (SEER 11 to SEER 14) in each climate zone inside ERCOT regions using DOE-2 hourly building simulation models. Therefore, the energy savings in each county are calculated from multiplying the number of new single-family and multi-family construction in each county (from 2001 to 2009) by the annual cooling energy savings for a typical residential building, considering adjustment factors (T&D Loss, Discount Factor). Since 2018 is the base year in this analysis, the actual and projected annual savings in each county are subtracted from energy saving of 2018. The corresponding OSP energy saving was calculated using an annual daily average. Also, the annual energy savings for all counties from 2019 to 2026 were calculated by incorporating the appropriate Degradation factor (see Table 19). The annual SEER14 electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors in the 2018 U.S. Environmental Protection Agency (US EPA) eGRID database (Figure *5-22* to Figure *5-29*).

[33] The "lifespan" of a central air conditioner is about 15 to 20 years. Department Of Energy (USDOE, 2021): https://www.energy.gov/energysaver/central-air-conditioning#:~:text=The%20%22lifespan%22%20of%20a%20central,new%20standard%20goes%20into%20effect.

[34] To estimate energy savings, the published data on typical residential construction characteristics provided by the NAHB (National Association of Home Builders) survey (NAHB 2003) was used for the base-code case single-family building. The code-compliant building envelope and system characteristics were determined from the general characteristics, for each climate zone as specified in the 2001 IECC. Also, the pre-code building envelope and system characteristics were determined based on the construction characteristics published by the NAHB (2000) for typical residential construction in East and West Texas for 1999. These buildings had SEER10 to SEER12 AC systems (AVG SEER11). For multi-family energy saving estimates, the 2001 IECC building code for both code-compliant and pre-code cases in multi-family calculation were used because there was no data for multi-family residences from NAHB report.

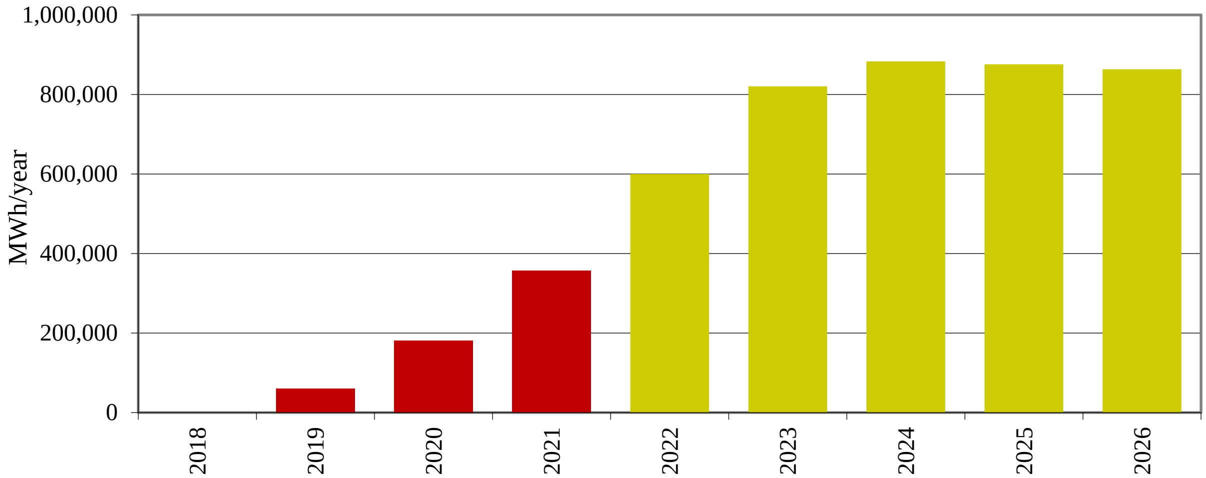


Figure 5-22: SEER 14 Single-Family Actual and Projected Annual Savings from 2019 to 2026 Based on the Year 2018.

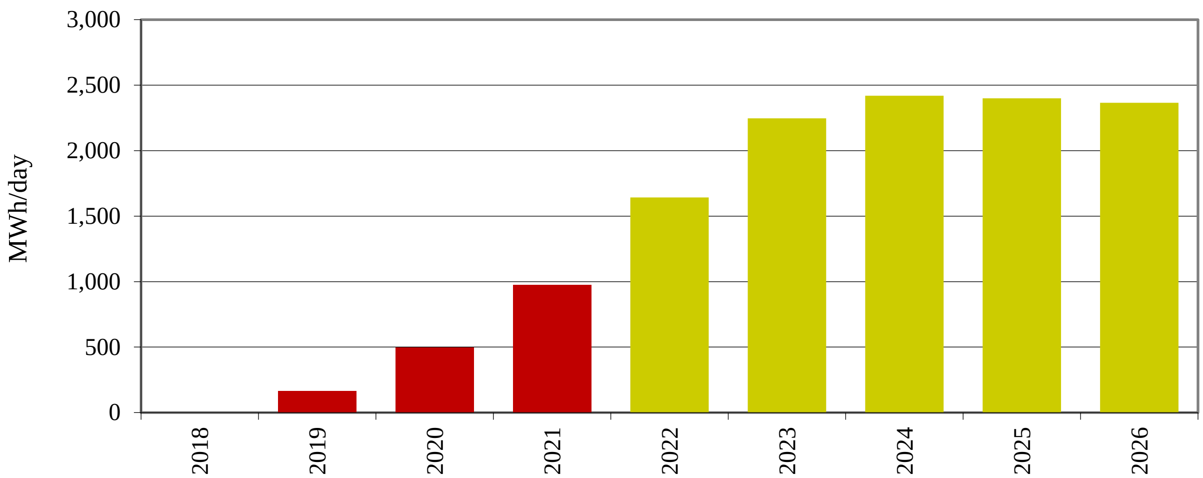


Figure 5-23: SEER 14 Single-Family Actual and Projected OSP Daily Average Savings from 2019 to 2026 Based on the Year 2018.

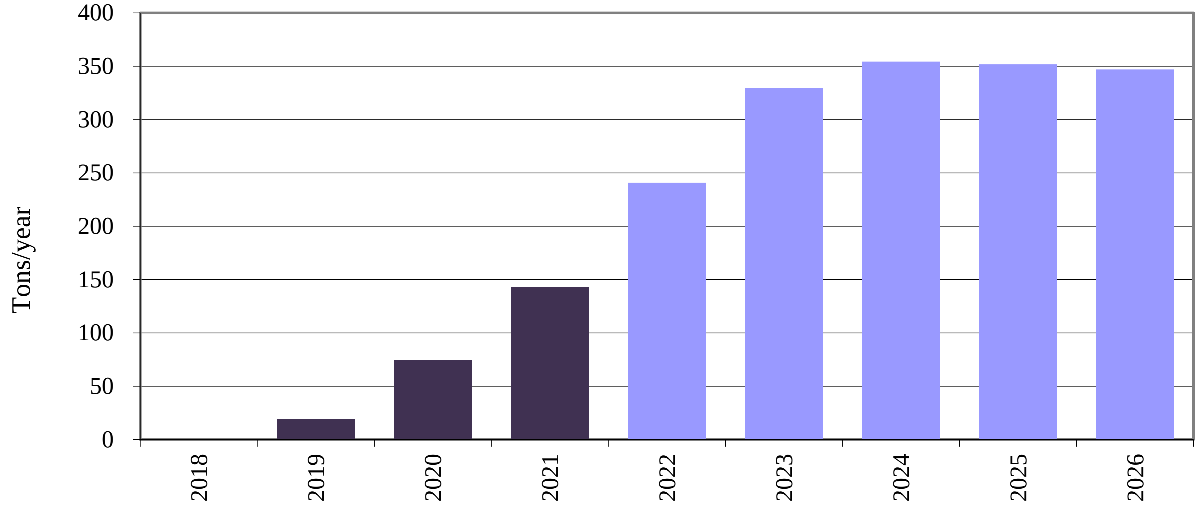


Figure 5-24: SEER 14 Single-Family Actual and Projected Annual NOx reduction from 2019 to 2026 Based on the Year 2018.

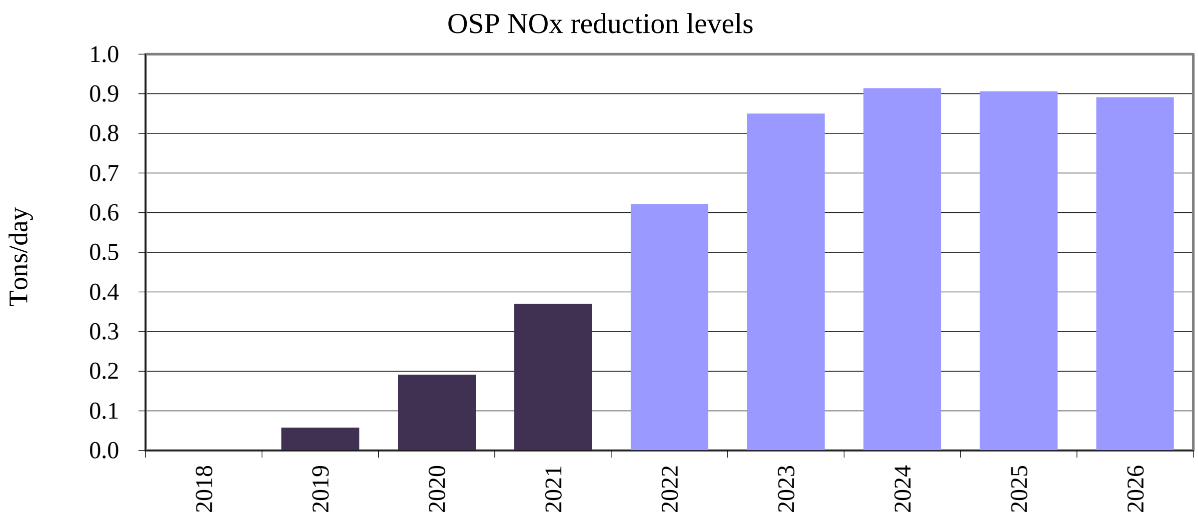


Figure 5-25: SEER 14 Single-Family Actual and Projected OSP Average Daily NOx reduction from 2019 to 2026 Based on the Year 2018.

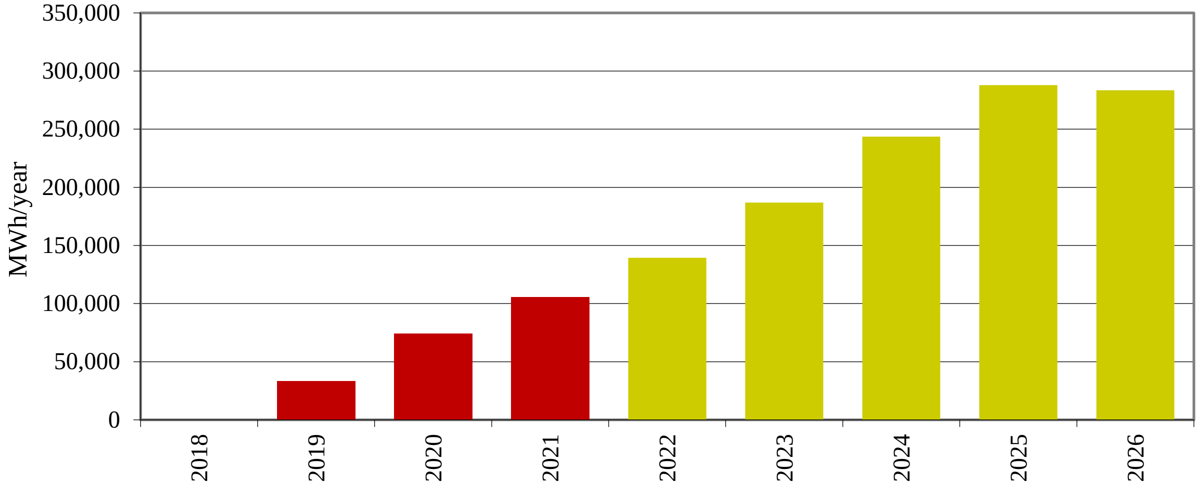


Figure 5-26: SEER 14 Multi-Family Actual and Projected Annual Savings from 2019 to 2026 Based on the Year 2018.

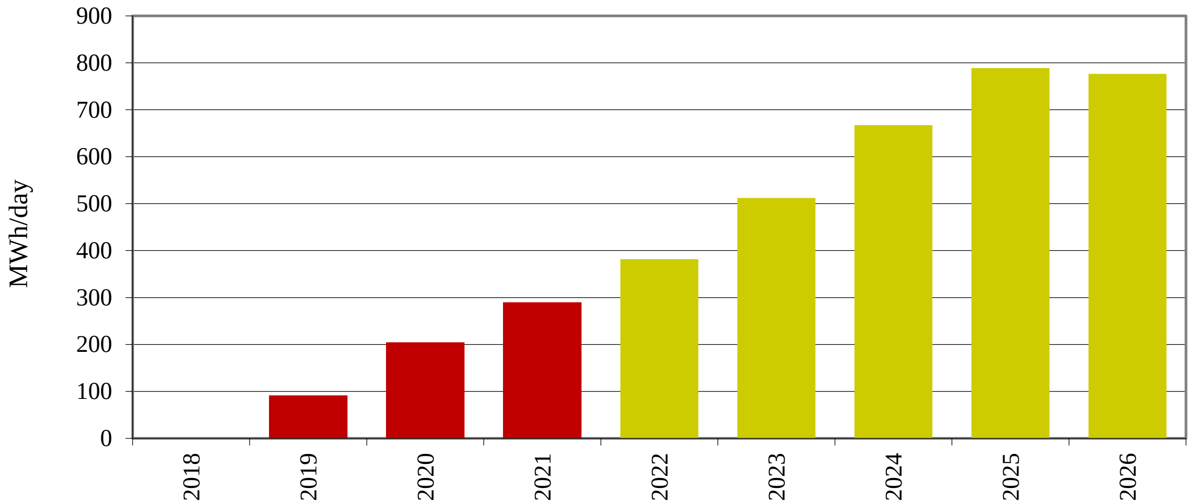


Figure 5-27: SEER 14 Multi-Family Actual and Projected OSP Daily Average Savings from 2019 to 2026 Based on the Year 2018.

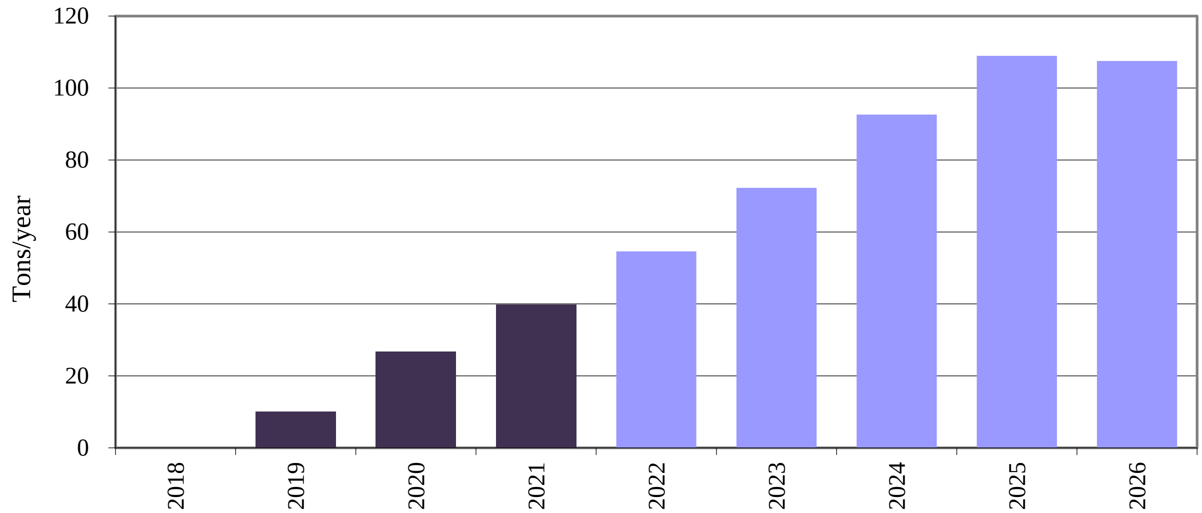


Figure 5-28: SEER 14 multi-Family Actual and Projected Annual NOx reduction from 2019 to 2026 Based on the Year 2018.

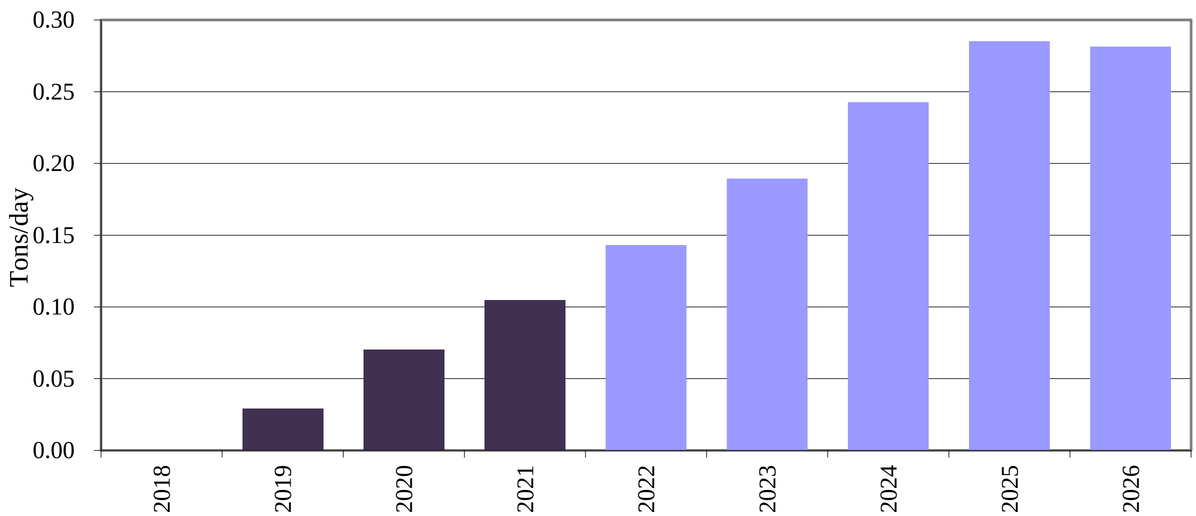


Figure 5-29: SEER 14 Multi-Family Actual and Projected OSP Average Daily NOx reduction from 2019 to 2026 Based on the Year 2018.

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 2026 as shown in Table 24, using the adjustment factors shown in Table 19. Annual and OSP NOx emissions reductions from the electricity savings (presented in Table 24) for all the programs in the integrated format were shown in Table 25. Integrated OSP NOx emissions reduction projection and integrated OSP individual programs NOx emissions reduction projection were presented in Figure 5-30 and Figure 5-31.

In 2021, the total integrated annual savings from all programs are 39,483,996 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 538,354 MWh/year (1.4% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 376,958 MWh/year (1.0%),
- Savings from SECO's Senate Bill 5 program are 828,391 MWh/year (2.1%),
- Electricity savings from renewable power generation are 37,278,263 MWh/year (94.4%), and
- Savings from residential air conditioner retrofits[35] are 462,030 MWh/year (1.2%).

In 2021, the total integrated OSP savings from all programs are 187,558 MWh/day, which would be 7,815 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 1,475 MWh/day (0.8%),
- Savings from the PUC's Senate Bill 7 programs are 1,033 MWh/day (0.6%),
- Savings from SECO's Senate Bill 5 program are 2,268 MWh/day (1.2%),
- Electricity savings from renewable power generation are 181,516 MWh/day (96.8%), and
- Savings from residential air conditioner retrofits are 1,266 MWh/day (0.7%).

By 2026, the total integrated annual savings from all programs will be 228,293,006 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 2,151,776 MWh/year (0.9% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 1,155,231 MWh/year (0.5%),
- Savings from SECO's Senate Bill 5 program will be 1,950,433 MWh/year (0.9%),
- Electricity savings from renewable power generation will be 221,888,583 MWh/year (97.2%), and
- Savings from residential air conditioner retrofits will be 1,146,983 MWh/year (0.5%).

By 2026, the total integrated OSP savings from all programs will be 887,442 MWh/day, which would be 36,977 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 5,895 MWh/day (0.7%),
- Savings from the PUC's Senate Bill 7 programs will be 3,165 MWh/day (0.4%),
- Savings from SECO's Senate Bill 5 program will be 5,342 MWh/day (0.6%),
- Electricity savings from renewable power generation will be 869,897 MWh/day (98.0%), and
- Savings from residential air conditioner retrofits will be 3,142 MWh/day (0.4%).

In 2021 (Table 23 and

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

Table 25), the total integrated annual NOx emissions reductions from all programs are 23,275 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 225 tons-NOx/year (1.0% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 141 tons-NOx/year (0.6%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 341 tons-NOx/year (1.5%),
- NOx emissions reductions from renewable power generation are 22,385 tons-NOx/year (96.2%), and
- NOx emissions reductions from residential air conditioner retrofits are 183 tons-NOx/year (0.8%).

In 2021, the total integrated OSP NOx emissions reductions from all programs are 106.93tons-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 0.57 tons-NOx/day (0.5%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs are 0.37 tons-NOx/day (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program are 0.87 tons-NOx/day (0.8%),
- NOx emissions reductions from renewable power generation are 104.65 tons-NOx/day (97.9%), and
- NOx emissions reductions from residential air conditioner retrofits are 0.47 tons-NOx/day (0.4%).

By 2026, the total integrated annual NOx emissions reductions from all programs will be 139,621 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 892 tons-NOx/year (0.6% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 430 tons-NOx/year (0.3%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 819 tons-NOx/year (0.6%),
- NOx emissions reductions from renewable power generation will be 137,026 tons-NOx/year (98.1%), and
- NOx emissions reductions from residential air conditioner retrofits will be 455 tons-NOx/year (0.3%).

By 2026, the total integrated OSP NOx emissions reductions from all programs will be 515.87 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 2.27 tons-NOx/day (0.4%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1.11 tons-NOx/day (0.2%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 2.1 tons-NOx/day (0.4%),
- NOx emissions reductions from renewable power generation will be 509.21 tons-NOx/day (98.7%), and
- NOx emissions reductions from residential air conditioner retrofits will be 1.17 tons-NOx/day (0.2%).

Table 23: 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)		25,227		22,999		1,744		21,121		1,135		1,799		823

Table 24: Integrated Annual and OSP Electricity Savings for the Different Programs (Base Year 2018)

PROGRAM	ANNUAL (MWh)								
	2018	2019	2020	2021	2022	2023	2024	2025	2026
ESL-Single Family	0	0	74,850	158,185	243,332	330,396	419,488	510,722	604,216
ESL-Multifamily	0	0	175,080	380,168	593,879	816,815	1,049,617	1,292,959	1,547,560
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	83,347	195,887	376,958	548,976	712,392	867,638	1,015,122	1,155,231
SECO	0	359,121	567,339	828,391	1,076,390	1,311,989	1,535,808	1,748,437	1,950,433
Renewables-ERCOT	0	4,091,723	22,537,959	37,278,263	48,106,652	65,434,397	93,882,613	141,434,510	221,888,583
SEER14-Single Family	0	60,071	181,188	356,259	599,673	820,221	883,003	875,735	863,529
SEER14-Multi Family	0	33,152	74,374	105,771	139,362	186,930	243,587	287,869	283,454
Total Annual (MWh)	**0**	**4,627,414**	**23,806,679**	**39,483,996**	**51,308,263**	**69,613,140**	**98,881,754**	**147,165,354**	**228,293,006**

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)								
	2018	2019	2020	2021	2022	2023	2024	2025	2026
ESL-Single Family	0	0	205	433	667	905	1,149	1,399	1,655
ESL-Multifamily	0	0	480	1,042	1,627	2,238	2,876	3,542	4,240
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	228	537	1,033	1,504	1,952	2,377	2,781	3,165
SECO	0	984	1,553	2,268	2,947	3,593	4,206	4,789	5,342
Renewables-ERCOT	0	114,596	150,844	181,516	224,490	291,205	398,333	574,655	869,897
SEER14-Single Family	0	165	496	976	1,643	2,247	2,419	2,399	2,366
SEER14-Multi Family	0	91	204	290	382	512	667	789	777
Total OSP (MWh)	**0**	**116,063**	**154,318**	**187,558**	**233,260**	**302,653**	**412,028**	**590,354**	**887,442**

Table 25: Integrated 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**	**2026**
ESL-Single Family	0	0	31	66	101	137	174	212	249
ESL-Multifamily	0	0	73	159	248	341	438	540	643
ESL-Commercial	0	0	0	0	0	0	0	0	0
PUC (SB7)	0	25	74	141	205	265	323	378	430
SECO	0	121	230	341	447	547	642	733	819
Renewables-ERCOT	0	1,800	13,849	22,385	29,062	39,788	57,446	87,019	137,026
SEER14-Single Family	0	20	74	143	241	329	354	352	347
SEER14-Multi Family	0	10	27	40	55	72	93	109	108
Total Annual (Tons NOx)	**0**	**1,975**	**14,358**	**23,275**	**30,358**	**41,480**	**59,471**	**89,343**	**139,621**

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)								
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
ESL-Single Family	0.00	0.00	0.08	0.16	0.25	0.34	0.43	0.53	0.62
ESL-Multifamily	0.00	0.00	0.19	0.41	0.64	0.88	1.13	1.39	1.65
ESL-Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUC (SB7)	0.00	0.07	0.19	0.37	0.53	0.69	0.84	0.98	1.11
SECO	0.00	0.35	0.59	0.87	1.14	1.40	1.65	1.88	2.10
Renewables-ERCOT	0.00	60.45	88.21	104.65	129.77	168.87	231.77	335.44	509.21
SEER14-Single Family	0.00	0.06	0.19	0.37	0.62	0.85	0.91	0.91	0.89
SEER14-Multi Family	0.00	0.03	0.07	0.10	0.14	0.19	0.24	0.29	0.28
Total OSP (Tons NOx)	**0.00**	**60.96**	**89.52**	**106.93**	**133.10**	**173.21**	**236.97**	**341.41**	**515.87**

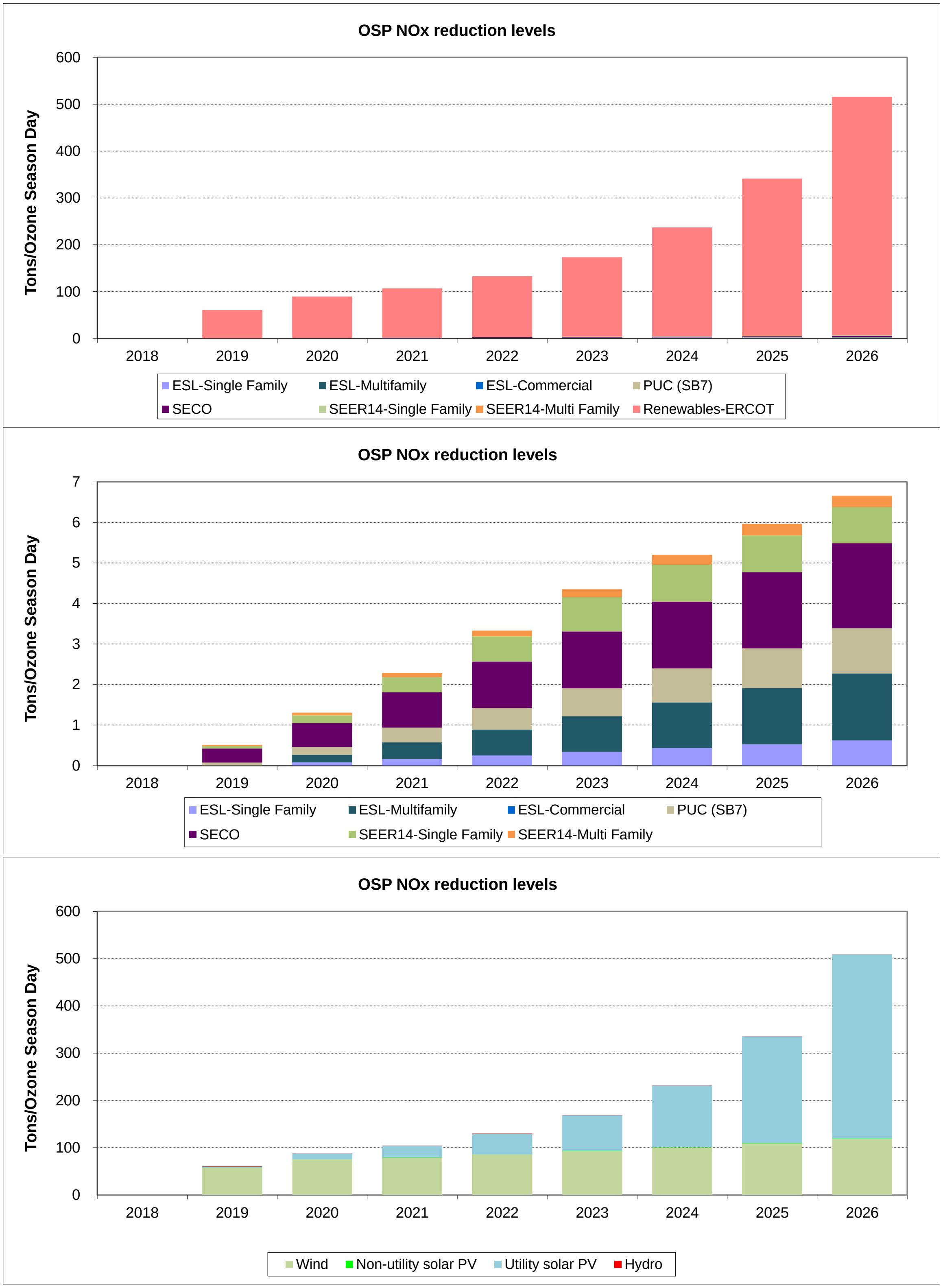


Figure 5-30: Integrated OSP NOx Emissions Reduction Projections through 2026. (Upper plot) all programs, (middle plot) all programs except Renewables, (lower plot) Renewables.

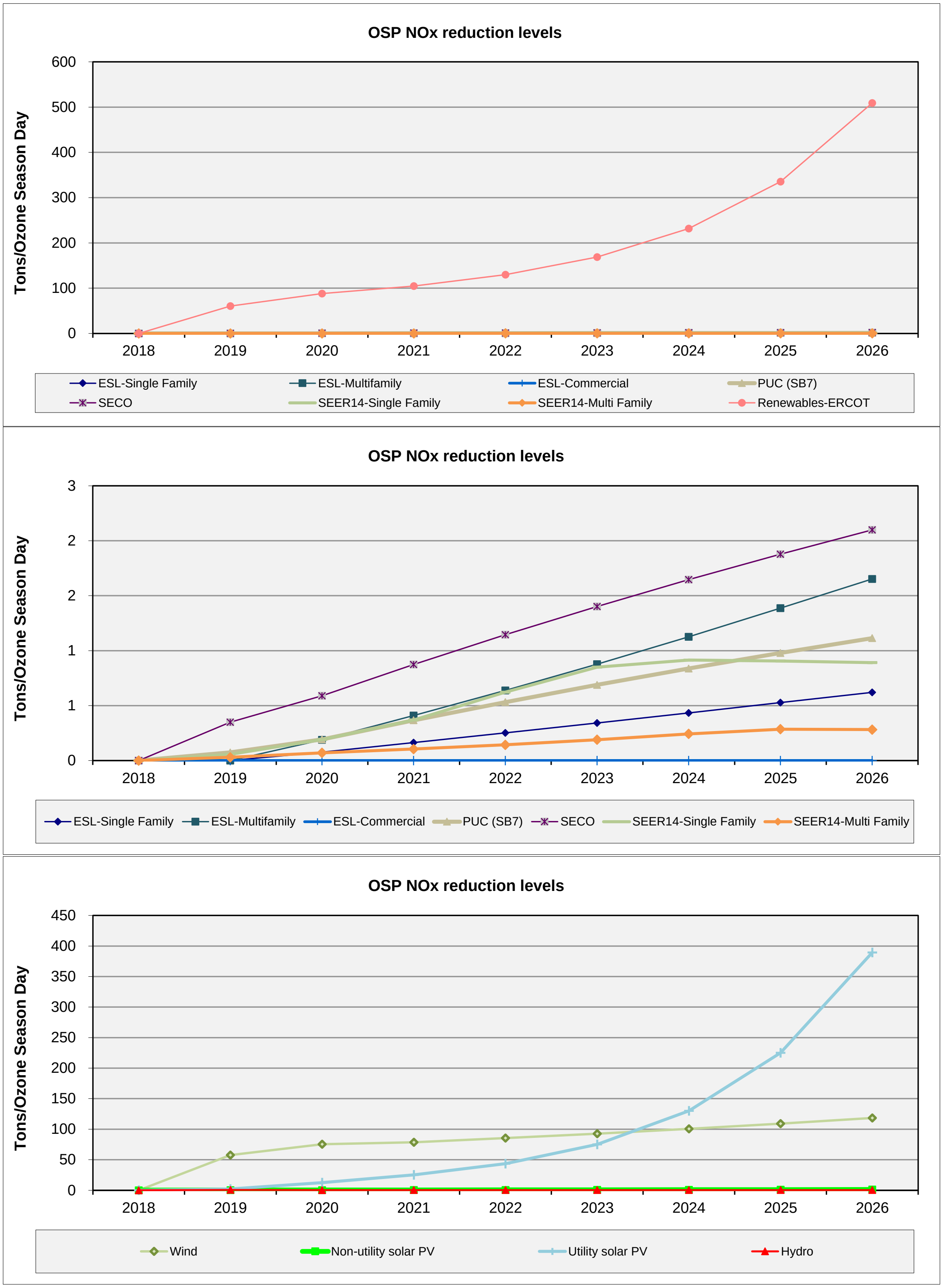


Figure 5-31: Integrated OSP NOx Emissions Reductions for Individual Programs through 2026. (Upper plot) all programs, (middle plot) all programs except Renewables, (lower plot) Renewables.

6 2021 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*[36] and *TCV*.[37] 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 2021, the reports continued, and numbers were gathered. Figure 6-1 shows the projects issued each month from January to December 2021. The projects are differentiated by the basic types, IECC performance path and ERI path. Figure 6-2 shows the cumulative users and projects through 2021. 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 6-3. Only counties with at least 10 new projects in 2021 are included in the chart. Figure 6-4 shows the certifications issued by city in 2021. Only those cities with at least 50 new projects are shown on the chart.

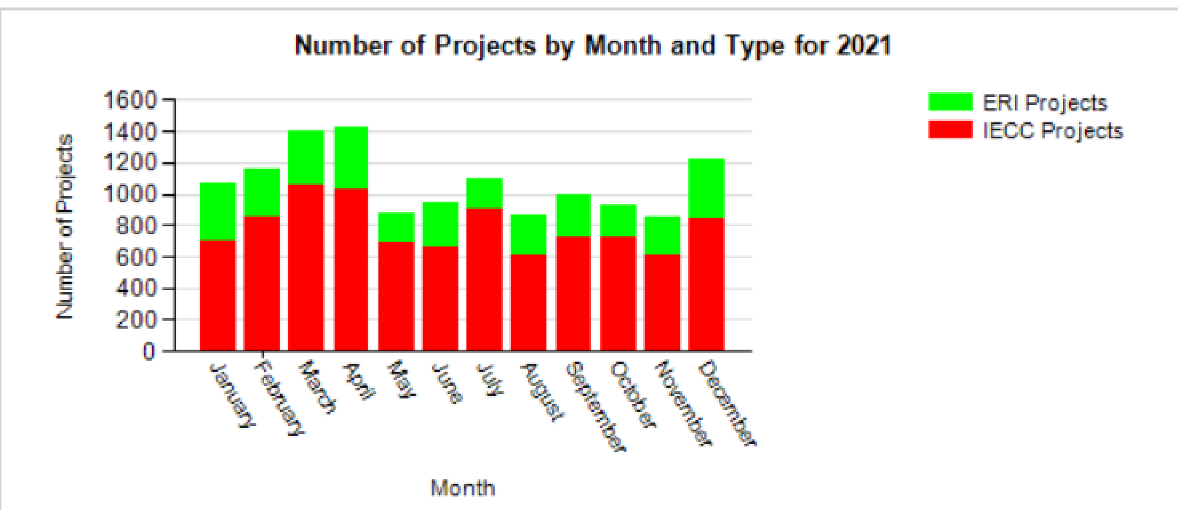


Figure 6-1: *IC3* 2021 Projects

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

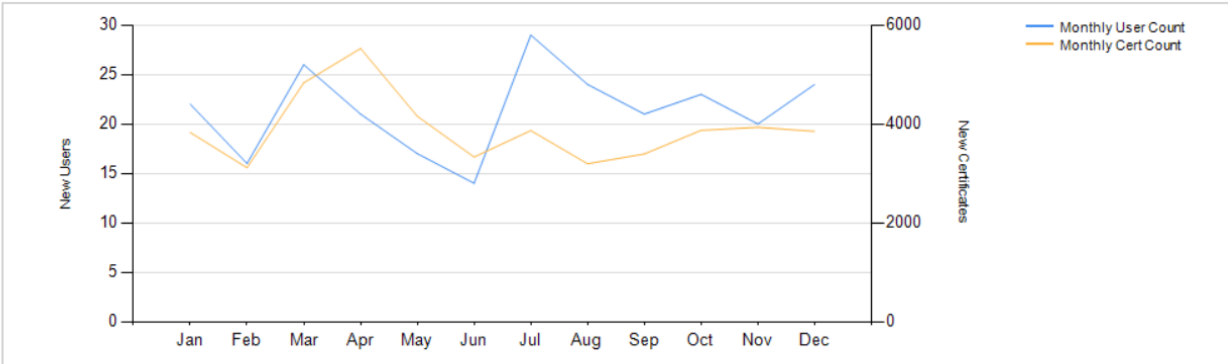


Figure 6-2: *IC3* 2021 New Users and Certificates

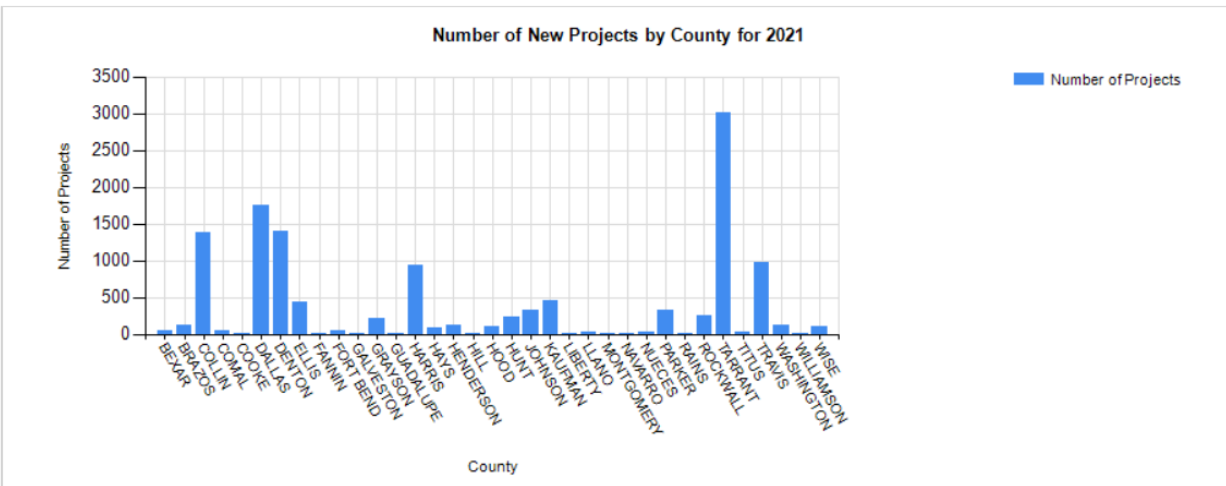


Figure 6-3: *IC3* 2021 Certificates – Counties with at least 10 Certificates

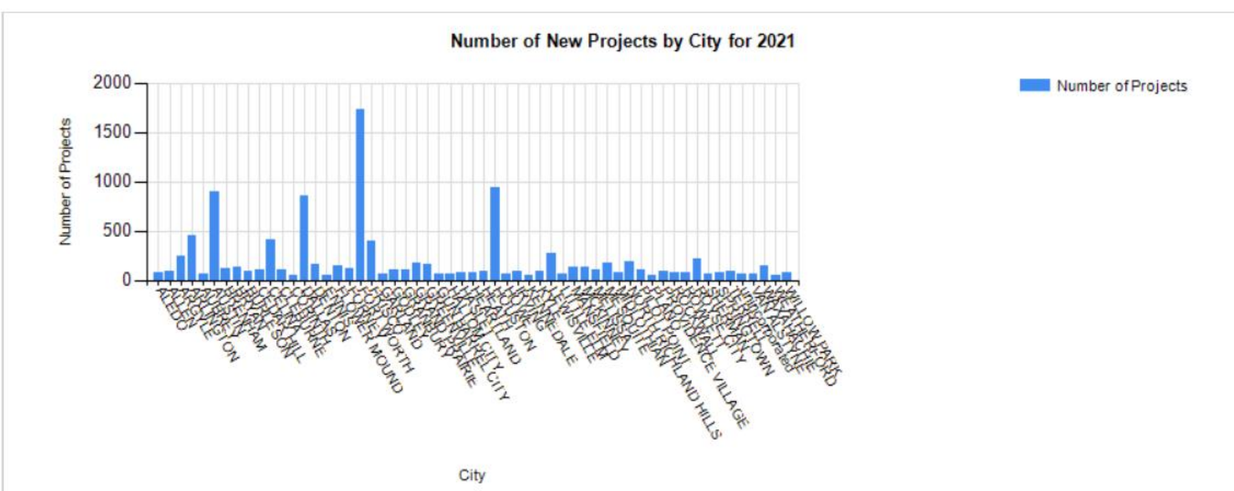


Figure 6-4: *IC3* 2021 Certificates – Cities with at least 50 Certificates

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, 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 6-5 shows the "layout" of the IC3 (v3.x and above) and TCV[38] (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.

[38] 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.

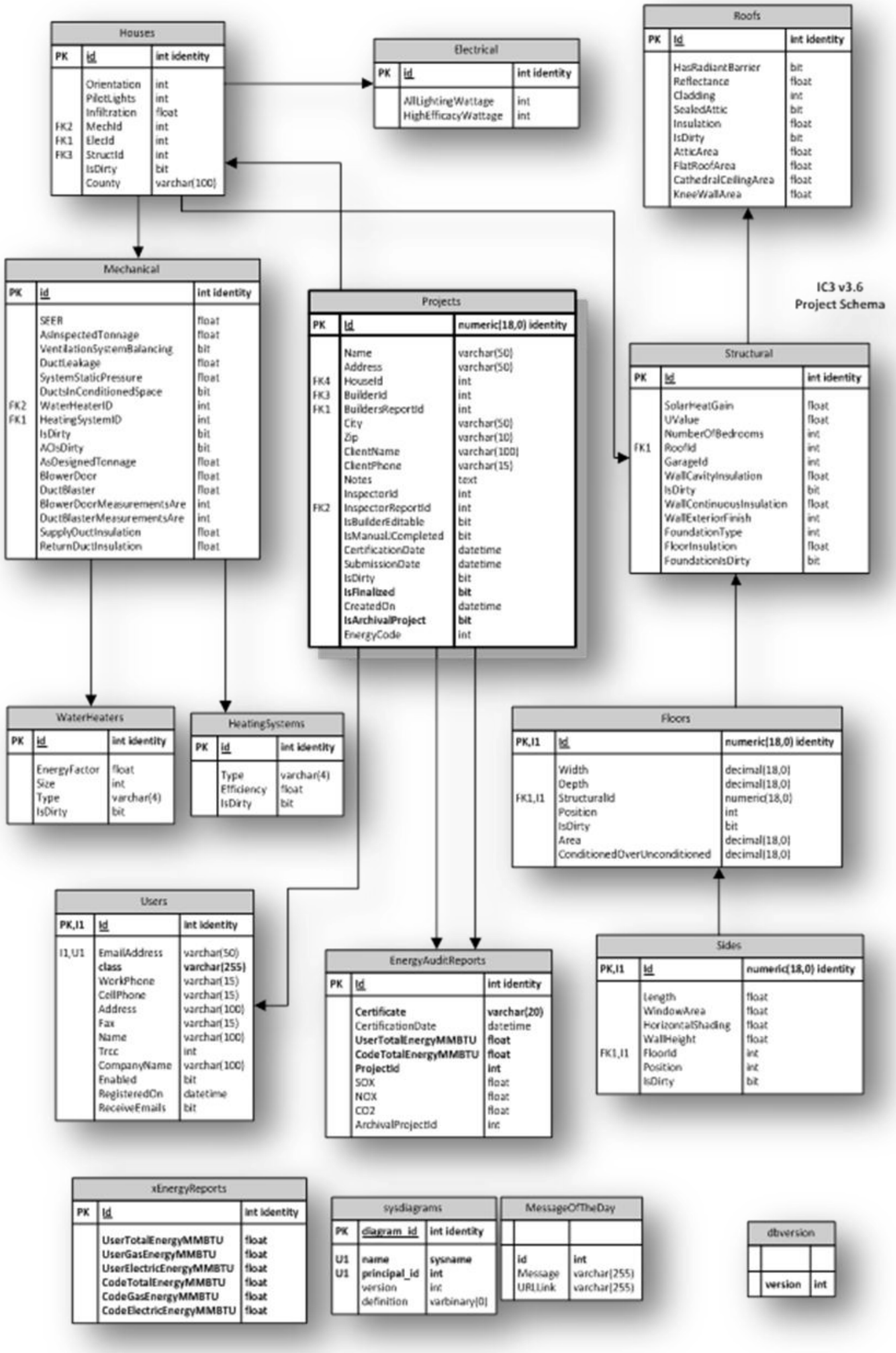


Figure 6-5: Database Schema

6.1.3 Usage Reports

Figure 6-2 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 2021.

Table 26: Counties Generating IC3 Certificates in 2021.

County	January	February	March	April	May	June	July	August	September	October	November	December
Bell				1	1					2		
Bexar	4	2	1	1	6	1	6	1	10	3	4	4
Brazoria							1				1	
Brazos	10	11	15	11	5	10	11	10	13	9	10	13
Burleson												1
Burnet	2		1		2	1		2	1			
Caldwell					1	1				1	1	
Chambers							1					
Coke							1					
Collin	204	162	142	138	79	114	96	62	100	66	98	127
Comal	3	10	2	4	7	4	4	10	4	1		
Cooke			1				1	1	4	1	2	8
Coryell						1						
Dallas	150	134	170	158	133	145	118	141	161	154	134	163
Denton	67	136	128	209	94	98	94	112	123	91	108	149
Ector			4	4								
Ellis	29	52	37	85	27	29	29	24	46	20	25	29
Fannin		1			1		1	1	6	1	2	2
Fort Bend		16	14	3						14		
Galveston	2		8	1	2	3				1	1	2
Gillepie								2			1	
Grayson	12	15	37	14	26	12	17	17	16	5	14	31
Gregg	3		1		1							
Guadalupe	3	2	2		1		1		2			
Harris	69	50	138	88	51	80	139	41	59	106	58	66
Hays											6	81
Henderson	6	4	2	32	6	18	19	6	7	9	6	8
Hill				2	1		4		1		1	1
Hood	1	2	4	6	12	7	12	2	39	2	5	8
Hopkins		1			1		1					
Houston						1						
Hunt	22	8	20	25	31	20	15	23	17	19	16	12
Jefferson								1				
Johnson	27	29	32	25	32	30	32	8	39	31	21	31
Kaufman	27	38	84	52	32	35	30	46	29	34	19	32
Lamar								2				1
Liberty	7	4		3	2	2	3				1	
Llano	3		1	9	3	1		1	1	3		3
Mason			1							1		
Mclennan			1									
Medina										1	1	
Montague			1	2		1		2				
Montgomer			3	1			6	1		9		1
Navarro	1	1	1		1	1		2	4	2	3	2
Nueces	16	4					2	1		4		
Palo Pinto			2									
Parker	16	25	28	41	38	28	49	21	29	38	13	9
Potter	1											

Table 26: Counties Generating IC3 Certificates in 2021 (Continued).

County	January	February	March	April	May	June	July	August	September	October	November	December
Rains	7	2	2					1			2	1
Randall	1		1								1	2
Red River												1
Rockwall	23	24	24	16	22	21	14	12	29	16	35	10
Smith							1					
Somerwill									1			
Tarrant	235	224	307	356	208	258	257	237	211	217	202	291
Titus	1	1	6	1		1	1	4	1	3	3	4
Travis	119	195	165	82	42	20	120	50	16	30	27	105
Van Zandt							1			1		
Waller		1		1								
Washington				43			7	15	12	20	20	6
Williamson							1				10	3
Wise	4	9	22	7	8	3	3	7	8	7	6	18
Zapata										4		

6.1.4 Parameter Reports

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

This report shows the yearly average wall cavity insulation distribution Texas for 2021 (Figure 6-6- Figure 6-15). The colors in the figure show the relevant insulation values.

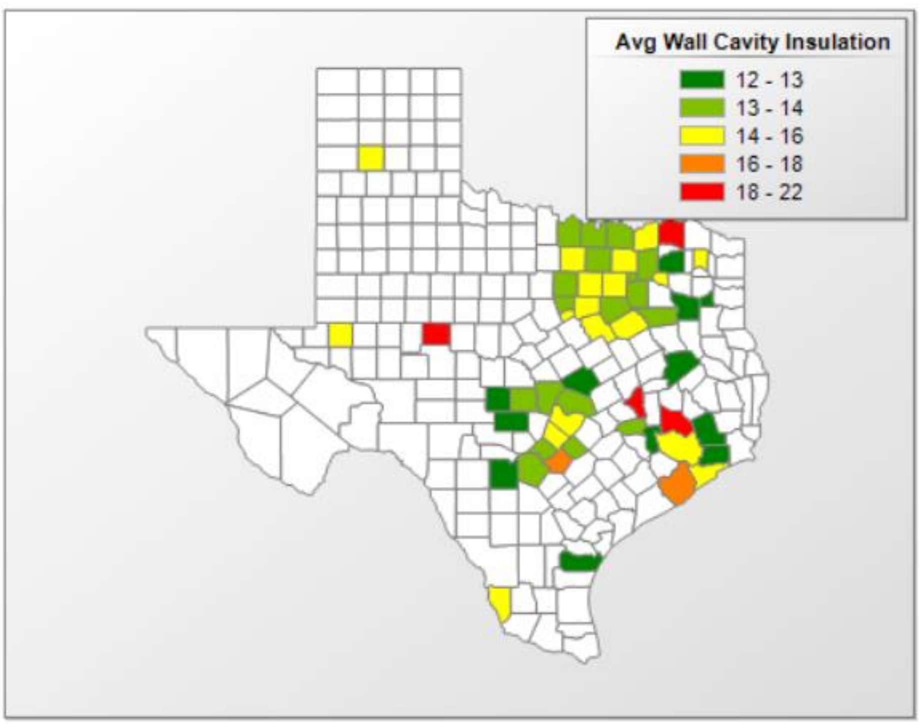


Figure 6-6: Yearly Average Wall Cavity Insulation Distribution by County in 2021

This report shows water heater efficiencies across Texas in 2021

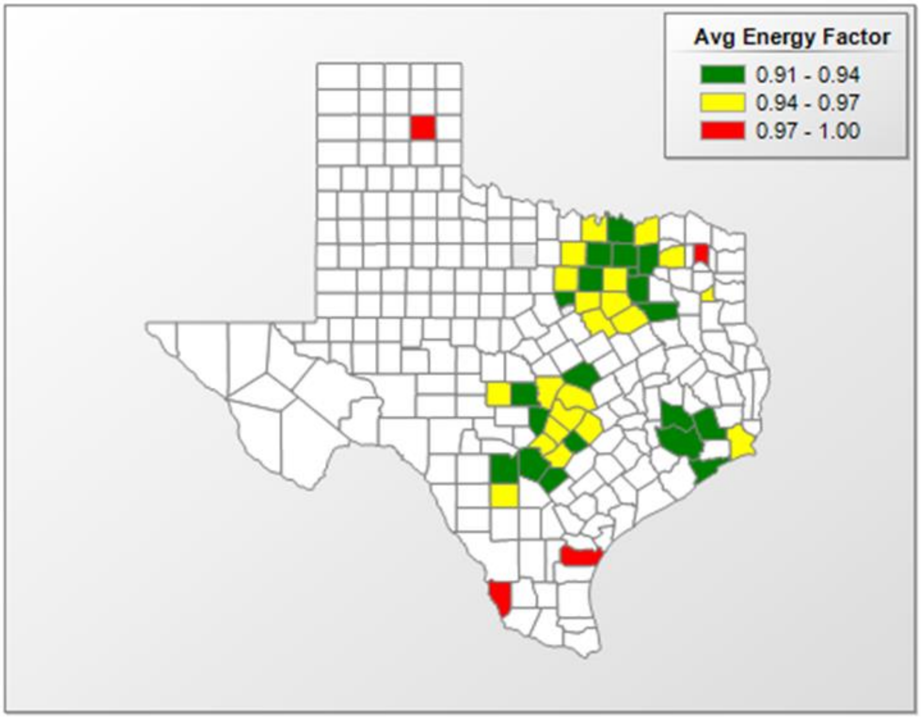


Figure 6-7: Yearly Average Electric Water Heater Energy Factor Distribution by County in 2021

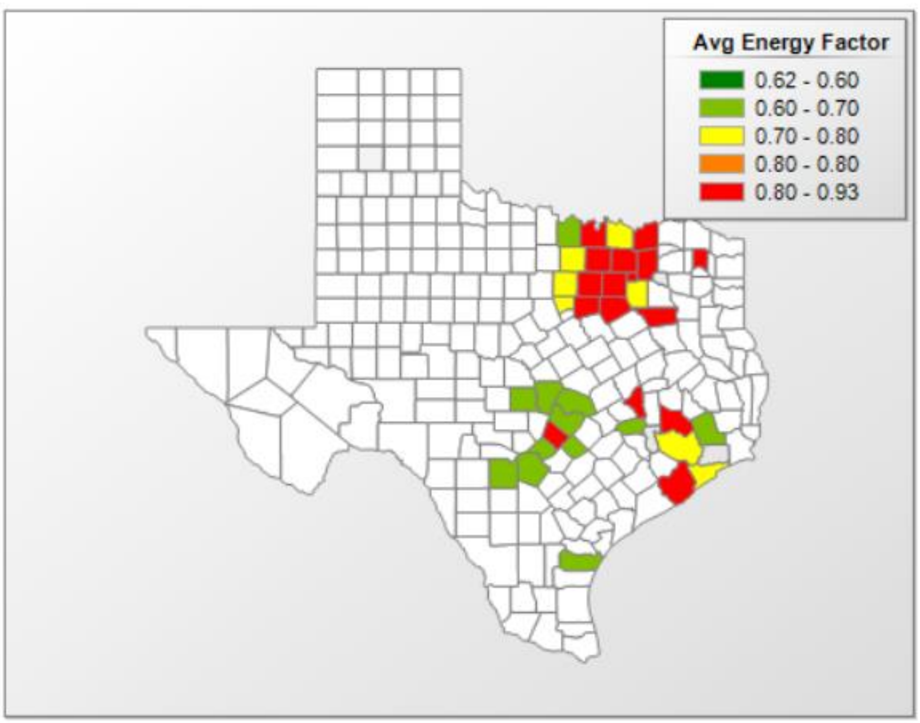


Figure 6-8: Yearly Average NGas Water Heater Energy Factor Distribution by County in 2021

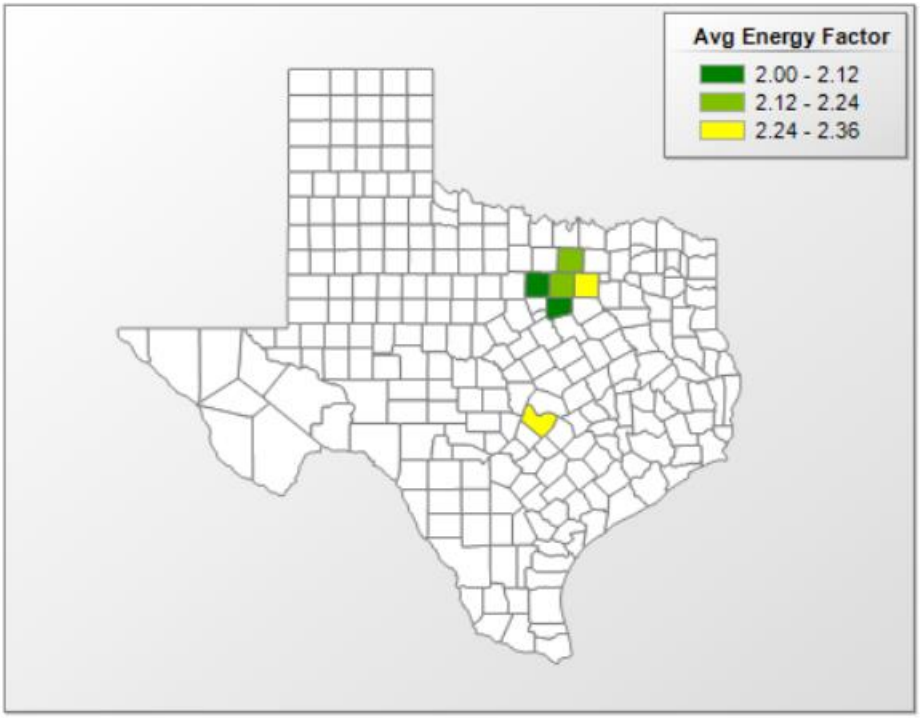


Figure 6-9: Yearly Average Heat Pump Water Heater Energy Factor Distribution by County in 2021

This report shows the average A/C SEER across Texas in 2021. The efficiency (and sizing) of air conditioning is a vital component of energy efficiency in Texas.

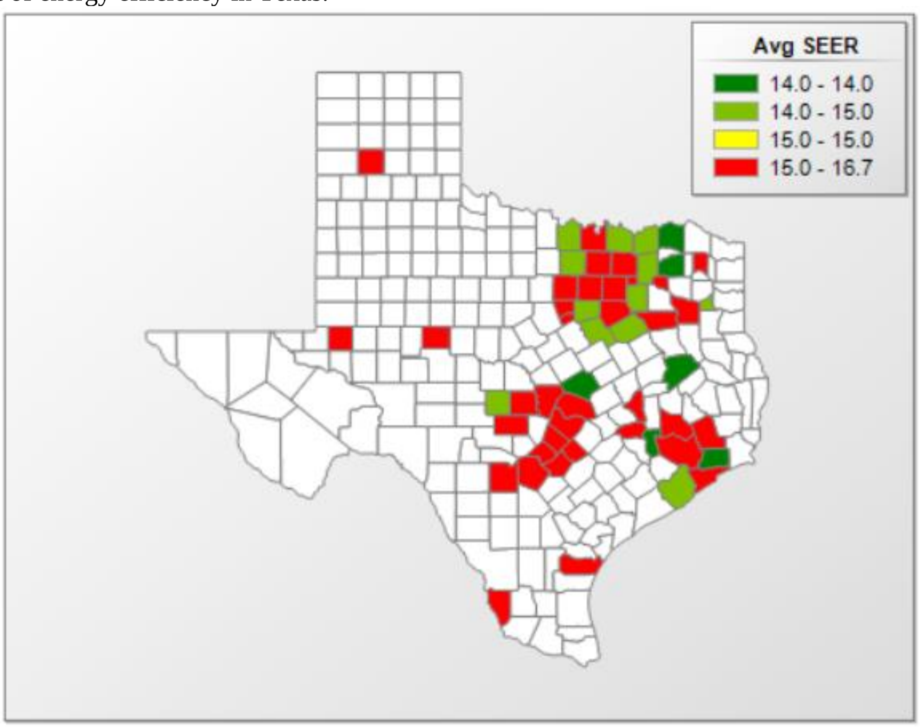


Figure 6-10: Average A/C SEER across Counties in 2021

This report shows the average ceiling insulation across Texas in 2021.

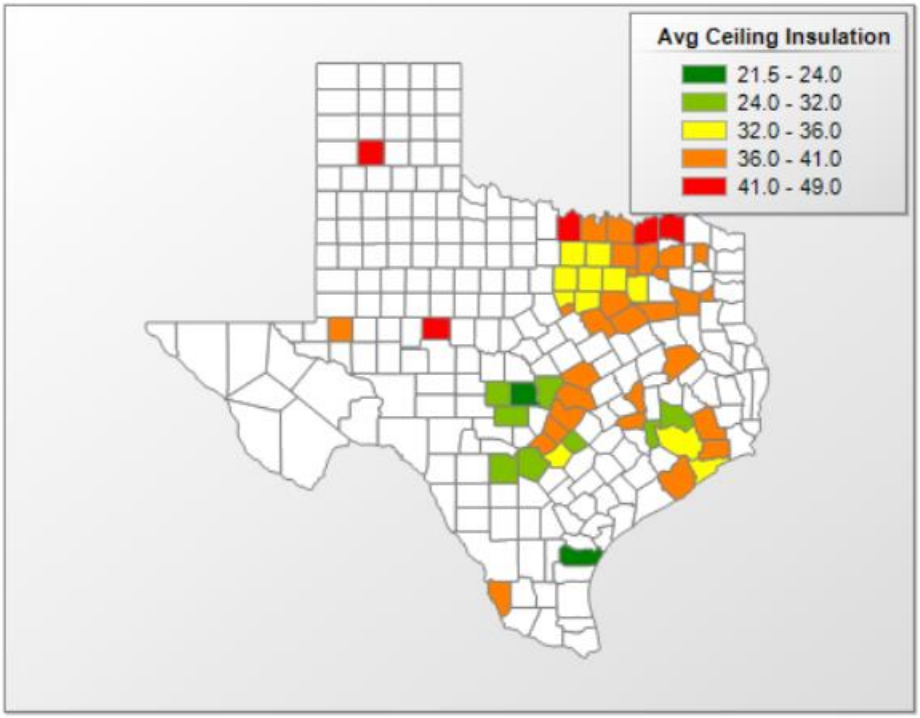


Figure 6-11: Average Ceiling Insulation across Counties in 2021

This report shows the average heating efficiency across Texas in 2021.

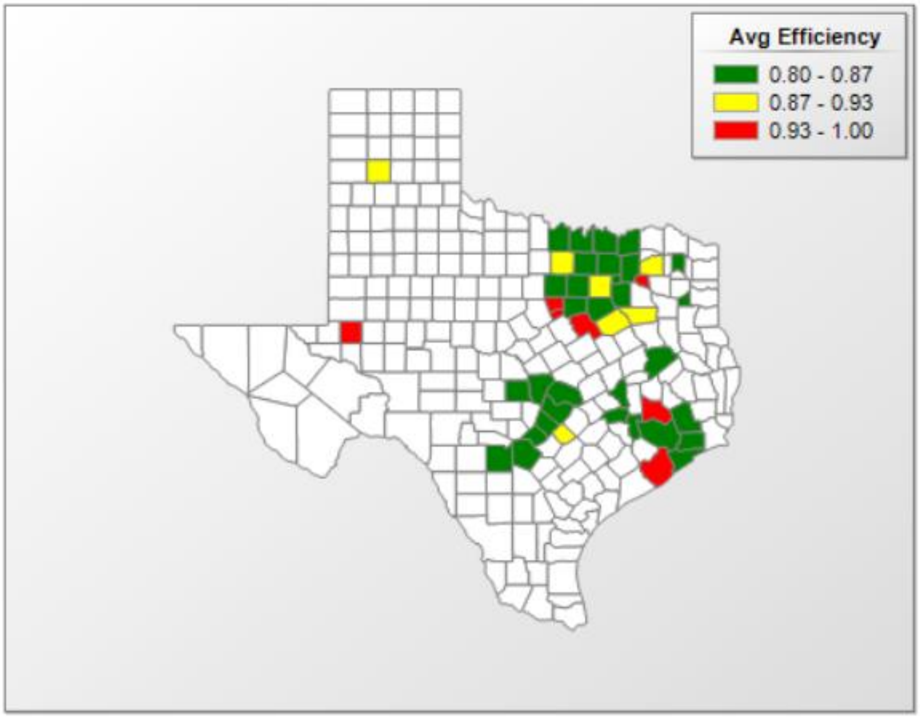


Figure 6-12: Average NGas Heating Efficiency across Counties in 2021

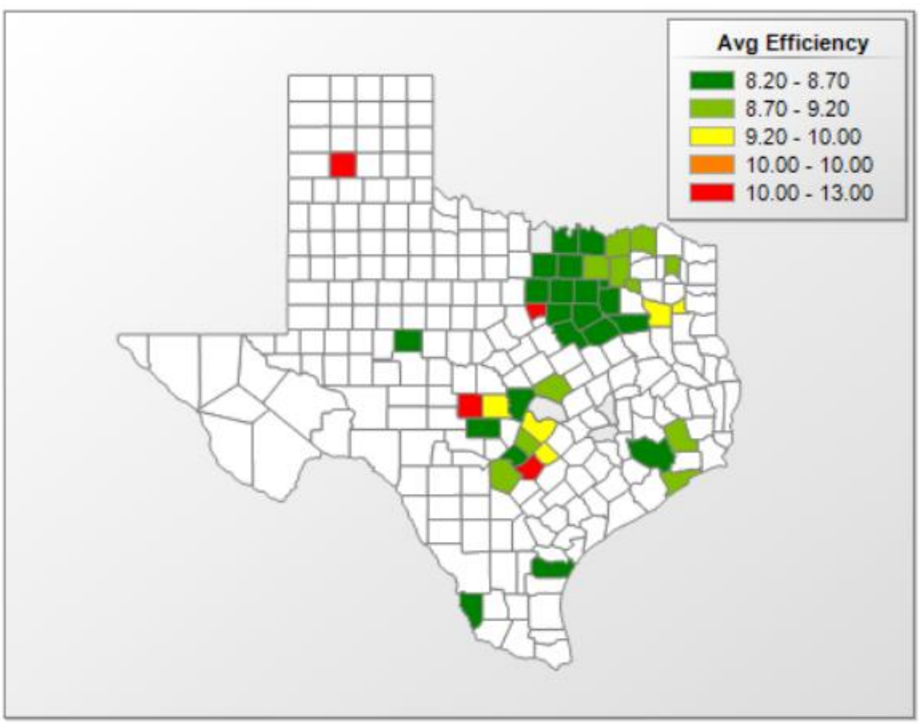


Figure 6-13: Average Heat Pump Heating Efficiency across Counties in 2021

This report shows the average SHGC across Texas in 2021.

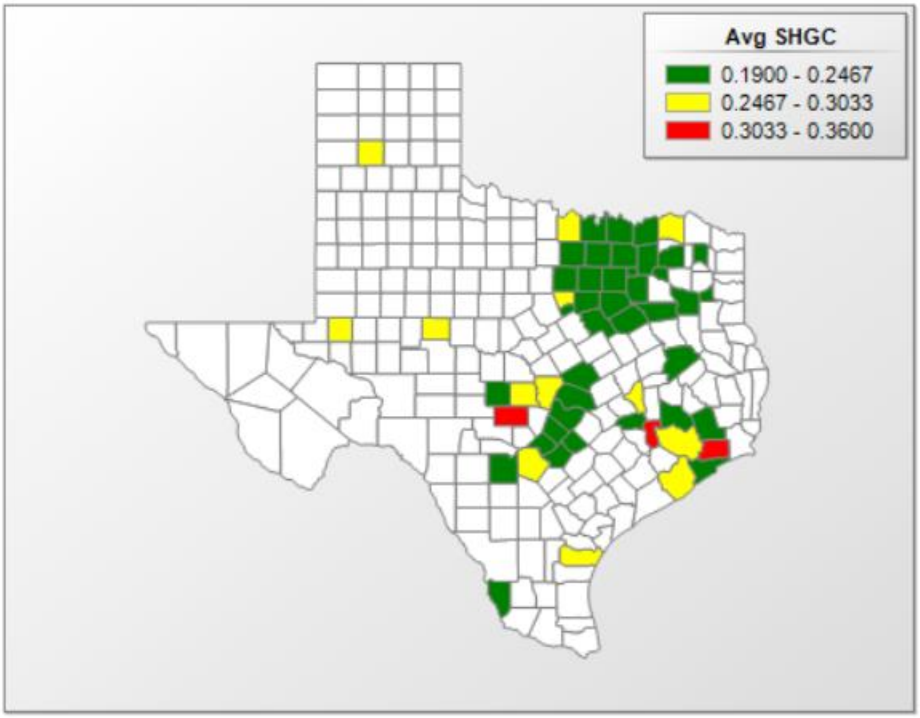


Figure 6-14: Average SHGC across Counties in 2021

This report shows the average U Factor across Texas in 2021. The U Factor applies to the heat transfer of a window caused by temperature, no direct solar radiation.

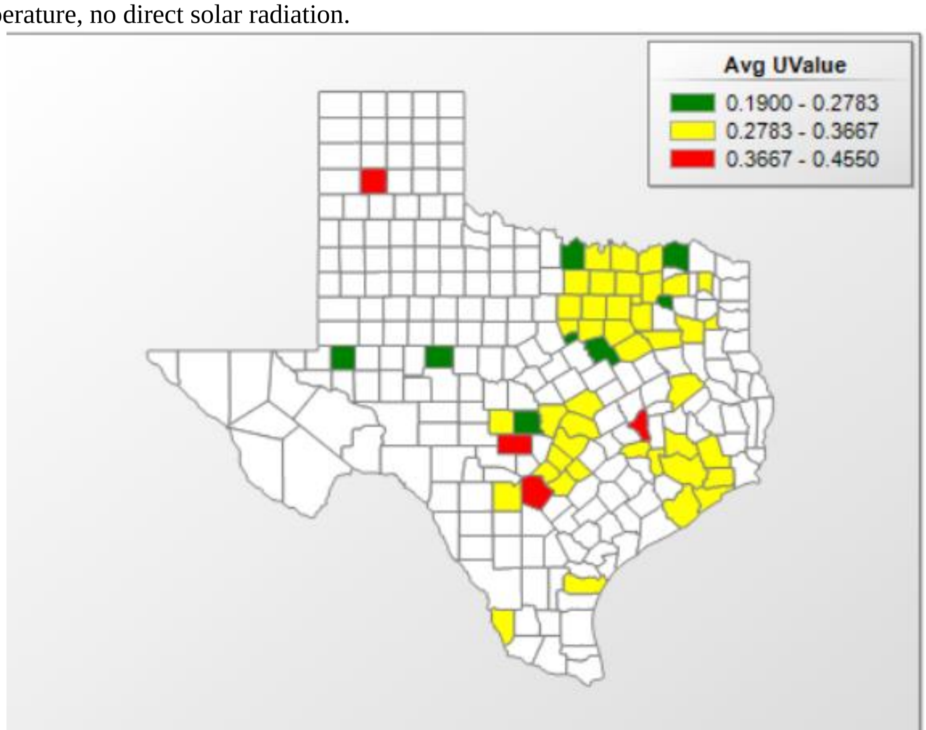


Figure 6-15: Average U Factor across Counties for Single-Family Homes in 2021

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

In Version 4.5.5 (September 19, 2021)

- IECC 2021 code supported
- IECC 2021 AE code supported

In Version 4.5.6 (December 10, 2021)
- IECC 2021 AE code added
- IECC 2021 code added
- New equipment: DHW UEF, New Duct System Interface

In Version 4.5.7 (May 23, 2022)
- New search features added in project page
- Alterations made to 2021 Energy Option selection

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 revised 2015 IECC AE code. Specifically, added 4th floor support.	

<u>*Added sensible and latent components for equipment heat gain*</u>
In order to incorporate the HERS Index calculations in IC3, it became necessary to elaborate the input for lighting, equipment and occupants.[39] 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.

[39] It should be noted that loads from occupants were included in the loads for equipment.

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 a 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 were 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.[40]
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).[41]

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.

[40] Email correspondence with Jeff Myron, EnergyGauge Technical Support (10/18/2013).
[41] 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 2021, the Laboratory redesigned its website to make navigation easier. On the navigation bar is a tab that links to the TERP homepage (Figure 6-16). 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 6-17)

- 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 2002-2021
    - Presentations
- Workshops
    - International Code Compliance Calculator
    - ASHRAE
    - IECC Commercial Energy Code Training

    - IECC Residential Energy Code Training
    - Continuous Commissioning
- TERP Links (Figure 6-18)
    - 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

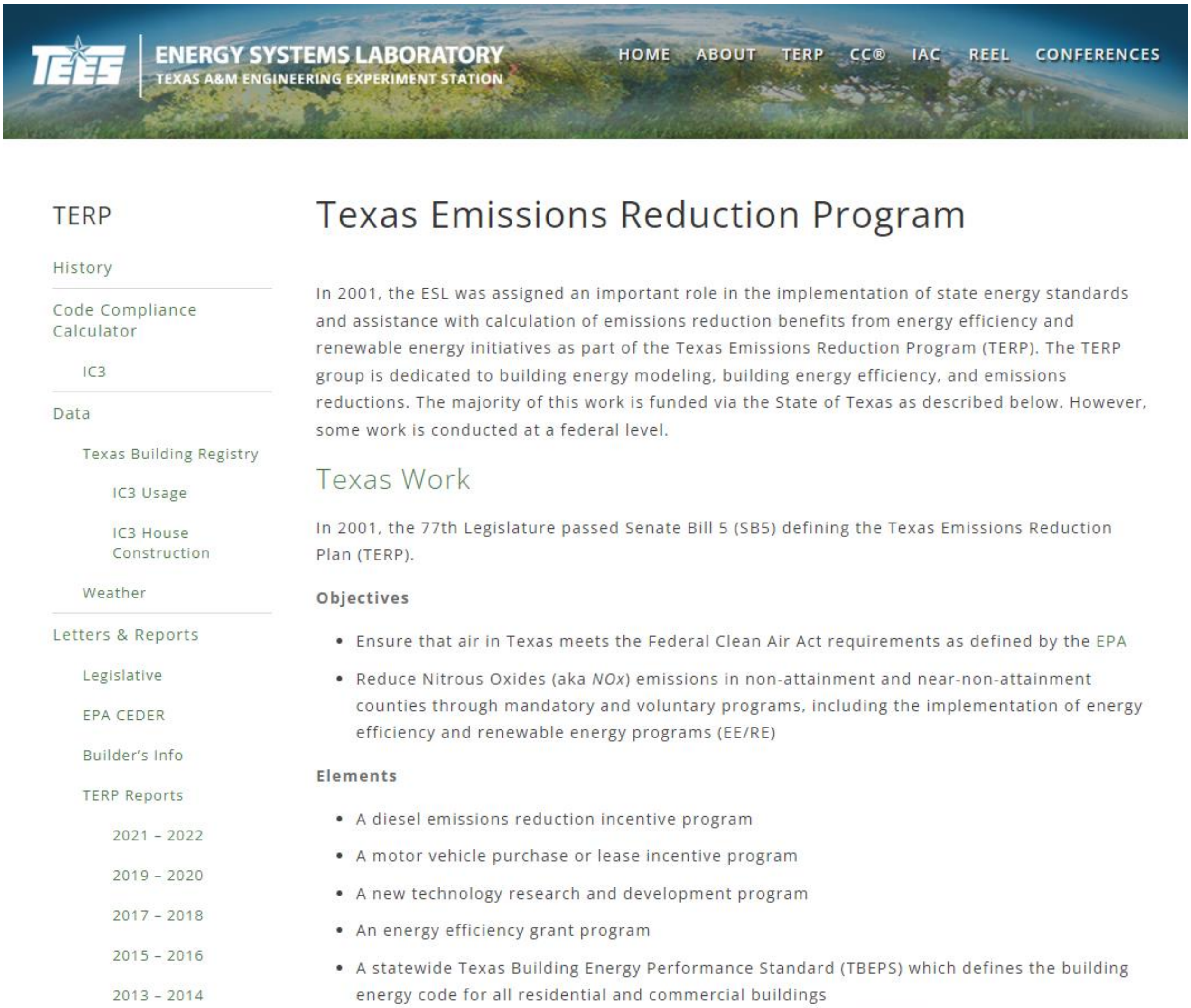
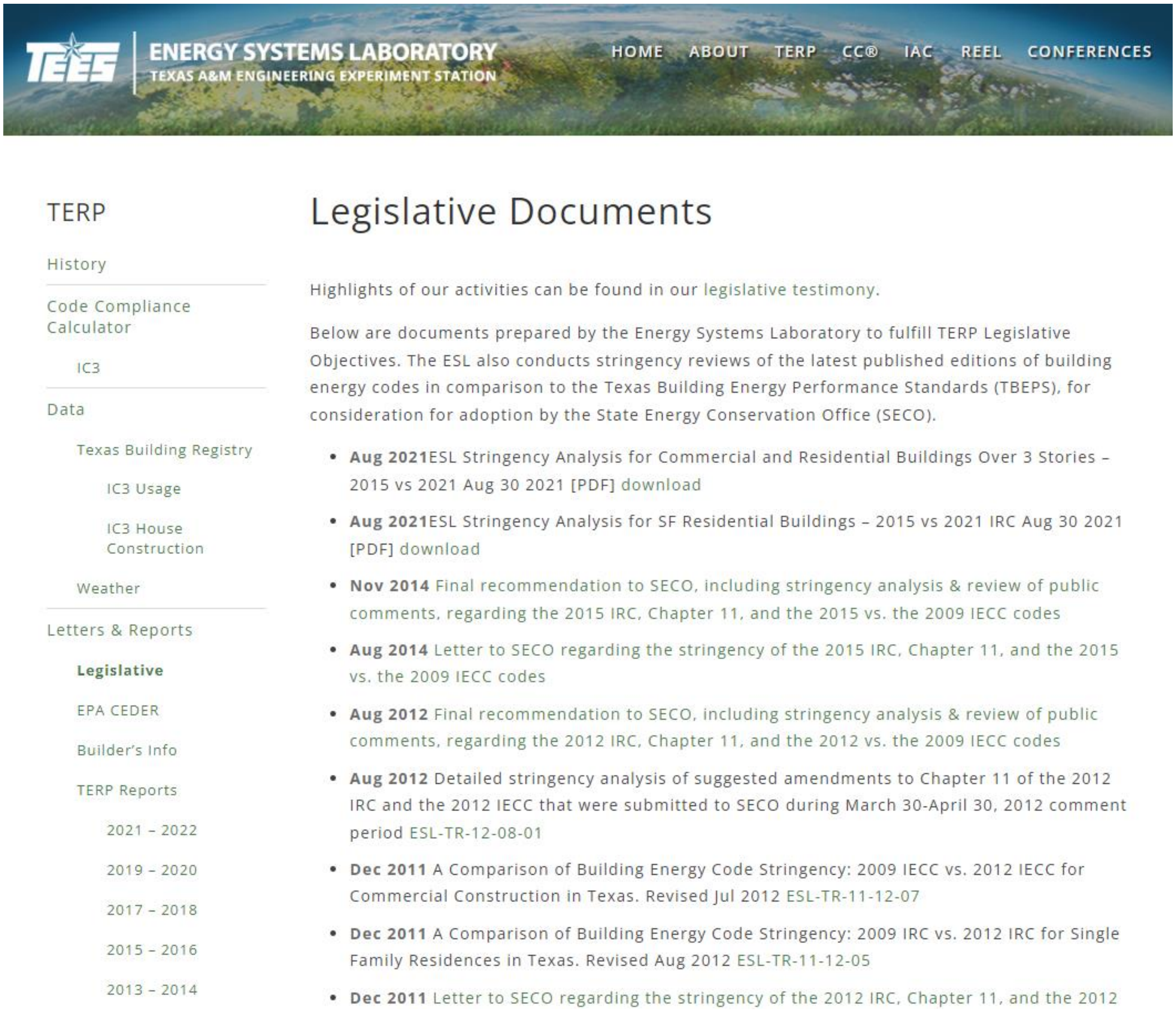


Figure 6-16. TERP Home Page



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
    - 2021 – 2022
    - 2019 – 2020
    - 2017 – 2018
    - 2015 – 2016
    - 2013 – 2014

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).

- **Aug 2021**ESL Stringency Analysis for Commercial and Residential Buildings Over 3 Stories – 2015 vs 2021 Aug 30 2021 [PDF] download
- **Aug 2021**ESL Stringency Analysis for SF Residential Buildings – 2015 vs 2021 IRC Aug 30 2021 [PDF] download
- **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

Figure 6-17: TERP –Legislative Documents

Figure 6-18: TERP Links (Accessed: 08/29/2022)

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. From 2005 to 2021, the Laboratory continued to work closely with the TCEQ to develop an integrated emissions calculation, which provided to the TCEQ with a creditable NOx emissions reduction from energy efficiency and renewable energy (EE/RE) programs. The integrated emission estimation includes data from the Laboratory, PUC, SECO, and Renewables-ERCOT.

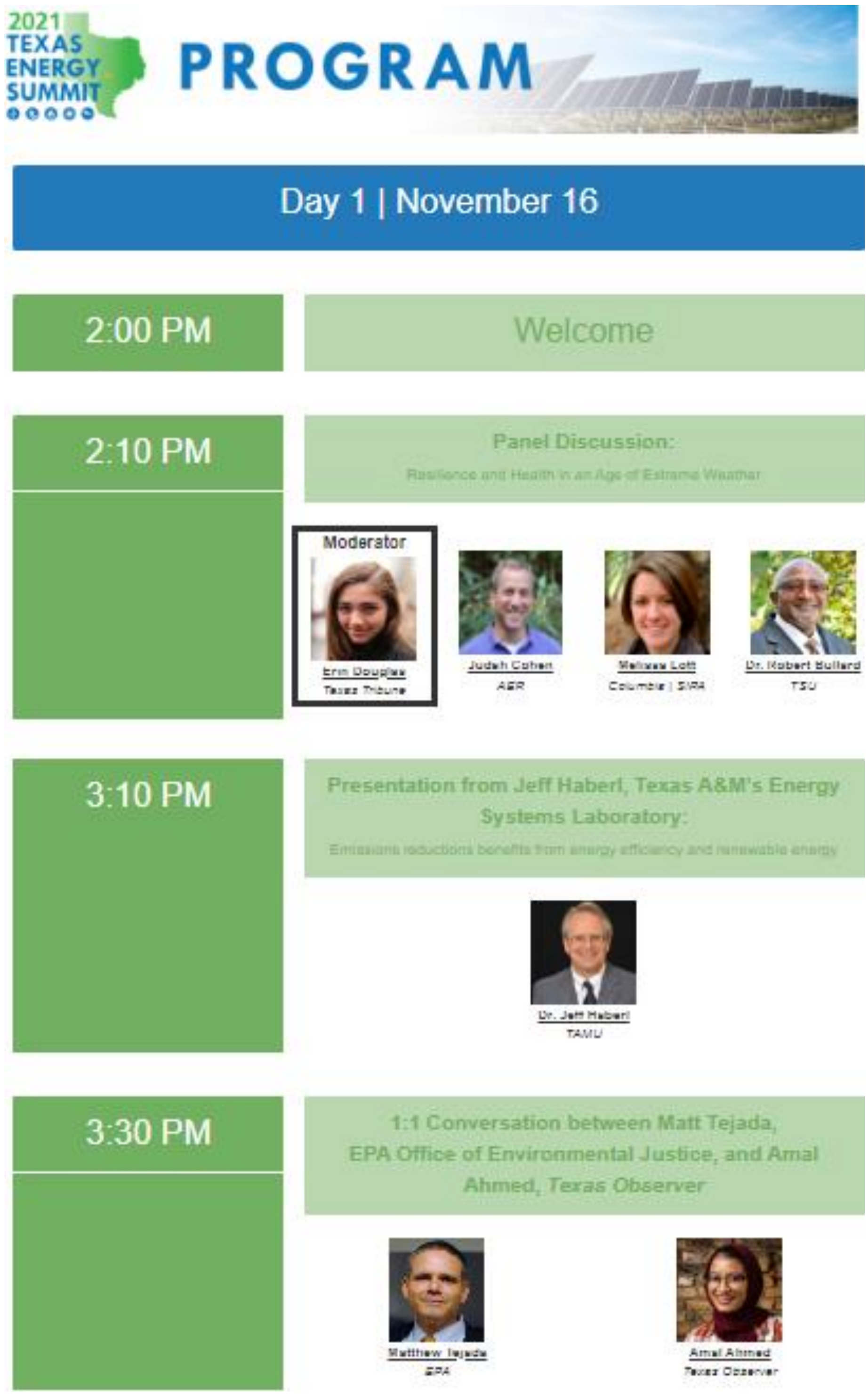
The Laboratory has and will continue to provide leading edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering the emissions and improving the air for all Texans. The Laboratory will continue 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. In 2021, due to COVID-19, there were no code training workshops.

6.4.3 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 2021. This conference was 100% online due to Covid-19 restrictions from November 16-17, 2021.



Texas Energy Summit 2021

Texas Energy Summit 2021

6.4.4 Papers, Theses, etc.

6.4.4.1 Theses and Dissertations.

The following theses and dissertations were published in 2021 incorporating work related to the Texas Emissions Reduction Plan (TERP).

- Park, D., "Performance Mapping and Life-Cycle Cost Modeling for Heat Exchanger Geometry Optimization in Vapor Compression Chillers," *M.S. Thesis, Dept. of Mechanical Engineering, Texas A&M University, College Station, TX, May. 2021.*

  With the significance of chillers in end energy use and the environment, chiller manufacturers face different regulations around the globe and changes in consumer demands. In the product development phase, components are put together to meet the cooling capacity and efficiency. However, many configurations are possible to meet such system requirements. An optimization study of heat exchanger geometries within a given chiller configuration is proposed to enable the economic comparison between different configurations. The heat exchangers will be optimized to meet the system requirements while minimizing the life cycle cost of the chiller. The resulting refrigerant cost and heat exchanger raw material cost can be used to compare different chiller configurations to one another. Several topics in chiller modeling will be addressed to conduct heat exchanger optimization within a chiller configuration. A universal method to empirically map heat exchangers will be developed to relieve the computational time associated with nested iterations. Using the mapping method, the iterative finite control volume heat exchanger model will be mapped to a non-iterative empirical map of the heat exchanger. A shell and tube heat exchanger model will be used to demonstrate the universal heat exchanger mapping method. An optimization framework is then formulated and demonstrated with a set of case studies. Lastly, modeling the chiller system and the chiller optimizer will be developed into an easy-to-use software that can carry out heat exchanger optimization study in a chiller configuration and inter-configuration cost comparison of chillers.

- Guo, F., "Large Scale Data Analytics for Fault Detection and Diagnosis of Residential HVAC Systems," *Ph.D. Dissertation, Dept. of Mechanical Engineering, Texas A&M University, College Station, TX, Jun. 2021*

  Residential heating, ventilation, and air conditioning (HVAC) equipment maintains the indoor environment with appropriate temperature and humidity levels. Meanwhile, it accounts for 51.3% of annual energy use and 40.1% of annual energy expenditures in the residential buildings in the U.S. However, residential HVAC systems often suffer from installation faults and operational faults leading to degradation in system capacity or even complete breakdowns, causing extra energy consumption and occupant discomfort. Fault detection and diagnosis (FDD) methods assist in identifying specific system faults, predicting gradual degradation and prompting necessary maintenance. Though plenty of researches have been conducted to develop FDD methods for commercial HVAC systems, relatively few researches focus on residential systems, mainly because FDD requires installation of additional sensors on each HVAC equipment, which is not cost-effective for the mass-produced residential systems. This research fills this gap by developing statistics-based FDD methods to identify faults and monitor behavior changes simultaneously from a large number of residential HVAC systems using smart thermostat data. Two main approaches for fault detection and preliminary diagnosis are proposed in this research, namely: comparing operational features between multiple systems and monitoring the changes of operational features within each system. Following the idea of each approach, a few useful FDD algorithms are developed, including the setpoint tracking failure detector, inadequate capacity detector, control problem detector, and degradation trend detector. Additionally, the research provides general preprocessing procedures for the smart thermostat data, which could be applied to all fault detectors. The preprocessing procedures ensure the data is clean and critical features are extracted that representative of the operational conditions of each system. The main body of this thesis presents each of the proposed detector. The setpoint tracking failure detector identifies degraded systems that cannot effectively regulate the indoor temperature around the desired setpoints. The inadequate capacity detector identifies systems with much lower cooling/heating capacity compared to other systems in the similar climate region, and in majority of the time the degradation of system capacity is imperceptible for home occupants. The control problem detector identifies systems with abnormally high cycle frequency and setpoint error in a large population, which is usually caused by control faults. Lastly, the degradation trend detector is able to detect slow system capacity degradation over time and quantify the magnitude of the degradation. Finally, the author proposes a few future research directions of FDD for residential HVAC systems. Possible research directions include (1) improving the performance of fault detectors through verified in situ faulty systems, (2) developing deep learning models such as the recurrent neural network and the Siamese network, and (3) incorporating additional features from limited numbers of low-cost sensors.

- Whittier, A., "A Model-Based Systems Engineering Approach to Product Value Optimization among Disparate Criteria," *M.S. Thesis, Dept. of Mechanical Engineering, Texas A&M University, College Station, TX, Jun. 2021*

  Model-based systems engineering (MBSE) is a popular approach for managing the technical aspects of large, complex systems. It provides a disciplined framework for capturing emergent properties and interactions early in the system life cycle, while still allowing for creative freedom at the component level. Capturing these properties is critical on large projects, but its value is often unrecognized on smaller projects. This thesis demonstrates that organizations of any size can benefit from incorporating MBSE into their development process. Specifically, product design needs from case studies in two different industries are processed concurrently using an MBSE approach to develop a single system capable of meeting both case study's needs. The resultant system not only meets the organizations' needs, but exhibits emergent properties that make it valuable in other potential applications. The first case study is a heating, ventilation, and air-conditioning (HVAC) manufacturer seeking to reduce its shipping costs through improved product design. The second case study is the National Aeronautics and Space Administration (NASA) seeking to determine the optimal contents of spaceflight medical kits based on multiple figures of merit. The thesis begins with a model-based needs analysis and system architecture design process, revealing a single, emergent, optimization algorithm that is applicable in many domains. Then, a model-based product realization and verification are conducted, resulting in fully functional optimization tools and applicable documentation for the two case study organizations. The demonstration of MBSE providing value to small-scale projects is the primary result of this study. Secondary results emerging from the process show that including shipping costs in product design can result in a lower life cycle cost, that including environmental figures of merit in spaceflight medical kit development can increase the value of the medical kit, and that multi-attribute value theory can be effectively applied in an automated optimization.

Papers
Published Papers in 2021

The following papers were published in 2021 incorporating work related to the Texas Emissions Reduction Plan (TERP).

- Claridge, D.E.,Culp, C.C., Liu, W., Pate, M., Haberl, J., Bynum, J., Tansky, O., Schaff, F. 2021. "A Performance Analysis of the Claridge-Culp-Liu Dehumidification Process: a Novel Approach for Drying Moist Air Based on Membrane Separation, Vacuum Compression and Sub-atmospheric Condensation", International Journal for Refrigeration, accepted for publication (November).

  This paper covers a basic model for analyzing the performance of the Claridge-Culp-Liu dehumidification process. The fundamental process efficiency limit for dehumidification is close to COPCarnot, but for the eight dehumidification cases examined, the limiting or ideal energy use required is 26% to 56% that of a Carnot condensing system as shown in an earlier paper. The model presented in this paper is used to show the membrane system performance reduction caused by finite membrane area, finite water vapor permeance, non-zero air permeance, non-zero system air pressure drop, non-ideal compressors, vacuum pumps, and condensers. The performance of a "conservative" membrane system based on the use of existing components is computed for eight specific conditions along with that of a "target" system that assumes expected component performance after additional future component development. The "conservative" membrane system would use 36% to 66% as much energy as a system with a COP=7 chiller to produce the same dehumidification for the eight cases examined while the "target" system would use 15% to 40% the energy of a system with a COP=7 chiller. In addition to the significant energy reduction over conventional technology, the membrane system offers the advantages of: 1) no HFC refrigerant use; 2) direct isothermal control over humidity ratio setpoint; 3) maximum capacity occurs at design conditions; and 4) system generates pure water extracted from air as a by-product.

Link: https://www.sciencedirect.com/science/article/pii/S0140700720304722

- Azizkhani, M., Haberl, J. 2021. "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, ESL-PA-20-06-02(July).

  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

7 References

ASHRAE 2013. ANSI/ASHRAE/IESNA Standard 90.1-2013, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2016. ANSI/ASHRAE/IESNA Standard 90.1-2016, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

Baltazar, J.C, Haberl, J., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., Kim, C., 2019, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume I", July 2019, Energy Systems Laboratory Report No. ESL-TR-19-07-02.

Baltazar, J.C., Haberl, J., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., Kim, C., 2019, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume II - Technical Appendix", July 2019, Energy Systems Laboratory Report No. ESL-TR-19-07-03.

Baltazar, J.C., Haberl, J., Yazdani, B., Parker, P., Ellis, S., Zilbertshtein, G., and Claridge, D. 2019. “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 2018 to December 2018, Energy Systems Laboratory, Report ESL-TR-19-10-01.

Baltazar, J.C., Haberl, J., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., Kim, C., 2020, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume I", July 2020, Energy Systems Laboratory Report No. ESL-TR-20-07-01.

Baltazar, J.C., Haberl, J., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., Kim, C., 2020, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume II - Technical Appendix", July 2020, Energy Systems Laboratory Report No. ESL-TR-20-07-02.

Baltazar, J.C., Haberl, J., Yazdani, B., Parker, P., Ellis, S., Zilbertshtein, G., and Claridge, D. 2020. “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 2019 to December 2019, Energy Systems Laboratory, Report ESL-TR-20-11-02.

Baltazar, J.C., Haberl, J., Yazdani, B., Parker, P., Ellis, S., Zilbertshtein, G., and Claridge, D. 2020. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II – Technical Appendix, Annual Report to the Texas Commission on Environmental Quality, January 2019 to December 2019, Energy Systems Laboratory, Report ESL-TR-20-11-03.

Baltazar, J.C., Haberl, J., Yazdani, B., Claridge, D., Azimi, M., Ahn, J., Li, Q.B., Sun, Y. 2021, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume I", July 2021, Energy Systems Laboratory Report No. ESL-TR-21-07-01.

Baltazar, J.C., Haberl, J., Yazdani, B., Claridge, D., Azimi, M., Ahn, J., Li, Q.B., Sun, Y. 2021, "Statewide Air Emissions Calculations from Wind and Other Renewables: Volume II - Technical Appendix", July 2021, Energy Systems Laboratory Report No. ESL-TR-21-07-02.

Baltazar, J.C., Haberl, J., Yazdani, B., Parker, P., Ellis, S., Zilbertshtein, G., and Claridge, D., Li, Q.B., 2021. “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 to December 2020, Energy Systems Laboratory, Report ESL-TR-21-11-01.

Baltazar, J.C., Haberl, J., Yazdani, B., Parker, P., Ellis, S., Zilbertshtein, G., and Claridge, D. Li, Q.B., 2021. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II –

Technical Appendix, Annual Report to the Texas Commission on Environmental Quality, January 2020 to December 2020, Energy Systems Laboratory, Report ESL-TR-21-11-02.

Baltazar, J.C., Haberl, J., Yazdani, B., Li Q., Claridge, D., Azimi, M., Ahn. J., and Sun. Y. (2022). "Statewide 2021 Air Emission Calculations from Wind and Other Renewables", Volume I - Technical Report, A Report to the Texas Commission on Environmental Quality, January 2021 to December 2021, Energy Systems Laboratory, Report ESL-TR-22-07-01.

CBECS 2012. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report. https://www.eia.gov/consumption/commercial/data/2012/#b34-b37

Dodge. 2019. Dodge Data & Analytics construction starts information, Texas at the county level by select project types. New York, NY: Dodge Data& Analytics. https://www.construction.com/.

Dodge. 2020a. Dodge Data & Analytics construction starts information, Texas at the county level by select project types. New York, NY: Dodge Data& Analytics. https://www.construction.com/.

Dodge. 2020b. COVID-19 Crusher Construction Starts in Most Metro Areas During First-Half 2020. New York, NY: Dodge Data & Analytics. https://www.construction.com/dodge-newsletters/covid-19-crushes-construction-starts-in-most-metro-areas-during-first-half-2020

Dodge. 2021. Dodge Data & Analytics construction starts information, Texas at the county level by select project types. New York, NY: Dodge Data& Analytics. https://www.construction.com/.

Dodge. 2022. Commercial and Multifamily Construction Starts Post Solid Recovery in 2021. New York, NY: Dodge Data & Analytics. https://www.construction.com/news/Commercial-and-Multifamily-Construction-Starts-Post-Solid-Recovery-in-2021

ERCOT. 2022. 2021 ERCOT Annual REC Report. Retrieved June 01, 2022, from: https://sa.ercot.com/rec/public-reports

ERCOT. 2022. REC Generator List. Retrieved June 01, 2022, from: https://sa.ercot.com/rec/rec-generator

ERCOT. 2022. Quarter / Annual Renewable Energy Generation in Texas by Technology Type. Retrieved June 01, 2022, from: https://sa.ercot.com/rec/account-tech

Haberl, J., Baltazar, J.C., Gilman, D., Culp, C., Yazdani, B., Claridge, D., Mao, C., Sun, Y., Narayanaswamy, A., 2011, "Statewide Air Emissions Calculations from Wind and Other Renewables", August 2011, Energy Systems Laboratory Report No. ESL-TR-11-08-01.

Haberl, J., Baltazar, J.C., Culp, C., Yazdani, B., Claridge, D., Mao, C., Do, S., 2012, "Statewide Air Emissions Calculations from Wind and Other Renewables", July 2012, Energy Systems Laboratory Report No. ESL-TR-12-07-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Mao, C., Kota, S., 2013, "Statewide Air Emissions Calculations from Wind and Other Renewables", July 2013, Energy Systems Laboratory Report No. ESL-TR-13-07-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Do, S., Oh, S., 2014, "Statewide Air Emissions Calculations from Wind and Other Renewables", July 2014, Energy Systems Laboratory Report No. ESL-TR-14-07-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Oh, S., Mao, C., 2015, "Statewide Air Emissions Calculations from Wind and Other Renewables", July 2015, Energy Systems Laboratory Report No. ESL-TR-15-07-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., 2016, "Statewide Air Emissions Calculations from Wind and Other Renewables", September 2016, Energy Systems Laboratory Report No. ESL-TR-16-09-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., 2017, "Statewide Air Emissions Calculations from Wind and Other Renewables", August 2017, Energy Systems Laboratory Report No. ESL-TR-17-08-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Claridge, D., Jung, S., Kheiri, F., Shin, M., 2018, "Statewide Air Emissions Calculations from Wind and Other Renewables", July 2018, Energy Systems Laboratory Report No. ESL-TR-18-08-01.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, and Turner, D., 2002, "Texas's Senate Bill 5 Legislation for Reducing Pollution in Non-attainment and Affected Areas," Annual Report to the Texas Natural Resource Conservation Commission, July, Energy Systems Laboratory Report ESL-TR-02-07-01.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, T., Bryant, J., Turner, D., 2003, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)," Volume II– Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2002 to August 2003, Energy Systems Laboratory Report ESL-TR-03-12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, Z., Baltazar, J.C., Bryant, J., Degelman, L., Turner, D. 2004. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2003 to August 2004, Energy Systems Laboratory Report ESL-TR-04-12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, Z., Baltazar, J.C., Bryant, J., Degelman, L., and Turner, D. 2006. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2004 to December 2005, Energy Systems Laboratory, Report ESL-TR-06-06-08.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Liu, Z., Baltazar, J.C., Mukhopadhyay, J., Degelman, L., McKelvey, K., Montgomery, C., Ahmed, M., Verdict, M., 2007. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2006 to June 2007, Energy Systems Laboratory, Report ESL-TR-07-12-02.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Liu, Z., Baltazar, J.C., Mukhopadhyay, J., Degelman, L., and Claridge, D. 2008. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2007 to December 2007, Energy Systems Laboratory, Report ESL-TR-08-12-02.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Muns, S., Liu, Z., Baltazar, J.C., Mukhopadhyay, J., Degelman, L., and Claridge, D. 2009. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2008 to December 2008, Energy Systems Laboratory, Report ESL-TR-09-12-02.

Haberl, J., Culp, C., Yazdani, B., Lewis, C., Liu, Z., Baltazar, J.C., Mukhopadhyay, J., Gilman, D., Degelman, L., McKelvey, K., and Claridge, D. 2010. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2009 to December 2009, Energy Systems Laboratory, Report ESL-TR-10-12-02.

Haberl, J., Yazdani, B., Lewis, C., Liu, Z., Baltazar, J.C., Mukhopadhyay, J., Gilman, D., Degelman, L., McKelvey, K., Zilbershtein, G., and Claridge, D. 2011. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions

Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2010 to December 2010, Energy Systems Laboratory, Report ESL-TR-11-12-03.

Haberl, J., Yazdani, B., Baltazar, J.C., Lewis, C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbershtein, G., and Claridge, D. 2012. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2011 to December 2011, Energy Systems Laboratory, Report ESL-TR-12-12-05.

Haberl, J., Yazdani, B., Baltazar, J.C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbershtein, G., and Claridge, D. 2013. "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)", Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2012 to December 2012, Energy Systems Laboratory, Report ESL-TR-13-10-04.

Haberl, J., Yazdani, B., Baltazar, J.C., Do, S.L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbershtein, G., and Claridge, D. 2014. "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 2013 to December 2013, Energy Systems Laboratory, Report ESL-TR-14-11-01.

Haberl, J., Yazdani, B., Baltazar, J.C., Do, S.L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbershtein, G., and Claridge, D. 2015. "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 2014 to December 2014, Energy Systems Laboratory, Report ESL-TR-15-11-01.

Haberl, J., Yazdani, B., Baltazar, J.C., Do, S.L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbershtein, G., and Claridge, D. 2017. "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 2015 to December 2015, Energy Systems Laboratory, Report ESL-TR-16-11-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Parker, P., Ellis, S., Zilbershtein, G., and Claridge, D. 2018. "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 2016 to December 2016, Energy Systems Laboratory, Report ESL-TR-17-12-01.

Haberl, J., Baltazar, J.C., Yazdani, B., Parker, P., Ellis, S., Zilbershtein, G., and Claridge, D. 2019. "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 2017 to December 2017, Energy Systems Laboratory, Report ESL-TR-18-12-02.

ICC. 2006. 2006 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc.

ICC. 2009 International Energy Conservation Code. Falls Church, VA: International Code Council, Inc.

ICC. 2015. 2015 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc

ICC. 2018. 2018 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc
Kats, G.H. et al. 1996. "Energy Efficiency as a Commodity," ACEEE Summer Study on Energy Efficiency in Buildings.

LBL. 1993. DOE-2 BDL Summary Version 2.1E. LBL Report No. 349346. Berkley, CA: Lawrence Berkeley Laboratory.

LBNL. (2022). Tracking the Sun. Retrieved June 01, 2022, from: https://emp.lbl.gov/tracking-the-sun

Lim, A., "A Comparative Analysis of Predicting Energy Savings From Energy Service Projects," Department of Civil Engineering, May 2014.

NOAA 2019. Local Climatological Data (LCD), National Oceanic and Atmospheric Administration, U.S. Department of Commerce. available at: https://www.ncdc.noaa.gov

NOAA. 2022. Local Climatological Data (LCD). Retrieved from: https://www.ncei.noaa.gov/products/land-based-station/local-climatological-data

Home Innovation Research Labs, 2013, 2014, 2015, 2016, 2018, 2020. Builder Practices Survey Reports, Upper Marlboro, Maryland.

NAHB. 2008. The Builders Practices Survey Reports. National Association of Home Builders. Upper Marlboro, MD: NAHB Research Center.

NREL. 2019. National Solar Radiation Data Base: 1991 - 2005 Update: Typical Meteorological Year 3, Golden, CO. National Renewable Energy Laboratory. available at: https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

PUC 2019. Project No. 26310-20: 2019 PUC Report on Evaluation of State Energy Efficiency Programs. Public Utility Commission of Texas, available at: https://interchange.puc.texas.gov/search/documents/?controlNumber=26310&itemNumber=20

PUC 2020. Project No. 26310-21: 2020 PUC Report on Evaluation of State Energy Efficiency Programs. Public Utility Commission of Texas, available at: https://interchange.puc.texas.gov/search/documents/?controlNumber=26310&itemNumber=21

PUC 2021. Project No. 26310-22: 2021 PUC Report on Evaluation of State Energy Efficiency Programs. Public Utility Commission of Texas, available at: https://interchange.puc.texas.gov/search/documents/?controlNumber=26310&itemNumber=22

PUCT. 2022. New Electric Generating Plants in Texas since 1995. Retrieved June 09, 2022, from: http://www.puc.texas.gov/industry/Electric/reports/Default.aspx

Real Estate Center (REC). 2019. Building permits Texas. https://www.recenter.tamu.edu/data/building-permits/

Real Estate Center (REC). 2021. Building permits Texas. https://www.recenter.tamu.edu/data/building-permits/

SECO. 2021. Energy Use Summary. SECO Local Government. Home Comptroller.Texas.Gov. Lyndon B. Johnson State Office Building. 111 East 17th Street. Austin. Texas. 78774, available at:https://bivisual2.cpa.texas.gov/QvAJAXZfc/CPA.aspx?document=documents/BI_Master_UI.qvw&sheet=SecoGov_Sheet_1

Simplemaps. 2022. Retrieved June 01, 2022, from: https://simplemaps.com

TCEQ. 2016. "Texas Emissions Reduction Plan: Guidelines for Emissions Reduction Incentive Grants", Report No. RG-388, Texas Commission on Environmental Quality, available at: https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg388/rg-388.pdf
Texas State Energy Conservation Office (SECO), 2021, available at: https://comptroller.texas.gov/programs/seco/reporting/local-gov.php

USDOE. 2011. Building Energy Standard Program: Final Determination Regarding Energy Efficiency Improvements in the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ANSI/ASHRAE/IESNA Standard 90.1-2010. Federal Register 76(202):64904-64923.

USDOE. 2014. Building Energy Standard Program: Final Determination Regarding Energy Efficiency Improvements in ANSI/ASHRAE/IES Standard 90.1-2013: Energy Standard for Buildings, Except Low-Rise Residential Buildings. Federal Register 79(187):57900-57915.

USDOE. 2021. Department of Energy (DOE). Central Air Conditioning: Energy Saver, Accessed: September 1. https://www.energy.gov/energysaver/central-air-conditioning

USEPA. 2008 "Estimation of Annual Reductions of NOx Emissions in ERCOT for the HB3693 Electricity Savings Goals", December 2008, Energy Systems Laboratory Report No. ESL-TR-08-12-04

USEPA. 2016. Emissions & Generation Resource Integrated Database (eGRID), eGRID 2016. Energy and the Environment, United States Environmental Protection Agency (July).

USEPA. 2018. Emissions & Generation Resource Integrated Database (eGRID). Energy and the Environment, United States Environmental Protection Agency. https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

USEPA. (2022). Emissions & Generation Resource Integrated Database (eGRID). Retrieved June 09, 2022, from: https://www.epa.gov/egrid

USEPA. (2022). Landfill Technical Data. Retrieved June 09, 2022, from: https://www.epa.gov/lmop/landfill-technical-data

8 Bibliography

Ahmed, M., Gilman, D., Mukhopadhyay, J., Haberl, J., Culp, C. 2005a. “Development of a Web-based Emissions Reduction Calculator for Code-compliant Single-Family and Multi-family Construction,” Proceedings of the 5th International Conference for Enhanced Building Operations, Pittsburg, PA (October).

Ahmed, M., Gilman, D., Kim, S., Haberl, J., Culp, C. 2005b. “Development of a Web-based Emissions Reduction Calculator for Code-compliant Commercial Construction,” Proceedings of the 5th International Conference for Enhanced Building Operations, Pittsburg, PA (October).

ASHRAE 1989. Energy Efficient Design of New Buildings Except Low-rise Residential Buildings. ASHRAE Standard 90.1-1989.

ASHRAE 1993. ANSI/ASHRAE Standard 136-1993 (RA 2006) - A Method of Determining Air Change Rates in Detached Dwellings. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

ASHRAE 2004a. “Advanced Energy Design Guide for Small Office Buildings,” American Society of Heating, Refrigeration and Air-conditioning Engineers, Atlanta, GA.

ASHRAE 2004b. ANSI/ASHRAE/IESNA Standard 90.1-2004, Energy Standards for Buildings Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2007. ANSI/ASHRAE/IESNA Standard 90.1-2007, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2010. ANSI/ASHRAE/IESNA Standard 90.1-2010, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2013. ANSI/ASHRAE/IESNA Standard 90.1-2013, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2016. ANSI/ASHRAE/IESNA Standard 90.1-2016, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

ASHRAE 2019. ANSI/ASHRAE/IESNA Standard 90.1-2019, Energy Standards for Building Except Low-Rise Residential Buildings. American Society of Heating and Refrigerating and Air-conditioning Engineers, Inc., Atlanta, GA.

Baltazar, J.C., Liu, Z., Gilman, D., Haberl, J., Culp, C. 2005a. "Development of a Web-based Emissions Reduction Calculator for Retrofits to Municipal Water Supply and WasteWater Facilities," Proceedings of the 5th International Conference for Enhanced Building Operations, Pittsburg, PA (October).

CBECS 2021. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report.

Cho, S., Mukhopadhyay, J., Culp, C., Haberl, J. S., Yazdani, B., 2007. "Recommendations for 15% Above-Code Energy-Efficiency Measures for Commercial Office Buildings," Energy Systems Laboratory Report No. ESL-TR-07-09-01, Texas A&M University.

Cho, S. "Methodology to Develop and Test an Easy-to-use Procedure for the Preliminary Selection of High-performance Systems for Office Buildings in Hot and Humid Climates" Ph.D., Department of Architecture, Aug 2009 ESL-TH-09-08-05

Choi, J-H. "Analysis of the Impact if Using Improved Multi-layer Window Models for Code-Compliant Residential Building Energy Simulation in Texas," M. S., Department of Architecture, Dec 2014 ESL-TH-14-12-02

Do, S. L., "Development and Application of a Ground-Coupled Heat Pump Simulation Model for Residential Code-Compliant Simulation in Texas," Department of Architecture, May 2014 ESL-TH-14-04-01

Dodge. 2005. MarkeTrack: McGraw-Hill Construction Analytics. McGraw-Hill Construction Information Group, 148 Princeton-Hightstown Rd., Hightstown, N.J. http://dodge.construction.com

Dodge. 2011. MarkeTrack: McGraw-Hill Construction Analytics. McGraw-Hill Construction Information Group, 148 Princeton-Hightstown Rd., Hightstown, N.J. http://dodge.construction.com.

Erbs, D., Klein, G., Duffie, S. 1982. "Estimation of the diffuse fraction for hourly, daily and monthly-average global radiation," Solar Energy, Vol. 28, pp. 293-301.

Haberl, J., Im, P., Culp, C. 2004. "NOx Emissions Reductions From Implementation of the 2000 IECC/IRC Conservation Code to Residential Construction in Texas," Proceedings of the 14th Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, Richardson, Texas, accepted for publication (February), pp. 139-150.

Haberl, J., Im, P., Culp, C., Yazdani, B., Fitzpatrick, T., Bryant, J., Turner, D. 2005. "A Simulation Methodology to Estimate NOx Emissions Reductions From the Implementation of the 2000 IECC/IRC Conservation Code in Texas," IBPSA Newsletter, Vol. 15, No. 2, pp. 39-48 (October).

ICC. 2015. 2015 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc.

ICC. 2018. 2018 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc.

ICC. 2021. 2021 International Energy Conservation Code. Country Club Hills, IL: International Code Council, Inc.

IESNA 2000. The IES Lighting Handbook, Reference and Application, 9th Edition. New York: Illuminating Engineering Society of North America.

Im, P. 2003. "A Methodology to Evaluate Energy Savings and NOx Emissions Reduction from the Adoption of the 2000 IECC to New Residences in Non-attainment and Affected Counties in Texas," Master's Thesis, Department of Architecture, Texas A&M University (December).

Im, Piljae. "Methodology for the Preliminary Design of High Performance Schools in Hot and Humid Climates" Ph.D., Department of Architecture, Dec 2009 ESL-TH-09-12-01

Kim, K. H., "Development of an Improved Methodology for Analyzing Existing Single-Family Residential Energy Use," Department of Architecture, Aug 2014 ESL-TH-14-08-04

Kissock, K., Haberl, J.S., Claridge, D.E. 2002. "Development of a Toolkit for Calculating Linear, Change-point Linear and Multiple-Linear Inverse Building Energy Analysis Models," Final Report for ASHRAE Research Project, No. 1050-RP.

Klein, S.A., Beckman, W.A. 1985. "PV F-Chart User's Manual: DOS Version," F-Chart Software, 4406 Fox Bluff Road, Middleton, Wisc. 53562, www.fchart.com.

Klein, S.A., Beckman, W.A. 1993. "F-Chart Solar Energy System Analysis: Version 6.17W," F-Chart Software, 4406 Fox Bluff Road, Middleton, Wisc. 53562, www.fchart.com.

Kootin-Sanwu, V. 2004. "Development of Energy Efficient Housing for Low-Income Families," *Ph.D. Dissertation*, Department of Architecture, Texas A&M University (May).

LBNL 1981. "DOE-2 Reference Manual Version 2.1A. LBL-8706 Rev. 1," Lawrence Berkeley National Laboratory, Berkeley, CA, and Los Alamos Scientific Laboratory, Santa Fe, NM.

Liao, J., Wang, L., and Claridge, D. E., "Analysis of Whole-Building HVAC System Energy Efficiency," ASHRAE Transactions, Vol. 124, Pt. I, pp. 72-87, 2018.

Liu, Z., Gilman, D., Haberl, J., Culp, C. 2005a. "Development of a Web-based Emissions Reduction Calculator for Street Light and Traffic Light Retrofits," Proceedings of the 5th International Conference for Enhanced Building Operations, Pittsburg, PA (October).

Liu, Z., Baltazar, J.C., Gilman, D., Haberl, J., Culp, C. 2005b. "Development of a Web-based Emissions Reduction Calculator for Green Power Purchases from Texas Wind Energy Providers," Proceedings of the 5th International Conference for Enhanced Building Operations, Pittsburg, PA (October).

Malhotra, M. 2005. "An Analysis of Maximum Residential Energy-Efficiency in Hot and Humid Climates," M.S., Department of Architecture, Dec 2005 ESL-TH-05-12-01

Malhotra, M. 2009. "An Analysis of Off-grid, Off-pipe Housing in Six U.S. Climates" Ph.D., Department of Architecture, Dec 2009 ESL-TH-09-12-02

Malhotra, M. and Haberl, J. 2006. "An Analysis of Building Envelope Upgrades for Residential Energy Efficiency in Hot and Humid Climates," Conference Paper for Presentation at SimBuild 2006, Second National Conference of IBPSA-USA. Cambridge, MA.

Malhotra, M. and J. Haberl. 2006. An Analysis of Maximum Residential Energy Efficiency in Hot and Humid Climates. Proceedings of the Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates. Orlando, FL.

Malhotra, M., J. Mukhopadhyay, B. Liu, J. Haberl, C. Culp, B. Yazdani. 2007. Recommendations for 15% Above-Code Energy Efficiency Measures for Single-Family Residences. Energy Systems Laboratory Report No. ESL-TR-07-09-01.

Mao, C., Baltazar, J.C, Haberl, J. 2018. "Comparison of Building Envelop Peak Load Design Methods", Science and Technology for the Built Environment, accepted for publication (December).

Mao, C., Baltazar, J.C., Haberl, J.S., 2018. "Literature Review of Building Peak Cooling Load Design Methods for Commercial Buildings in the United States", Science and Technology for the Built Environment, Volume 24, No. 3, pp. 228-237 (March).

Mukhopadhyay, J. 2005. "Analysis of improved fenestration for code-compliant residential buildings in hot and humid climates," Master's Thesis, Department of Architecture, Texas A&M University.

NAECA. 2015. National Appliance Energy Conservation Act.

NAHB 2000. Builder Practices Survey Reports, National Association of Home Builders, Research Center, Upper Marlboro, Maryland (September).

NREL 1995. User's Manual for TMY2's (Typical Meteorological Years). NREL/SP-463-7668, and TMY2s, Typical Meteorological Years Derived from the 1961-1990. National Solar Radiation Data Base, June 1995 [CD-ROM]. Golden, Colorado: National Renewable Energy Laboratory.

NOAA 1993. Automated Surface Observing System Guide for Pilots, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, National Weather Service (April).

NREL. 2001. Building America house performance analysis procedures. (NREL/TP-550-27754) Golden, CO: National Renewable Energy Laboratory. p. 34.

Oh, S., Haberl, J. 2016. "Origins of the Methods for Simulation of Building Energy Simulation: Part I: Whole Building Energy Use", Science and Technology for the Built Environment, Volume 22, Issue 1, pp.118-137, ESL-PA-16-01-02 (January).

Oh, S., Haberl, J. 2016. "Origins of the Methods for Simulation of Building Energy Simulation: Part II: Lighting and Daylighting Simulation", Science and Technology for the Built Environment, Volume 22, Issue 1, pp. 107-117, ESL-PA-16-01-03 (January).

Oh, S., Haberl, J. 2016. "Origins of the Methods for Simulation of Building Energy Simulation: Part III: Solar Thermal, PV and Passive Solar Simulation", Science and Technology for the Built Environment, Volume 22, Issue 1, pp. 87-106, ESL-PA-16-01-04 (January)

Ottinger, R.L., Wooley, D.R., Robinson, N.A., Hodas, D.R., and Babb, S.E. 1991. Environmental Costs of Electricity. Oceana Publications, Inc., New York, N.Y.

Parker, D.S., Dunlop, J.P., Barkaszi, S.F., Sherwin, J.R., Anello, M.T., and Sonne, J.K. 2000. "Towards Zero Energy Demand: Evaluation of Super-Efficient Building Technology with Photovoltaic Power for New Residential Housing," Proceedings of the 2000 ACEEE Summer Study of Energy Efficiency in Buildings, 1.207-1.223.

RERC 2022. Texas Real Estate Research Center, College of Business, Texas A&M University, College Station, Texas. URL: https://www.recenter.tamu.edu/

Reilly, M., Winkelmann, D., Arasteh, D., and Caroll, W. 1992. "Modeling windows in DOE-2.1e. Proceedings of Thermal Performance of the Exterior Envelopes of Buildings VI," American Society of Heating Refrigeration and Air-Conditioning Engineers, 1992.

Song, S. 2006. "Development of New Methodologies for Evaluating the Energy Performance of New Commercial Buildings," Texas A&M University, in preparation, (August).

U.S. Census 2021. Annual Estimates of the Resident Population for Counties: April 1, 2020 to July 1, 2021 (CO-EST2021-POP) and Annual and Cumulative Estimates of the Components of Resident Population Change for Counties in the United States: April 1, 2020 to July 1, 2021 (CO-EST2021-COMP), U.S. Department of Commerce, March 1, 2022, URL: https://www.census.gov/en.html

USCB. 2002. Square Footage by Household and Unit Size, Income, and Costs—Occupied Units. American Housing Survey for the United States: 2001, p. 84. U.S. Census Bureau, Current Housing Reports, Series H150/01. Washington, DC: U.S. Government Printing Office.

USDOE. 2021. Final Determination Regarding Energy Efficiency Improvements in ANSI/ASHRAE/IES Standard 90.1-2019: Energy Standard for Buildings, Except Low-Rise Residential Buildings. Federal Register 83(39):8463-8465.

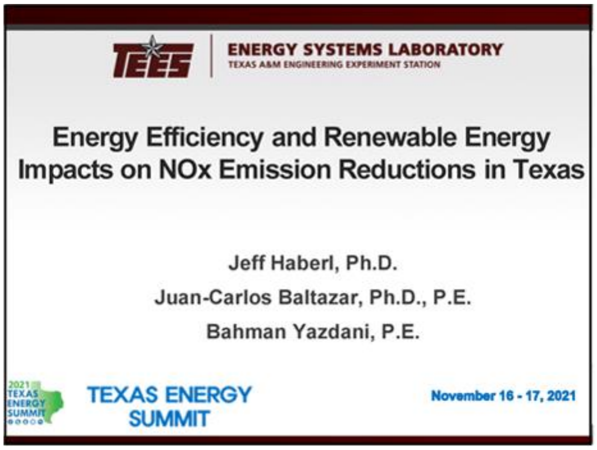
Appendix A: Presentations to Various Entities at Conferences and Workshops in 2020

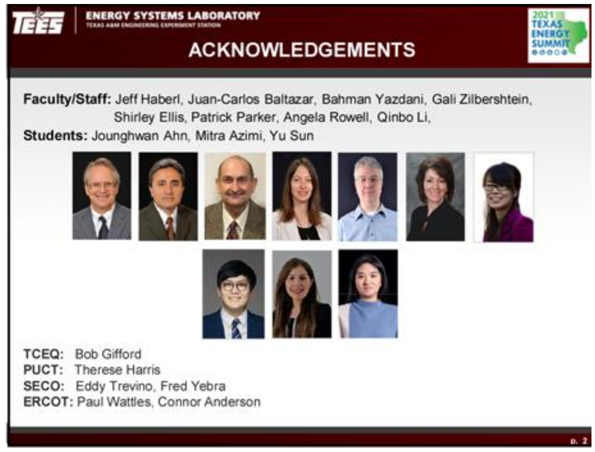
Appendix B: IC3 Parameter Reports

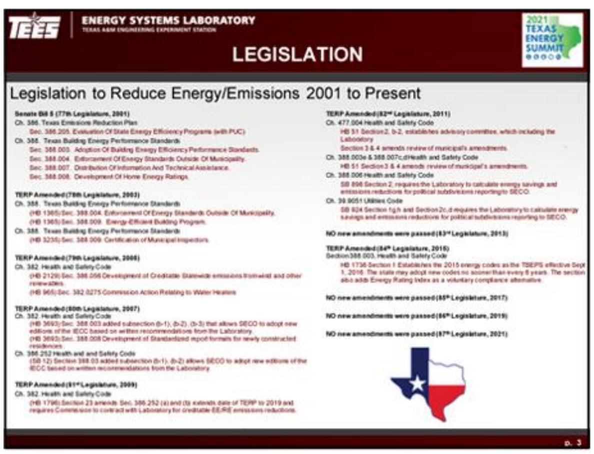
Appendix A: Presentations to Various Entities at Conferences and Workshops in 2021

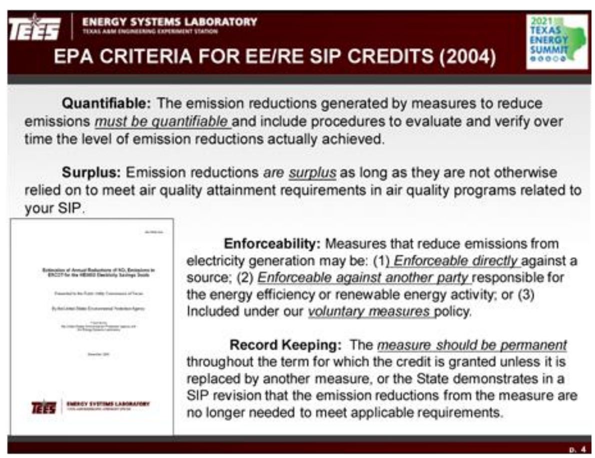
The Energy Systems Laboratory made presentations at several conferences and workshops about ways to save energy, and the appendix shows the presentation slides.

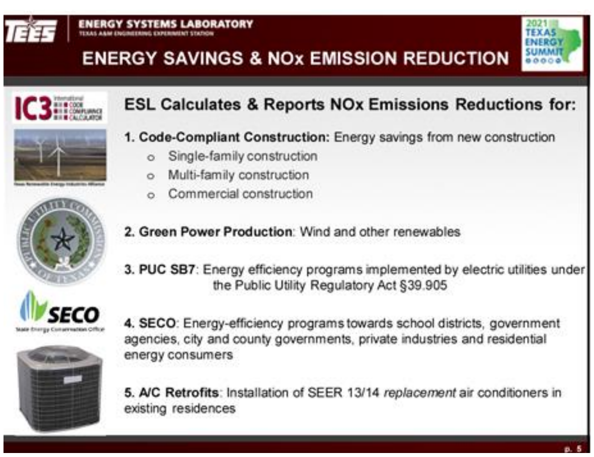
- "Energy Efficiency and Renewable Energy Impacts on NOx Emission Reductions" Texas Energy Summit conference, Online Virtual Event, Nov 2021, presented by Jeff Haberl.

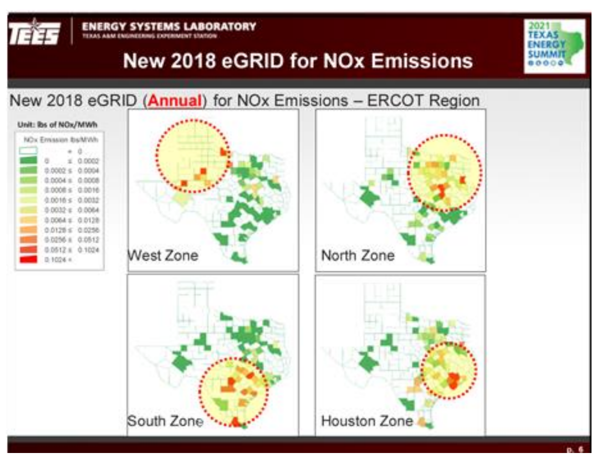


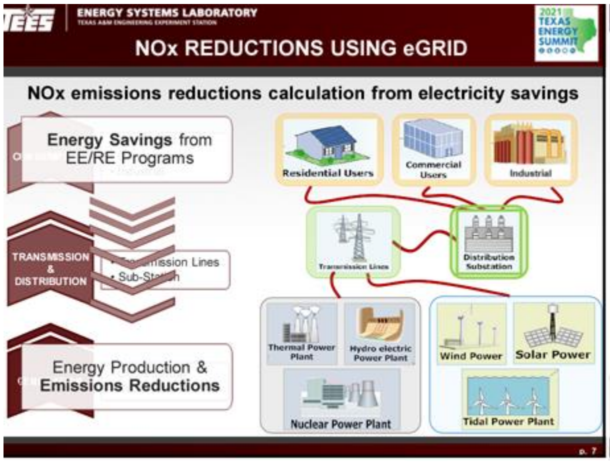


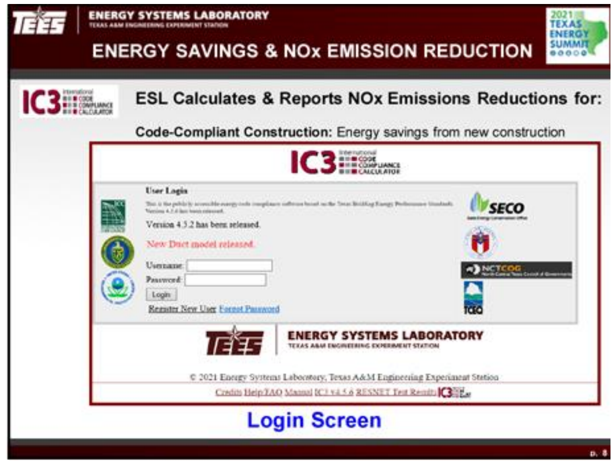


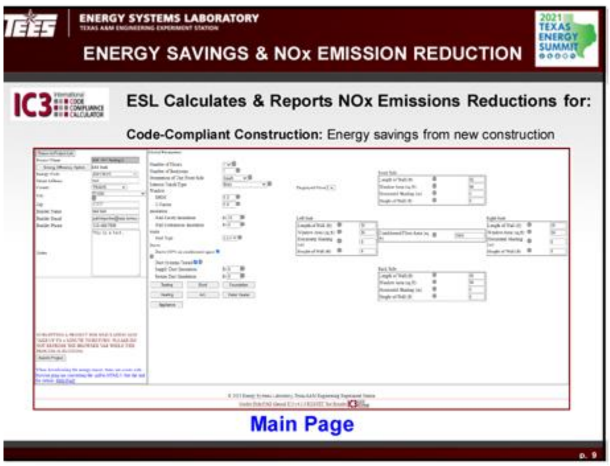


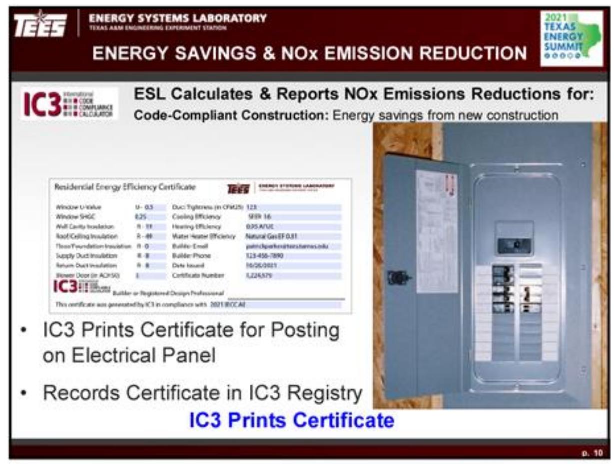


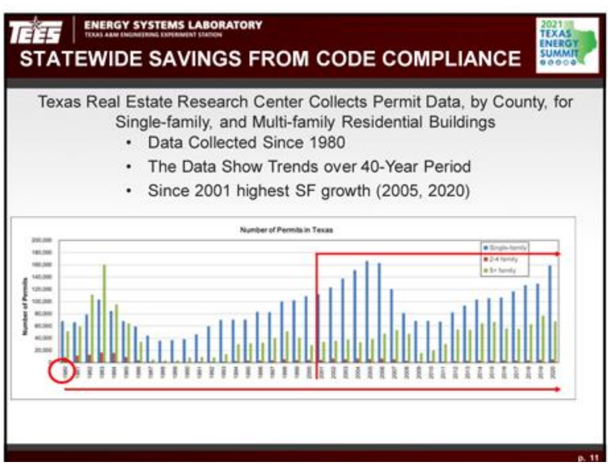


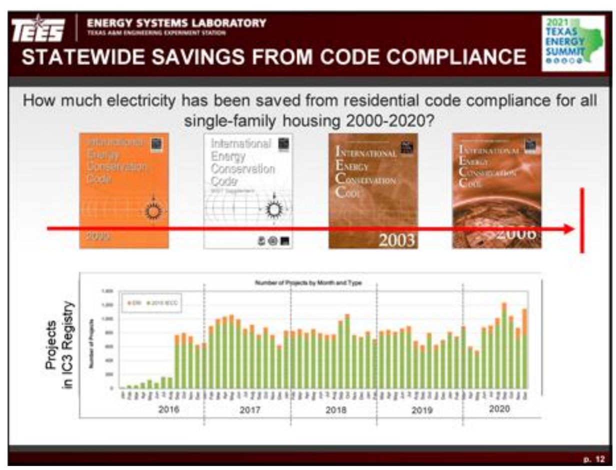

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS USING eGRID
NOx emissions reductions calculation from electricity savings
Energy Savings from EE/RE Programs
Residential Users
Commercial Users
Industrial
TRANSMISSION & DISTRIBUTION
Transmission Lines
Distribution Substation
Energy Production & Emissions Reductions
Thermal Power Plant
Hydro electric Power Plant
Wind Power
Solar Power
Nuclear Power Plant
Tidal Power Plant
p. 7

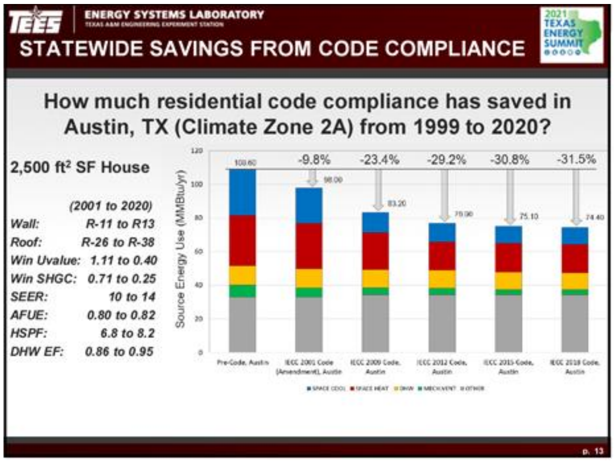

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS & NOx EMISSION REDUCTION
ESL Calculates & Reports NOx Emissions Reductions for:
Code-Compliant Construction: Energy savings from new construction
User Login
Version 4.5.2 has been released.
New Duct model released.
Username:
Password:
Login
Register New User Forgot Password
SECO
ENERGY SYSTEMS LABORATORY
Login Screen
p. 8

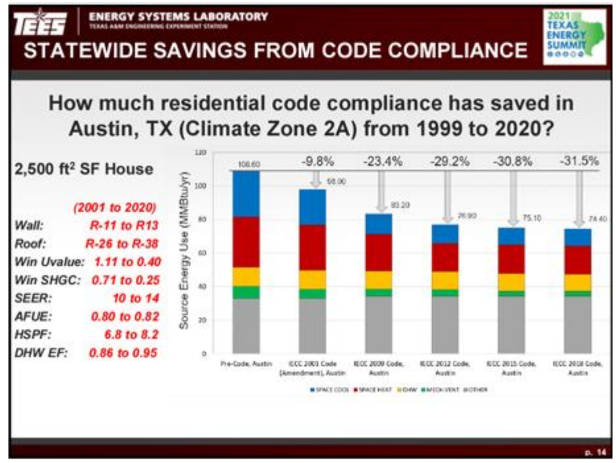

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS & NOx EMISSION REDUCTION
ESL Calculates & Reports NOx Emissions Reductions for:
Code-Compliant Construction: Energy savings from new construction
Main Page
p. 9

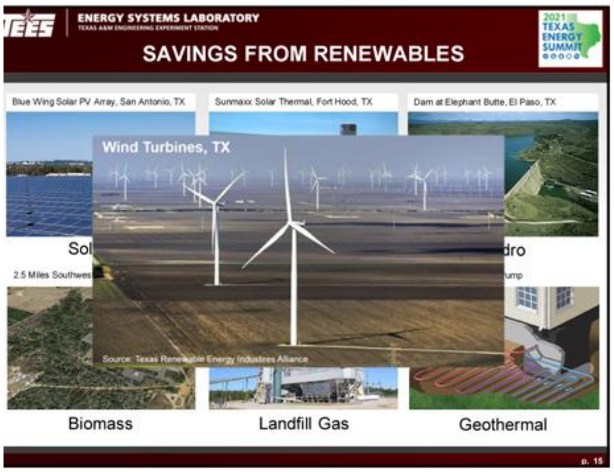

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS & NOx EMISSION REDUCTION
ESL Calculates & Reports NOx Emissions Reductions for:
Code-Compliant Construction: Energy savings from new construction
Residential Energy Efficiency Certificate
• IC3 Prints Certificate for Posting on Electrical Panel
• Records Certificate in IC3 Registry
IC3 Prints Certificate
p. 10

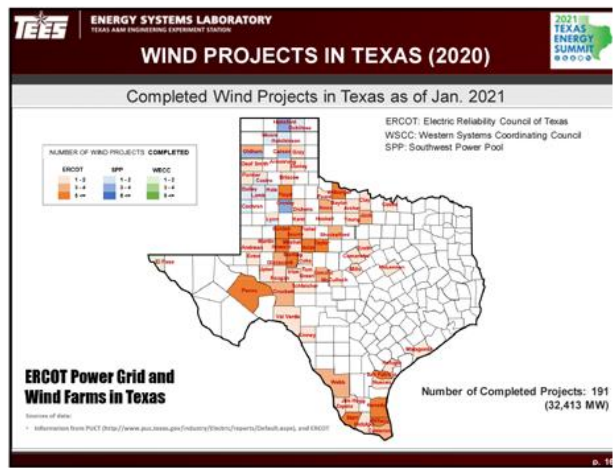

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
Texas Real Estate Research Center Collects Permit Data, by County, for Single-family, and Multi-family Residential Buildings
• Data Collected Since 1980
• The Data Show Trends over 40-Year Period
• Since 2001 highest SF growth (2005, 2020)
Number of Permits in Texas
Number of Permits
Single-family
2-4 family
5+ family
p. 11

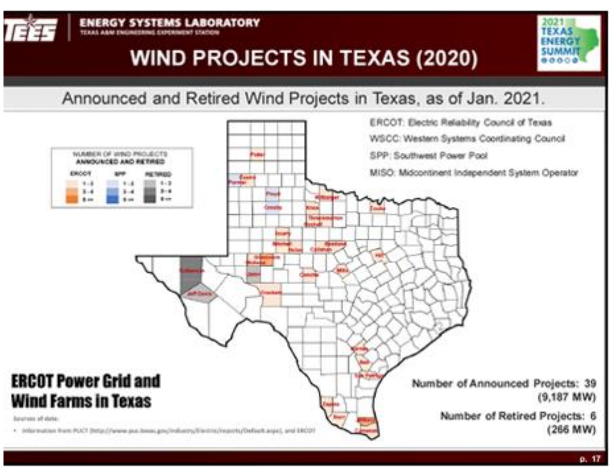

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
How much electricity has been saved from residential code compliance for all single-family housing 2000-2020?
International Energy Conservation Code
2003
Number of Projects by Month and Type
Projects in IC3 Registry
Number of Projects
2016
2017
2018
2019
2020
p. 12

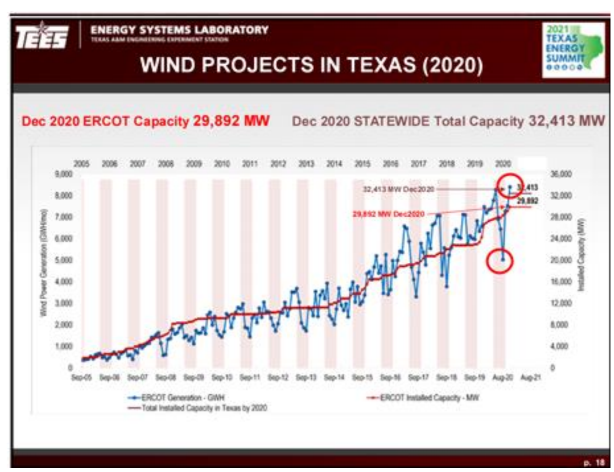

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
How much residential code compliance has saved in Austin, TX (Climate Zone 2A) from 1999 to 2020?
2,500 ft² SF House
(2001 to 2020)
Wall: R-11 to R13
Roof: R-26 to R-38
Win Uvalue: 1.11 to 0.40
Win SHGC: 0.71 to 0.25
SEER: 10 to 14
AFUE: 0.80 to 0.82
HSPF: 6.8 to 8.2
DHW EF: 0.86 to 0.95
Source Energy Use (MMBtu/yr)
-9.8%
-23.4%
-29.2%
-30.8%
-31.5%
p. 13

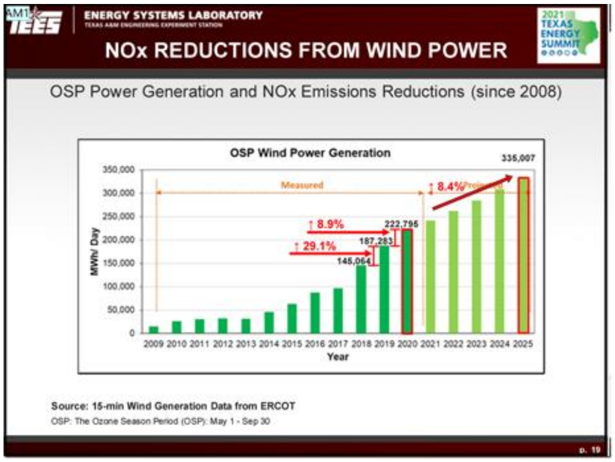

ENERGY SYSTEMS LABORATORY
STATEWIDE SAVINGS FROM CODE COMPLIANCE
How much residential code compliance has saved in Austin, TX (Climate Zone 2A) from 1999 to 2020?
2,500 ft² SF House
(2001 to 2020)
Wall: R-11 to R13
Roof: R-26 to R-38
Win Uvalue: 1.11 to 0.40
Win SHGC: 0.71 to 0.25
SEER: 10 to 14
AFUE: 0.80 to 0.82
HSPF: 6.8 to 8.2
DHW EF: 0.86 to 0.95
Source Energy Use (MMBtu/yr)
-9.8%
-23.4%
-29.2%
-30.8%
-31.5%
p. 14

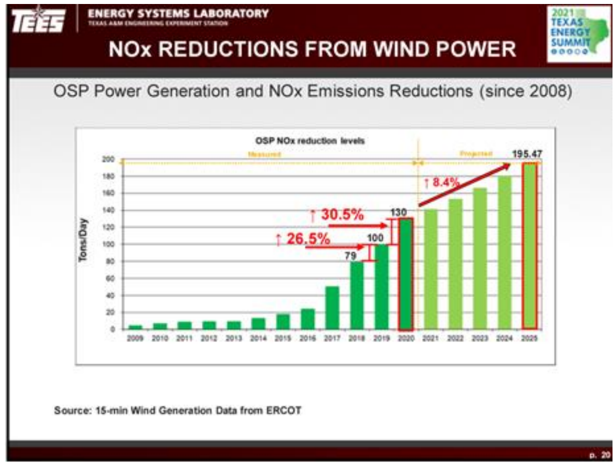

ENERGY SYSTEMS LABORATORY
SAVINGS FROM RENEWABLES
Blue Wing Solar PV Array, San Antonio, TX
Sunmaxx Solar Thermal, Fort Hood, TX
Dam at Elephant Butte, El Paso, TX
Wind Turbines, TX
Source: Texas Renewable Energy Industries Alliance
Biomass
Landfill Gas
Geothermal
p. 15

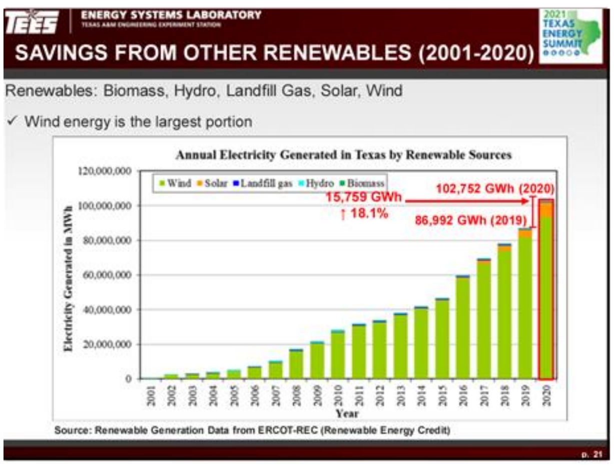

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2020)
Completed Wind Projects in Texas as of Jan. 2021
ERCOT: Electric Reliability Council of Texas
WSCC: Western Systems Coordinating Council
SPP: Southwest Power Pool
ERCOT Power Grid and Wind Farms in Texas
Number of Completed Projects: 191 (32,413 MW)

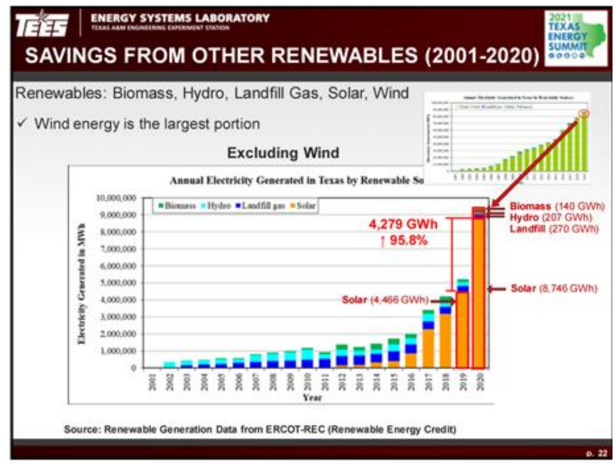

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2020)
Announced and Retired Wind Projects in Texas, as of Jan. 2021.
ERCOT: Electric Reliability Council of Texas
WSCC: Western Systems Coordinating Council
SPP: Southwest Power Pool
MISO: Midcontinent Independent System Operator
ERCOT Power Grid and Wind Farms in Texas
Number of Announced Projects: 39 (9,187 MW)
Number of Retired Projects: 6 (266 MW)
p. 17

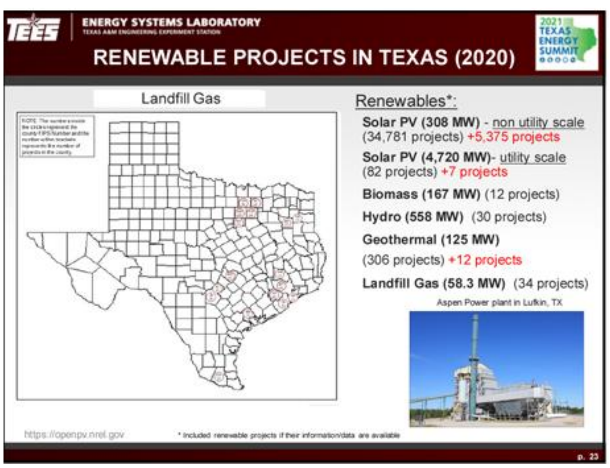

ENERGY SYSTEMS LABORATORY
WIND PROJECTS IN TEXAS (2020)
Dec 2020 ERCOT Capacity 29,892 MW
Dec 2020 STATEWIDE Total Capacity 32,413 MW
32,413 MW Dec2020
29,892 MW Dec2020
ERCOT Generation - GWH
Total Installed Capacity in Texas by 2020
ERCOT Installed Capacity - MW
p. 18

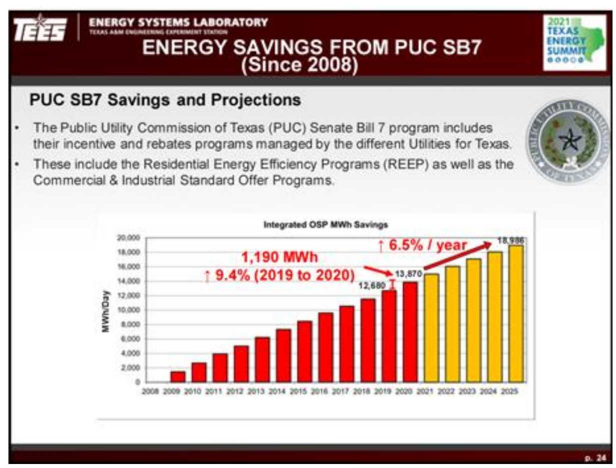

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS FROM WIND POWER
OSP Power Generation and NOx Emissions Reductions (since 2008)
OSP Wind Power Generation
Measured
↑ 8.4%
335,007
↑ 8.9%
222,795
↑ 29.1%
187,283
145,064
MWh/ Day
Year
Source: 15-min Wind Generation Data from ERCOT
OSP: The Ozone Season Period (OSP): May 1 - Sep 30
p. 19

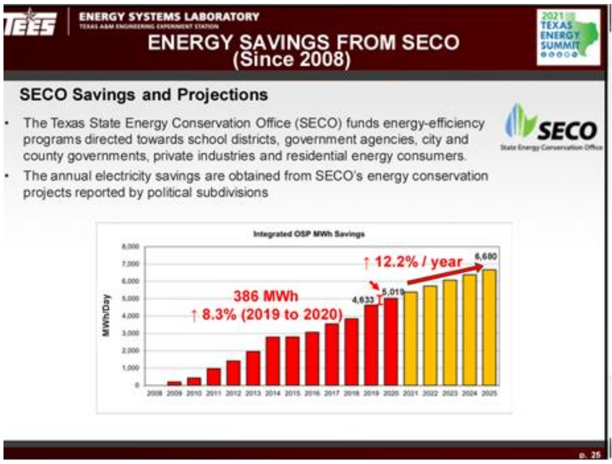

ENERGY SYSTEMS LABORATORY
NOx REDUCTIONS FROM WIND POWER
OSP Power Generation and NOx Emissions Reductions (since 2008)
OSP NOx reduction levels
Measured
Projected
195.47
↑ 8.4%
↑ 30.5%
130
↑ 26.5%
100
79
Tons/Day
Source: 15-min Wind Generation Data from ERCOT
p. 20

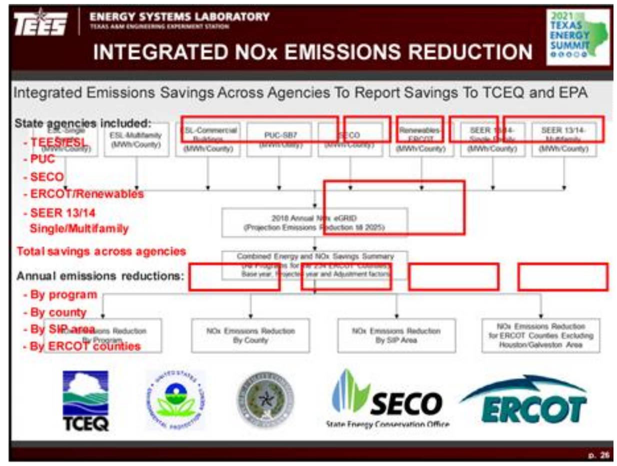

ENERGY SYSTEMS LABORATORY
SAVINGS FROM OTHER RENEWABLES (2001-2020)
Renewables: Biomass, Hydro, Landfill Gas, Solar, Wind
✓ Wind energy is the largest portion
Annual Electricity Generated in Texas by Renewable Sources
Wind Solar Landfill gas Hydro Biomass
15,759 GWh
↑ 18.1%
102,752 GWh (2020)
86,992 GWh (2019)
Electricity Generated in MWh
Year
Source: Renewable Generation Data from ERCOT-REC (Renewable Energy Credit)
p. 21

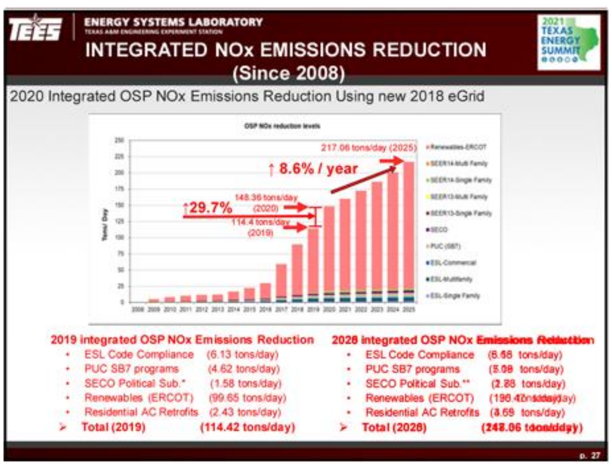

ENERGY SYSTEMS LABORATORY
SAVINGS FROM OTHER RENEWABLES (2001-2020)
Renewables: Biomass, Hydro, Landfill Gas, Solar, Wind
✓ Wind energy is the largest portion
Excluding Wind
Annual Electricity Generated in Texas by Renewable So
Biomass Hydro Landfill gas Solar
4,279 GWh
↑ 95.8%
Biomass (140 GWh)
Hydro (207 GWh)
Landfill (270 GWh)
Solar (4,466 GWh)
Solar (8,746 GWh)
Electricity Generated in MWh
Year
Source: Renewable Generation Data from ERCOT-REC (Renewable Energy Credit)
p. 22

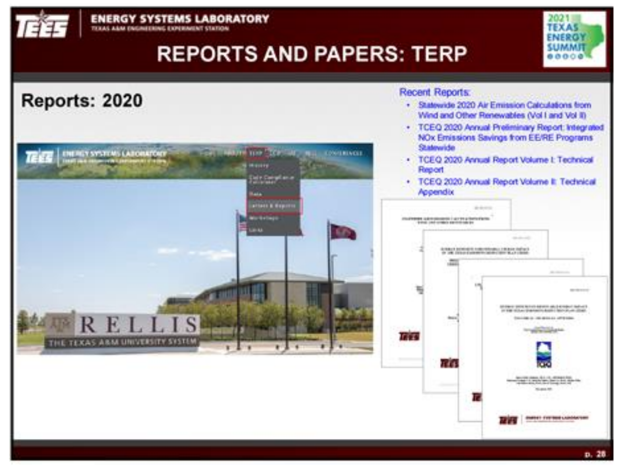

ENERGY SYSTEMS LABORATORY
RENEWABLE PROJECTS IN TEXAS (2020)
Landfill Gas
Renewables*:
Solar PV (308 MW) - non utility scale (34,781 projects) +5,375 projects
Solar PV (4,720 MW)- utility scale (82 projects) +7 projects
Biomass (167 MW) (12 projects)
Hydro (558 MW) (30 projects)
Geothermal (125 MW) (306 projects) +12 projects
Landfill Gas (58.3 MW) (34 projects)
Aspen Power plant in Lufkin, TX
https://openpv.nrel.gov
* Included renewable projects if their information/data are available
p. 23

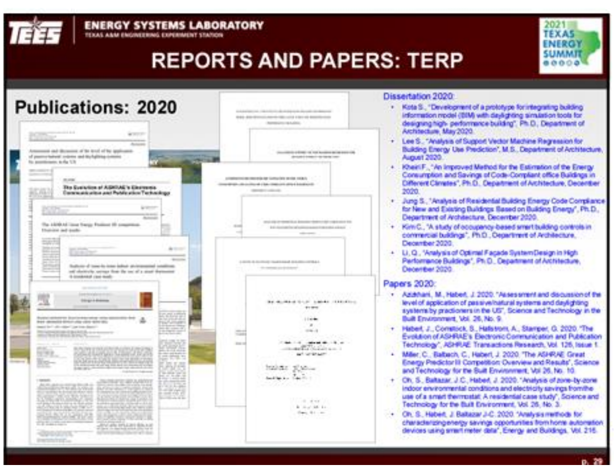

ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS FROM PUC SB7 (Since 2008)
PUC SB7 Savings and Projections
The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes their incentive and rebates programs managed by the different Utilities for Texas.
These include the Residential Energy Efficiency Programs (REEP) as well as the Commercial & Industrial Standard Offer Programs.
Integrated OSP MWh Savings
↑ 6.5% / year
18,986
1,190 MWh
↑ 9.4% (2019 to 2020)
13,870
12,680
MWh/Day
p. 24


ENERGY SYSTEMS LABORATORY
ENERGY SAVINGS FROM SECO (Since 2008)
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
Integrated OSP MWh Savings
↑12.2% / year
386 MWh
↑8.3% (2019 to 2020)
MWh/Day
p. 25


ENERGY SYSTEMS LABORATORY
INTEGRATED NOx EMISSIONS REDUCTION
Integrated Emissions Savings Across Agencies To Report Savings To TCEQ and EPA
State agencies included:
- TEES/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
SECO
ERCOT
TCEQ
p. 26


ENERGY SYSTEMS LABORATORY
INTEGRATED NOx EMISSIONS REDUCTION (Since 2008)
2020 Integrated OSP NOx Emissions Reduction Using new 2018 eGrid
217.06 tons/day (2025)
↑8.6% / year
148.36 tons/day (2020)
↑29.7%
114.4 tons/day (2019)
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)
ESL Code Compliance (6.68 tons/day)
PUC SB7 programs (5.09 tons/day)
SECO Political Sub.** (2.88 tons/day)
Residential AC Retrofits (3.59 tons/day)
p. 27


ENERGY SYSTEMS LABORATORY
REPORTS AND PAPERS: TERP
Reports: 2020
Recent Reports:
Statewide 2020 Air Emission Calculations from Wind and Other Renewables (Vol I and Vol II)
TCEQ 2020 Annual Preliminary Report: Integrated NOx Emissions Savings from EE/RE Programs Statewide
TCEQ 2020 Annual Report Volume I: Technical Report
TCEQ 2020 Annual Report Volume II: Technical Appendix
RELLIS
THE TEXAS A&M UNIVERSITY SYSTEM
p. 28


ENERGY SYSTEMS LABORATORY
REPORTS AND PAPERS: TERP
Publications: 2020
Dissertation 2020:
Papers 2020:
p. 29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http://esl.tamu.edu/terp
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THE TEXAS A&M UNIVERSITY SYSTEM
p. 30

Appendix B: IC3 Parameter Reports

Table 28 to Table 37 show the annual average values by county from projects that passed code compliance in IC3. Table 28 shows wall cavity insulation across Texas in 2021.

Table 28: **Annual** Average Wall Cavity Insulation Distribution by County in 2021.

County	Avg Wall Insulation (R-value)	House		County	Avg Wall Insulation (R-value)	House
Bell	13.0	1		Hunt	13.3	224
Bexar	13.5	40		Johnson	14.7	330
Brazoria	16.5	2		Kaufman	13.7	439
Brazos	21.5	4		Lamar	19.0	2
Burnet	13.4	9		Liberty	12.2	18
Caldwell	13.2	4		Llano	13.9	25
Chambers	13.0	1		Mason	13.0	2
Coke	20.0	1		Medina	13.0	1
Collin	14.6	1362		Montague	13.8	6
Comal	13.3	47		Montgomery	18.3	17
Cooke	13.0	18		Navarro	14.6	18
Dallas	14.8	1702		Nueces	13.0	27
Denton	14.0	1345		Palo Pinto	14.0	2
Ector	15.0	8		Parker	13.9	317
Ellis	13.6	420		Rains	14.6	14
Fannin	14.4	14		Randall	15.0	3
Fort Bend	13.0	43		Red River	13.0	1
Galveston	15.6	20		Rockwall	13.4	241
Gillespie	13.0	2		Smith	13.0	1
Grayson	13.2	205		Somerville	15.0	1
Gregg	13.0	5		Tarrant	14.1	2891
Guadalupe	17.3	7		Titus	15.4	23
Harris	15.9	887		Travis	15.4	915
Hays	15.0	83		Van Zandt	13.0	2
Henderson	13.7	123		Waller	13.0	1
Hill	14.2	10		Washington	13.0	122
Hood	13.9	91		Williamson	13.1	14
Hopkins	13.0	3		Wise	14.5	99
Houston	13.0	1		Zapata	15.0	2

Table 29 to Table 31 show water heater efficiencies by county from projects that passed code compliance in IC3.

Table 29: Annual Average Electric Water Heater Energy Factor Distribution by County in 2021.

County	Avg Electric Energy Factor	House		County	Avg Electric Energy Factor	House
Bell	1.0	1		Hunt	0.9	113
Bexar	0.9	20		Johnson	0.9	274
Brazos	0.9	1		Kaufman	0.9	200
Burnet	0.9	8		Lamar	1.0	2
Caldwell	1.0	1		Liberty	0.9	6
Coke	1.0	1		Llano	0.9	3
Collin	0.9	165		Mason	0.9	2
Comal	0.9	4		Montague	1.0	4
Cooke	0.9	16		Navarro	1.0	18
Dallas	0.9	924		Nueces	1.0	4
Denton	0.9	449		Palo Pinto	0.9	1
Ector	1.0	8		Parker	0.9	234
Ellis	0.9	225		Rains	1.0	13
Fannin	1.0	12		Red River	0.9	1
Galveston	0.9	16		Rockwall	0.9	78
Gillespie	0.9	2		Smith	0.9	1
Grayson	0.9	164		Somerville	1.0	1
Gregg	0.9	5		Tarrant	0.9	1170
Guadalupe	1.0	3		Titus	0.9	19
Harris	0.9	151		Travis	0.9	62
Hays	0.9	1		Van Zandt	0.9	2
Henderson	0.9	116		Washington	0.9	1
Hill	0.9	10		Williamson	0.9	2
Hood	0.9	80		Wise	1.0	87
Hopkins	0.9	3		Zapata	0.9	2
Houston	0.9	1				

Table 30: Annual Average NGas Water Heater Energy Factor Distribution by County in 2021.

County	Avg NGas Energy Factor	House		County	Avg NGas Energy Factor	House
Bexar	0.7	7		Hunt	0.8	111
Brazoria	0.9	2		Johnson	0.8	49
Brazos	0.9	2		Kaufman	0.8	239
Burnet	0.7	1		Liberty	0.6	12
Caldwell	0.6	1		Llano	0.7	19
Chambers	0.9	1		Medina	0.6	1
Collin	0.9	892		Montague	0.6	2
Comal	0.6	43		Montgomery	0.9	2
Cooke	0.8	2		Nueces	0.7	23
Dallas	0.9	597		Parker	0.7	76
Denton	0.9	813		Rains	0.9	1
Ellis	0.9	182		Randall	0.9	2
Fannin	0.8	2		Rockwall	0.9	156
Fort Bend	0.6	43		Tarrant	0.9	1655
Galveston	0.8	4		Titus	0.8	3
Grayson	0.8	40		Travis	0.7	776
Harris	0.8	711		Waller	0.9	1
Hays	0.8	82		Washington	0.6	121
Henderson	0.8	6		Williamson	0.6	12
Hood	0.8	8		Wise	0.7	11

Table 31: Annual Average Heat Pump Water Heater Energy Factor Distribution by County in 2021.

County	Avg Heat Pump WH Energy Factor	House
Dallas	2.4	1
Denton	2.2	1
Johnson	2.0	1
Parker	2.1	2
Tarrant	2.2	16
Travis	2.3	13

Table 32 shows the average A/C SEER by county from projects that passed code compliance in IC3.

Table 32: Average A/C SEER across Counties in 2021.

County	Avg A/C SEER	House		County	Avg A/C SEER	House
Bell	14.0	1		Johnson	14.9	330
Bexar	15.4	40		Kaufman	15.0	439
Brazoria	15.0	2		Lamar	14.0	2
Brazos	15.5	4		Liberty	15.2	18
Burnet	15.8	9		Llano	16.0	25
Caldwell	16.3	4		Mason	15.0	2
Chambers	14.0	1		Medina	16.0	1
Coke	16.0	1		Montague	14.7	6
Collin	15.6	1362		Montgomery	16.2	17
Comal	15.6	47		Navarro	14.9	18
Cooke	15.2	18		Nueces	16.0	27
Dallas	15.1	1700		Palo Pinto	14.5	2
Denton	15.4	1345		Parker	15.4	317
Ector	16.0	8		Rains	15.9	14
Ellis	15.1	420		Randall	16.7	3
Fannin	14.4	14		Red River	14.0	1
Fort Bend	15.9	43		Rockwall	15.8	241
Galveston	16.1	20		Smith	16.0	1
Gillespie	16.0	2		Somerville	16.0	1
Grayson	15.0	205		Tarrant	15.3	2890
Gregg	14.2	5		Titus	15.3	23
Guadalupe	15.4	7		Travis	16.1	915
Harris	15.5	887		Van Zandt	15.0	2
Hays	16.0	83		Waller	14.0	1
Henderson	15.7	123		Washington	16.0	122
Hill	15.0	10		Williamson	16.0	14
Hood	15.6	91		Wise	14.9	99
Hopkins	14.0	3		Zapata	16.0	2
Houston	14.0	1		Travis	2.3	13
Hunt	14.6	224				

Table 33 shows the average ceiling insulation by county from projects that passed code compliance in IC3.

Table 33: Average Ceiling Insulation across Counties in 2021.

County	Avg Ceiling Insulation (R-value)	House		County	Avg Ceiling Insulation (R-value)	House
Bell	38.0	1		Hunt	38.2	224
Bexar	30.0	40		Johnson	33.7	330
Brazoria	38.0	2		Kaufman	34.4	439
Brazos	38.3	4		Lamar	49.0	2
Burnet	28.7	9		Liberty	38.0	18
Caldwell	29.0	4		Llano	21.5	25
Chambers	38.0	1		Mason	30.0	2
Coke	49.0	1		Medina	30.0	1
Collin	36.5	1362		Montague	42.6	6
Comal	37.1	47		Montgomery	30.9	17
Cooke	37.5	18		Navarro	38.8	18
Dallas	35.7	1701		Nueces	23.1	27
Denton	36.0	1345		Palo Pinto	38.0	2
Ector	38.0	8		Parker	34.4	317
Ellis	36.0	420		Rains	37.4	14
Fannin	41.2	14		Randall	49.0	3
Fort Bend	37.6	43		Red River	38.0	1
Galveston	35.0	20		Rockwall	37.0	241
Gillespie	26.0	2		Smith	38.0	1
Grayson	38.2	205		Somerville	38.0	1
Gregg	38.0	5		Tarrant	35.2	2891
Guadalupe	32.3	7		Titus	36.6	23
Harris	34.6	887		Travis	36.7	915
Hays	38.2	83		Van Zandt	43.5	2
Henderson	36.0	123		Waller	30.0	1
Hill	36.5	10		Washington	38.0	122
Hood	32.1	91		Williamson	37.9	14
Hopkins	38.0	3		Wise	35.8	99
Houston	38.0	1		Zapata	38.0	2

Table 34 and Table 35 show the average heating efficiency by county from projects that passed code compliance in IC3.

Table 34: Average NGas Heating Efficiency across Counties in 2021.

County	Avg NGas Efficiency	House		County	Avg NGas Efficiency	House
Bexar	0.8	18		Houston	0.8	1
Brazoria	0.9	2		Hunt	0.8	169
Brazos	0.8	2		Johnson	0.8	84
Burnet	0.8	2		Kaufman	0.8	254
Caldwell	0.9	2		Liberty	0.8	12
Chambers	0.8	1		Llano	0.9	18
Collin	0.8	1220		Medina	0.8	1
Comal	0.8	43		Montague	0.8	2
Cooke	0.8	2		Montgomery	0.9	17
Dallas	0.9	1201		Navarro	0.9	7
Denton	0.8	910		Palo Pinto	1.0	1
Ector	1.0	8		Parker	0.8	155
Ellis	0.8	241		Rains	0.9	10
Fannin	0.8	6		Randall	0.9	2
Fort Bend	0.8	43		Red river	0.8	1
Galveston	0.8	4		Rockwall	0.8	171
Grayson	0.8	54		Somerville	1.0	1
Gregg	0.9	3		Tarrant	0.8	1774
Harris	0.8	745		Titus	0.9	8
Hays	0.8	82		Travis	0.8	822
Henderson	0.9	26		Waller	0.8	1
Hill	0.9	4		Washington	0.8	121
Hood	0.9	24		Williamson	0.8	12
Hopkins	0.9	3		Wise	0.9	9

Table 35: Average Heat Pump Heating Efficiency across Counties in 2021.

County	Avg Heat Pump Efficiency	House		County	Avg Heat Pump Efficiency	House
Bell	9.0	1		Johnson	8.6	246
Bexar	8.9	22		Kaufman	8.6	185
Brazos	8.2	2		Lamar	9.0	2
Burnet	8.3	7		Liberty	8.8	6
Caldwell	9.3	2		Llano	9.2	7
Coke	8.5	1		Mason	10.8	2
Collin	8.7	141		Montague	8.2	4
Comal	8.5	4		Navarro	8.5	11
Cooke	8.4	16		Nueces	8.7	27
Dallas	8.6	499		Palo Pinto	9.0	1
Denton	8.5	435		Parker	8.5	162
Ellis	8.6	177		Rains	8.9	4
Fannin	8.9	8		Randall	13.0	1
Galveston	8.8	16		Rockwall	8.3	70
Gillespie	8.5	2		Smith	9.6	1
Grayson	8.4	151		Tarrant	8.7	1113
Gregg	9.3	2		Titus	9.0	14
Guadalupe	10.6	7		Travis	9.9	93
Harris	8.6	135		Van Zandt	8.3	2
Hays	9.0	1		Washington	8.2	1
Henderson	8.3	97		Williamson	8.2	2
Hill	8.2	6		Wise	8.5	90
Hood	10.1	67		Zapata	8.6	2
Hunt	8.8	55				

Table 36 shows the average SHGC by county from projects that passed code compliance in IC3.

Table 36: Average SHGC across Counties in 2021.

County	Avg SHGC	House		County	Avg SHGC	House
Bell	0.2	1		Hunt	0.2	224
Bexar	0.3	40		Johnson	0.2	330
Brazoria	0.3	2		Kaufman	0.2	439
Brazos	0.3	4		Lamar	0.3	2
Burnet	0.3	9		Liberty	0.2	18
Caldwell	0.2	4		Llano	0.3	25
Chambers	0.3	1		Mason	0.2	2
Coke	0.3	1		Medina	0.2	1
Collin	0.2	1362		Montague	0.3	6
Comal	0.2	47		Montgomery	0.2	17
Cooke	0.2	18		Navarro	0.2	18
Dallas	0.2	1701		Nueces	0.3	27
Denton	0.2	1344		Palo Pinto	0.2	2
Ector	0.3	8		Parker	0.2	317
Ellis	0.2	420		Rains	0.2	14
Fannin	0.2	14		Randall	0.3	3
Fort Bend	0.2	43		Red River	0.3	1
Galveston	0.2	20		Rockwall	0.2	240
Gillespie	0.4	2		Smith	0.2	1
Grayson	0.2	205		Somerville	0.2	1
Gregg	0.2	5		Tarrant	0.2	2891
Guadalupe	0.2	7		Titus	0.2	23
Harris	0.3	886		Travis	0.2	914
Hays	0.2	83		Van Zandt	0.3	2
Henderson	0.2	123		Waller	0.3	1
Hill	0.2	10		Washington	0.2	122
Hood	0.3	91		Williamson	0.2	14
Hopkins	0.2	3		Wise	0.2	99
Houston	0.2	1		Zapata	0.2	2

Table 37 shows the average window U-Factor by county from projects that passed code compliance in IC3.

Table 37: Average Window U-Factor across Counties in 2021.

County	Avg U-factor	House		County	Avg U-factor	House
Bell	0.3	1		Hunt	0.3	224
Bexar	0.4	40		Johnson	0.3	330
Brazoria	0.3	2		Kaufman	0.3	439
Brazos	0.4	4		Lamar	0.3	2
Burnet	0.3	9		Liberty	0.3	18
Caldwell	0.3	4		Llano	0.2	25
Chambers	0.3	1		Mason	0.3	2
Coke	0.3	1		Medina	0.3	1
Collin	0.3	1362		Montague	0.3	6
Comal	0.4	47		Montgomery	0.3	17
Cooke	0.3	18		Navarro	0.3	18
Dallas	0.3	1701		Nueces	0.3	27
Denton	0.3	1345		Palo Pinto	0.3	2
Ector	0.3	8		Parker	0.3	317
Ellis	0.3	420		Rains	0.2	14
Fannin	0.3	14		Randall	0.4	3
Fort Bend	0.3	43		Red River	0.2	1
Galveston	0.3	20		Rockwall	0.3	241
Gillespie	0.5	2		Smith	0.3	1
Grayson	0.3	205		Somerville	0.2	1
Gregg	0.3	5		Tarrant	0.3	2891
Guadalupe	0.4	7		Titus	0.3	23
Harris	0.3	887		Travis	0.3	914
Hays	0.3	83		Van Zandt	0.3	2
Henderson	0.3	123		Waller	0.3	1
Hill	0.3	10		Washington	0.3	122
Hood	0.3	91		Williamson	0.3	14
Hopkins	0.3	3		Wise	0.3	99
Houston	0.3	1		Zapata	0.3	2