

**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 2016-December 2016**



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December 2017



ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION



**TEXAS A&M ENGINEERING
EXPERIMENT STATION**

Energy Systems Laboratory

December 22, 2017

Vincent Meiller
Air Quality Planning Section
Air Quality Division, Office of Air
Texas Commission on Environmental Quality Austin, TX 78711-3087

Dear Mr Meiller:

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

cc: Commissioner Toby Baker
Commissioner Jon Niermann
Executive Director Richard A. Hyde, P. E.

Disclaimer

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

VOLUME II – APPENDIX

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

1 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.

Accomplishments are as follow:

1.1 Energy Code Amendments

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

1.2 Technical Assistance

The Laboratory provided technical assistance to the TCEQ, PUCT, SECO, ERCOT, and several political subdivisions, as well as Stakeholders participating in improving the compliance of the Texas Building Energy Performance Standards (TBEPS). The Laboratory also worked closely with the TCEQ to refine the integrated NO_x emissions reduction calculation procedures that provide the TCEQ with a standardized, creditable NO_x 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 NO_x 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.

1.3 NO_x 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 NO_x emissions reduction through 2020 for the electricity and natural gas savings from the various EE/RE programs.

In 2016, the annual NO_x emissions reduction from code-compliant residential and commercial construction is calculated to be 769 tons-NO_x/year (6.3% of the total NO_x savings), savings from the PUC's Senate Bill 7 programs will be 874 tons-NO_x/year (7.2%), savings from SECO's Senate Bill 5 program will be 294 tons-NO_x/year (2.4%), electricity savings from green power purchases (wind) will be 10,143 tons-

NOx/year (83.5%), and savings from residential air conditioner retrofits will be 61 tons-NOx/year (0.5%). The total annual NOx emissions reduction from all programs will be 12,142 tons-NOx/year.

By 2020, the annual NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 1,832 tons-NOx/year (10.4% of the total NOx savings), savings from the PUC’s Senate Bill 7 programs is 1,241 tons-NOx/year (7.1%), savings from SECO’s Senate Bill 5 program is 397 tons-NOx/year (2.3%), electricity savings from green power purchases (wind) are 14,057 tons-NOx/year (80.0%), and savings from residential air conditioner retrofits are 50 tons-NOx/year (0.3%). The total annual NOx emissions reduction from all programs is 17,576 tons-NOx/year.

In 2016, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 2.18 tons-NOx/day (6.3%), savings from the PUC’s Senate Bill 7 programs will be 2.39 tons-NOx/day (6.9%), savings from SECO’s Senate Bill 5 program will be 0.81 tons-NOx/day (2.3%), electricity savings from green power purchases (wind) will be 28.91 tons-NOx/day (83.3%), and savings from residential air conditioner retrofits will be 0.43 tons-NOx/day (1.2%). The total OSD NOx emissions reduction from all programs will be 34.72 tons-NOx/day.

By 2020, the OSD NOx emissions reduction from code-compliant residential and commercial construction is calculated to be 5.09 tons-NOx/day (10.2%), savings from the PUC’s Senate Bill 7 programs will be 3.4 tons-NOx/day (6.8%), savings from SECO’s Senate Bill 5 program will be 1.09 tons-NOx/day (2.2%), electricity savings from green power purchases (wind) will be 10.07 tons-NOx/day (80.1%), and savings from residential air conditioner retrofits will be 0.35 tons-NOx/day (0.7%). The total OSD NOx emissions reduction from all programs will be 49.99 tons-NOx/day.

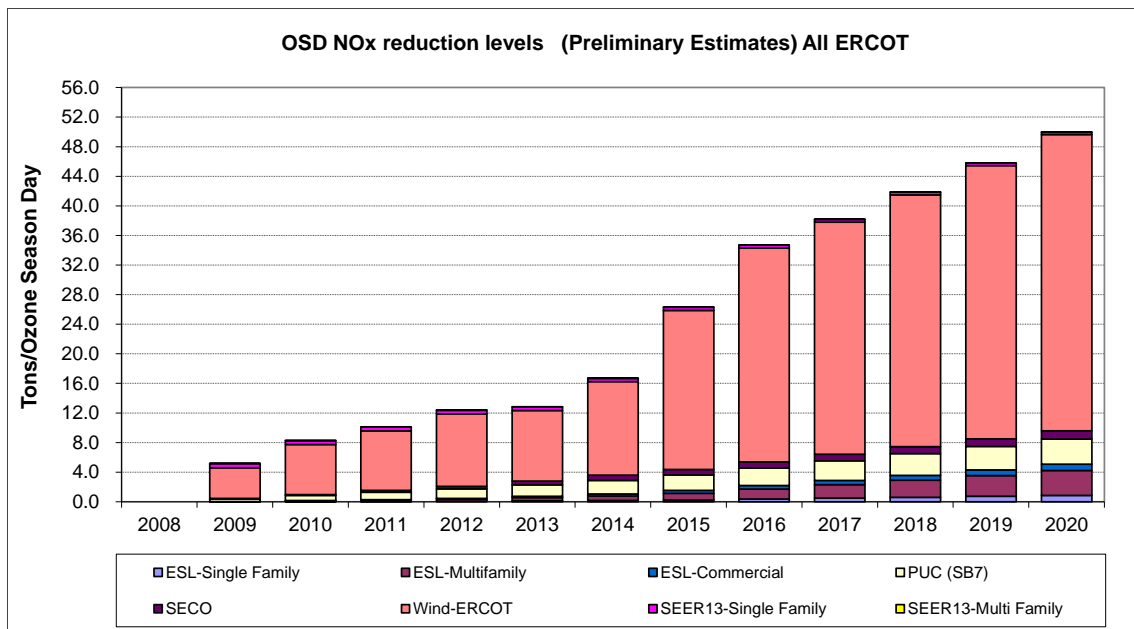


Figure 1: Integrated OSD NOx Emissions Reduction Projections through 2020 (Base Year 2008)

1.4 Technology Transfer

The Laboratory, along with the TCEQ, is host to the annual Clean Air Through Energy Efficiency (CATEE) conference, which is attended by top experts and policy makers in Texas and from around the country. At the conference the latest educational programs and technology are 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 include the publications of peer-reviewed papers. The Laboratory will continue to provide technical assistance to the TCEQ, counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering emissions and improving the air quality for all Texans.

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

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

If any questions arise, please contact us by phone at (979) 845-9213.

ACKNOWLEDGEMENTS

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

The authors are also grateful for the timely input provided by the following individuals, and agencies: Mr. Art Diem, US EPA, for providing the eGRID database and Vincent Meiller and Robert Gifford, TCEQ.

Likewise the authors appreciate the contributions of Mr. Sungkyun Jung, Mr. Farshad Kheiri, and Mr. Minjae Shin to this report.

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2 CODE AND PRE-CODE SIMULATION RESULTS BY COUNTY

This appendix to the Laboratory's 2016 annual report contains the simulation results for single-family and multi-family residences in the 36 counties. For each county, code and pre-code simulation, and annual results for individual residence are provided (Single-family and Multi-family).

For each county, pre-code and code simulation, and annual results, for 2008 base year, for individual Single-family and Multi-family residences can be viewed using the links provided in Table 2. For counties other than 36 non-attainment and affected counties, simulations were performed for one representative county per climate zone. The annual savings for each county were calculated using the simulation results for the representative county for the same climate zone and number of houses.

Table 1: List of Counties

	County	Climate Zone
Affected County	Bastrop	2
	Bexar	2
	Caldwell	2
	Comal	2
	Gregg	3
	Guadalupe	2
	Harrison	3
	Hays	2
	Nueces	2
	Rusk	3
	San Patricio	2
	Smith	3
	Travis	2
	Upshur	3
	Victoria	2
	Williamson	2
Wilson	2	
Nonattainment County	Brazoria	2
	Chambers	2
	Collin	3
	Dallas	3
	Denton	3
	El Paso	3
	Ellis	3
	Fort Bend	2
	Galveston	2
	Harris	2
	Johnson	3
	Kaufman	3
	Liberty	2
	Montgomery	2
	Parker	3
	Rockwall	3
	Tarrant	3
	Waller	2
Wise	3	

Table 2: Simulation Results for Individual Single Family and Multi Family Residences for All Counties.

Non-attainment or Affected Counties	2008		
	Summary	Single Family	Multifamily
BASTROP	Summary	Single Family	Multifamily
BEXAR	Summary	Single Family	Multifamily
CALDWELL	Summary	Single Family	Multifamily
COMAL	Summary	Single Family	Multifamily
GREGG	Summary	Single Family	Multifamily
GUADALUPE	Summary	Single Family	Multifamily
HARRISON	Summary	Single Family	Multifamily
HAYS	Summary	Single Family	Multifamily
NUECES	Summary	Single Family	Multifamily
RUSK	Summary	Single Family	Multifamily
SAN PATRICIO	Summary	Single Family	Multifamily
SMITH	Summary	Single Family	Multifamily
TRAVIS	Summary	Single Family	Multifamily
UPSHUR	Summary	Single Family	Multifamily
VICTORIA	Summary	Single Family	Multifamily
WILLIAMSON	Summary	Single Family	Multifamily
WILSON	Summary	Single Family	Multifamily
BRAZORIA	Summary	Single Family	Multifamily
CHAMBERS	Summary	Single Family	Multifamily
COLLIN	Summary	Single Family	Multifamily
DALLAS	Summary	Single Family	Multifamily
DENTON	Summary	Single Family	Multifamily
EL PASO	Summary	Single Family	Multifamily
ELLIS	Summary	Single Family	Multifamily
FORT BEND	Summary	Single Family	Multifamily
GALVESTON	Summary	Single Family	Multifamily
HARRIS	Summary	Single Family	Multifamily
JOHNSON	Summary	Single Family	Multifamily
KAUFMAN	Summary	Single Family	Multifamily
LIBERTY	Summary	Single Family	Multifamily
MONTGOMERY	Summary	Single Family	Multifamily
PARKER	Summary	Single Family	Multifamily
ROCKWALL	Summary	Single Family	Multifamily
TARRANT	Summary	Single Family	Multifamily
WALLER	Summary	Single Family	Multifamily
WISE	Summary	Single Family	Multifamily

ERCOT Counties (*Representative counties)		2008		
*	COLEMAN	Summary	Single Family	Multifamily
	CALLAHAN		Single Family	Multifamily
	EASTLAND		Single Family	Multifamily
	ERATH		Single Family	Multifamily
	FISHER		Single Family	Multifamily
	HASKELL		Single Family	Multifamily
	JACK		Single Family	Multifamily
	JONES		Single Family	Multifamily
	MITCHELL	Summary	Single Family	Multifamily
	NOLAN		Single Family	Multifamily
	PALO PINTO		Single Family	Multifamily
	SHACKELFORD		Single Family	Multifamily
	STEPHENS		Single Family	Multifamily
*	TAYLOR		Single Family	Multifamily
	THROCKMORTON		Single Family	Multifamily
	YOUNG		Single Family	Multifamily
*	LEON	Summary	Single Family	Multifamily
*	BELL		Single Family	Multifamily
	BOSQUE		Single Family	Multifamily
	BROWN		Single Family	Multifamily
	COMANCHE		Single Family	Multifamily
	CORYELL		Single Family	Multifamily
	FALLS		Single Family	Multifamily
	FREESTONE		Single Family	Multifamily
	HAMILTON	Summary	Single Family	Multifamily
	HILL		Single Family	Multifamily
	LAMPASAS		Single Family	Multifamily
	LIMESTONE		Single Family	Multifamily
	MCLENNAN		Single Family	Multifamily
	MILLS		Single Family	Multifamily
	NAVARRO		Single Family	Multifamily
	BRISCOE	Summary	Single Family	Multifamily
*	HALL		Single Family	Multifamily
*	BASTROP	Summary	Single Family	Multifamily
	CALDWELL		Single Family	Multifamily
	LEE		Single Family	Multifamily
	BLANCO		Single Family	Multifamily
	BURNET		Single Family	Multifamily
	GILLESPIE		Single Family	Multifamily
	KERR	Summary	Single Family	Multifamily
	REAL		Single Family	Multifamily
	HAYS		Single Family	Multifamily
	LLANO		Single Family	Multifamily

ERCOT Counties (*Representative counties)		2008	
	MASON		<u>Single Family</u> <u>Multifamily</u>
	SAN SABA		<u>Single Family</u> <u>Multifamily</u>
*	TRAVIS		<u>Single Family</u> <u>Multifamily</u>
	WILLIAMSON		<u>Single Family</u> <u>Multifamily</u>
*	CHAMBERS	Summary	<u>Single Family</u> <u>Multifamily</u>
	BROOKS		<u>Single Family</u> <u>Multifamily</u>
	CAMERON		<u>Single Family</u> <u>Multifamily</u>
*	HIDALGO	Summary	<u>Single Family</u> <u>Multifamily</u>
	KENEDY		<u>Single Family</u> <u>Multifamily</u>
	STARR		<u>Single Family</u> <u>Multifamily</u>
	WILLACY		<u>Single Family</u> <u>Multifamily</u>
	JIM HOGG		<u>Single Family</u> <u>Multifamily</u>
*	ZAPATA	Summary	<u>Single Family</u> <u>Multifamily</u>
*	KLEBERG	Summary	<u>Single Family</u> <u>Multifamily</u>
	ARANSAS		<u>Single Family</u> <u>Multifamily</u>
*	NUECES		<u>Single Family</u> <u>Multifamily</u>
	DUVAL		<u>Single Family</u> <u>Multifamily</u>
	JIM WELLS	Summary	<u>Single Family</u> <u>Multifamily</u>
	LIVE OAK		<u>Single Family</u> <u>Multifamily</u>
	SAN PATRICIO		<u>Single Family</u> <u>Multifamily</u>
	DIMITT		<u>Single Family</u> <u>Multifamily</u>
	LA SALLE		<u>Single Family</u> <u>Multifamily</u>
	MAVERICK		<u>Single Family</u> <u>Multifamily</u>
	MCMULLEN	Summary	<u>Single Family</u> <u>Multifamily</u>
*	WEBB		<u>Single Family</u> <u>Multifamily</u>
	ZAVALA		<u>Single Family</u> <u>Multifamily</u>
	HENDERSON	Summary	<u>Single Family</u> <u>Multifamily</u>
*	SMITH		<u>Single Family</u> <u>Multifamily</u>
*	DALLAS		<u>Single Family</u> <u>Multifamily</u>
	ELLIS		<u>Single Family</u> <u>Multifamily</u>
	HOOD		<u>Single Family</u> <u>Multifamily</u>
	JOHNSON	Summary	<u>Single Family</u> <u>Multifamily</u>
	SOMERVELL		<u>Single Family</u> <u>Multifamily</u>
	TARRANT		<u>Single Family</u> <u>Multifamily</u>
	LAMAR		<u>Single Family</u> <u>Multifamily</u>
	RED RIVER	Summary	<u>Single Family</u> <u>Multifamily</u>
*	TITUS		<u>Single Family</u> <u>Multifamily</u>
*	COLLIN		<u>Single Family</u> <u>Multifamily</u>
	DELTA		<u>Single Family</u> <u>Multifamily</u>
	DENTON		<u>Single Family</u> <u>Multifamily</u>
	FRANKLIN	Summary	<u>Single Family</u> <u>Multifamily</u>
	HOPKINS		<u>Single Family</u> <u>Multifamily</u>
	KAUFMAN		<u>Single Family</u> <u>Multifamily</u>
	PARKER		<u>Single Family</u> <u>Multifamily</u>

ERCOT Counties (*Representative counties)		2008	
	RAINS		Single Family Multifamily
	ROCKWALL		Single Family Multifamily
	VAN ZANDT		Single Family Multifamily
	WISE		Single Family Multifamily
	CULBERSON		Single Family Multifamily
*	HUDSPETH	Summary	Single Family Multifamily
	ANDERSON		Single Family Multifamily
	ANGELINA		Single Family Multifamily
	CHEROKEE	Summary	Single Family Multifamily
	HOUSTON		Single Family Multifamily
	NACOGDOCHES		Single Family Multifamily
*	RUSK		Single Family Multifamily
	BRAZORIA		Single Family Multifamily
*	GALVESTON	Summary	Single Family Multifamily
	AUSTIN		Single Family Multifamily
	BRAZOS		Single Family Multifamily
	BURLESON		Single Family Multifamily
	COLORADO		Single Family Multifamily
	FAYETTE		Single Family Multifamily
	FORT BEND		Single Family Multifamily
	GRIMES	Summary	Single Family Multifamily
*	HARRIS		Single Family Multifamily
	MADISON		Single Family Multifamily
	MONTGOMERY		Single Family Multifamily
	ROBERTSON		Single Family Multifamily
	WALLER		Single Family Multifamily
	WASHINGTON		Single Family Multifamily
*	MILAM	Summary	Single Family Multifamily
	BORDEN		Single Family Multifamily
	CHILDRESS		Single Family Multifamily
	CROSBY		Single Family Multifamily
	DAWSON		Single Family Multifamily
	DICKENS	Summary	Single Family Multifamily
	KENT		Single Family Multifamily
	KING		Single Family Multifamily
	MOTLEY		Single Family Multifamily
*	SCURRY		Single Family Multifamily
	STONEWALL		Single Family Multifamily
*	CRANE		Single Family Multifamily
	REAGAN	Summary	Single Family Multifamily
	UPTON		Single Family Multifamily
	ANDREWS		Single Family Multifamily
*	ECTOR	Summary	Single Family Multifamily
	GLASSCOCK		Single Family Multifamily

ERCOT Counties (*Representative counties)		2008	
	HOWARD		Single Family Multifamily
	JEFF DAVIS		Single Family Multifamily
	LOVING		Single Family Multifamily
	MARTIN		Single Family Multifamily
	MIDLAND		Single Family Multifamily
	REEVES		Single Family Multifamily
	WARD		Single Family Multifamily
	WINKLER		Single Family Multifamily
*	ATASCOSA	Summary	Single Family Multifamily
	FRIO		Single Family Multifamily
*	BEXAR	Summary	Single Family Multifamily
	COMAL		Single Family Multifamily
	GONZALES		Single Family Multifamily
	GUADALUPE		Single Family Multifamily
	KINNEY		Single Family Multifamily
	MEDINA		Single Family Multifamily
	UVALDE		Single Family Multifamily
	VAL VERDE		Single Family Multifamily
	WILSON		Single Family Multifamily
	BANDERA	Summary	Single Family Multifamily
*	KENDALL		Single Family Multifamily
	BREWSTER	Summary	Single Family Multifamily
	EDWARDS		Single Family Multifamily
	KIMBLE		Single Family Multifamily
	PECOS		Single Family Multifamily
	PRESIDIO		Single Family Multifamily
	SUTTON		Single Family Multifamily
	TERRELL		Single Family Multifamily
	CONCHO		Single Family Multifamily
	CROCKETT		Single Family Multifamily
	IRION		Single Family Multifamily
	MCCULLOCH		Single Family Multifamily
	MENARD		Single Family Multifamily
	RUNNELS		Single Family Multifamily
	SCHLEICHER		Single Family Multifamily
*	TOM GREEN		Single Family Multifamily
*	COKE	Summary	Single Family Multifamily
	STERLING		Single Family Multifamily
	COOKE	Summary	Single Family Multifamily
	FANNIN		Single Family Multifamily
	GRAYSON		Single Family Multifamily
*	HUNT		Single Family Multifamily
	MONTAGUE		Single Family Multifamily
	ARCHER	Summary	Single Family Multifamily

ERCOT Counties (*Representative counties)		2008	
	BAYLOR		<u>Single Family</u> <u>Multifamily</u>
	CLAY		<u>Single Family</u> <u>Multifamily</u>
	COTTLE		<u>Single Family</u> <u>Multifamily</u>
	FOARD		<u>Single Family</u> <u>Multifamily</u>
	HARDEMAN		<u>Single Family</u> <u>Multifamily</u>
	KNOX		<u>Single Family</u> <u>Multifamily</u>
*	WICHITA		<u>Single Family</u> <u>Multifamily</u>
	WILBARGER		<u>Single Family</u> <u>Multifamily</u>
	BEE		<u>Single Family</u> <u>Multifamily</u>
	CALHOUN		<u>Single Family</u> <u>Multifamily</u>
	GOLIAD		<u>Single Family</u> <u>Multifamily</u>
	JACKSON		<u>Single Family</u> <u>Multifamily</u>
	MATAGORDA	Summary	<u>Single Family</u> <u>Multifamily</u>
	REFUGIO		<u>Single Family</u> <u>Multifamily</u>
*	VICTORIA		<u>Single Family</u> <u>Multifamily</u>
	WHARTON		<u>Single Family</u> <u>Multifamily</u>
	DE WITT		<u>Single Family</u> <u>Multifamily</u>
*	KARNES	Summary	<u>Single Family</u> <u>Multifamily</u>
*	LAVACA	Summary	<u>Single Family</u> <u>Multifamily</u>